SOMALI DEMOCRATIC REPUBLIC
MINISTRY OF JUBA VALLEY DEVELOPMENT
FEDERAL REPUBLIC OF GERMANY
DEUTSCHE GESELLSCHAFT FÜR
TECHNISCHE ZUSAMMENARBEIT (GTZ) GMBH

MASTERPLAN FOR JUBA VALLEY DEVELOPMENT

ANNEXES 1 - 4

APRIL 1990

AGRAR- UND HYDROTECHNIK GMBH
Beratende Ingenieure · Consulting Engineers · Ingénieurs-Conseils
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S O M A L I A

Masterplan for Juba Valley Development

Land Resources and Land Use

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List of Abbreviations

AHT	-	Agrar- und Hydrotechnik GmbH
FAO	-	Food and Agriculture Organization of the United Nations
GTZ	-	German Agency for Technical Cooperation
HTS	-	Hunting Technical Services Ltd.
LRDC	-	Land Resources Development Center
MJVD	-	Ministry of Juba Valley Development
NRA	-	National Range Agency
ODA	-	Overseas Development Agency
RMR	-	Resource Management Research
SGU	-	Socio-Geographic Unit
USAID	-	United States Agency for International Development
USBR	-	United States Bureau of Reclamation
USDA	-	United States Department of Agriculture

Summary

This ANNEX deals with the land resources and land use for the Masterplan for Juba Valley Development.

It starts with a short description of the geology and geomorphology of the Study Area and its associated landforms and soils.

The land resources in the Juba Valley have been assessed in two different classification systems. The one classifies the land capability for rainfed agriculture and rangeland for the whole Study Area while the second one classifies land suitability for irrigated agriculture of the area below the 160 m contour line (the height of the outlet of the future Bardheere Dam).

For the land capability classification a total of 34,710 km^2 has been surveyed. Class 1 mainly occurs in the Jamaame, Jilib and Bu'aale Districts. Kismayo District shows the largest extent of class 2 lands due to the inclusion of some coastal hinterland in this class for climatic reasons. Classes 3 to 7 show the largest extent in Afmadow, which has a high potential as range land.

The second classification is based purely on physical (pedologic and topographic) criteria, consequencies no economic criteria have been considered in this classification (in ANNEX 4 economically relevant parameters, like pumping lift and distance from river, are considered).

A total of 1,050,100 ha was surveyed, of which 360,400 ha were classified as being arable. The remaining rest was land unsuitable for irrigation, due to soil chemical and/or physical limitations. Land suitability classes 1 and 2 show the largest extent in Bu'aale, Jilib, Jamaame and Saakow Districts. Lands with a potential for wetland paddy rice production show the largest extent in Bardheere, Saakow and Jamaame Districts.

Both classification maps can be found in the accompanying atlas. In this ANNEX only the extent and location of each capability and suitability class is given.

Land use and vegetation is classified in 16 land use units, subdivided in cultivated and uncultivated lands. The Land Use and Vegetation Map is also given in the accompanying atlas.

In Figure 6.1 of this ANNEX a sketch of the land use and vegetation repartition is given in which the 16 land use units are summarized by taking all cultivated lands under one heading.

The three districts in the North, Bardheere, Dinsor and Saakow show the largest extent of area under rainfed cultivation.

Irrigation is mainly practised in Jamaame and Jilib Districts. The extent of area under irrigation is rapidly expanding.

The main conclusion of this Land Resources and Land Use Study is that after construction of the Bardheere Dam and subsequent agricultural development, land resources will not be the limiting factor for development, but most probably human or water resources will restrict development.

Land Resources and Land Use

1. Introduction

This ANNEX deals with the land resources and land use in the Juba Valley and surrounding areas. The exact location of the Study Area is between longitudes 42° and 43° E and latitudes 2°36' N and 0°30' S.

The assessment of the land resources and land use is completely based on available studies of the Study Area or parts of it. Field checks and the interpretation of recent aerial photographs, dating from March 1987, have been conducted to update the available information.

Several types of land use, soil and capability surveys on different levels of detail have been performed in the Juba River Valley over a period of many years.

The study of land resources and land use has primarily been based on the following studies (1):

- FAO: Soil Survey of Juba River Valley, 1968 [11]
- HTS/Settlement Development Agency, Mogadishu, Inter-Riverine Agricultural Study, Borehamwoood, England 1977. [23]
- LRDC/ODA: Land-Use in Tsetse-Affected Areas of Southern Somalia, London 1985. [40]
- MJVD/GEOSURVEY: Landsat Interpretation Atlas of the Juba Valley Region, 1984. [61]
- MJVD/GTZ/AHT: [62 - 70]
- MJVD/USAID/USBR: Juba Valley, Analytical Studies of Land and Water Resources, 1987. [82]
- RMR: Southern Rangelands Survey, for NRA, 1984 [85]

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1) References are listed in the Bibliography in the Main Report of the Masterplan. Figures in brackets refer to sequence in that list.

2. Geology and Geomorphology

Towards the end of the Jurassic, the uplifting of the Precambrian basement complex has divided the broad geological basin, stretching into Kenya and Ethiopia, into two sub-basins:

- the northern Xuddur-Bardheere Basin, consisting of upper Jurassic to cretaceous sediments, and
- the coastal basin, consisting of Jurassic to Quaternary series.

The coastal basin is separated from the basement by the Bandar-Jalalosi fault, which extends some 500 km in a North-East to South-West direction.

The uplifting of the basement was followed by active subsidence of the two sub-basins, with the deposition of thousands of meters of sediments during the Tertiary and the Quaternary.

The northern part of the Study Area, between the dam site and Saakow, is cha- racterized by the exposure of rocks of Jurassic age consisting of lime- stones, marls, shales and sandstones. This geomorphologic unit is called the Mantled Limestone Plain.

Between Saakow and Bu'aale Precambrian gneisses and schists crop out which is due to faulting.

West of Saakow a 'Residual Upland' consisting of apparently mixed marine and alluvial sediments exists. It is uncertain whether these sediments are of Quaternary age or older.

The area between Bu'aale and the coast is characterized by a Marine Plain. This featureless plain is believed to be a former lagoon of the Indian Ocean and the sediments are deposited (sub)horizontally, slightly dipping south- wards. The sediments are of alluvial origin and consist mainly of marls and shales with interbedded sands and gravel.

The coastal area is characterized by sand dunes and coral rocks, West of the Juba River.

The floodplain of the Juba River is build up out of alternating sands, clays and deposits of intermediate textures.

From the river inland there are successively a levee, consisting of material with a coarse texture, a deshek, with or without external drainage, an allu- vial fan, built up by a togga (1) having its outlet in the river. Next in sequence is a small pediplain escarpment preceding a pediplain, which can sometimes be slightly eroded.

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1) Togga describes a kind of gully which drains a plain.

In the southern stretch of the river, South of Bu'aale, the floodplain is 2 to 4 km wide. Other occurring features in the floodplain are oxbow-lakes, cutoffs and old meander channels.

Typical cross sections of several stretches of the Juba River and its main physiographic features are given in Figure 2.1.

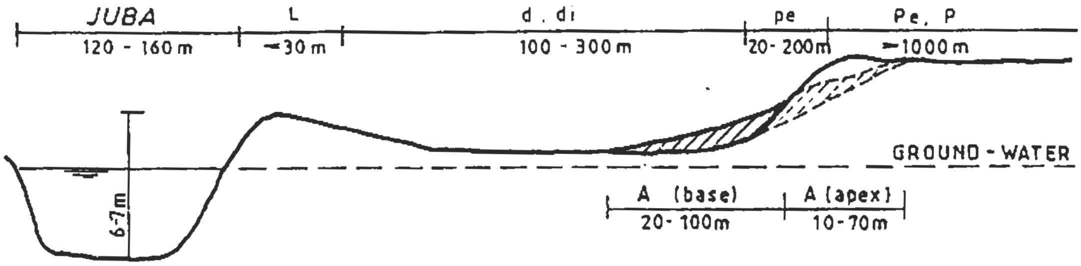
In the southwestern part alluvial deposits of the Shebelli River occur. This area is characterized by swamps and the Shebelli River disappears. There are distinct differences between the deposits North and South of the swamps. These will be discussed in Chapter 6.

The original vegetation of the sand dunes has disappeared, leaving the very erodible sands at the surface. At some places erosion is clearly detectable and the dunes start moving in northerly directions.

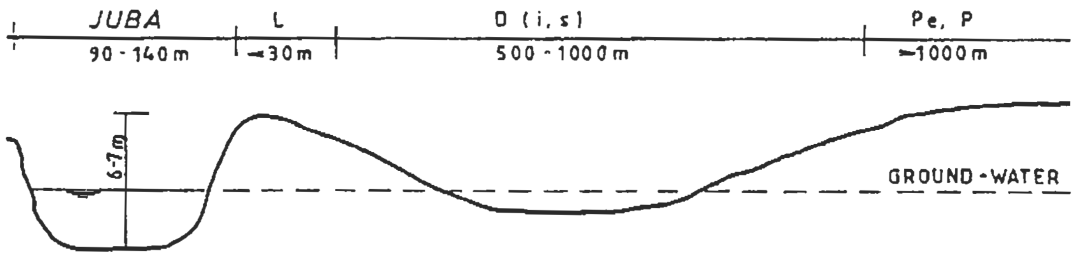
Deshek Waamo, located between Afmadow and Kismayo serves as a buffer for the precipitation fallen in its watershed and to buffer high floods occurring in the Juba River.

Figure 2.1 Cross-Sections of River Physiographic Features

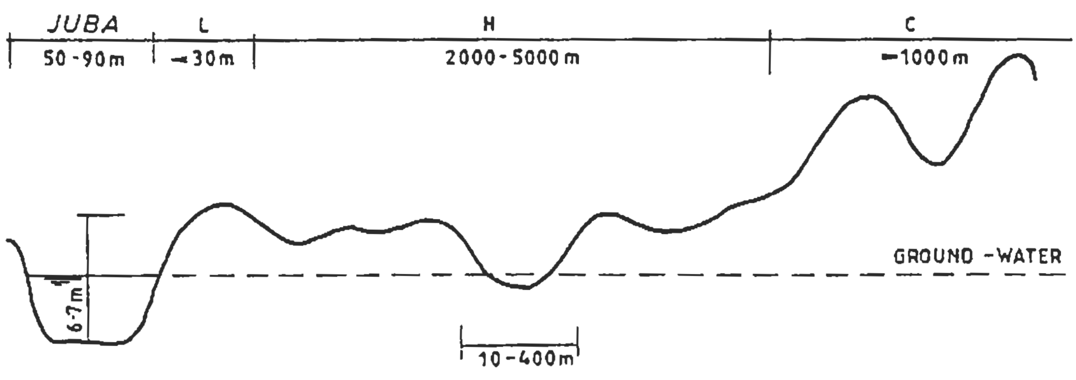
BARDHEERE - CANOOLE



CANOOLE - JILIB



JILIB - GOBWEYN



Legend:

L - Levee
d - Deshek with external drainage
D - Deshek without external drainage
pe - Escarpment
Pe - Slightly eroded pediplain
P - Pediplain
H - Heterogeneous alluvial sediments
C - Coral reefs
i - Irrigated agriculture
s - Rainfed agriculture

3. Associated Landforms and Soils

Most of the terminology used in this section is based on the MJVD/USAID/USBR study [82], which unfortunately does not include a Soil Map in its report. In Figure 3.1 the landforms occurring in the Study Area are presented (1).

3.1 Mantled Limestone Plain

Soils of the mantled limestone plain are of variable thickness (2 to 3 m deep) but near the escarpment to the alluvial plain and the tertiary rocks they become very shallow. They develop in situ through weathering of parent calcareous, occasionally gypsiferous clays overlying limestone and marl. The mantled limestone plain soils are generally uniform with slight variations in gradient, soil color and vegetation. Generally they possess heavy textures and low permeability with a tendency to poor drainage. Vertisols are predominant in the region. Soils show evidence of swelling and shrinking during the wetting and drying cycle in the form of slickensides or pressure faces and they show a gilgai development with cracks up to 1 m deep and 1 cm wide in the dry season. Salinity and sodicity levels of the upper 30 cm are moderate to low but are increasing with depth. Soils with a rapid increase with depth in salinity and sodicity have been classified as non-arable. Three classes of soils have been distinguished on the mantled limestone plain related to suitability for irrigation, R1, R2 and 6 (2) (Class 6 includes saline, sodic and shallow soils and soils on steep areas). Mostly classes are recognizable at their changing surface colors varying from yellowish brown, brown and yellowish red for R1, R2 and 6, respectively.

3.2 Marine Plain

The marine plain soils are developing on a vast featureless flood plain of fine textured ancient estuarine sediments. Most of these soils, as those of the mantled limestone plain, are classified as Vertisols. The textures are almost invariably clays with a depth varying from 0 - 300 cm. The colors vary from dark gray (5 YR 4/1) at the surface to olive (5 YR 4/3) at the subsurface. Normally the structure of the soil is weak coarse blocky at the surface grading to massive and structureless at a depth of 60 to 300 cm.

Like the soils of the mantled limestone plain these soils also show the features of swelling and shrinking. The permeability and drainage of the soils are moderate to slow/poor, respectively.

Because of the deposition of the sediments in a marine environment, the soils show a tendency to salinisation after prolonged irrigation. Also on this landform in relation to suitability for irrigation, three classes have been identified, R1, R2 and 6.

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1) The soils and their suitability for irrigation are classified according to the Soil Taxonomy of USDA Soil Conservation Service and the USBR system for land suitability assessment, respectively.
2) For an explanation of the USBR classification, see Chapter 5.

3.3 Alluvial Plain

The alluvial soils are the most important ones for agriculture at least under present conditions. The recent alluvial soils are developing in the bottomlands and lower terraces of the Juba River in recently deposited sedimentary material. Older deposits occur in the lower Juba. The physical characteristics of these soils are more favorable for irrigation than those of the mantled limestone plain and the marine plain since they have coarser textures, are more friable with better structures and have higher rates of hydraulic conductivity. Their colors range from dark brown (7.5 YR 3/2) to strong brown (7.5 YR 4/2). Textures are variable and certain profiles are unstratified clay loams while others are stratified with a textural range of clay loam to fine sandy loams or lighter textures.

The soil surface structure is usually weak subangular blocky, grading to moderate medium prismatic and to massive or structureless below 120 cm depth. The soils seldom have those dense clay horizons and massive structure near the surface that is found in the soils of the mantled limestone plain and the marine plain.

Physical and chemical properties are such that these soils have good drainage both horizontally and vertically. Most of the soils are classified in Class 1 or 2 with regard to irrigation suitability.

3.4 Residual Plain (near Saakow)

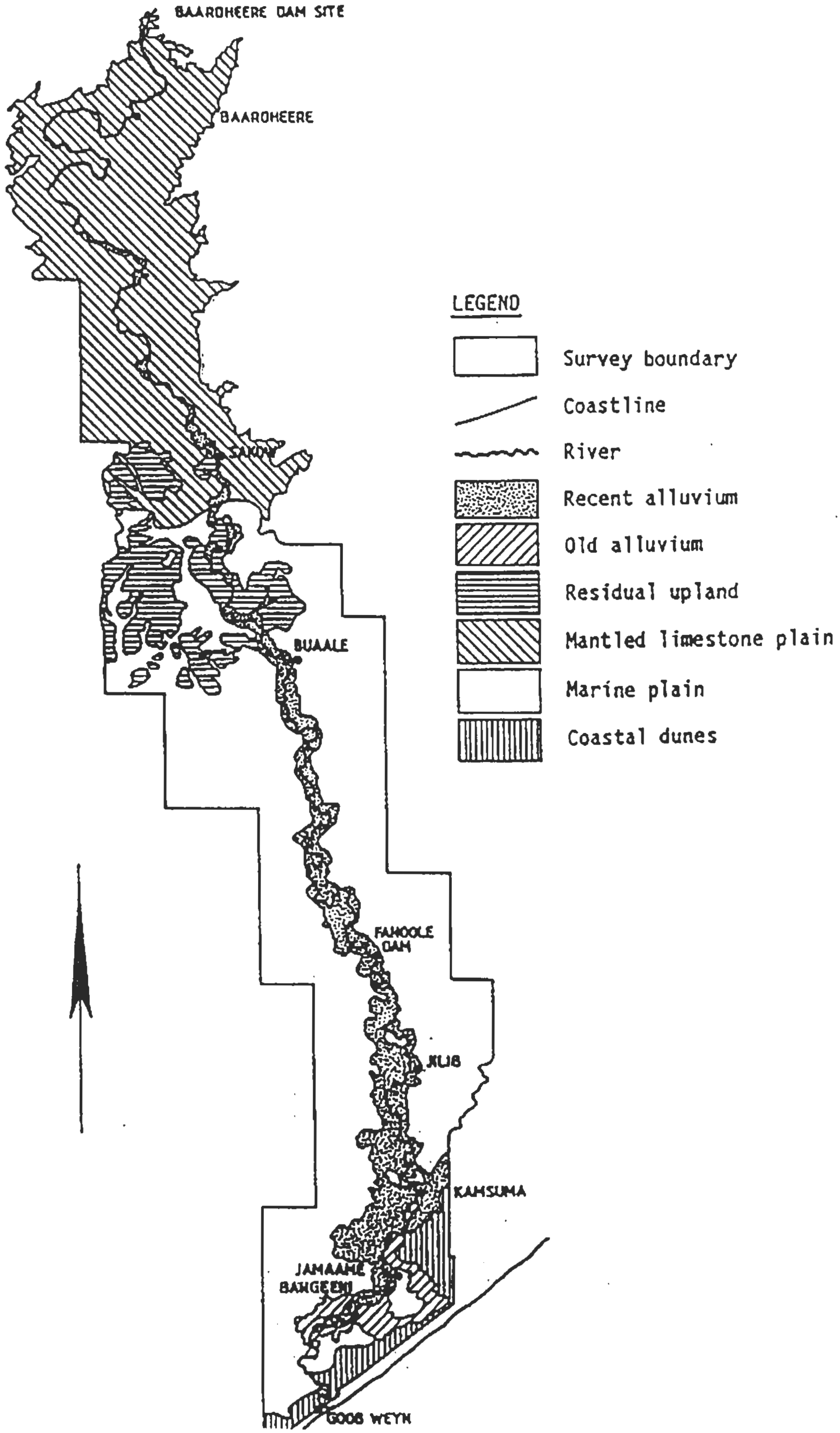
The residual plain, although not a distinct major landform, is discussed separately here due to its significant soil development which has a strong effect on irrigation suitability. These soils, although they may have heavy subsoil layers over calcareous gravels, are somewhat lighter in texture than the surrounding Vertisols and commonly have gravelly layers within the profile. They are more free draining than their associated soils of the mantled limestone plain.

The soils are non-saline and non-sodic at the surface becoming slightly saline and sodic with increasing depth. With regard to suitability for irrigation these soils belong to class 2.

3.5 Other Minor Landforms

The deshek, old alluvial plain, river levee, and the river meander areas have rather complex soils, which develop in conjunction with the alluvial soils. The following textures have been determined: coarse sand for the levees, clay to clay loam surfaces overlying clay to clay loam subsurfaces interchanged with stratifications of loams, sandy loams and sandy clay loams for the desheks. In the deepest part of the deshek a sedimentation of clay, 10 - 20 cm per flood, takes place.

Figure 3.1 Landforms in the Study Area (Source: [82])



4. Land Capability for Rainfed Agriculture and Rangeland

4.1 Description of the Land Capability Classification

Some land capability classifications on reconnaissance level exist for the Study Area or parts of it.

Survey	Area (km2)	Map Scale
HTS 1977	150,000	1:500,000
GEOSURVEY 1984	27,000	1:200,000
LRDC 1985	250,000	1:500,000

HTS (1977) [23] has based their work primarily on the Soil Survey of FAO/Lockwood (1968) [11]. They have reinterpreted the soil map in terms of land suitability for both rainfed and irrigated agriculture.

MJVD/GEOSURVEY (1984) [61] based their work on satellite image processing and some additional field work. Unfortunately their interpretation is based on satellite images Landsat MSS from 1976 which have not been corrected. Therefore this interpretation is questionable.

LRDC/ODA (1985) [40] slightly adapted the work of HTS and produced a very comprehensive map which was most suited to the purposes of the Study.

The legend of the LRDC study has been adopted with some adaptations for the land capability classification for rainfed agriculture and rangeland. LRDC has taken a mean annual rainfall of 450 mm/yr as an arbitrary limit for rainfed cropping with an acceptable degree of reliability. In practice, however, rainfall distribution through the year is more critical than the mean annual total. Towards the coast, where much of the rain falls in the extended Gu/Xagai season and despite mean annual totals below 450 mm, a single rainfed crop is reliably assured. Hence certain coastal hinterland was included in the areas of rainfed cropping potential.

In Table 4.1 the land capability classification is presented. Three main groups are distinguished: potential for rainfed cropping, potential for rangeland and unsuitable land, which are subdivided into a total of 10 classes.

Table 4.1 Land Capability Classification

- Potential for Rainfed Cropping (annual rainfall exceeds 450 mm or concentrated in a single wet season)

  Class 1 Land very suitable or suitable

  Class 2 Land suitable but exhibiting soil chemical or physical limitations which will invariably reduce crop yields significantly

- Potential for Rangeland

  Class 3 Intermediate soil textures but annual rainfall less than 450 mm.

  Class 4 Coarser soil textures (sandy or gravelly) and/or dissected topography predominate, including the inland lagoonal sands

  Class 5 Saline soils predominate, including gypseous deposits

  Class 6 Coarse soil textures, sand dunes

  Class 7 Poorly drained, mostly alkaline soils

- Unsuitable for agricultural purposes (other than poor seasonal grazing, browse or charcoal production)

  Class 8 Shallow soils and/or stony dissected land with rock outcrops

  Class 9 Swamp or open water (permanent or semipermanent)

  Class 10 Barren land (rocky; active dunes; or intense salinity)

Class 1 for rainfed cropping implies that the land is very well suited for a range of crops. Neither the topography nor the soils pose any problems as to workability or depth. Some smaller limitations however may occur such as locally impeded drainage, moderate salinity or alkalinity in the subsoil.

Class 2 land for rainfed cropping is still available for traditional food cropping but suffers extensively from at least one major defect. Salinity and alkalinity levels in the subsoil may be high.

In the case of class 3 land, with good soils though inadequate rainfall, the limitation stems from risk of crop failure.

Those lands, with attributes inhibiting any effective production, have defects that are self-explanatory, like sodicity, alkalinity, topography etc.

In this classification no provision is made for land suitable for irrigation.

4.2 Results of the Land Capability Classification

In Table 4.2 and Map 5 (in atlas) the results of the land capability classification are presented.

The occurrence of class 1 land is restricted to the Juba River Floodplain south of Dujuma and a small part of the Shebeelle Floodplain. The larger part of these soils are presently under irrigation while the rest is used for rainfed agriculture.

Class 2 land is mainly concentrated in a circle with a radius between 10 - 15 km around Dinsor and in the coastal hinterland North of Kismayo. In these areas a potential for rainfed cropping with adequate precipitation exists. Also in the western part of Saakow District some 600 km^2 of land class 2 are found, the same surface appears in Jilib District.

West of the Juba River there is a potential to use land as range. Land classes 3 to 7 are highly represented here. In general the capability for the marine plain soils is restricted to land class 7, with poorly drained, mostly alkaline soils.

Classes 8 to 10 mainly appear in Bardheere District. In Jamaame District eroded sand dunes belong to class 10.

Table 4.2 Extent of Land According to the Capability Classes in the Study Area (in km^2)

District	Land Classes				Total
	1	2	3 - 7	8 - 10	
Kismayo	43	1,496	1,716	425	3,680
Jamaame	519	142	1,490	149	2,300
Jilib	574	683	3,688	105	5,050
Bu'aale	246	0	5,214	0	5,460
Saakow	0	685	3,995	930	5,610
Bardheere	7	221	1,631	3,071	4,930
Afmadow	0	235	5,295	150	5,680
Dinsor	7	842	1,507	644	3,000
Total	1,396	4,304	24,536	5,474	35,710

Source: Own calculations

5. Land Suitability Classification for Irrigation

5.1 Description of Classification

The assessment of land suitability for irrigation for the Masterplan was prepared by the US Bureau for Reclamation [82] (USBR). Although their study is not complete, for example a comprehensive soil map is missing and the number of profiles analyzed is rather low, this USBR study will be taken as a basis for the assessment of suitability for irrigation.

The normal procedure for suitability mapping is at first the elaboration of a soil map from which, using classification specifications, a suitability or capability map can be deducted.

The study area was restricted by USBR to all the lands situated below the 160 m contour line, the height of the outlet of the future Bardheere Dam. (For the Study Area see Figure 3.1.)

5.2 Land Classification Specifications

In Table 5.1 the land classification specifications used for the assessment of irrigation suitability are shown. In the first column the land characteristics with restrictive value for the determination of the specific classes are listed. In the following columns the minimum requirements per land characteristic for each land class is given.

Table 5.1 Land Classification for Irrigation Suitability - Juba River Valley, Somalia

Soil / Land classes:	Class 1 Highly suitable	Class 2 - suitable	Class R1 Highly suitable for paddy rice	Class R2 Suitable for paddy rice
Texture (1)				
Surface (0-30 cm)	Fine sandy loam to heavy clay loam	Loamy fine sand to permeable clay	Fine sandy loam to clay	Loamy sand to clay
Subsoil (30-100 cm)	Sandy loam to permeable clay	Loamy fine sand to permeable clay	Loamy sand to clay	Loamy sand to clay
Rooting depth (2)	More than 100 cm	More than 60 cm	More than 60 cm	More than 40 cm
Available water capacity	More than 12 cm in the 0-100 cm zone	More than 8 cm in the 0-60 cm zone	Not applicable	Not applicable
Reaction, pH in paste (3)	6.5 to 8.2 in the 0-100 cm zone	6.0 to 8.7 in the 0-60 cm zone	6.0 to 8.7 in the 0-60 cm zone	5.5 to 9.0 in the 0-60 cm zone
Salinity EC in mmhos (4)	Less than 4.0 in the 0-100 cm zone	Less than 8.0 in the 0-60 cm zone	Less than 4.0 in the 0-60 cm zone	Less than 8.0 in the 0-40 cm zone
Sodicity, SAR with irrigation (5)	SAR not to exceed 9.0 in fine textured soils but maybe higher with coarser textures			
Cation-exchange capacity at pH 8.2	More than 16 mq/100 g in the 0-100 zone	More than 10 mq/100 g in the 0-60 cm zone	More than 16 mq/100 g in the 0-60 cm zone	More than 10 mq/100 g in the 0-40 cm zone
Topography (t):				
General slope	Less than 2%	Less than 2%	Less than 2%	Less than 2%
Microrelief (surface roughness)	Low grading requirement, less than 0.1 m average cut and fill	May require moderate grading, less than 0.25 m average cut and fill	Low grading requirement, less than 0.1 m average cut and fill	May require moderate grading, less than 0.25 m average cut and fill
Surface rocks or stones	Less than 20 m^3/ha	Less than 60 m^3/ha	Less than 20 m^3/ha	Less than 60 m^3/ha
Trees and brush	Low or moderately low clearing cost	May have moderately high clearing cost	Low or moderately low clearing cost	May have moderately high clearing cost
Drainage (d):				
Internal drainage (6)	Relatively well-drained, low subsurface drainage construction requirement	Moderately well-drained, low to moderately high subsurface drainage construction requirement	Soil drainage characteristics and position must be favourable for continuous flooding	Soil drainage characteristics and position must be favourable for continuous flooding
Flood hazard	None to very low (rarely flooded)	None to low (may be subject to infrequent floods or short duration)	None to low (may be subject to infrequent floods of short duration)	May be subject to frequent floods of short duration

1) Appraisal of surface texture, rooting depth, and available water capacity will be based on the conditions existing after grading or levelling.
2) Refers to the minimum depth (after grading or levelling) to sand, gravelly or sand layers, hardpans, or any material that physically restricts root development.
3) Soil pH measurement in paste by glass-electrode pH meter.
4) Refers to the electrical conductivity of the saturation extract (EC) in millimhos/cm at equilibrium with irrigation.
5) Refers to the sodium-adsorption ratio of the saturation extract, at equilibrium with irrigation.
6) To be based on profile characteristics including hydraulic conductivity and depth to relatively impermeable (barrier) zone as measured or as inferred from profile characteristics such as texture, structure, mottling, gley colors, etc.

Class 6 - non-arable lands: Includes all lands that do not meet the minimum requirements for irrigation suitability. They include lands with coarse-textured surface soils having low available water capacity, and/or low cation-exchange capacity, soils that are shallow over clean sand, gravelly or sandy materials, ironstone, bedrock or other materials unfavourable for root development or impervious to water; lands with salt-affected soils (saline, sodic, or saline-sodic) that are too costly to reclaim because of position, low permeability, or other factors restricting leaching and drainage, rocky, rough, steep and gullied or channel-dissected lands; isolated tracks; high areas such as hillocks and other areas above commands; overflow and runoff channels; permanent swamp or wetland areas; and all other obviously non-irrigable lands.

Source: [illegible]

5.3. Results of the Land Classification

A total of 1,050,100 ha was surveyed, of which 360,400 ha were classified as being arable. This land is subdivided in 170,500 ha being suitable for diversified cropping and the rest being 189,900 ha is considered suitable for paddy rice production.

Table 5.2 gives the extent of arable land per district and per Socio-Geographic Unit (SGU).

Main indications of the Land Suitability Map for Irrigation (Map 6) are that the land suitable for diversified cropping is generally found at lower elevations adjacent to the river. The largest potential is found in the area South of Jilib to Bangheeni. Here a number of large-scale irrigation projects are located, e.g. Juba Sugar Project, Fanoole Rice Project, Mogambo Irrigation Project.

Class 1 croplands are suitable for growing a wide range of climatically adapted crops. These lands have an adequate size with smooth topography and the soils are typified by fine textures, moderately good water holding capacity, and moderate inherent fertility. The subsoils exhibit moderate rates of vertical and horizontal permeability.

Class 2 croplands are less suitable for irrigation and are adapted to a narrower range of crops. The soil chemical and physical properties cause a lower suitability. The soils are measurably higher in salinity and sodicity than class 1 soils. In some cases topography causes higher land levelling costs.

The R1 and R2 lands with homogeneous clayey profiles and nearly level topography show a potential for wetland paddy rice production due to restricted drainage. The ricelands are further away from the Juba River and are slightly elevated above the floodplain. Under present rainfall conditions the surface drainage is sufficient to enable moderate to good crop yields under rainfed agriculture. Under irrigation, these lands require a water control and surface drainage system. Generally these soils will be slightly saline-sodic at the surface and moderately saline-sodic at the subsurface.

Non arable lands, Class 6 lands, comprise some desheks, lands with high electric conductivity (EC) and Sodium Absorption Ratio (SAR) values, toggas, escarpments, swamps, coastal dunes and rough topography, and other lands with seriously deficient features.

Table 5.2 Extent of Land Suitable for Irrigation (in ha) per District and Socio-Geographic Unit (SGU) (1)

Area	Land Class 1	2	R1	R2	Total
Kismayo	-	800	-	-	800
Jamaame	6,650	24,200	20,300	7,550	58,700
Jilib	11,350	27,200	200	1,550	40,300
Bu'aale	3,550	66,500	750	17,350	88,150
Saakow	400	22,800	-	38,900	62,100
Bardheere	1,300	5,750	350	102,950	110,350
Total	23,250	147,250	21,600	168,300	360,400
SGU 1	1,300	6,050	-	87,950	95,300
SGU 2	3,950	88,750	750	36,150	129,600
SGU 3	11,750	29,150	200	1,550	42,650
SGU 4	6,250	22,600	13,100	5,600	47,550
SGU 5	-	-	-	12,600	12,600
SGU 6	-	400	7,200	-	7,600
SGU 7	-	-	-	2,000	2,000
SGU 8	-	300	350	11,200	11,850
SGU 9	-	-	-	11,250	11,250
Total	23,250	147,250	21,600	168,300	360,400

Source: USBR [82]

1) For the definition of SGU, refer to Chapter 2 of Main Report.

6. Land Use

6.1 Land Tenure

There are two different systems on which land ownership is based in Somalia, the codified land use rights and the traditional land tenure system.

Since 1975, when the Land Reform Law No. 73 came into force, all land is state owned. The Government may grant concessions to individuals or groups, giving them the right to use the land under certain conditions.

The law is generally ignored in the Juba Valley; it has only been applied to a limited extent in the irrigated areas. In other areas, however, land tenure practice is still based on the traditional system.

Observations in the field have shown evidence of a rapidly changing tenure system, at least in the areas adjacent to the river where the best soils are to be found. It appears that these changes are to the disadvantage of smallholders, individually as well as for their communities.

The great majority of the smallholders have never registered their lands since they relied on their traditional rights. Therefore they are in a legally weak position. Although individual land rights still seem to be respected, share cropping arrangements which are in breach of the law, are reducing the actual rights of smallholders. Lands, mainly located on the river levees, are increasingly being claimed and registered by outsiders who try to obtain land rights for the future, when river flows will be regulated. The extent of this trend cannot be quantified but certainly requires immediate attention.

6.2 Land Use Categories

Table 6.1 shows the legend for the land use classification as used for the Land Use Map (Map 7 in atlas). A division has been made between cultivated and uncultivated lands.

From the uncultivated lands bushland, open bushland, bushed duneland, grassland, bushed grassland are used as rangeland for livestock. Forest and thicket are also used for grazing depending on the penetration possibilities for the animals. Forest has not been mapped separately, since only scattered patches occur in the area along the Juba River, with extends too small to depict at a 1:500,000 scale map.

Forest and range potential is assessed in ANNEX 8.

Table 6.1 Legend for Land Use Classification

Cultivated Lands	
- Small-/Large-Scale Irrigation	I
- Rainfed Cultivation	C
- Rainfed Cultivation on Dunelands	CD
- Flood Recession Cultivation in Desneks	D
Range and Forest Lands	
- Bushland, shrubs up to 6 m in height, canopy cover is more than 50%	B
- Open Bushland, same as bushland with canopy cover 25 - 50%	BO
- Bushed Grassland; grassland with scattered or grouped shrubs or trees, canopy cover 5 - 25%	BG
- Bushed Duneland; duneland with scattered or grouped shrubs or trees, canopy cover 5 - 25%	BD
Grassland; canopy cover of trees <2%., land is dominated by grasses or other herbs	G
- Thicket; An extreme form of bushland where the woody plants form a closed stand	T
Other	
- Swamps; permanent or semipermanent swamps	S
- Eroded Dunelands	E

6.2.1 Cultivated Lands

6.2.1.1 Large- and Medium-Scale Irrigation Projects

Small-scale irrigation schemes are defined as irrigated areas of less than 20 ha. The area on which small-scale irrigation takes place, was estimated in the AHT [63] study at 1,600 ha, predominantly occurring in the area between the Bardheere damsite and Saakow. A new estimate of the area based on aerial photographs of March 1987 shows an increase of the area to about 4,100 ha and an increasing extension into Bu'aale District.

In the flood plain area south of Jilib several irrigation projects are located. Per definition medium-scale irrigation perimeters cover areas from 20 to 200 ha, and large-scale irrigation schemes have an extent of over 200 ha.

The largest one is the Juba Sugar Project with an area suitable for irrigation of about 21,000 ha. At present some 7,000 ha are irrigated and planted with sugar cane.

The Mogambo Rice Project has the second largest land development potential in the region. According to the figures given in the USBR study [82], some 2,400 ha land of class 2 are already developed. Another 4,000 ha of class 2 land and 3,400 ha of classes R1 and R2 land have been allocated to the project, which consequently has a development potential of 9,800 ha.

The Fanoole Rice Project has a potential of about 7,500 ha of which 1,500 ha have been developed.

A new project, the Homboy Flood Storage Project, provides the possibility to develop about 3,000 ha. All the lands of this project are classified as class 2 lands.

In the same stretch of the Juba River many banana farms are located. The total arable land under irrigation on the banana farms and other medium-scale irrigation projects amount to 12,000 ha of Class 1 and 2 lands. An estimate of the area under banana cultivation amounts to 8,300 ha (gross area).

6.2.1.2 Flood Recession Cultivation in Desheks

Desheks are defined as natural depressions in the flood plain of the Juba River. These are seasonally flooded by river water and may in addition be flooded by underground flow from the river or by run-off from adjacent areas. River levees or artificial bunds hinder the return flow when river levels recede.

When water levels have dropped (evaporation) the soils still retain enough moisture to support one crop and farmers plant these desheks.

The main crops cultivated are: sesame, maize and vegetables.

An estimate of all desheks presently under cultivation in AHT/MJVD study [63] amounts to 7,000 ha, excluding about 4,400 ha of levee land, which is normally included in the land under flood recession cultivation.

6.2.1.3 Rainfed Cultivated Area

In the AHT study [70] the area under rainfed agriculture in the study area was assessed and a total of 122,500 ha was found. This figure does not include the districts of Dinsor and Afmadow.

In the same study a subdivision of the total farm land into bushland, fallow land, unutilized land and area under actual cultivation was proposed. The percentages of the area under actual cultivation were 70%, 66%, and 66% for Bardheere, Saakow and Bu'aale, respectively. For Jilib, Jamaame and Kismayo the percentages were lower, being 21%, 49% and 10%, respectively.

Parts of the districts of Dinsor and Afmadow are included in the Study Area. For these regions only the total rainfed farming land has been determined.

The percentage of actually cropped land in the Dinsor region is estimated to be higher than 70%, since the conditions in soil potential and precipitation are very favorable for rainfed agriculture. In the Afmadow Region hardly any rainfed agriculture is practiced.

Cropping intensities in rainfed agriculture are 200% depending heavily on labour availability.

6.2.2 Forest and Rangelands

6.2.2.1 Forest

Small spots of gallery forest are still present on the embankments of the Juba River. The need for fuel wood, building wood (houses and canoes), however, has put an extreme pressure on this land use category.

6.2.2.2 Bushland

Like most uncultivated lands, also bushland is used as rangeland for livestock. If the canopy cover is less than 50%, the area is mapped as open bushland, which can be considered as a degraded form of bushland because of more intensive grazing. Duneland which is covered by shrubs and trees is mapped separately.

6.2.2.3 Grassland

This is land dominated by grasses and occasionally other herbs, sometimes with widely scattered or grouped shrubs and trees, the canopy cover of which does not exceed 5%. If the canopy cover exceeds 5%, the area is classified as bushed grassland.

6.3 Occurrence of Land Use Categories in the Study Area

Table 6.2 and Figure 6.1 show the present extent of land use types in the Study Area. Figure 6.1 is a simplified version of Map 7 in the atlas.

Table 6.2 Extent of Land Use Units in the Study Area (km^2)

District	Cultivated Land			Range & Forest Land	Towns, Villages & Other	Total	Floodplain	
	Rain-fed	Flood Recession	Irri-gated				Area	%
Kismayo	15	0	5	3,380	280	3,680	90	2
Jamaame	190	0	45	1,600	465	2,300	1,020	44
Jilib	70	20	75	4,350	535	5,050	510	10
Bu'aale	20	35	10	5,260	135	5,460	505	9
Saakow	350	15	10	4,950	285	5,610	595	11
Bardheere	580	0	25	4,050	275	4,930	1,030	21
Afmadow	20	0	0	5,550	110	5,680	0	-
Dinsor	420	0	0	2,400	180	3,000	0	-
Total	1,665	70	170	31,540	2,265	35,710	3,750	11

Source: Own calculations

A total area of 35,710 km^2 has been classified. The extents of the Land Use Categories are approximate figures only, since scale of mapping (1:500,000) does not allow exact surface planimetrition. Among of the cultivated lands the area under rainfed cultivation has the largest extent; approximately 166,500 ha (including the Dinsor District). The three districts in the North, Bardheere, Dinsor and Saakow show the largest area under traditional rainfed cultivation.

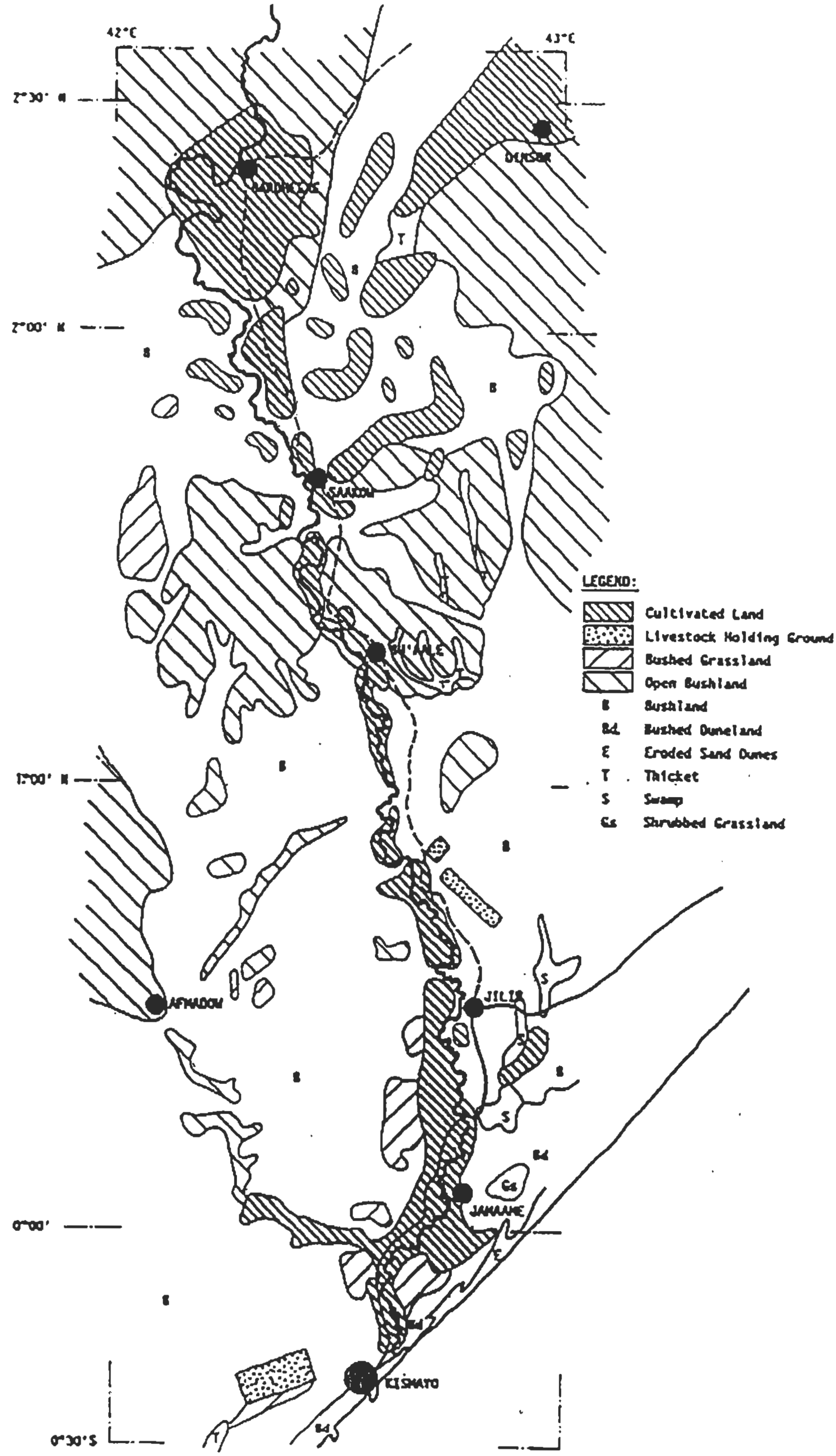
In Bardheere and Saakow Districts the chance of crop failure is high, since precipitation in large parts of these district amounts to less than 450 mm per year; and the main crops (sorghum) are generally low.

In Dinsor and the southern districts, rainfall conditions are more favourable. Precipitation exceeds 450 mm per year, enough to support one crop. The main crop cultivated is maize. cultivated dunelands have been mapped in Kismayo and Jamaame Districts.

Flood recession cultivation is mainly practised in the middle stretch of the Juba River, 20 km North of Saakow to Jilib.

The potential for Deshek cultivation is estimated at approximately 22,800 ha of which presently some 7,000 ha are being cultivated.

Figure 6.1 Land Use and Vegetation in the Study Area



The area under irrigated agriculture amounts to 17,000 ha. This is a gross area figure, including roads and other inclusions which were too small to delineate separately.

Small-scale irrigation schemes occur predominantly in the area between the Bardheere damsite and Saakow and extends further into Bu'aale District. The average farm size is approximately 3.5 ha.

Medium-scale irrigation schemes, to which include banana farms, are mainly found in the southern stretch of Juba River, between Kamsuma and Yoontoy.

In the same stretch of the river, the before mentioned large-scale irrigation projects, are located. At present some 8,500 ha (net area) are being irrigated, which corresponds to 20% of the total development potential.

Range an forest lands occupy approximately 3.1 million ha. This land use category, with the largest extent, besides exploitation as grazing land, serves also to extract fuel and building wood.

Gallery forest mainly occurs in Bu'aale District but is rapidly diminishing due to increasing population pressure.

Bushland in all its graduations has the largest extent in Afmadow District, about 98% of the district has been classified under this land use category.

Estimates of available biomass and carrying capacity have been made in ANNEX 8.

Thicket mainly occurs on sites where soil moisture conditions favour the growth of a dense vegetation eg. in ephemeral drainage ways.

ANNEX 2

S O M A L I A

Masterplan for Juba Valley Development

Water

ANNEX 2

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ANNEX 2

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List of Abbreviations

AHT	-	Agrar- und Hydrotechnik GmbH
BDP	-	Bardheere Dam Project
EC	-	Electric Conductivity
ELC	-	Electroconsult, Milano/Italy
FAO	-	Food & Agriculture Organization of the United Nations
GTZ	-	German Agency for Technical Cooperation
GWh	-	Giga Watt hours
m.a.s.l.	-	meter above sea level
MJVD	-	Ministry of Juba Valley Development
MW	-	Mega Watt
NTC	-	National Technical Committee
SAR	-	Sodium Adsorption Ratio
SGU	-	Socio-Geographic Unit
SoSh	-	Somali Shilling
TLU	-	Tropical Livestock Unit
USDA	-	United States Department of Agriculture

Water

1. Introduction

To promote the rational management of Somalia's water resources in the Juba Valley, a development concept and specific measures need to be defined for the better use, conservation and protection of surface- and groundwater resources in the Juba River catchment in Somalia (see Figure 1/1). Such a development concept should incorporate the following basic principles:

- a basin approach to water management and administration
- a right to water subject to the principle of both beneficial and reasonable use
- water use must respect quality standards
- the methods and means of diverting and using water must be rational and efficient
- waste water and irrigation return flow should not limit further use of river water
- the rational use, conservation and protection of water resources are to be based on an adequate monitoring system.

The proposed National Water Resources Law (1) constitutes legislation for this purpose, sets out the objectives, assigns the responsibilities and specifies the constituent elements for such a concept as follows:

a) an inventory of existing and potential water supplies and water needs which are, or could be served by each identified water source and a list of projects (in order of priority) necessary to meet such needs;

b) an inventory of water sources threatened by pollution and a determination of specific measures necessary to eliminate or reduce such risk;

c) a schedule for the sectoral allocation of water on a district by district basis between domestic, livestock, agricultural, commercial and industrial water users;

d) a consideration of the problems of water conservation and reuse and a list of projects (in order of priority) necessary to effectuate the conservation or reuse of water;

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1) Prepared by the FAO mission in 1984 within the project TCP/SOM/2314

e) an evaluation of the merits of water desalination and a list of projects (in order of priority) to be undertaken for the purpose of reducing the salinity of water where it is economically feasible to do so;

f) measures for the protection of catchment areas;

h) measures to be instituted in the event of a drought or other natural or man-made water emergency;

i) measures to be undertaken for the purpose of preventing or controlling the transmission of waterborne diseases, and

j) flood and drainage protection measures.

It is against this background that this ANNEX describes the potential of the Juba Valley, derives a development concept and defines specific development measures.

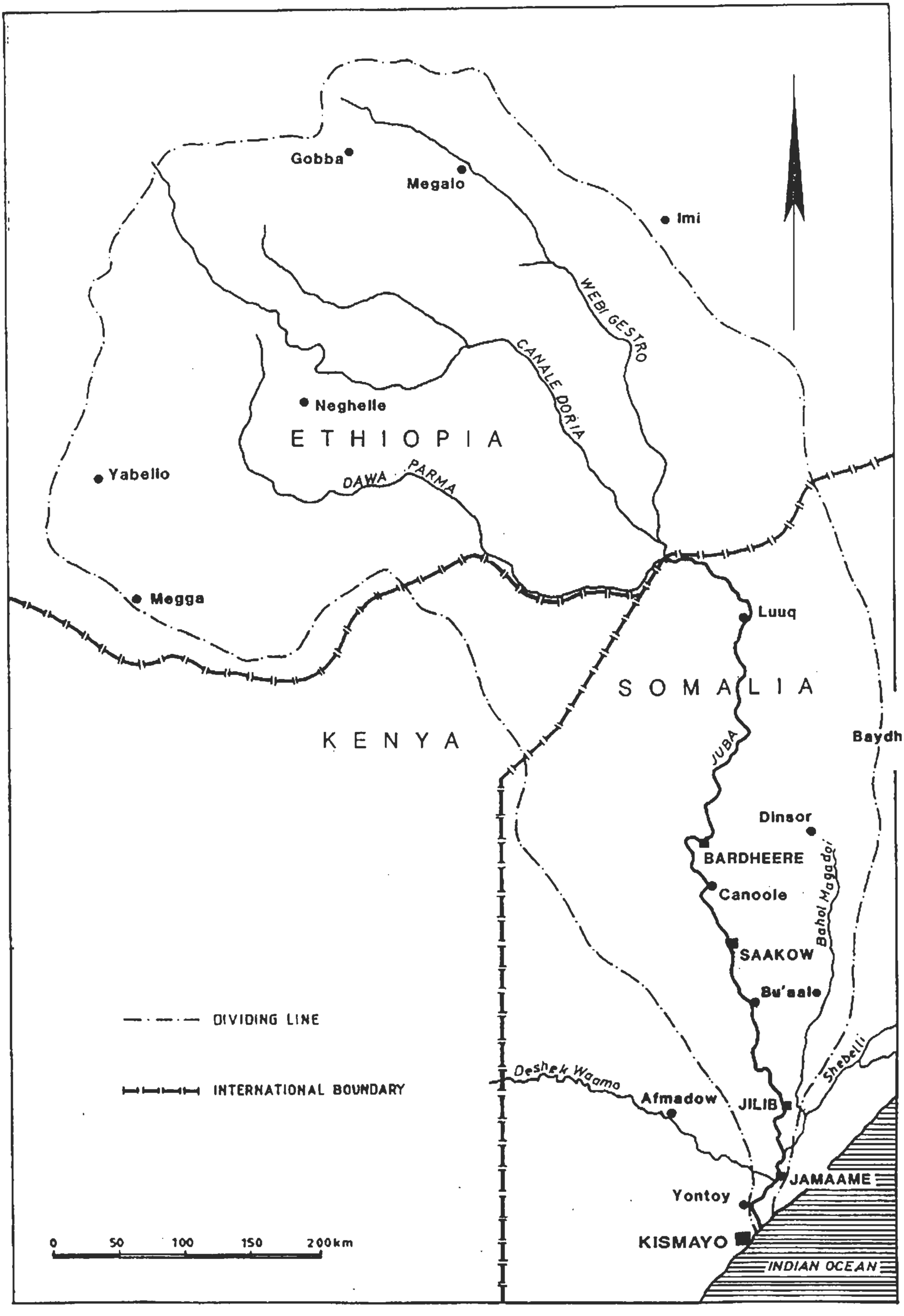
This ANNEX provides the basic data and analysis of the present situation by looking at the climatic factors (Chapter 2), the hydrogeology (Chapter 3), the hydrology of the Juba River (Chapter 4) and the present stage of development of the irrigation potential (Chapter 5).

From this, the constraints to further development of irrigated agriculture and a reduction of flood damages are analyzed (Chapter 6) and a development concept for irrigated agriculture and flood protection derived (Chapter 7).

This concept is then looked at in a regional context in Chapter 8, which the last Chapter contains the specific development proposals.

This ANNEX had been completed before the detailed JESS data on water quality were available and the potential salinity hazard was identified. This aspect is, therefore, not covered in any detail here. It has, however, been included in the Main Report and the respective development proposal.

Figure 1/1 Juba River Catchment



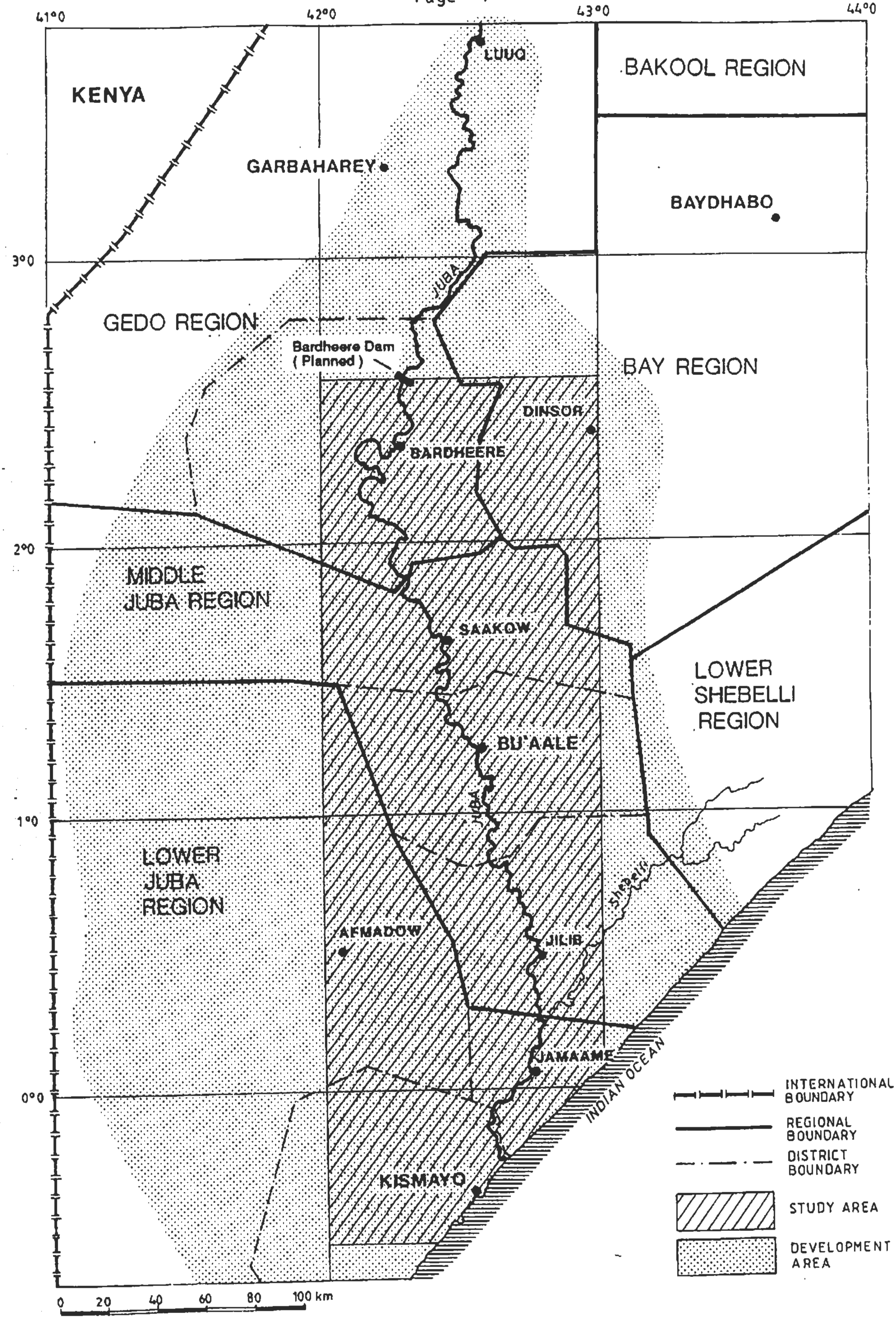


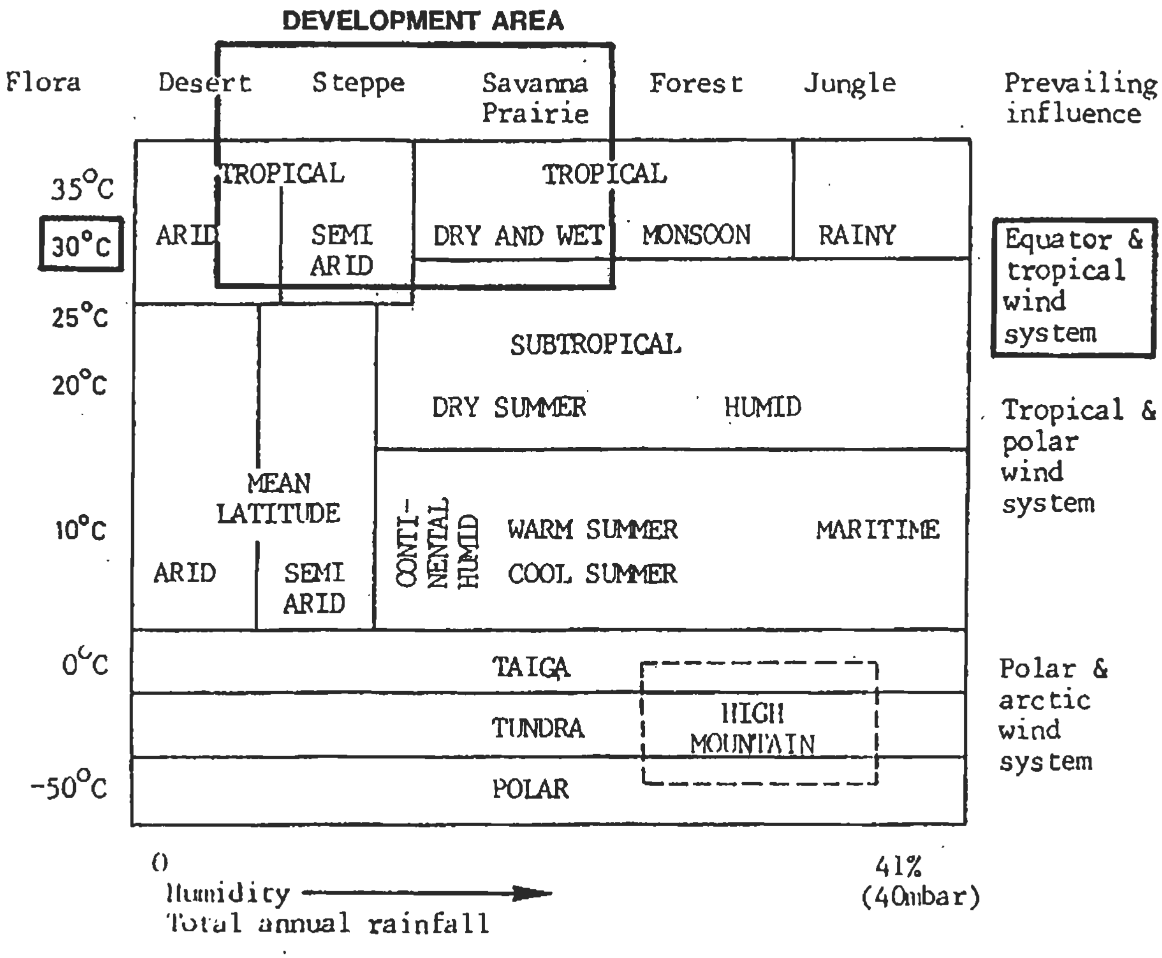
Figure 1/2 DEFINITION OF THE PLANNING AREA

2. Climatology

2.1 General

According to categorization of climate (see Figure 2/1) the Juba valley has a tropical climate: dry and wet in the South and semi-arid to arid in the North.

Figure 2/1 Categorization of climate according to humidity and mean annual temperature, characteristic flora and prevailing factors of influence according to the structure of Critchfield (1960):



The rainfall regime is under the influence of the Equator and tropical air mass movement. The rainy seasons are determined by the periodic passing of the Intertropical Convergence as it follows the sun's annual cycle back and forth across the Equator. Four distinct annual seasons are recognized:

- Jilaal is a hot and dry season that occurs during the months of December through March. This is also the season of minimum stream flow.

- Gu is a rainy season which lasts 50 up to 95 days from April through June-July. Annual rainfall maxima are recorded in April and May in the North and South respectively. Stream flow increases, but substantial discharges can be expected in wet years only.

- Xagai is a season with intermittent rains. It lasts from July to September and is drier in the North than in the South. Discharges are high due to a substantial rainfall in the upmost catchment in Ethiopia.

- Der is a rainy season which lasts 40 up to 50 days from October to November. River discharges having a substantial share of flow from the upper catchment reach their maxima.

Beginning and end of the distinct annual seasons are not fixed by calendar dates. They vary from year to year according to the first and last rainfalls.

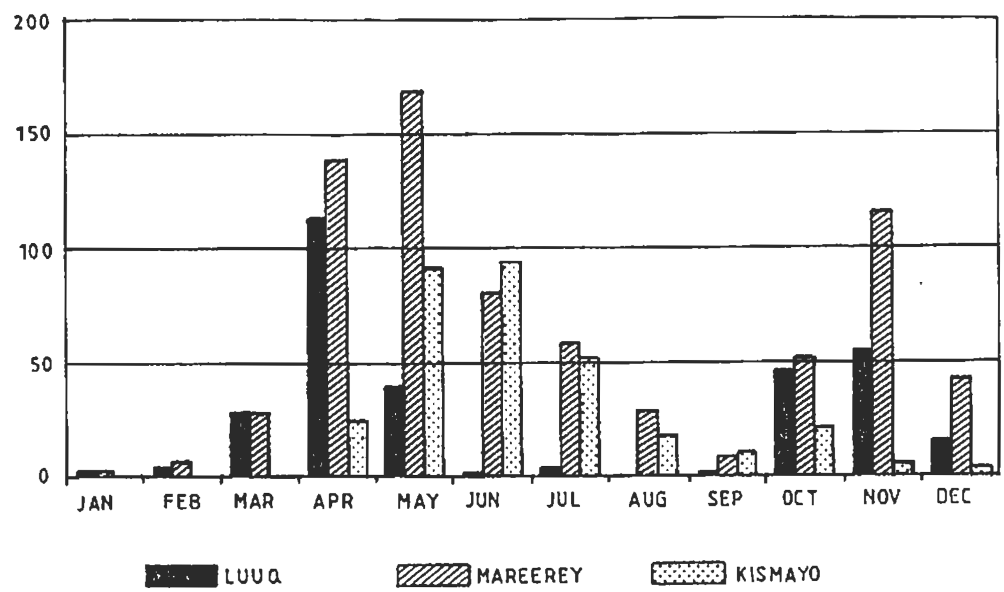
2.2 Rainfall

Recorded precipitation varies from 200 to 400 mm yearly and total in the vicinity of Luuq and Bardheere (as well as at the seashore (Kismayo)) to some 600-750 mm in the rainfall pocket (Mareerey-Jilib-Kamsuma) (see Table 2.3/1). The variability of rainfall within a year has its maximum in the rainfall pocket and decreases to North and to seashore (e.g. Luuq (North), Mareerey (rainfall pocket), Kismayo (seashore), see Figure 2/2).

For the intense monsoon rainstorms most of the precipitation occurs within two to three hours. Rainfall intensities in excess of 75 mm per hour have been recorded throughout the area. The effective rainfall is relatively low. In the dry year it extends from 0 to 25 mm and 40 to 60 mm during the Gu and Der season, respectively, with the exception of the rainfall pocket, Mareerey-Jilib- Kamsuma, where the total amounts up to 250 mm in the Gu season.

Areal distribution and historical patterns of rainfall throughout the Juba river basin are little known owing to the small number and uneven distribution of observation stations and the scarce and fragmentary information available on record. Several rainfall stations have operating periods spanning 30 to 50 (and more) years, most of them outside the project catchment area; rainfall information is generally limited to average figures summarizing long periods of observation.

Figure 2/2 Mean Monthly Rainfall at Luuq, Mareerey and Kismayo



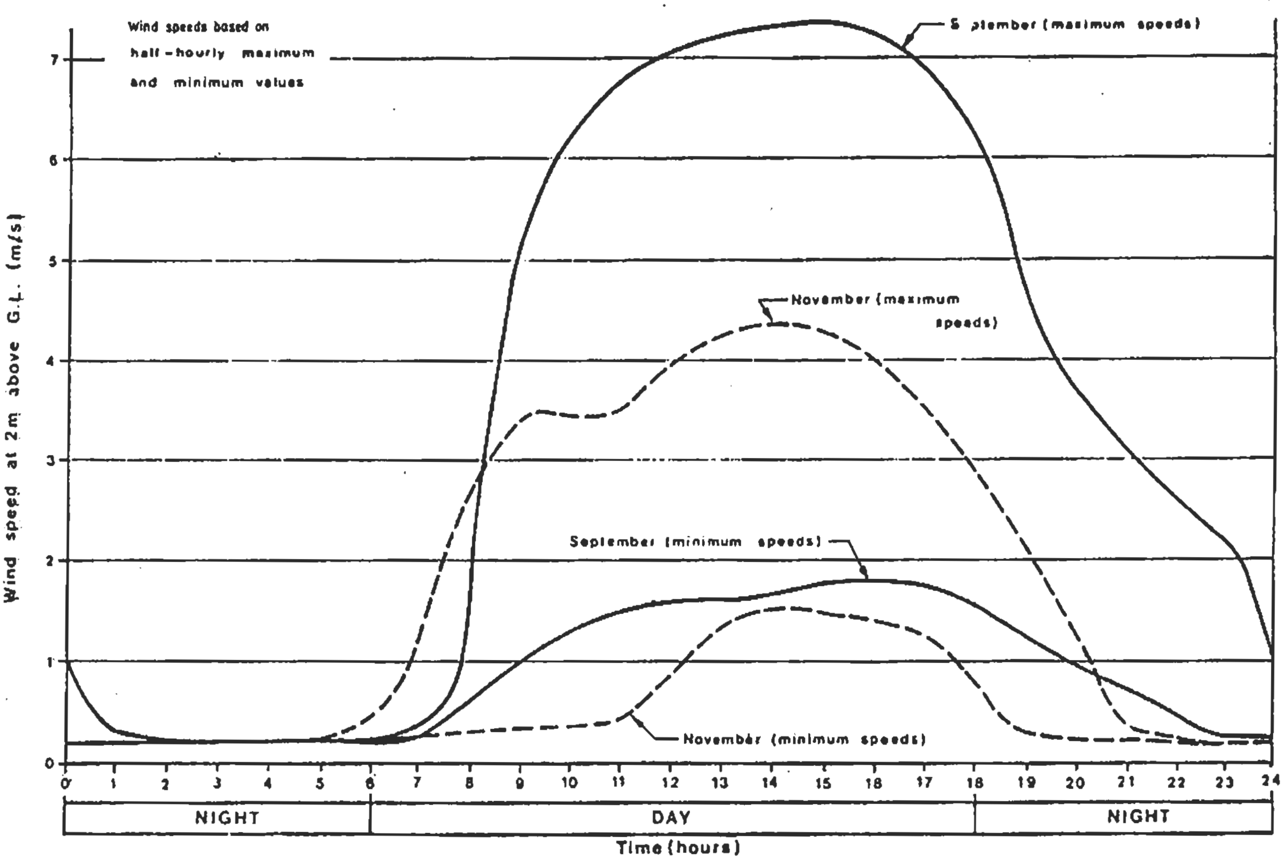
Among the stations of interest for the river catchment - two of them - Bardheere and Baydhabo have more than 50 years of records [67], whilst the rest of the stations have 10 to 50 years of records (Kismayo, Afmadow, Yontoy, Alessandra, Mareerey, Luuq). Based upon the information on rainfall data collected from the above-mentioned rainfall stations average annual and annual as well as monthly isohyetal maps have been prepared for a 0.8 probability of occurrence for the river basin up to Bardheere.

2.3 Temperature, Wind, Evaporation

Mean monthly temperatures are sustained and vary between 25.5 and 28.7°C in the South only with maxima in March-April and minima in August. They increase towards inland: they are some 4°C higher on average at Luuq where the highest mean January temperatures of North Africa have been recorded. Diurnal variations in temperature are low: maximum 12 to 16°C (see Table 2.3/1).

The maximum average wind speed occurs at the seashore (yearly mean at Kismayo : 518 km/d) decreases towards the rainfall pocket (Mareerey) and increases again in the North (Luuq, Bardheere) (see Table 2.3/1). During the day the wind speed is about 5 times higher as at night (e.g. Mareerey, see Figure 2/3).

Figure 2/3 Wind Speed Patterns (Mareerey)



Humidity is medium (50 to 70%) and high in the South (average 72% at Mareerey). It decreases with increasing distance from the sea and open water surfaces to an average of 57% at Luuq. The ratio between daily actual and maximum possible sunshine duration is medium high (up to 80%), and incoming radiation is fairly constant over the valley and throughout the year (see Table 2.3/1).

The resulting evaporation and evapotranspiration are high, especially at Bardheere, Luuq and at the seashore. Reference monthly evapotranspiration varies between 205 mm in December and January and 115 mm in June at Mareerey with an annual total of some 1,950 mm. In the rest of the area the annual total is up to 25% higher, and the monthly fluctuation is less pronounced (see Table 2.3/1).

Table 2.3/1 Mean Monthly Climatological Data

SGU	Station	Type of climate data	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
		Total rainfall (mm)	2	4	28	113	40	1	3	0	1	47	56	15	310
		Temperature (°C) min.	23.8	24.5	25.3	25.0	24.8	23.8	23.1	22.6	23.5	23.7	23.7	23.0	23.9
		Temperature (°C) av.	31.5	32.3	33.2	31.8	30.3	29.5	28.2	28.2	29.6	30.5	30.5	30.5	30.5
		Temperature (°C) max.	38.6	39.6	40.5	38.3	36.0	35.0	33.5	33.8	36.0	37.1	37.5	37.8	37.0
0	Luuq	Windspeed (km/d)	260	173	156	130	225	328	328	259	242	173	173	173	216
	(193 m.a.s.l.)	Humidity (%)	50.8	43.6	46.1	60.9	64.9	61.2	63.0	63.0	56.9	58.5	61.0	54.6	57.4
		Sunshine Duration (h/d)	9.96	10.32	9.60	8.28	8.76	8.76	7.68	8.28	9.12	8.04	8.76	9.60	8.98
		Tot. Evaporation (mm)	382	327	363	287	314	341	328	317	340	305	288	314	3,896
		Tot. Evapotranspiration (mm)	268	229	254	201	220	239	230	222	238	214	202	220	2,739
		Total rainfall (mm)	1	6	23	151	118	12	19	7	13	141	80	14	585
		Temperature (°C) min.	19.8	20.2	20.8	21.0	20.7	20.0	19.2	19.3	19.6	20.3	20.1	20.1	20.1
		Temperature (°C) av.	27.2	28.0	27.5	27.5	26.0	25.0	24.0	24.2	25.1	25.5	26.0	26.5	26.1
		Temperature (°C) max.	34.2	35.6	35.7	34.0	31.5	30.3	28.7	29.2	30.7	30.8	31.5	32.8	32.1
-	Baydhabo	Windspeed (km/d)	242	233	225	181	181	250	268	259	225	181	155	199	216
	(487 m.a.s.l.)	Humidity (%)	50.8	48.6	46.1	61.0	64.9	61.2	62.9	62.9	56.7	58.4	60.9	54.5	57.4
		Sunshine Duration (h/d)	9.36	9.72	8.76	7.44	7.56	6.72	5.04	6.60	7.20	6.24	7.92	9.00	7.56
		Tot. Evaporation (mm)	317	293	330	257	240	244	234	254	268	237	225	314	3,213
		Tot. Evapotranspiration (mm)	222	209	231	180	168	171	164	178	188	166	158	182	2,217
		Total rainfall (mm)	5	2	21	109	49	14	12	4	9	44	71	25	365
		Temperature (°C) min.	21.3	22.0	22.8	22.8	22.5	21.2	20.3	20.8	21.5	22.0	21.6	21.5	21.7
		Temperature (°C) av.	29.7	30.6	32.1	30.4	29.0	27.6	26.4	26.9	28.2	29.0	28.7	29.1	29.0
		Temperature (°C) max.	38.1	39.2	41.3	38.0	35.5	34.0	32.5	33.0	34.8	36.0	35.8	36.6	36.2
1	Bardheere	Windspeed (km/d)	294	207	190	130	259	363	380	397	337	242	216	199	268
	(118 m.a.s.l.)	Humidity (%)	53.3	51.3	50.7	62.7	67.5	65.7	64.1	63.1	60.4	69.5	69.2	62.6	61.7
		Sunshine Duration (h/d)	9.60	9.60	8.86	6.70	6.70	6.70	6.70	6.70	7.68	6.60	7.68	8.76	7.66
		Tot. Evaporation (mm)	410	359	412	280	295	341	340	385	410	289	250	254	4,025
		Tot. Evapotranspiration (mm)	267	227	251	180	199	211	223	238	240	196	187	207	2,525
		Total rainfall (mm)	2	6	27	139	169	81	59	28	8	52	116	43	738
		Temperature (°C) min.	21.3	21.8	21.7	22.7	22.2	19.8	18.7	18.5	19.0	19.8	21.2	21.6	20.7
		Temperature (°C) av.	28.5	29.2	29.1	29.0	27.0	25.1	24.9	24.5	25.0	26.6	28.0	28.5	27.1
		Temperature (°C) max.	35.7	36.6	36.5	35.2	31.7	30.4	31.0	30.5	31.0	33.3	34.8	35.3	33.5
3	Mareerey	Windspeed (km/d)	206	206	138	103	77	95	112	181	224	198	95	258	158
	(60 m.a.s.l.)	Humidity (%)	67	63	67	72	75	78	77	73	75	75	72	71	72.1
		Sunshine Duration (h/d)	10.9	9.8	9.9	7.0	6.0	7.1	8.0	8.6	8.7	9.4	8.7	8.0	8.5
		Tot. Evaporation (mm)	315	305	323	233	184	186	198	233	258	257	211	253	2,956
		Tot. Evapotranspiration (mm)	205	193	197	150	124	115	130	144	151	174	158	206	1,947
		Total rainfall (mm)	1	24	2	155	139	86	55	20	6	46	70	41	623
		Temperature (°C) min.	22.1	21.7	22.3	23.0	23.0	21.3	20.5	20.2	20.3	21.5	22.0	21.8	21.6
		Temperature (°C) av.	28.6	28.6	29.2	29.3	28.2	26.7	25.5	25.7	26.3	27.3	27.9	28.2	27.6
		Temperature (°C) max.	35.0	35.5	36.0	35.5	33.3	32.0	30.5	31.2	32.3	33.0	33.7	34.5	33.5
3	Alessandra	Windspeed (km/d)	150	170	160	78	35	52	52	60	86	95	78	95	93
	(24 m.a.s.l.)	Humidity (%)	53.3	51.3	50.7	62.7	67.5	65.7	64.1	63.1	60.4	69.5	69.2	62.6	61.7
		Sunshine Duration (h/d)	9.91	8.96	10.00	7.62	7.62	6.87	6.98	7.93	8.51	7.47	6.72	8.21	8.0
		Tot. Evaporation (mm)	318	307	346	242	211	204	195	225	267	236	207	215	2,973
		Tot. Evapotranspiration (mm)	201	194	211	156	142	126	128	139	156	160	154	173	1,942
		Total rainfall (mm)	0	0	0	42	124	82	52	15	9	3	28	28	383
		Temperature (°C) min.	23.6	23.2	24.5	24.7	23.7	22.5	21.7	21.5	22.2	23.3	23.2	23.5	23.1
		Temperature (°C) av.	28.2	28.0	28.7	29.1	27.6	26.0	25.4	25.6	26.0	27.4	27.6	28.0	27.3
		Temperature (°C) max.	32.7	32.8	32.8	33.5	31.5	29.5	29.1	29.7	29.8	31.5	32.0	32.5	31.5
4	Yontoy	Windspeed (km/d)	60	52	43	43	45	43	52	60	60	52	52	60	52
	(8 m.a.s.l.)	Humidity (%)	53.3	51.3	50.7	62.7	67.5	65.7	64.1	63.1	60.4	69.5	69.2	62.6	61.7
		Sunshine Duration (h/d)	7.68	7.68	8.76	7.68	7.68	6.60	6.60	6.60	7.68	7.68	6.60	7.68	7.32
		Tot. Evaporation (mm)	258	247	275	216	191	184	181	207	238	210	190	201	2,598
		Tot. Evapotranspiration (mm)	168	156	168	139	129	114	119	128	139	142	142	164	1,709
		Total rainfall (mm)	5	12	32	102	81	23	30	13	18	84	97	53	550
		Temperature (°C) min.	21.5	21.7	22.5	22.6	21.8	20.2	19.5	19.5	19.5	21.0	21.5	21.5	21.1
		Temperature (°C) av.	29.8	30.5	31.1	29.8	28.1	26.4	25.8	26.3	27.3	28.4	28.5	28.7	28.4
		Temperature (°C) max.	38.1	39.3	39.6	37.1	34.3	32.6	32.0	33.0	35.0	35.8	35.5	35.8	35.7
7	Afmadow	Windspeed (km/d)	189	163	155	112	138	189	215	241	232	163	112	120	169
	(29 m.a.s.l.)	Humidity (%)	53.3	51.3	50.7	62.7	67.5	65.7	64.1	63.1	60.4	69.5	69.2	62.6	61.7
		Sunshine Duration (h/d)	8.76	8.40	7.92	6.24	6.36	6.96	6.72	6.72	7.32	6.36	7.56	7.80	7.20
		Tot. Evaporation (mm)	347	327	371	263	234	244	239	283	330	261	218	221	3,338
		Tot. Evapotranspiration (mm)	226	207	226	169	158	151	157	175	193	177	163	180	2,182
		Total rainfall (mm)	0	0	0	24	92	94	52	17	10	21	5	3	318
		Temperature (°C) min.	24.1	24.5	25.5	25.7	24.7	23.5	23.0	23.2	23.2	24.0	24.5	24.3	24.2
		Temperature (°C) av.	26.8	27.2	28.3	28.7	27.5	26.0	25.5	25.7	25.9	26.8	27.5	27.4	26.9
		Temperature (°C) max.	29.5	29.8	31.0	31.7	30.3	28.5	28.0	28.2	28.5	29.5	30.5	30.5	29.7
10	Kismayo	Windspeed (km/d)	585	544	492	449	492	518	544	553	536	484	449	518	518
	(10 m.a.s.l.)	Humidity (%)	53.3	51.3	50.7	62.7	67.5	65.7	64.1	63.1	60.4	69.5	69.2	62.6	61.7
		Sunshine Duration (h/d)	7.68	8.76	8.28	7.44	7.08	6.84	6.72	7.44	7.68	7.92	7.92	7.92	7.56
		Tot. Evaporation (mm)	366	340	371	311	269	272	273	311	350	304	263	271	3,701
		Tot. Evapotranspiration (mm)	238	215	226	206	200	168	179	192	205	206	197	221	2,427

Source: FAO Agroclimatological Data for Africa, Vol. 1.2, Rome 1984
and own computations.

2.4 Agro-Climatology

The river valley shows four major climatic features important from the irrigated agriculture point of view:

- The occurrence of two pronounced rainy seasons, Gu and Der, with intermittent rains in the season in between (Xagai). The seasons determine the cropping cycles which need to be followed for both rainfed and for irrigated agriculture.

- Temperatures (mean, maximum and minimum) decrease from Luuq to Kismayo, from a high monthly mean of 33°C at Luuq to 28°C at Kismayo in March, to a low monthly mean of 28°C at Luuq to 25°C at Kismayo in July. The decrease is almost linear.

- Total yearly rainfall increases from the arid areas of Dolo/Luuq with rainfall around 300 mm, towards the highest rainfall area around Mareerey, Jilib-Kamsuma where rainfall reaching 600 to 900 mm/year while subsequently rapidly decreasing again to 450 mm (and less) at Jamaame towards Gobweyn at the coast (see Figure 2/4).

- Minimum and maximum wind speed in km/day varies between 130 (April) to 400 (August) at Bardheere, 77 (May) to 260 (December) at Mareerey, and 450 (April) to 580 (January) at Gobweyn/Kismayo.

These last three features combined result in high evaporation of 4,025 mm at Bardheere, to 2,956 mm at Mareerey to 3,701 mm at Kismayo, with potential average irrigation water requirements being lowest in the Mareerey-Jilib-Kamsuma rainfall pocket, where the soil water content is enriched by frequent flooding.

This conclusion is of extreme importance in establishing priority areas for further irrigation development. It has obviously been recognized as can be seen from the present focus of irrigation development in the lower water requirement area of the Fanoole to Bangheni reach of the Juba river.

Table 2.4/1 presents the details of the effective rainfall for four stations, that has been calculated using the standard coefficients (see Table 6.2/1).

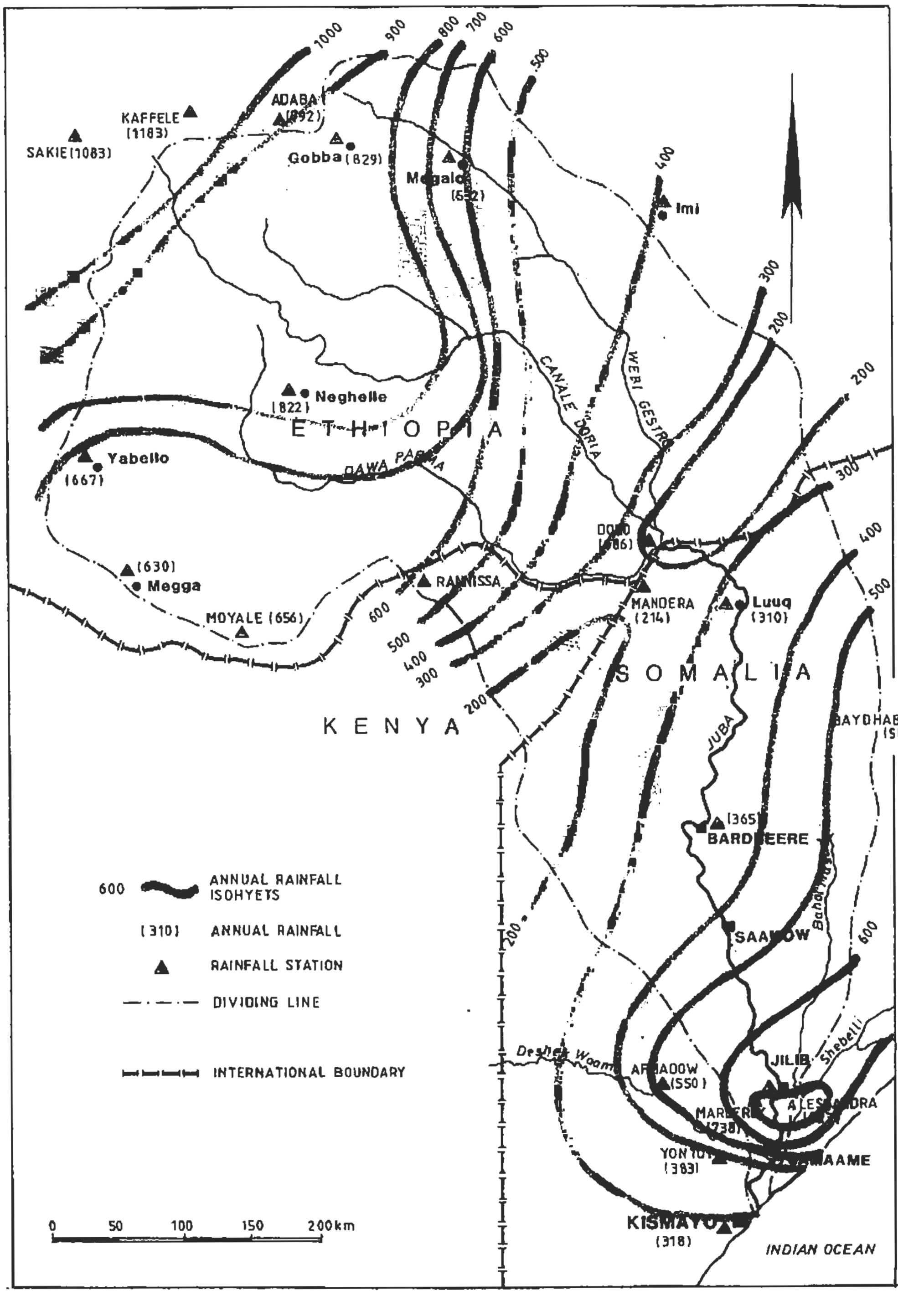
Table 2.4/1 Effective Rainfall along the Juba River (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bardheere	4	2	19	72	43	13	11	4	8	39	59	22	296
Mareerey	2	5	24	79	96	61	49	25	7	46	77	38	509
Alessandra	1	2	2	88	79	65	48	18	5	80	58	36	481
Yontoy	0	0	0	37	82	62	43	14	8	3	25	25	299

Source: Own computations, using coefficients of US Bureau of Reclamation Method (1967).

The effective rainfall amount of 509 mm for the Mareerey area is significant, in that it can be considered the equivalent of irrigation applications of about 1,700 mm, assuming an overall irrigation efficiency of around 30%.

Figure 2/4 Rainfall Isohyets in the Juba River Catchment



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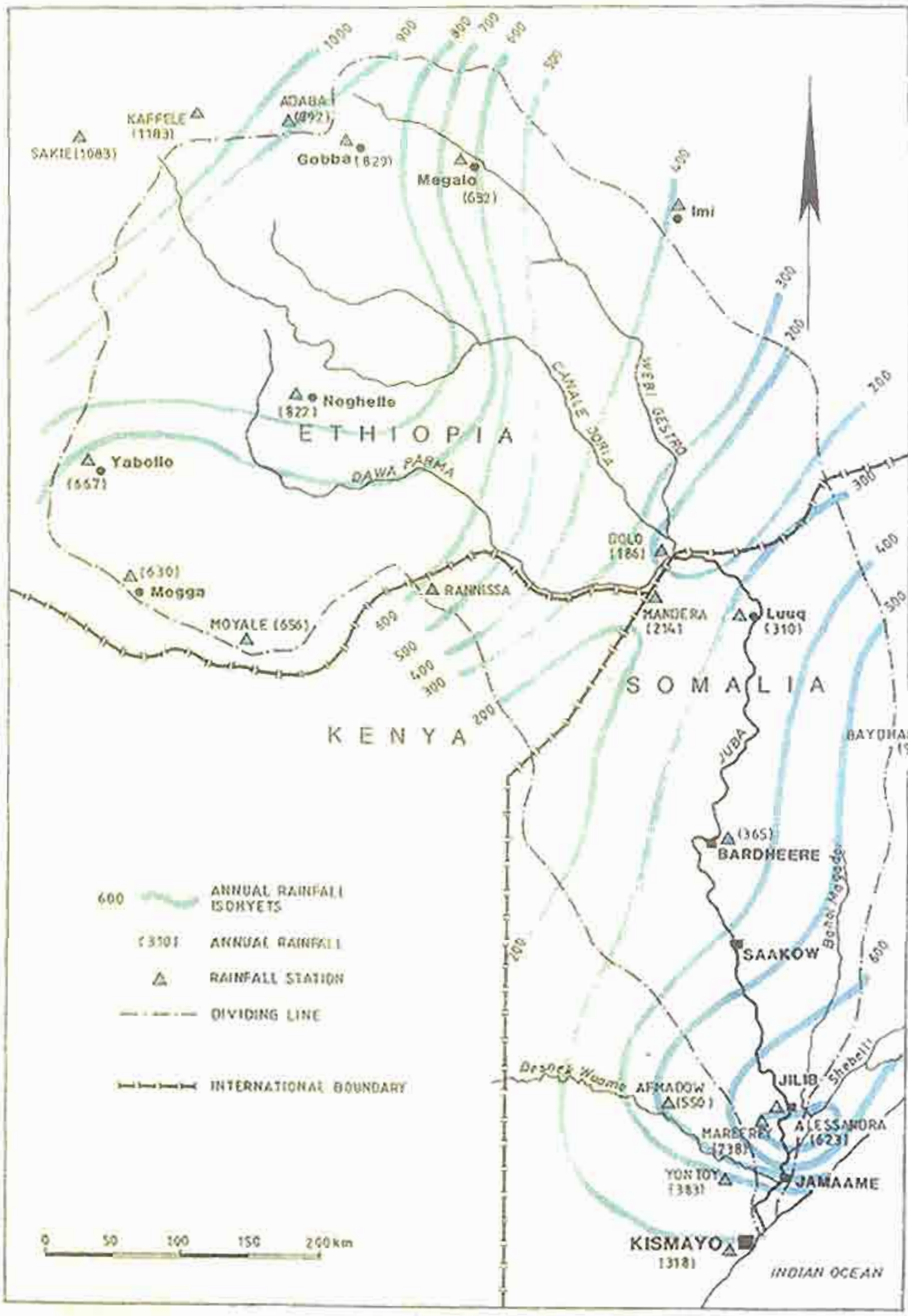


3. Hydrogeology

3.1 Geologic Units and Groundwater Occurrence

The Project Area can be subdivided in three geologic units (see Figure 3/1):

- the Quaternary Coastal Plain, consisting of fluvio-lagunal deposits, coral limestone,alluvial and eolian sediments
- the Cretaceous Xuddur-Bardheere Basin, consisting of marls, shales, limestones, sandstones and gypsum
- the Precambrian Basement with granites, gneisses and crystalline shists.

3.1.1 The Coastal Plain

The Coastal Plain covering the southern half of the Development Area is formed by four stratigraphic units. These are from bottom to top:

Fluvio-lagunal deposits constitute clay, sandy clay, silt, sand and gravel, generally intercalated in lenticular beds and covered by either pervious sandy or impervious clayey and deltaic deposits. Generally there exists an upper aquifer yielding water of very poor quality and a deep aquifer below 150 m with water of fair to marginal quality, i.e. with EC-values of 3.0 to 7.0 mmhos/cm (for classification of water quality see Table 3.2/1). However, the confining layer sometimes is leaky or missing at all resulting in high salinities over the total thickness.

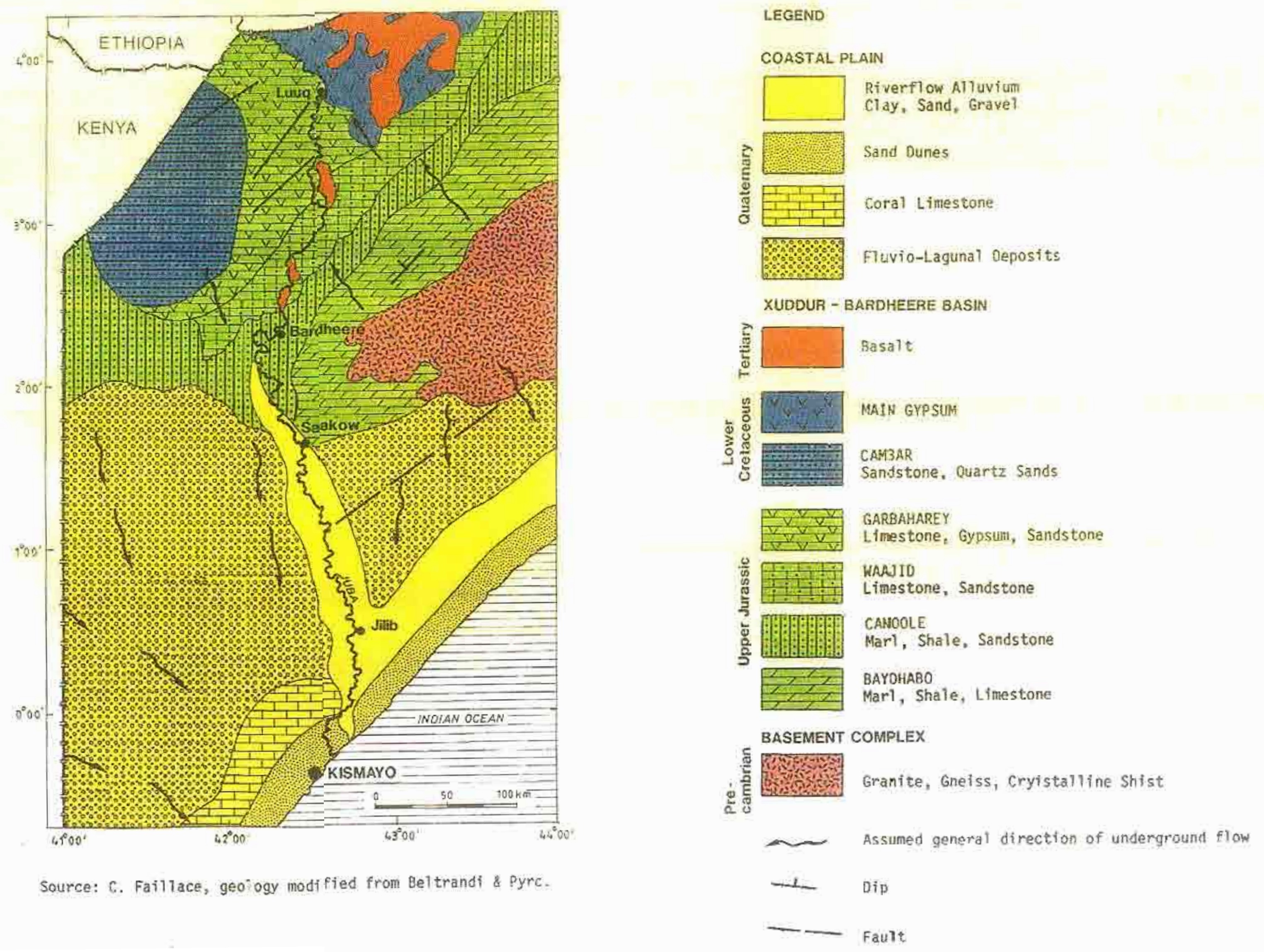
The area covered by these sediments offers good prospects of finding water. Especially deposits of Laaq Dhere, Galley Madhere, Laaq Bassiq, Laaq Baadana and of other seasonal channels, the deposits of the former Juba river delta as well as floodable areas have potentials of groundwater with fresh to fair qualities (EC of 0.6 to 1.7 mmhos/cm) down to a depth of 50 m. Well capacities will be small in clayey to silty sediments, but can reach 20 m^3/h in sands and gravels as locally recorded.

Two hand-dug wells in Afmadow located in close vicinity offer water of differing quality: one fresh water (EC of 1.4 mmhos/cm) and the second water of marginal quality - the nearby deep well offers water of critical quality (EC of 11 mmhos/cm). An investigation of shallow aquifers for Afmadow is recommended. Further investigation is recommended for the large area northwest of Kismayo.

The area covered by impervious deposits does not give any substantial yield in the surface layers. Deep wells having yields of about 10 to 20 m^3/h offer water of poor to marginal quality (sodium chloride). In some areas an upper semi-confined aquifer exists which yields water of critical or unsuitable quality.

The coral limestone whose thickness varies between 15 and 25 m lies on top of the fluvio-lagunal deposits and is covered by sand on the seaside and by a thin clay layer on the inland side. The seawater intrusion results in critical or unsuitable water qualities. Deep wells can occasionally catch water of good quality (calcium bicarbonate type) in the underlying deposits (Laaq Badaana).

Figure 3/1 Generalized Geological Map of the Juba Valley Area



Source: C. Faillace, geology modified from Beltrandi & Pyrc.

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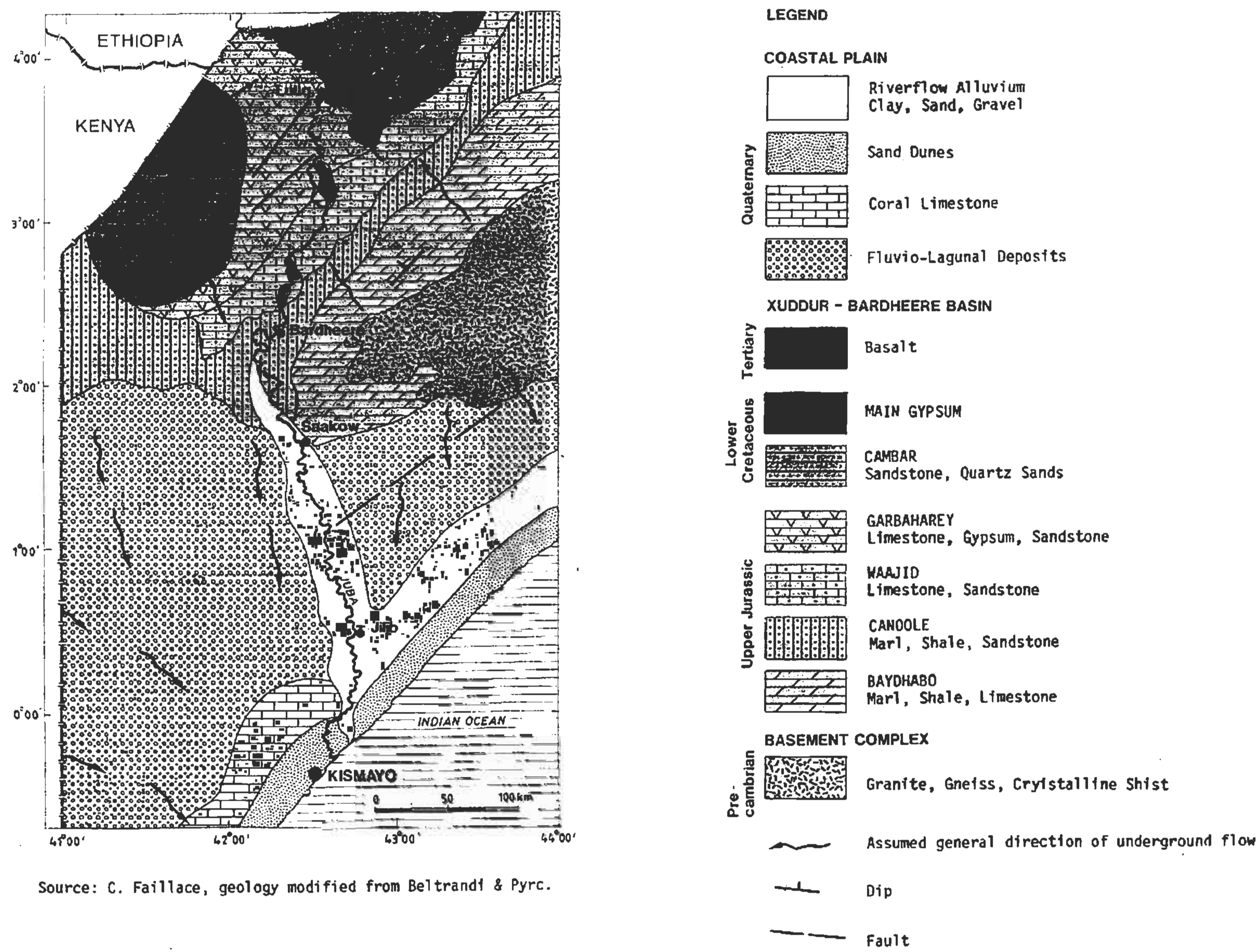
Figure 3/1 Generalized Geological Map of the Juba Valley Area



Source: C. Faillace, geology modified from Beltrandi & Pyrc.

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Sand dune deposits, stretching along the coast, are highly pervious and contain locally freshwater lenses formed by a thin silty clay underground. Stored rainwater is fresh (EC ranging from 0.25 to 0.5 mmhos/cm). Excessive withdrawal results in deterioration of the water quality. Water is then of sodium chloride type with EC up to 7 mmhos/cm. The yield of the wells depends on the size of the catchment which is relatively small. Some freshwater lenses float on brackish water, whose salinity increases with depth and the distance to the sea. Additional investigations are required to assess potential of freshwater lens.

Riverflow alluvium. Along the Juba river these deposits overlie the bedrock of the cretaceous Xuddur Bardheere Basin as well as the fluvio-lagunal sediments. The Riverflow Alluvium has a thickness between 5 and 30 m and consists mainly of silty and sandy clay followed by sand with fine gravel. The yield of shallow wells in these deposits varies between 5 and 40 m^3/h and the water quality between fresh and fair (EC 0.7 to 2.0 mmhos/cm). High recharge from surrounding formations results in deterioration of water quality (e.g. at Luuq).

The alluvial belt is narrow in the Xuddur-Bardheere Basin and widens north of Saakow. Water quality in existing wells of this formation varies widely: wells tapping aquifers recharged by the river have fresh water; deep wells penetrating into the bedrock have water of mixed quality; the low water quality is a sign that the recharge from the river is insufficient or does not exist. Alluvial deposits offer favorable possibilities for village water supply without any water treatment. Numerous villages in the lower catchment already use ground water from hand-dug wells in these deposits, but the hydrogeological conditions have not yet been systematically investigated.

3.1.2 The Xuddur-Bardheere Basin

Almost the entire northern half of the Project Area is covered by Jurassic to Cretaceous Series forming the syncline of Xuddur-Bardheere. The series, which are intruded by tertiary basaltic rocks can be subdivided into the following stratigraphic units (from bottom to top):

The Baydhabo strata series consists of marls and shales and karstified limestone. In the limestone areas (largely outside the Development Area) at the contact with the Basement, mostly outside the Project Area, numerous permanent and intermittent springs with fresh to fair water qualities (EC of 0.9 to 2.4 mmhos/cm) are existing. Wells, drilled in the area of marls and shales generally have low yields. Water quality is ranging from good to brackish, the salinity increasing with groundwater depth.

The Canoole strata series is constituted by marls, shales and sandstone, locally interstratified by thinly bedded limestone. The series generally acts as an aquiclude. Prospects of finding ground water are negligible and the water quality varies from brackish to salty.

The Waajid strata series consists of limestone, calcarenite, marls and intercalations of shale. The series is water bearing only in its lower part (near the Canoole series). The water qualities (shallow wells) range from fresh to poor (EC of 0.25 to 4.9 mmhos/cm).

The Garbaharey strata series covering the North of the Bardheere reservoir area is composed of limestone, gypsum and sandstone interlaid with clay and marls. It offers great differences in water quality and quantity in boreholes located even within short distances from each other. A lot of drilled wells struck salt water and were abandoned. Deep wells can yield considerable amounts of water (Garbaharey 13 m^3/h, depth 103 m) of poor to critical quality (EC of 4.4 to 8.1 mmhos/cm).

The Cambar strata series consists of sandstone and quartz sands. The series are considered to be of great importance for local water supply.

The Main Gypsum strata series outcropping northeast of Luuq offers fair to poor water qualities of the calcium sulphate type (EC of 2.6 to 5.2 mmhos/cm) in shallow wells. In deep wells the water is salty.

Basalt outcrops are water bearing in depressions and streambeds e.g. of few localities south of Bardheere (Muumin Dhoorow, Wakaala Weya, Daggaras). Water quality in basalt formations is fair to critical (EC of 2.1 to 7.2 mmhos/cm).

3.1.3 Basement Complex

The Basement Complex consists of folded and peneplained granite, granodiorite, marble, quartzite, gneiss, micashists and amphibolite covered by residual soils and alluvial deposits. Deep boreholes in this complex have been drilled mostly with negative results. Ground water can be found in alluvial deposits of wadis (toggas) and in small lenses at the base of outcrops of intrusive rocks (buurs). The major buurs in the Basement Complex are at a distance of 5 km from Dinsor near the southern edge of the Baydhabo Plateau. Prospects of water withdrawal from dug wells as well as conditions for infiltration galleries and water storing by surface and underground dams exist. The yield and water quality cannot be predicted because they vary locally (quality from fresh to salty).

3.2 Groundwater Quality Standards

Responsibility for the urban and rural water supply is with the Ministry of Water and Mineral Resources and its Water Development Agency (WDA). In the Study Area, the WDA is represented in Kismayo with two offices. One office is responsible for the deep well programme and the urban water supply, the other for the shallow well programme. The establishment of deep wells must be licenced by this Ministry. The initial water quality testing is conducted in Mogadishu - no operational water quality checking is done. Wells are also constructed by bodies outside this Ministry, being the Ministry of Livestock, GTZ (Luuq), Caritas (Jilib), Swedish Church Relief (Bu'aale and Saakow Districts).

The main problem of the supply of sanitary unobjectionable water in Somalia is the catastrophic lack of water with a low content of dissolved solids. The content of solids in ground water mostly exceeds 1 g/l or even 5 g/l which is the highest limit admissible according to international standards for man and livestock, respectively. Apart from total salinity, sometimes a high sulphate content makes the water unsuitable for human consumption.

Population having no other choice in these areas have used this water for generations and are accustomed to drink it. Water consumption results in diseases, health defects and high mortality. In addition, change in drinking water quality also causes health troubles: People who are used to drink river water of poor bacteriological quality without treatment may suffer from diarrheal diseases when drinking salty though bacteriologically not objectionable well water.

Respecting the scarcity of fresh water all over the country and having in mind the necessity of improving sanitary standards for population and livestock (to increase the production), a rough categorization of water quality has been derived (see Table 3.2/1).

Table 3.2/1 Classification of Water Quality and Limits of Water Use for Population and Livestock in Somalia

Water Quality	Total Dissolved Solids (TDS) (g/l)	Electrical Conductivity (mmhos/cm)	Uses
Fresh	0 - 1.0	0 - 1.5	Suitable for drinking
Fair	1.01- 3.0	1.51- 3.5	Marginal for humans, suitable for livestock
Poor	3.01- 5.0	3.51- 6.0	Unsuitable for humans, suitable for livestock
Marginal	5.01- 7.0	6.01- 8.0	Suitable for camels, marginal for other livestock
Critical	7.01-10.0	8.01-13.0	Suitable for camels, marginal for goats and sheep, unsuitable for cattle
Unsuitable	10.01-15.0	13.01-18.0	Marginal for camels, emergency only for goats and sheep
Salty	over 15.0	over 18.0	Unsuitable for any domesticated animal life

Source: Local data, completed.

Primitive habits, non-awareness of health hazards and difficult living conditions (the main motivation is mere survival) result in low sanitary standards of surface and groundwater extraction, transport and use. Safe water supply is available to a minor segment of the population (from wells that have a fresh water quality, are hygienically protected and well kept), i.e. only exceptionally. This results in dehydration, disturbed metabolism, high maternal, infant and child mortality, low life expectancy and many diseases.

The physiological water requirements, i.e. stable complementing of water losses in the human organism, under local circumstances reach an average of 3 to 5 liters per day. In a contemporary society this water should be available in sanitary, unobjectionable and physiologically beneficial quality (agreeability for drinking cannot be achieved due to high temperature) and in adequate quantity per capita.

Due to the lack of water of adequate quality for drinking and other purposes and non-availability at many locations, water of differing quality

- fresh (in minor quantity) and

- fair to salty (in relatively sufficient quantity),

should be made available and the supply organized in two to three different qualities (drinking water, water for watering cattle and other domestic purposes) depending on local conditions of relevant water requirements and availability.

Water for other domestic uses, as well as for washing, should also be available in adequate quantity and in sanitary, unobjectionable quality. The quantity of water used for these purposes depends on the access. Under very primitive conditions, 5-10 l per capita and day is used. Nearby outdoor wells and reservoirs with adequate water quantity, street faucets leapt to an increase in requirements up to 25 l/capita and day. Running indoor water and showers may cause an increase of requirements up to 90 l/capita and day. This depends also on water rates and conditions of payment in relation to the socioeconomic situation: possibilities and willingness to pay.

25 l/capita per day is the design figure that has been adopted by Somalia as part of its Water Decade commitment. Extrapolating a review of water usage in Central Sudan and the Caribbean Basin in relation to diarrheal diseases and bilharzia (and assuming a reasonable standard of water quality), Juba Environmental and Socioeconomic Studies show that the rising of water consumption to 65 liters per capita per day may decrease the infant mortality from 33 to 16 per 1000 children of less than 5 years.

Table 3.2/2 Recommended Water Quality for Population and Livestock

Quality	Electrical Conductivity (mmhos/cm)	Characteristics	Requirement per head	Source (equipment)
Fresh	EC < 1.5	drinking water sanitary unobjectionable, physiologically beneficial	5 l/day/ capita	sanitary secured springs and wells with fresh water, treated surface water, solar treatment plants
Fair to marginal	1.5 < EC < 8.0	water for cattle watering	30 l/TLU/ day in dry season (1)	ground water or surface water downstream from the withdrawal for population
Marginal to critical	8.0 < EC < 13.0	service water (for domestic purposes ex. drinking and cooking)	rural 30(15) urban 50(25) per head and day (2)	springs and wells surface water protected against bacteriological pollution (with settling basins etc.)

1) Tropical livestock unit (TLU) = 250 kg
(1 camel = 1.2 TLU, 1 cattle = 0.8 TLU, sheep, goat ≐ 0.1 TLU).
2) Data in brackets are minimum requirements.

Source: Local data, completed.

3.3 Groundwater and Urban Supply

Ground water is used for drinking and domestic water supply as well as for watering cattle, but the prevailing part of the rural and urban population often drinks the sanitarily objectionable untreated surface water.

Table 3.3/1 Present Sources of Rural Water Supply in the Juba Valley

Source	Capacity	Average quality	Suitability for drinking	Sanitary hazard	Current equipment	Recommended measures
Springs	< 1 l/s seasonal	fresh to fair	suitable	bacteriol.	primitive	separation protection
Dug wells (9)	seasonal	fresh to critical	marginally suitable	bacteriol.	primitive	separation(1) protection(2)
Drilled wells	sustained	fresh to critical	suitable	relatively safe	motor pumps	rehabilit.(3)
Water harvesting basins	seasonal (high evap. losses)	changing (4)	unsuitable	physical (sediments)	settling basins	coverage (5) rehabilit.(3)
River watering points	sufficient	fresh but polluted (8)	unsuitable	bacteriol. physical	without any equipment	shallow wells (6)
Depressions ponds, desheks	seasonal	fresh but polluted (8)	unsuitable	bacteriol. physical	without any equipment	shallow wells (6)
Underground reservoirs		fresh but polluted (8)	marginally suitable	bacteriol.	varies	separation(1) protection(2)
Rain-filled ponds	seasonal (high evap. losses)	fresh but polluted (8)	unsuitable	bacteriol.	primitive	shallow wells or filtration

1) Separation of population supply and livestock watering.
2) Sanitary protection of the source by technical and organizational measures.
3) Rehabilitation of mechanical equipment.
4) Salinity and pollution increases towards the end of the dry season.
5) Coverage by floating flexible impervious cover.
6) Shallow wells in alluvial deposits for drinking water supply (protected and located upstream).
7) Filtration/recharge of ground water for drinking water supply.
8) Salinity (EC) is low.
9) In some cases wells are lined, covered and properly kept and no livestock is able to reach the place.

Source: Local data, own analysis.

Table 3.3/2 Present Urban and Other Water Supply Systems

System (number of population)	Source (depth) Treatment*	Capacity system Length -transp.	Water quality Sanitary hazard+	Electrical conductivity (mmhos/cm) (add. wells)(1)	Additional wells Recommended measures # (4)
Kismayo	river	3,000 m^3/	doubtful	0.4-1.0	5 dug wells
(80,200)	havarious	40 km		(2.7, 4.6,	rehabilitation of the system
	state*		acute+	6.8, 38)	and treatment plant #
Jamaame	deep well	unknown	fair	1.0	2 dug wells
(9,400)		charts (2)		(2.9, 3.1)	new piped system #
Kamsuma	deep wells	unknown	marginal	3.2, 7.5	Somalfruit, mosque
	(70, 70 m)			(1.8)	shallow wells in alluvial
					deposits #
Fanoole	dry wells	sufficient	fresh	0.85-1.1	dug wells
	(22, 25 m)			(2.8, 2,5)	no measures #
Juba	4 deep wells	sufficient	fresh	0.9, 1.6	
Sugar					no measures #
Mogambo	deep well	sufficient	fair to	1.8-4.0	
	(100, 65 m)				no measures #
Homboy	dug wells	sufficient	fresh	0.5, 1.8, 2.3	1 well 7 m, others 20 m
	7.4 x 20 m)		to poor	2.5, 3.8	no measures #
Jilib	2 deep wells	unknown	fair	1.9-	13 dug wells (12-16 m)
(16,400)		3.5 km		(2.2-4.1)	8 drilled wells
				(1.1, 1.8)	no measures #
Bu'aale	2 deep wells	unknown	fresh	0.4-1.9	dug and drilled wells
(2,800)	(73, 73 m)	1.5 km	to fair	(1.1-2-1)	rehabilitation #
				(0.4-1.9)	
Saakow	4 deep wells	unknown	fair	1.7	dug wells
(6,800)	now	1.5 km		(4.5-16)	rehabilitation of the pipe
					system #
Bardheere	river	marginal	doubtful	0.2-1.5	1 drilled (1957) and 1 dug
(17,200)		charts (2)		(3.0-14.2)	(7 m^3/h, unsuitable)
	no*		acute+		3 drilled (200-500 m, salty)
					abandoned
					infiltration wells, piped
					system #
Luuq	river	sufficient	doubtful	0.2-1.5	3 wells (3 x 40 m^3/h),
(12,500)	4 drilled		fresh	0.5-1.2	2 dug wells with hand pump
	wells	medium		(15-27.5 m)	motor driven pumps #
	(15-27 m)				
Dinsor	harvesting	marginal	unsuitable	0.3-4.0	dug wells (low yield, marginal)
(5,000)	basin	charts (2)	acute+ (3)	(3.2, 7.5)	floating cover for basin, reha-
	no*			(2.2-16)	bilitation of equipment #
Afmadow	2 dug wells	marginal	fresh	0.8	drilled well (marginal
(5,000)			fair	1.5	quality)
	(17.2, 10)	critical		(11.0)	shallow wells in alluvium #

1) Systematic data not available.
2) Donkey driven charts etc.
3) Extra high content of sediments at the end of the dry season.
4) # is the symbol for recommended measures.

Source: Local data

4. Hydrology

4.1 Catchment and River Morphology

The Juba river originates near the border between Somalia and Ethiopia at the confluence of Dava Parma, Canale Doria and Webi Gestro. The upper part of the catchment lying at the altitude 1,500 - 4,400 m.a.s.l. with a precipitation of some 800 - 1,300 mm annually and a high runoff coefficient contributes to a substantial amount of river flows whose long-term annual average decreases downstream from Bardheere. The Juba catchment covers some 220,000 km^2, of which 34% are in Somalia and 61 and 5% in Ethiopia and Kenya respectively.

The river meanders throughout much of its length (more than 900 km) from the border to the Indian Ocean first through the mantled limestone plain interrupted by gneisses and shists between Saakow and Bu'aale, followed then by a marine alluvial plain. Bedrock ledges within the river channel constitute locally a fairly resistant base level. The meander pattern appears to be, with some local exceptions, relatively inactive. The gradient of the river channel in Somalia averages between 0.0003 and 0.0001. The average velocity of flow ranges between 0,3 m/s during average discharges up to 1 m/s during flood periods.

The cross section of the channel and valley of the Juba river varies widely, controlled by geologic factors and hydrologic regime. Numerous ephemeral tributaries join the river and contribute to its discharges in the rainy season. Other peter out in natural depressions, where the water is lost by evaporation, infiltration and deep percolation. Some 10 km before Saakow the floodplain widens. Natural depressions , so-called "desheks", store flood water, decreasing thus flood discharges. Flood bunds 1 to 1.5 m high have been constructed locally. Exclusion of desheks decreases the natural storage and results in gradual increase of flood discharges and flood water levels downstream.

The largest man-made impact on the river to date came about by the construction of the Fanoole barrage, which has a capacity to pass 800 m^3/s. This barrage, planned in the early 1970's and constructed between 1977 and 1980, has a power house with low-head turbines and supplies a gravity diversion canal. At Fanoole the channels of the Little Juba (Yaro) and Far Shebeel on the right bank bypass a part of discharges exceeding 800 m^3/s. These flows discharge into the marine plain, follow old channels of the Juba river and return into the main channel near Kamsuma or through the Deshek Waamo some 30 km downstream.

The Deshek Waamo presents a special flood problem. It fills up by internal drainage from its catchment which covers some 16,000 km^2, and by excess flood water from the Juba via Far Shebeel, Far Waamo Relief Canal, other old channels that can be traced on air photographs and by backwater of the Juba River. They are indications that it is supplied in addition to the surface inflow by underground flow from the Lorian Swamps in Kenya. The direction of flow in the estuary of Deshek Waamo is a function of the relative water levels.

On the left bank between Jilib and Jamaame the catchment of the Shebelli and of the Hara Naga and Kormajirto join the Juba river. The direction of flood flow in the old Kormajirto channel north of Jilib depends on relative water levels. The seasonal Hara Naga and Kormajirto (Bohol Magaday) river discharges into the Harnaga and Tucelle system of lakes. The Shebelli river with a catchment of some 300,000 km^2 and mean monthly flow reaching up to 145 m^3/s at Beled Weyne irrigates some 132,000 ha and peters out in pools and swampy lands (an area of some 850 km^2) at Hawaay before entering the Juba river.

The lakes and swamplands have enormous capacity to absorb and mitigate the Shebelli River flows. But during exceptional rains the waters of this complicated system of natural channels reach the Juba river. Flooding in the Homboy area near the confluence of the Juba and Shebelli is largely associated with heavy rainfall onto already high water levels in the swamps and local rainfall in the Homboy area.

The construction of the Fanoole Diversion Dam with bunds along both river banks upstream, of the left bank water conveyance canal 56 km long for the Fanoole Rice Project, of flood protection bunds for this project, bunds of banana plants, as well as for the Juba Sugar Project on the right bank and further the construction of roads in fillings and the Fanoole Supply Canal negatively affected and changed the situation in drainage of this area. This canal and roads Kismayo-Jilib-Fanoole, Jilib-Mogadishu have no adequate cross-drainage structures (though the attenuated peak flow across the Jilib-Mogadishu road reaches some 400 m^3/s). This resulted in frequent flooding (1981, 1985, 1987), in overtopping of roads (and resulting damage to these communications).

Excessive discharges of the Juba river downstream Kamsuma can be bypassed through the Bulo Yaag Relief Gates (100 m^3/s) and the Far Waamo Relief Canal constructed for the protection of banana plantations. Nevertheless, the mixed effect of the Juba and Shebelli floods affect the area which is some 8 to 18 km wide. Drainage of rain water and floods from the adjoining Hara Naga, Kormajirto and Shebelli catchments is, in addition impeded by high water levels in the Juba river.

The final stretch of about 45 km between the Arare bridge and the estuary is often, and in recent time even increasingly, subject to sea water intrusion.

4.2 River Flows

Available information on river discharge has been gathered from several sources. Daily figures of discharge have been supplied basically by the Ministry of Agriculture (Department of Land and Water) and have been complemented with daily data of river stages published by Gemmel (Brian A.P. Gemmel - Hydrological Data Collection and Upgrading of the National Hydrometric Network on the Juba and Shebelli Rivers, May 1982), together with the relevant stage discharge rating curves.

In addition to these sources of data, monthly figures for discharge and other appurtenant information have been drawn from previous studies, mainly those of Selchozpromexport (The Juba River in the Somali Democratic Republic - Moscow 1973), Technital (Juba River Valley Development Study, 1975) and MMP (Sir M. MacDonald & Partners Ltd. - Bardheere Reservoir Review, 1978).

All hydrological data up to 1984 have been published by Agrar- und Hydrotechnik in "Hydrology of the Juba River" (Main Report + 4 Annexes) in 1985. These data have been updated by AHT in 1988 (Hydromet Data of the Juba Valley: Volume I - Daily Records, Volume II - Statistical Evaluations). Serious gaps in data series have been identified and completed by simulation. The following graphs (Figure 4/1) illustrate the fluctuation of Juba discharges at Luuq during dry and wet years.

Figure 4/1 Daily Mean Discharges at Luuq

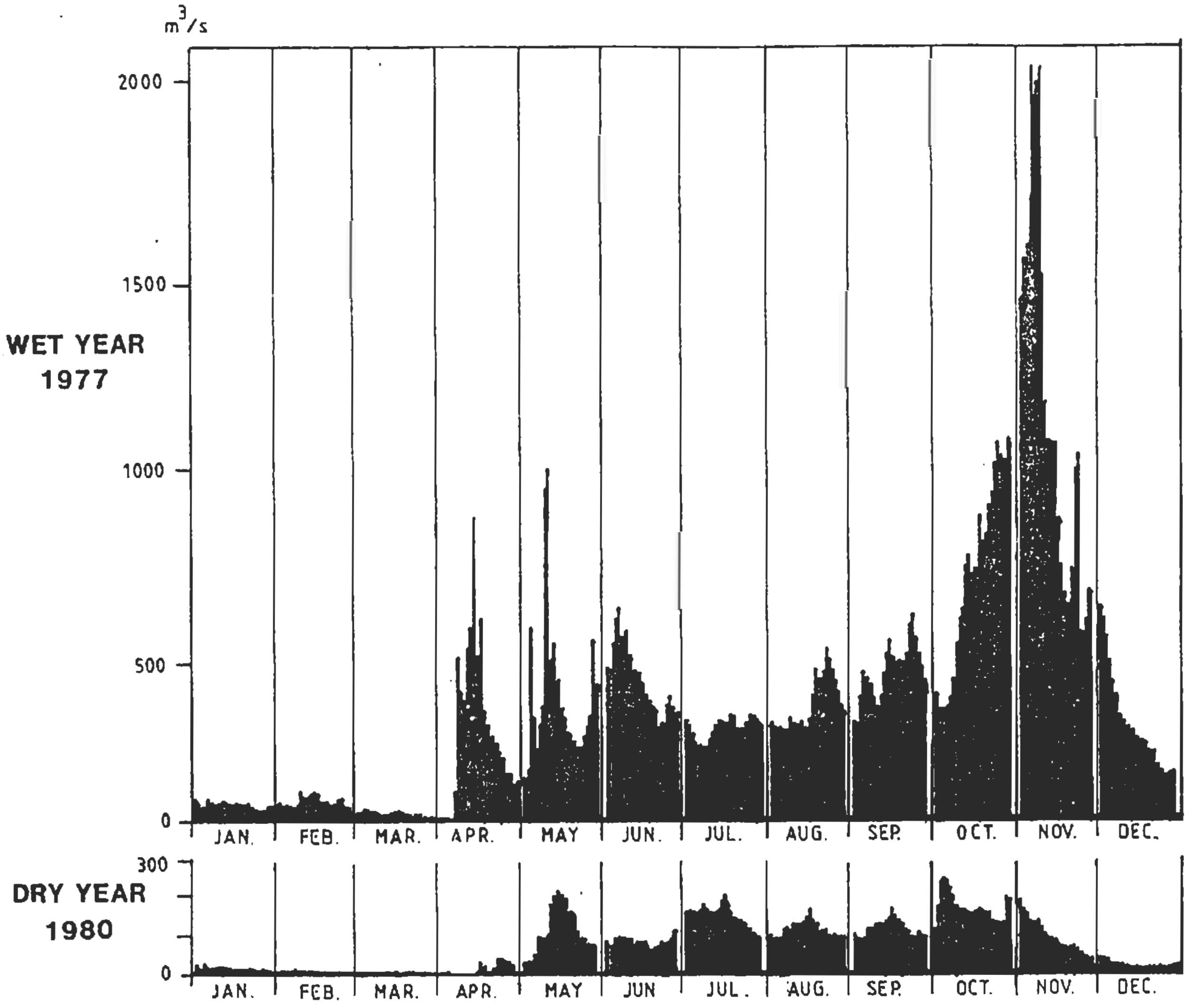


Table 4.2/1 gives basic information about gauging stations, type of recorded data and observation periods.

Table 4.2/1 Recording Periods of Gauging Stations

Station	Location	Recording period		
		Flows	Interruptions/ Remarks	Salinity
Luuq	End of future reservoir	1951-88	59-60, 67-9, 79 82-3	-
Bardheere	40 km downstream the planned dam	1963-88	67-9, 73-4, 77-83	
Kaytoy	Upstream Fanoole Diversion Dam	1963-64 1972-80	by the operation of the dam	
Mareerey	Downstream Fanoole Diversion Dam	1977-88	-	1977-88
Kamsuma		1972-76 1985-88	rehabilitated 1985	
Mogambo	Mogambo Project		local importance	
Jamaame	50 km upstream	1963-67	67-71	

Source: Own investigation

The Juba river flow in the planning area consists of:

- discharges from the upper catchment in Ethiopia measured at Luuq
- occasional seasonal flood inflow from different wadi and ephemeral rivers within the area of the planned reservoir
- impact of the intermediate catchment and rainfall (daily maximum 150 mm) within the Study Area.

The river regime is bimodal (see Table 4.2/2 and Figure 4/2 for Luuq), having two pronounced peaks in May (relatively smaller) and October - (in the middle catchment) - November (in the lower catchment). Annual streamflow at Bardheere varies between the minimum of 2.7 x 10^9 m^3 and 4.1 x 10^9 (in the year 1980 and 1955 respectively), maximum of 10.3 x 10^9 m^3 (1977) with a computed long-term average (period 1951-84) of 6.2 x 10^9 m^3 (average annual discharge 198 m^3/s, Table 4.2/3). The floods affect some 40 to 145,000 ha of land (20 and 54,000 ha of crop land) every second to third year.

The average annual discharge decreases downstream (187 m^3/s at Jamaame) - evaporation and groundwater recharge exceed on average the inflow from the intermediate catchment. The relative magnitude of the difference in flow between Bardheere and Jamaame ranges from 32% more discharge in December due to rainfall runoff to 22% less in August due to groundwater recharge and evaporation (Figure 4/3). Inflow into the river from the intermediate catchment in May and June, flow losses during July through October, inflow in November through March, tailing off into a flow loss in April have been recorded.

Table 4.2/2 Monthly Average Discharges at Luuq for Different Probabilities of Exceedance (m^3/s)

Type of input	Probability of exceedance	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dis-	0.8(1)	23	9	6	10	125	102	126	189	211	227	186	71
charge	0.5(2)	47	30	39	128	241	159	189	279	299	462	368	142
Luuq	0.2(3)	64	40	47	234	371	263	246	358	372	565	460	155
Volume(4)	0.5	120	71	100	327	637	401	498	739	775	1,224	940	367

(1) dry year
(2) average year
(3) wet year
(4) Million m^3

Source: Own computations.

Figure 4/2 Mean Monthly Discharges at Luuq
Probabilities of Exceedance = 0.8, 0.5, 0.2

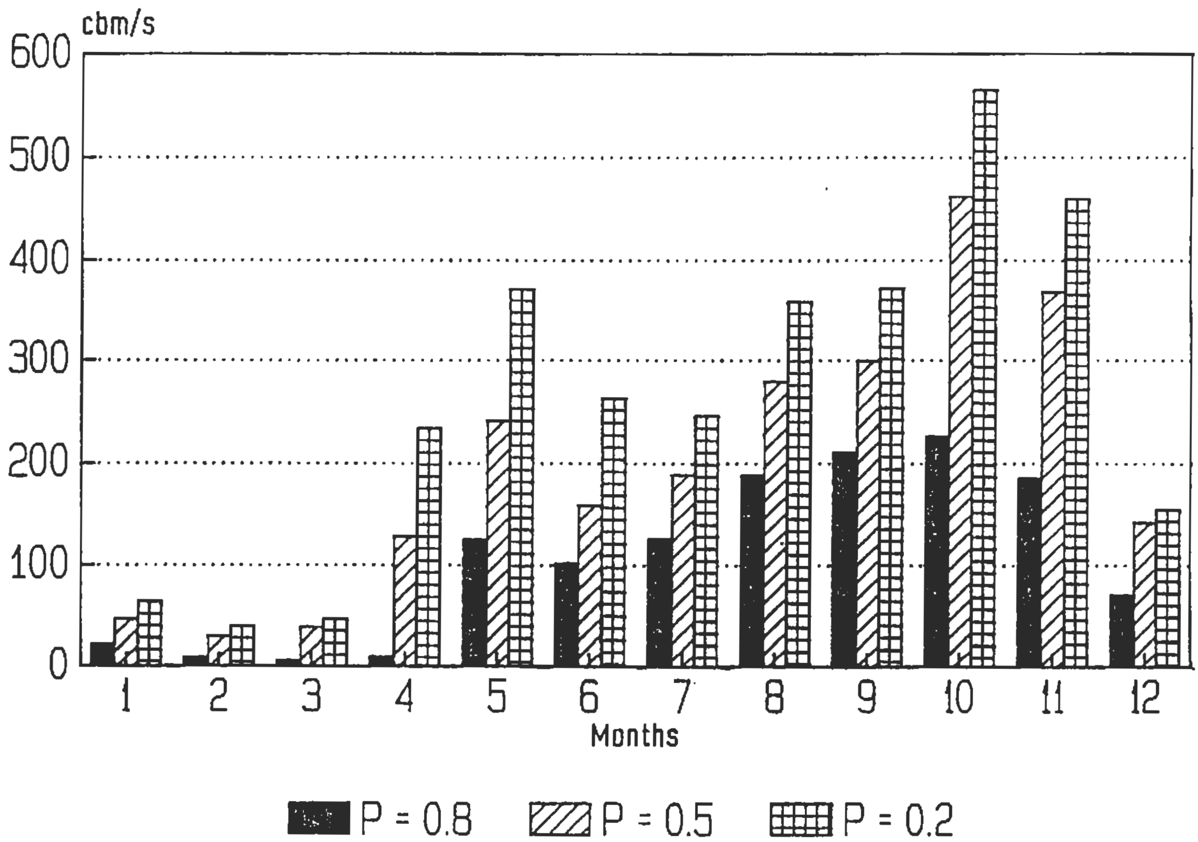
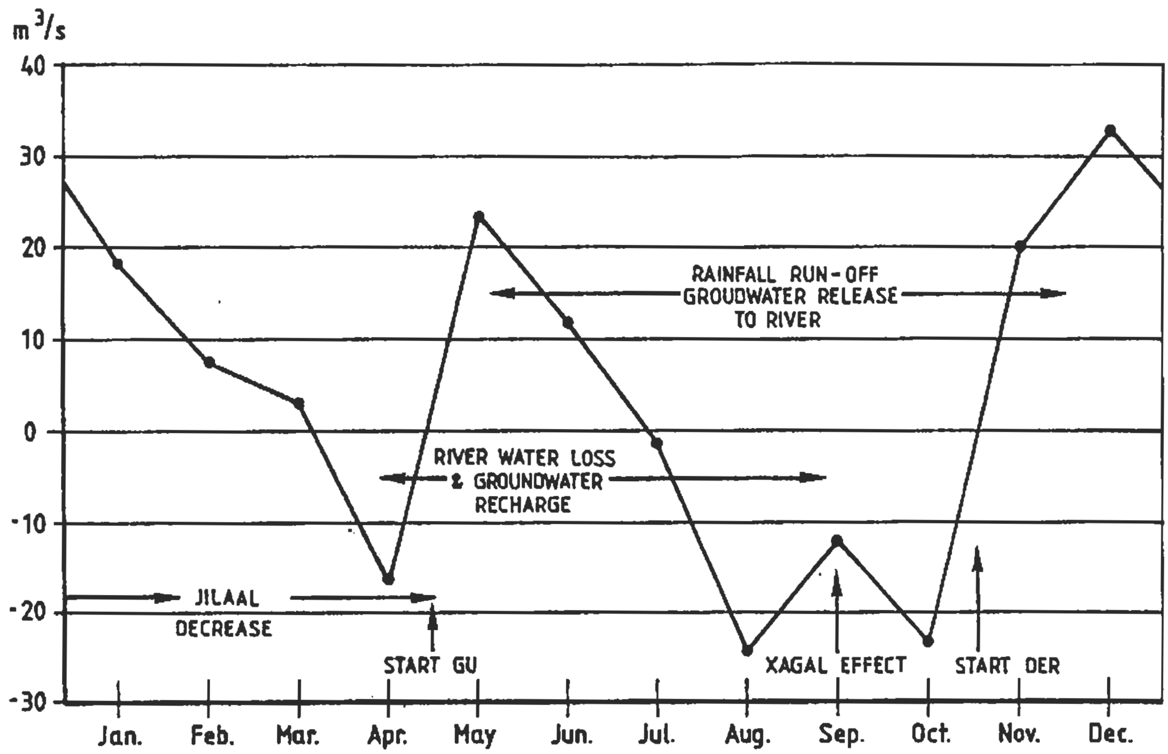


Table 4.2/3 Monthly Average and Minimum (1955) Reconstituted Discharges (m^3/s)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Luuq:													
average	48	30	39	149	255	177	189	270	287	428	335	136	196
minimum	44	40	14	49	117	36	88	198	257	396	195	83	126
Bardheere (average)	54	33	40	141	261	182	185	262	186	416	361	149	198
Kaytoy:													
average	64	39	38	122	258	185	172	244	278	376	375	172	194
minimum	23	18	3	30	108	17	56	206	272	329	193	51	109
Jamaame:													
average	64	35	35	103	234	190	170	236	275	338	371	184	187

Source: ELC Final Design and own computations.

Figure 4/3 Effect of the Intermediate Catchment between Bardheere and Kamsuma



Source: Own computations

The period of floods starts in April or May (Gu season) with the arrival of flood waters from Ethiopia. Der floods start normally in August and end in November. Flows then recede until the following April.

The average flood discharges decrease from Bardheere downstream due to storage capacity of the intermediate catchment/desheks. The flooding of desheks starts locally (e.g. below Fanoole) at 300 m^3/s. The exceedance of this discharge is on average six weeks annually (Table 4.2/4). According to the level of the bank relative to the riverbed, stage discharge relation and flow in the relevant river stretch, the frequency and duration of flooding in individual desheks is highly variable. These desheks do not contribute to the reduction of flood discharges above 900 m^3/s due to their return flow. Flows of 800-900 m^3/s do not cause serious damage; such damage occurs when the discharge exceeds 1,200 m^3/s at Bardheere (approximately the one-in-five-year flood event, Table 4.2/5), receding to some 1,000 m^3 at Kaytoy and 500 m^3/s at Jamaame, where the riverbank capacity is lower.

Floods are normally caused by a combination of high flow from Ethiopia, rainfall in the catchment in Somalia and contribution from the Shebelli and Bohol Magaday catchment. Local rainfall and inflow from the adjoining catchments (Bohol Magaday, Shebelli, Deshek Waamo etc.) causes flooding of waste areas and occasionally contributes substantially to the flood discharges in the lower catchment. Drainage of rainwater towards the Juba river is impeded by the high water level in the river and by communications and bunds.

Table 4.2/4 Pattern of the Mean Annual Flood Discharges (m^3/s)

Location	Mean annual floods (duration)						
	1 day	2 days	3 days	7 days	10 days	20 days	30 days
Luuq	918	873	848	793	758	664	593
Bardheere	840	826	814	770	740	656	589
Kaytoy	748	739	730	702	682	614	556
Jamaame	627	625	623	608	595	545	505

Source: ELC, Sir MacDonald Ltd.

Table 4.2/5 Discharges of Super Floods (m^3/s)

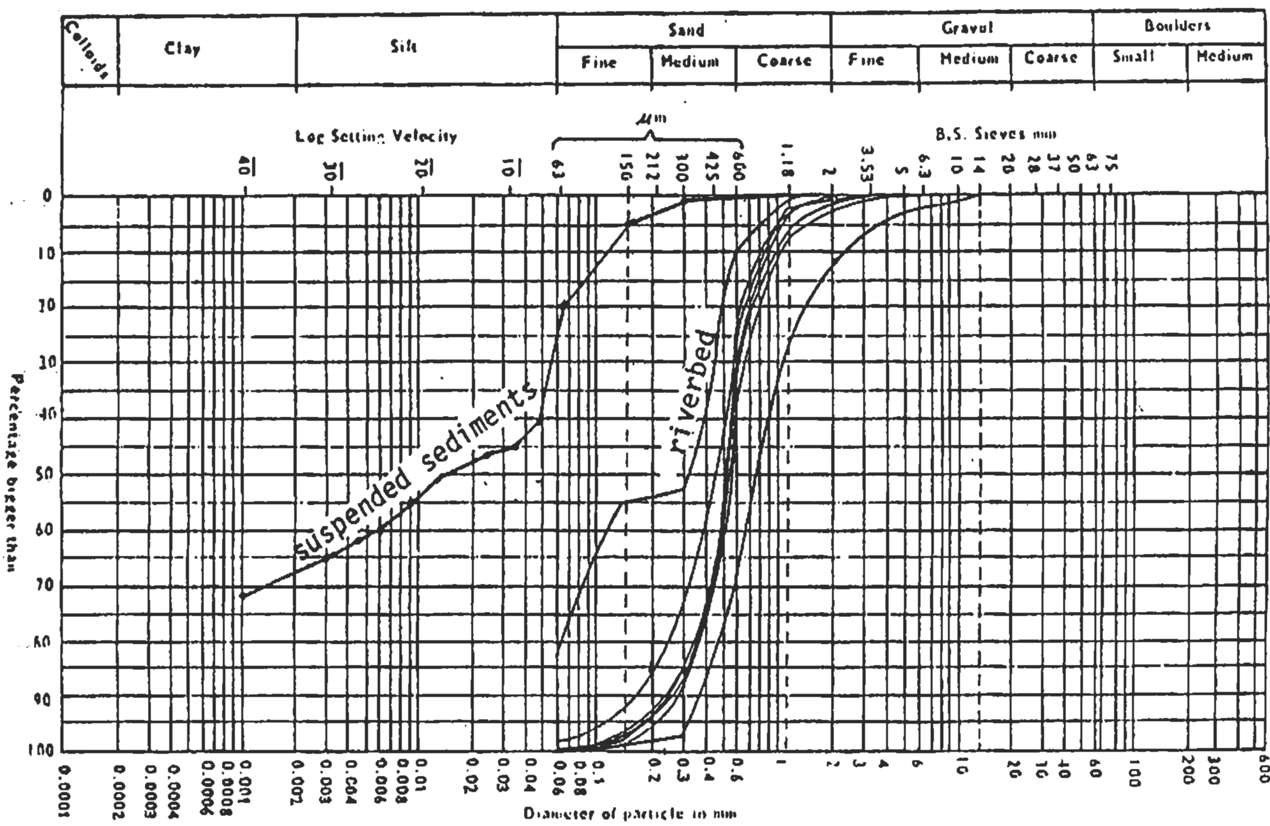
Location	Occurrence				Bankfull capacity
	5-year	20-year	100-year	1000-year	
Luuq	1,200	1,650	2,300	3,070	900
Bardheere	1,150	1,450	2,850	3,850	750
Kaytoy	950	1,250	2,400	-	550
Jamaame	750	1,050	2,400	-	400

Source: Sir MacDonald Ltd.

4.3 Water Quality and Sediment Transport

The quantity of suspended and bed load transported as well as the chemical characteristics of the Juba river water depend on discharges and rainfall in the intermediate catchment. Calculations by ELC show that the suspended and bed load at Luuq vary between 1.8 and 18 million m^3 annually in dry and wet years respectively, corresponding to medium concentration of suspended load varying between 666 to 1,748 ppm. In the lower catchment values varying between 144 and 4,111 ppm have been recorded. The amount of transported sediment decreases downstream and is influenced also by the operation of the Fanoole Diversion Dam. The grain size distribution of suspended sediments and bed load is shown in Figure 4/4.

Figure 4/4 Grain Size Distribution of Riverbed and Suspended Sediments



Source: Sir Mac Donald Ltd., completed.

The trap efficiency of the planned Bardheere reservoir is about 95%, resulting in the decrease in contents of sediments downstream this dam. The released kinetic energy varying from some 0.4 to 2 MW for 131 m^3/s and 700 m^3/s respectively (computed according to Bagnold, 1966) will result in changes in the cross-sectional form (increase in depth) and in changes of the local gradient of the river channel, increasing thus gradually the content of suspended and bed load. The extent to which these changes in channel morphology will propagate downstream to the Fanoole dam (where the erosion/sedimentation process depends on the operation of gates) depends upon the geophysical resistence of the river channel controlled locally by bedrock ledges. Continuous measurement of channel cross sections at selected profiles should determine the rate and distance of propagation and specify the necessary stabilization measures.

According to international standards the quality of the Juba river water can be considered as good for irrigation purposes as well as for raw water that may be treated for drinking purposes. The salinity varies throughout the year and is low from July through November, medium in May and June, December and January and high from February to April (Table 4.3/1).

Table 4.3/1 Salinity Hazard of the Juba River Water According to USDA Classification for Irrigation Purposes

Salinity	Class	Electrical conductivity EC (mmhos/cm)	Chemical analyses (number)	Occurrence
Low	C1	< 0.25	8	Jul.- Nov.
Medium	C2	0.25-0.75	60	May - June Dec.- Jan.
High	C3	0.75-2.25	29	Feb.- Apr.
Very high	C4	2.25-5.00 (1)	3	Feb.- Apr.

1) Maximum 4.7 mmhos/cm.

Calcium and magnesium are the main cations, except during low flows or in the salt plugs, when sodium predominates. High salinities are caused mainly by chlorides: bicarbonate is the predominant ion during dry periods. Salt plugs have daily patterns approximating the quantity of suspended solids with peaks occurring in the first flushes of April (maximum 4.1 g/l at Bardheere) and lower peaks during October floods. There is a general tendency for salinity to increase around Jilib and then decrease downstream. The turbidity and the content of suspended as well as settling solids vary locally, and the content of dissolved phosphates and nitrates decreases towards the ocean. Starting mid-March throughout the end of May usually one or two saline crests occur and last no more than a few days. The sharp salinity increase is due to the fact that salts from the gypsiferous formations in the middle and upper catchment are flushed out by the first rains of the year. The salinity also increases during the dry season as the share of groundwater contribution increases.

Sea water intrusion in the river estuary depends on discharges and tidal range. In the dry season from March until April or May, the high tide (maximum 3.5 m) drives water upstream to Yontoy (river km 30 to 40) where it influences the intake of the Kismayo Water Supply System. With even small river flows (15 m^3/s) the sea water is driven back to Gobweyn.

The sodium-adsorption ratio (SAR) generally ranges from 0.18 to 2.0. Higher values, up to 6, are exceptional. Based on the USDA classification system the sodium hazard of 97% of the samples is low: only 3% fall into the medium range. Yield decrements are to be expected for certain crops like stone fruit trees and vegetables during the months from February to April when the EC-value exceeds 0.75 mmhos/cm and SAR value increases correspondingly. The water then cannot be used for irrigation on soil with restricted drainage and even on sandy soils.

5. Present Stage of Development

5.1 General

The flow of the Juba river contributes to soil fertility and the balance of ecosystems along its course, while the river also interacts strongly with groundwater. The river is an in-stream habitat for fish and wildlife, as well as an artery for irrigation and public water supply and livestock watering. The most important in-stream use is hydropower generation at the Fanoole Barrage. Important flood water use is for deshek cultivation in the middle and lower reaches, while large floods support the livestock/range-type ecosystem between the Little Juba offtake, the Far Shebel, and the Deshek Waamo.

Agriculture is the primary water consumer. A differentiation can be made into two major types of river water use for agriculture, each with a particular set of characteristics and requirements:

1. Flood recession (deshek) cultivation.

2. Irrigation systems (pump or gravity supplied).

To a large extent, further subdivision in water use systems coincides with Juba river reaches, in which each has typical irrigation characteristics and needs. An overview of the major water use system for crop production, based on the major river reaches, is presented in Table 5.1/1.

Table 5.1/1 Water Use Systems

Planning unit or reach	Valley area	Principal irrigation system	Major crops	Start of operation	Planned spec. water requirement (1/s/ha)	Present irrigated area (ha) (net)	Planned (east.) capacity (m^3/s)	Estimated irrigation efficiency
Upper catchment	(no information/unknown)							
Upstream of reservoir	North of Luuq	small-scale pumps	vegetables sesame	1975	(3.0)	1,100 unplanned	(3.3)	0.2 (4)
Future reservoir	Luuq to dam site	small-scale pumps	vegetables sesame	1975	(3.0)	600 unplanned	(1.8)	0.2 (4)
1. Bardheere riverine area	dam site to 20 km north of Saakow	small-scale pumps	onions) tobacco) sesame)	1975	(3.0)	2,500 unplanned	(7.2)	0.2 (4)
2. Saakow Bu'aale area	20 km north of Saakow to Fanoole	flooding desheks & small-scale pumps	maize) sesame) sorghum) veg/fruit)	1980	 (3.0)	(3,800) (1) 1,600	 (2.7)	(5) 0.2 (4)
3. Fanoole/ Kamsuma area	Fanoole to Kamsuma	Juba Sugar Fanoole	sugar cane rice seasonals rice	1980 1982	1.89	7,000 (7,365) 800 (7,750) 200 600	13.6 20.7	0.4 (6) 0.15 (7)
4. Kamsuma/ Gobweyn area	Kamsuma via Yontoy to Gobweyn	Estate (Mogambo) medium-scale pumps	seasonals bananas	1986 1925	1.68	1,000 (2,200) 3,400+	3.7	0.15 (7) 0.2
6. Homboy	Shebelle	gravity	seasonals bananas rice			(3,600)(2) (8,850)(3)	12.7	n.a.
Subtotal 1-5 (downstream Bardheere)						17,100 ha		0.33 (8)
Total (with area upstream Bardheere)						18,800 ha		

1) Flood recession.
2) Rainfed.
3) Potential net command area.
4) Expanding rapidly.
5) Changing towards controlled irrigation.
6) Stable.
7) Slow/behind schedule..
8) Determined in Chapter 5.1.

Source: Own survey

An overview of the locations for deshek cultivation and modern irrigation systems is given in Figure 5/1.

5.2 Flood Recession (Deshek) Cultivation

Desheks are defined as natural depressions in the flood plain which are seasonally flooded by overbank flow from the Juba River or its tributaries, rainfall runoff within the deshek area and from adjacent plain or by the groundwater table recharged by rainfall and flood runoff. The frequency of flooding depends on the hydrometeorological factors as well as location and elevation of the deshek, its levees and flood protection bunds in relation to the water level in the adjacent river stretch.

Deshek cultivation is a risky enterprise for the local farmers, in that they have to make decisions and take measures based on the unknown stochastic occurrence of floods and the unpredictability of nature. The cultivated area under deshek cropping in the districts of the Juba River is presented in Table 5.2/1.

Table 5.2/1 Area Under Deshek Cropping

District	Saakow	Bu'aale	Jilib	Jamaame	Total
Area (ha)	1,500	3,460	2,000	(7,900)(1)	6,960

1) Deshek flooding being prevented by the construction of flood bunds, now cropped mostly on rainfall alone.

Source: ANNEX 4, Crop Production

Desheks in the middle Juba reach start flooding at a river discharge level of around 400 m^3/s; all the desheks are flooded when the discharge reaches around 700 m^3/s. This means that with increasing flood levels, an increasing number of desheks become flooded due to levee or embankment overtopping or due to water intake through man-made openings in bunds along the river.

With increasing flows, the volume of water being stored in the desheks can reach up to 15% to 20% of the river water. In the desheks encountered below Fanoole, the river discharge level at which flooding starts is lower, and is in the range of 300 to 450 m^3/s. This is due to the elevation of the flood inflow section of a deshek on the river embankment in respect to water levels: and the degree of man-made protection already provided to minimize or to control flooding.

The uncertainty of the natural factors, their occurrence and magnitude, have great socioeconomic consequences, in that deshek farmers are reluctant to invest time, effort and money in agricultural practices, agro-production inputs, and into organization and management beyond a certain level.

Trends and changes in deshek agriculture in recent years include:

- construction of flood protection bunds,
- introduction of irrigation to cultivate cash crops on the levees,
- lending of transportable pumps to farmers on the basis of 50-50 crop sharing arrangements,
- appropriation of land particularly in the vicinity of the administrative centers of Bu'aale and Saakow,
- increased legal insecurity of small traditional farmers as a result of the extensive acquisition of land by outsiders,
- increased use of deshek land as rainfed land,
- expansion of cultivation into the higher levee areas.

5.3 Irrigation Systems

5.3.1 Differentiation of the Systems

Irrigation systems can be distinguished into three groups regarding the interrelationship of the discharge capacity of the pump, the size of the area served, and the crops they serve:

1. Large-scale schemes (supplied by water diversion and/or pumping, surface irrigation for rice and other crops, sprinkler irrigation for sugar cane).
2. Medium-scale schemes (supplied by pumping, primarily in banana estates, with a capacity range of 120 to 170 l/s, for 30 to 70 ha, furrow irrigation).
3. Small-scale schemes (supplied by pumping, mainly for seasonal crops, average capacity 5 to 20 l/s, 10 to 12 hours of daily operation, average size 4 to 10 ha, primitive surface irrigation).

5.3.2 Large-Scale Schemes

The Fanoole Irrigation System (see Figure 5/1) is served by the Fanoole barrage, constructed in 1977-1982, with four gated openings (capacity 800 m^3/s); and by a 56 km long conveyance canal.

Under full development, the Fanoole system is expected to divert 33.4 m^3/s for some 15,250 ha to two areas: the Fanoole command area, between the Juba river and the Fanoole main supply canal and to the Homboy area. This Homboy area, south/south-east of Jilib is presently a rainfed agriculture area of about 3,600 ha, located in a 7 km long strip of the Shebelli river alluvial plain. The Homboy irrigation area is planned for 7,500 ha net.

The Fanoole command area is about 8,200 ha and has a net irrigable area of approximately 7,750 ha, served by a design capacity of 20.7 m^3/s.

The system is planned as a double cropped rice irrigation scheme, using basin irrigation. The area to be irrigated is not yet fully developed today, with only about 1,800 ha cleared, and a cropped area in 1987 of about 800 ha rice and 200 ha seasonals.

The Juba Sugar Project (see Figure 5/1) covers a gross area of 7,780 ha, out of which 7,000 ha (net) are under sugar cane, irrigated mainly by sprinkler and including 320 ha of surface irrigated lands. Irrigation water is supplied by two major pumping stations with a joint capacity of 12 m^3/s and two minor stations together 1.6 m^3/s.

The lack of water has been quite pronounced in recent years during February to April, resulting in a yield reduction of up to 40%. Information in early 1988 indicated that only 12 irrigations were being applied for a total of 10,000 m^3/ha, whereas 20,000 m^3/ha through 24 irrigations was required.

The Mogambo Irrigation Project (see Figure 5/1) Phase I was completed in 1986 for 2,040 ha of surface and 160 ha of sprinkler irrigation. Water is provided through a 3.7 m^3/s pumping station.

The project is planned as a double cropped rice project. Originally perceived as a state farm, the project now includes smallholder farmers, locally recruited. The result for 1987 has been that out of the total irrigable area of 2,200 ha, 1,600 ha are state farm operated, and 600 ha have been handed to smallholders, each having 2 ha. Presently only 1,600 ha are under irrigation.

Irrigation is achieved with basins of 2 ha each, with individual inlets and outlets. Groundwater table is rising and an increase in soil salinity is being reported and under investigation. Crop rotation of rice with seasonal crops is under consideration.

5.3.3 Medium-Scale Pump Schemes

Medium-scale pump schemes supply primarily banana estates on a total area of some 3,300 to 3,400 ha from 8,300 ha that is under control of all 54 banana growers. These are irrigated with pumps with an average capacity of 170 l/s. Presently, about 125 such pumps are in operation, mainly located in the lower Juba reach, below Kamsuma (see Figure 5/1).

Medium-scale systems have similar problems as derived from irrigation practices for small pumps (see below). The overall level of technology is better in comparison with small-scale systems: in some instances the main canal being partially lined, with control structures, but with no flow measurement facilities. Nevertheless, the larger areas irrigated can lead to relatively larger distribution losses.

Medium-scale irrigation for banana production requires a much higher level of both land preparation and improved irrigation practices as the crop is fixed on the field for at least 3 to 4 years, and the irrigation layout can only be changed at great costs. This offsets the often better main system water control and distribution possibilities. They are furrow irrigated (furrows 100 m long spaced 2.5 m). Some schemes have a drainage system consisting of 1 to 2 m deep drains at a spacing of 80 to 120 m, discharging into the river or into depressions, but in the rainy or flood periods, farmers report using their irrigation pumps for drainage purposes.

Many of the banana plantations have drainage problems and different soil types. This in combination with the age of the plantation influences the irrigation practices, which with crop residues in the furrows also affect irrigation efficiencies. Since banana plantations are at the river's end for offtake, they are highly vulnerable to upstream abstractions.

5.3.4 Small-Scale Pump Schemes

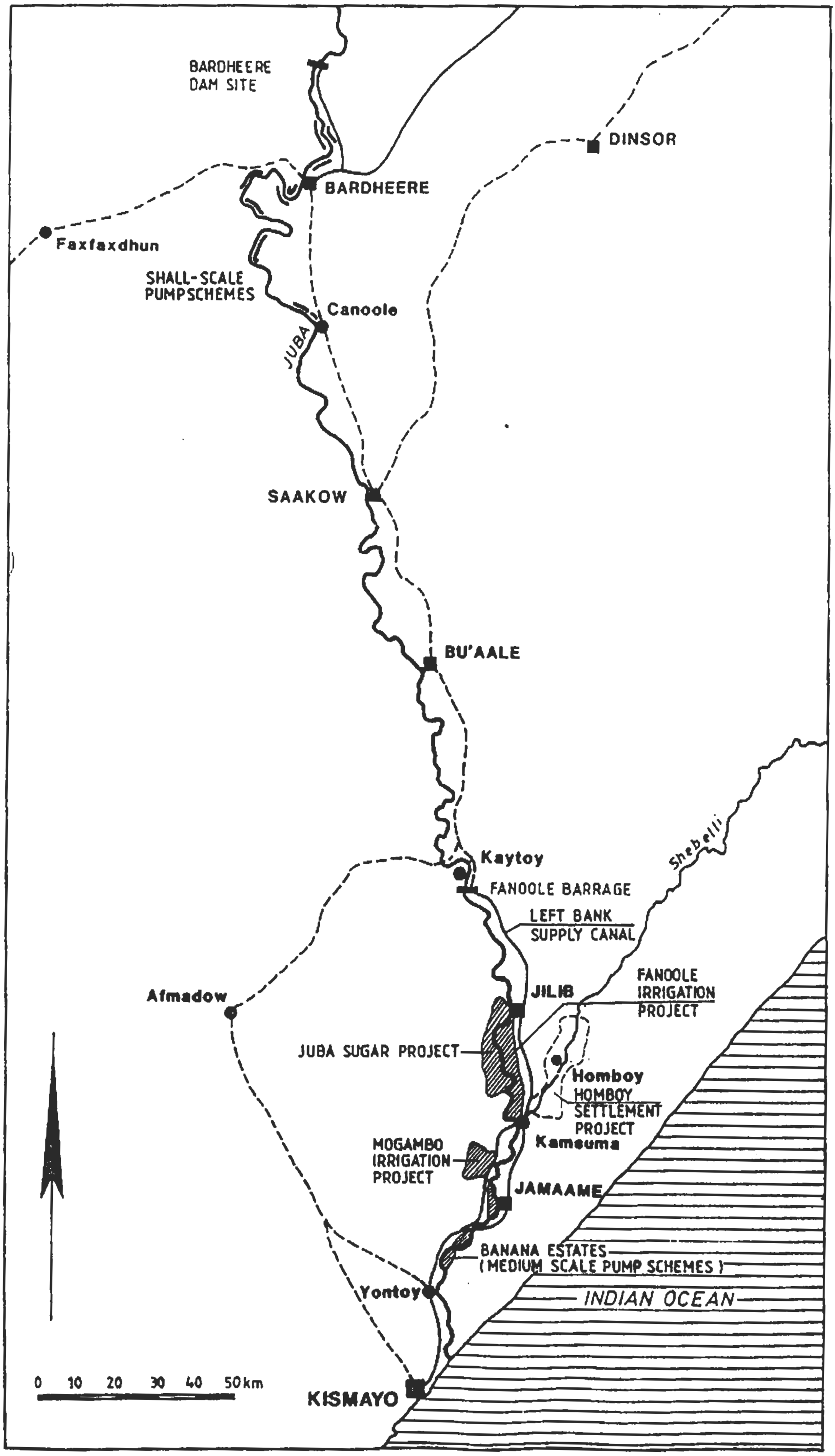
Small-scale pump irrigation is rapidly increasing in the upper valley reach and is expanding from here into the middle valley reach. In Luuq district, an increase of 10 small pumps per month in the last 2 years has been recorded, with an average capacity of 20 l/s per pump, and operating time of 5 to 12 hours per day, supplying 3 to 12 ha.

In the Bu'aale - Dujuma area (see Figure 5/1) , 50 new pumps (effective capacity ranges from 15 to 20 l/s for 5 to 7 m head) have been distributed to farmer groups under a credit and cooperative arrangement. The number of small pumps was estimated to be at 260 in 1984, at 300 in 1986, at 600 in 1987, downstream of the planned Bardheere dam, and at 900 for the total river length in Somalia. This trend has resulted in a substantial decrease in river discharges and lack of water for medium and large schemes during the dry season, in the area downstream of the Fanoole Barrage.

Pumps are placed in a position in the embankment of the river, in a vertical height often between the water level and the fields to be irrigated. These small pumps are then difficult to remove when water rises rapidly. Problems of operating and maintaining these small-scale pumps include poor pump selection, use of pumps outside efficiency range, lack of fuel, spares, and poor alignments. Small Holder irrigators still lack also the basic knowledge on crop water requirements. This leads to an erratic pattern of overirrigation, high water losses and low efficiency.

The present ongoing expansion trend in small-scale, smallholder irrigation development leads to a situation where all available land in a narrow trip along the banks of the Juba River would be brought under irrigation, denying thus access to the river for further irrigation projects, whose implementation is planned in the framework of the Masterplan.

Figure 5/1 Irrigation Projects



5.4 Tendencies Influencing the Development

5.4.1 General

A number of irrigation related trends are ongoing in the Juba valley at present. These need to be recognized and quantified for incorporation into the regional planning process. A comparison with the irrigation and water projects is needed in order to determine whether these projects cover the needs of the trends or whether additional action and measures are required. Upon review, Government actions for controlling and regulating these trends can be put forward for political decisions.

5.4.2 Speculation and Positioning in Access to Land and Water

According to District Authorities, an increase in land registration is clearly apparent in the Bardheere and Saakow/Bu'aale riverine systems. This has progressed to the extent that today almost no land in the immediate vicinity of the river remains unregistered in the Bardheere riverine system. This trend results in increased insecurity of traditional (small) landowners who are in no position to pay for the costs associated with this land registration. This trend is accompanied by an increase in number of small pump units and increased land clearing, degrading the riverine natural vegetation. Thus, the conclusion is one of increasing speculation and positioning along the river in anticipation of future increased water supplies due to the Bardheere dam. A variety of arrangements between land and pump owner and sharecroppers exist, but the overall trend is one of increased tenancy.

Competition in the use of land for crop production or livestock breeding in the fertile floodplain has been recorded also, with a minor trend of sedentarization by nomadic pastoralists as a consequence.

5.4.3 Recognition of Need for Small Holder Participation

There is an increased willingness to accept subsistence farmers as owner/smallholders in large estate development, as the recent attempts to improve production in the Mogambo Project show. Similar plans are being considered for the Fanoole Project, and the Homboy Project has been planned in this manner. Without doubt, the disappointing results and slow pace of development in part of these state-owned estates have contributed to this recognition of the need for beneficiaries' participation in development efforts.

5.4.4 Inter- and Intra-Regional Competition for River Water Resources

The strong increase in the number of pumps in the Bardheere and in the Saakow/Bu'aale riverine systems has undoubtedly contributed to the lack of water in the Jilaal season in the lower Juba reach between Fanoole and Gobweyn. In addition, an increase in rising groundwater level and salinity in the Kamsuma/Gobweyn riverine system have been observed, the cause of which is still undetermined, but can be traced towards overirrigation resulting in more saline return flows. Also, the increased use of water north of the Study Area also contributes to this trend of an increasing, pronounced, dry season conflict.

From the comparison, a discrepancy becomes clear that calls for trend correction or improvements which are only partially covered by the Government policies towards irrigation and water resources development:

- The lack of water legislation and the lack of legislative protection of the traditional land user are presently not corrected in any formal project-type effort, nor is cadastral surveying in step with such trends.

- The almost uncontrolled development in use of land and water in both the upper watershed and the Bardheere and Saakow/Bu'aale Riverine Areas, results in increasing water shortages in the lower Juba reaches. The salinity increases downstream through overirrigation and seawater intrusion.

- Involvement of smallholders in irrigated agricultural development still occurs only on an ad hoc basis as in Mogambo Irrigation Project, rather than to be planned and structurally incorporated from the beginning. In addition, whereas smallholders in the lower Juba are being asked to become participants, they are becoming excluded from development trends as owners in the Bardheere and Saakow/Bu'aale Riverine Areas.

- The sustained benefits of projects that were implemented in the past or are ongoing are hampered by the inadequate consideration of recurrent maintenance and operation costs. The aspect of regular maintenance, servicing and periodical replacement of equipment is one of the most important limitations for achieving long-term development goals.

- Another limitation for the same issue of sustainability is the lack of skills at all levels and in all sectors, corroborated by inadequate programmes to improve upon this problem through the creation of training facilities based on a sound national and regional strategy.

5.4.5 Irrigation in the Before-Dam Situation

Irrigation development in the before-dam situation will result in an increase in water demand. The tendency appears to be one of an increase in the severity of the dry season. Already there is insufficient water in the river in the Jilaal season, and perennial crops will continue to be stressed for lack of water.

The approximate 25 m^3/s lack of water in January through March results mainly from the requirements of 7,000 ha of cane and 3,400 ha of bananas (plus the requirements of existing small-scale pumping systems whose cropping calendar can be adapted and still secure two harvests a year). Farmers in the Bardheere and the Saakow/Bu'aale Riverine Area divert whatever water passes their pumps. The below-Fanoole users are during the dry season without water, being at the tail end of the river system.

Thus, uncoordinated expansion of irrigation in this before-dam situation will be at the expense of the users in the Fanoole-Kamsuma-Gobweyn Riverine Area. The expansion should be controlled by the Authority (Water Development

Apart from this, medium-term (5 years) and long-term (20 to 50 years) balances should be determined for planning purposes.

To analyze this, one of the most important limiting factors of development, water balances in the Juba valley have been compiled for the

- present state of development (17,100 ha irrigated - see Table 6.2/2) and actual irrigation efficiency (to identify existing limitations);

- initial operation of the Bardheere reservoir (27,000 ha under irrigation see Table 6.2/2) and expected initial irrigation efficiency (to specify the situation after the dam);

- stage of full development and different realistic irrigation efficiencies (to identify the irrigation potential under different assumptions).

These balances have been compiled on a monthly basis for a medium dry year (Q_{80}) with a 80% probability of exceedance and for an average year for all analyzed stages. Input hydrological data, discharges at Bardheere, have been already presented in Table 4.2/3.

6.2.2 Water Abstractions

The water abstractions and inflow downstream Bardheere include:

- impact of the interim basin
- irrigation requirements
- rural water requirements.

The impact of the interim basin consists of groundwater contribution and recharge in the river stretch Bardheere-Kamsuma (465 km) that has been evaluated by the use of computer (Figure 4/3) and evaporation losses in the river stretch Kamsuma-estuary (96 km).

Methodology of the compilation of water balances is explained in footnotes of Tables 6.2/7 to 6.2/11.

6.2.3 Irrigation Requirements

Water requirements at various irrigation system levels are:

- crop water requirements or evapotranspiration (being the amount of water used per unit cropped area, to account for the crop specific transpiration and surface evaporation);

- irrigation requirement (being evapotranspiration (see Table 2.3/1) minus effective rainfall (coefficients of effective rainfall see Table 6.2/1), plus the leaching requirement to maintain a favorable salt balance in the soil when applicable);

Agency/Irrigation Development Support Services). Further offtake from the river upstream Fanoole in the dry season should be avoided in order not to decrease the water supply for the existing large-scale projects and banana plantations that already suffer from water scarcity. The area under irrigation can be increased by pumping in the period May till December when there is still ample water supply in the Juba river. Any expansion of irrigation in the before-dam situation should and can only be directed towards expansion of seasonal crops in the period of guaranteed water availability.

6. Irrigation Development Constraints

6.1 Natural and Management Constraints

The irrigation development in the Juba valley is hampered by different constraints. Crucial development constraints arise from problems of efficient mobilization and rational management of human and soil resources in harmony with the development of water resources. Legal, institutional and economic problems of water management and basic physical constraints arising from irregular water occurrences, i.e.

- water scarcity resulting from low discharges in the Juba river and high irrigation requirements in the period January to April

- flood hazard resulting from periodic monsoon rainfall occurring in April-May and October-November as well as from the bankfull capacity of the Juba which decreases downstream from Luuq to the estuary

will be analyzed in this Chapter.

Environmental problems are briefly mentioned in Chapter 7.2.3. Environmental constraints are analyzed in Chapter 7.7 and in ANNEX 14 - Environmental Management in Juba Valley. Problems of agricultural management will be analyzed in ANNEX 4, Crop Production.

6.2 Water Balances

6.2.1 General

The balance of water resources and needs compares the quality and quantity of available water resources in a certain geographical unit, with the water requirements, so that the measures which are necessary to satisfy the demands can be analyzed. The unfavorable (passive) water balance indicates the need for a development of new water resources. From the operational point of view it indicates the need for restricting cutting down existing water uses by excluding inefficient uses, by adapting the cropping calendar by introducing water saving techniques etc.

The operational management of water resources utilization requires

- a current evaluation of the actual state of the water balance
- a periodic yearly evaluation of the balance of the previous year.

Figure 6/1 Crop Coefficient for Banana (5-year cycle)

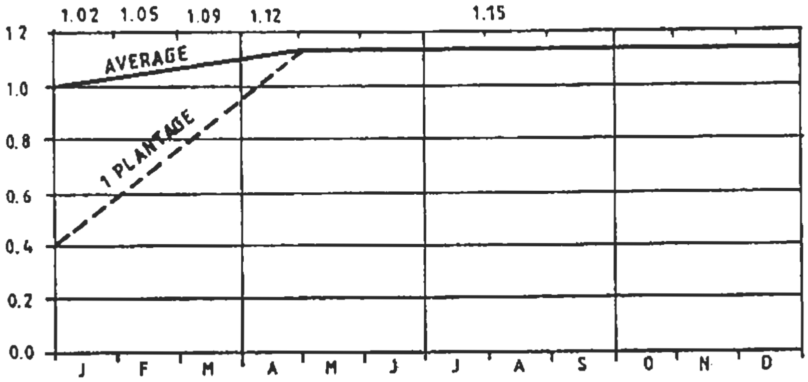
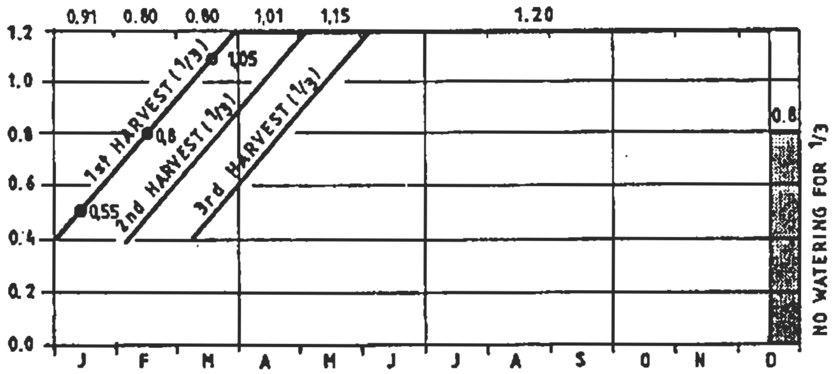


Figure 6/2 Crop Coefficient for Sugar Cane (1-year cycle, 3 harvests)



Source: Own survey

Table 6.2/3 Average Crop Coefficient for Juba Valley

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bananas	1.02	1.05	1.09	1.12	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Sugar cane	0.91	0.80	0.80	1.01	1.15	1.2	1.2	1.2	1.2	1.2	1.2	1.0
Rice	0.75	0.0	0.75	1.5	1.3	1.05	0.75	0.0	0.75	1.5	1.3	1.05
Seasonals	0.65	0.2	0.4	0.8	1.1	0.9	0.65	0.2	0.4	0.8	1.1	0.9
Present (2)	0.84	0.60	0.74	0.99	1.15	1.08	0.98	0.78	0.91	1.09	1.18	1.0
1995 (3)	0.77	0.45	0.61	0.92	1.13	1.02	0.86	0.57	0.72	0.98	1.14	0.97
Reduced (1)	0.59	0.45	0.50									

1) Recommended cropping calendar reduces the cropping of seasonals in the period January-March, which together with introduction of plants with a shorter growing period enables the reduction of the average crop coefficient in this period.
2) Total of the crop coefficients multiplied by relevant share (2nd column of Table 6.2/4).
3) Total of the crop coefficients multiplied by relevant share (4th column of Table 6.2/4).

Source: Own survey

- field irrigation requirements (being the evaporation irrigation requirement plus the field losses, due to surface runoff and deep percolation);

- diversion requirements (being the field irrigation requirements plus the distribution and conveyance losses, i.e. crop irrigation requirements divided by the total irrigation efficiency [Table 6.2/2]).

Table 6.2/1 Coefficients of the Effective Rainfall

Monthly rainfall (mm)	Coefficients (%)
0- 25	90.0
25- 50	87.5
50- 75	83.3
75-100	75.0
100-125	66.0
125-150	56.7

Source: US Bureau of Reclamation Method (1967), as adapted by MacDonald Ltd.

Table 6.2/2 Estimate of the Average Irrigation Efficiency

Crops	Hectarage (net)		Share		Irrigation efficiency		
	Present	1995	Present	1995	Present	Share at Present	(1) 1995
Bananas	3,400	(3,400)	0.199	0.126	0.32	0.064	0.040
Sugar cane	7,000	(7,000)	0.409	0.259	0.45	0.184	0.117
Rice	1,400	(1,400)	0.082	0.052	0.24-0.27	0.021	0.014
Seasonals	5,300	(15,200)	0.310	0.563	0.20	0.062	0.113
Total	17,100	(27,000)	1	1		0.331	0.284 (2)

(1) Share of irrigation efficiency in relation to the hectarage
(2) Resulting irrigation efficiency (1995 with no improvement - pessimistic assumption).

Source: Own estimate

Crop water requirements for the Juba valley have been determined by multiplying the average evapotranspiration with the average crop coefficient (see also Figure 6/1 and 6/2 for banana and sugar cane), which has been derived in Table 6.2/3.

It is expected that the development of modern irrigation systems will result in an increase of irrigation use efficiency which may in average reach some 40% in 1995. Pessimistic assumption (Table 6.2/2) shows, neverthelees, that this efficiency may even decrease to some 28% due to the extension of the less efficient small-scale development.

6.2.4 Rural Water Requirements

The present rural water requirements (Table 6.2/6) consist of

- livestock watering 2.72 mill. TLU (tropical livestock units)

30 l/TLU and day -	81.600 m^3 per day =	0.944 m^3/s
February-April	90% supplied from the river	0.85 m^3/s
May-November	10% supplied from the river	0.09 m^3/s
December-January	50% supplied from the river	0.47 m^3/s

- domestic supply

	Population	l/capita/day	
Population Kismayo	78,020	x 0.100	7,800 m^3/day
Bardheere	16,700	x 0.050	835 m^3/day
Rural	402,000	x 0.020	8,040 m^3/day
			16,675 m^3/day = 0.192 m^3/s

Table 6.2/6 Monthly Rural Water Requirements (Livestock Watering plus Domestic Supply)

Period	Present	1995 (1)
February - April	1.04 m^3/s	1.5 m^3/s
May - November	0.28 m^3/s	0.8 m^3/s
December - January	0.66 m^3/s	1.2 m^3/s

1) 1995 - an expected increase by - 0.5 m^3/s.

Source: Own estimate.

6.2.5 Water Balance at Present

The results of the water balance compiled for the present state (Table 6.2/7 - 17,100 ha under irrigation, 10,400 ha seasonals) show that the water scarcity occurs not only in dry years but also in average years. The discharge in an estuary of the Juba river in a dry year in the period February up to April (row 13 of Table 6.2/7) is zero. The water deficit exceeds 20 m^3/s in a medium dry year (80% probability of exceedance). During an average year the discharges in estuary drop below 15 m^3/s during this season, and seawater intrusion reaches up to the intake of the water supply system of Kismayo. Under such circumstances, the water balance also can be considered as passive. The water balance in the estuary of the Juba River, therefore, is passive every second year.

Table 6.2/4 Hectarage and Share of Crops in the Present Development Stage and After the Dam Completion (see Table 6.2/2)

Crop	Present stage		1995	
	Hectarage (net ha)	Share	Hectarage (net ha)	Share
Bananas	3,400	0.199	3,400	0.125
Sugar cane	7,000	0.409	7,000	0.259
Rice	1,400	0.082	1,400	0.052
Seasonals	5,300	0.310	15,200	0.563
Total	17,100	1	27,000	1

Source: Own survey and computations.

Crop coefficients have been derived for the following crop periods and crop calendars:

Rice - crop period 140 days
Seasonals - crop period 120 to 135 days

The crop coefficients of seasonals is presented in Table 6.2/5.

Table 6.2/5 Crop Coefficients of Seasonals (incl. 10% of Alfalfa)

Month Cropping pattern		1	2	3	4	5	Growing period (days)
<u>Gu season</u>							
Alfalfa	10%	0.4	1.0	1.05	1.05	1.05	365
Groundnuts	25%	0.4	0.8	1.05	0.85	0.55	90
Vegetables	15%	0.4	0.7	1.05	0.8	0.6	120
Maize	30%	0.3	0.8	1.2	0.9	0.6	100
Onions	20%	0.4	0.8	1.1	0.85	0.75	120
Average		0.4	0.8	1.1	0.9	0.65	5 months
<u>Der season</u>							
Alfalfa	10%	0.4	1.0	1.05	1.05	1.05	365
Water melons	10%	0.4	0.7	0.95	0.8	0.5	90
Maize	15%	0.3	0.8	1.2	0.9	0.6	100
Onions	20%	0.4	0.8	1.1	0.85	0.75	120
Sesame	25%	0.3	0.7	1.0	0.8	0.5	90
Tobacco	20%	0.3	0.7	1.0	0.9	0.75	120
Average		0.4	0.8	1.1	0.9	0.65	5 months

Source: Crop water requirements (FAO 1977), ANNEX 4, Crop Production.

One of the reasons of this unfavorable situation is the low irrigation efficiency and the insufficiently adapted cropping calendar of seasonals. But even with an irrigation efficiency of 60%, the minimum gross water requirements of perennials (bananas and sugar cane) would be for March 11.1 m^3/s (10,400 ha x 0.166 [crop water requirements, see Table 6.2/7] : 30 : 24 : 3,600 : 0.6). This would result in an active water balance in an average year and in a water deficit up to -19 m^3/s (6 + 3 - 1 - 11.1 - 1 [see Table 6.2/7] - 15 [minimum discharge needed to prevent sea water intrusion]) in a medium dry year.

Seasonals have a growing season of 3 to 5 months. Minimum gross water requirements (derived from Table 6.2/7, row 8) for the actual irrigation efficiency 0.33 (see Table 6.2/2) vary between 1,1 l/s/ha (May) and 2,3 l/s/ha (January) depending i.a. on rainfall occurrence. The irrigation potential without storage for a rational cropping pattern (with a cropping interlude for seasonals in the period January - April) can be derived from minimum discharges of the period when both perennials and seasonals are irrigated (December). It depends on the impact of the interim basin as well as return flow and amounts to some 50,000 ha: (71+33-0.6-0.7) m^3/s : 2,1 l/s/ha (see Table 6.2/7 for December). The expected return flow is some 13,5 m^3/s which may be enough for flushing against see water intrusion. Unregulated discharges of the Juba river, therefore, enable having two crops on 45,000 ha of seasonals within the period of water availability April to December and irrigating 5,000 ha of perennials (see next paragraph) even for the average irrigation efficiency of some 0.33.

The share of perennials that might be irrigated without stress management can be derived from discharges in March. It amounts to some 5,000 ha: (6+3-1-1+1) m^3/s : 1,9 l/s/ha, without flushing against seawater intrusion, 1 m^3/s expected return flow. A storage (Bardheere reservoir), therefore, is needed to prevent seawater intrusion even for the present area of seasonals under irrigation with a cropping calendar of seasonals adapted to the period (January-April) of water scarcity. The feasibility of the multipurpose Bardheere Dam Project (total storage 5,666 x 10^6 m^3) must be secured mostly from the power generation : the share of benefits from improving/ securing irrigation of 7,000 ha of sugar cane as well as 3,400 ha of bananas and from preventing seawater intrusion and flood control is minor.

6.2.6 Water Balance After Dam and Irrigation Potential

The results of the water balance compiled for the initial stage of reservoir operation (27,000 ha under irrigation, Table 6.2/8 - row 13) confirm the secured active balance in the estuary even in the dry year. On the basis of the water balance in equilibrium (minimum flow of 15 m^3/s in estuary) during a medium dry year with an 80% probability of exceedance the irrigation potential has been derived for a cropping pattern containing:

- 38% of perennial crops (1/3 banana and 2/3 sugar cane)
- 8% of rice
- 54% of seasonals (incl. 10 % alfalfa),

and taking into account the efficiency standard of:

- 28% (theoretically lowest standard, see Table 6.2/9)
- 40% (realistic standard under local circumstances with a systematic programme to increase the water use efficiency, see Table 6.2/10)
- 60% (optimistic assumption, see Table 6.2/11).

Table 6.2/7 Juba River Water Balance for Present Stage of Development (m^3/s) (17,100 ha under irrigation)

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1a)	Q_{80} m^3/s	23	9	6	10	125	102	126	189	211	227	186	71
1b)	Q_{50}	47	30	39	128	241	159	189	279	299	462	368	142
2)	Contribution/recharge in interim basin	18	8	3	-16(15)	23	12	-1	-24	-12	-23	20	33
3)	Evaporation (m^3/s)	0.9	0.9	1.0	0.7	0.6	0.6	0.6	0.7	0.8	0.7	0.6	0.6
4)	Evapotranspiration (mm)	236	210	224	165	162	163	177	191	196	185	173	207
5)	Average coefficient	0.84	0.60	0.74	0.99	1.15	1.08	0.98	0.78	0.91	1.09	1.18	1.00
6)	Crop water requirements (mm)	198	126	166	163	186	176	173	149	178	202	204	207
7)	Effective rain (mm)	0	0	0	37	82	62	43	14	8	3	25	25
8)	Irrigation water requirement (mm)	198	126	166	126	104	114	130	135	170	199	179	182
9)	Diversion requirement (net) m^3/s)	13.06	8.31	10.95	8.31	6.86	7.52	8.58	8.91	11.22	13.13	11.81	12.01
10)	Diversion requirement (gross) (m^3/s)	39.6	25.2	33.2	25.2	20.8	22.8	26.0	27.0	34.0	39.8	35.8	36.4
11)	Return flow (m^3/s)	5.1	3.3	4.3	3.3	2.7	3.0	3.4	3.5	4.4	5.2	4.7	4.7
12)	Rural water (m^3/s)	0.7	1.0	1.0	1.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.7
13)	Discharge in estuary dry year (m^3/s)	5	-7(16)	-22(16)	-24(16)	129	93	101	140	168	168	174	71
14)	Discharge in estuary av. year (m^3/s)	29	14	11	88	245	150	164	230	256	403	356	142
							passive water balance						

1) Average discharge Luuq/Bardheere: Q_{80} medium dry year, Q_{50} average year.
2) Bardheere-Kamsuma incl. evaporation losses (see Figure 4/2).
3) Kamsuma-estuary: length 96 km, width 80 m, evaporation data Alessandria: (A) x 96,000 x 80 : 30 : 24 : 3,600 = 2.96 x (A).
4) Average from Bardheere and Mareerey meteorological station.
5) See Table 6.2/3.
6) (6) = (4) x (5).
7) Data Yontoy (coefficient 0.66-0.9), see Table 2.4/1.
8) (8) = (6) - (7).
9) (9) = (8) x 17,100 ha : 30 : 24 : 3,600 = 65,972 x (8).
10) Average irrigation operation efficiency 0.33 (see Table 6.2/2) (10) = (9) : 0.33.
11) 25% from banana and seasonals - Juba Sugar and Mogambo not drained into river, share related to the hectarage: 0.13 x (10).
12) See Table 6.2/6.
13) (13) = (1a) + (2) - (3) - (10) + (11) - (12).
14) (14) = (1b) + (2) - (3) - (10) + (11) - (12).
15) 10 m^3/s for Q_{80}.
16) Discharge = 0 m^3/s. These data and data 15 m^3/s signal sea water intrusion.

Source: Own computations

Table 6.2/8

Juba River Water Balance after Dam (m^3/s)
(27,000 ha under cultivation, adapted cropping calendar)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1a)	Q_{80} m^3/s	131	146	138	146	139	142	136	136	142	144	146	131
1b)	Q_{50}	133	149	141	149	145	151	145	147	154	264	257	136
2)	Contribution/recharge in interim basin	18	8	3	-16	23	12	-1	-24	-12	-23	20	33
3)	Evaporation (m^3/s)	0.9	0.9	1.0	0.7	0.6	0.6	0.6	0.7	0.8	0.7	0.6	0.6
4)	Evapotranspiration (mm)	236	210	224	165	162	163	177	191	196	185	173	207
5)	Average crop coefficient	0.59	0.45	0.50	0.92	1.13	1.02	0.86	0.57	0.72	0.98	1.14	0.97
6)	Crop water requirements (mm)	129	95	112	152	183	166	152	109	141	181	197	201
7)	Effective rain (mm)	0	0	0	37	82	62	43	14	8	3	25	25
8)	Irrigation water requirement (mm)	139	95	112	115	101	104	109	95	133	178	172	176
9)	Diversion requirement (net) m^3/s)	14.48	9.90	11.67	11.98	10.51	10.83	11.35	9.90	13.85	18.54	17.91	18.33
10)	Diversion requirement (gross) (m^3/s)	51.7	35.4	41.7	42.8	37.5	38.7	40.5	35.4	49.5	66.1	64.0	65.5
11)	Return flow (m^3/s)	8.8	6.0	7.1	7.3	6.4	6.6	6.9	6.0	8.4	11.2	10.9	11.1
12)	Rural water (m^3/s)	1.2	1.5	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.2
13)	Discharge in estuary dry year (m^3/s)	104	122	104	92	130	120	100	81	87	65	111	108
							active water balance						

1) Reservoir release at Bardheere: Q_{80} medium dry year, Q_{50} average year (see Table 7.2/2).
2) Bardheere-Kamsuma incl. evaporation losses (see Figure 4/2).
3) Kamsuma-estuary: length 96 km, width 80 m, evaporation data Alessandria: (A) x 96,000 x 80 : 30 : 24 : 3,600 = 2.96 x (A).
4) Average from Bardheere and Mareerey meteorological station.
5) See Table 6.2/3.
6) (6) = (4) x (5).
7) Data Yontoy (coefficient 0.66-0.9), see Table 2.4/1.
8) (8) = (6) - (7).
9) (9) = (8) x 27,000 ha : 30 : 24 : 3,600 = 104.1667 x (8).
10) Average irrigation operation efficiency 0.28 (see Table 6.2/2) (10) = (9) : 0.33.
11) 25% from banana and seasonals - Juba Sugar and Mogambo not drained into river, share related to the hectarage: 0.17 x (10).
12) See Table 6.2/6.
13) (13) = (1a) + (2) - (3) -(10) + (11) - (12).

Source: Own computations

Table 6.2/9

Juba River Water Balance and Irrigation Potential
Irrigation Efficiency 28% (38% sugar cane and bananas, 8% rice)

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1a)	Q_{80} m^3/s	131	146	138	146	139	142	136	136	142	144	146	131
1b)	Q_{50}	133	149	141	149	145	151	145	147	154	264	257	136
2)	Contribution/recharge in interim basin	18	8	3	-16	23	12	-1	-24	-12	-23	20	33
3)	Evaporation (m^3/s)	0.9	0.9	1.0	0.7	0.6	0.6	0.6	0.7	0.8	0.7	0.6	0.6
4)	Evapotranspiration (mm)	236	210	224	165	162	163	177	191	196	185	173	207
5)	Average crop coefficient	0.59	0.45	0.50	0.92	1.13	1.02	0.86	0.57	0.72	0.98	1.14	0.97
6)	Crop water requirements	139	95	112	152	183	166	152	109	141	181	197	201
7)	Effective rain (mm)	0	0	0	37	82	62	43	14	8	3	25	25
8)	Irrigation water requirement (mm)	139	95	112	115	101	104	109	95	133	178	172	176
8a)	Irrigation potential (10^3 ha net)	47	43	64	85	85	85	64	43	47	51	51	51
9)	Diversion requirement (net) m^3/s)	27.3	18.7	36.8	37.7	33.1	34.1	35.7	31.1	26.0	35.0	33.8	34.6
10)	Diversion requirement (gross) (m^3/s)	98	65	131	135	118	122	128	111	93	125	121	124
11)	Return flow (m^3/s)	16.6	11.1	22.2	22.9	20.1	20.7	21.8	18.9	15.8	21.3	20.5	21.0
12)	Rural water (m^3/s)	1.2	1.5	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.2
13)	Discharge in estuary dry year (m^3/s)	65	97	29	15	63	51	27	18	51	15	64	59
	Discharge in estuary average year (m^3/s)	67	100	32	18	69	60	36	29	59	135	165	64
14)	Rest discharge dry year (m^3/s)	50	82	14	0	48	36	12	3	36	0	49	44
15)	Specific water requirements (l/s/ha)	3.58	3.18	3.40	1.99	1.32	1.62	2.09	2.70	2.86	2.76	2.28	2.79
16)	Additional theor. potential (10^3 ha)	14	26	4	0	36	22	6	1	4	0	21	16
17)	Additional requirements (m^3/s)	50	45	14	0	8	10	12	3	3	0	32	39
18)	Discharge in estuary (m^3/s)				water balance in equilibrium - 15 m^3/s guaranteed								
	dry year	15	52	15	15	55	41	15	15	48	15	32	20
	average year	17	55	18	18	61	50	24	26	60	135	143	25
19)	Total theor. potential (10^3 ha net)	61	57	68	85	91	91	70	44	48	51	65	65

1) Reservoir release at Bardheere: Q_{80} medium dry year, Q_{50} average year (see Table 7.2/2)
2) Bardheere-Kamsuma incl. evaporation losses (see Figure 4/2).
3) Kamsuma-estuary: length 96 km, width 80 m, evaporation data Alessandria: (A) x 96,000 x 80 : 30 : 24 : 3,600 = 2.96 x (A).
4) Average from Bardheere and Mareerey meteorological station.
5) See Table 6.2/3.
6) (6) = (4) x (5).
7) Data Yontoy (coefficient 0.66-0.9), see Table 2.4/1.
8) (8) = (6) - (7).
8a) Computed by iteration.
9) (9) = (8) x 85,000 ha: 30 : 24 : 3,600 = 327.93 x (8) - period April-June.
(9) = (8) x 51,000 ha: 30 : 24 : 3,600 = 196.75 x (8) - period October-December.
10) Average irrigation operation efficiency (see Table 6.2/2) (10) = (9) : 0.28.
11) 25% from banana and seasonals - Juba Sugar and Mogambo not drained into river, share related to the hectarage: 0.17 x (10).
12) See Table 6.2/6.
13) (13) = (1a) + (2) - (3) -(10) + (11) - (12).
14) (13) = (1a) + (2) - (3) -(10) + (11) - (12).
15) (15) = ([4] x 1.1 - [7]) x 10,000 : 30 : 24 : 3,600 : 0.28 = ([4] x 1.1 - [7]) x 0.0138.
16) (16) = (14) : (15).
17) (17) = (min. 16) x (15).
18) (18) = (13) - (17).
19) (19) = (8a) + seasonal minimum (16).

Source: Own computations

Table 6.2/10

Juba River Water Balance after Dam and Irrigation Potential (ha)
Irrigation Efficiency 40% (38% sugar cane and bananas, 8% rice)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1a)	Q_{80} m^3/s	131	146	138	146	139	142	136	136	142	144	146	131
1b)	Q_{50}	133	149	141	149	145	151	145	147	154	264	257	136
2)	Contribution/recharge in interim basin	18	8	3	-16	23	12	-1	-24	-12	-23	20	33
3)	Evaporation (m^3/s)	0.9	0.9	1.0	0.7	0.6	0.6	0.6	0.7	0.8	0.7	0.6	0.6
4)	Evapotranspiration (mm)	236	210	224	165	162	163	177	191	196	185	173	207
5)	Average crop coefficient	0.59	0.45	0.50	0.92	1.13	1.02	0.86	0.57	0.72	0.98	1.14	0.97
6)	Crop water requirements	139	95	112	152	183	166	152	109	141	181	197	201
7)	Effective rain (mm)	0	0	0	37	82	62	43	14	8	3	25	25
8)	Irrigation water requirement (mm)	139	95	112	115	101	104	109	95	133	178	172	176
8a)	Irrigation potential (10^3 ha net)	65	59	89	118	118	118	89	59	65	71	71	71
9)	Diversion requirement (net) m^3/s)	38.1	26.0	50.9	52.4	46.0	47.3	49.6	43.2	36.4	48.8	47.1	48.2
10)	Diversion requirement (gross) (m^3/s)	95	65	127	131	115	118	124	108	91	122	118	121
11)	Return flow (m^3/s)	12.9	9.1	17.8	18.3	16.1	16.6	17.4	15.1	12.7	17.1	16.5	16.9
12)	Rural water (m^3/s)	1.2	1.5	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.2
13)	Discharge in estuary dry year (m^3/s)	65	96	29	15	62	51	27	18	50	15	63	58
	Discharge in estuary average year (m^3/s)	67	99	32	18	68	60	36	29	58	135	164	63
14)	Rest discharge dry year (m^3/s)	50	81	14	0	47	36	12	3	35	0	48	43
15)	Specific water requirements (l/s/ha)	2.51	2.23	2.38	1.39	0.92	1.13	1.46	1.89	2.00	1.93	1.60	1.95
16)	Additional theor. potential (10^3 ha)	20	36	6	0	51	32	8	2	17	0	30	22
17)	Additional requirements (m^3/s)	50	45	14	0	7	9	12	3	4	0	32	39
18)	Discharge in estuary (m^3/s)				water balance in equilibrium - 15 m^3/s guaranteed								
	dry year	15	51	15	15	55	42	15	15	46	15	31	19
	average year	17	54	18	18	61	51	24	26	58	135	142	24
19)	Total theor. potential (10^3 ha net)	85	79	95	118	126	126	97	61	67	71	91	91

1) Reservoir release at Bardheere: Q_{80} medium dry year, Q_{50} average year (see Table 7.2/2).
2) Bardheere-Kamsuma incl. evaporation losses (see Figure 4/2).
3) Kamsuma-estuary: length 96 km, width 80 m, evaporation data Alessandria: (A) x 96,000 x 80 : 30 : 24 : 3,600 = 2.96 x (A).
4) Average from Bardheere and Mareerey meteorological station.
5) See Table 6.2/3.
6) (6) = (4) x (5).
7) Data Yontoy (coefficient 0.66-0.9), see Table 2.4/1.
8) (8) = (6) - (7).
8a) Computed by iteration.
9) (9) = (8) x 85,000 ha: 30 : 24 : 3,600 = 327.93 x (8) - period April-June.
(9) = (8) x 51,000 ha: 30 : 24 : 3,600 = 196.75 x (8) - period October-December.
10) Average irrigation operation efficiency (see Table 6.2/2) (10) = (9) : 0.28.
11) 25% from banana and seasonals - Juba Sugar and Mogambo not drained into river, share related to the hectarage: 0.17 x (10).
12) See Table 6.2/6.
13) (13) = (1a) + (2) - (3) -(10) + (11) - (12).
14) (13) = (1a) + (2) - (3) -(10) + (11) - (12).
15) (15) = ([4] x 1.1 - [7]) x 10,000 : 30 : 24 : 3,600 : 0.28 = (14) x 1.1 - [7]) x 0.00966.
16) (16) = (14) : (15).
17) (17) = (min. 16) x (15).
18) (18) = (13) - (17).
19) (19) = (8a) + seasonal minimum (16).

Source: Own computations

Table 6.2/11

Juba River Water Balance after Dam and Irrigation Potential (ha)
Irrigation Efficiency 60% (38% sugar cane and banana, 8% rice)

	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1a)	Q_{80} m^3/s	131	146	138	146	139	142	136	136	142	144	146	131
1b)	Q_{50}	133	149	141	149	145	151	145	147	154	264	257	136
2)	Contribution/recharge in interim basin	18	8	3	-16	23	12	-1	-24	-12	-23	20	33
3)	Evaporation (m^3/s)	0.9	0.9	1.0	0.7	0.6	0.6	0.6	0.7	0.8	0.7	0.6	0.6
4)	Evapotranspiration (mm)	236	210	224	165	162	163	177	191	196	185	173	207
5)	Average crop coefficient	0.59	0.45	0.50	0.92	1.13	1.02	0.86	0.57	0.72	0.98	1.14	0.97
6)	Crop water requirements	139	95	112	152	183	166	152	109	141	181	197	201
7)	Effective rain (mm)	0	0	0	37	82	62	43	14	8	3	25	25
8)	Irrigation water requirement (mm)	139	95	112	115	101	104	109	95	133	178	172	176
8a)	Irrigation potential (10^3 ha net)	84	76	115	153	153	153	115	76	84	92	92	92
9)	Diversion requirement (net) m^3/s)	49.3	33.7	66.1	67.9	59.6	61.4	64.3	56.0	47.2	63.2	61.0	62.5
10)	Diversion requirement (gross) (m^3/s)	82	56	110	113	99	102	107	93	79	105	102	104
11)	Return flow (m^3/s)	0	0	0	0	0	0	0	0	0	0	0	0
12)	Rural water (m^3/s)	1.2	1.5	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.2
13)	Discharge in estuary dry year (m^3/s)	65	96	29	15	62	51	27	18	50	15	63	58
	Discharge in estuary average year (m^3/s)	67	99	32	18	68	60	36	27	58	135	164	63
14)	Rest discharge dry year (m^3/s)	50	81	14	0	47	36	12	3	35	0	48	43
15)	Specific water requirements (l/s/ha)	1.67	1.48	1.59	0.93	0.62	0.76	0.98	1.26	1.33	1.29	1.06	1.30
16)	Additional theor. potential (10^3 ha)	30	55	7	0	75	46	12	2	26	0	45	33
17)	Additional requirements (m^3/s)	50	44	14	0	8	9	12	3	3	0	32	39
18)	Discharge in estuary (m^3/s)				water balance in equilibrium - 15 m^3/s guaranteed								
	dry year	15	52	15	15	54	42	15	15	47	15	31	19
	average year	17	55	18	18	60	51	24	24	59	135	142	24
19)	Total theor. potential (10^3 ha net)	114	106	122	153	165	165	127	78	86	92	122	122

1) Reservoir release at Bardheere: Q_{80} medium dry year, Q_{50} average year (see Table 7.2/2).
2) Bardheere-Kamsuma incl. evaporation losses (see Figure 4/2).
3) Kamsuma-estuary: length 96 km, width 80 m, evaporation data Alessandria: (A) x 96,000 x 80 : 30 : 24 : 3,600 = 2.96 x (A).
4) Average from Bardheere and Mareerey meteorological station.
5) See Table 6.2/3.
6) (6) = (4) x (5)
7) Data Yontoy (coefficient 0.66-0.9), see Table 2.4/2.
8) (8) = (6) - (7).
8a) Computed by iteration.
9) (9) = (8) x 85,000 ha: 30 : 24 : 3,600 = 327.93 x (8) - period April-June.
(9) = (8) x 51,000 ha: 30 : 24 : 3,600 = 196.75 x (8) - period October-December.
10) Average irrigation operation efficiency (see Table 6.2/2) (10) = (9) : 0.28.
11) 25% from banana and seasonals - Juba Sugar and Mogambo not drained into river, share related to the hectarage: 0.17 x (10).
12) See Table 6.2/6.
13) (13) = (1a) + (2) - (3) -(10) + (11) - (12).
14) (13) = (1a) + (2) - (3) -(10) + (11) - (12).
15) (15) = ([4] x 1.1 - [7]) x 10,000 : 30 : 24 : 3,600 : 0.28 = ([4] x 1.1 - [7]) x 0.00644.
16) (16) = (14) : (15).
17) (17) = (min. 16) x (15).
18) (18) = (13) - (17).
19) (19) = (8a) + seasonal minimum (16).

Source: Own computations

Figure 6/3 Reservoir Releases and Discharges in Estuary
Average Dry Year (Q_{80}), Ultimate Development Phase

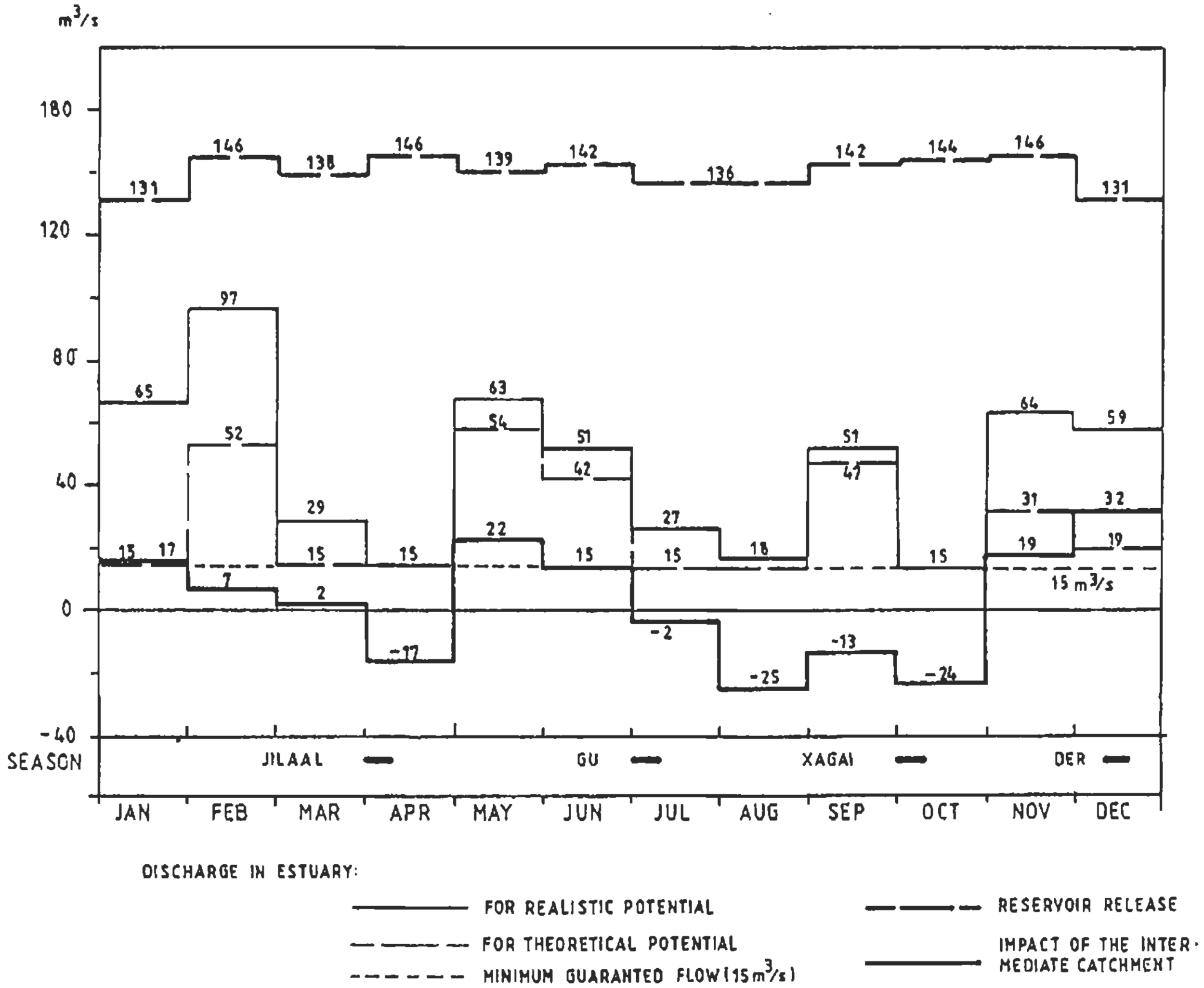
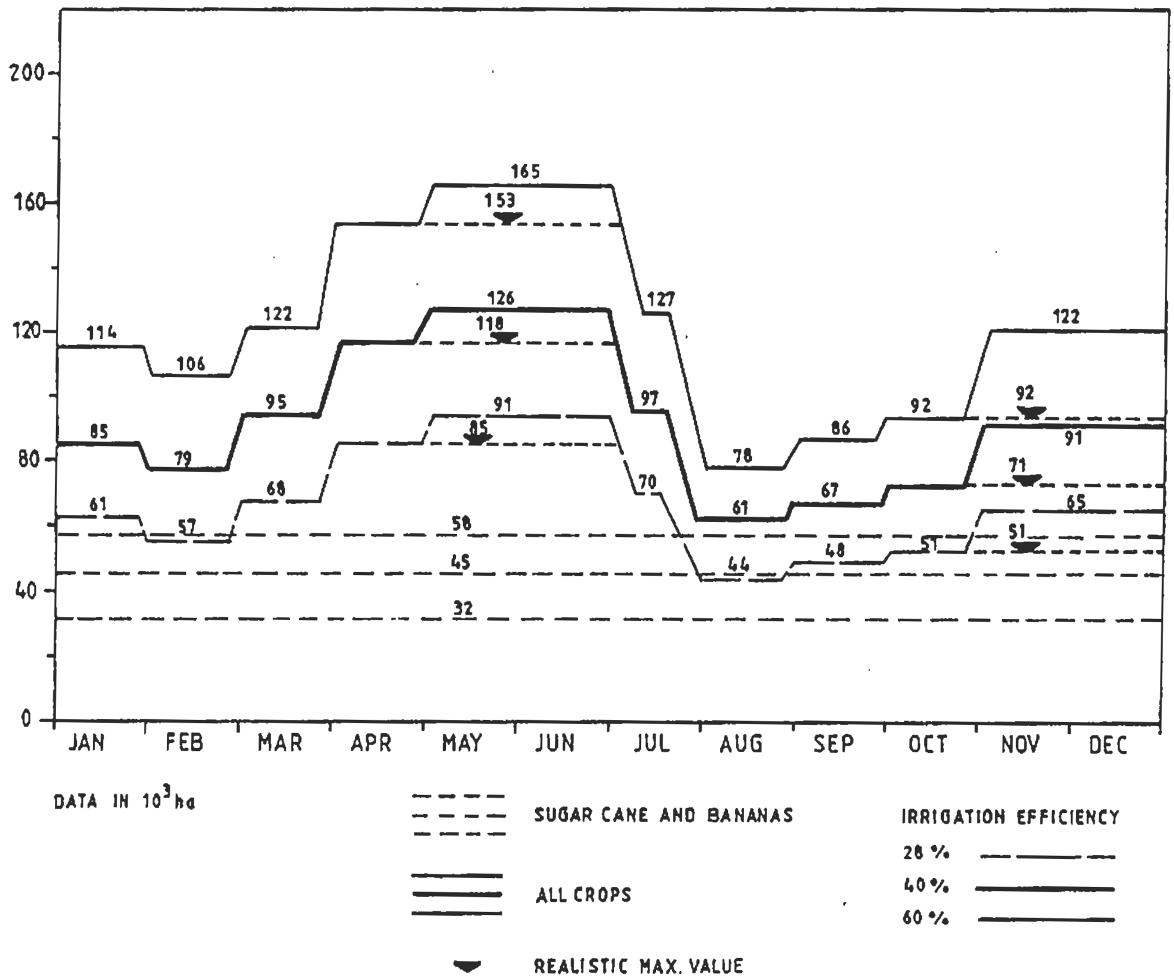


Figure 6/4 Theoretical and Realistic Irrigation Potential for Different Efficiency Levels



The irrigation potential (see Table 6.2/12 and Figure 6/4 for different efficiencies) can be defined as the maximum area that can be irrigated without stress management by reservoir release. It changes throughout a year and is higher in the Gu season April-June (due to the high rainfall) than in the Xagai season October-December. It allows a cropping intensity of at least 160% in the medium dry year as can be seen from Tables 6.2/11 and 6.2/12. The water delivery from the reservoir during the Gu season does not differ in an average year too much from that in a medium dry year (2-6%). The irrigation potential remains almost stable.

But the differences in reservoir release are substantial in the Xagai season of the medium dry and average years (around 70% - see Table 6.2/12). The assumed reservoir operation enables under such circumstances to increase the cropping intensity up to 200% in an average year (with no impact on the power generation).

Table 6.2/12 Irrigation Potential (10^3 ha net)

Average irrigation efficiency (%)	Gu-season April-July (1) Medium dry year	Gu-season Average year	Xagai-season October-December Medium dry year	Xagai-season Average year	Perennials (Fig.6/4)	Crop. intensity (%) Medium dry year	Crop. intensity (%) Average year
28	85	87	51	87	32	160	200
40	118	120	71	120	45	160	200
60	153	156	92	156	58	160	200

1) The maximum theoretic potential in the Gu-season is some 6% and in the Xagai-season some 20-30% higher, see Figure 6/4.

Source: Own computations.

Optimization of the cropping pattern and calendar (incl. plantation of crops with a short growing period off-season) may increase the estimated irrigation potential by 8 up to 30% (the difference of the irrigation potential and total theoretical potential - see Tables 6.2/9 - 6.2/11) as well as increase the cropping intensity (up to 170 - 180 % in a medium dry year). But this increased potential is not considered realistic, because it requires a cropping pattern with a high share of crops with short maturing times (beans, groundnuts, sesame, sorghum) and a high level of management that is, under local circumstances, difficult to achieve.

6.3 Floods

6.3.1 Flood Occurrence

Floods in the Juba Valley result from either

- heavy rainfall in the upper catchment and subsequent high discharges in the Juba river at Luuq
- heavy rainfall and subsequent high discharges in the catchment of its seasonal tributaries
- concentrated heavy rainfall in the intermediate catchment which has a poorly developed drainage network
- impoundment of water by man-made structures like bunds, roads across the natural drainage structure etc.
- concentration of flow by flood protection bunds

or from combination of two or more quoted random and deterministic causes.

The highest flows and worst flooding usually occur in October or November (see Figure 4/1 and 4/2) when floods are often of considerable volume with multiple peaks. Relatively smaller floods occur in May. The river floodplain (desheks) is often lower than the river banks. The worst flooding occurs when two floods occur close together: the first peak fills local depressions and drainage channels and the second peak causes widespread sheet flooding.

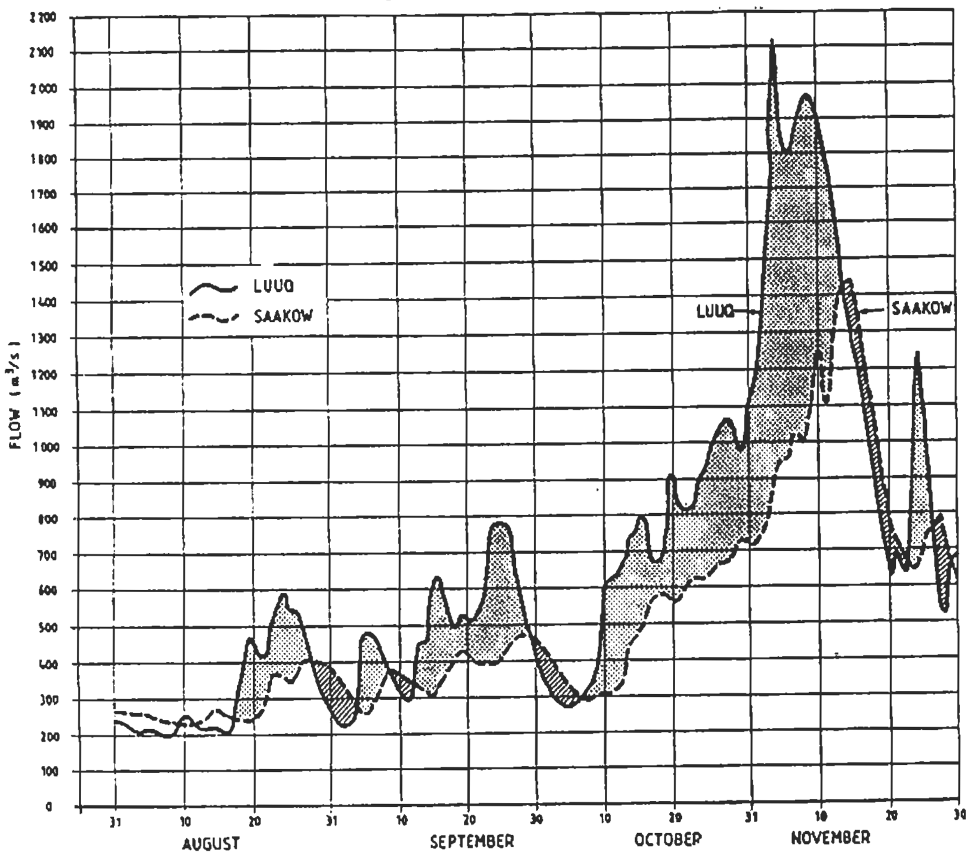
A considerable attenuation in flood peak occurred up to 1977 between Luuq and Kamsuma due to natural storage. Substantial amounts entered the floodplain (the flooding starts locally with 300-350 m^3/s). Much of this water did not reappear during falling stage: it was lost by percolation and evaporation in natural depressions. Substantial return flow has been observed, when the discharges exceeded 900 m^3/s. Reductions in peak flow in the sector between Luuq and Kaytoy reached up to 15 to 30% and depended on the impact of rainfall in the intermediate catchment.

The lack of important tributaries and overbank spillage onto the surrounding floodplains have resulted in a progressive decrease in the bankfull capacity downstream (900 m^3/s at Luuq, 400 m^3/s at Jamaame).

The recent development of flood bunds protecting desheks in the Juba Sugar and the Fanoole Rice Projects, has caused a remarkable concentration of discharges and an increase in the heights of water levels downstream. Man-made impacts in addition to the high rainfall in the catchment below Bardheere, are some causes why the water tables recorded along the river from Kaytoy to Mareerey have been higher in 1981 than during the superflood in 1977.

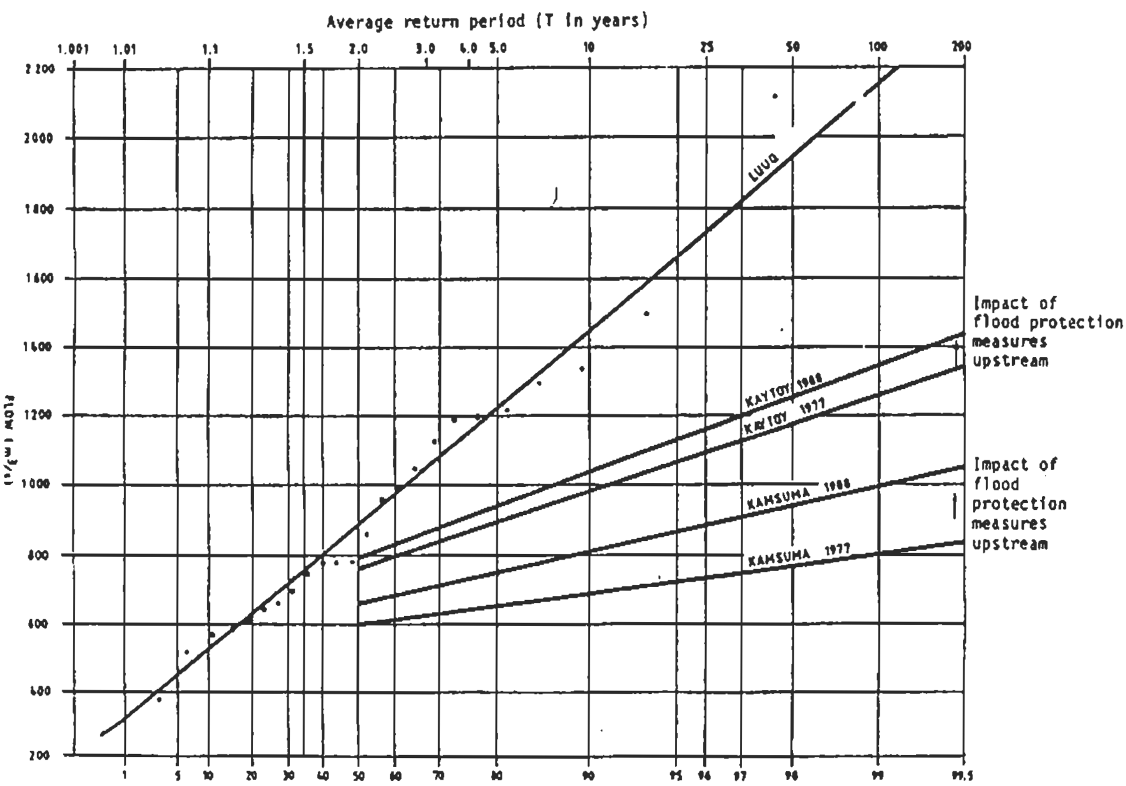
While 1977 (see Figure 6/5) was the worst flood in the upper Juba (the unanimous opinion of the local population was that this flood was the highest in living memory) below Saakow, the 1981 flood was higher due to larger inflow from the intermediate catchment below Bardheere and different pattern of overbank flooding and floodplain storage in the river stretch between Bardheere and Kamsuma. In principle the floods increase and, therefore, the return periods of floods will be shorter as it can be seen from Figure 6/6.

Figure 6/5 Flood Attenuation Between Luuq and Saakow August-November 1977



Source: Mac Donald

Figure 6/6 Return Periods of Flows in Juba River



SOURCE: MAC DONALD, COMPLETED

6.3.2 Characteristics of Flood Events

The course of floods depends on the discharge and river morphology. At Luuq the Juba lies in deeply entrenched meanders. Below Luuq the alluvial plains are widened out and the river passes through steeply sloping hills. 20 km upstream Bardheere the river exits from the gorge and the floodplain broadens out. It is still bordered by low hills up to Saakow. Floods are confined to the levees and coverplains of the recent alluvium which are 200 m up to 800 m wide. The older alluvium is 3 up to 5 m above normal bankfull level.

From Saakow to Dujuma the river is weakly incised into slightly undulating terrain of older alluvial plains. There are many old river channels downstream of Dujuma. The river meander belt lies in a shallow trough set. Floods are confined mostly to 11 desheks which are up to 1 km wide and up to 4 km long.

Upstream Fanoole up to Manaane the river is clasped by the embankment of the Fanoole Diversion Dam. At the dam profile the channel of Far Shebeel on the right bank bypasses a part of discharges and causes flooding of the Deshek Waamo. Downstream of Fanoole the floodplain broadens to some 2.5 km, being limited by the Fanoole Left Bank Canal to the East.

The recent alluvium is incised some 6 m into the marine plain. There are a number of former Juba channels which link also the Juba, Shebelli and Bohol Magaday (Hara Naga and Kormajirto) floodplain on the left bank. These are cut by the roads Jilib-Mogadishu and Jilib-Kamsuma constructed without adequate cross drainage structures.

The flood embankment for the protection of the Juba Sugar Project cuts the channel of the Little Juba (Yaro) which diverted in the past some 15 to 20% of flood discharges in the reach Maleenda-Mareerey. That contributes together with the flood embankment on both riverbanks to the rise in water level by some 1 m (corresponding 150 m^3/s) in comparison with the situation before embankment construction.

Fast drainage of the water toward the Juba is impeded by the high water level in the river. The direction of flow depends on the relative altitude of water levels in the river and in the plain. Excessive discharge of the Juba river are bypassed through the Bulo Yaag Relief Gates (capacity 100 m^3/s) and Far Waamo Relief Canal.

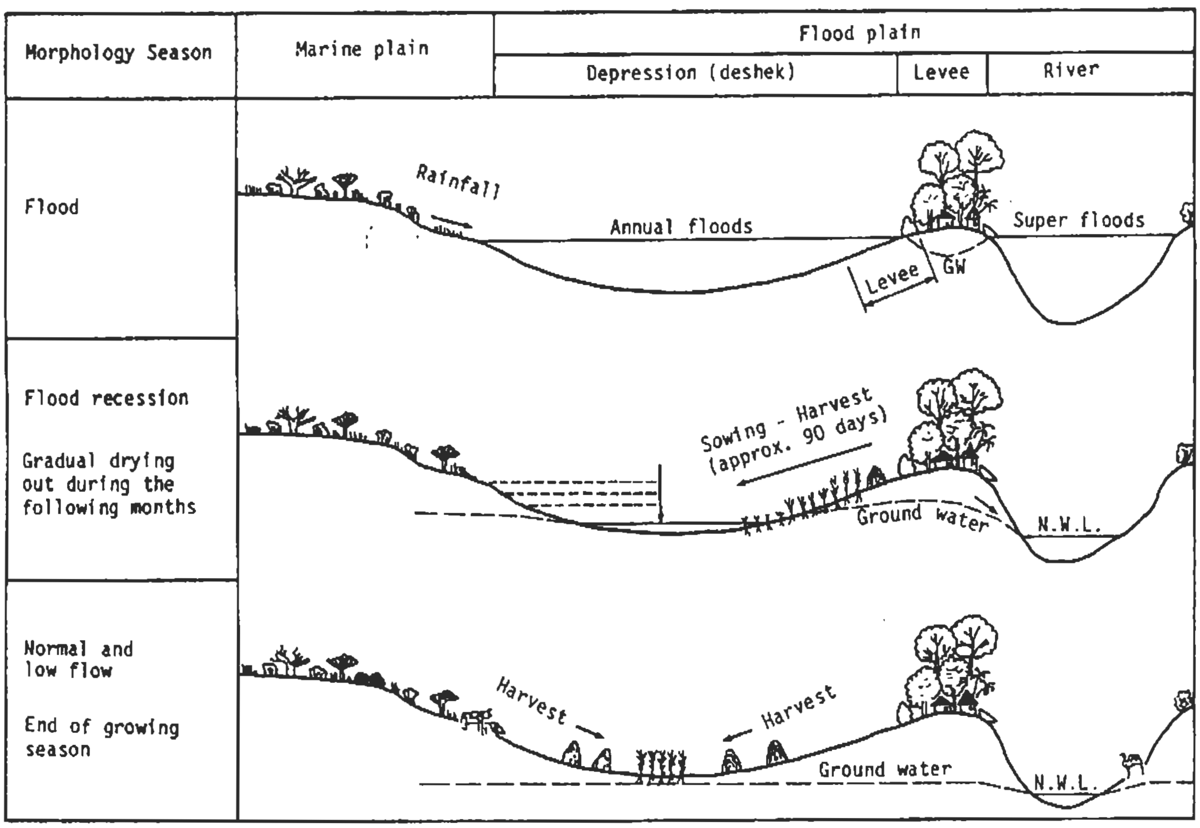
Roads between Luuq and Fanoole are located outside the floodplain of the Juba river. They are unmade and become impassable after heavy rainfalls and where there are flash floods in the toggas flowing towards the river Juba. Some stretches are subject to waterlogging. The standard practice is to make diversions through the bush to pass round areas affected. But after a heavy rainfall these tracks are not passable even for specially equipped four-wheel drive vehicles. The transport and access to the area is interrupted for several weeks or even two to three months.

The effect of flooding is partially useful:

- for leaching salinity and alkalinity
- for providing soil moisture for bush and pasture as well as for flood recession cultivation.

As flood waters return to the channel, or drain into the soil, farmers replant on the residual moisture cowpeas, maize, sesame, bananas, vegetables (deshek agriculture - see Figure 6/7).

Figure 6/7 Flooding and Flood Recession Agriculture in Saakow-Bu'aale Riverine Area (Schematic Profile)



Source: J. Janzen, 1986, adapted.

But the greater parts of the flooded areas (see Table 6.3/1) remain flooded for many weeks, the high cost of pumping precluded any reclamation of arable land.

Table 6.3/1 Flooded Area

Reach	Total area ha		Net area of cropland ha	
	1981	1985	1981	1985
Dolo to Bardheere	8,000	-	2,400	-
Bardheere to Fanoole	40,600	3,391	16,250	2,050
Fanoole to Coast	96,000	37,777	35,000	17,415
Total	144,600	41,168	53,650	19,465

Source: FAO Survey

Movement of water on to the arable land is facilitated by the low-lying alluvial plains of desheks. Most of the damage to farmland and river banks occurs when levees were breached or overtopped. Flooded crops including maize, sorghum, sesame, potatoes, onions, papaya and tobacco - rainfed and irrigated - are most completely rotted away where submerged for more than a few days. Sorghum survives at places where it is sufficiently mature for the head to be above the flood level. Bananas are rotted when the water floods them for more than three weeks. Limes, date palms, pomegranates, custard apple, mangoes, tamarix, eucalyptus and acacia are more resistant to flooding.

Mixed effect of Juba and Shebelli floods and rain affect area which is some 8 to 18 km wide downstream Mareerey. The Homboy area is subject to flooding from the Shebelli, Hara Naga, Kormajirto and a lesser extent from Juba river (via the old channel of Kormajirto). It comprises a system of meandering channels which are usually dry, but occasionally carry large discharges mainly from the mentioned Hara Naga and Kormajirto rivers. In dry and normal years the floods of the Shebelli river are absorbed by swamps and natural lakes. The one-in-fifty-year flood from this area has been estimated to exceed 400 m^3/s. These super floods cross the road Kamsuma-Jilib- Fanoole, worsen the flood situation and cover the floodplain south of Jamaame where their effect is combined with waters coming from the Waamo Deshek.

Downstream Yontoy the river narrows and cuts through the stabilized sand dunes and coral cliffs to the sea. The flooded area is confined to the narrow strip along the channel up to the Indian Ocean.

6.4 Legal Aspects

According to the Mejelle (Ottoman) Code which regulated the use of water in Somalia until 1922 everyone was entitled to use water from rivers and lakes for irrigation purposes provided the rights of third parties were not infringed upon. Until independence, Somalia had two sets of legal enactments: one applying in former Italian Somalia, and one in former British Somaliland. Parallel with these legal enactments, Islamic and Somali customary water law were also applied.

In 1966, a new and consolidated water law was promulgated which repealed all former Italian and British legislation. The Constitution was suspended by the First Charter of the Revolution, of October, 21, 1969. Somalia is constitutionally an Islamic state and its legislation is based also on the Shariah and Somali customary law. Title of all land is vested in the state. The state determines the ownership of public property. However, persons or groups improving land are considered as having a right to it. There is no effective basic legislation in the water sector. The valid legal enactments which govern water resource conservation, development, and use are:

- Law No. 28, of February 20, 1971, governing the Water Development Agency

- Decree Law No. 29, of April 24, 1982, deciding on the establishment of the Ministry of Juba Valley Development

- Law No. 16, of April 1, 1970, governing autonomous agencies and audit of industrial and economic undertakings and credit institutions with state participation.

In addition, the provisions Decree Law No. 1 of February, 1966, establishing the Agricultural Development Agency and of other laws such as Law No. 13 of 1966 and Law No. 77 of 1972, the civil and penal, land, forestry and mining legislation as well as principles of Moslem and Somali customary law, directly or indirectly influence water appropriation and use rights. The only legislation which regulates harmful effects of water such as floods, overflow, soil erosion and embankment protection are contained in the Decree Law No.361 of April 20, 1963 which, in setting up District Agricultural Committees, stipulates measures for a better use of cultivable lands and of irrigation water.

Customary water law applies with respect to order of priorities between existing uses in rural areas for domestic purposes, watering of animals, and other agricultural purposes. There is currently no established order of priority between different areas. Everyone is entitled to use water from lakes, rivers, torrents, springs, reservoirs, cisterns, canals for personal and domestic uses. A land owner/user has the right to use rain water and water naturally flowing on his land for irrigation provided he returns the surplus flow to its natural channel, no damage is caused to adjacent lands, and other existing rights are neither diminished nor impaired.

According to traditional local custom the right to use river water for irrigation in the Juba valley depends only on access to land along the river. Anyone who purchases a pump and owns or has right to use land along the river can pump Juba river water. No approval and no registration appear required. Such a situation results in water overuse, wastage or misuse, all of which under these circumstances are unmanageable.

An FAO mission carried out in 1984 within the project TCP/SOM/2314 (Ma) finalized the bill making provision for the Coordinated Planning and Implementation of Water Resources Development, for the Regulation of Water Uses and for the Control of Water Pollution (National Water Resources Law). It is presumed that the responsible government authorities will give prompt consideration to this National Water Resources Law with a view to its early enactment because it is indispensable to use all legal and other tools for protecting the public against wastage, misuse and degradation of water resources, excessive water withdrawals, interventions that threaten or have a negative impact on water availability and on the environment.

6.5 Institutional Aspects

The mechanism for coordinated water development and management in Somalia exists in the National Water Committee (consisting of Ministers) and the National Technical Committee. These bodies include members from the Ministries of Mineral and Water Resources, Planning and Juba Valley Development, Agriculture, Livestock, Forestry and Range, Health. The Committee deals in its agenda with water and water related issues including water legislation.

The Ministry of Mineral and Water Resources functions as a central water authority. Within the Water Resources Division of this Ministry a National Water Center has been established responsible for data collection, processing and analysis. The Water Development Agency of this Ministry is engaged in the groundwater development. Theoretically there is also a mechanism to deal with the problem of competing water users. The Ministry of Agriculture (which also administers the gauging stations) assigns an Agricultural Coordinator to each region and a corresponding structure exists at the district level. But this system is not conducive to efficiency.

The responsibility for the water development in the Juba valley rests with the Ministry of National Planning and Juba Valley Development. There appear to be three issues to be clarified as soon as possible:

- Water Management Administration - government bodies should provide the funds needed and secure a rational water management without stimulating administrative inefficiency by creating a large administration without regulating power.

- Sectoral Water Allocation - water management must include the integrated and beneficial use of the Juba water, favor efficient users and restrict inefficient water allocation to perennial crops being presently accorded a high priority.

- Water Pricing Policy - water management must fit within the framework of national aims and policies with due regard to the social, economic, environmental and regional aspects. This principle must govern decision making on every aspect of water and its optimum use (see Chapter 6.6).

6.6 Economic Aspects

Legal tools and fixing of charges for water, in-stream water use, effluent disposal etc., as well as variations and exemptions from such charges influence the socioeconomic efficiency of water utilization. But the degree of such influence depends on local and particular economic conditions.

The smallholders in the Juba valley live at the subsistence level and are not able to pay fees for water utilization or fines for water misuse. They are not aware of rules of appropriate irrigation water use and have no adequate equipment for irrigation. They are not informed on the negative effects of overirrigation on yield and soil quality and irrigate irrespective of the real crop water needs. The only control and limiting factor is fuel consumption for pumping.

There is a similar situation in the medium-scale and large-scale projects. But these differ from small-scale water users because

- the users have (or should have) a better knowledge of irrigation practices (which is in the case of medium-scale systems based on long-term experience without any theoretical background - and large-scale projects have - or should have - relevant irrigation management specialists);

- they are able (or should be able) to bear relevant fees and fines for water use and misuse.

These medium- and large-scale users represent the major part of water demand (and overuse). Adequate economic tools should be formulated and enforced to manage medium-scale and large-scale irrigation rationally. Water for large-scale agriculture and industry should be supplied under economic conditions, because these consumers derive economic benefits from water utilization and are able to pay. In the formulation of water pricing policies, the following factors should be taken into account:

- Cost recovery:
  Management and control, operation and, if possible, also maintenance, rehabilitation, modernization, investment cost.

- Time:
  Seasonal limitations of availability. Long-term limitation of water needs.

- System constraints:
  Limitation of actual water requirements. Limitation of water demand in the long run.

- Water quality:
  Decrease of water pollution. Increase in environmental quality.

The above consideration concerning cost recovery involves the irrigation canals and structures and does not include either the Bardheere nor the Fanoole and other planned dams whose investment and operation costs should be fully covered from power generation.

The water fees and payment should be based on the actual quantity of water delivered, i.e. on continuous measurement. Low costs, constant average water prices and lump sums (depending on hectarage irrigated and not on volume of water delivered) are bound to encourage inefficiencies during peak water requirements. An effective system of fines should be introduced in order to prevent the damage or misuse of irrigation facilities and obtain means for emergency repairs.

Small Holder should be in the initial phase of the development, supported and given an exemption from payment. The basic quantity should be supplied to the consumer even without payment. A rate which would not reduce his living standard but would cover operation cost could be introduced at the final stage, when he is able to pay and was transferred an appropriate knowledge of water saving irrigation practices.

An adequate system of irrigation service fees should be introduced in the ultimate development phase to achieve gradually farmers' interest in water savings. Adopting a differentiated rate structure, reflecting differences in water deliveries, the crop diversification and preference for crops with low water requirements should be encouraged.

7. Water Development Concept

7.1 Objective

The regulating effect of the planned Bardheere Dam Project (BDP) will remove the basic physical development constraints defined in Chapter 6 and create thus basic preconditions for irrigation development in the Juba valley downstream the dam as described further.

The mobilization of available soil and water resources aimed at increasing the agricultural production in this area (Chapter 7.3), however, requires further the establishment of:

- adequate water diversion and distribution systems for conveying water to the field (Chapter 7.4)

- adequate field irrigation systems for achieving a high delivery and field application efficiency (Chapter 7.5)

- adequate flood protection and drainage system to complete the flood protection effect of the reservoir (Chapter 7.6).

The operation of the reservoir has various environmental consequences which are listed in Chapter 7.2.3 and the most important of which (from the water development view) is the change in riverbed formation. This problem is further analyzed in Chapter 7.7.

7.2 Bardheere Dam Project

7.2.1 Operational and Technical Characteristics

The Bardheere Dam Project (BDP) was designed

- to produce annually 550 GWh of firm energy (101 GWh of secondary energy) with an installed capacity 4 x 35 MW

- to balance the outflow in order to increase the availability of water (downstream the dam) in months of peak demand for irrigation

- to limit the discharge downstream the dam to 700 m^3/s for floods having a return period of less than 100 years.

The dam site was proposed at a site about 35 km upstream of the town of Bardheere identified already in 1924, and the maximum reservoir level was fixed in order not to inundate the town of Luuq. The main technical features of the Project are listed in Table 7.2/1.

The Bardheere power plant offers a possibility for peak energy production and for an increase in installed capacity (by increasing the head and the rated discharge) resulting in an increased economic efficiency. The average power and energy requirements for the Juba valley and the Mogadishu area have been estimated at 130 MW and 560 GWh respectively in the year 2000. Present supply amounts to some 50% of this figure and is strikingly lower than the requirements which results to date in load shading.

Table 7.2/1 Technical Characteristics of the Bardheere Dam Project

Dam:		
concrete gravity, length 600 m, height 75 m		
Reservoir:	**W.L. at:**	**Volume/area**
dead storage	128 m.a.s.l.	768 x 10^6 m^3
operation storage	142 m.a.s.l.	2540 x 10^6 m^3 (3280 x 10^6 m^3)
flood control storage	148 m.a.s.l.	2388 x 10^6 m^3 (1648 x 10^6 m^3)
total storage volume		5666 x 10^6 m^3
reservoir area max.		425 km^2
operation		320 km^2
Maximum discharge:	**at W.L. of:**	**Outflow**
spillway	148 m.a.s.l.	1050 m^3/s
bottom outlet	148 m.a.s.l.	750 m^3/s
irrigation outlet		70 m^3/s
power plant (3 to 4 units, head 44 m)		310 to 413 m^3/s, 35 MW each

Source: ELC Final Design

Data in brackets are those as proposed by Lahmayer Int. (1988): Operation storage water level at 144 m.a.s.l.

7.2.2 Reservoir Operation

The operation of the Bardheere Dam Project will secure the irrigation water supply. If the hydropower demand will be below the specified irrigation target, the outflow will be increased to just meet this target. If the reservoir level at the end of the month will fall below the threshold reservoir volume the target supply will be reduced accordingly. Never should the reservoir level be allowed to exceed the maximum monthly operating level which safeguards the requested degree of flood protection which should be adapted so as to minimize economic losses.

It is assumed that the irrigation development in Ethiopia will not substantially reduce the inflow into the Bardheere reservoir and that the reservoir and its operation will be multipurpose, respecting the hierarchy of purposes in the following way:

- the reservoir storage above the level 144 m.a.s.l. will be reserved for flood protection (additional flood protection can be gained by emptying the operation storage on the basis of a short-term forecast of inflow)

- the operation storage between 128 and 144 m.a.s.l. will be used for regulating the discharges for power generation and irrigation water supply. Average daily discharges downstream the dam will correspond to the crop water requirements increased by the need for rural supply (1.5 m^3/s) and flushing to avoid sea water intrusion in the estuary (approx. 15 m^3) and will vary between minimum of some 131 m^3/s (in December and January) to 146 and 264 m^3/s (in October or November) during dry and normal years respectively

- these required daily discharges will be used for daily peaking (varying releases during the day due to the peak operation are regulated by the prism storage of the river channel and so do not hamper the irrigation operation)

- additional releases for power generation will be allowed in the wet season when the water availability exceeds the actual irrigation, rural and flushing requirements.

Table 7.2/2 below presents the river discharge data for each month in the before-dam situation (as taken from Table 4.2/2 for Luuq) and for the with-dam operation situation for both historic (hist.) and synthetic (synt.) inflows into the reservoir (see also Figure 7/1 and 7/2).

The outflow data are the result of the simulated operation of the dam over a period of 32 years (length of the period for which data from Luuq are available). The simulated dam operation is based on:

- historical data of Luuq with corrected and missing data filled in
- synthetic data produced stochastically by the Fiering-Model.

The correction of the historical data was done by including the contributions of the wadi flows between Luuq and the dam site. Regarding these two different inflow approaches for the Bardheere reservoir, the future water supply will be different for probabilities of exceedance 0.8, 0.5 and 0.2 as can be seen from the Table 7.2/2.

The reservoir releases in medium dry and average years (80% and 50% probability of exceedance) are quite similar for historical and synthetic data. The difference occurs in the medium wet year in the period September to December. The synthetic outflows are more evenly distributed over the year with a less pronounced peak discharge in October.

Reviewing the procedure of data simulation, it was found that the following characteristics were apparently not included or considered in the Fiering-Model as applied by ELC:

- yearly auto-correlation and correlation over several pre-months (a so-called 'multi-lag-correlation')

- different theoretical distribution functions to describe the stochastic variations.

A correlation and frequency analysis of the historic discharges shows that

- a yearly auto-correlation and a multi-lag-correlation exist

- no single theoretical distribution function exists to describe the stochastic variation of the discharges of each month, and

- a log-transformation of the data in order to simulate data cannot be used because in 90% the historic data are not log-distributed.

Table 7.2/2 Monthly Average Discharges below Bardheere in Before-Dam and in After-Dam Operation for Different Probabilities of Occurrence

Type of input	Probab. of exceed.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Before dam													
Inflow	0.8(1)	23	9	6	10	125	102	126	189	211	227	186	71
data	0.5	47	30	39	128	241	159	189	279	299	462	368	142
Luuq	0.2	64	40	47	234	371	263	246	358	372	565	460	155
After-dam operation													
Bardheere	0.8	131	146	138	146	139	142	136	136	142	144	146	131
0 km (2)	0.5	133	149	141	149	145	151	145	147	154	264	257	136
hist.	0.2	135	155	146	155	151	155	150	232	308	517	400	222
Bardheere	0.8	132	147	138	143	139	143	138	142	145	144	144	131
0 km (2)	0.5	133	152	142	152	146	151	145	149	153	162	203	140
synt.	0.2	143	159	146	156	150	158	151	220	244	406	381	167
Kaytoy	0.8	145	152	141	134	157	151	135	118	133	127	161	156
358 km	0.5	147	156	143	137	162	157	144	129	144	248	277	163
hist.	0.2	150	162	148	142	169	165	149	214	292	500	420	220
Mareerey	0.8	148	154	141	132	160	153	135	114	131	123	154	161
423 km	0.5	150	158	144	135	165	159	144	125	141	244	282	169
hist.	0.2	153	163	149	139	172	166	149	209	289	496	425	226
Kamsuma	0.8	149	154	141	130	162	154	135	112	130	121	166	164
536 km	0.5	152	159	144	133	168	160	144	123	140	242	284	172
hist.	0.2	155	164	149	138	175	167	149	207	288	494	427	229
Jamaame	0.8	151	155	142	128	165	155	135	109	128	119	169	168
567 km	0.5	155	160	145	131	171	161	144	120	139	240	288	177
hist.	0.2	158	165	150	136	178	169	149	205	286	491	431	234

1) Probability of occurrence : 0.8 = medium dry year, 0.5 = average year : 0.2 = medium wet year.
2) Reservoir releases.

Source: Own computer simulation based on ELC proposed dam operation and the Luuq river discharge data.

Figure 7/1

Mean Monthly Discharges
Medium Dry Year (0.8)

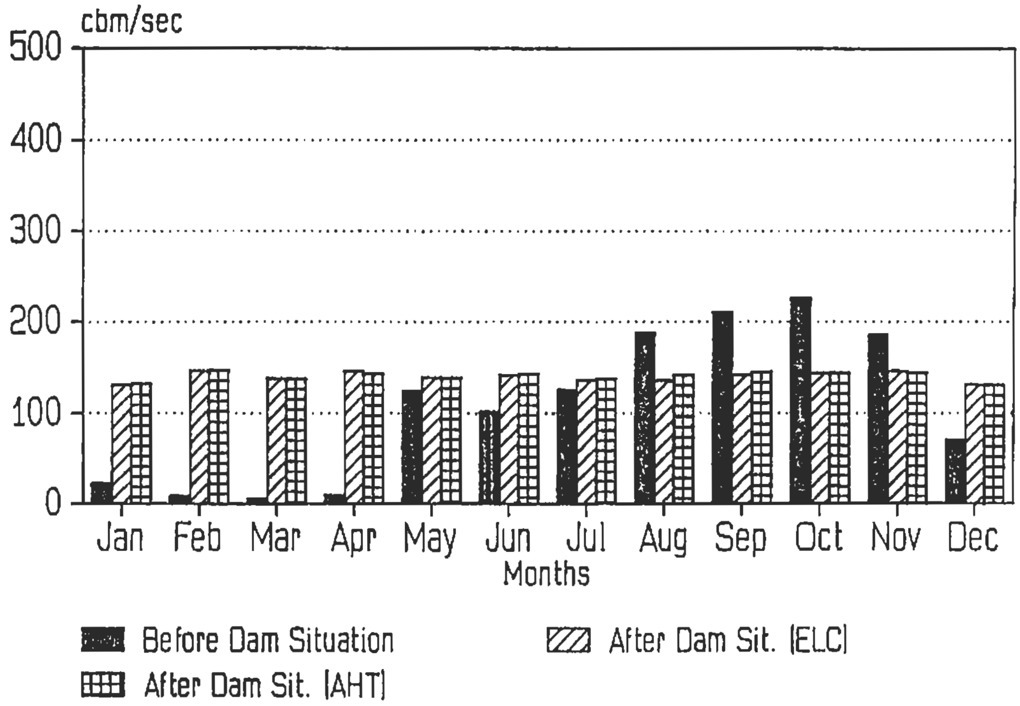
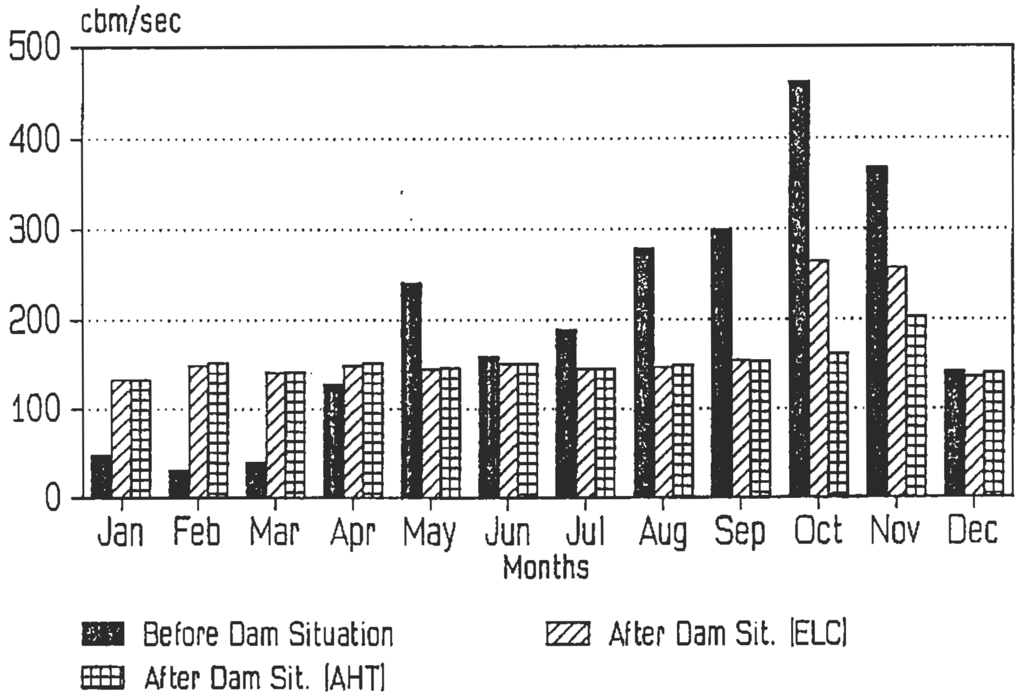


Figure 7/2

Mean Monthly Discharges
Average Year (0.5)



Because of these reasons, the series of outflow from the operation simulation with synthetic inflow do not represent the future possible water supply as the inflow simulation disregards the apparent characteristics of the historic flow situation. The series of the synthetic discharges can thus not be used for a water balance of future water supply and water demand. The historical data have, therefore, been used for the compilation of water balances in the after-dam situation.

The flood protection effect of the reservoir will reduce flood discharges, which are under favorable conditions (low rainfall) further attenuated in the downstream catchment. But the effect of the intermediate catchments is unregulated. High rainfall, super floods from the lower Shebelli, Hara Naga and Kormajirto catchment will continue contributing additional 200 to 400 m^3/s and more to discharges of the Juba river downstream Kamsuma.

Table 7.2/3 presents possible outflow data, if the dam operation will be realized under the regard of a better flood protection in the months October - December (wet years).

Table 7.2/3 Monthly Average Discharges below Bardheere Dam as a Result of a Better Dam Operation

River flows without peak flows (After Dam)
Results of empirical distribution

Possibility of exceedance = 0.8 = medium dry year
Possibility of exceedance = 0.2 = medium wet year

Station	Probab. of exceed.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bardheere	0.8	131	147	139	146	139	142	137	137	144	144	146	131
Dam Site	0.5	133	150	141	149	145	151	147	147	155	273	267	138
0 km	0.2	136	156	147	155	151	155	221	258	313	417	355	251
Kaytoy	0.8	145	153	142	134	157	151	136	119	135	127	161	156
358 km	0.5	147	157	143	137	162	157	146	129	145	257	287	165
	0.2	151	163	149	142	169	165	220	240	297	400	375	249
Mareerey	0.8	148	155	142	132	160	153	136	115	133	123	164	161
423 km	0.5	150	159	144	135	165	159	146	125	142	253	292	171
	0.2	154	164	150	139	172	166	220	235	294	396	380	255
Kamsuma	0.8	149	155	142	130	162	154	136	113	132	121	166	164
536 km	0.5	152	160	144	133	168	160	146	123	141	251	294	174
	0.2	156	165	150	138	175	167	220	233	293	394	382	258
Jamaame	0.8	151	156	143	128	165	155	136	110	130	119	169	168
567 km	0.5	155	161	145	131	171	161	146	120	140	249	298	179
	0.2	159	166	151	136	178	169	220	231	291	391	386	263

Table 7.2/4 was derived from the inflow into the reservoir under design and operation criteria of ELC.

Table 7.2/4 Juba River Flows in the Before-Dam (natural regime) and After-Dam (regulated regime) Situation

Flow range (m^3/s)	Natural regime (before dam) %	Regulated regime (after dam) %	Mean occurrence days
0 - 100	34	1	4
100 - 200	19	81	295
200 - 300	24	8	28
300 - 400	11	4	15
400 - 500	7	3	11
500 - 600	3	2	8
600 - 700+	2	1	4

Source: Own calculations based on ELC Final Design Report for Reservoir Operation.

While the bankfull capacity below the dam is some 900 m^3/s, it decreases to 400 m^3/s at Kamsuma. The flood protection effect of the reservoir is, therefore, sufficient in the area just downstream and unsatisfactory in the lower Juba valley where it will hamper intensive irrigation development. Flood situation has been analyzed in Chapter 6.3.

7.2.3 Environmental Impact of the Bardheere Reservoir

7.2.3.1 General Effects to the Development Area

Once the Bardheere dam is operational, it will greatly affect the Juba valley with respect to:

- the future reservoir area and its surroundings, that will be drastically altered by inundation, creating a completely new eco- and socio-graphic system, and

- the river itself, in its flow and morphological characteristics, with a regulated flow regime, which includes a significant decrease in high flows (flood control) and an increase in lower flows, changing riverbed formation and sediment deposition pattern

- the areas downstream of the dam.

7.2.3.2 Reservoir Area

Due to the reservoir, the agricultural areas presently within the reservoir boundaries and immediate periphery will be lost, and acceptable solutions will have to be found for the population affected.

In addition, the creation of the reservoir will have important impact on:

- the town of Luuq, located on an oxbow peninsula with a narrow 60 m neck, where the sedimentation at the reservoir entrance and related backwater effects constitute a flood hazard that will require attention at an early stage (operating the reservoir at a lower level would move the zone of deposition further downstream and alleviate the problem),

- the socioeconomic structure and the environment in the area surrounding the reservoir from the dam site up to Luuq and beyond to the North towards Dolo. The loss of agricultural area of high value, and the relocation/resettlement of many people will have drastic repercussions on the socioeconomic structure of the entire Gedo Region,

- the sedentary and nomadic livestock sectors by the loss of grazing areas flooded by the reservoir. This loss cannot be compensated by grazing on lands that are subject to periodical flooding with the rise and fall of the reservoir pools. The replacement vegetation will have considerably lower nutritional value, and measures to improve nutrition may not be economic,

- the composition of river fauna and flora that will change to an as yet unspecified extent. Leaving the vegetation, particularly trees within the future reservoir area, in place will have negative consequences for water quality and its clearing and use prior to flooding is difficult to organize economically,

- The meso- and microclimate: The large body of reservoir water will decrease air temperature and increase humidity thereby improving habitat not only for human population, but also for tsetse flies and mosquitos. The occurrence of malaria will undoubtedly increase, both in the area of reservoir and downstream, in the area under irrigation,

- the increase in bilharzia occurrence as well as in a possibility of a changeover from the urinary form to the more severe intestinal form is highly probable.

The upper layers of the reservoir are trophogenic, i.e. nutritive. Assimilation is their prevailing process, while dissimilation occurs only partially. Lower layers are trophylitic, i.e. they support the disintegration of organic matter. The changes of water quality may result in the creation of a comparatively heavier, cooler layer at the reservoir bottom enriched by products from the mineralization and decomposition processes.

The existence of relevant fish species depends on the water quality - mainly on its temperature and oxygen content -, on the water depth, rate of flow, morphology and material of the bottom and the banks, and on the occurrence of aquatic flora. The construction and operation of a reservoir changes all these conditions. The dam forms an invincible obstacle for the draw of migratory fishes.

The ecosystem of the reservoir will include:

- fishes which occur in the reservoir from the original ecosystem of the stream and which are able to adapt to the changed environment and breed naturally,
- fishes which have extremely favorable conditions for their natural breeding and development and are able to exterminate other fish species,
- fishes of the original ecosystem which are able to adapt to the changed conditions only in restricted areas of stream estuaries, where conditions have not been changed drastically,
- fishes which are able to live in the reservoir, but do not have the ability to breed naturally, thus requiring artificial breeding for replenishment of their occurrence,
- fishes which need to be imported artificially to fulfill some of the required functions in the reservoir ecosystem: weed reduction, maintenance of ecosystem equilibrium, meat production etc.

7.2.3.3 Riverine Area Downstream the Dam

The operation of the reservoir will change the river regime. The flood protection effect of the reservoir will decrease the periodicity of floods and reduce the flooded areas in desheks (presently some 3,800 ha under cultivation, 11,000 ha pasture land). Floodplain vegetation will be degraded as a result of reduced flooding and reduced nutrient supply from floods as well as due to drop in groundwater table. The impact of the Bardheere dam in the deshek farming has been studied and artificial floods recommended to compensate the reduced flooding in the interim period of conversion of flood recession agriculture to irrigated agriculture. Agricultural development will reduce floodplain range lands. Greater integration, e.g. suitable crop residues available to livestock, access corridors to pasture and water will be required to maintain livestock production.

Floods recharge the ground water which is used for rural water supply and livestock watering. The flood protection achieved by the reservoir operation may decrease downstream the yield of shallow wells which were earlier recharged from flooding. But yields of wells downstream recharged by infiltration through river banks will be higher. This higher water level and yield of the wells are due to an increase in lower discharges downstream the dam. Combined effect of irrigation and rise in low river water tables will lead to rising groundwater tables.

Sediment characteristics of the river will be changed by the reservoir operation in that the reservoir will act as a sediment trap and that the discharges will be regulated. The water will be deprived of a considerable amount of sediments containing valuable nutrients. These come mainly from the upper catchment, fertilize the plain during floods and are consumed by plankton. This will drastically disturb the ecosystem.

The trap efficiency of the reservoir will decrease the sediment flow and thus increase the kinetic energy of flow below the dam. This will intensify the erosion process and change the natural process of channel formation. Stabilization measures will be required in order to prevent the deepening of the riverbed in the longitudinal profile and changes in the cross section.

The high evaporation from the reservoir surface estimated at 1×10^9 m^3 annually will decrease the annual river flow by some 16% in average. It will result in an increase of average water salinity of the outflow from the reservoir to which will contribute also the irrigation development in Ethiopia. The maximum salinity below the dam will decrease and minimum salinity increase due to the regulation effect of the reservoir.

A decrease in quality of the reservoir outflow can be expected due to the decomposition of the flooded biomass. Downstream the dam the irrigation development will be accompanied by an increase in use of agro-chemicals and in addition, under prevailing or only marginally improved irrigation practices will increase soil and water salinity with a significant negative impact on the quality of the return and overland river flows. The extent of resulting changes in river water quality (decrease in nutrient content and temperature, change of biochemical composition) is hard to predict, but river wildlife (hippopotami, crocodiles etc.) and fish might be affected. It also will have consequences on future irrigation water use.

In brief, the new river ecosystem will be drastically different from the present and original one; the regulated river regime will eliminate not only negative aspects associated with devastating floods and with low flows, but also beneficial sedimentation, groundwater recharge etc.

The area, while not densely populated, has been intensively exploited by large nomadic-livestock herds for centuries. Most of the evergreeen forest covering once the Juba floodplain has been already cleared/extracted for agriculture, pasture, construction material and fuel. The cultivated land reverts to woodland, bushland, shrub- and grassland or mixed types if farming is abandoned. Forest regeneration on previously cleared land is unlikely even if left undisturbed. In 1960 some 10,000 ha of forest remained, but presently less than 900 ha survived.

Predominance of livestock, hunting, poaching, deforestation and subsequent agricultural activities have lead already to elimination of much riverine wildlife. Opening of riverside lands and deshek conversion will increase livestock occupancy, thereby increasing competition for forage. Human need for wood will increase as population increase. In such a way wood removal will be greater than wood production around the areas of population concentration. Increased erosion and transformation of the natural river channel will have an additional impact on all these environmental changes which will require radical conservation measures.

7.3 Development Potential and Schedule

The unregulated flow of the Juba now limits the potential for irrigated crop production to an estimated 50,000 ha (under conditions of an adapted cropping pattern and calendar respecting the cropping interlude of seasonals in the period of water scarcity from January to April see Chapter 6.2.5). Of this, only about 17,100 ha (without any optimization and coordination effort concerning the cropping pattern and calendar - see Chapter 6.2.3) are actually irrigated, most of which by the large-scale projects in the lower Juba. Recently, however, a significant increase of small-scale pump irrigation can be observed, mainly between Bardheere and Saakow.

This small-, medium- and large-scale development will gradually continue up to the ultimate development phase which pattern depends on:

- water availability after dam construction
- availability of soil resources and the feasibility of their development
- planning and implementation capacity
- environmental constraints.

Water availability after the dam construction determines the irrigation potential, which further depends on the irrigation efficiency. This has been analyzed on the basis of water balances in Chapter 6.2.6 for 38% share of the perennial crops. Lower share of perennial crops and adherence to the plantation interlude for seasonals in the dry period from January to April enables an increase in irrigation potential.

The following Table 7.3/1 summarizes the irrigation potential under the above assumptions for the different realistic efficiency standards (see also Figure 6/4).

Table 7.3/1 Irrigation Potential for Different Efficiency Standards (38% perennials)

Efficiency standard (%)	Irrigation potential	
	Jilaal (10^3 ha)	Der (10^3 ha)
28	85	51
40	118	71
60	153	92

Source: Own computation

The assessment of land suitability for irrigation under the Masterplan was restricted to the lands situated below the 160 m contour line. A total of 10,000 km^2 was surveyed, of which 360,400 ha were classified. 170,795 ha are suitable for diversified cropping; the rest, 189,605 ha, is considered to be suitable for paddy rice production and classified as R1 and R2 lands. Table 7.3/2 gives the areas of classified land by Socio-Geographic Unit (1).

1) Subdivision see Chapter 8.1.

Table 7.3/2 Land Classification for Irrigation (in ha) per socio-geographic unit (SGU)

Land class / Socio-geographic unit	For diversified cropping 1	2 alluvial plain	2 marine plain (2)	For paddy rice R 1 alluvial plain	R 1 marine plain (2)	R 2 alluvial plain	R 2 marine plain (2)	Total
Bardheere	1,480	6,270	-	-	325	-	84.605	92,680
Saakow-Bu'aale	4,210	39,060	50,925	-	735	-	33,735	128,665
Fanoole-Kamsuma	12,100	29,995	-	180	-	1,530	-	43,805
Kamsuma-Gobweyn	3,520	21,710	-	11,505	-	5,530	-	42,265
Dinsor-Bardheere	-	-	-	-	-	-	23,145	23,145
Homboy-Demo	-	1,525	-	5,345	-	180	-	7,050
Subtotal	21,310	98,560	50,925	17,030	1,060	7,240	141,485	337,640
Deshek Waamo (1)	-	-	-	-	-	-	2,020	2,020
West Juba Plain (1)	-	-	-	-	30	-	7,620	7,650
East Juba Plain (1)	-	-	-	-	-	-	13,120	13,120
Total.	21,310	98,560	50,925	17,030	1,090	7,240	164,245	360,400

1) rainfed.
2) distant from river, requires highlift pumping.

Source: Different soil surveys

170,795 ha gross of land classes 1 and 2 that are available in SGU 1 to 4 and 6 (which may be supplied from the Juba river - SGU 5, 7 to 9 are rainfed - dependent on other, mostly seasonal surface resources and ground water) makes some 136,000 ha net. In addition, a substantial part of class 2 land in the SGU 2 is situated outside the alluvial plain of the Juba river. It requires high lift pumping and its distance from the river is up to 25 km. Irrigation of this land may be feasible under special circumstances only.

On the basis of available maps it can be considered that not more than 35,000 ha net are available in the alluvial plain of the SGU 2. It can therefore be estimated that not more than 120,000 ha of land in SGU 1 to 5 and 6 offer favorable conditions for economically feasible irrigation development. This development should be located especially in SGU 3 and 4 which have the most favorable climatologic conditions (higher rainfall, lower evapotranspiration) and depends i.a. on the feasibility of development of R1 and R2 land in SGU 4. Taking this and the necessity of intensive development of the SGU 1 into account (due to the expected boom in this area initiated by the construction activities) the irrigated area in the ultimate development phase was distributed as follows in the last column of Table 7.3/3.

The development schedule should safeguard a gradual and smooth transfer from the present to the ultimate development stage. It depends not only on the development need, but inter alia on:

- financing possibilities and
- planning and especially construction capacities.

Before completion of the dam it is estimated that the present rate of expansion of irrigated area will continue at about 1,250 ha per year which results in 27,000 ha under irrigation in 1995. This rate of expansion is determined by the technical and other constraints the development agency faces in bringing land under irrigation. For the period following completion of the dam, it is expected that this rate could be increased to some 3,000 ha per year. By 2005 and 2015, totals of 50,000 and 80,000 ha respectively are projected to be under irrigation (see Table 7.3/3, Figure 7/3).

The larger scale of works and the impact of the development pace on the economic rate of return make it essential that a special study be made analyzing the development timing and establishing a national implementation programme coordinated with the financial and construction schedule of the Bardheere Project. The development pace may have an important impact on the development concept: high pace would require the construction of diversion dams in the early stages while a moderate pace may allow basing the irrigation supply on pumping providing thus more flexibility as regards construction programme and time.

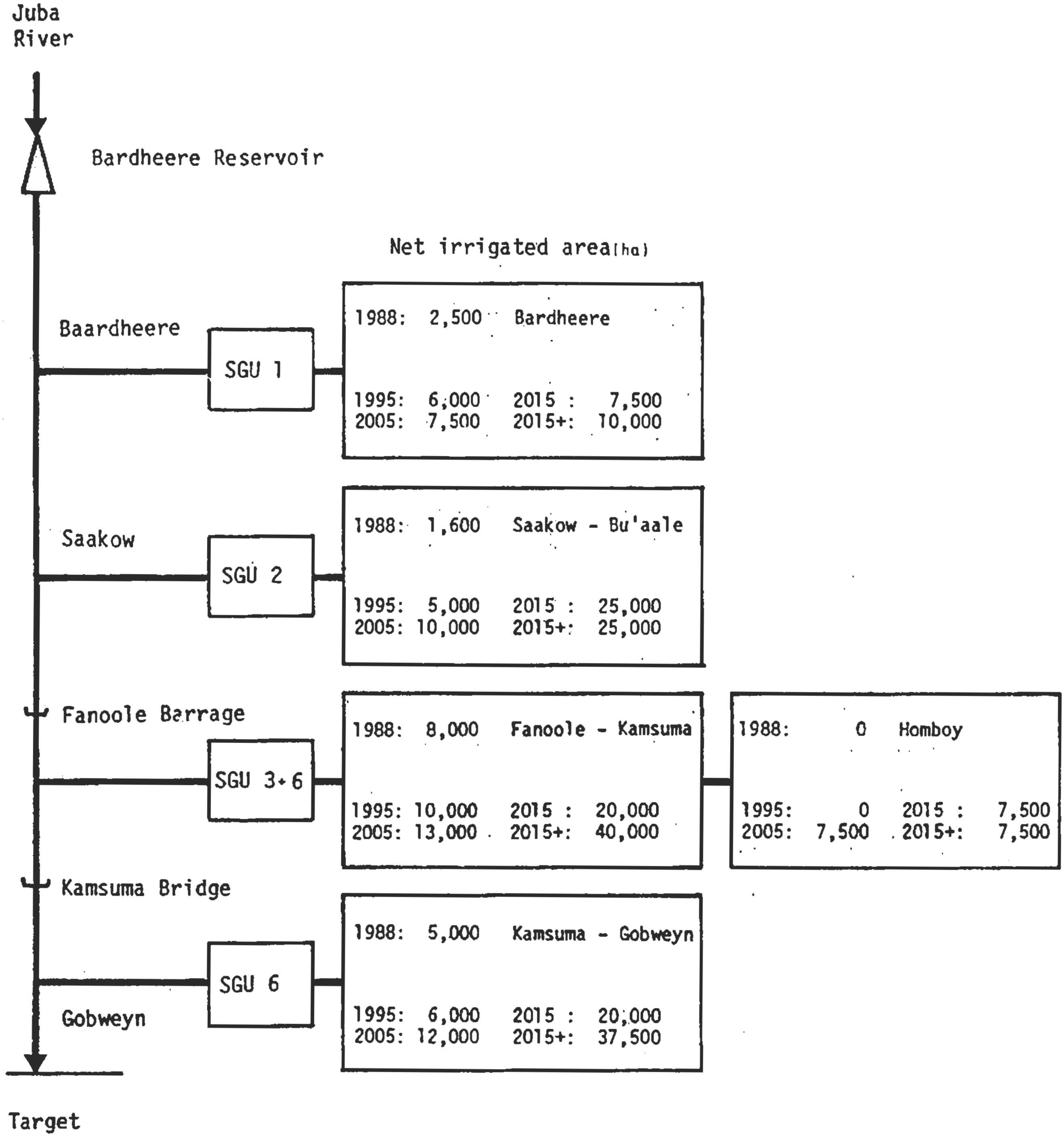
Table 7.3/3 Areas for Irrigation Development per SGU (gross ha)

Available land			Period (time horizon)				
			Present (1988)	Before dam (1995)	After dam 2005	2015	Ultimate development
	Class		Target irrigation efficiency (%)				
SGU	For diversified cropping 1+2	For paddy rice R1+R2	33	40 (28)(2)	45 -	50 -	60 (40)(2)
1	7,375	87,937	2,500	6,000	7,500	7,500	10,000
2	92,694	36,928	1,600	5,000	10,000	25,000	25,000
3	40,988	1,722	8,000	10,000	13,000	20,000	40,000
4	28,858	18,659	5,000	6,000	12,000	20,000	37,500
6	6,456 (3)	5,702(1)	0	0	7,500	7,500	7,500
Total			17,100	27,000	50,000	80,000	120,000

1) Class 3.
2) Pessimistic assumption used for the compilation of water balances.
3) SGU 6 receives water from SGU 3.

Source: Own soil survey analysis

Figure 7/3 Overview of Development Areas and Schedule



7.4 Water Resources and Irrigation Development

Two basic alternatives can be considered for the water diversion and supply of irrigation systems in the Juba valley (see Table 7/4.2):

- gravity diversion
- pumping.

Gravity diversion is feasible for large-scale systems, while pumping is generally more suitable for small-scale development. If low-cost hydropower is available, the pumping solution may appear preferable from the investment cost point of view. Gravity diversion will have lower operation cost but will be accompanied by higher evaporation and seepage losses (due to greater length of supply canals). It will provide less flexibility as regards construction programme and time.

The large-scale pumping plant may consist of the following components:

- intake on the river bank, i.e. concrete structure with openings protected by trash racks

- feeder canal or concrete culvert

- pump house with vertical-shaft, self-priming pumps

- pipes with a stilling basin

- supply canal.

Small- and medium-scale pumping plants consist of the

- intake and pipeline

- pump erected on a concrete block

- pipeline with the stilling pool

- supply canal.

Pumping costs for the small-scale systems amounting to 39,000 SoSh annually per ha irrigated have been estimated using the following assumptions:

- investment costs of a small pump to serve 4 ha	SoSh 300,000
- depreciation (20% p.a.)	SoSh 60,000
- maintenance and repair (20% p.a.)	SoSh 60,000
- fuel consumption (1.2 l diesel/h at 25 SoSh/l 1,200 h annual use for 4 ha)	SoSh 36,000
	SoSh 156,000
Pumping costs/ha annually 156,000 : 4	SoSh 39,000

It should be stressed that the constraints on irrigation area development appear to be not of those of lack of water, land or human resources availability, but those of physical implementation capacity and the overall socioeconomic, environmental, management and legal framework, as market incentives, agro-inputs and extension, lack of trained manpower at all levels, access to and appropriate registration of land and water, investment costs recovery and user contribution to operation and maintenance, irrigation related health issues such as bilharzia, malaria, proper drinking water supplies for human and animal consumption. The present severely limited capacity in implementing irrigation development may result in an undesirable imbalance.

Under such circumstances, the construction of the diversion dams will be feasible, if the investment cost of the dam, headworks and supply canals will be less than 39,000 SoSh/ha irrigated (cost for dam should be excluded when the dam would be needed for stabilization of the riverbed).

At the present planning stage it has been envisaged that the final development situation most of the irrigation area downstream Saakow would be gravity fed from three planned diversion dams (see Table 7.4/1, Figure 7/4):

- Saakow Diversion Dam
- Bu'aale Diversion Dam
- Kamsuma Diversion Dam

and from the existing Fanoole Diversion Dam.

The Bardheere riverine area will be supplied by pumping.

Table 7.4/1 Planned Structures Across the Juba River

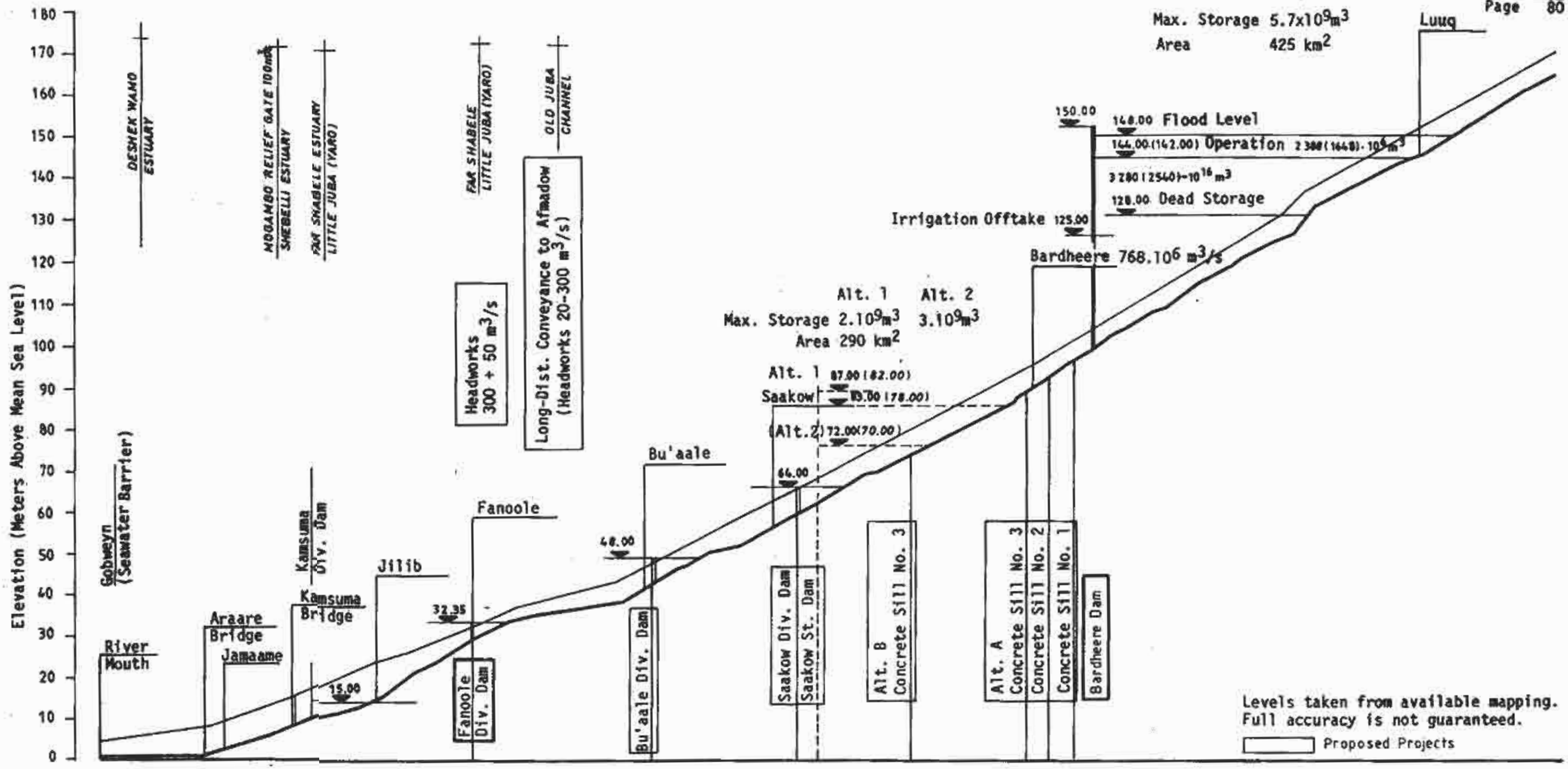
Location	Description	Width (m)	Head (m)	Purpose	Possible power output
Bardheere 1	concrete sill	100	0	riverbed	0
Bardheere 2	& piling	100	0	stabilization	0
Bardheere 3		100	0		0
Saakow	concrete bar-	100	3 to 4	water diversion	4.0 MW
Bu'aale	rage with	100	3 to 4	for irrigation	3.5 MW
Kamsuma	gates	100	2 to 3	riverbed stabilization (power generation)	1.5 MW
Gobweyn	barrage with gates or concrete sill	100	2 to 3	protection against sea water intrusion in the ultimate development phase	0

Gravity diversion development consists of the following components:

- diversion dam (see Figure 7/6)

- headworks

- supply canal and secondary (branch) canals.

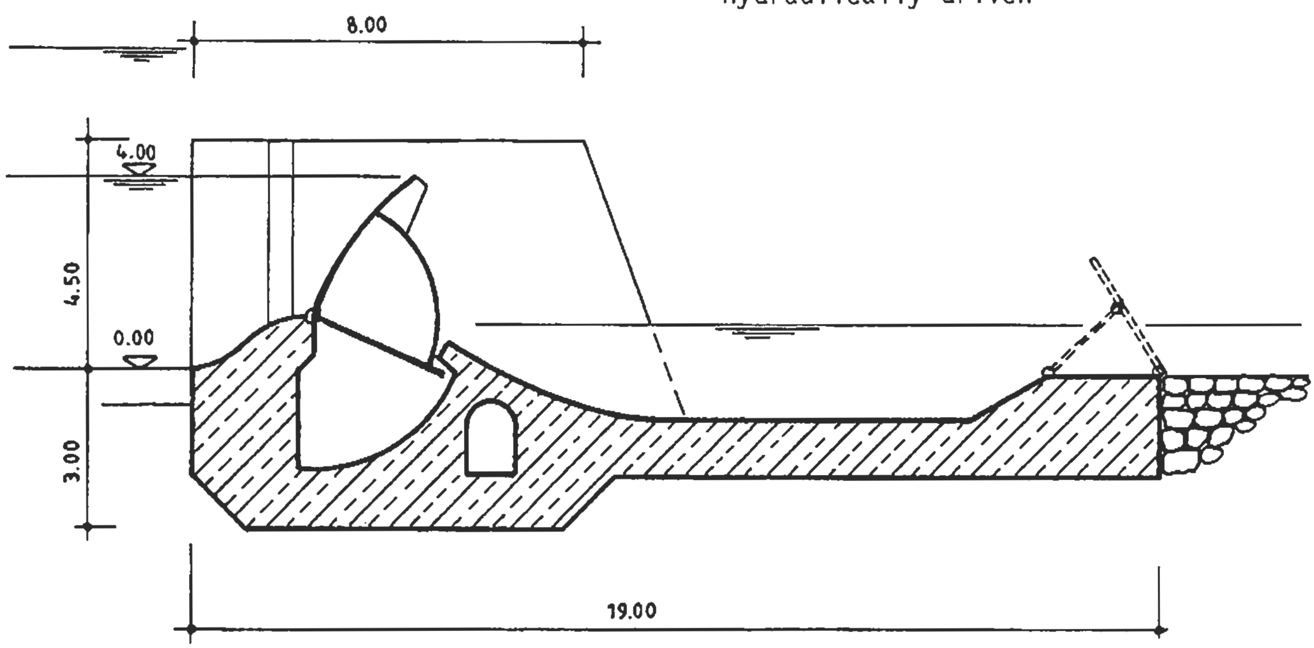


RIVER DISTANCE FROM MOUTH km	0, 100, 200, 300, 400, 500, 600, 700, 800, 880
VALLEY DISTANCE km	49, 24, 35, 113, 74, 162, 234, 80
1981 PEAK WATER LEVELS	8.3, 12.7, 15.2, 20.0, 22.0, 24.1, 26.1, 32.6, 33.18, 65.2, 75.9, 95.2, 147.7, 155.6
RIVER BED LEVELS TAKEN FROM MAPPING	0.5, 3.8, 5.9, 8.6, 11.6, 12.9, 15.0, 19.6, 29.1, 30.4, 54.8, 69.2, 89.5, 142.6, 150.0
FLOOD PLAIN WATER LEVELS	5.0, 5.1, 6.6, 7.5, 8.8, 9.5, 14.8, 16.9, 20.0
DEVELOPMENT ALTERNATIVES	SGU 4: 1. Small & medium pumps 2. Gravity diversion; SGU 3: 1. Right bank canal and pumps 2. Right bank canal without pumps; SGU 2: 1. Small-scale pumping 2. Medim-scale pumping 3. Gravity diversion; SGU 1: 1. Small-scale pumping 2. Medium-scale pumping; Reservoir: Small-scale pumping; Small-scale pumping

Figure 7/5 Diversion Dam - Cross Section

RECOMMENDED ALTERNATIVE

Automatic drum gate, hydraulically driven



CONVENTIONAL ALTERNATIVE

Taintor gate, mechanically driven

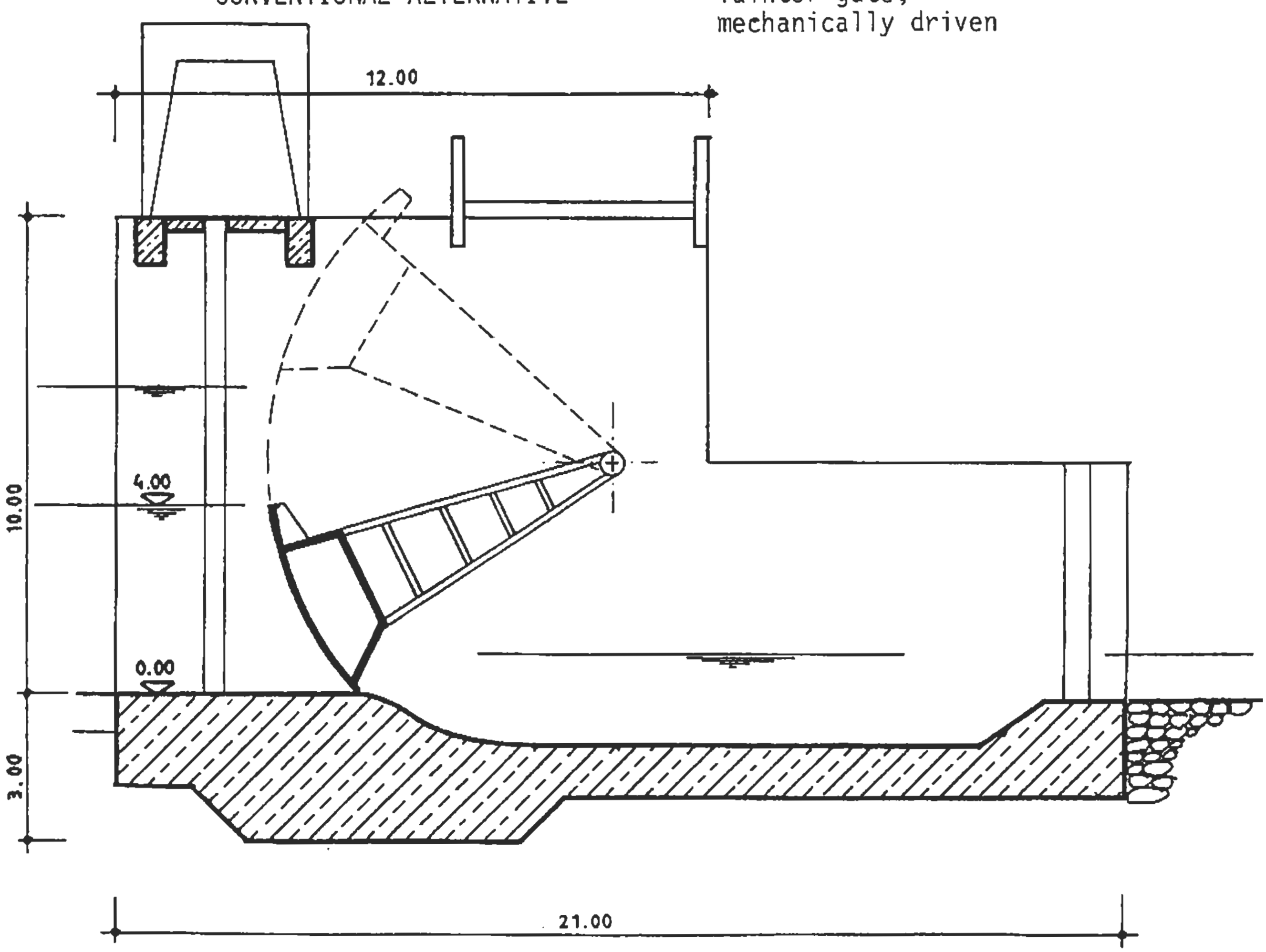


Table 7.4/2 Characteristics of Gravity Diversion and Pumping Systems

Indicator/system	Gravity diversion	Pumping
Investment costs	not known	SoSh 39,000/ha (see pg.86)
Operation costs	lower	higher
Foreign exchange	less	more
Suitability for crops	for all crops	highly productive export crops, no rice
Irrigation methods	for all methods	sprinkling preferred
Flexibility as regards construction schedule	lower	higher
Power requirements	nil	high (30-50 MW in total)
Realistic management standard	good	good
Suitability for development	large scale	medium and small scale

Source: Own analysis

The feasibility of these alternatives and their optimum combination for relevant development areas and time horizons depends on local circumstances and should be studied individually in the framework of the Study of Diversion Alternatives for Saakow, Bu'aale, Fanoole Right Bank and Kamsuma Projects.

Relevant activities include:

- topographical and geotechnical survey
- feasibility study
- design and tender documents
- prequalification of tenderers, adjudication, contract award
- construction and construction supervision
- maintenance.

The feasibility and the timing of construction of diversion dams will be influenced by their dual-purpose utilization: by the necessity of their construction for stability of the riverbed which will be analyzed in the River Morphology Study (see Chapter 7.7).

For the construction of diversion dams, modern submersible structures with low piers (not requiring electric power supply) and equipped by automatic drum gates operated by the water pressure should be used to reduce investment costs and shorten the construction time. These structures enable the reduction of the investment cost by some 40% and therefore basically influence the feasibility of the gravity diversion (see Figure 7/5).

The possible power generation by utilization of the head created by these dams does not seem to be of economic interest over the medium term because of the abundant power supply from the planned Bardheere power plant. It may appear feasible in the long term.

7.5 Irrigation Management and Irrigation Methods

7.5.1 Management Constraints

Socioeconomic and institutional constraints in the Juba valley jeopardize

- the successful use of modern agricultural practices and irrigation techniques

- the introduction of cropping patterns adapted to variable conditions of rainfall occurrence and river water availability.

Obsolete irrigation networks and land preparation methods at small-scale farms, low level of management and operation control at large-scale estates result in low water utilization efficiency and excessive water withdrawals which in turn affect the river water availability and have a negative impact on the economic successes of the Juba Sugar, Fanoole Rice, and Mogambo Projects as well as on the economy of banana plantations. The water utilization efficiency observed (but not yet measured) is the basic problem hindering successful irrigated agriculture in the Juba valley.

Water utilization efficiency must be studied on such items as

- irrigation water utilization efficiency for harvested yield and
- irrigation operation efficiency (i.e. conveyance, distribution and field application efficiency)

for each project.

The project efficiency - its usefulness in the overall development of the country and the region - expressed in economically measurable improvements depends on:

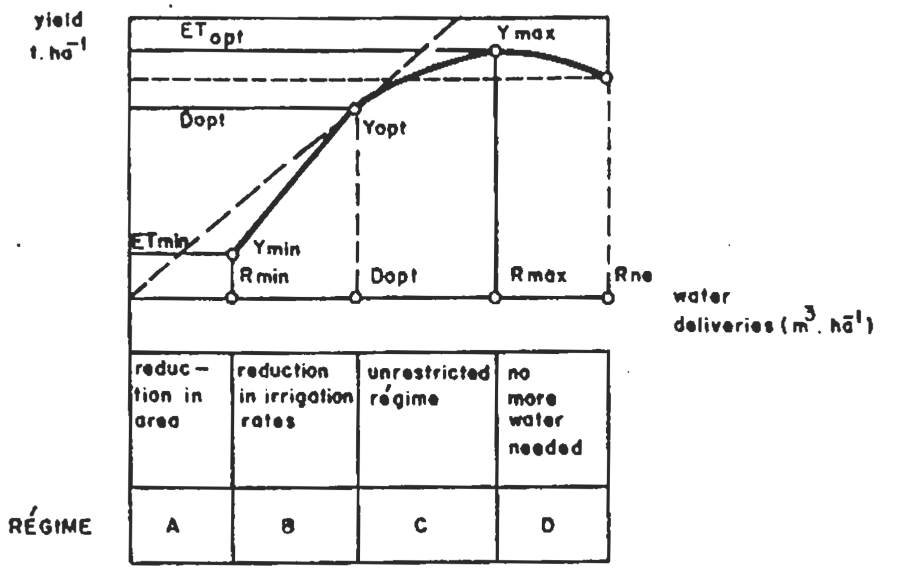
- the marketing capability of the project produce
- the maximization of the total production under a limited water supply and
- the sustained efficiency of the project operation, which in turn depends on adequate maintenance and on proper watershed management.

7.5.2 Irrigation Water Utilization Efficiency

Irrigation water utilization efficiency for the harvested yield is characterized by the harvested yield per volume of delivered irrigation water (kg of product per m^3 of water withdrawn). It depends on the crop selection (crops differ substantially in water utilization efficiency as well as in the share of the crop on the total weight of the green matter) and on the correspondence of crop water requirements with rainfall and soil water occurrence.

The maximum yield level of a crop is primarily determined by its genetic characteristics (see Table 7.5/1) and how well the crop is adapted to the environment. In addition to climatic conditions the yield is also determined by the duration of an adequate water supply. To maximize the total production under a limited water supply the water utilization efficiency of crops for harvested yield and the yield response to water deficit in different growth stages is of major importance. Since the relationship also depends on factors other than water such as crop variety, soil conditions, pest and plant diseases, fertilizer application etc., the quantification of the water stress on yield is location specific. Yield response to salinity is also location specific and should be determined by adaptive research.

Figure 7/6 Interrelationship of the Yield and the Adequacy of the Water Delivery



Symbols: Y_{max} - maximum yield, Y_{min} - minimum yield. ET_{opt} - optimum evapotranspiration, D_{opt} - optimum water delivery, R_{min} - minimum (unavoidable) water requirements

Source: Jermar: Water Resources and Water Management (Elsevier 1987)

When selecting the cropping pattern consideration must be given to match, in the best way, the crop water requirement and the available water supply. A crop calendar should be used in which crop water requirements are synchronized with the river water availability. Moreover when selecting crops and their hectarages preference should be given to crops which are:

- most efficient in water utilization under sufficient water supply: high harvested yield per unit of water consumed

- able to maintain an acceptable yield level under reduced water supply (having low ratio between relative yield decrease and relative water deficit).

- promising from the marketing point of view (export crops).

Table 7.5/1 Water Utilization Efficiency, Sensitivity to Water Supply, Salt Tolerance and Water Requirements of Crops

Crop	Water utilization efficiency		Sensitivity to water supply		Salt tolerance	Water requirement	Crop coefficient
	moisture content %	kg/m3		(-)		mm	(-)
High producing:							
Cabbage	90	12-20	low	0.95	moderate	400- 500	0.7 -0.8
Tomato	80	10-12	medium	1.05	moderate	500- 600	0.75-0.9
Onion	85	8-10	medium	1.1	sensitive	450- 550	0.8 -0.9
Pineapple	85	5-10	low	0.9	sensitive	800-1,000	1.0 -1.2
Sugar cane	80	5-8	high	1.2	moderate	1,500-2,500	0.85-1.05
Watermelon	90	5-8	medium	1.1	moderate	470- 600	0.75-0.95
Citrus	85	2-5	medium	1.0	sensitive	400-1,200	0.7 -0.9
Grape	80	2-4	low	0.85	moderate	500-1,200	0.55-0.75
Banana	70	2-4	high	1.3	sensitive	1,200-2,200	0.7 -0.9
Bean	80	1.5-2	medium	1.1	sensitive	500- 650	0.85-0.9
Pepper	90	1.5-3	medium	1.1	moderate	600- 900	0.7 -0.8
Alfalfa	10	1.5-2	medium	1.0	moderate	800-1,600	0.8 -1.5
Low producing:							
Maize	10	0.8-1.6	high	1.25	moderate	700- 850	0.8 -0.95
Rice	15	0.7-1,1	high	1.2[1]	moderate	900-1,000	1.1 -1.2
Wheat	12	0.8-1.1	high	1.15	tolerant	580- 650	0.8 -0.9
Sorghum	12	0.6-1.0	low	0.9	tolerant	470- 550	0.75-0.85
Groundnut	15	0.6-0..	low	0.8	moderate	550- 650	0.75-0.85
Pea	70	0.5-0.7	high	1.15	sensitive	500- 600	0.2 -0.95
Soybean	6	0.4-0.7	low	0.85	tolerant	550- 800	0.75-0.9
Cotton	10	0.4-0.6	low	0.8	tolerant	700-1,000	0.8 -0.9
Tobacco	10	0.4-0.6	low	0.9	sensitive	800- 900	0.85-0.95
Sunflower	6	0.3-0.5	low	0.95	tolerant	670- 800	0.75-0.85
Sunflower	10	0.2-0.5	low	0.8	tolerant	800-1,200	0.65-0.7

1) Depends highly on period of growth.

Source: Yield Response to Water (FAO)

Table 7.5/2 Characteristics of the Main Crops in the Juba Valley

Crop	Growing period (days)	Sensitivity to salinity	Water requirement mm/period	Sensitivity to water supply (K_y)	Water-utilization efficiency kg/m^3	Marketing suitability
Banana	300-365	sensitive	1,200-1,600	high-1.35	high 2.5-6	excellent
Cane	270-365	moderate	1,500-2,500	high-1.2	high 5-6	excellent
Rice	90-120	moderate	350- 800	high (1)	fair 0.7-1.1	good

1) Depends on period of growth.

Source: Yield Response to Water (FAO)

Except banana and sugar cane other local crops with high water utilization efficiency are chillies, onions, tomatoes and cucurbits. Their water utilization efficiency is almost ten times higher than that of rice (5 to 10 kg per m^3 of supplied water at 90% moisture content). These crops have medium-high sensitivity to water stress (see Table 7.5/1).

7.5.3 Delivery Efficiency

Conveyance and distribution losses in the existing small-scale, medium- and large-scale projects are high. They comprise canal seepage, bypass water escape, spill and drainage water, deep percolation, evaporation from the canal free water surface but also delivery of water to unproductive land. A part of the canal seepage in the banana plantations is recovered by the low lying fields and contributes to the improvement of field application efficiency. A part is wasted by unproductive evapotranspiration and the rest (also in the fields of Juba Sugar - irrigated by sprinklers where, nevertheless, waterlogging occurs) contributes to the enrichment of the groundwater table.

Water withdrawals are not measured; water is not paid for, which results in inefficiency of water withdrawal and delivery. Measures to cope with this unacceptable situation require establishment of an agency in charge of water management in the areas irrigated and depend on the size of the project.

The water delivery to large- and medium-scale projects can be measured continuously by the help of sharp-crested and broad weirs, siphons, drop structures, measuring flumes, sluice gates, submerged orifices. They must be calibrated, i.e. the relationship between stage and discharge determined by current meter measurements. Flow measurement on the basis of pump output and time of operation may be acceptable exceptionally, for the interim period and medium-scale banana plantations. Flow of water has to be controlled and measured at strategic points from the head regulator or stilling pool to the field canal turnout. Correct functioning of gates of the Fanoole, Juba and Mogambo Projects should be checked regularly. Water measurements will also enable a just allocation of water amongst the users of the Mogambo Project. To ensure efficient operation an 'Operation and Maintenance Manual' should be elaborated or reviewed for each project.

In order to prevent excessive seepage losses, canal stretches with high seepage rate should be specified by direct measurement of flow in subsequent canal profiles and adequate rehabilitation measures accepted (see Table 7.5/3). A similar approach is to be followed in planned large- and medium-scale development.

Table 7.5/3 Recommended Rehabilitation Measures to Reduce Seepage from Canals

Method	Probable drop in seepage (%)
Treatment with chemicals	50-75
Floating with clay or loam	40-75
Clay layer	70-85
Concrete lining	80-95

Source: Jermar: Water Resources and Water Management (Elsevier 1987)

The small-scale farms are numerous and similar measures are not manageable. Land registration, pump licencing and water pricing are required, but their impact on efficiency of water delivery and water utilization is not sufficient. The pumping costs of these systems are higher than those of the medium systems. Independent, small-scale systems are most probably the solution acceptable for the interim period of development before a high efficiency of irrigation operation will be required. These systems can survive on small patches of land along the river. Economy and methods of their restructuring in large agricultural plains should be analyzed in the framework of the Deshek Conversion Programme and/or Irrigation Development Study.

7.5.4 Field Application Efficiency

Sugar cane plantation

Sprinkler irrigation is used for the sugar cane plantation which has, under local circumstances, the best economic results. Sugar is an export crop and its supply does not meet the demand from the internal market. Sugar cane has a high water utilisation efficiency per harvested yield and is moderately sensitive to salinity. It is for many reasons a prosperous crop. The crop coefficient of sugar cane varies between 0.4 in the period after planting up to 1.2 for full canopy. The cropping calendar is adapted to river water availability in that the crop is organized in three stages during the dry season of Jilaal.

But the sprinkler irrigation as locally used achieves (as derived from compilation of water balances) some 50% of the theoretical efficiency. The relatively strong wind causes a minor part of this deficiency. The major part of water losses is caused by an inappropriate technique of irrigation operation. The efficiency of sprinkler irrigation depends on the harmony of the irrigation rate with the suction pressure of soil, which decreases evaporation. By exceeding the appropriate irrigation rate, as it happens often in the Juba Sugar Project, the flooding of the entire strip occurs resulting in evaporation from free water surfaces. The accumulation of water that has been observed on the entire strip and also outside the irrigated area results in waterlogging and/or additional deep percolation losses.

Rice cultivation

Very low efficiencies have been recorded locally in basin irrigation used for rice cultivation. Since rice is mostly grown under submerged conditions and soil saturation, high percolation losses occur. To reduce them a dense subsoil layer should be created before the establishment of the plant, by puddling the wet soil: this requires up to 300 mm of water including the preplanting irrigation. For the improvement of local rice irrigation practices in the Fanoole and Mogambo Projects, the following should be taken into consideration:

Although rice is an aquatic plant, deep and prolonged submersion adversely affects the plant growth and reduces the yield. Undesirable submergence also increases water losses through percolation, unproductive evaporation from free water surface, by surface runoff, and decreases the amount of rainfall which can be used effectively by the plant.

Several irrigation scheduling practices have been recently developed for rice to save water and ensure high yields. In the course of the intermittent submergence, water is kept at 100 mm for about a week after transplanting. In the vegetative phase, water is kept at 20 to 30 mm which results in maintaining high soil temperature for increased yield. Drainage may be practiced during the period when rice can tolerate a reasonable water shortage and must be stopped at head initiation by submerging the field for 30 days till the head is flowering. From this time onward, adequate water supply is essential up to the seed formation phase, during which rice fields should again be gradually drained. Timely drainage, some 30 days before harvesting, safeguards high yields and facilitates harvest operations. The described intermittent submersion increases the yield by some 10% and reduces the water requirement by some 25% in comparison with traditional continued submersion.

The percolation loss is an important matter - up to 35 to 40%. To avoid practices of excessive water gifts leading to wastage (difficult to overcome in later stages), percolation loss must be measured before the beginning of the project operation in each soil group. Rice field irrigation losses are decisive for the determination of the share of rice in the cropping pattern. Obsolete irrigation practices result in excessive water losses and reduce the yield. An early introduction of the described water saving irrigation is essential. Rice may constitute an important part of the improved food pattern.

Banana plantations

The furrow irrigation method that is used for banana plantations has a standard efficiency up to 80%. But the total efficiency of irrigation in local banana plantations has been estimated at some 20%, which, together with drainage problems, indicates also overirrigation. Bananas are sensitive to water supply and overirrigation results in decreases in crop quality as well as in reduction of yield. Banana is an export crop whose economic contribution substantially improves the economic imbalance of Somalia. For this reason, as well as from the point of view of the water utilisation efficiency for harvested yield, its hectarage is to be extended.

The relatively good results of the banana plantations may allow an improvement in irrigation technologies. Trials are done with the sprinkler system, but achieved results, though promising, do not by far achieve the possible value of some 85%. Maximum irrigation efficiency in banana plantations can be achieved by drip/trickle irrigation. This efficiency follows from the limitation of the area irrigated to the immediate vicinity of the plant, controlled by the suction pressure. It results in reduction of drainage requirements which are one of the main constraints of banana production under local circumstances. An upgrading of the efficiency of banana irrigation connected with systematic water metering is recommended to improve the described situation.

Small-scale irrigation

Small-scale irrigation systems use basin and furrow irrigation with a poor field alignment supplied by an intrinsic, complicated canal system. Small Holder irrigators still lack the basic technical knowledge on crop water requirements and efficient irrigation systems (but also materials and equipment including tools to introduce them). This results in wasteful application of water, high evaporation, seepage, escape and high percolation losses. The main canals of these systems are short which would theoretically result in lower delivery losses, but poor alignment of the stilling pool and the canal results in a low delivery efficiency (see Table 7.5/4). The main problem which cannot be solved by an improvement of the technical standard and which will endanger the efficiency of the whole Juba valley irrigation system also in the future is an effective management of these small-scale systems. The water cannot be metered nor water withdrawals monitored continuously.

To achieve an adequate operation control for small-scale farms, it is advisable to regroup them in medium-scale irrigation systems which are centrally supplied from one single pumping plant or diversion dam. The feasibility of this solution should be studied.

Table 7.5/4 Efficiencies of Irrigation Methods in the Juba Valley

Method	Crop	Field efficiencies Stand.	Max.	Local (1)	Delivery efficiency	Total efficiency
Basin	rice	0.4	0.6	0.3	0.8-0.9 (2)	0.24-0.27 (2)
	mixture	0.4	0.6	0.25	0.8	0.20
Furrow	banana	0.6	0.8	0.4	0.8	0.32
Sprinkler	sugar cane	0.7	0.87	0.5	0.9	0.45

1) Including overirrigation (management efficiency).
2) Higher efficiency - Mogambo Project.

Source: Own estimate

Only a minor part of the irrigated land, i.e. medium-scale and small-scale networks supplying scattered patches of land along the river should be supplied by pumping in the ultimate development phase.

7.5.5 Measures for Improving Irrigation Efficiency

In the before-dam situation periods of water scarcity occur regularly. To reduce the resulting financial losses and to increase the economic efficiency a Water Allocation Strategy is to be defined to distribute the available water among the main users: the Juba Sugar, Fanoole and Mogambo Projects, the banana plantations and small-scale farms during the period of water deficiency. Water Allocation Committee should be strengthened to:

- promote the adoption of cropping calendars to rainfall occurrence and water availability;

- specify irrigation regimes for relevant crops, periods of growth and different degrees of water scarcity;

- decide on water allocation in the period of the water scarcity.

In each large-scale system

- the Juba Sugar Project
- the Fanoole Rice Project
- the Mogambo Project

the Operation and Maintenance Manual is to be reviewed and modified in order to enhance the use of water saving irrigation techniques. Corresponding guidelines should be elaborated as an Operation and Maintenance Manual for

- the banana plantations and
- small-scale farms.

In each of the six socio-geographic units

- riverine area upstream Luuq
- reservoir area
- Bardheere riverine area
- Saakow/Bu'aale riverine area
- Fanoole/Kamsuma riverine area
- Kamsuma-Gobweyn riverine area

a pilot farm and a research station are needed as a part of extension services.

Also in the with-dam situation different irrigation regimes are to be defined according to the degree of development to the area, achieved irrigation efficiency, season and resulting actual water scarcity. The multipurpose operation of the reservoir according to the reservoir and dam operation and maintenance manual should respect these irrigation regimes. At the beginning of the season the irrigation regime will be selected on the basis of the water in the reservoir storage. Threshold reservoir volumes (MCM) and threshold stages (m.a.s.l.) for this decision are to be defined and cropping patterns optimized to achieve high water utilization.

7.5.6 Irrigation Methods

Taking economic constraints into account, surface irrigation is generally proposed: the main methods being furrow, border strip and basin irrigation. These irrigation techniques generally involve fewer capital and operation costs than sprinkler irrigation. Sprinkler irrigation should be used

- for those areas where the topography and the soil strata are such that the quantity of earthwork required for land levelling would be impracticable or would result in the exposure of infertile sub-layers;

- for high-yielding (export) crops like sugar cane, banana or vegetables.

The advantages of selected methods can be compared in the Table 7.5/5.

Table 7.5/5 Characteristics of Basic Irrigation Methods

Irrigation method	Suitable for	Water delivery	Socio-agri-cultural adaptation requirements	Levelling	Costs	Distribution efficiency	Field efficiency	
							Theoretical	Local
Furrow	general arable crops, vege-tables	gravity	medium	accurate	low	medium	0.7-0.8	0.2
Borderstrip	close growing field crops	gravity	medium	accurate	low	medium	0.6-0.7	-
Basin	rice, maize vegetables (1)	gravity	low	medium	low	low	0.4-0.6	0.15
Sprinkler	sugar cane bananas vegetables	pressure	high	low	high	high	0.7-0.87	0.4

1) Maize and vegetables are not kept flooded.

Source: Own evaluation

The basic advantage of basin irrigation or level-border method (except the low degree of socio-agricultural adaptation) is that it can be used for a large number of subsidiary food crops without changing their planting patterns. Crops less susceptible to flooding can be flat-planted or shallow bedded. Crops which are adversely affected by flooding can be planted on higher beds and irrigated with controlled applications in the furrows adjoining the beds. But this method has high water losses and should be used for rice in rotation with maize only and in small-scale development.

Surface irrigation methods that differ from basin systems like furrows (and corrugations) can be used for nearly all field crops without adaptation. The amount of water applied by these methods can be easily adjusted to meet seasonal variations and actual water requirements by changing the duration and size of the irrigation gift. No irrigation water needs to be lost through surface runoff. Percolation and evaporation losses are far less than for the basin method. Due to these reasons, no additional energy requirements and relatively low cost, the furrow irrigation method is recommended for application in large-scale development. The actual adaptation of the irrigation method will be influenced by site characteristics and variability of soil type, aimed at achieving the theoretical application efficiency.

7.6 Flood Protection and Drainage

7.6.1 Flood Protection Measures

Floods and problems of their occurrence are analyzed in Chapter 4.2 and 6.3. Reduction in flood damage in Juba valley can be achieved by an integrated application of the following measures :

1) by flood storage effect of the Bardheere reservoir, which may decrease the flood discharges to 700 m^3 or more depending on their size, duration, period of occurrence and reservoir operation;

2) by construction of flood protection bunds wherever the river has overtopped its banks;

3) by increasing the discharge capacity of the Juba river channel (regular dredging of silt deposits in the channel, straightening of some river oxbows especially in the Lower Juba etc.);

4) by bypassing the flood water and storing of flood water in natural depressions and reservoirs wherever the morphology of the terrain permits;

5) by construction of flood relief structures and gates in bunds wherever a diversion channel reducing the discharge during floods takes off from the river and efficient operation of these sluices;

6) by improving the drainage system in areas where it is not sufficiently developed or disturbed by man-made obstacles like roads, irrigation canals, flood protection bunds, river embankments etc.;

7) by an effective flood warning system based on efficient monitoring and interpretation of rainfall and river flow data and consisting of a signalling, decision making and operation system (permanent observers, short wave transmitters etc.);

8) by resettling of affected dwelling areas and houses;

9) by an efficient emergency and rescue service equipped by an adequate number of bulldozers, scrapers, excavators, levellers, tractors, cranes, trucks, boats, emergency gates, mobile workshops etc.

The application of individual flood protection measures and their combination depends on local conditions:

- on the morphology of the terrain and its position (altitude) in relation to the flood level;

- on the size and importance of the area (economic and other losses) decisive for the degree of the protection (probable return period of flooding);

- on its distance from the planned Bardheere reservoir and its operation (the impact of the reservoir operation decreases with the size of the intermediate catchment);

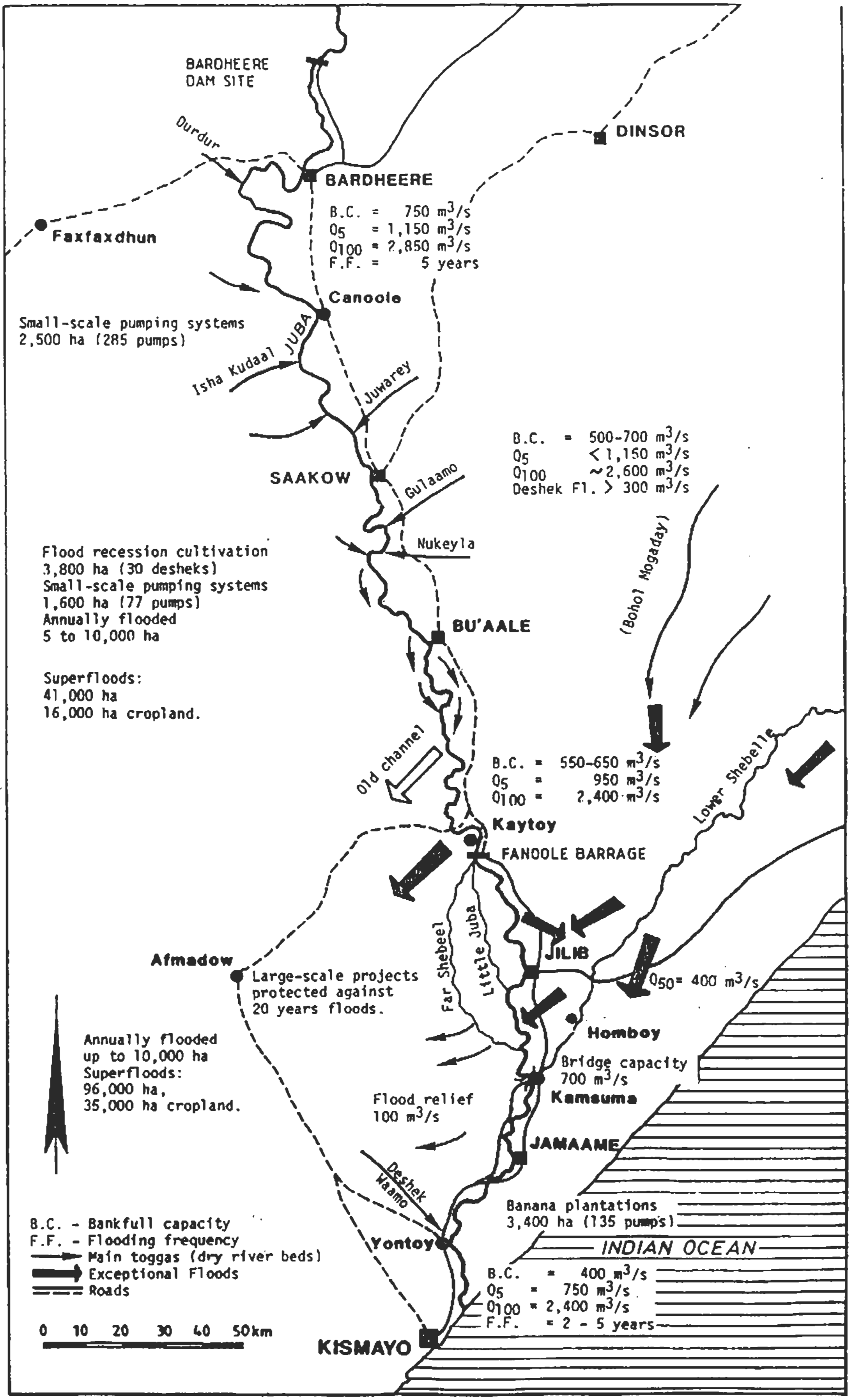
- on the local infrastructure.

The regulation of floodplain use in developed countries requires the following standard protection from flooding:

	Return period
extensive agriculture	1 in 5 years
intensive irrigated agriculture	5 to 20 years
dwelling centers (with stable masonry houses, modern infrastructure)	20 to 50 years

The degree of protection (probable return period of flooding) depends not only on these limits, but also on the course of flood events. It is basically an economic problem: the cost of protection measures should be separated, shared by the different users and compared with potential benefits for each of the protected areas. All these problems should be analyzed in the framework of the Drainage and Flood Control Study.

Figure 7/7 Flood Hazard in the Juba Valley



7.6.2 Flood Protection Bardheere-Fanoole

In the Bardheere Riverine Area floods are confined to scattered alluvial plains and levees which are partially protected by low, mostly primitive bunds: The planned reservoir operation should restrict the maximum discharges to some 700 m^3/s. The difference of altitude for 300 and 700 m^3/s derived from the rating curve is some 2 m. Flood protection bunds of 1.5 to 2 m in height in the lowest spot of these plains would guarantee a more than sufficient protection of these lands and safeguard conditions for intensive irrigated agriculture. Villages are located at higher altitudes so that the resettlement would involve huts and shelters scattered in depressions of the floodplain.

The operation of the planned reservoir does not offer any protection from the floods from small tributaries of the Juba river which carry brief torrential flows. Flood discharges of these tributaries depend on the size of the catchment and gradient of the channel. Bunds along both banks of these tributaries may offer sufficient protection.

The problems of flood protection for alluvial plains of the Bardheere Riverine Area are to be solved in the course of irrigation development. Adequate attention is to be paid to the drainage of rainfall water and of flood water from small tributaries that do not discharge directly into the river but into desheks. Gated structures (manually operated) and locally also pumping may be required for an adequate disposal of drainage water in several alluvial plains of the Bardheere Riverine Area. The main toggas (dry riverbeds) Durdur, Isha Kudaal, Juwarey do not form special serious flood and erosion problems.

In the Saakow-Bu'aale Riverine Area, the flood situation is more serious. In the autumn Der season desheks are flooded almost annually - probability of flooding is 0.6 in average. Most of the farmers only plant when the flood water recedes, making use of the residual soil moisture. The probability of flooding in the spring Gu season is one in five to six years: farmers take the risk of planting rainfed crops at the beginning of every Gu season. Flood protection bunds along the river, equipped locally by gates enabling controlled flooding, when required would safeguard conditions for intensive agriculture. The concept of flood protection will be specified in the framework of the Deshek Conversion Study.

In the river sector downstream Bu'aale, the alluvial belt widens to 5 km. Some 20 and 30 km downstream, old river channels exist in the marine plain on the right bank. These are able to bypass excessive flood waters into the depressions and finally into Far Shebeel/Deshek Waamo. The natural capacity of this measure that may reach up to 200-300 m^3/s should be analyzed in order to safeguard adequate flood protection downstream. This measure would require headworks, a link channel some 4 km long and likely a diversion dam.

Similar opportunity for bypassing flood discharges exists also just upstream of the Fanoole Diversion Dam; where the channel of Far Shebeel takes off. It bypasses a part of the flow during super floods. The network of old river channels extends up to Lac Dera and Deshek Waamo.

The network of old river channels is able to bypass excessive flood water via non-arable lands with scattered nomadic population:

- to the area of Afmadow, where it may be stored in an offshore reservoir. It may have a positive effect on livestock production, enabling the rehabilitation of overgrazed areas and

- to protect the alluvial belt along the Juba river which contains arable and irrigable lands suitable for a wide range of crop and also

- to bypass the water and protect the main communications and the Kamsuma bridge, whose discharge capacity is reported to be some 700 m^3/s only (730 m^3/s up to bridge soffit level).

Maps with 1 m contours are needed to analyze the feasibility of this proposal. By-pass canals equipped by adequate headworks may be enlarged by using the kinetic energy of the river flow, which should be concentrated by digging of pilot channels. The feasibility of storage possibilities should be studied in the framework of the Drainage and Flood Control Study.

7.6.3 Flood Protection Fanoole-Gobweyn

The flood situation protections of the area downstream the Fanoole Diversion Dam is complicated due to:

- the additional and substantial inflow from other catchments Shebelli, Hara Naga and Kormajirto (or Bohol Magaday) on the left bank and Deshek Waamo on the right bank;

- insufficient drainage of large areas on the left bank, caused mainly by the construction of fillings across the natural drainage direction: flood protection bunds, irrigation supply canal, roads without adequate drainage networks and cross drainage structures;

- concentration of flow by the embankment of the Fanoole Diversion Dam and flood protection bunds of the Juba Sugar Project, Fanoole Rice Project, Mogambo Project and banana plantations.

The concentration of flow resulted in increased velocities of flow (and higher erosion hazard) as well as in raising the flood water table as may be seen from the comparison of areas flooded 1981, 1985 and 1987. The irrigation development will require the construction of bunds for flood protection of areas whose development is planned - and construction of collector drains and pumping stations for drainage of rainwater from areas outside the bunds in the period of high discharges in the Juba river.

Following areas have been identified as often suffering from seasonal flooding (see Figure 7/7):

- left bank between the upper end of the dikes upstream from Fanoole and Jilib (a)

- right bank between the upper end of the bunds upstream from Fanoole Diversion Dam and the Yaro (Little Juba) near Harawe (b)
- right bank between the confluence of Far Shebeel with the Juba River and the natural drain south of Mogambo Project (c)
- the Lower Shebelli river basin downstream of Homboy up to the Juba River (d)
- the area of the Deshek Waamo on the right bank (e)
- the area between Jamaame, Turdho and Bulo Guduud on the left bank (f).

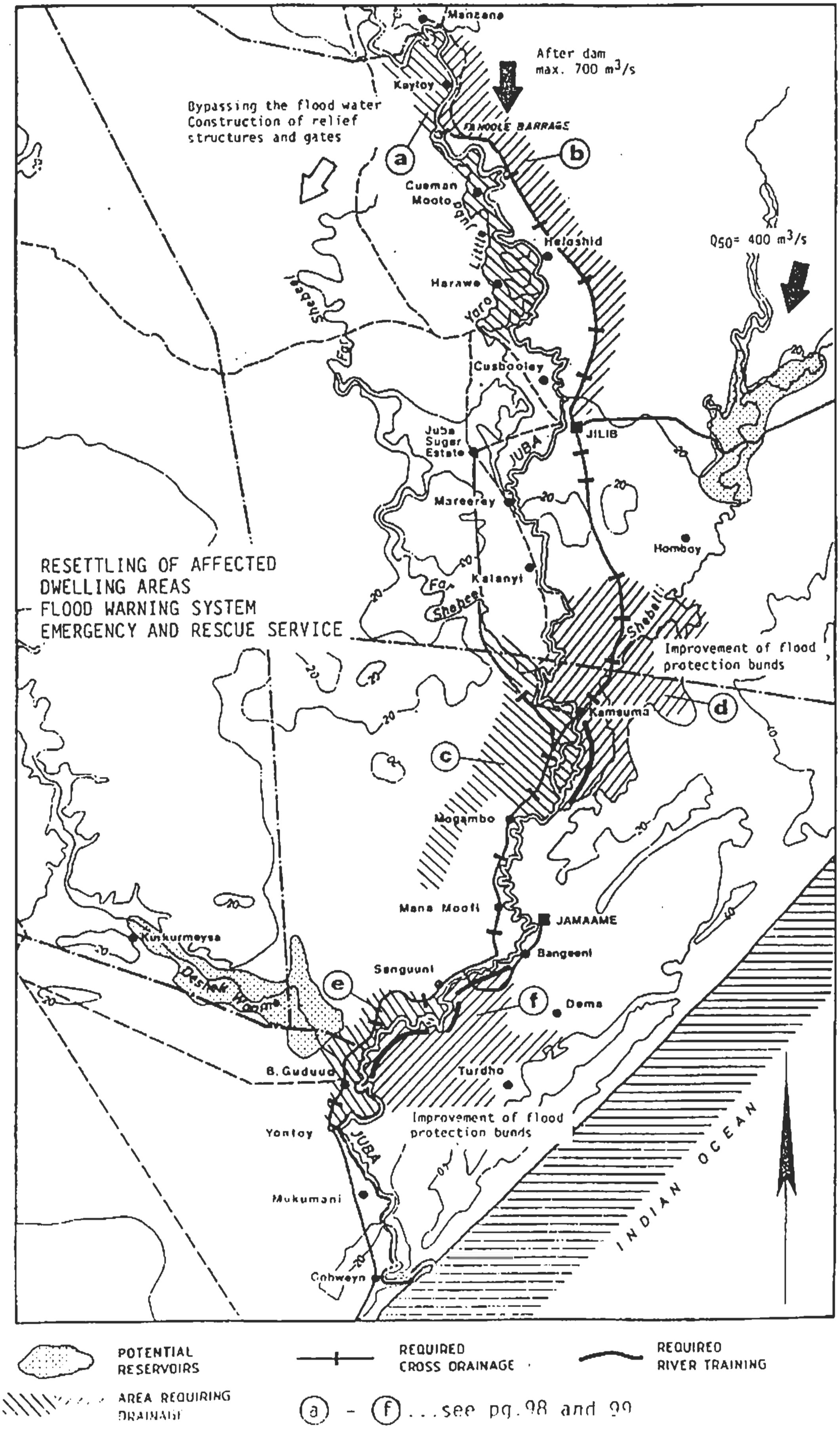
The area on the left bank of the Fanoole Left Bank supply canal can be drained into the Shebelli river using the old channel of the Kormajirto river. But this would increase the irrigation problems of the Homboy Project: a longitudinal drain and a gated cross drainage structure below the Fanoole Left Bank Canal are needed. Similar arrangement should be made for the area north of Kamsuma and east of Jamaame - along and below the flood protection bund and the road to Jamaame respectively. The construction of pumping stations for drainage purposes may be required, because part of the flooded area will be under intensive cultivation.

The protection of the Homboy Project can be achieved by the already planned flood storage of 154 x 10^6 m^3 in a reservoir with a maximum depth of 5 m and an area of 80 km^2 located 6 km downstream the Jilib-Mogadishu road. This requires construction of a bridge or bridges on this road, having a total discharge capacity of at least 400 m^3/s plus freeboard of 1 m. The upper inflow drain will convey water to the reservoir formed by an earthdam and equipped with a bottom outlet. The capacity of this outlet and the outfall drain may be some 10 to 20 m^3/s. This reservoir would contribute to a substantial reduction in flood discharges downstream Kamsuma, where the capacity of the mainstream channel is 400 m^3/s.

The Juba Sugar Project is protected against a 1,250 m^3/s flood by bunds 3 to 5 m high with a freeboard allowance of 0.75 m. The bunds consist of a riverside section of 45.1 km and three sections (total length 11.3 km) which extend from the Juba river: the first near Kumbareero, second near Fanoole and the third southern extension bund near Bander Jedid. The first and second extension bunds cross the Little Juba river and restrict its discharge capacity. The Fanoole Rice Project is protected similarly.

The main cause of flooding in the Mogambo project area was the insufficient capacity of the relief canal passing some 100 m^3/s into the Deshek Waamo lake. This canal has been enlarged and equipped by embankments on either bank. Western flood bank extends from the left embankment and protects the area from the flooding caused by one in 25 year return period flood. A similar bund is planned to extend from the fill of the road and join the right bank embankment to protect the northern area, whose development is planned.

Figure 7/8 Flood Protection Measures and Areas Requiring Drainage in the Lower Juba Valley



7.6.4 Drainage

Drainage is required

- to prevent long-term flooding of the irrigated area after heavy rains as well as floods (see also Chapter 7.6.3) and

- to drain excess irrigation water as well as water used for leaching.

In the existing large-scale projects unit drains discharge into surface branch (collector) and main collector drains which are trapezoidal in section. Drainage water moves southwards following the natural around slopes, but its disposal presents a problem. The saline water discharged into the river from the drains would increase the salinity of river water which is not acceptable in periods February-April. In this period the salinity of river water is already high, endangering the water quality for abstraction downstream. Drainage water from the Juba Sugar Project is discharged into area of Labadad South and Kamsuma North: some of the main drains in the lower lying areas have to be pumped into the outfall drains.

Banana estates are also drained by pumping. Water supply pumps are locally used and supply canals operated for drainage purposes. Outfall drains discharge into natural depressions or back to the river channel. Remedial measures are planned in the framework of the Homboy and Small Holder Banana Cultivation Project.

In the flat depression soils trapezoidal surface field drains (minimum depth of 0.5 m, nominal discharge about 50 l/s) should divert water to escape and collector drains. Elsewhere drainage water should naturally flow to the lower end of the field, field drains need not be provided. Reservation should be made, however, where a field drain could be erected at a later date, should the need arise. To reduce the required nominal capacity of field, escape and collector drains, ponding of water on the fields could be tolerated for short periods (up to two days for return period of two years and general arable as well as banana fields). Drainage rates for paddy rice should be calculated for the critical case of newly planted rice and average storage up to 0.1 m. The drainage system should be designed for the rainfall with a return period of 10 years. Deeper drains may be required locally to keep the groundwater table at an acceptable depth so that neither waterlogging nor salinisation of the root zone occur.

The data from existing large-scale projects show that the water level in the greater part of their area has risen to within 3 to 4 m of the soil surface during the irrigations seasons. The natural sub-surface drainage cannot cope with high percolation losses.

Control structures (one for 20-30 km drainage unit) will serve the dual purpose of throttling the flow to avoid surcharging the main drainage system and, locally, preventing erosion due to the head drop into the main drains. Other drain structures comprise outfalls, canal underpasses, junction and road culverts.

Outfall structures should discharge the drainage flow to the Juba river or to uncropped natural depressions. In the first case they should be equipped by return gates in order to prevent the river backing up into the drainage system at times of high flow. In depressions pumping stations may be required (or irrigation pumps should be used) to divert the collected water.

A monitoring system to record the movement of the groundwater table levels should be installed prior to the commencement of large-scale irrigation. A systematic checking of irrigation intensities is required. Overirrigation may cause the water table to rise to dangerous levels requiring locally a deep sub-surface drainage system.

7.7 Riverbed Stabilization

7.7.1 Sediment Transport

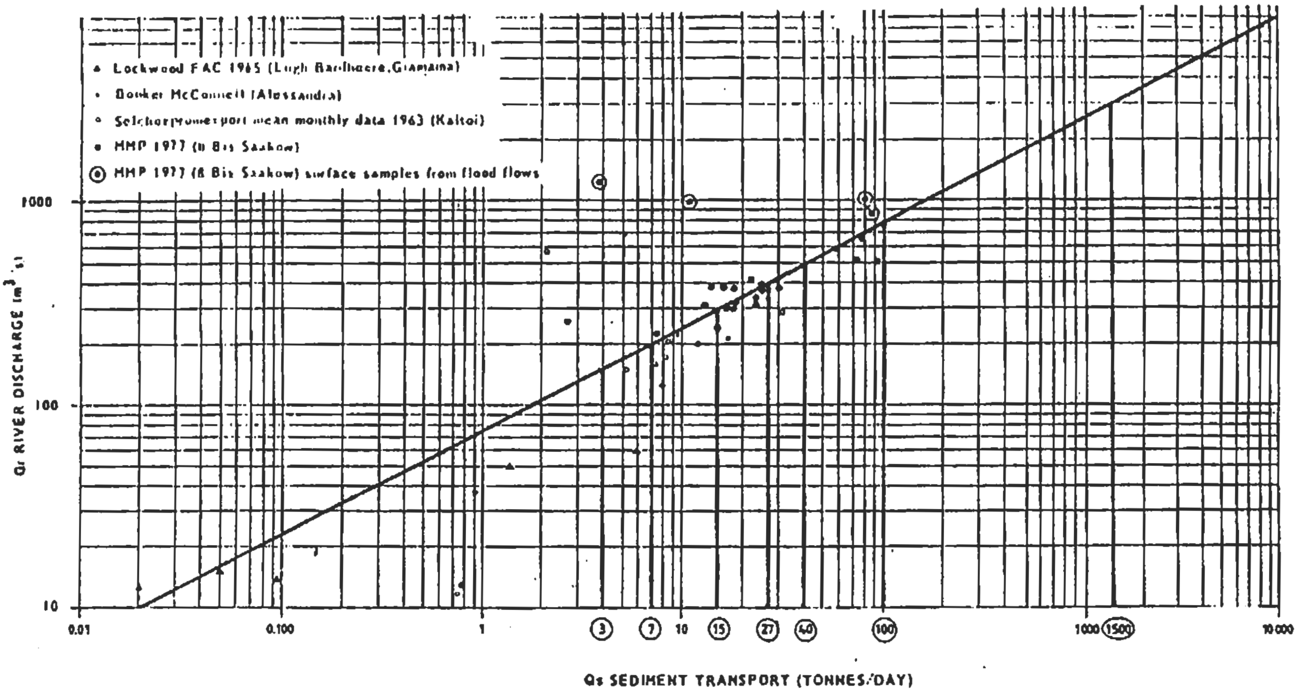
The riverbed is relatively stable under present conditions. It consists of fine and medium sands: particles smaller than 1 mm prevail (75 up to 99%). The share of medium gravel (10 mm diameter) is below 1%. Bedrock ledges and coarse materials deposited in the channel by ephemeral tributaries, form sections with a higher resistance against erosion but do not guarantee the stability of the longitudinal profile.

Measurement of suspended sediment started in 1963. Many of the measurements of sediment load were made by point sampling at 0.6 depth midway across the river, but detailed records of how measurements were made are not available.

Available data were plotted in 1978 by Sir MacDonald & Partners. The reliability of the established sediment rating curve (Figure 7/9) has been checked by direct detailed measurements. The validity of the rating curve has been confirmed when used for monthly mean flow up to 500 m^3/s. The density flow/concentration of sediment in the cross section is presented in Figure 7/10. The particle size distribution curve (Figure 4/4) shows that some 30% of the suspended sediments is clay, 50% silt and 15% fine sand (0.06-0.2 mm). The share of medium and coarse sand (0.2-1 mm) is 4% and 1% respectively. Unit mass is estimated at some 0.7 t/m^3. The recorded concentrations of the suspended sediment show a reduction during the main flow period, which may be attributed to sedimentation in the flooded river plain.

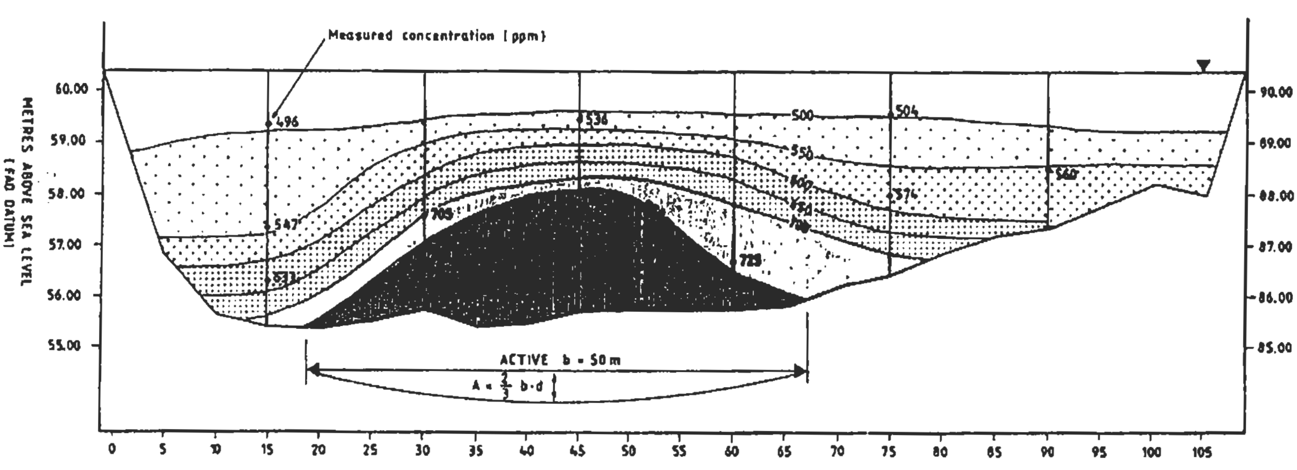
On the basis of the data available (Figure 7/8), the sediment transport can be estimated at 3,000, 7,000, 15,000, 27,000 and 40,000 tons/day for river discharges of 150, 200, 300, 400 and 500 m^3/s respectively.

Figure 7/9 Sediment Rating Curve



Source: Sir MacDonald Ltd., 1978.

Figure 7/10 Density Flow/Concentration of Suspended Sediments (section 8 bis, discharge 420 m^3/s, 26/9/1977)

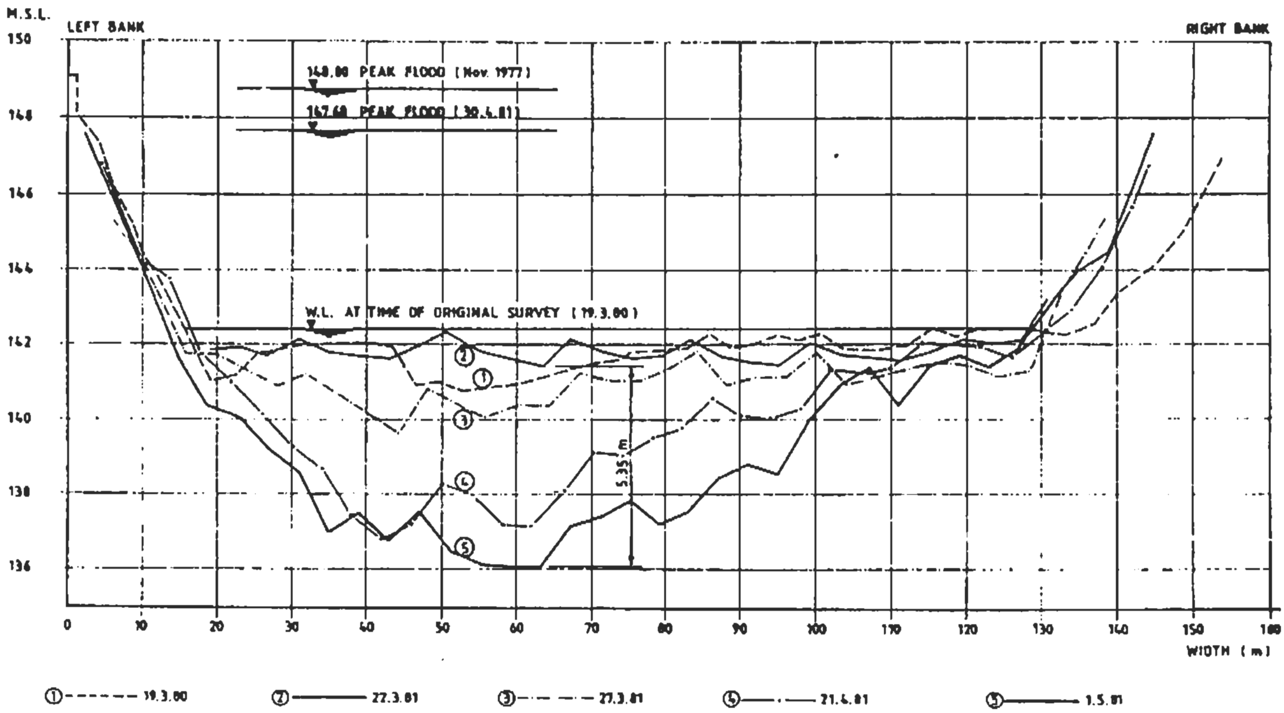


Source: Sir MacDonald Ltd., 1977.

No information is available concerning the bed load transport. The bed load flow during floods can be estimated at some 25% of the volume of the suspended sediment flow. It consists of 35 to 90% of fine and medium sand and up to 10% of medium gravel (Ø 2 - 14 mm). The rest is coarse sand (0.6-2 mm). Unit mass is estimated at some 1.7 t/m^3. Average unit mass of the sediment and bed load is (0.25 x 1.7 + 0.7) : 1.25 = 0.9 t/m^3.

Practical experience shows that deep scours occur after floods - the deepening of the riverbed by some 2 to 5 m and more has been recorded after one single flood (see Figure 7/11). It can be expected that the trap efficiency of the planned reservoir will result in a change of the longitudinal profile and cross sections of the riverbed. The erosion will increase the depth of the channel increasing the pumping lift of existing and potential stations and decrease its width. The extent to which such a change will propagate downstream from the dam site depends upon complex interactions.

Figure 7/11 Cross Section of the Juba River at Luuq Before and After Flood of April 1981



Source: FAO - Survey 1980-81

7.7.2 Erosion Pace during Reservoir Operation

The ability of a river to transform the morphology of its channel is determined by

- available energy W dependent on discharge and channel gradient
  W = G x g x Q x S (G - unit mass of water, g - gravity constant, Q - discharge, S - gradient);

- the resistance of the riverbed to erosion;

- the characteristics of transported sediments.

The river responds to changes in discharge and sediment transport by

- changes in its cross section (depth, width, shape), which may be selective, leaving a coarser fraction (gravel, boulders) in place;

- changes in the gradient of the channel;

- changes in the planform of the river (meander wave length, sinuosity).

These changes are interrelated and proceed at differing rates. The riverbed and sediment material of the Juba River are fine and homogeneous which speed up the erosion pace. It can be assumed that sediment transport downstream the dam will continue after putting the reservoir into operation not having the input from the upper catchment. The input of sediments from the intermediate catchment which increases with its size i.e. downstream has not been measured yet.

The monthly amount of the suspended sediment load in Table 7.7/1 has been derived from the suspended sediment rating curve in Figure 7/9.

Table 7.7/1 Suspended Sediment Load (10^3 t)

Discharge m^3/s	150	200	300	400	500	700	1,200
Daily	3	7	15	27	40	100	1,500
Monthly	90	210	450	810	1,200	3,000	45,000

As the gradient of the river decreases, the kinetic energy gradually diminishes. It has been considered that the erosion zone ends downstream Bu'aale (250 km length) where the ribbed gradient decreases substantially. The maximum erosion pace below the dam has been determined taking into account a gradual linear reduction of erosion depth downstream, a 50 m wide active parabolic riverbed (see Figure 7/10) and 90% trap efficiency of the reservoir, without taking the input of sediments from the intermediate catchment into consideration.

The existence of alternating zones of erosion/sediment transport and aggradation depends on local conditions of gradient, geology, channel morphology and vegetation. This irregularity may even aggravate the erosion process in less resistent stretches with a higher gradient and deep scours will occur locally. Scouring will decrease in time - with the decreasing river gradient.

Floods exceeding 500 m^3/s are extremely dangerous for the stability of the riverbed, when the reservoir traps the sediments. A five-year flood may occur during the construction of the dam. When some 90% of sediments will be trapped and the flood remains unregulated (which is highly probable), the estimated drop of the riverbed at Bardheere that one particular year will be some 1.50 m.

The reliability of max. figures of erosion rate has been confirmed by direct measurements of the cross section deepening. The recorded drop of the riverbed between March 22 and May 1, 1981 in Luuq is 5.35 m (Figure 7/11). This may be considered as a local extreme, but testifies to the estimated range of expected riverbed deepening, when the sediment input will be stopped.

Table 7.7/2 Expected Initial Erosion of the Riverbed

Characteristic year	(1) Average monthly discharges (m^3/s)	(2) Suspended sediment load 10^3 t	(3) Total load 10^3 m^3	(4) Average annual erosion (m)	(5) Maximum annual erosion (m)
Dry	12 x (131-146)	1,080	1,350	0.15	0.30
Medium	10 x (141-154) 2 x (257-264)	1,560	1,950	0.21	0.42
Wet	7 x (135-155) 2 x (222-232) 308, 517, 400	3,630	4,538	0.48	0.96
With 5 year flood	2 x 150, 3 x 50 3 x 200, 2 x 260 1.75x500,0.25x1,200	5,360	6,700 (6)	0.73	1.46

1) See Table 7.2/2.
2) Derived from Table 7.7/1.
3) (3) = (2) x 1.25:0.9 x 0.9 (25% bed load, 90% trap efficiency, 0.9 t/m^3 unit mass).
4) (4) = (3) : 250 : 10^3 : 50 : 0.66 x 0.9 (see Figure 7/10).
5) (5) = (4) x 2 (Bardheere max., Bu'aale = 0).
6) Calculations by ELC show that the total load amounts 18,000.10^3 m^3 in a wet year.

7.7.3 Stabilization Measures

The riverbed should, therefore, be stabilized already in the period before construction of the dam, if the drop in the channel altitude and subsequent drop in water levels during low discharges (requiring higher pumping lifts in future) is to be avoided. The river channel will deepen especially between the dam and Saakow. The erosion will gradually decrease downstream, endanger the bridge at Bardheere and change step by step the channel cross section.

These changes will most probably be minor in backwater of the Fanoole Diversion Dam, but may reappear downstream (if the contribution of sediment load from the intermediate catchment is minor). Only a continuous measurement of sediment and bed load transport as well as of channel cross sections at selected points of interest and investigation on mathematical models may determine the rate and distances of erosion propagation and enable the optimization of relevant stabilization measures.

At this preliminary planning stage the following stabilization structures are considered appropriate:

- three concrete sills with sheet piling (last one downstream Bardheere)
- three double-purpose diversion dams (Saakow, Bu'aale, Kamsuma) - also for water diversion by gravity.

If the above assumptions are right, the construction of necessary erosion control and riverbed stabilization measures is to be completed before the trap efficiency of the reservoir area occurs, i.e. some two to three years before the completion of the dam.

In order to minimize the time for the relevant River Morphology Study, the following activities should start as soon as possible:

- water quality and sediment transport monitoring
- topographical (cross sectional) survey
- collection of soil samples at selected points, laboratory testing
- investigation of the riverbed stability connected with optimization of stabilization measures.

8. Regional Water Development

8.1 Socio-geographic Units

Socio-geographic units (SGU - see Figure 8/1) were defined in the Juba valley as areas with a specific set of common characteristics and conditions. Of the total ten planning units, five (1, 2, 3, 4 and 6) are riverine, four along the Juba river course and one where the Shebelli meets the Juba river. These riverine units are:

SGU 1 - The Bardheere Riverine Area

From Markabley (the future Bardheere dam site) to Batuulo/Gurmeyso, about 10 km north of Saakow, a distance of about 199 km. This area is characterized by dry land farming and small-scale irrigation systems on the river levees along a rather pronounced river channel. The river floods the area and in five years in average. Effective rainfall is low and evaporation is very high.

Irrigable land in the Bardheere Riverine Area is confined to

- scattered alluvial plains along the river channel suitable for diversified cropping: about 7,800 ha (Classes 1 and 2)

- land suitable for paddy rice production: about 85,000 ha (Classes R1 and R2) in the marine plain.

The hectarage of the scattered alluvial plains along the river channel varies between 27 and 710 ha. These plains are 0.2 to 1 km wide and 2 to 12 km long. The total area is 1,480 ha of Class 1 and 6,270 ha of class 2 land (see Table 7.3/2). 2,670 ha gross is already under small-scale, smallholder irrigation and supplied by some 285 pumps. Generally, the owner of the land and the pump is one and the same person. The typical farm of this small-scale, smallholder development, whose average size is some 3 ha, is managed mostly with family labor. One pump whose average capacity is 20 l/s supplies 3 to 12 ha of land. On large farms the cultivation is done by sharecroppers.

SGU 2 - The Saakow-Bu'aale Riverine Area

From Gurmeyso to the Fanoole barrage (140 km) subdivided into three parts:

- the actual riverine floodplain with the deshek depressions

- the area on the right bank on the periphery of the floodplain, with class 2 soils

- the similar area on the left bank also featuring class 2 soils.

The latter two subsystems are never flooded by the Juba river, resulting in a drier ecosystem.

From the north of this area the small-scale irrigation schemes change over a relatively short distance into primarily deshek-type agriculture - the determining factor for this planning unit.

Figure 8/1 Socio-geographic Units in the Juba Valley

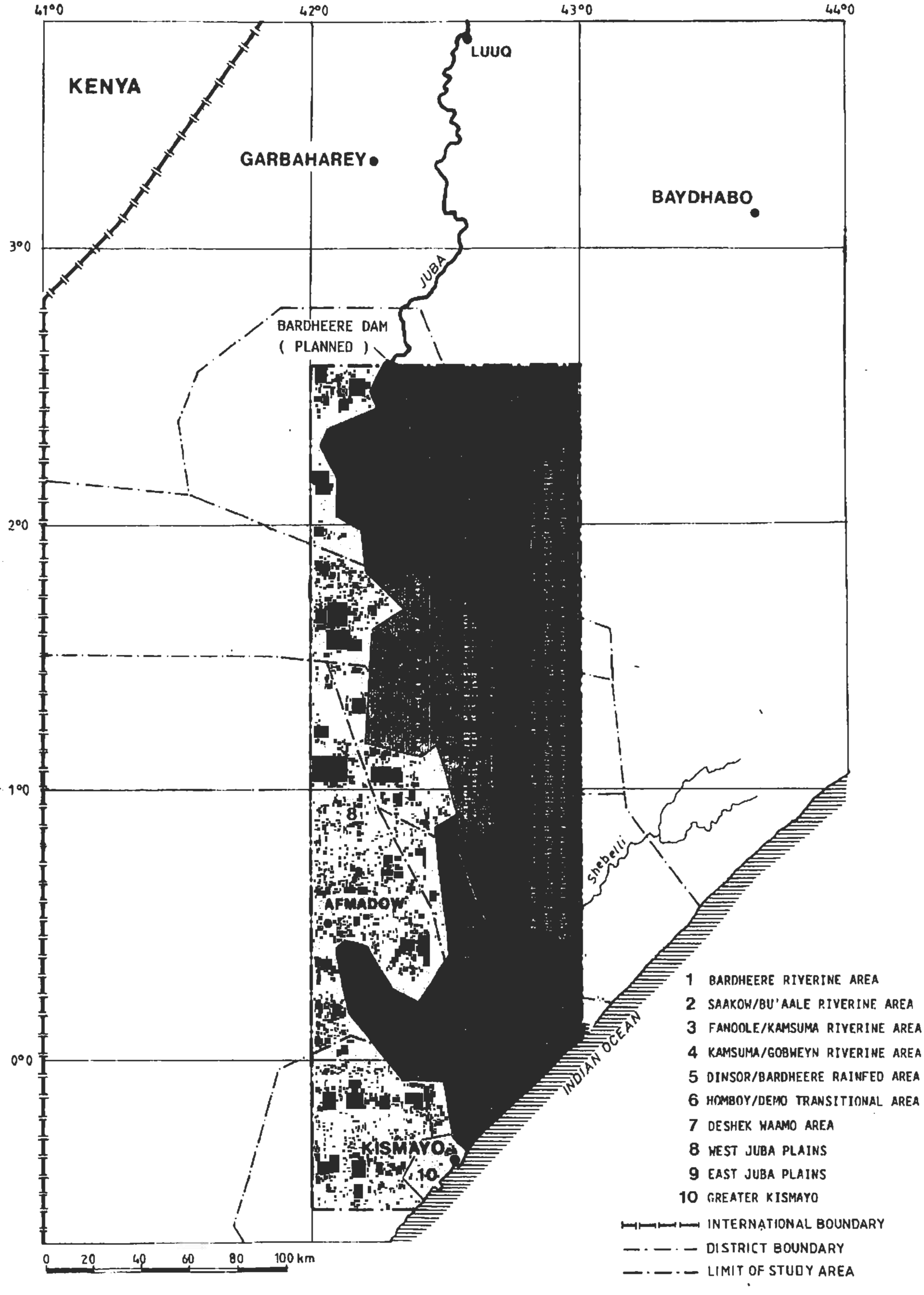
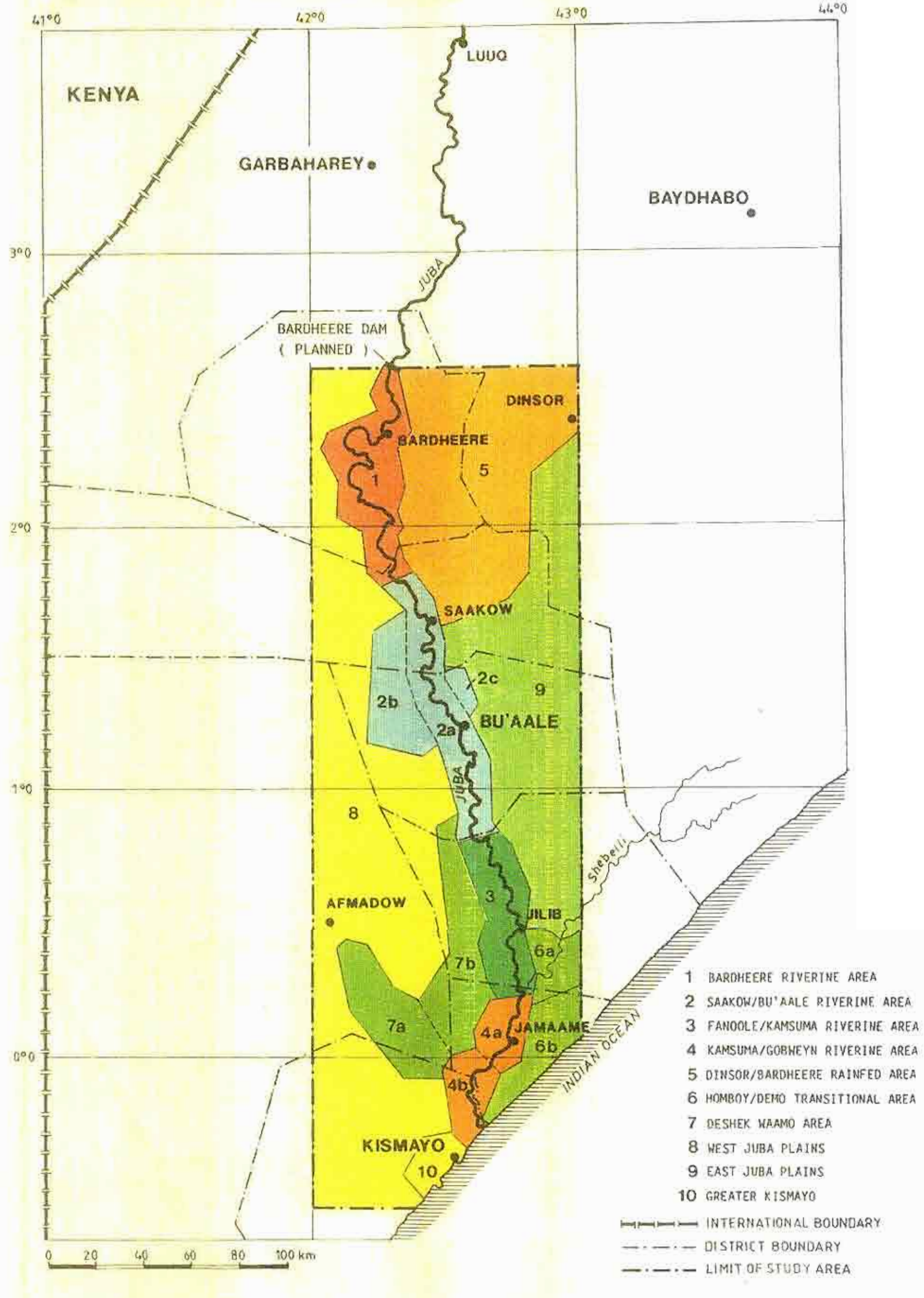


Figure 8/1 Socio-geographic Units in the Juba Valley



Irrigable land in the Saakow-Bu'aale Riverine Area is confined to

- some 43,300 ha in the alluvial plain along the river channel suitable for diversified cropping (Classes 1 and 2)

- some 85,500 ha in the marine plain consisting of land suitable for paddy rice production (Classes R1 and R2 - about 34,500 ha) and land suitable for diversified cropping (Classes 1 and 2 - about 51,000 ha) at high elevation in relation to the riverbed (20 to 60 m) and 10 to 20 km distant from the river (see Table 7.3/2).

The alluvial plain in the Saakow-Bu'aale Riverine Area runs continuously along the river channel from Gurmeyso up to Fanoole. Its width varies between 2 to 4 km and 0.5 to 2 km on the left and right banks respectively. The main bulk of the irrigable land is north of Bu'aale. Downstream Bu'aale the plain narrows to some 0.5 to 0.75 km on each bank.

Cultivation systems identified in the area include flood recession (deshek) cultivation under controlled or partly controlled flooding with or without additional irrigation. The number of desheks amounts to about 30 and 37 in the Saakow and Bu'aale districts respectively, some of them have been abandoned. The return period of flooding is annual in the Der season and once in two to ten years in the Gu season.

Farms are managed individually or cooperatively both with family and/or hired labor. The distribution of farm holdings varies considerably among the desheks. 55 and 45% of the farmers cultivate between 0.25 and 1.0 ha in the Saakow and Bu'aale Districts respectively; 5% of the farmers in both districts cultivate more than 5 ha.

Some 25 pumps were recorded during the air survey in the Saakow District and there were no pumps in the Bu'aale District where 50 pumps were recently distributed. The owner of the pump and the land is often one and the same person, common ownership or pump hiring is also practiced. Farmers in the Saakow/Bu'aale Riverine Area depend on flood recession agriculture. Their agricultural yields will be negatively affected by the operation of the Bardheere Dam.

SGU 3 - The Fanoole-Kamsuma Riverine Area

From Fanoole to Oumtiirrey, 5 km upstream of the Kamsuma bridge over the Juba river (192 km). The presence of two large estate irrigation schemes (Juba Sugar Project and the Fanoole Irrigation Project), their accompanying flood protection measures and the related particular socioeconomic structure dominate this planning unit. During the dry season (Jilaal), the river flow may become zero here, resulting in mass fish mortality.

Irrigable land in the Fanoole-Kamsuma Riverine Area consist of

- 12,100 ha Class 1 and about 30,000 ha Class 2 land of alluvial plains on both banks of the Juba River

- about 1,700 ha Classes R1 and R2 land suitable for paddy rice production forming 5 discontinuous patches (see Table 7.3/2).

The alluvial plain is up to 6 km wide on the right bank and less wide and discontinuous on the left bank.

A substantial portion of the irrigable land - some 12,200 ha gross - is already under large-scale irrigation (Juba Sugar and Fanoole Rice Projects) and protected by high bunds against floods with a periodicity of some twenty years. The Fanoole Rice Project is supplied by gravity from the Fanoole Diversion Dam. The Juba Sugar Project is supplied by pumping.

Agricultural production also takes place in desheks. The number of desheks amounts to about 14. Rainfed cultivation is preferred due to the relatively high and regular rainfalls. But uncontrolled or partly controlled flooding still exists: in period when the precipitation is insufficient, farmers open protection bunds and flood fields to ensure reasonable yields. Moreover, flood recession cultivation is practiced after uncontrolled floods have destroyed crops. The return period of flooding ranges from 1 to 2 years (desheks Wagadey, Marwaaogo, Bodboode, Xaramka, Balley, Nasiib Bunde, Tawakal, Haraawe) or exceeds some 5 years (desheks Malenda, Mayenda, Helashid, Limoole, Manyagaabo, Qalaliyoo/ Gamole).

42% of the farmers cultivate 0.25 to 1 ha, 43% 1 to 2.5 ha, 9% 2.5 to 5 ha and 6% more than 5 ha. Farms are individually managed or cooperatives, both with family and/or hired labor. On average the sizes of the individually managed farms tend to be larger than those of cooperatives.

SGU 4 - The Kamsuma-Gobweyn Riverine Area

From Qumtiirrey, just south of the Juba Sugar Project area, at the Kamsuma bridge, to the estuary of the Juba river (101 km). The unit is subdivided into:

- the section from Kamsuma to Bulo Guduud (with the Mogambo Irrigation Project and the majority of the banana estates), with salinity problems originating from irrigation return flows and groundwater fluctuations;

- the section from Bulo Guduud to Gobweyn (mainly with the remainder of banana estates, but also some cotton), being the estuary riverine section, is strongly influenced by tidal action and seawater intrusion.

Similar to planning unit 3, this area has a particular socioeconomic structure due to the presence of large- to medium-scale estates, coupled with a specific situation concerning water use in the period of drought.

Irrigable land in the Kamsuma-Gobweyn Riverine Area consists of

- about 3,500 ha Class 1 and about 21,000 ha Class 2 land of large alluvial plains on both banks of the Juba River

- about 11,500 ha Class R1 and 5,300 ha Class R2 land suitable for paddy rice production forming large continuous strips on both banks.

- some 750 ha of Class 2 and 200 ha of Class R2 land in small scattered alluvial patches between Yontoy and Gobweyn.

The alluvial plain is up to 16 km wide on both river banks. The bankfull capacity of the river channel is low, and flooding of the alluvial plain occurs once in four to five years on average.

The cultivation systems identified in the area include the large-scale irrigation Mogambo Project, medium-scale banana plantations and small-scale rainfed cultivation. A substantial portion of the irrigable land - some 11,000 ha gross - is already under irrigation control (Mogambo Project and banana plantations). The net irrigated area is far less: from 8,300 ha that has been identified as banana area from air photographs some 3,300 to 3,400 ha are presently under irrigation. Some plantations have been abandoned: large areas are fallow. Under the Mogambo Project only 1,000 ha of the 2,200 ha completed under Phase I are actually irrigated . This project is protected by high bunds against floods with a periodicity of some twenty years. Banana plantations are also protected but, the degree of protection is lower and differs depending on the location.

The total registered area for banana plantation is 12,400 ha. The average size of a banana farm holding (76 registered farmers) amounts to 65 ha, including 30% for banana rotation - only 40% of the farm is used for banana plantation. The fallow (land for banana rotation) is during the Gu and Der season partially used for maize, sesame or groundnut cultivation. Banana farms are individually managed and irrigated with pumps. About 125 pumps were identified during the air survey. The average pumping capacity is some 170 l/s.

Desheks are quite distant from the river channel. The cultivation in desheks is mostly rainfed but some small-scale irrigation perimeters exist. The classification of sizes of the farm holdings for the desheks show that 35% of the farmers cultivate 0.25 to 1 ha, 40% 1 to 2.5 ha, 22% 2.5 to 5 ha and 3% more than 5 ha. Crops of desheks in the der season are destroyed by floods every fourth or fifth year.

SGU 6 - The Homboy-Demo Transitional Area

Being subdivided into:

- a rapidly developing rainfed area immediately around Homboy, with favorable rainfall conditions. This area, however, is influenced significantly by runoff from the so-called 'Jilib drainage area' (Lower Shebelli and Bohol Magaday catchment), with backwater effects during high flows of the Juba;

- the so-called 'Eastern drainage area', east of Jamaame, around Demo village, including the coastal dune lands and some left bank depressions towards the river mouth.

The SGU 3 and 4 in the lower Juba valley are most affected by salinity, i.e.:

- the effect of an increase in salinity levels of the river flow during low-flow periods, due to saline groundwater contribution to the less saline river flow: during periods of high river flow this can be reversed into rising ground water which pushes salt upwards into the root zone;

- the more saline return flows (surface and subsurface) from upstream irrigation users emerge here, even though a number of these present users (Juba Sugar Project) are directed to dispose surface drainage return flows away from the river system: and

- the varying but generally high degrees of seawater intrusion depending on the season.

It is the part of the system, where the large-scale systems with saline sensitive crops (bananas and moderately sensitive sugar cane) exist.

Irrigation development in the above planning units will be influenced by the development in the upper catchment in Ethiopia and in the Dolo-Luuq and Reservoir Area.

The bypassing of excess water may have an important impact on two further socio-geographic units:

SGU 7 - The Deshek Waamo Area

- Deshek Waamo itself where the cropping system is determined by the amount of runoff water in the depression, at different times.

- the triangle between Afmadow, the offtake of the natural spillway of the Juba river (Far Shebeel) about 4 km west of Yontoy and the drainage area of Deshek Waamo into the Juba river near Bulo Guduud. This area has been retained as a flood retention area at high river flows, setting it apart from all its surrounding areas.

SGU 8 - West Juba Plains

Located around Afmadow towards the Kenyan border and Faxfaxdhun in the north. This is a transitional area to the rangelands of Northeast Kenya. The major use of this area is for nomadic livestock.

8.2 Integrated Agricultural and Irrigation Development

The multi-objective planning in the Juba valley requires a look at the complex tradeoffs between various development options to facilitate development for a wide range of users, mainly farmers and pastoralists, both within the Juba valley and in adjacent areas in dealing with three components of river basin development, namely: reservoir resettlement, village development and sponsored settlement programmes for new lands.

In planning irrigation systems key attention needs to be paid to multipliers arising not only from the increased production, but also from the increased purchasing power of water users. The increased production costs per hectare (and per household) that are associated with irrigation must be justified by increased outputs and benefits from the irrigated land. The rise in disposable incomes of farmers and pastoralists living within the area activates off-farm commercial and manufacturing activities and generates possibilities of non-farm employment. For that reason, adequate attention needs to be given to marketing systems for safeguarding the adequate flux of money into the area and to the development of local production, especially of that replacing imported goods.

In addition, at the national level emphasis is to be paid to export local products (bananas, mangoes, papayas, watermelons, canned mixed fruits, tomato and eggplant paste etc.) on the one hand and to achieve selfsufficiency in home-grown cereals (maize), vegetable oil (sesame), cotton, etc., on the other.

Paying adequate attention to regional, local and environmental accounting, respecting the traditional production systems, habits and making use of the ties of clanship among local population, the irrigation development should be organized in a way that the productivity of irrigated fields should largely exceed, supplement and gradually replace the productivity of flood plains cultivated using traditional agricultural and pastoral techniques.

Experience in many African countries shows that yields and disposable incomes from small- and medium-scale schemes run by communities of farmers with technical assistance from the responsible institution exceed those on large-scale schemes run by the state/parastatal organization. Basic preconditions for this success are an adequate irrigation efficiency and a reasonable degree of irrigation management.

These basic experiences should be used during the planning of irrigation systems in the Juba valley, respecting the local development situation and its peculiarities. For that reason, emphasis should be on village or kin-based irrigation medium scale (50 to 500 ha) projects which offer a reasonable degree of irrigation management and use the traditional ties of clanship which are important for an efficient and sustained irrigation operation. These projects enable the integration of crops and livestock within a single production system of settled producers.

Small-scale systems in the Juba valley are systems of individual farmers or small groups of farmers depending on one pump with an average capacity of 20 l/s per pump, supplying 3 to 12 ha. These systems are actually characterized by an erratic pattern of overirrigation and low water utilization efficiency. Their expansion is spontaneous and, therefore, considered as an efficient and dynamic tool for irrigation development in the period to come.

But the target water utilization efficiency and operating costs that can be achieved in these small-scale schemes are not considered to be satisfactory for the final development stage. For this reason, medium- and large-scale, smallholder schemes are preferred. Small-scale perimeters can be incorporated within medium- and large-scale perimeters.

Large-scale systems in the Juba valley are planned as gravity systems supplied by diversion dams. They should consist of a number of community-managed sections with incorporated village stock. Corridors between sections of different communities should be left to provide stock of nomadic herders with access from their rainy season pastures to traditional watering points. Gravity supply is considered as the cheapest option as opposed both to diesel-fueled and electric pumping. But the success of larger schemes depends on active, local participation in the operation and maintenance activities, i.e. on the cooperation between the development authority and water user organizations.

Farmers and herders in the Juba valley often belong to different clans and households which may lead to conflicts destabilizing further development. There are neither local experiences from the Valley with water users groups nor experiences with the integration of crops and livestock within a single production system. In-depth studies are needed to define an efficient balance of production systems (from the socioeconomic, agricultural, agro-pastoral and technical point of view) corresponding to local conditions in relevant socio-geographic units. Following rough analysis tries to specify the basic irrigation development trends on the basis of data available at the preliminary level of the Masterplan and define the programmes, projects and measures needed generally as well as in relevant socio-geographic units.

8.3 Options of Water and Irrigation Development

8.3.1 Bardheere Riverine Area (SGU 1)

This area may continue to develop strongly in the before-dam situation because of improved access to lands on the left bank, but also in view of the additional demand for seasonal crops created through the influx of people for the construction of the dam and the anticipated expansion of Bardheere town.

Some 7,300 ha gross of class 1 and 2 soil in the alluvial plain (and 88,000 ha of R2 land in upper elevation) are available for development. The area under irrigation will expand from 2,500 ha now, to an estimated 6,000 ha by 1995, to a maximum of 10,000 ha (see Table 7.3/3 and Figure 7/3).

More than 5,000 ha gross of R2 lands (special use - moderately suitable for wetland paddy production) are located on the left bank between the planned dam and Bardheere. They can be irrigated by gravity using the irrigation outlet of the Bardheere dam (recommended capacity 7 to 12 m^3/s). But the cultivation of rice should be discouraged because of the extreme evaporation rate in this area resulting in high field losses. The expansion into class Rl and R2 lands should be downplayed, controlled, and greater focus should go to rainfed agriculture.

The planned irrigation development is some 500 ha annually in the period 1988-95, i.e. before and during the construction of the Bardheere dam after $hich it decreases to some 150 ha annually. This appears quite realistic due to the expected increases and decreases in population pressure and the resulting small-scale, smallholder irrigation development boom and slump.

Small-scale, smallholder development can be supported by pump distribution under a credit and cooperative arrangement. That enables achievement of the planned development target by using the initiative of local farmers and new settlers from the area flooded by the planned reservoir. This type of development is suitable for

- small and narrow plains
- for family or kin-based irrigation schemes (2 to 20, max 100 ha net)
- for diesel-fueled pumps

located in the proximity of existing villages (see Table 8.3/1).

There is a natural tendency for the farmer to secure as much water as can be obtained, unaware of the decrease in yield and drainage problems this may create. This results in regular overirrigation and excessive water wastage. Small- scale, smallholder irrigation does not offer any rational opportunity for a systematic control of water abstractions and efficiency of water use. It does not allow any efficient checking of water withdrawals in the dry period, January - mid April, when the irrigation of seasonals should be prohibited. The present development trend, therefore, results in high field losses and cannot achieve an adequate degree of irrigation management and efficiency.

Particular attention is to be paid to this problem in the framework of further development: the grouping of these small-scale systems into some 20 medium-scale systems in the Bardheere riverine area (supplied each by one pumping station and one or two main canals up to 15 km long) offers a sufficient degree of irrigation management required in the ultimate development stage. This development should be aided by activities of the Irrigation Development Support Services.

Some of the undeveloped plains in the Bardheere Riverine Area are distant from existing dwelling centers which requires the creation of new villages. For such conditions, as well for large and wide alluvial plains, the medium-scale, small holder irrigation development (100 to some 600 ha net) is more suitable. This type of irrigation scheme is suitable especially for village or water users association based irrigation projects. It also makes use of the traditional ties of clanship among the local population.

Medium-scale pumping schemes according to the proposed concept are supplied by one pumping station and main canal whose offtakes are equipped by measuring devices. These schemes offer a reasonable opportunity for a rational irrigation management including systematic checking of water abstractions and efficiency of water use. In addition, they enable a rational pump electrification leading to reduction of operation costs. The support of this type of irrigation development may safeguard or even increase the target development pace and create a modern irrigation scheme which may be used for demonstration purposes in this area. Locations where the small-scale development did not yet start, e.g. on the right bank opposite Caanoole (710 ha gross) or on the left bank at the oxbow on the south edge of the Bardheere Riverine Area (240 ha gross) should be selected for this medium-scale development.

The available land of some 7,800 ha gross in the alluvial plain makes for some 6,200 to 6,800 ha net. To achieve the planned target of 10,000 ha, some 3,200 to 3,800 ha of land Class R2 in the marine plain should be irrigated. The marine plain is located some 10 to 60 m above the bed level. Gravity supply directly from the planned Bardheere Reservoir enables to avoid once of high lift pumping. The supply canal would be some 25 km and 40 km long on the right and left banks respectively. Rice cultivation, for which the land is suitable, may not appear economic under these marginal conditions (long diversion canal and highest evaporation losses in the area under study). Diversified cropping requires adequate drainage and so the irrigation of this land can be economic for high-yielding crops only.

Table 8.3/1 Development Options for the Bardheere Riverine Area

Option 1 (actual)	small-scale pumping irrigation schemes
Option 2	medium-scale pumping irrigation schemes
Prognosis	gradual transition from small-scale to medium-scale irrigation schemes

The construction of the Saakow Storage Dam (considered e.g. by LAHMAYER in previous preliminary planning) would severely restrict development possibilities of the Bardheere riverine area. Some 1,000 ha of class 1 and almost 4,000 ha of class 2 land would be flooded and the Canoole region severely affected. Only 12 of the 20 planned medium-scale systems in the riverplain could be developed resulting in a necessity to irrigate class R2 land (located at higher elevation and having thus high power demand) in order to maintain the regional development balance.

Irrigation development should be accompanied by minor drainage measures and minor improvements for flood protection, since the present frequency of flooding is less than once in five years. In addition, the riverbed should be stabilized by construction of two or three concrete sills with sheet piling across the river. These measures will be investigated in the River Morphology Study (based on the Water Quality and Sediment Transport Monitoring). They are aimed at stabilizing the longitudinal profile downstream the dam and conterbalancing the increase of kinetic energy of flow below the planned Bardheere dam released by the sediment-trap effect of its reservoir.

8.3.2 Saakow-Bu'aale Riverine Area (SGU 2)

The technical concept of the irrigation development in this area largely depends on the development pace and availability of investment funds. Some 94,000 ha gross of class 1 and 2 land is available (see Table 7.3/2), a substantial part at higher altitude of the marine plain, too distant from the river to be economically feasible (more than 43,000 ha in the riverplain). As shown in Table 8.3/2 three types of development appear feasible.

Table 8.3/2 Development Options for the Saakow-Bu'aale Riverine Area

Option 1
small-scale pumping (actual):

Option 2
medium-scale development (pumping systems) based on some 16 up to 25 pumping stations for 25,000 ha

Option 3
large-scale development (diversion system) based on the erection of two diversion dams near Saakow and Bu'aale: width 100 to 150 m, gated height 4 m (automatic drum or similar gates moved by hydraulic pressure offer important investment advantages in comparison with taintor radial gates used at Fanoole -see Chapter 7/4)

Prognosis
construction of diversion dams (needed also for the riverbed stabilization) at the early development stage, gradual transition from small-scale development (Option 1) to Option 3. The continuation of present irrigation development (small-scale pumping, share cropper arrangements) should be gradually discouraged, because of low efficiency and insufficient level of management

An economic analysis of these development options of conversion from flood recession agriculture to irrigated agriculture and of grouping of small-scale systems is needed to select an optimum development scenario. This should be studied in the framework of the Irrigation Development Study and respected in the Deshek Conversion Programme.

Any large-scale development in the period before the Bardheere dam completion would result in an increase in water scarcity endangering the lower riparian water users. In such a way the area development would rise from the present 1,600 ha to some 5,000 ha of pumping schemes by 1995, 10,000 ha (5,000 ha by diversion) in 2005 and 25,000 ha in 2015 (see Table 7.3/3 and Figure 7/3). Irrigation of additional land in the marine plain is only marginally feasible because of high pumping lift and/or long distance from the river. This land forms a development reserve.

The planned irrigation development pace in the period 1988-95, therefore, is quite high: 500 to 600 ha annually based mainly on the private indicative of farmers. The uncontrolled expansion of small-scale systems in the broad alluvial plain may lead to a situation where available land in a narrow strip along the banks of the Juba River would be brought under irrigated cultivation, denying thus access to the river and irrigation development of the land not having direct contact with river banks. In addition, a large portion of the deshek land located in the deep depressions, which will be regularly flooded by ground water even in the after dam situation cannot be efficiently used for irrigated cultivation. These depressions whose depths often exceed 6 m do not dry up and form an obstacle which will be difficult to overcome for the supply canals of small-scale irrigation schemes on external slopes (at the edge of the alluvial plain).

The guided development based on a medium-term irrigation development plan, therefore, is needed from the early development stage. To guide the trends of change from the traditional deshek system to modern irrigation the Saakow Deshek Pilot Project will be established. Preliminary survey shows that the medium-scale, small holder irrigation schemes (100 to 1000 ha net) may be well suited for the deshek conversion.

Efficient crop production systems on deshek lands will be established through the Deshek Conversion Programme which will be based on experiences gained in the framework of the Deshek Pilot Project. This will enable to increase the development pace at some 1000 ha on average in the period after 1995. The optimum combination of the small- and medium-scale development in village systems of single desheks depends on local topographical conditions and will be established in the Irrigation Development Study.

The required development target of 20,000 ha over 20 years in the after-dam situation appears suited even for large-scale development by gravity diversion and long-distance conveyance and distribution. The feasibility of diversion dam construction depends on the potential necessity of their double- or multipurpose utilization. These dams whose location has been at this preliminary stage fixed near Saakow and Bu'aale respectively may even be needed for the riverbed stabilization to cope with the erosion which will increase in the after-dam situation due to the trap efficiency of the reservoir. Under such circumstances even large-scale, smallholder development may definitely prove feasible.

Large-scale schemes consist of a diversion dam and main supply canals on both river banks. Irrigation offtakes are equipped by measuring devices offering thus an excellent opportunity for a rational irrigation management including systematic checking of water abstractions and efficiency of water use.

The net irrigable area available in the alluvial plain is estimated at some 25,000 ha and may even be less due to losses of irrigable land in deep depressions. The irrigated agriculture on land in the marine plain where additional 85,500 ha is available due to its distance from and elevation in relation to the river channel can be economically feasible only under special circumstances: for high-yielding export crops.

Accelerated development and the need for riverbed stabilization may require the construction of the Saakow and/or Bu'aale Diversion Dams to be completed simultaneously with the Bardheere dam. This will be investigated in the framework of the River Morphology Study and Irrigation Development Study. The construction of diversion dams would fulfill the basic preconditions for the irrigation of some 25,000 ha to be established already in 2005 (does not appear realistic because of limited construction capacities, credits, unfamiliarity with irrigation, and potential marketing problems).

The alluvial plains in the Saakow-Bu'aale riverine area are flooded once or twice almost every year. Adequate flood protection (against 5 to 20 year floods) would require:

- construction of relatively high bunds, because the levees which constitute the highest spot between the river channel and the deshek depression are annually inundated to a depth up to 2 m;

- change in the reservoir operation regime, decreasing the flood discharges to some 500 m^3/s (which may reduce the planned protection capacity during super floods);

- bypassing excessive floods using old river channels taking off south of Bu'aale (protects the area from the offtake up to the estuary of the Deshek Waamo).

All these measures should be investigated in the framework of the Drainage and Flood Control Study in depth (requires cross sections of the valley or topographical maps with 1 m contours). Bypassing floods via old river channels offers possibilities to store surplus flood water in the Afmadow district, where it is urgently required for improving the unfavorable water balance in the period of drought. Offshore storage in this area would enable an adequate agricultural development, substantially improve the production of this livestock centre and improve the flood protection up to the estuary.

8.3.3 Fanoole - Kamsuma Riverine Area (SGU 3)

Further development of this area in the before-dam situation appears limited, because of limited water supplies in the Jilaal season, and apparent limited capacity to speed up the development of the Fanoole system. More than 40,000 ha gross of class 1 and 2 land (see Table 7.3/2) are available for development.

The Fanoole - Kamsuma Riverine Area is more developed in comparison with other socio-geographic units. Almost all land along the river is already distributed among banana plantations. New land available for irrigation development is distant from the river. The planned initial irrigation development pace is very low due to the water scarcity in the annual dry period (January-mid April) in the times before dam completion. 150 ha in annual average should be brought under irrigation in the period up to 1995. This concerns seasonals, i.e. mainly intensification of the Fanoole Rice Project. The extension of perennials is planned in the time after dam completion only, when sufficient water will be available in the dry period and includes mainly the Juba Sugar Project.

The area under irrigation is planned to be extended from the present 8,000 ha to 10,000 ha in 1995, 20,000 ha in 2015 and to 40,000 ha in the ultimate development stage. 300 ha in annual average should be brought under irrigation in the period 2005. The large-scale development is planned in the period after 2005 (see Table 8.3/3).

The bulk of new lands is located between Fanoole and Jilib and can be supplied by gravity from the existing Fanoole Diversion Dam. Fanoole Diversion Dam exists and offers favorable possibilities for an accelerated development in the after-dam situation. The Left Bank Supply Canal has been constructed already for diversion of water to the Fanoole Rice and Homboy Projects. Its diversion efficiency should be checked and canal sectors with high seepage losses lined or sealed in order to improve the supply of the Fanoole Rice, Homboy and other planned projects. Its diversion capacity is considered to be satisfactory for the planned development on the left bank.

The Fanoole Diversion Dam also offers an advantageous opportunity for gravity supply on the right bank. The Right Bank Supply Canal can be some 25 up to 40 km long. Its length and command area are basically an economic problem and should be derived through comparison of different supply/pumping/command alternatives. This canal can even supply the Juba Sugar Project by gravity (and substantially reduce relevant operation costs), but this also depends on respective percolation and evaporation losses.

The construction of the Right Bank Canal offtaking from the Fanoole Diversion Dam should be completed simultaneously with the Bardheere dam. This will enable the full development of the area up to Qaliakoko-Kamsuma and economize the water supply to the Juba Sugar Project, replacing the pumping with gravity diversion. The development timing depends mainly on construction pace and financing. This should be studied in the framework of the Improving and Extension of Existing Large Irrigation Schemes.

The irrigation development of the lands downstream the Fanoole Rice and Juba Sugar Project up to Fanoole should be studied in the framework of the Irrigation Development Study. Due to the morphology of the terrain and the distance from the river which exceeds 500 m, the land on both banks is better suited for medium-scale, small holder development than for small-scale development. It can also be developed in the framework of a large-scale gravity scheme but that depends on the location of the diversion dam and its impoundment. At this preliminary planning stage, the location of the diversion dam is foreseen between Qualikoko and Kamsuma.

Table 8.3/3 Development Options for the Fanoole - Kamsuma Riverine Area

Option 1	Full utilization of the capacity of the Left Bank Supply Canal. Construction of the Right Bank Supply Canal, Juba Sugar Project supplied by pumping as actually
Option 2	Full utilization of the capacity of the Left Bank Supply Canal. Construction of the Right Bank Bank Supply Canal, Juba Sugar Project supplied by gravity
Prognosis	Transition from Option 1 to 2.

The right bank areas suffer from serious flood and drainage problems which are contributed by:

- the rise in water tables caused by bunds of the Fanoole Rice and Juba Sugar Projects:

- the blocking of the Little Juba channel, which is presently used as the main irrigation canal of the Juba Sugar Project.

Water can be bypassed to the Afmadow area (using old Juba channels - see Chapter 7.6) and also through the Far Shebeel channel. The inflow into the Far Shebeel and Little Juba should be controlled by headworks. If the by-pass of excessive flood water and the effect of the Bardheere storage would not guarantee a satisfactory flood protection against floods with a 10 to max. 20-year probability of occurrence then the bankfull capacity of the Juba river should be increased by bunds and river training. Flood protection of the Juba Sugar Project from backwaters can be increased by bunds along low-lying spots on the Little Juba banks and by relocation of the estuary of the Far Shebeel in the area south of the South Extension Bund of the Juba Sugar Project. These problems will be studied in the framework of the Drainage and Flood Control Study.

8.3.4 Kamsuma-Gobweyn Riverine Area (SGU 4)

This area will see the smallest expansion in the before-dam situation. The present total area of 5,000 ha (3,400 ha of bananas and 1,600 ha rice/seasonals) may expand to 6,000 ha (3,500 ha bananas and 2,500 ha rice/seasonals) using the water made available by increasing the irrigation efficiency in the valley.

In total, more than 25,000 ha gross of class 1 and 2 land and 17,000 ha gross of class R1 and R2 land are available for development (see Table 7.3/2). The area may expand from 6,000 ha to 12,000 ha by 2005 (divided into 5,000 ha bananas and 7,000 ha of rice/seasonals). If labor is no constraint, the target area of 12,000 ha could be expanded up to 37,500 ha net (12,500 ha wetland for paddy rice): however, in view of the rising tendency to waterlogging in the area, growth should be monitored and controlled.

Almost all land along the river is already distributed among banana plantations. New land available for irrigation development is distant from the river. The planned initial irrigation development pace is very low due to the actual water scarcity in the annual dry period (January-mid April) in the times before Bardheere Dam completion. 150 ha in annual average should be brought under irrigation in the period up to 2005. This concerns the completion of the Mogambo Project Phase I and improvement in banana cultivation and irrigation.

The development pace planned for the period after Bardheere Reservoir completion amounts to some 600 ha annually and even more after that period. In this period some up to 1,000 ha annually are planned to be brought under irrigated agriculture. The main bulk of the development area is located west of Kamsuma on the right bank of the Juba River. This area can be supplied by gravity from the diversion dam that is planned to be constructed near Kamsuma or Qualikoko. The dam may serve for riverbed stabilization which should economize the investment. Diversion canals can even supply the Mogambo Project and the banana plantations by gravity, thus reducing operating costs of these projects (see Table 8.3/4).

Some 16,000 ha of land suitable for paddy production and located near Jamaame on both river banks may be located at the end of this system. But the length of the supply canal which may exceed some 40 km may result in high percolation and evaporation losses and make this solution not feasible.The technical concept for irrigation water supply of this area depends on the cropping pattern of these lands and should be studied in the framework of the Irrigation Development Study.

Under the present situation medium-scale pumping is considered to be economically not feasible for rice plantation due to high operation costs but may be feasible for high-yielding, especially export, crops like bananas. Gravity supply with a low-cost diversion dam, located near Jamaame and medium-scale pumping schemes appear as solutions marginally suitable for a large variety of crops including rice and banana production respectively. The selection of the development alternative for this area depends on further studies including results of a detailed soil and marketing survey which will decide about the most appropriate cropping pattern.

Small-scale, small holder development is suitable for the first of the small alluvial plains between Yontoy and Gobweyn. Medium-scale, small holder schemes are better suited for the second and third plain because of their width exceeding 2 km.

For the future development, a diversion dam located between Kamsuma and Qualikoko is envisaged as one of the development options. The gravity supply from the left and right bank canals will replace the pumping used in existing projects (Mogambo and banana plantations) and economize their operations. This should be studied in the framework of the Improvement and Extension of Existing Large Irrigation Schemes.

Table 8.3/4 Development Options for the Kamsuma - Gobweyn Riverine Area

Option 1	Water supply of the existing and developed schemes by pumping
Option 2	Diversion dam near Kamsuma, irrigation water supply by gravity
Prognosis	Gradual transition from the actual Option 1 to Option 2

Large parts of the area suffer from flooding. The frequency of flooding, flood flows and water levels increases simultaneously with flood protection measures upstream. A substantial share of flood water often comes from the intermediate catchment and from the catchments of the Deshek Waamo, Bohol Magaday, as well as the Lower Shebelli and cannot be regulated by the Bardheere reservoir. Flood bypassing projects (recommended in Chapter 7.6) protect the area up to the confluence of the Juba river with Waamo Deshek. All bypassed water (if not stored) return here to the main channel. Backwater effects will result in flooding of land some 20 km upstream so that no improvement in the present situation could be expected. These problems will be investigated during the Drainage and Flood Control Study.

Flood storage in the Homboy and Afmadow area may contribute to the improvement of the flood situation, but flood protection bunds, resectioning and straightening of some river oxbows may still be required.

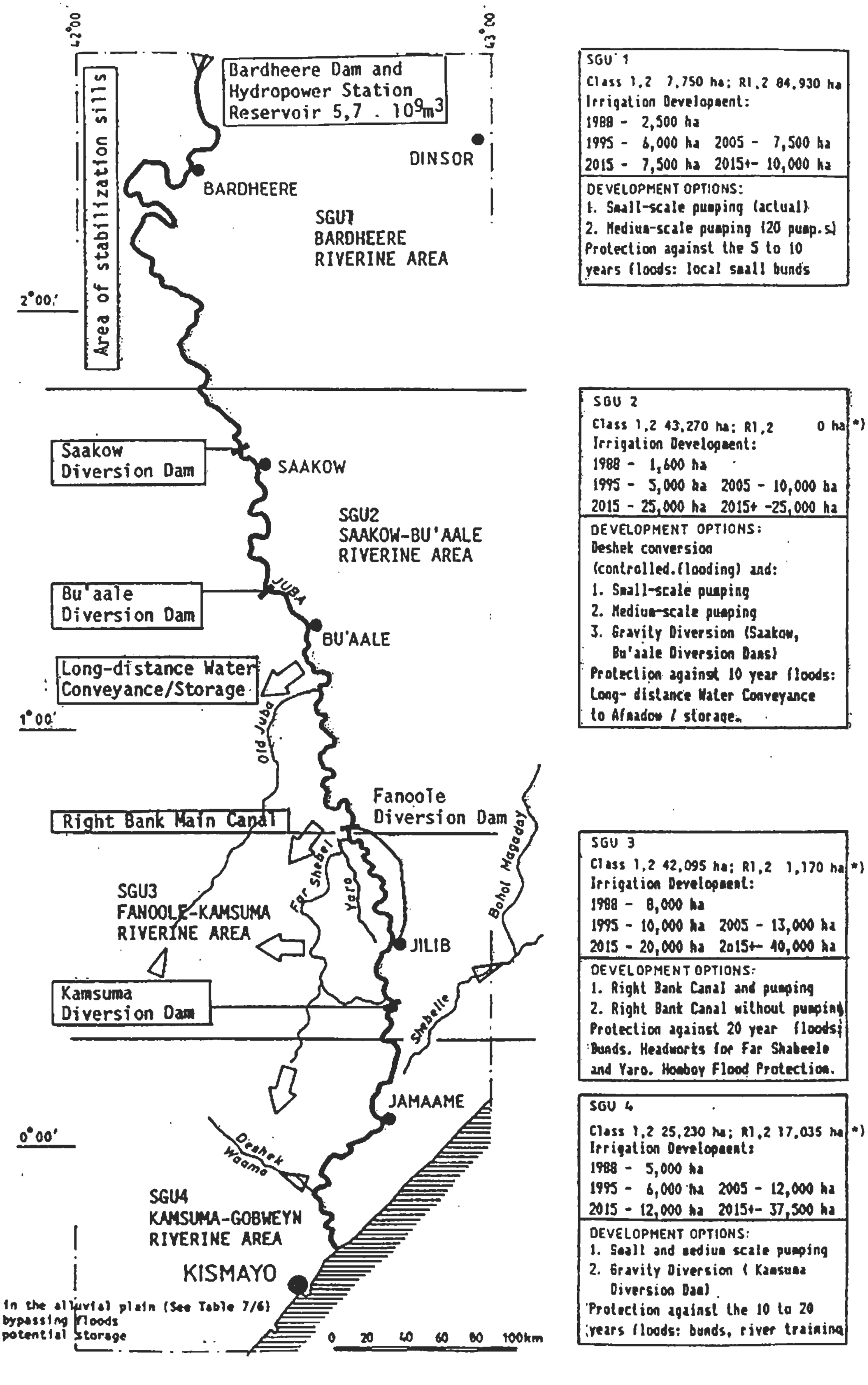
As it can be seen from the water balances (Tables 6.2/9 - 6.2/11), the effect of the reservoir shall prevent seawater intrusion also in the ultimate development stage by securing the minimum discharge of 15 m^3/s. Nevertheless, a seawater intrusion barrier may be constructed downstream Gobweyn in the ultimate development phase (see Gobweyn Seawater Intrusion Barrier Study). This will make the full utilization of regulated discharges for irrigation possible enable to irrigate additional 6 - 9,000 ha and avoid seawater intrusion in the period of maximum demand.

8.3.5 Homboy Area (SGU 6)

Some 6,400 ha gross of class 2 lands and 5,700 ha of class 3 land are available for development. Irrigation water will be supplied to the Homboy area from the Fanoole Left Bank Main Canal. Full operation of this project (7,500 ha net) can only occur if the Bardheere reservoir is under operation. In the before-dam situation that supply can be secured partially by the improvement in irrigation efficiency of existing projects upstream. These problems will be studied under the Homboy Irrigation Project.

According to the existing study Homboy Area and Smallholder Banana Cultivation in the Lower Juba Valley and Assessment of Agricultural Benefits, 1987 (MJVD/MacDonald and Partners, Ltd.), construction of the irrigation facilities could start by 1991 to be ready in first phase (for growing seasonals crops only) by 1994; bananas and rice should only be planted after dam construction and pending initial outcome of water quality monitoring.

Figure 8/2 Overview of Development Options



The flood protection of the Homboy Project can be secured by a flood storage reservoir of 154 x 10^6 m^3 located downstream the Jilib-Mogadishu road. This requires construction of bridges on this road, having a total passing capacity of at least 400 m^3/s. The upper conveyance canal will convey water to the reservoir formed by and earth dam some 4.5 m high. The outfall canal should have capacity of some 10 to 20 m^3/s, not to affect substantially the flood discharge of the Juba river.

8.3.6 Dolo - Luuq and Reservoir Area

As mentioned in Chapter 7.5 irrigation of seasonal crops occurs at present on approx. 1,100 ha up to Luuq and on 600 ha in the reservoir area. Flow abstraction for irrigation cannot be easily prevented and prevention of diversion is not necessary, as long as it occurs in the period mid-April to mid-January in the before-dam period.

Irrigation should be limited to max. 2,000 ha, because of better soil downstream.

8.3.7 West Juba Plains and Deshek Waamo Area (SGU 7 and 8)

The former bed of the Juba river, deflecting some 40 km upstream the Fanoole Diversion Dam, offers favorable possibilities for bypassing of excessive flood discharges (up to 300 m^3/s) as well as long-distance water conveyance of excess discharges during the wet season (up to 50 m^3/s). These discharges can be stored in an (off-storage) reservoir in the West Juba Plains/Deshek Waamo area. Such reservoir/seasonal reservoir may largely improve the livestock breeding and enable the development of irrigated agriculture.

This proposal at a prefeasibility level of the Drainage and Flood Control Study includes:

- topographical survey along the former Juba river (longitudinal profile, cross sections), inlet structure and sections within the area of the potential reservoir dam and outlet;

- studies to determine the layout of the long distance water conveyance and reservoir that gives the adequate storage volume at minimum cost;

- examination of the effects of the scheme on environment, regional development and on flood protection downstream Fanoole;

- preliminary cost estimate.

9. Organization and Development Strategy

9.1 Development Management

The procedure leading to adequate utilization of human, water and soil resources in the Juba valley, i.e. the construction and subsequent operation of the Bardheere dam and the irrigation network (with other accompanying measures according to the Masterplan) contains the following three distinct complexes of management activities: planning, construction management and water resources management.

(i) Planning Activities

Planning is the organization of all activities of the local and international staff (design consultants, constructors etc.) leading to award of contracts for the dam, riverbed stabilization works, diversion structures, pumping stations, irrigation systems, infrastructure as well as other structures and coordination of all activities resulting in:

- the design of the dam, irrigation systems, infrastructure etc. conformed with the optimized multipurpose utilization of water resources available and with the requirements of all groups of users especially farmers, pastoralists and new settlers;
- the prequalification of tenderers, issuing tender documents, appraisal of tenders and contract award etc. leading to a rational gradual and integrated development of soil and water resources;
- the most efficient schedule and methods of construction, mobilizing local forces to the maximum possible extent.

The planning activities will be managed centrally by the Ministry of Juba Valley Development.

(ii) Construction Management

Construction management is the coordination and organization of all activities of the local and international staff (design consultants, contractors, supervising engineers etc.) leading to a rational construction procedure, timely supply of mechanical, electrical and other equipment for the dam, diversion and other structures along the river and for the irrigation systems as well as infrastructure. The construction activities can be managed centrally by the Ministry of National Planning and Juba Valley Development

(iii) Water Resources Management

Water resources management is the organization and performance of all activities leading to a rational water resources allocation and utilization in the before-dam situation and to multipurpose operation, utilization and adequate maintenance of the Bardheere dam and reservoir. It includes an efficient operation and appropriate maintenance of the river channel, water management structures, pumping plants, bunds etc. as well as of the irrigation mains (the responsibility for the maintenance of the secondary and tertiary network may remain with the water user).

While the planning and construction activities can be managed centrally by the Ministry of National Planning and Juba Valley Development, water resources management requires decentralization. For the rational operation and adequate maintenance of water systems a central organization unifying national and regional interests should be supported by a regional Water Development Agency in the Juba Valley. This agency should operate within the physical limits of the Juba river basin in Somalia and manage as well as administer both water resources and water services. The nucleus of this Agency should be established within the framework of the Irrigation Development Support Services.

Water management is a legitimate responsibility of the government whose task should be facilitated by the enforcement of a legal code, but Somalia has virtually no substantive water legislation (see Chapter 6.4). For this reason the FAO consulting group elaborated in 1984 the Text of the National Water Resources Law and a Report with the following five recommendations:

a) The Government should enact water legislation of sufficiently wide scope to lay down clearly its policy objectives, provide water management guidelines and set out the responsibilities of the various institutions that comprise the water management structure.

b) The legislation should provide the National Technical Committee with terms of reference that include the development of a draft water resources master plan with specified contents, and vest the National Technical Committee (NTC) with authority to obtain suitably diverse staff so as to bring a multi-disciplinary approach to water planning. Further, the plan prepared by the NTC should not be considered final and binding until it is presented to, and approved by a ministerial-level National Water Committee.

c) The National Water Resources Master Plan should include provision for the sectoral allocation of water, District by District. The Technical Staff Group should be provided with the authority to monitor and enforce such allocation in accordance with a scheme of diversion priorities. The Ministry of Agriculture should be technically assisted in operating its system of regulating surface water users.

d) Legal authority should be given to the Government to delineate important water catchment areas and water sources threatened by upstream development or pollution. Authority should also be given to adopt specific watershed protection and pollution control guidelines in the Water Resources Master Plan to be observed by Government ministries and private individuals.

e) A simple and practical programme for monitoring and enforcement should be worked out in Somalia. This programme should provide for the monitoring of compliance with the Water Resources Master Plan by all Ministries represented on the National Technical Committee, with coordination provided by the Ministry of Mineral and Water Resources. Enforcement should be likewise coordinated and should be implemented through the existing system of District Officers.

9.2 Summary of Constraints and Potential

In the before-dam situation, the area under irrigation can only be expanded by growing more seasonal crops from mid-April to early January and/or by increasing the actual irrigation efficiency. However, the potential for expansion without storage is considerable: The non-regulated flow of the Juba River in the period of eight wet months during a medium dry year (with 80% probability of occurrence and for the average irrigation efficiency of 33%) enables to irrigate some 50,000 ha and two crops a year (see Chapter 6.2.5). The existing 10,400 ha of perennials, sugar cane and bananas cannot be irrigated without stress management due to low discharges in the dry season January- April.

The extension between 1988 and 1995 for seasonal crops in Juba valley is estimated at 10,000 ha. The start of switching flood recession cultivation to irrigated agriculture is expected to take place in this period. It should be considered to introduce rigid water allocation in the dry period January to April. Nevertheless, no legislative or institutional mechanisms exist at present which would result in a guided and efficient development.

Overall irrigation efficiency is now at about 30%. For the large-scale projects, the efficiency is higher, while it is considerably lower for small-scale irrigation. An expansion of the latter may therefore lead to a decrease in the overall irrigation efficiency, as long as no corrective measures are taken. Priority should be given to medium-scale and large-scale development, which allows a higher degree of irrigation management and efficiency. In the medium term, an overall efficiency of 40% appears to be realistic and 60% should be considered as the ultimate target.

Construction and subsequent operation of the dam will significantly alter the river regime as average flows will be more regular and most of the silt and bedload carried by the river trapped in the reservoir. It can be expected that the changes in the river regime will substantially alter river channel morphology with respect to its gradient, cross section and planform if no adequate measures would be performed. Similarly, the quality of water will change and affect fauna and flora of the river and riverine area.

Reducing flood frequencies and peaks is an important objective of the Bardheere dam. However, peak water release from the dam will be 500-700 m^3/s, while the desheks in the Middle Juba start flooding at 300 m^3/s and the bankfull capacity of the river below Kamsuma is only 400 m^3/s. In addition, the flood inflow from the adjoining catchments of the Shebelli and Bohol Magaday reaches up to 400 m^3/s, while drainage in the Lower Juba is hampered by bunds and roads constructed across natural drains. Flooding will therefore still occur, particularly in the Lower Juba, requiring flood protection works to achieve protection against floods with a frequency of one-in-ten to one-in-twenty years. Operation of the reservoir will require careful balancing of the conflicting needs for electricity, irrigation and flood control.

Drainage is a serious problem in the Lower Juba, requiring immediate large-scale measures in specified problem areas (see Chapter 7.6.3). At the same time, the area under irrigation will require an effective surface drainage system to avoid the problems of waterlogging and salinisation. Monitoring and locally subsurface drainage may be needed to control the rise of groundwater table.

While approximately 360,000 ha gross of irrigable land have been identified, water will only be sufficient to irrigate about 120,000 ha with 160 and 200% of cropping intensity in the dry and average year respectively (Table 6.2/12) (assuming an irrigation efficiency of 40%, up to 38 % of perennial crops) which corresponds to the net hectarage of land land whose altitude and proxmity to the river allows an economically feasible irrigation (see Table 7.3/2).

Before completion of the dam, it is estimated that the present rate of expansion of irrigated area will continue at about 1,250 ha per year. This rate of expansion is not determined by the availability of water, which would allow a much more rapid growth, but by the technical and other constraints the farmers face in bringing land under irrigation. For the period following completion of the dam, it is expected that this rate could be increased to about 3,000 ha per year.

To arrive at the above geographic distribution of irrigated areas, topographical, soil and climatologic conditions were taken into account. At the end of the planning period for this Master Plan, 50,000 ha are thus projected to be under irrigation.

9.3 Outline of the Water Development Strategy

Increased pressure on the available water and land resources in the Juba Valley demands a systematic and flexible approach with a long-term prospect in mind to ensure that a positive trend in water resources is achieved, and development speeded up and stabilized.

The Regional Development Programme sets out the following objectives for the water resources development in the Juba Valley:

- 120,000 hectares net under irrigation in the ultimate phase of development
- the hydraulic system (natural and man-made) to be environmentally compatible.
- flood protection and drainage is adequate.
- irrigation systems secure an adequate standard of water utilization efficiency and an economically feasible operation.

The planned Bardheere dam will regulate the flow of the Juba river creating basic preconditions for irrigation development of 120,000 hectares in the Juba valley. The potential expansion of the irrigated area is determined by geographical and technical factors as well as by other constraints. Three basic development options exist (small-scale, medium-scale, gravity diversion): their balanced application will depend on results of further studies, on the measures to be adapted to control/support further development and on the gradual transfer from the actual predominantly small-scale, smallholder irrigation to other options.

Economic factors will decide on the feasibility of the development options of various sites. The development rate is highly influenced by actual development trends (private initiative in small-scale pumping). The irrigation development in the before-dam situation should be focused on seasonals and requires unavoidably the adaptation of the cropping calendar to the period of water scarcity. The target of 120,000 hectares under irrigation cannot be economically achieved by pumping and small-scale development: gravity systems will be needed to guarantee the feasibility of large-scale development. The dual purpose of the diversion dams (riverbed stabilization, irrigation water diversion) will positively influence the economy of gravity diversion systems.

The trap effect of the planned Bardheere Reservoir will reduce drastically the natural process of sediment transport and channel formation (being presently in an environmental equilibrium). The erosion rate will speed up, increasing the depth (and reducing the width) of the river channel downstream of the dam.

Further studies may confirm the need for construction of stabilization sills/diversion dams to stabilize the riverbed and secure the environmental balance. This could speed up large-scale development in the Saakow-Bu'aale and Kamsuma-Riverine Areas. In the Fanoole-Kamsuma Riverine Area, the Fanoole Diversion Dam exists and forms a favorable precondition for gravity diversion also on the right bank. The narrow valley and scattered alluvial plains in the Bardheere Riverine Area are not favorable for gravity diversion: the efficiency and economy of irrigation in this area should be improved through a transit to medium-scale pumped systems.

The flood protection effect of the planned Bardheere reservoir does not offer adequate security against flooding in areas which are affected by direct runoff from the intermediate catchment. Water and irrigation development measures should therefore contain additional local flood protection components; local bunds, river training, bypassing of excessive discharges (to Afmadow area, where a storage would support agricultural and livestock development). Appropriate large-scale and detail drainage measures are required to drain floodwater, rainwater as well as excess irrigation water to prevent waterlogging, salinisation and increase yields.

The economic feasibility of the Juba valley development will depend on the sustained efficiency of the project operation which includes adequate water use efficiency at the farm level and depends on the project acceptance by the local population. The technical preconditions for this must be secured by the technical standard and economy of water diversion, distribution and field application. Basic preconditions for appropriate water system management to achieve an adequate standard of water utilization efficiency should be formed by the National Water Law, pump and land registration and fixing of charges for water usage.

For the rational operation and adequate maintenance of water systems water management and delivery etc., a central organization in Mogadishu should be supported by a Water Development Agency in the Juba Valley. This agency should act within the physical limits of the Juba catchment in Somalia and manage as well as administer both, water resources and water services: operate the main installations and determine i. a. the measures to ensure the efficient distribution and use of water, adequate flood protection, water conservation as well as measures for controlling the transmission of waterborne diseases.

Summarizing results and findings of Chapters 2 to 7, following water development and management fundamentals have been formulated and measures, projects as well as programmes for their implementation planned (see specification in Chapter 9.4).

Table 9.3/1 Water Development and Management Strategy Principles and Action Plan

Water Development and Management Strategy Principles:	Action Plan: Corresponding Measures, Projects, Programmes	Code (1)
1. Securing the environmental balance downstream the dam and the stability of the Juba channel which are endangered by the regulating effect and trap efficiency of the Bardheere Reservoir	River Morphology Study Riverbed Stabilization Works	WAT 3 WAT 4
2. Excluding saline and other non-irrigable or marginally irrigable land from irrigation, forests and woodland from development, developing class 1 and 2 land first and land for special use in distant time horizons	Irrigation and Drainage Development Study Strengthening of Conservation Efforts for Remaining Riverine Forests	IRR 3 RAN 4
3. Using small-scale pumping to mobilize irrigation development in the Bardheere Riverine Area, reservoir area and upstream Luuq, but focus the effort on grouping of smallholders into medium-scale systems in order to achieve a higher degree of management and decrease operation costs	Deshek Conversion Programme Establishment of Irrigation Development Support Services	IRR 2 IRR 5
4. Using medium-scale pumping schemes to mobilize irrigation development and increase its flexibility in the area downstream Saakow and taking in mind the future integration of individual pumping schemes into medium-/large-scale gravity diversion systems which safeguard a higher degree of management under lower operation costs	Deshek Conversion Programme Irrigation Development Study	CRO 5 IRR 3
5. Developing gravity diversion schemes (Fanoole Right Bank Canal first) according to the availability of investment funds in order to decrease operation costs in existing schemes and widen the feasibility of irrigation for crops other than banana, sugar cane and vegetables	Construction of Irrigation Infrastructure	IRR 4
6. Keeping the utilization of water resources for irrigation purposes in line with their availability, specifying cropping patterns best suited for relevant areas and schemes, adapting the cropping calendar in the before-dam period and gradually increasing the management, delivery and field efficiency of water use	Establishment of a Water Allocation Strategy Establishment of Irrigation Development Support Services	WAT 5 IRR 5
7. Checking the basic technical preconditions and introducing legal and economic tools needed for an efficient operation of main irrigation projects, measuring water delivery and water losses, specifying and implementing remedial and rehabilitation measures	Water Law, Water Pricing Introduction of Cadastral Mapping and Land Registration Training in Irrigation System Management Establishment of Irrigation Development Support Services	- CRO 1 IRR 8 IRR 5
8. Respecting the irrigation priority in the course of multipurpose reservoir operation and securing adequate flood protection by integrating all rational flood protection measures in order to stabilize yields and optimize profit	Bardheere Reservoir Multipurpose Operation Study Drainage and Flood Control Study Establishment of Drainage and Flood Control System	WAT 2 WAT 9 WAT 10
9. Bypassing excess flood water using natural channels for this purpose, storing flood water in offshore reservoirs in order to use it for development of areas distant from the river (Afmadow Area)	Drainage and Flood Control Study Establishment of Drainage and Flood Control System	WAT 9 WAT 10
10. Safeguarding adequate drainage, land levelling in order to increase yields, save water and decrease the salinisation of soils	Homboy Irrigation Project Improvement and Extension of Existing Large Irrigation Schemes	IRR 7 IRR 6
11. Establishing medium-term and short-term balances of water resources and needs and managing the operation of irrigation systems according to actual hydrological and agrometeorological data	Rehabilitation and Extension of River Gauging Stations Establishment of a Water Allocation Strategy	WAT 6 WAT 5
12. Preferring irrigation methods with low irrigation losses (furrow for general arable crops and sprinkler for high-yielding crops) and using water saving techniques in order to achieve a high degree of irrigation operation efficiency	Establishment of Irrigation Development Support Services Improvement and Extension of Existing Large Irrigation Schemes	IRR 5 IRR 6
13. Monitoring of potential problems incl. the rise in groundwater table, water quality and sediment transport and developing adequate mechanism for remedial measures	Introduction of a Water Quality Control System Rehabilitation and Extension of River Gauging Stations	WAT 7 WAT 6

1) Code is the symbol of relevant Project Profiles.

9.4 Development Measures, Projects and Programmes

9.4.1 Objectives

To ensure a sustained and rational use of the river water before and after completion of the BARDHEERE DAM PROJECT a set of measures, projects and programmes is needed for:

- developing water resources and irrigation systems (see Chapter 9.4.2)
- stabilizing the river channel (see Chapter 9.4.3)
- securing flood control and drainage (see Chapter 9.4.4)
- optimizing reservoir operation (see Chapter 9.4.5)
- managing the use of water by legal, economic and organizational tools (see Chapter 9.4.6)
- preventing seawater intrusion into the Juba estuary (see Chapter 9.4.7).

"Measure" is a specific and limited action of short-term duration, which may be preparatory, such as a study, or has to be integrated into ongoing or proposed projects or programmes. "Project" is an action with a fixed time horizon for which required inputs can be clearly defined. "Programme" is a complex of one or several measures and/or programmes and constitutes a long-term development effort for which a clear time horizon and input requirements can only be approximately defined. In the following, specific development measures, projects and programmes are presented.

9.4.2 Water Resources and Irrigation Development

Individual socio-geographic units offer different conditions for the irrigation development. The advantages and disadvantages of basic development options (small-scale and medium-scale, smallholder pumping, gravity diversion, smallholder/parastatal farms etc.) should be investigated individually in each of these units in order to find out their optimum combination.

The irrigation development of 1,250 to 3,000 ha annually will require a coordinated private and governmental effort. It might be desirable to promote the organization of users in more complex special systems or associations. For fully utilizing the available water to irrigate the planned 120,000 ha, several diversion dams (Saakow, Bu'aale and Kamsuma), which may also be required for riverbed stabilization, should be constructed so that water can be supplied by gravity, thus reducing operating costs in comparison with pumping. Alternative programmes for the development of water resources will be evaluated and priority projects selected in the framework of the measure IRRIGATION AND DRAINAGE DEVELOPMENT STUDY. This Study will also have to make an in-depth analysis of the potential salinity hazard that could threaten the exploitation of the irrigation development potential.

Follow-up feasibility studies and all activities leading to award of contracts for the individual irrigation projects as well as all activities leading to a rational construction procedure will be organized and coordinated during a long-term programme CONSTRUCTION OF IRRIGATION INFRASTRUCTURE according to the institutional division of responsibility among the Ministry of National Planning and Juba Valley Development, Ministry of Agriculture and Ministry of Mineral and Water Resources.

The three large-scale irrigation projects (Juba Sugar, Fanoole, Mogambo), are not operating at their design capacity. This is due to water shortage during the dry season, lacking irrigation infrastructure as well as management shortcomings. To prepare these projects for the after-dam situation, when water shortages will not occur, a programme of IMPROVEMENT AND EXTENSION OF EXISTING LARGE IRRIGATION SCHEMES is proposed so that the full potential of these schemes is used efficiently. One of the main tasks of this programme will be the reorganization of the Fanoole and Mogambo projects into smallholder schemes. One large-scale, smallholder HOMBOY IRRIGATION PROJECT has already been studied and should be completed before the Bardheere Dam Project will improve the water supply.

To raise the standard of developing small- and medium-scale irrigation schemes, an effective support service is needed which will advise farmers on the suitability of their land for irrigation, basic layout of fields and canals, forming of water user groups, selection of pumps and design and construction of canals. The establishment of such programme of IRRIGATION DEVELOPMENT SUPPORT SERVICE is therefore proposed. Such support services can effectively only be provided by an organization with staff, offices and other facilities within the Study Area.

One of the tasks of this support service will be assistance to farmers for forming Water User Groups, which are essential to ensure that medium-scale irrigation schemes develop and continue to function on an equitable basis. In the Shebelli River Basin, a long tradition of Water User Groups' exists, and it should not be too difficult to transfer this experience to the farmers in the Juba Valley, as they have the same social background and traditions.

The support services should not be restricted to the initial development, but also to the subsequent operating and maintenance phase. This support should be aimed at increasing the irrigation efficiency, so that an average rate of some 40% is achieved. Improving the efficiency is desirable, even though water will be amply available at least until about 2015, so that farmers understand the importance of correct irrigation and drainage techniques to avoid waterlogging, salinisation and reduce pumping costs. To achieve a higher efficiency, operating and maintenance guidelines have to be developed to form the basis for the work of the support services during the operating phase. To reduce water wastage, on-farm water management practices have to be improved.

It is desirable to convert the flood recession (deshek) agriculture into irrigated agriculture and limit the extent to which irrigation is practiced on a small-scale, as irrigation efficiencies are low and control over abstraction of water is difficult. Instead, medium-scale irrigation schemes of 50-500 ha should be promoted involving 50-150 farmers. To gain experience with the development of such medium-scale schemes the SAAKOW DESHEK PILOT PROJECT is proposed to be followed by a DESHEK CONVERSION PROGRAMME in which the experiences from the pilot effort with respect to irrigation as well as agricultural development will be applied throughout other socio-geographic units. The proposed Irrigation Development Support Services will have to play an active role in this so that the experience made can be fully utilized for the further development of the area under irrigation.

To properly guide and plan irrigation development in the Study Area, well qualified staff are required. To upgrade the knowledge and skills of the national irrigation personnel at the managerial level, a programme of TRAINING IN IRRIGATION SYSTEMS MANAGEMENT AND IRRIGATION ENGINEERING is proposed for selected personnel at recognized overseas institutions.

9.4.3 River Channel Stabilization

The changed flow and sediment transport after construction of the dam will significantly affect the natural process of the channel formation and possibly require stabilization works. Monitoring water quality and sediment transport of the river in the framework of the programme of the WATER QUALITY CONTROL SYSTEM will provide the data required for checking river water quality and riverbed erosion.

To investigate the stability of the river channel and plan stabilization works, a measure named RIVER MORPHOLOGY STUDY is proposed. It also includes a topographical survey of the river channel and floodplains to gain basic data for investigation and mathematical modelling and allow the identification of any measures that might be necessary there. The timing of the study has to be such that the necessary project for RIVERBED STABILIZATION WORKS can be undertaken before the dam starts operating.

9.4.4 Flood Control and Drainage

While the regulated flow of the Juba after completion of the dam will reduce the frequency and magnitude of flooding, especially in the Bardheere and Saakow - Bu'aale socio-geographic units, flood control and drainage works are still required particularly in the Fanoole - Kamsuma and Kamsuma - Gobweyn socio-geographic units to protect the cultivated area against floods with a periodicity up to 10 to 20 years and to drain the excessive water in time. To plan such works, a DRAINAGE AND FLOOD CONTROL STUDY (measure) is proposed which will include topographical surveys, hydraulic studies and the design of the required physical structures. In this study, it will also be taken into account that flood control measures will increase downstream flows which might require the establishment of bypasses and reservoirs for accommodating excessive flows. The Old Juba Channel, for example, appears to be suitable for such a purpose, also allowing that the diverted excess water could be used for development in the Afmadow area. Based on the recommendations of this study, execution of the drainage and flood control works (project: ESTABLISHMENT OF DRAINAGE AND FLOOD CONTROL SYSTEM) is then proposed.

To improve the monitoring of water levels of the river after construction of the dam, the river gauging stations need to be extended and reliably operated in the framework of the measure REHABILITATION AND EXTENSION OF RIVER GAUGING STATIONS. The hydrologic data collection and evaluation system will, together with the system of meteorological stations, form the basis for a proposed flood warning system that will be designed in the framework of the Drainage and Flood Control Study. In addition, the necessary telecommunication and other physical facilities will be established.

9.4.5 Reservoir Operation

Operating of the reservoir of the Bardheere Dam Project requires a tradeoff between partly conflicting goals: hydropower generation, irrigation water supply, cattle and wildlife watering, other in-stream uses, flood protection, sanitary and environmental purposes etc. The hierarchy of objectives and goals should be newly formulated on the basis of planned investigations and experiences gained. It is therefore proposed to undertake a MULTIPURPOSE OPERATION STUDY (measure) for the Bardheere Reservoir. The study will identify criteria for decision-making, optimize the function of the system and define operating rules for different periods of reservoir operation incl. the construction period. Since conditions will change over time, the study will also indicate in which manner it can be ensured that operational requirements will be reviewed and modified accordingly.

9.4.6 Management of Water Use

Passing of the National Water Resources Law is a precondition for any activity aiming at regulating the access to and use of the Juba water. It is of upmost importance that MJVD actively works on accelerating this legislative process. Water legislation should institutionalize water management through laws that regulate the functioning of the institutions involved. This arrangement establishes the conditions on which water may be exploited rationally, and endows organizations with certain resources as well as with the authority to facilitate development and efficient utilization of water resources.

Water management is most effective if regional agencies are established that operate within the physical limits of the catchment basins and are responsible for regional water planning and management. To properly carry out this function, MJVD will have to establish a WATER DEVELOPMENT AGENCY in the Juba Valley with a qualified staff and appropriate facilities. Among the functions of this regional water development and management organization are the following:

- formulating and keeping up-to-date the inventory of the supply and uses of water in the catchment;
- operating and maintaining the water installations necessary to regulate the quantity and quality of water in the catchment;
- reviewing and where appropriate, approving execution and operation of public or private projects that might affect the quantity and quality of water resources in the catchment;
- determining the measures needed to ensure the efficient distribution and use of water in the region including measures in the event of a drought;
- determining the measures needed for flood protection
- determining the measures for water conservation and protection of the catchment area;

- determining the measures to be undertaken for preventing or controlling the transmission of waterborne diseases.

The Water Development Agency will manage the implementation and operation of the irrigation as well as water development and regulate the use of water through

- licenses for the water use (of limited duration, specifying the maximum quantities to be used for relevant periods of time)

- discharge permits (specifying the effluent quality, specific levels of contaminating ingredients in relation to the river flows)

- abstraction and discharge tariffs (based mostly on systematic measurement of water quality supplied and promoting the efficient and beneficial use of water).

As a first step, a programme for establishment of IRRIGATION DEVELOPMENT SUPPORT SERVICES is proposed also involving registration of all pump owners. In addition, the existing Water Allocation Committee consisting of the representatives of the main users is proposed to be reorganized and extended. It will have an advisory role for deciding on reservoir operation in the period after dam. In a further programme the WATER ALLOCATION STRATEGY will be defined already for the actual period and form the basis for controlling the use of water. This should be allocated among the users according to its availability (in the period before dam), the need and relative importance of the users.

9.4.7 Prevention of Seawater Intrusion

A basic river flow of at least 15 m^3/s will be maintained to avoid seawater intrusion in the Juba estuary so that the problem of seasonally deteriorated water quality for irrigation as well as for domestic supply, particularly of Kismayo is avoided. Water quality problems will be followed up systematically after the Introduction of the Water Quality Control System.

In future, although not considered likely at this point in time, it is conceivable that a basic river flow of some 15 m^3/s cannot be maintained at all times. In such a case, construction of a seawater barrier might be needed and a corresponding measure GOBWEYN SEAWATER INTRUSION BARRIER STUDY is proposed.

ANNEX 3

S O M A L I A

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List of Abbreviations

AHT	-	Agrar- und Hydrotechnik GmbH
JESS	-	Juba Environmental Socioeconomic Studies
JSP	-	Juba Sugar Project
LF	-	Labour Force
MIP	-	Mogambo Irrigation Project
MJVD	-	Ministry of Juba Valley Development
MNP	-	Ministry of National Planning
MU	-	Manpower Unit
SGU	-	Socio-Geographic Unit
SoSh	-	Somali Shilling
USBR	-	US Bureau of Reclamation

Human Resources

1. Present Stage of Development

1.1 Data Situation

The assessment of human resources and labour force potentials in the Juba valley proves to be extremely difficult. In addition to the lack of economic and labour statistics even the most basic requirement of reliable population statistics on regional and district level is not given. Data of the recent national census conducted until early 1987 are not yet available.

Most of recent population estimates mainly referring to the first nationwide census in 1975 vary considerably according to different assumptions on population growth rates, refugee figures and on the portion of the nomadic population. However, not only recent population estimates are quite problematic, also the 1975 Census cannot be regarded as a basis for a realistic population estimate. This is due to problematic enumeration procedures (the census was combined with a mass adult education and vaccination campaign and enumerated only its participants) and particular historical circumstances (the Ogaden conflict which increased the number of refugees; and the 1975 extreme drought causing nomadic movements to the river valley) which biased the census' results, as well as to changes of administrative subdivisions after 1975 (for further discussion of the 1975 Census and recent population estimates see APPENDIX).

Basic information on settlements and households could be drawn from the "Sampling Frame for Somalia" [Source: 50] elaborated by the Statistic Central Bureau of Sweden/Ministry of National Planning. This source, however, provides only roughly estimated information on urban and rural settled population (for further discussion see APPENDIX). The authors themselves concede that "number of households might be grossly in error". Consequently, household figures of the sampling frame had to be reconsidered by evaluating also other sources of information. This was possible on the basis of the evaluation of aerial photographs, different field studies and own observations. It was found that rural figures of the sampling frame entail considerable over estimations of the rural and urban settled population in areas with a low population density and a high proportion of nomadic population. However, figures of the rural settled population in districts of the Study Area which are not characterized by an outstanding proportion of nomads proved to be quite reliable. With the exception of Kismayo, urban figures were clearly overestimated and were recalculated on the basis of aerial photographs.

In order to achieve a realistic population estimate, a mixed approach was adopted based on the following elements:

- recalculated data based on the 1975 population census
- information on settlements, households and nomadic population provided by the Ministry of National Planning [50, 52]
- the interpretation of aerial photographs
- household, demographic and socioeconomic data derived from field studies.

The analysis of the present socioeconomic situation in the Study Area is mainly based on data which could be derived from the JESS Baseline Survey (1). It has to be considered that at the time of report preparation, the survey was not yet completed. The major part of data was restricted to the rural settled population in five districts: Kismayo, Jamaame, Jilib, Bu'aale and Saakow. Only for a minor part, data of the rural settled population in Bardheere District and the urban population of all district centers in the Study Area could be included. The nomadic sample of the survey was not available as well as data of the women's baseline survey. The JESS survey comprises data on individual as well as on household level. At the time of report preparation, a rural settled sample of 1,945 individuals was available, later supplemented by 1,094 individuals of the Bardheere sample. The figures, however, include also absentee persons. Since absentees were mainly former household members (see 4.6), it was decided to subtract them for the purpose of data analysis on household level. The rural settled household sample consists of 257 households and the urban sample of 244 households.

1.2 Population in the Study Area

1.2.1 General Considerations and Assumptions

Different assumptions on population growth rates, the portion of nomads in the total population, and the average household size lead to considerable variations in population estimates. The following considerations are made:

1.2.1.1 Population Growth Rate

Estimates with regard to population growth rates range from 2.6% to 3.9% (1975-1980) respectively, and up to 8.1% concerning the period from 1980 to 1985 (2). Estimates concerning the period after 1985 tend to assimilate to figures around 3% (3). The particularly high estimates of annual population growth rates before 1985 can be explained by the inclusion of refugee figures into population statistics (see APPENDIX). Apart from refugee figures, annual growth rates high above 3% seem to be as unlikely as its decrease below 2% until 2015 [33]. High birth rates are countered by an extremely high infant mortality. Extraordinarily high death rates of children below the age of six are reported for the Study Area.

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1) The JESS Baseline Survey (Juba Environmental and Socioeconomic Studies) is carried out for the Ministry Juba Valley Development by the U.S. Agency for International Development/Associates in Rural Development, Inc. Data were not yet elaborated by the JESS team itself and had to be worked up before the elaboration for this report.

2) Estimates of annual population growth rates before 1985: 8.1% resp. 3.9% by U.S. Census Bureau for the periods 1975-1980 and 1980-1985; 3.78% by FAO for 1980-1985; 2.91% by United Nations; 2.8-3.0% by World Bank 1985 and 1987; 2.6% by Impresit 1979; 2.81/3.1% by MNP 1986; 3.1% by MNP 1987; 2.7% by AHT 1985.

3) Estimates after 1985: 3% by ASHS/U.S. Census Bureau 1985; 3.1% by MNP 1987; decreasing to 1.9% until 2015 by Impresit 1979.

According to a survey by the Swedish Church Relief in the Middle Juba Region, between 76% and 85% of the dead children, recorded by families in the districts of Saakow, Bu'aale and Jilib, were below the age of 6 years [89]. This is supported by JESS data. The majority of family members reported as dead were children. On account of that it is most unlikely that the average annual population growth rate will by far exceed 3%. Since infant mortality in the Study Area is extremely high, it is assumed that an annual average population growth rate of 2.8% is a reasonable figure.

1.2.1.2 Nomadic Population

A realistic estimate of the nomadic population is extremely difficult. All recent population estimates are not based on enumeration of nomads but on an assumed percentage of their proportion to the total population. Those percentages range from 42% to 60% and more (1). Furthermore, reliable information about sedentarization processes are not available. No clear distinction can be made between nomadic and semi-nomadic lifestyles. Forms of partial sedentarization - part-time settlements or settlements of parts of nomadic families - are still poorly studied. In addition, it has to be considered that sedentarization processes are reversible.

On this background, the population estimate for the Study Area has, again, to refer to assumptions on the nomadic portion in the total population. Figures on district level are provided by the most recent statistical publication of the Ministry of National Planning [52]. According to this source the distribution of settled and nomadic population is 62% to 38% with regard to the Lower Juba Region, 42% to 58% for Middle Juba Region, and 35% to 65% for Gedo Region. On district level there are considerable variations ranging from 12% to 78% in Lower Juba Region, 39% to 46% in Middle Juba Region, and 27% to 92% in Gedo Region. The following figures are reported for the districts of the Study Area and are taken for further calculations:

Kismayo:	18%
Jamaame:	12%
Jilib:	38%
Bu'aale:	39%
Saakow:	46%
Bardheere:	37%

Due to the nature of nomadic lifestyle and sedentarization processes which are often forced by droughts, it is, however, not possible to assume that these statistical proportions are in line with the real distribution at certain periods of the year and over several years.

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1) The following estimates are made: 50-60% by Janzen 1986; 60% by AHT 1985; 44% by Technital 1976; 44.4% by MNP 1987; 46% by World Bank 1987; 42.4% by MNP 1986; 44.4% by ASHS/U.S. Census Bureau 1985; 46% by Population Census 1975.

1.2.1.3 Average Household Size

Since the estimate of the rural settled population is based on household figures the determination of the average household size is most decisive. However, as it is true for other socioeconomic indicators, also assumed average household sizes vary considerably, ranging between 4.5 to 7.5 persons. The World Bank assumes an average household size of 5.5 persons [32]. The Impresit mission of 1979 [33] found that a nuclear family consists of 6 persons in urban centers and of 7 persons in rural areas, expecting that these figures tend to decrease.

Recent studies in the Study Area came to similar results. The Homboy Study of 1980 found an average household size of 5.48 persons. Figures collected by the successive Homboy study in 1986 indicate a wide variation of family size but with a typical household of five to six persons [76, ANNEX 1]. In its 1983 study Swedish Church Relief found average household sizes between 5.4 and 6.9 persons with regard to different districts [89]. Another study in the same areas, however, reports considerably lower household sizes between 4.4 to 5.5 persons on average [69, ANNEX 6].

From the data collected for the JESS Baseline Survey, covering all districts and the largest household sample, an average household size of 5.9 persons for the rural settled and of 6.3 persons for the urban population was calculated. The first figure was used for calculating the rural settled population of the Study Area.

1.2.2 Population Groups and Distribution

Based on the above considerations and assumptions, the evaluation results in an estimated amount of about 510,000 inhabitants in 1988 in the Study Area. JESS data indicate a population of 1,034,100 people for the three regions of Gedo, Middle Juba and Lower Juba, an area about three times larger than the Study Area.

The breakdown of total population into its urban, rural settled and nomadic parts on district level is shown on Table 1.2/1.

Of the total population, some 26% live in urban and 74% in rural areas, the latter consisting of 59% rural settled and 41% nomadic population. About 80% of the urban population is concentrated in the southern part of the Study Area, the majority (60%) in Kismayo. High concentrations of the rural settled population occur in Bardheere and Jamaame Districts followed by Jilib District. The lowest concentration of the settled population occur in Saakow and Bu'aale Districts.

The highest concentrations of nomads appear to be around Bardheere, followed by Jilib and Saakow Districts. However, as mentioned above, these figures are of little significance.

Table 1.2/1 Population in the Study Area 1988

District	Urban No.	%	Rural No.	%	Nomadic No.	%	Total No.	%
Kismayo	80,200	15.7	20,400	4.0	22,100	4.3	122,700	24.0
%	(60.4)		(9.2)		(14.2)		(24.0)	
Jamaame	9,400	1.8	53,100	10.4	8,500	1.7	71,000	13.9
%	(7.1)		(23.9)		(5.5)		(13.9)	
Jilib	16,400	3.2	44,700	8.8	37,500	7.3	98,600	19.3
%	(12.3)		(20.1)		(24.1)		(19.3)	
Bu'aale	2,800	0.6	18,700	3.7	13,800	2.7	35,300	7.0
%	(2.1)		(8.4)		(8.9)		(6.9)	
Saakow	6,800	1.3	28,000	5.5	29,600	5.8	64,400	12.6
%	(5.1)		(12.6)		(19.1)		(12.6)	
Bardheere	17,200	3.4	57,400	11.2	43,800	8.6	118,400	23.2
%	(13.0)		(25.8)		(28.2)		(23.2)	
Study Area	132,800	26.0	222,300	43.6	155,300	30.4	510,400	100.0
%	(100.0)		(100.0)		(100.0)		(99.9)	
Afmadow	5,400							
Dinsor	7,400							
Luuq	12,000							

In order to arrive at a more significant picture of population distribution, the following analysis concentrates on the settled population. Table 1.2/2 shows the degree of urbanization per district not considering nomads.

Table 1.2/2 Degree of Urbanization

District	Urban population	Rural settled population	Degree of urbanization (%)
Kismayo	80,200	20,400	80
Jamaame	9,400	53,100	15
Jilib	16,400	44,700	27
Bu'aale	2,800	18,700	13
Saakow	6,800	28,000	20
Bardheere	17,200	57,400	23
Total	132,800	222,300	37

The highest degrees of urbanization in the Study Area are to be found in the southern districts of Kismayo and Jilib. Whereas Kismayo District has a low concentration of rural settled population, high concentrations coincide with high urban densities in Jilib and Bardheere Districts. In Jamaame District most of the settled population is living in rural areas. In Bu'aale and Saakow Districts low concentrations of the rural settled population coincide with low urban densities.

With reference to particularly agricultural activities, population concentrations occur in two major zones:

- the area of large estates and medium scale farms (bananas) in the Jilib/Jamaame area, and
- the intensive rainfed and small-scale irrigation areas around Bardheere and to the North-East between Bardheere, Dinsor and Saakow.

The lowest population densities occur along the middle portion of the Juba river between Saakow and Fanoole; this fact can partly be explained by the lack of accessibility of this area.

Table 1.2/3 shows clearly that by far the majority of the rural settled population is living in the riverine area; in the case of Bu'aale District practically no rural settled population lives outside this zone. While population densities are generally low in the Study Area, the highest densities with regard to the riverine population as well as to the off-river population occur in Jamaame District.

Table 1.2/3 Densities of Rural Settled Population

District	Area per district km^2	Rural settled population people	Density per district people/km^2	Population near river people	Density near river(1) people/km^2	Population off river people	Density off river people/km^2
Kismayo	7,630	20,400	2.7	17,400	77.2	3,000	0.4
Jamaame	1,620	53,100	32.8	39,000	47.6	14,100	17.7
Jilib	7,860	44,700	5.7	36,100	37.1	8,600	1.2
Bu'aale	6,400	18,700	2.9	18,600	18.7	100	-
Saakow	5,940	28,000	4.7	14,700	18.4	13,300	2.6
Bardheere	10,410	57,400	5.5	33,300	27.5	24,100	2.6
Total	39,860	222,300	5.6	159,100	33.7	63,200	1.8

1) A 15 km stretch along the river has been taken as basis for the determination of population density in the area close to the river as against the overall density.

1.2.3 Age and Sex Structure

1.2.3.1 Age and Sex Structure on National Level

Figures which are available on national level with regard to the age and sex structure of the Somali population do not show remarkable differences. Figures of the overall sex ratio vary between 1.04 and 1.045 [51]. Figures concerning the age structure also do not differ significantly, but use different age groupings [32, Social Indicator Data Sheet] (see Table 1.2/4).

Table 1.2/4 Age Structure on National Level

World Bank Age group	World Bank %	MNP Age group	MNP %
< 15	44.9 %	< 10	32.2 %
15 - 64	52.3 %	10 - 64	63.7 %
> 64	2.8 %	> 64	3.1 %

Source: [32, 52]

1.2.3.2 Age and Sex Structure in the Study Area

The age and sex structure found in the Study Area according to the JESS Baseline Survey is similar to figures reported for the national level. The age groups below 10 and 15 years cover 31% and 45% of the total population respectively. The sex structure in these age groups is relatively balanced. Only 4.6% of the total population reaches an age of 60 years, females being considerably under-represented. 52% of the total population is covered by the age groups between 15 and 64 years. Table 1.2/5 illustrates the present age and sex structure (in %) of the Study Area as it could be derived from the JESS Baseline Survey:

Table 1.2/5 Age and Sex Structure of Settled Population (in %)

Age group	Male	Female	Total
< 10	16.0	15.1	31.1
10-14	7.8	6.2	14.0
15-19	5.9	5.5	11.4
20-29	6.2	8.7	14.9
30-39	3.9	6.0	9.9
40-49	4.2	4.1	8.3
50-59	3.3	2.5	5.8
60-64	1.3	0.8	2.1
> 64	1.5	1.0	2.5
Total	50.1	49.9	100.0

Source: [81].

1.2.4 Household Composition and Size

The average household size found for the settled population in the Study Area is 6.1 persons. Rural settled households consist of 5.9 persons (Bardheere District not included), and urban households of 6.3 persons on average. Absentees not related to the household by support for or from the family, but included in the JESS household sample are not considered. As shown in Section 1.2.1.3, figures which could be derived from the JESS Baseline Survey are confirmed by other studies reporting household sizes between 5.5 and 6.5 persons.

Although a clear network of ties exists between members of the larger extended family group, households are dominated by the nuclear family relationship: first grade relations make up 97% of the average household composition. 14% of all household members are household heads, 19% wives, and 63% sons and daughters. Thus, an average household of six persons consists of one household head (in 93% of cases male persons), one or two wives, and three or four children.

The overall ratio between husbands and wives of 100 to 150 reflects the polygamous marriage system which is less marked in urban than in rural settled households, the first showing a ratio of 100 to 130, the latter of 100 to 160.

Table 1.2/6 Household Composition (in %)

Household member	Rural settled	Urban	Total
Male/Female household head	12.6/0.8	13.2/1.1	12.9/0.9
Wife/Husband	20.0/0.7	17.4/0.7	19.1/0.7
Children	62.7	63.9	63.1
Parent/Sibling	1.6	1.7	1.6
Others	1.6	2.0	1.7
Total	100.0	100.0	100.0

Source: [81]

1.3 Labour Force Participation and Distribution

1.3.1 General Considerations

According to an estimate of the World Bank [32, Select Demographic Indicators] the labour force of Somalia in 1985 consisted of 72% males and 28% females. The respective labour participation rates for males and females are 54% and 22%. The underlying labour force definition, however, is problematic for the following reasons:

- it does not entail subsistence and informal economic activities
- it does not consider that a significant part of agricultural work is performed by women
- it only covers the age groups between 15 and 64 years.

Figures which are based on this labour force definition usually underestimate the economically active population at least in two respects: the contribution of females and of children below 15 years.

Considering a female participation rate of 22% and an age dependency ratio of about one, about 40% of all women would not be regarded as economically active. This assumption has to be reconsidered in the following way: household work, at least in developing countries, contributes significantly to subsistence production as well as to production for local markets. Furthermore, it is well known that women, apart from household work and home production, perform a high proportion of agricultural work.

Taking into account that the portion of children between 10 and 14 years in the total population is about 14%, its exclusion from the labour force definition leads to a considerable distortion of reality. In Somalia it is an obvious fact that even children below the age of ten are economically active, particularly with regard to herding activities, and play an important role for the family's labour supply.

1.3.2 Labour Force Participation in the Study Area

The above is confirmed by the evaluation of JESS baseline data: 89% of children at the age of 10 to 14 years, and still 77% at the age of 7 to 9 years were found to be economically active (however, to a lesser degree). Most of them are engaged in farming, herding and household activities. The labour force participation of females is as high as of males.

A labour force definition which is employed for assessing labour potentials has to consider these facts. Therefore, an equal labour force participation rate for males and females is assumed, and the age groups between 7 and 14 years are included in the labour force definition.

According to these considerations, about 346,000 persons are economically active in the Study Area in 1988, consisting of 23% children below the age of 15 and 77% young and adult people up to the age of 64. Labour force participation in rural areas (72%) is considerably higher than in urban areas (57%) resulting in an overall labour force participation of 68%.

Economically active children and elderly people (considering health conditions), however, do not supply a full manpower unit. In order to achieve a rough order of magnitude concerning labour potentials, labour supply, therefore, has to be weighed according to the relative work performance of different age groups. Using 1.0 as the weighing factor for age groups between 15 and 39 years, 0.8 for those above 39 years, and 0.4 for those below 15 years, the supply of manpower units is 57% for the rural settled and 51% for the urban population, resulting in an overall manpower supply rate of 55%. The present labour force of about 346,000 persons, thus, supplies 288,500 manpower units.

1.3.3 Distribution of Labour Force to Economic Sectors

Since clear information about the nomadic population as well as studies of the urban secondary and tertiary sector is not available, the labour force distribution to economic sectors is difficult to assess. In addition, the common occupational multiplicity makes sectoral divisions to a certain degree arbitrary.

According to the JESS Baseline Survey, more than 90% of the rural labour force is absorbed by agricultural and subsistence activities. Some 58% is engaged in farming, some 25% in household work, and some 11% in herding as the major occupation. About 55% of the rural settled labour force is engaged in additional economic activities which are also dominated by agricultural and subsistence activities.

Secondary and tertiary sector employment is of minor importance in rural areas, particularly in the Middle Juba Region. Only 5% of the labour force were found to be employed in these sectors as the major occupation, and 7% as the second major occupation. The lack of infrastructure and economic opportunities, particularly in the districts of Saakow and Bu'aale, is a structural obstacle for development of non-agricultural employment. This is true for crafts and trading but also for marketing activities of farmers. It has, however, to be considered that a considerable part of handicraft activities (performed by women) in the household may not be covered by the categories of major and second major occupation. This is suggested by a Swedish Church Relief survey in Middle Juba Region [89], reporting that the majority of women are engaged in handicraft activities and sell their products on the local market.

In urban areas the situation is different with regard to the commercial and services sector. Within the latter civil service employment plays a major role, particularly in regional centers. Not taking into account household work which is performed by about 53% of economically active people (usually females), some 28% of the remaining labour force was found to be employed as civil servants. Further 22% are engaged in trading and private business as the major occupation.

Manufacturing and crafts activities are not significantly developed. About 11% of the urban labour force is employed as wage labourers, drivers and mechanics. Agricultural employment, however, is still the most important field of activity covering some 32% of the urban labour force apart from household activities.

The sectoral labour force distribution, presented in Table 1.3/1, is based on the following assumptions:

- off-farm employment in rural areas concerns some 10% of total employment
- off-farm employment in urban centers is differentiated according to their economic and administrative importance, making up
  . 90% in Kismayo
  . 70% in Jilib
  . 50% in Bardheere
  . 40% in Jamaame
  . 30% in Bu'aale
  . 20% in Saakow
- off-farm employment within the nomadic sector does not cover more than 2% of the total nomadic labour force.

Table 1.3/1 Sectoral Distribution of Labour Force

Labour force	Agricultural		Non-agricultural		Total	
	No.	%	No.	%	No.	%
Urban	19,700	5.7	56,100	16.2	75,800	21.9
Rural	143,000	41.4	15,900	4.6	158,900	46.0
Nomadic	108,800	31.5	2,200	0.6	111,000	32.1
Total	271,500	78.6	74,200	21.4	345,700	100.0

Some 79% of the labour force is engaged in the agricultural sector, consisting of about 41% rural settled labour force, 32% nomadic labour force and, 6% urban labour force.

The non-agricultural labour force covers some 21% of the total of which about 16% are in the urban, 5% in the rural settled, and 1% in the nomadic labour force.

The rural settled labour force makes up 46% of the total, followed by the nomadic (32%) and the urban labour force (22%).

The present labour force potential in urban and rural settled agriculture is about 47% of the total labour force.

1.3.4 Geographical Distribution of Labour Force

In order to arrive at a spatial distribution pattern for the settled population, Table 1.3/2 illustrates the distribution of farm and off-farm labour per district.

Table 1.3/2 Geographical Distribution of Settled Labour Force

District	Agricultural		Non-agricultural		Total	
	No.	%	No.	%	No.	%
Kismayo	17,700	10.9	42,700	59.3	60,400	25.7
Jamaame	37,400	23.0	5,900	8.2	43,300	18.5
Jilib	31,600	19.4	9,800	13.6	41,400	17.6
Bu'aale	13,100	8.1	1,800	2.5	14,900	6.4
Saakow	21,100	13.0	2,800	3.9	23,900	10.2
Bardheere	41,800	25.7	9,000	12.5	50,800	21.6
Total	162,700	100.1	72,000	100.0	234,700	100.0

Labour force concentrations occur in southern and northern districts. Farm labour potentials are concentrated in the districts of Bardheere, Jamaame and Jilib.

Non-agricultural employment is highly concentrated in Kismayo, followed by Jilib and Bardheere. As already indicated in Table 1.2/3, the vast majority of these labour potentials is located in the riverine area.

1.4 Socioeconomy and Labour in the Rural Settled Subsistence Economy

1.4.1 Main Economic Activities and Occupational Patterns

Almost all households covered by the rural settled JESS sample do farm and own a farm. Out of a total of 257 households 93% are engaged in farming and 90% own a farm.

The predominant occupational pattern of farming is followed by household work in which 22% of all individuals are engaged as the major occupation and 17% as the second major occupation. Besides farming and household activities only herding is of considerable importance: 9% of the sample population perform herding as their major and also 9% as their second major occupation.

These three main economic activities cover about 87% of all individuals performing major occupations and 79% of all individuals performing additional occupations.

The distribution of major and second major occupations is shown in detail in Table 1.4/1.

Table 1.4/1 Rural Settled Occupational Patterns

Occupation	Major Occupation No.	Major Occupation %	Second Major Occupation No.	Second Major Occupation %
Farming	807	57.5	240	17.1
Household	355	25.3	283	20.2
Herding	153	10.9	142	10.1
Driver/Mechanics	21	1.5	8	0.6
Civil Servant	21	1.5	5	0.4
Private Business	13	0.9	13	0.9
Hunter/Gatherer/Fisher	11	0.8	3	0.2
Wage Labourer	8	0.6	12	0.9
Crafts	4	0.3	45	3.2
Trading	4	0.3	10	0.7
Others	7	0.5	4	0.4
Total	1,404	100.1	765	54.5

Source: [81]

Farming and other economic activities are combined considerably indicating that occupational multiplicity of individuals and within households is an important security-seeking strategy of rural households.

Out of a total of 807 individuals engaged in farming as the major occupation only 43% (348 persons) do not perform additional occupations. Occupational multiplicity will even be higher on household level. The combination of farming as the major occupation with other economic activities is illustrated in Table 1.4/2.

Table 1.4/2 Occupational Multiplicity of Farming Labour Force

Major Occupation	Second Occupation	No.	% of farmers
Farming	Household work	241	29.7
	Herding	110	13.6
	Crafts	33	4.1
	Wage labourer	12	1.5
	Private Business	9	1.1
	Driver/Mechanic	5	0.6
	Civil Servant	4	0.5
	Hunter/Gatherer	3	0.4
	Other	42	5.2
Total	807	459	56.7

Source: [81]

Most of additional activities, household work in particular, is performed by women which are mainly engaged in farming. A further important additional occupation performed by farmers is herding. Herding makes up 24% of all additional activities and is performed by 13.6% of the individuals who are mainly engaged in farming. Occupational multiplicity is also recorded for those persons whose major occupation is herding. Out of a total of 153 individuals only 34% do not have an additional occupation. 47% of all individuals engaged in herding as the major occupation are additionally engaged in farming activities. The combination of farming and herding is the most important type of combining economic activities and income sources in the Study Area.

Though secondary sector performance is low and meets structural limitations, the combination of primary and secondary occupations is an important employment pattern that will increase in future. Actually about 8% of individuals, mainly engaged in farming activities, perform trading, crafts, private business as additional occupations or work as driver, mechanic and wage labourers.

With regard to off-farm employment as the major occupation it is striking that about 50% of employees also depend on other economic activities and income sources. This supports the assumption that employment in the secondary sector as well as in the tertiary sector generally does not earn a living for a family and is mainly regarded as an additional economic activity.

1.4.2 Female Labour

As said before, household work is performed by about 39% of all individuals covered by the household sample. 22% are engaged in household work as the major and 17% as the second major occupation. The bulk of household work is performed by women. They cover 95% of the household work that is performed as the major and 91% as the second major occupation.

It is important to recognize that household work is not equivalent to housework that is often defined by the tasks of caring for husbands, children and kitchen. Household work, at least in rural areas of developing countries, covers a considerable part of subsistence production. As necessary production of means of living it has to be considered as a main economic activity.

Though household work is mainly female labour it does not dominate female occupational patterns. This is expressed in Table 1.4/3 which illustrates the portion of males and females in major and second major occupations.

Table 1.4/3 Sexual Division of Labour by Occupations

Occupation	Major Occupation Male %	Major Occupation Female	Second Major Occupation Male %	Second Major Occupation Female
Farming	51.9	48.1	42.5	57.5
Household	4.8	95.2	8.8	91.2
Herding	66.6	34.0	64.1	35.9
Driver/Mechanics	90.5	9.5	100.0	0.0
Civil Servant	100.0	0.0	80.0	20.0
Private Business	69.2	30.8	83.3	16.7
Hunter/Gatherer	63.6	36.4	100.0	0.0
Wage Labourer	87.5	12.5	91.7	8.3
Crafts	50.0	50.0	44.4	55.6
Trading	25.0	75.0	60.0	40.0
Total	48.8	51.2	53.3	46.7

Source: [81]

The above figures show that occupations are evenly distributed to males and females. In particular, this is true with regard to farming. Farming as the major occupation is performed by 52% of males and 48% of females. Farming as the second major occupation is performed by only 43% of males but 57% of females.

More women are engaged in farming as the major occupation (388) than in household work (338). Most females engaged in farming as the major occupation perform household work as the second major occupation (62%). And many females engaged in household work as the major occupation are engaged in farming as the second major occupation (34%).

Household work as the only and major economic activity is only performed by 24% (185) of all females economically active.

In addition to household work and farming women are considerably engaged in herding, crafts and trading. Herding is performed by 52% of females as the major and by 51% of females as the second major occupation. The absolute number of persons in crafts and trading is low but the relative share of females in these economic activities is high: in crafts 50% as the major and 56% as the second major occupation; in trading 75% as the major and 40% as the second major occupation.

Female labour plays a decisive role in labour supply strategies of rural households. The polygamous marriage system has to be regarded as a labour supply system: separate plots of farmers are allocated to different wives who, additionally, have to work on the husbands' plots.

1.4.3 Subsistence Farming and Combination of Income Sources

More than 90% of rural settled households do farm and own a farm. The percentage of households which farm and own a farm decreases from Saakow District in the North to Kismayo District in the South. The combination of farming and livestock is an important element subsistence economies, a considerable part of farmers combine farming activities and livestock keeping (see Table 1.4/4). 53% of farming households also keep cattle, a security-seeking strategy that often is used by rainfed farmers. Occupational patterns show that about 17% of economically active individuals perform both farming and herding activities. Furthermore, for 37% of farming households livestock is a source of monetary income (see Table 1.4/6). This figure is even higher in Saakow District (53%), in Bu'aale District (43%), and in Jamaame District (41%).

Table 1.4/4 Farm Households and Livestock Keeping

Item	Kismayo		Jamaame		Jilib		Bu'aale		Saakow		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Do farm	31	86.1	68	88.9	48	88.9	57	95.0	36	100.0	240	93.4
Own a farm	30	83.3	62	87.3	48	88.9	56	93.3	36	100.0	232	90.3
Keep cattle	21	58.3	50	70.4	14	25.9	33	55.0	19	52.8	137	53.3
Keep camels	1	2.8	7	9.9	3	5.6	9	15.0	6	16.7	26	10.1

Source: [81]

Another security-seeking strategy within the agricultural sector is the combination of cropping pattern and land types. With 65% of all households owning land the majority cultivates rainfed farms. 29% owns river bank plots, 20% desheks and 2% levee land. 19% of households combine different land types. 7% combine rainfed with river bank plots, 7% deshek with river bank plots and 5% deshek with rainfed plots. The combination of land types is mainly used by deshek farmers. 58% of them cultivate other land types enabling them to grow other crops and at deshek flood times (see Table 1.4/5).

Table 1.4/5 Farm Households by Land Type and its Combination

Item	Kismayo		Jamaame		Jilib		Bu'aale		Saakow		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Land Type												
1 River bank	6	19.4	10	14.7	22	45.8	21	36.8	15	41.7	74	30.8
2 Levee	0	0.0	0	0.0	1	2.1	3	5.3	1	2.8	5	2.1
3 Deshek	0	0.0	19	27.9	13	27.1	9	15.8	11	30.6	52	21.7
4 Rainfed	30	96.8	50	73.5	15	31.3	36	63.2	19	52.8	167	69.6
1+4	5	16.1	1	1.5	5	10.4	3	5.3	5	13.9	19	7.9
1+3	0	0.0	2	3.0	1	2.1	6	10.6	9	40.0	18	7.5
3+4	0	0.0	4	6.0	4	8.3	2	3.5	2	5.6	12	5.0

Source: [81]

However, in the Juba valley a remarkable market production does not exist. As shown above about 47% of all farmers do not receive monetary income from farm activities. Assuming that an annual income up to the limit of SoSh 20,000, equivalent to a daily income of SoSh 55, is still far below subsistence level, another 42% of households farm on subsistence level. Furthermore, the distribution of total household income showed that other income sources as farming do not raise total income considerably above subsistence level. In general, it can be said that the subsistence economy in the Juba Valley is still the most crucial basis of survival though it does not depend on farming activities alone. The subsistence economy is not yet disintegrated to a considerable extent by the market economy and the separation of farmers from their land and means of production.

This is confirmed by the fact that different land tenure systems still do not play an important role in the Juba Valley. According to JESS data only 3% of all farming households cultivate under share cropping arrangements. However, important changes in land tenure can be recently observed (particularly in Bardheere District, and to a lower extent in Middle Juba Districts). This can be explained as a speculative effect with regard to economic opportunities in connection with the Bardheere Dam, and has to be expected to accelerate in future.

A crucial question within this development is the regulation of land registration. The JESS survey found that only 27% of farm owners registered their land, and that even 38% of them were not aware of the problem. Thus, it can be assumed that the subsistence economy will be challenged by future development.

Although absorbing most of family labour subsistence farming is a precarious economic system that still does not satisfy basic requirements and guarantee economic security of rural households. To procure cash income and further economic security, labour allocation strategies of households are usually directed towards the diversification of economic activities beyond the agricultural sector.

On household level, the importance of combining farm and other income sources is particularly significant. 16% of all farming households receive monetary income from crafts activities, 14% from business activities, and 23% from wage labour. Crafts income for farming households is most important in Bu'aale and Saakow District, business income in Kismayo and Saakow District, and income from wage labour is concentrated in the southern districts of Jilib, Jamaame and Kismayo. Table 1.4/6 shows the combination of farming with other sources of monetary income in detail.

Table 1.4/6 Farm Households and Combination of Monetary Income Sources

Income Source	Kismayo		Jamaame		Jilib		Bu'aale		Saakow		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Farming												
+ Livestock	5	16.1	25	36.8	6	12.5	9	15.8	12	33.3	57	23.6
+ Crafts	3	9.7	4	5.9	2	4.2	5	8.8	11	30.6	24	10.0
+ Wage Labour	4	12.9	17	25.0	5	10.4	2	3.5	8	22.2	36	15.0
+ Business	4	12.9	4	5.9	3	6.3	3	5.3	5	13.9	19	7.9
+ Others	0	0.0	12	17.6	2	4.2	3	5.3	3	8.3	9	3.8

Source: [81]

1.4.4 The Use of Outside Labour

The use of labour from outside the household in principle is a common feature in Juba Valley. Nearly half of all farm owners use labour from outside, including tractor drivers. The extent of labour use from outside, however, is usually low and limited to a few decisive days during the cropping periods in order to meet peak labour requirements.

Hired labour makes up the majority of used labour from outside. Disregarding labour types, however, it is most striking that almost all outside labour used is paid in cash, namely 97%. 71% of labourers also receive additional meals. On this background, it can be assumed, though not proved, that the restricted use of outside labour may not be due to low labour requirements but to the fact that subsistence farmers cannot afford it.

The use of mutual help as a means to tackle family labour shortages does not seem to be of outstanding importance according to JESS data. 16% of households use labour from relatives and neighbors. However, there are considerable variations with regard to single districts. This labour type is not reported for Bu'aale District, and only for 13% and 17% of all sample households in Kismayo and Jamaame Districts. On the contrary, in Jilib and Saakow Districts more than one quarter of households use this type of labour. According to own observations this is particularly true in rainfed farming systems. Mutual help systems, however, are not permanent systems of labour supply used in every season and by everyone. It can be described as a security system that only will be actualized if farmers face severe problems of harvesting their crop. Nevertheless, it plays an important role for the precarious economy of subsistence farmers, particularly in rainfed areas.

Table 1.4/7 illustrates the use of outside labour by rural settled households.

Table 1.4/7 Use of Outside Labour

Item	Kismayo No.	Kismayo %	Jamaame No.	Jamaame %	Jilib No.	Jilib %	Bu'aale No.	Bu'aale %	Saakow No.	Saakow %	Total No.	Total %
Use of outside labour	15	50.0	36	58.1	19	39.6	10	30.3	15	41.7	95	46.3
Labour type												
Mutual help	2	13.3	6	16.7	5	26.3	0	0.0	4	26.7	15	15.8
Hired labour	6	40.0	18	50.0	13	68.4	8	80.0	9	60.0	55	57.9
Mixed	0	0.0	0	0.0	1	5.3	2	20.0	0	0.0	3	3.2
Tractor	7	47.7	12	33.3	0	0.0	0	0.0	2	13.3	21	22.1
Compensation												
Money	15	100.0	35	97.2	17	89.5	10	100.0	15	100.0	92	96.8
Meals	8	53.3	27	75.0	15	79.0	6	60.0	13	86.7	67	70.5

Source: [81]

1.4.5 Income Situation

The following discussion of income patterns derived from the JESS Baseline Survey has to be considered carefully. The validity of data cannot be really proved. It is known that respondents often do not know their annual income or do not want to disclose their income conditions. Some inconsistencies concerning the comparison of income and expenses indicate that data cannot be taken for granted and are subject to interpretation.

1.4.5.1 Sectoral Income Distribution

Table 1.4/8 shows the average contribution of economic sectors to the annual monetary income of rural settled households (in SoSh). According to these figures the average household income in the Middle and Lower Juba Region is about SoSh 27,000 per year. Agriculture is not only the predominant subsistence basis and employment pattern but also the most important source of monetary income. However, taking into account that some 90% of households and some 60% of individuals are engaged in farming the 30% portion of agricultural income in total income is low. Therefore, it can be assumed that most farmers are subsistence farmers who are hardly in the position to market their products.

With the exception of crafts income (5%) the contribution of other income sources is distributed equally: 18% by livestock, 16% by private business, and 16% by wage labour.

Table 1.4/8 Sectoral Distribution of Household Income

Sector		Kismayo	Jamaame	Jilib	Bu'aale	Saakow	Average
Farming		2,150	19,820	1,510	4,030	7,470	8,080
	%	3.9	53.1	14.7	25.6	35.6	30.2
Livestock		5,140	4,450	1,010	7,600	6,190	4,790
	%	9.4	11.9	9.8	48.3	29.5	17.9
Crafts		1,860	300	210	2,260	2,530	1,260
	%	3.4	0.8	2.0	14.4	12.1	4.7
Business		17,880	650	6,270	260	1,260	4,240
	%	32.6	1.8	60.8	1.7	6.0	15.8
Wage Labour		12,110	8,510	910	130	800	4,460
	%	22.1	22.8	8.9	0.8	3.8	16.4
Others		15,690	3,570	400	1,440	2,720	3,990
	%	28.6	9.6	3.9	9.2	13.0	14.9
Total		54,830	37,300	10,310	15,720	20,970	26,830

Source: [13]

The breakdown of the above figures on district level reveals considerable variations. Whereas total household income in the southern districts of Jamaame and Kismayo is significantly above average, districts in the Middle Juba Region have an extremely low annual household income. This reflects the fact that Middle Juba Region is characterized by low economic and employment opportunities as compared to the southern districts in particular.

The breakdown on district level also reveals variations in the districts' economic structure as well as in the regional distribution of economic sectors as a source of monetary income.

Agriculture as a source of monetary income has an outstanding importance in Jamaame District where it makes up 53% of the total average household income. The second major income source in Jamaame District is wage labour with a contribution of 23%. Compared to other districts this is the highest contribution in relative terms, and the second highest in absolute terms, only surpassed by Kismayo District. The outstanding importance of monetary income from agriculture and wage labour indicates that the southern districts of the Juba Valley are most developed in terms of modernization and market orientation of agricultural production.

In Kismayo District the contribution of wage labour to total household income is even higher in absolute terms. The general assumption that economic development is concentrated in the southern districts is confirmed by this fact as well as by the outstanding importance of the private business sector. Not of great importance in other districts (to some extent with the exception of Jilib), the private business sector contributes 32.6% to household income in Kismayo District. Agriculture plays only a minor role. Thus, it can be assumed that the dual structure of modernization and prevailing subsistence economy is a striking feature in the two southernmost Districts (and to some extent in Jilib District - see below).

The economic structure in Jilib District is also characterized by the domination of subsistence farming. Monetary income from farming is lowest in absolute terms. On the other hand, there is a dynamic performance of the private business sector contributing 61% of total monetary household income. In terms of economic development and infrastructure this indicates the central position of Jilib District and its urban center within the Study Area. Furthermore, as already argued with respect to occupational patterns, though the importance of wage labour demanded by large-scale projects is high, it is not represented in the JESS household sample.

Monetary income from livestock keeping is concentrated in Bu'aale and Saakow Districts. 48% of total household income in Bu'aale, and 30% in Saakow District come from the livestock sector. Both districts are characterized by the predominance of subsistence farming, livestock keeping and the mixed economy of both. Another feature of these districts is the relative importance of crafts with a contribution of 14% and 12% respectively to total household income.

1.4.5.2 Income Distribution by Income Groups

The above indicative conclusions depend on highly aggregated figures. In order to provide a more differentiated picture the distribution of monetary income to income groups has to be analyzed. Table 1.4/9 presents the distribution of annual household income by income groups (in SoSh) and districts.

Table 1.4/9 Annual Household Income by Income Group

Annual Income in SoSh	Kismayo No.*	Kismayo %	Jamaame No.	Jamaame %	Jilib No.	Jilib %	Bu'aale No.	Bu'aale %	Saakow No.	Saakow %	Total No.	Total %
None	1	2.8	3	4.2	18	33.3	3	5.0	1	2.8	26	10.1
<5000	3	8.3	5	7.0	20	37.0	18	30.0	6	16.7	52	20.2
5000-19999	11	30.6	29	40.8	11	20.4	24	40.0	14	38.9	89	34.6
20000-49999	12	33.3	24	33.8	3	5.6	11	18.3	13	36.1	63	24.5
50000-99999	4	11.1	6	8.5	0	0.0	3	5.0	1	2.8	14	5.4
>99999	5	13.9	4	5.6	2	3.7	1	1.7	1	2.8	13	5.1
Total	36	100.0	71	99.9	54	100.0	60	100.0	37	100.1	257	99.9

* No. of households

Source: [81]

In order to clarify the meaning of this income grouping, it is broken down to monthly and daily salaries (in SoSh) and correlated to employment groups which usually receive such salaries:

Income Limit	Per Month	Per Day	Employment Group
5,000	417	14	None
20,000	1,667	55	Casual and unskilled
50,000	4,167	137	Semi- and skilled
100,000	8,334	274	Lower management

Table 1.4/9 shows that monetary income of at least 65% of households is far below subsistence level. A monetary income of a maximum of SoSh 55 a day can only be regarded as a marginal additional income that cannot even meet additional cash requirements. Even the income of the next 25% in the income group between So 20,000 and 49,000, equivalent to daily wages between SoSh 55 and 110, can hardly be understood as sufficient for a family. Consequently, about 90% of all households receive monetary income only as an additional income and depend on other income sources.

This assumption is even more true with regard to the farming sector. The income distribution within this sector is shown in Table 1.4/10. Nearly half of all households do not receive monetary income from farming. In Bu'aale, Kismayo and Jilib Districts this percentage is even higher, namely between 58% and 65%. The income group below SoSh 20,000, far below subsistence level and a marginal additional income, comprises 42% of all households. 9% of households, most of them concentrated in Jamaame District, receive a considerable additional income. However, only 2% of all households can earn a living by market production.

Table 1.4/10 Annual Farming Income by Households and Income Group

Income	Kismayo		Jamaame		Jilib		Bu'aale		Saakow		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	21	58.3	17	23.9	35	64.8	35	58.3	12	25.0	55	21.4
5000-19999	6	16.7	28	39.4	2	3.7	8	13.3	10	27.8	54	21.0
20000-49999	1	2.8	13	18.3	1	1.9	3	5.0	4	11.1	22	8.6
50000-99999	0	0.0	2	2.8	0	0.0	1	1.7	1	2.8	4	1.6
>99999	0	0.0	1	1.4	0	0.0	0	0.0	0	0.0	1	0.4
Total	36	100.0	71	99.9	54	100.0	60	100.0	36	100.0	257	100.1

Source: [81]

Wage labour can only be regarded as an additional income source. About 75% of households fall into the income group below SoSh 20,000. Even the next 18% of households earning between SoSh 20,000 and 50,000 a year cannot depend on wage labour alone. Table 1.4/11 shows the income distribution within the wage labour sector.

Table 1.4/11 Household Income from Wage Labour by Income Groups

Income	Kismayo		Jamaame		Jilib		Bu'aale		Saakow		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	27	75.0	46	64.8	40	74.1	55	91.7	26	72.2	194	75.5
<5000	1	2.8	12	17.0	12	22.2	4	6.7	9	25.0	38	14.8
5000-19999	4	11.1	2	2.8	1	1.9	1	1.7	1	2.8	9	3.5
20000-49999	2	5.6	8	11.3	1	1.9	0	0.0	0	0.0	11	4.3
50000-99999	0	0.0	1	1.4	0	0.0	0	0.0	0	0.0	1	0.4
>99999	2	5.6	2	2.8	0	0.0	0	0.0	0	0.0	4	1.6
Total	36	100.1	71	100.1	54	100.1	60	100.1	36	100.0	257	100.1

Source: [81]

1.4.6 Absence and Migration

331 household members of the rural settled sample (not including Bardheere District) live absent from the household being 17% of all individuals defined as household members by the JESS Survey. Thus, the average absence rate per household is 1.2 persons.

Significant differences occur on district level. For Bu'aale District only 11% of family members are recorded to be absent, but for District Kismayo the figure increases to 29%. Thus, the average absence rate per household ranges from 0.7 persons in Bu'aale District to 2.2 persons in Kismayo District. This increasing mobility from the northern parts to the southern parts of the Juba valley is illustrated in Table 1.4/12.

Table 1.4/12 Absence by District

District	No. of absentees	% of population	Average per household
Kismayo	78	28.8	2.2
Jamaame	96	18.1	1.3
Jilib	66	19.2	1.2
Bu'aale	40	10.6	0.7
Saakow	51	12.1	1.0
Total	331	17.0	1.2

Source: [81]

Most absentees fall into the age groups of the economically active population. 72% of them are concentrated in the age groups between 15 and 39 years. With the exception of Jilib District, showing an average absentee age of 39 years, the age average ranges between 27 and 29 years. This results in an overall age average of absentees of 30 years. More than two-thirds of absent family members are females. Table 1.4/13 shows the number of absent family members by sex, age average and age groups.

Table 1.4/13 Absence by Age and Sex

District	Male	% Female	Av. Age	15-39	% 15-64
Kismayo	30.8	69.2	27	71.8	87.2
Jamaame	34.4	65.6	29	91.7	91.7
Jilib	33.3	66.7	39	37.9	50.0
Bu'aale	30.0	70.0	27	80.0	87.5
Saakow	23.5	76.5	28	74.5	92.2
Total	31.1	68.9	30	72.2	81.9

Source: [81]

Both the predominance of females as well as the relatively high age average require an explanation that can be derived from data on reasons for absence which are recorded for 312 persons out of a total of 331 absentees: marriage (40%) and divorce (39%).

The third important reason for absence is labour. 13% of absentees are working abroad or looking for work. This reason is of highest relevance in Kismayo and Bu'aale Districts: 23% and 22% respectively are absent because of working or looking for work.

The distribution of reasons for absence per district is shown in Table 1.4/14.

Table 1.4/14 Reasons for Absence

Item	Kismayo No.	Kismayo %	Jamaame No.	Jamaame %	Jilib No.	Jilib %	Bu'aale No.	Bu'aale %	Saakow No.	Saakow %	Total No.	Total %
Looking	5	6.9	2	2.1	0	0.0	2	5.3	1	2.1	10	3.2
Working	12	16.4	6	6.3	3	5.2	6	15.8	2	4.3	29	9.3
Marriage	25	34.3	52	54.2	13	22.4	22	57.9	23	48.9	135	40.1
Divorce	27	37.0	30	31.6	38	65.5	6	15.8	21	44.7	122	39.1
Other	4	5.5	6	6.2	4	7.0	2	5.2	0	0.0	16	5.3
Total	73	100.1	96	100.4	58	100.1	38	100.0	47	100.0	312	100.0

Source: [81]

The fact that employment as a reason for absence is not as important as may be expected is also reflected in the low importance of support which is given to or received from the household. Only Kismayo and Jamaame Districts have a considerable number of absentees working abroad and supporting the family with money or goods. In Jilib and Saakow Districts, however, there are more absentees receiving support from than giving support to their family.

Table 1.4/15 Absence and Support from/of Household

District	Work for Household No.	Work for Household %	Giving Support No.	Giving Support %	Receiving Support No.	Receiving Support %
Kismayo	3	3.6	22	28.2	10	12.8
Jamaame	5	5.2	22	22.9	11	11.5
Jilib	5	7.6	7	10.6	15	22.7
Bu'aale	2	5.0	6	15.0	4	10.0
Saakow	3	5.9	5	9.8	8	15.7
Total	18	5.4	62	18.7	48	14.5

Source: [81]

In defining households as income pooling units, it can be said that the inclusion of absentees as defined in the JESS Survey is highly questionable. Persons who left the household because of marriage and divorce making up the vast majority of absentees definitely cannot be regarded as household members.

1.4.7 Household Labour Allocation and Availability

As shown above, rural subsistence households are not self-reliant units of production and consumption. They depend on subsistence farming as well as on the diversification of economic activities in order to satisfy their cash requirements and to achieve a maximum of economic security under existing conditions.

Furthermore, necessary subsistence activities absorb a significant part of the available family labour. For instance, in rainfed areas the procurement of drinking water absorbs up to one full manpower unit. Additionally, bad health conditions significantly reduce the amount of labour statistically available.

Considering the economic and social conditions of subsistence households, it can be assumed that they are usually not characterized by labour surplus.

To the contrary, own field observations showed that the economic performance of rural households is often limited by labour strains. This is reflected in household strategies to increase their labour supply, particularly the use of outside hired labour as well as mutual help. A considerable part of subsistence farmers cultivate their own plot in the afternoon while working on other farms in the morning.

Further important means for increasing labour availability are two social patterns of labour supply: child labour and polygamy. Children are drawn very early to economic activities. They not only relieve adults from necessary subsistence activities but also play an important role in herding and as labour in large-scale projects and banana farms (see section 1.5). The increase of female labour in the form of polygamy and women's double burden of production plus reproduction is a common labour supply strategy of rural households: separate plots are allocated to different wives who, additionally, have to work on the husband's plot.

The analysis of population and labour force data showed that an average household of 5.9 persons has 4.2 persons who are economically active. This labour force definition, however, does not mean that all economically active persons contribute equally to the household labour supply. Although performing necessary and important economic activities, children cannot undertake all kinds of work and their labour productivity is lower than that of adults. Furthermore, the labour productivity of persons in rural areas above the age of 40 usually decreases considerably because of bad health conditions. In order to assess the labour availability of an average household the contribution of different age groups has to be weighted according to their relative work performance.

The labour supply is weighted by a factor of 0.4 for children between the age of 7 and 14 years, a factor of 1.0 for adults and young people between 15 and 39 years, and a factor of 0.8 for adults between 40 and 64 years. Table 1.4/16 shows that an average households of 5.9 persons can supply 3.4 manpower units to economic activities.

Table 1.4/16 Manpower Units per Rural Settled Household

Item	Age Groups 7-14	15-39	40-64	Total
% of labour force	18.6	36.3	16.6	71.5
Persons per household	1.1	2.1	1.0	4.2
Weight factor	0.4	1.0	0.8	
Manpower equivalent	0.5	2.1	0.8	3.4

Farm labour requirements vary considerably according to farm size, land type and cropping pattern. Analysis of monthly farm labour requirements indicate that a minimum of 2.1 manpower units per household is necessary to meet peak labour requirements [70, 76, ANNEX 1].

From this point of view agro-economic analysis emphasizes the underutilization of family labour (21). However, as shown before, subsistence households have considerable labour requirements outside the farming sector. Therefore, it is necessary to supplement the agro-economic view with the socioeconomic analysis of households' labour supply and allocation necessities.

Taking into account labour requirements within the farming sector (about 2.1 man-days), labour requirements for subsistence activities (at least one man-day), and the requirements of additional income activities, subsistence households face labour scarcity rather than labour surplus.

What seems to be underutilization of labour at the first glance, turns out to be a vicious circle of subsistence households: they do not have sufficient family labour to increase their farming activities and to allocate a considerable part of their labour force to additional income sources.

1.5 Labour Situation in Large-scale Projects and Banana Farms

Recent large and medium-scale irrigation and industrial development has been concentrated to the southern part of the Study Area. All large-scale projects of the Juba valley (Juba Sugar Project, Fanoole State Farm, Mogambo Irrigation Project, Somalfruit), 61 medium-scale banana farms and some industrial units are situated in the riverine areas of Jilib, Jamaame and Kismayo Districts. Therefore, the labour market situation of this area differs considerably from that of the northern districts. Contrary to small-scale flood recession and rainfed farms which are cultivated by a mixed allocation of family and hired labour, all work is carried out by hired labour. Between 6,000 and 8,000 households and more than 10,000 workers depend on these projects and enterprises in 1988. The labour force is made up of a pool of permanent labourers and a high but varying number of casual labourers both being recruited from surrounding rural areas.

The following information is mainly based on interviews with management staff in 1987.

1.5.1 Juba Sugar Project (JSP)

The project is located on the west bank of the Juba River near Mareerey village, opposite the town of Jilib on the east bank and 105 km north of the port of Kismayo. The total project area covers some 17,000 ha. Although the distance between the factory site and Jilib is not more than 15 km, the lack of a bridge connection expands the distance to about 80 km.

The adjacent area of the project traditionally had a low population density. Important population increases were due to the resettlement of mainly former nomads from Dujuma, and almost all villages were founded or increased significantly only when the project started.

1.5.1.1 Employment, Salaries and Working Conditions

According to information of the Personnel and Training Management of JSP the permanent project staff comprised about 2,000 persons in 1987 consisting of some 1,300 employees in the agricultural sector and 700 employees in the sugar factory. These employees consist of about 150 management staff, skilled labourers and accountants, lower grade semiskilled labourers like machine operators and tractor drivers as well as unskilled employees like watchmen and headmen. The permanent staff is supplemented by about 1,200 to 2,000 casual labourers on daily basis, depending on labour requirements and availability within the cropping and harvesting period from August to April. Cane cutting demands the highest labour requirements. 1,600 cane cutters are necessary to supply the factory with sugar cane for 2,000 tons of crashing per day.

Salaries of the lower management grades (superintendents and supervisors) making up the majority of the management staff range between SoSh 8,000 and 12,000 per month. Lower grades of the permanent staff earn about SoSh 1,500 and some additional benefits.

Casual labourers are paid by result. The work results depend on the size of tasks and the physical ability of labourers and assisting family members. The usual work result is reported to be 1 or 1.5 tasks. Tasks are measured in different ways and paid according to difficulty and responsibility. The weeding task is measured as a piece of land 60 meters in length and one row (approx. 1 m) in width. Weeding is paid by SoSh 37 per task. With a few exceptions most tasks are paid between SoSh 37 to 45. The task of cane cutters is measured in rows per 60 meters. Payment per task in 1987 is SoSh 74. Thus, the maximum daily wage casual labourers can earn is about SoSh 150.

The project never succeeded in attracting adult males to any considerable extent. Usually females and children work on the fields. Given this fact and taking into account the physical capability of workers, daily wages usually do not exceed SoSh 100. An often used possibility to increase the wage income is to send more assisting family members to the fields.

1.5.1.2 Recruitment Practices and Labour Turnover

JSP has the authority to recruit its staff directly without consulting the Ministry of Labour, although the Ministry will be informed. Each department of the project has to report their labour requirements to the Personnel and Training Management. Advertisements are published in the JSP office itself, and in the Labour Offices of Jilib and Kismayo. In addition, newspaper advertisements in Mogadishu and individual initiatives of the Personnel and Training Management are undertaken to increase the labour supply of particularly skilled staff.

Casual labourers are recruited by headmen who are permanently employed and are key persons in specific villages. Those middlemen are chosen by superintendents who inform them of the daily labour requirements. The headman selects the workers and supervises them in the field. The transport of workers is provided by the project.

The labour turnover in the project is remarkably high with regard to factory work. Whereas the group of skilled workers showed a labour turnover of 2.7% in January 1987, there was no turnover in the following month. However, semiskilled grades had a labour turnover between 3% and 7% increasing up to 12% in single months. The agricultural section faces fewer problems with regard to labour turnover. Being lower in general, the average labour turnover per month is less than 1%.

1.5.1.3 Labour Supply and Shortage

Since the beginning of the project, its agricultural development has been hampered by scarcity of skilled, semiskilled and unskilled labourers. Presently, the project faces great problems in recruiting qualified staff. The area as well as the project itself has a low reputation and attractiveness in economic, social and cultural terms. Though the project provides accommodation and many additional benefits the salary level of the management staff appears to be too low to keep them in the project or to attract new qualified staff.

A comparison with earnings in Mogadishu shows that the same person would earn up to three times less in the Juba Sugar Project. In addition, the project cannot compete with the social and cultural opportunities available in cities, especially in Mogadishu. As confirmed during a stay in JSP, the social and cultural isolation is especially complained about by professional groups. At last, due to the prevalence of malaria in the project area, the health situation is regarded as a problem.

Regarding skilled and semiskilled staff of lower grades similar problems arise: the low salaries are even more problematic because the project area has to be regarded as a high cost area. Provided food costs of at least SoSh 250 a day there is hardly any money left for other expenses. Also, there is a shortage of low-cost houses for lower grades.

Because of these working conditions a lot of skilled and semiskilled labourers leave the project. Former JSP trained staff can be found in almost all projects in Lower Juba as well as in the cities' service sector. This is especially true for the engineering staff. It can be said that the JSP investment in human resources by its large training programme does not pay off for JSP itself. Since labour turnover is highest in semiskilled groups working in the sugar factory it can further be assumed that a low commitment to industrial production processes and labour conditions is another factor of labour supply problems.

Concerning casual labourers, cane cutters in particular, the project is up against the barrier of labour supply. According to the Personnel and Training Management there is no further possibility to expand agricultural operations. Out of a maximum labour requirement of 2,000 field workers per day the project definitely needs 1,600 regular workers. However, the number of daily workers that is available regularly and without problems is only about 1,200.

1.5.2 Mogambo Irrigation Project (MIP)

The Mogambo Irrigation Project is located on the east river bank some 40 km downstream of the JSP factory site. Project implementation began in 1984, cropping began in 1985, and at the end of 1986 about 900 ha were under cultivation. The construction of a rice mill was completed in August 1987. The project was originally designed in the early 1980's as a state farm under the responsibility of the Ministry of Agriculture although it was also planned that 10% of the project area would be given to smallholders for rice cultivation. The project is under the responsibility of the MoA, it is, however, semiautonomous [76].

1.5.2.1 Employment, Salaries and Working Conditions

According to management information MIP employed a permanent Somali staff of 61 persons in 1987. The majority of permanent staff work as supervisors and foremen. Whilst salaries are low even in comparison with Juba Sugar Project standards there are additional allowances, overtime and productivity bonuses.

The following farm labour requirements are reported for 1986:

Table 1.5/1 Labour Requirements of MIP

Labour Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Permanent	200	200	220	290	290	290	290	290	295	295	295	295
Foremen	11	11	12	15	15	15	15	15	15	15	15	15
Casual					3,600 man-days							
Cotton Pickers	90	90									200	200
Bird Scarers	740	740					320	1280	1280			320

According to information in 1987, MIP actually employs not more than an average of 50 casual labourers per day carrying out different tasks. However, this figure does not include the task of bird scaring that is usually carried out by up to about 70 children plus some adult supervisors.

Similar to JSP, casual labourers are usually made up of very young people and women. Men usually are responsible for irrigation and sprinkling, women for picking and weeding. Children usually assist their mothers in the fields.

Wages are paid per day as well as by result. In general, the daily wage is SoSh 80 plus lunch that is served in the fields. In the beginning of August 1987 the MIP management decreased the wages from SoSh 100 plus lunch per day. Because of complaints of other projects the management first tried to decrease wages to SoSh 65 plus ration but had to compromise because workers refused to work for such a salary. Bird scaring of children is paid SoSh 50 per day plus ration. Adults supervising them get SoSh 100 plus ration. Payment by result and task is paid e.g. for chemicals sprayers. SoSh 30 is paid per task plus a daily ration of milk that can be valued as SoSh 20. Wages per task also vary according to the labour supply situation and urgency of demand for labour.

1.5.2.2 Smallholder Programme

The original concept of allocating 10% of the land to smallholders has been revised to 25%. 600 ha out of 2,200 ha irrigable area should be run by smallholders cultivating 2 ha each. 300 smallholders signed a contract with MIP obliging them to operate their farm personally and to follow the project's recommendation of crop rotation and irrigation. The annual rent is SoSh 1,000 plus the equivalent of 10% of their crop production.

According to the Homboy Study [76, ANNEX 1] the allocation of land to smallholders has not been a success so far. When the land was taken over by MIP only 30 families out of 323 in the Mogambo village were allocated plots within the project area. None of the farmers who lost land had registered holdings and therefore received no compensation. Therefore there is some resentment towards the project.

The majority of land allocated to smallholders has been given to settlers from Mogadishu. About 300 were selected in 1985 but only 180 took up residence and 160 have stayed. The majority of settlers are ex-civil servants and townspeople who are not used to farming.

1.5.2.3 Labour Recruitment and Supply

In general, labour recruitment does not seem to be a problem for MIP. This might be due to three different factors:

- the more favourable infrastructure given by a village structure existing before MIP came into operation
- better road access
- the relative low demand for labour
- more attractive conditions of wages and additional services.

Recruitment practices of casual labourers are similar to JSP. Labourers are selected by headmen or foremen in the surrounding villages. MIP does not complain about labour supply problems. Every morning people wait in front of the project's gate for being selected for work. The project also does not face a high labour turnover. Most of the workers come regularly.

1.5.3 Fanoole State Farm

The Fanoole Rice Project is located on the east bank of the Juba river, South of Jilib. The Fanoole rice farm is designed for an area of about 7,500 ha of net irrigated land. The cultivation of 1,500 ha was achieved in 1987. Agricultural operations such as harvesting, final levelling, fertilizing (partly) and harvesting are carried out mechanically. The remaining works are carried out by hand.

1.5.3.1 Employment, Salaries and Working Conditions

According to information in 1987, the Fanoole State Farm employs about 1,200 permanent and about 1,000 casual labourers. Casual labourers are employed in times of peak labour requirements for picking and weeding, and consist mainly of females. A considerable amount of casual labourers, usually women and children, are required for bird scaring within 40 days before harvesting. Bird scarers receive a daily wage of SoSh 35. Other casual labourers receive daily wages of SoSh 60.

1.5.3.2 Labour Recruitment and Supply

Similar to other projects, casual labourers are recruited by headmen and village committees. Considerable labour supply problems were reported in 1987 with regard to unskilled as well as to skilled labour. Lack of skilled labour is reported to be a main problem.

1.5.4 Somalfruit

1.5.4.1 Employment, Salaries and Working Conditions

Labour force data on farm level were not available for Somalfruit. The five banana packing stations employ about 500 casual labourers per day, supplemented by 5 permanent labourers and 15 technical assistants.

Most tasks, particularly packing bananas and carrying them from the fields, are performed by women and children. Casual labourers receive SoSh 7 per hour.

The labour rates of all Somalfruit staff, permanent and casual labourers, are reported as follows for 1986 (in SoSh):

Table 1.5/2 Wage Labour Rates of Somalfruit

Farm labour		Packing shed labour		
Daily rate	% of payroll	Monthly rate	% of payroll	Daily rate
30- 70	36	1,500- 1,800	1	60- 70
130-170	17	2,000- 2,800	33	75-110
180-220	39	3,000- 4,000	33	115-155
230-270	5	4,300- 6,500	23	165-250
280-320	3	7,200- 9,500	6	280-365
		10,000-13,000	3	385-500
		14,000-20,000	1	540-770

Source: [82, App.2; 76, ANNEX 1]

1.5.4.2 Labour Recruitment and Supply

Permanent staff is recruited by the labour office in Jamaame. Casual labourers are recruited by headmen of farms and packing stations.

Somalfruit actually faces labour supply problems. With regard to casual labourers shortage is most acute in the Gu season when subsistence households have to work on their own farms.

1.5.5 Medium-Scale Banana Farms

All commercial banana farms are located in the stretch of floodplains between Kamsuma and Yontoy downstream Jamaame. There are 61 banana farms and 54 producers in Lower Juba Region, almost all private farmers, the majority having between 10 and 50 ha of bananas. 3,315 ha of the total nominal area of 8,287 ha are actually under banana cultivation. The other part is still used for annual cropping and could be redeveloped for banana production [76, ANNEX 2].

1.5.5.1 Employment, Salaries and Working Conditions

There is no information available on the total labour force working on banana fields. An estimate on the basis of labour requirements per hectare is problematic because agro-economic analyses of labour requirements vary considerably (6). Taking the actually cultivated area of 3,315 hectare and an average of 26 work days per month this would result in a daily required labour force between 2,9 and 6,3 labourers. On the basis of assumed labour requirements of two man-days per hectare [63; 76, ANNEX 2] the total labour force would be about 6,600 daily labourers.

Labour peaks occur during the months of March and September. The lowest labour requirements are during the months of January, February and August [63]. Many of the operations are carried out by task or by contract. Typical wage rates are shown in Table 1.5/3.

Table 1.5/3 Contract Labour Rates on Banana Farms 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
Fertilizer placement	0.20	per plant
Planting	0.60	each
Pruning	100.00	ha
Harvesting	1.00	bunch+rejected fruit
Weeding	1000.00	ha

Source: [76, ANNEX 2]

1.5.5.2 Labour Supply Situation

Labour shortages are reported for skilled labour in irrigation and mechanization [66] as well as for casual labourers. This might be due to the labour market competition with the large-scale projects.

1.5.6 Limiting Factors of Wage Labour Supply

The labour supply situation of medium- and large-scale irrigation schemes differs considerably according to different project designs (size, concept of tenure) and project environments (population density, labour requirements outside of projects). In the following, reasons for labour shortages in large-scale projects are identified by the example of the Juba Sugar Project.

1.5.6.1 Location and Physical Infrastructure

With regard to location and infrastructure there are two main problems which hamper the labour supply of the project. The first one is the long distance between urban living places and the project site mainly caused by the lack of a bridge connection to Jilib. The assumption that the urban center of Jilib would supply labourers turned out to be wrong. The 80 km long road from Jilib to the factory site takes at least 1.5 hours/one way. Such a three-hour travel time for JSP employees would not only be a loss of leisure opportunities, it would deprive those labourers of the opportunity to generate necessary additional economic activities.

The second problem is that the project is located in an area which has no traditional village structure. The recruitment of labourers could not be based on the existing village population but had to rely on the resettlement of outsiders. Some villages in the area were not founded before the project came into operation. Most are former nomads and were resettled from Dujuma and refugee camps in 1980. About 3,200 persons were transferred from Dujuma and distributed to mainly three villages. Despite a considerable population increase the existing labour pool is still insufficient. In the meantime, a new resettlement campaign is envisaged. Own observations in Dujuma proved that the remaining population developed new economic activities and will not be ready to leave. If JSP will apply for new resettlements it will depend on the refugee camps in the northern part of Gedo District.

1.5.6.2 Social Infrastructure

Low levels of social and cultural opportunities as well as health services, the lack of appropriate housing and of communication facilities to urban centers are extremely unattractive for particularly young and qualified staff members.

1.5.6.3 Labour Market Competition

The competitiveness of JSP in the labour market in terms of wages and additional benefits is restricted mainly because of two factors: on the one hand the labour requirement of JSP is considerably higher than that of other projects, and on the other hand economic calculations of the project are bound to the low Government-fixed sugar price (SoSh 35/kg in August 1987). Effective wages in the nearby Mogambo Irrigation Project are usually higher. Before August 1987 wages were even higher, having been reduced only because of complaints of other projects. Furthermore, the Juba Sugar Project does not provide an additional daily food ration.

1.5.6.4 Wage Level

The absolute level of wages is extremely low. This is not only true for JSP, but in general. The daily wages paid are hardly sufficient for the labourer's survival, not to speak about his family. Thus, at least for male adults, it will be more economic to work on their own plots. For additional income and for monetary requirements they send their wives and children to the JSP fields.

1.5.6.5 Employment Preferences

In general it can be said that wage labour in large-scale projects does not enjoy a high preference in employment alternatives of small-scale farmers and former nomads. This tendency is proved by those persons leaving JSP and taking up economic activities in the urban service sector as well as by newly arising economic activities like repair shops and craft activities in surrounding villages which will be an increasingly competitive labour market factor for JSP. This tendency is further proved by the fact that former nomads started to cultivate their own plots within the project area.

1.5.6.6 Labour Allocation of Subsistence Households

The determining sociological factor of labour supply is to be seen in the socioeconomic situation of subsistence households upon which a specific rationality of labour allocation is based.

A typical example of households' labour supply strategies could be derived from own observations and interviews in Hargeysa, a village of former Dujuma people directly attached to the JSP factory site. In Hargeysa nearly all families have some member working for JSP. Almost all families use a mixed labour allocation to both the JSP project and their own plots. This is true for indigenous farmers as well as for former nomads.

Facing the need of monetary income for basic household consumption they are urged to allocate a part of their family labour to the wage labour sector. However, since JSP wages cannot guarantee their survival they depend heavily on the opportunity of subsistence farming.

In rough outlines, though varying according to actual monetary requirements and family labour availability, two types of mixed labour allocation can be identified. The first type allocates labour chronologically: the family or a part of the family, sometimes including the household head, work on JSP fields in the daytime, and then shift to their own plot in the afternoon. The second type allocates labour simultaneously: one part of the family work on JSP fields and the other part on their own plot, usually including the household head.

Though some household heads work in JSP, usually women and children are sent as casual labourers. According to own observations of sugar cane harvesting, children from the age of about 10 on work in the fields. According to information of a headman in Hargeysa the average age of labourers is about 20 years. Mothers usually bring their elder children who can assist them to achieve a higher payment by result.

Though the first type of allocation seems to entail a stronger orientation towards JSP wage labour than the second one it is most striking that the relative importance of income from JSP does not change essentially: under existing conditions it is never more than an additional income source. The economic survival of all families, irrespective of the actual extent of labour supply, depends on subsistence production. On the background of their socioeconomic situation it is most rational to adopt a "security-seeking" labour supply strategy that does not allow supplying more labour to JSP. This is even more necessary since the production cycle does not demand labour continually during the whole year.

Both types of labour allocation are economically precarious. The restricted availability of family labour results in the alternative either to expand wage labour supply at the cost of subsistence production or not to be able to satisfy basic monetary requirements.

1.6 Present Farming Patterns and Farm Labour Potentials

Farm labour potentials depend on the amount of labour which is available and can be supplied to farming activities, as well as on labour requirements demanded by different cropping patterns and farming systems. Labour availability is determined by a manpower supply rate of 57% (refer to 1.3.2) and labour allocation patterns of farm households (refer to 1.4.7). Labour requirements are determined by the actual area under crop production and cropping patterns. Since the dominant rainfed farming system is characterized by continuous shifts in cropping intensities and the total acreage under crop production, an assessment of overall labour requirements and availability has to be regarded as a tentative approach in order to identify at least an order of magnitude.

Based on the preceding population estimate, considerations on labour force participation and labour allocation of rural households, a total of about 65,000 manpower units (MU) is presently available for farming activities (see Table 1.6/1). Assuming a maximal labour supply of 312 man-days/year/MU, the present area under crop production (not total farmland) of about 110,000 ha requires some 47,000 MU resulting in an overall supply/demand ratio of 1.4 to 1.

Taking into account a necessary elasticity between labour requirements according to cropping calendars and the amount of labour statistically available (i.e., spatially separated labour force - herding activities or wage labour considerably apart from farm plots - cannot be aggregated in reality; the statistically assumed supply of 312 man-days/year/MU can be significantly diminished by negative impacts such as bad health conditions), it can be assumed that, by and large, labour requirements and availability are balanced under present conditions.

On district level differentiations occur with regard to population densities, available farm land and farming systems. Those districts which are dominated by large areas of dryland cultivation have an extremely low elasticity between labour availability and requirements (a ratio of 1.1 in Bardheere and 1.0 in Saakow District) indicating labour stresses at least in times of peak labour requirements. In densely populated riverine areas the elasticity factor is considerably higher being 1.4 in Bu'aale District, 1.3 in Jilib District and 1.8 in Jamaame District. The situation in Jilib and Jamaame Districts is different mainly because of high wage labour demands of large-scale projects and banana farms (refer to 1.5.4.1), on the one hand, and a specific situation in dryland farming, on the other. High demands for wage labour could only be coped with by in-migration and resettlement from outside the project areas. Flooding problems considerably reduce annual labour requirements of rainfed farming households in southern districts. If flood protection measures allow for higher cropping intensities the labour elasticity factor would decrease to 1.2 in both districts. Kismayo is the only district of the Study Area which appears to be characterized by a structural imbalance between agricultural employment opportunities and labour availability: a fairly high concentration of population is confronted with limited farm areas resulting in a surplus of labour force with a drain to adjacent areas and urban employment.

Not considering the high surplus of labour potentials in Kismayo District, the overall ratio of labour availability and requirement in the Study Area decreases from 1.4 to 1.3.

Table 1.6/1 Farming Patterns and Labour Potentials 1988

District	FS	Annually cropped ha	MD ha/year	MU1	MU2	MU2/ MU1	MU1/ ha
Bardheere	R1	41,000	106	13,900			
	SI	2,500	180	1,400			
		43,500		15,300	16,700	1.1	0.35
Saakow	R1	22,000	106	7,500			
	D	1,800	140	800			
	SI	900	180	500			
		24,700		8,800	8,400	1.0	0.36
Bu'aale	R1	2,000	106	700			
	D	5,900	140	2,700			
	SI	700	180	400			
		8,600		3,800	5,200	1.4	0.44
Jilib	R2	6,500*	57*	1,200			
	D	3,700	140	1,700			
	SI	200	180	100			
	LI	7,800		6,400**			
		18,200		9,400	12,600	1.3	0.52
Jamaame	R2	10,000*	57*	1,800			
	SI	1,000	180	600			
	BI	2,900	595	5,500			
	LI	600		600			
		14,500		8,500	14,900	1.8	0.59
Kismayo	R2	500*	57*	100			
	BI	500	595	1,000			
		1,000		1,100	7,100	6.5	1.1
Total		110,500		46,900	64,900	1.4	0.42

FS = Farming system
R1 = Rainfed farming system 1
R2 = Rainfed farming system 2
D = Deshek/levee cultivation
SI = Small scale irrigation
BI = Banana irrigation farms
LI = Large scale irrigation
MD = Labour requirements in man-days
MU1 = Manpower units required
MU2 = Manpower units available

Note: * Low labour requirements in rainfed farming system 2 are due to flooding problems in Der season; vast areas of rainfed farmland, particularly in Jamaame District (9,000 ha), are not annually cropped.

** Including 1,000 MU of Fanoole State Farm, 3,400 MU of Juba Sugar Project, and 2,000 MU of households, being employed in projects and working on own farm but not being included in rainfed figures; Manpower units required in large scale projects are not calculated on the basis of required man-days per ha/year but were taken from presently available employment figures.

1.7 Labour Potentials and Population Structure per Socio-Geographic Unit

For the purpose of development planning, the Study Area was regrouped into a number of socio-geographic units (see Main Report, Chapter 2).

The delineation of Socio-Geographic Units (SGU) roughly identifies population groups with similar characteristics regarding their access to physical, economic and social resources. The socio-geographic structuring of the population follows one major aspect: their physical distance from the river and, therefore, the extent to which they are affected by the dam construction and future irrigation opportunities.

Following the definition and delineation of SGUs, the analysis of human resources will be related to this structuring. The following sections describe the distribution of the settled population and labour force, the relation between farming patterns and farm labour potentials, the specific characteristics of the target population with respect to their labour situation and socioeconomy.

1.7.1 Population and Farm Labour Potentials

It appears that the relatively uneven population distribution on district level is less pronounced on SGU level. Labour potentials of farm households are fairly evenly distributed among SGUs.

A population of 163,800 people (72%) is living in the settled agriculture systems of the near-river SGUs, whereas only 63,800 people (28%) are living in off-river SGUs.

The riverine population consists of 36,800 people (6,100 households) in SGU 1 (Bardheere Riverine Area), 35,800 people (6,000 households) in SGU 2 (Saakow/Bu'aale Riverine Area), 36,100 people (6,000 households) in SGU 3 (Fanoole/Kamsuma Riverine Area), and 55,100 people (9,200 households) in SGU 4 (Kamsuma/Gobweyn Riverine Area).

The off-river population consists of 33,200 people (5,600 households) in SGU 5 (Bardheere/Saakow Rainfed Area), 21,000 people (3,500 households) in SGU 6 (Homboy/Demo Transitional Area), 2,700 people (400 households) in SGU 7a (Deshek Waamo), and 6,400 people (1,100 households) in SGU 10 (Greater Kismayo Urban Area).

Labour potentials in terms of labour force (LF) and manpower units (MU) available for farming activities are relatively evenly distributed among the major SGUs: SGU 1,2,3 and 5 cover each about 12-13,000 LF and some 10,000 MU. SGU 4 has the highest labour potentials with about 20,000 LF and 16,000 MU. SGU 6 covers the lowest labour potentials with about 7,500 LF and 6,000 MU.

1.7.2 Farming Patterns and Farm Labour Potentials

Present farming patterns and farm labour potentials on district level are discussed in chapter 1.6. Employing the same method, this section describes the relation between labour requirements and availability for farming activities on SGU level.

Since land use figures on SGU level are not available with sufficient significance, the breakdown of the total acreage from district to SGU level entails only rough estimates with respect to rainfed farming areas.

Table 1.7/1 illustrates present farming patterns and farm labour potentials for the six major SGUs:

Table 1.7/1 Farming Patterns and Labour Potentials 1988

SGU	FS	Annually cropped ha	MD ha/year	MU1	MU2	MU2/ MU1	MU1/ ha
SGU 1	R1	21,000	106	7,100			
	SI	2,500	180	1,400			
		23,500		8,500	10,500	1.2	0.36
SGU 2	R1	7,000	106	2,400			
	D	7,700	140	3,500			
	SI	1,600	180	900			
		16,300		6,800	10,200	1.5	0.42
SGU 3	R2	2,300	57	400			
	D	3,700	140	1,700			
	SI	200	180	100			
	LI	7,800		6,400			
		14,000		8,600	10,300	1.2	0.61
SGU 4	R2	7,000	57	1,300			
	SI	1,000	180	600			
	BI	3,400	595	6,500			
	LI	600		600			
		12,000		9,000	15,700	1.7	0.75
SGU 5	R1	36,000	106	12,200	9,600	0.8	0.34
SGU 6	R2	7,700	57	1,400	6,000	4.3	0.18

FS = Farming system
R1 = Rainfed farming system 1
R2 = Rainfed farming system 2
D = Deshek/Jimo cultivation
SI = Small scale irrigation
BI = Banana irrigation farms
LI = Large scale irrigation
MD = Labour requirements in man-days
MU1 = Manpower units required
MU2 = Manpower units available

Table 1.7/1 clearly shows that labour stresses mainly occur in large rainfed areas with a low population density. This is particularly true for SGU 5 covering only rainfed farming system I. The situation in SGU 6 also covering only rainfed areas is different because of three reasons: (1) rainfed system 2 allows for only one cropping period a year and, therefore, requires significantly less labour input; (2) households engaged in rainfed farming in system II also function as labour force for large-scale enterprises in SGU 3 and 4; (3) the Homboy area is a rapidly developing rainfed area with favourable rainfall conditions, and is a transitional area with respect to future irrigation.

A relatively balanced situation between present labour requirements and availability can be found in SGU 1 and SGU 3, the first consisting of a mix of large rainfed areas and small-scale irrigation, the latter made up of only a small portion of rainfed farming and small-scale irrigation, but facing high labour demands of large-scale projects (Juba Sugar and Fanoole State Farm). Taking into account a necessary elasticity between labour required and labour statistically available (see Chapter 1.6), the situation in SGU 2 may be still balanced, showing a slight tendency towards labour surplus. SGU 2, however, is an area with considerable expansion potential for irrigated agriculture, particularly in the with-dam situation with increasing labour requirements.

SGU 4, though characterized by a mix of farming systems and cropping patterns requiring the highest labour inputs per hectare and year, seems to have a significant surplus of labour. The interpretation of this fact, however, has to consider the following points: (1) there is a considerable drainage of labour force from Kismayo District in which farming opportunities are restricted; (2) SGU 4 covers a significant rainfed system II area which requires low annual labour inputs; (3) a part of the labour force (or of their household members) which is casually employed in banana farms but also crop rainfed areas might not have been covered by rainfed figures.

1.7.3 Socio-Geographic Units and Population Structure in Settled Agriculture

This section intends to characterize the population per Socio-Geographic Unit with respect to labour potentials and socioeconomic characteristics.

Following the distinction between near- and off-river populations, the following socioeconomic systems in settled agriculture can be distinguished:

- the near-river subsistence economy, characterized by considerable labour requirements of deshek cultivation and small-scale irrigation, and relatively high population densities and, therefore, high labour potentials
- the off-river subsistence economy, characterized by low labour requirements of rainfed farming system I and extremely low population densities. Two-thirds of the labour potentials of this system are allocated to Bardheere, one-third is allocated to Saakow District
- the off-river subsistence economy, located in the Homboy area, South-East of Kamsuma and South of Jamaame, characterized by lowest labour requirements of rainfed farming system II, higher population densities and easier access to the urban and near-river economy

- the near-river mixed economy of subsistence farming, large-scale estates and medium-scale banana farms, mainly located in Jilib and Jamaame, characterized by lowest labour requirements of rainfed farming system II and high wage labour demands

- the greater Kismayo urban area with low labour potentials and requirements outside the urban economy, nevertheless, with the strongest tendency towards labour surplus on the background of limited agricultural potentials.

On SGU level the following socioeconomic and labour characteristics of the population have to be taken into account:

SGU 1

The area is characterized by a mix of relatively high labour requirements of small-scale irrigation and low labour requirements of rainfed farming system I. Compared to other riverine areas in the Juba valley, SGU 1 has a medium population density (urban and rural settled) of 28 people/km^2. About 58% of farm labour potentials in Bardheere District are concentrated in this area.

Concerning farming patterns two major populations groups can be identified:

- some 800 households engaged in small-scale irrigation
- some 5,300 households engaged in rainfed farming.

In line with the expansion of irrigation areas the establishment of share cropping arrangements increases. The number of households depending on these arrangements is not of outstanding significance today. However, present tendencies of land speculation and the increase of medium-scale farming indicate that sharecroppers have to be considered a specific group in future.

The conditions of rainfed farming in SGU 1 are, by and large, not different from other rainfed areas (see SGU 5). With respect to future development two differences are of importance: the near-river rainfed farming population is less isolated from urban centers and their infrastructure; and they may partly benefit from expected irrigation opportunities and infrastructure development.

SGU 2

The Saakow/Bu'aale riverine area is characterized by a mix of relatively high labour requirements of the predominant deshek cultivation and lower rainfed farming labour requirements. The population densities are lowest for riverine areas of the Juba valley (18 people/km^2 in Saakow and 19 people/km^2 in Bu'aale District). In Bu'aale District almost all farm labour potentials and in Saakow District about 50% are concentrated in this area.

The population in SGU 2 consists mainly of three subgroups:

- some 400 households engaged in small-scale irrigation
- some 3,800 households engaged in deshek farming
- some 1,900 households engaged in rainfed farming.

Whereas irrigation is already rapidly expanding, deshek and rainfed farming in the riverine area will decline and disappear in future. Land speculation and in-migration of outsiders are leading to social conflicts for the indigenous population. Security of land tenure is already a major problem. Support and guidance should be given to three major groups:

- small-scale irrigation farmers
- deshek/levee farmers being subject to conversion
- indigenous small farmers being subject to increasing insecurity of land tenure.

The implementation of measures in the deshek farming system has to consider that the socioeconomic security of deshek farmers not only depends on cultivation of desheks but usually on a mixed allocation of labour to deshek, levee and rainfed plots.

SGU 3

The Fanoole/Kamsuma Riverine Area is characterized by a socioeconomic mix of high wage labour demands from large scale irrigation projects and lowest labour requirements of rainfed farming system II. The population density near the river is relatively high (37 people/km^2 in Jilib District). Though about 82% of farm labour potentials in Jilib District are concentrated in this area, large-scale projects emphasize labour constraints.

Mainly three different groups of population are located in SGU 3:

- 1,800 households engaged in deshek/levee cultivation
- 1,000 households engaged in rainfed farming
- some 3-4,000 subsistence farm households being employed in large-scale projects with one or two family members.

The first two groups are largely subject to conversion into small-scale irrigation and require support and guidance in this respect.

The third group should be considered in two respects:

- As argued in 1.5.6.5, employment preferences tend to self-employment and the cultivation of own land. In order to counteract wage labour supply problems as well as to meet the needs of the population, projects for which large designs cannot be avoided should be implemented on smallholder basis.

- The socioeconomic security of farm households engaged in large-scale projects as wage labourers depends heavily on subsistence farming (see Chapters 1.4 and 1.5.6.6). Being additionally in need of monetary income, those households face the precarious alternative either to expand their wage labour supply at the cost of subsistence farming or not to be able to satisfy their basic monetary requirements. This vicious circle should be broken in the future by either converting large-scale projects into smallholder schemes, or by raising both project wages and the performance of subsistence farming. Within or near large project areas households should be given the opportunity to cultivate their own land.

SGU 4

The Kamsuma/Gobweyn Riverine Area is characterized by a high population density (48 people/km^2 in Jamaame District and 77 people/km^2 in Kismayo District). About 74% of farm labour potentials in Jamaame District and about 85% in Kismayo District are concentrated in the riverine area. Similar to SGU 3, the socioeconomic mix of medium- and large scale schemes demanding wage labour, on the one hand, and rainfed farming system II requiring low labour inputs, results in a permanent flow of labour force between the two systems.

The population in SGU 4 consists of:

- some 500 households engaged in small-scale irrigation
- some 3,000 households engaged in rainfed farming
- 4-5,000 households engaged in projects and banana farms as wage labourers.

The first and third groups have to be addressed in the same way as wage labourers in projects and small-scale irrigation farmers in SGU 3.

The second group are farmers in rainfed system II. Presently, these farm households are able to crop only one season; in order to allow them a higher return from their land and labour flood protection and other measures should be taken into consideration.

SGU 5 (not including Dinsor)

The Bardheere/Saakow Rainfed Area is almost exclusively determined by a subsistence economy characterized by low labour requirements of rainfed farming system I and extremely low population densities. The necessities of labour allocation to others than farming activities causes considerable labour stresses.

The rainfed farmers in the eastern parts of Bardheere and Saakow Districts can be identified as a relative homogeneous population in terms of given resources and constraints as well as in terms of future development prospects. The off-river rainfed farming population in SGU 5 consists of about 5,600 households.

Since those farms will not benefit from the changing river regime they have to be addressed as a major population group in future in order to achieve a regional development based on economic and social equity.

Regarding physical and socioeconomic constraints, the population concerned and its environment are characterized by:

- low rainfall and lack of potable water supply
- lack of extension and support services
- low standard of production techniques
- lack of capital input and access to markets
- low quality of sanitation and health conditions
- low population densities

- high labour requirements for basic needs supply
- low labour requirements for crop production
- labour stresses and loss of labour productivity due to bad health conditions and necessary labour allocation to other economic activities
- no future irrigation opportunities.

Since processes of social differentiation in these areas are less developed, this population should be addressed within a community approach identifying the highest priority measures for upgrading health conditions, standard of living, labour productivity and reducing isolation.

The implementation of measures within these areas has to consider the following characteristics:

Socio-economic security in these areas depends largely on the combination of dryland farming and livestock keeping. Since livestock has to be moved according to rainfall conditions (up to Bu'aale), labour is under stress seasonally. Labour allocation is following two patterns: either a part of the household (usually wives with their children) are moving with the livestock while the other part of the household is engaged in farming; or, if the family is not large enough to be split, the whole family will shift with the livestock if there is no rain. Though farming patterns in rainfed subsystem I are less labour intensive, farmers face labour stress in times of peak labour requirements. Labour supply problems are solved by locally hired labourers , mainly in the form of traditional mutual help systems. A community oriented approach will have to strengthen these existing self-help structures. In periods of low labour requirements, family members also try to find jobs as wage labourers near Saakow, particularly in deshek cultivation.

SGU 6

The Homboy/Demo Transitional Area is characterized by lowest labour requirements of rainfed farming system II, and the highest off-river population density (18 people/km^2 in Jamaame District) in the Juba valley. About one quarter of farm labour potentials in Jamaame District is situated in this area. Since these rainfed areas have an easier access to the adjacent river and urban economies than the northern rainfed farming system, the interfaces to the socioeconomic systems of SGUs 3 and 4 have to be taken into consideration.

The population in SGU 6 covers 3,500 households, and has the following characteristics:

- slightly better rainfall conditions
- more favourable infrastructure and access to urban centers
- higher population densities
- allocation of a considerable portion of household labour to the wage labour sector (banana farms and large-scale projects)
- better expectations for future irrigation.

SGU 7a

Deshek Waamo is a 3-tied cropping system with each particular system being determined by the amount of runoff water available in the depression, through which the farming system varies over time.

The population covers presently some 400 households.

SGU 10

The Greater Kismayo Urban Area is characterized by low labour requirements outside the urban economy. If the non-agricultural urban sector will not increase employment opportunities, this area would be the first facing severe labour surplus problems.

The following Figure 1.7/1 illustrates the structure of the population in settled agriculture (not including SGU 7b, 8 and 9).

1.8 Limiting Factors of Labour Supply

In the following, limiting factors which affect labour availability of subsistence farm households and labour supply to large-scale projects are summarized:

Lack of basic requirements:

The labour availability and productivity of subsistence households is extremely hampered by time-absorbing activities, such as drinking water supply (up to one man-day in rainfed areas), and productivity-reducing conditions, such as bad health conditions.

Casual labour and subsistence economy:

The work organization of large-scale projects is largely based on casual labour supplied by rural households depending on subsistence farming. The structure of subsistence economies and the system of casual labour, however, create a context of demand for and supply of labour that necessarily reproduces labour shortages. On the one hand, casual labour with wages below subsistence level can only be of limited importance for rural households. On the other hand, as shown above, the labour availability of rural households is limited. Thus, it is most rational for these households to supply only a limited proportion of their labour force, mainly women and children, to the wage labour market.

Preference for self-employment:

Generally, there is a strong tendency towards self-employment. The rural settled population (including former nomads) prefer to farm their own plots. They only supply labour to the wage labour sector if they are forced by cash requirements. Experiences, like in the Afgoi Mordille Irrigation Project, show that mobilization of labour is more successful for smallholder farming. This preference is further confirmed by those former nomads, resettled and employed in the Juba Sugar Project, who started to cultivate their own plots, as well as by former JSP employees who changed into the services sector.

Figure 1.7/1 Population in Settled Agriculture

Total population: 510,000		
Urban: 133,000	Rural settled: 222,000	Nomadic: 155,000

Non-agricultural 123,000	Agricultural 387,000
Urban: 98,000	Urban: 35,000
Rural: 22,000	Rural: 200,000
Nomadic 3,000	Nomadic: 152,000

Settled agriculture: 35-37,000 households

Near river: 24,500-26,500

1. Households in rainfed farming:

SGU 1:	5,300
SGU 2:	1,900
SGU 3:	1,000
SGU 4:	3,000

2. Households in deshek/levee farming:

SGU 2:	3,700
SGU 3:	1,800

3. Population in small scale irrigation:

SGU 1:	800
SGU 2:	400
SGU 3:	100
SGU 4:	500

4. Households in large scale + banana:

SGU 3:	3-4,000
SGU 4:	4-4,000

Off river: 10,600

Households in rainfed system I (SGU 5):

1. Southeast of Bardheere:	3,000
2. Along boarder of Bardheere/Saakow:	1,000
3. Northeast of Saakow:	1,600

Households in rainfed system II (SGU 6):

1. Homboy :	1,400
2. Kamsuma:	1,000
3. Bangeeni:	1,100

Households in SGU 7a:

Deshek Waamo:	400

Households in SGU 10:

Urban Kismayo:	1,100

Low wage level:

The extremely low wage level is a limiting factor for recruiting management, skilled as well as unskilled staff. Salaries of management and technical staff are not competitive to salaries paid in Mogadishu. Salaries of lower grade permanent and of casual labourers are far below subsistence level satisfying only additional cash requirements.

Lack of social and physical infrastructure:

Low levels of social facilities and services in large-scale projects, the lack of housing and communication facilities to urban centers are unattractive for the permanent staff. The supply of permanent as well as casual labourers is hampered by bad connections to the project site. For instance, the lack of a bridge between Jilib and the Juba Sugar Project confronts workers with an unacceptable three-hour trip to work and cuts off the access to urban labour markets.

Oversized projects:

The comparison between larger and smaller projects shows that labour supply problems arise, if the dimension of projects is not adjusted to the labour supply capacity of surrounding villages. Smaller projects can easier be integrated into the labour market structure of rural areas.

2. Population Dynamics and Development of Labour Potentials

In this section estimates of future population dynamics are presented in order to identify at least an order of magnitude concerning available manpower for future development. This can only be done on the basis of certain hypothetical assumptions on factors influencing these dynamics. The order of magnitude, then allows for a comparison with the other primary factors determining future development in the Study Area being land and water resources.

2.1 Population Dynamics in the Study Area

The estimate of the present inhabitants was based on an assumed average annual population growth rate of 2.8%. In order to assess future population growth rates, this natural population growth rate is maintained assuming that, by and large, decreasing child death rates as a consequence of improving health conditions will be compensated by changing generative behaviors and first measures of family planning.

In addition, population dynamics have to be considered with respect to the in-migration of outsiders as well as to shifts between the rural settled, nomadic and urban portions in total population. In the following, those assumptions are differentiated with regard to the before-dam situation and the with-dam situation.

2.1.1 Population Dynamics and Growth in the Before-Dam Situation

It is assumed that population dynamics in the before dam situation will mainly concern urban development and will be connected to infrastructure development and the dam construction. Most significant urbanization processes will occur in Jilib as a major development center regarding its favourable location in the Study Area, and in Bardheere considering that the dam construction will attract people looking for work and will particularly increase activities in the services sector. Outstanding urbanization processes in the middle Juba towns of Bu'aale and Saakow cannot be expected in the before-dam situation. The assessment of further urbanization processes in Kismayo includes some uncertainties. If harbor facilities and export activities will be extended, urbanization rates might be outstanding. This, however, depends largely on which economic and administrative role Kismayo can achieve in the future. Here, a conservative estimate of an annual growth rate of 4% is employed.

Regarding the nomadic population, it is assumed that sedentarization process will lower their growth rates but not significantly. Also in this respect the conservative estimate is adopted that the annual growth rate of the nomadic population will decrease to 1.5%.

Furthermore, it is expected that the annual growth rate of the rural settled population will remain 2.8% assuming that sedentarization processes will be balanced by rural-urban migration.

In detail, the following annual population growth rates are assumed for the period between 1987 and 1995:

- Rural settled population: 2.8%
- Nomadic population: 1.5%
- Urban population
  . Kismayo: 4.0%
  . Jamaame: 3.0%
  . Jilib: 6.0%
  . Bu'aale: 3.0%
  . Saakow: 3.0%
  . Bardheere: 8.0%
  . Afmadow: 3.0%
  . Dinsor: 3.0%
  . Luuq: 4.0%

Table 2.1/1 illustrates the distribution of population groups on district level in 1995:

Table 2.1/1 Population in the Study Area 1995

District	Urban		Rural		Nomadic		Total	
	No.	%	No.	%	No.	%	No.	%
Kismayo	105,500	16.9	24,800	4.0	24,500	3.9	154,800	24.8
Jamaame	11,600	1.9	64,400	10.3	9,400	1.5	85,400	13.7
Jilib	24,700	4.0	54,200	8.7	41,600	6.7	120,500	19.3
Bu'aale	3,400	0.5	22,700	3.6	15,300	2.4	41,400	6.6
Saakow	8,400	1.3	34,000	5.4	32,900	5.3	75,300	12.0
Bardheere	29,500	4.7	69,600	11.1	48,600	7.8	147,700	23.6
Study Area	183,100	29.3	269,700	43.1	172,300	27.6	625,100	100.0
Afmadow	6,600							
Dinsor	9,100							
Luuq	15,800							

According to the above table, the portion of the urban population will increase from 26% in 1988 to 29% in 1995; whereas the portion of the rural settled population will slight decrease from 44% to 43%, and the portion of the nomadic population will decrease from 30% to 28%.

2.1.2 Population Dynamics and Growth in the With-Dam Situation

The structure of population dynamics will change in the with-dam situation, and will be more related to the implementation of agricultural projects than infrastructure development. Urban population growth rates considerably higher as in the before-dam situation can be expected in the Middle Juba

Region. Jilib as an "entrance" and a center of motion for this region will benefit from the accelerated development of all economic sectors. Annual population growth rates in Bu'aale and Saakow will increase with respect to intensified implementations of development projects under the condition of dam operation. The outstanding growth rates of Bardheere, however, will slow down after the dam is constructed.

Slight increases of annual population growth rates of the rural settled population can be assumed because sedentarization processes will be intensified, rural-urban migration will be compensated by in-migration of new settlers, and health conditions will improve.

In detail, the following assumptions on population growth rates until 2005 are made:

- Rural settled population: 3.0%
- Nomadic population: 0.5%
- Urban population
  . Kismayo: 4.0%
  . Jamaame: 3.0%
  . Jilib: 8.0%
  . Bu'aale: 6.0%
  . Saakow: 6.0%
  . Bardheere: 6.0%
  . Afmadow: 3.0%
  . Dinsor: 3.0%
  . Luuq: 3.0%

Table 2.1/2 illustrates the distribution of the urban, rural settled and nomadic population on district level in 2005:

Table 2.1/2 Population in the Study Area in 2005

District	Urban		Rural		Nomadic		Total	
	No.	%	No.	%	No.	%	No.	%
Kismayo	156,200	18.5	33,300	4.0	25,800	3.1	215,300	25.5
Jamaame	15,500	1.8	86,600	10.3	10,000	1.2	112,100	13.3
Jilib	53,200	6.3	72,900	8.7	43,700	5.2	169,800	20.1
Bu'aale	6,200	0.7	30,500	3.6	16,100	1.9	52,800	6.3
Saakow	15,000	1.8	45,700	5.4	34,500	4.1	95,200	11.3
Bardheere	52,800	6.3	93,600	11.1	51,100	6.1	197,500	23.4
Study Area	298,900	35.5	362,600	43.0	181,200	21.5	842,700	100.0
Afmadow	8,900							
Dinsor	12,200							
Luuq	21,200							

The portion of the urban population will increase significantly to 36%; whereas the portion of the nomadic population will decrease to 22% and the portion of the rural settled population to 43% out of total population.

2.2 Sectoral and Geographical Distribution of Labour Force

Future development in the Study Area will be reflected in social changes indicated by changing household structures, age and sex structures, and labour force participation. These developments, however, are hardly to assess from the present point of view. Therefore, the following labour force assessment relies on preceding population estimates and analysis of the present labour force situation.

In order to assess the future distribution of labour force to economic sectors structural changes of employment patterns have to be considered. It is assumed that the employment structure within the rural settled and nomadic population will not change significantly, the first supplying some 10% and the latter some 2% to secondary and tertiary sector employment.

The urban employment structure, in terms of the proportion of off-farm employment, is assumed to change as follows:

Table 2.2/1 Urban Off-farm Employment

Urban Area	1987	1995	2005
Kismayo	90	90	90
Jamaame	40	40	50
Jilib	70	80	90
Bu'aale	30	40	50
Saakow	20	30	50
Bardheere	50	70	70

On the background of assumed population dynamics and considerations on labour force participation, the labour force in the Study Area is estimated to increase from 345,700 persons in 1988 to 419,400 in 1995 and 564,900 in 2005.

The following Tables 2.2/2 and 2.2/3 illustrate the sectoral labour force distribution in the before- and with-dam situation.

Table 2.2/2 Sectoral Distribution of Labour Force 1995

Sector	Agricultural		Non-agricultural		Total	
	No.	%	No.	%	No.	%
Urban	22,600	5	82,400	20	105,000	25
Rural	173,600	41	19,300	5	192,900	46
Nomadic	119,000	28	2,500	1	121,500	29
Total	315,200	75	104,200	25	419,400	100

Table 2.2/3 Sectoral Distribution of Labour Force 2005

Sector	Agricultural No.	%	Non-agricultural No.	%	Total No.	%
Urban	32,200	6	145,900	26	178,100	31
Rural	233,300	41	25,900	5	259,200	46
Nomadic	125,000	22	2,600	1	127,600	23
Total	390,500	69	174,400	31	564,900	100

The labour force of the Study Area is estimated to increase by about 74,000 persons in the before-dam and by further 146,000 persons in the with-dam situation until 2005. The labour force of farming households will increase by 34,000 and 70,000 persons respectively. Its relative share in total employment, however, will remain stable (47% in 1988, 46% in 1995 and 47% in 2005). The portion of nomadic labour force will decrease from 32% to 29% and 23%, whereas that of urban and off-farm employment will increase : the first from 22% in 1988 to 25% in 1995 and 31% in 2005; the latter from 21% to 25% and 31% respectively.

In order to arrive at a spatial distribution pattern of the settled labour force, Tables 2.2/4 and 2.2/5 illustrate the distribution of settled agricultural and non-agricultural employment per district and socio-geographic unit (SGU) in 1995 and 2005. The major part of non-agricultural employment will further be concentrated in Kismayo, facing the highest growth rates, however, in Jilib (SGU 3) and Bardheere (SGU 1). Concentrations of the settled agricultural labour force will occur in Bardheere, Jamaame and Jilib Districts. With respect to socio-geographic units the distribution pattern is more even showing the highest concentrations in SGU 4 (mainly Jamaame riverine area) and the lowest in SGU 6 (Jilib and Jamaame off-river rainfed areas). It has, however, to be considered that the implementation of development projects and related resettlement schemes in the Middle Juba Region will cause intraand inter-regional migration dynamics resulting in other distribution patterns as predicted in the following tables.

Table 2.2/4 Sectoral Distribution of Settled Labour Force by District

District	Agricultural 1995	Agricultural 2005	Non-agricultural 1995	Non-agricultural 2005	Total 1995	Total 2005
Kismayo	21,900	30,300	56,000	82,700	77,900	113,000
Jamaame	45,400	60,200	7,200	10,600	52,600	70,800
Jilib	37,900	50,600	15,500	39,200	53,400	89,800
Bu'aale	15,800	21,400	2,400	4,000	18,200	25,400
Saakow	25,300	33,700	3,800	7,600	29,100	41,300
Bardheere	49,800	69,200	16,800	27,800	66,600	97,000
Total	196,100	265,400	101,700	171,900	297,800	437,300

Table 2.2/5 Sectoral Distribution of Settled Labour Force by SGU

SGU	Agricultural		Non-agricultural		Total	
	1995	2005	1995	2005	1995	2005
SGU 1	30,900	43,900	17,200	25,000	48,100	68,900
SGU 2	30,700	41,100	5,100	10,200	35,800	51,300
SGU 3	31,200	41,600	14,700	38,200	45,900	79,800
SGU 4	47,800	63,400	7,500	10,900	55,300	74,300
SGU 5	29,300	39,300	3,300	4,400	32,600	43,700
SGU 6	17,700	23,800	2,000	2,600	19,700	26,400
Other*	8,500	12,300	51,900	80,600	60,400	92,900
Total	196,100	265,400	101,700	171,900	297,800	437,300

* mainly urban Kismayo (SGU 10)

Labour potentials in terms of labour force (LF) and manpower units (MU) available for farming activities will be evenly distributed among the major SGUs in 1995: SGU 1,2,3 and 5 cover each about 15,000 LF and some 12,000 MU (2005: 20-21,000 LF and 16-17,000 MU). SGU 4 will have the highest labour potentials in 1995 with about 24,000 LF and 19,000 MU (2005: 32,000 LF and 25,000 MU). SGU 6 covers the lowest labour potentials with about 9,000 LF and 7,000 MU (2005: 12,000 LF and 10,000 MU).

Table 2.2/5 shows clearly that most significant increases of the settled population will be found in SGU 3 (increasing from 52,500 persons in 1988 to 125,000 in 2005) and in SGU 1 (increasing from 50,500 persons in 1988 to 107,100 in 2005). This rapid population growth is, however, mostly related to urbanization processes and the expansion of off-farm employment in Jilib and Bardheere rather than to the development of the settled agricultural sector. The highest increase of population and households in settled agriculture in absolute terms occurs in SGU 4.

2.3 Future Farming Patterns and Farm Labour Potentials

The assessment of labour potentials for farming activities is based on both the macro-analysis of labour availability derived from population dynamics, and the micro-analysis of labour requirements demanded by different cropping patterns and farming systems.

Future development in the Juba valley will change the existing mix of cropping patterns and farming systems considerably. In order to give a first rough assessment of the area which can be brought under irrigation with the available labour force in 1995 and 2005, two basic models can be employed:

- the first assesses the possible expansion of irrigated crop production (in ha), irrespective of changes in present cropping patterns and labour intensities, on the basis of assumed increments of labour potentials until 1995 and 2005;

- the second assesses the possible expansion of irrigated crop production assuming that the total mix of cropping patterns and labour intensities will change.

Both possibilities can be further differentiated according to labour requirements of cropping patterns. Future labour requirements, in terms of man-days required per year and hectare, for irrigated crop production vary from 115 man-days in irrigated crop production on vertisoils (land preparation by tractor), 165 man-days in mechanized irrigated crop production on vertisols, 170 man-days in irrigated crop production on levee land (land preparation by tractor), to 210 man-days in rice double cropping (not regarding outstanding labour requirements of 595 man-days in banana cultivation).

Taking into account a necessary elasticity between labour requirements and the amount of labour statistically available, these labour requirements result in a demand for 0.44 to 0.81 manpower units (MU) per hectare and year. These patterns of labour requirements are presently represented by the mix of farming systems and cropping patterns in SGU 2 (0.4 MU/ha), SGU 4 (0.8 MU/ha) and SGU 3 (0.6 MU/ha).

According to analysis and assumptions made on labour supply, the labour force available for farming activities will increase from 64,900 manpower units in 1988 to 78,200 in 1995 and 105,800 in 2005. Thus, increments of farm labour force make up 13,300 manpower units until 1995 and further 27,600 until 2005.

Table 2.3/1 presents four development scenarios of possible increments of irrigated crop production on the basis of assumed labour force increases.

Scenario 1 assumes that increments of irrigated areas under crop production will demand 0.4 manpower units/ha;

Scenario 2 assumes that increments of irrigated areas under crop production will demand 0.8 manpower units/ha;

Scenario 3 assumes that the total mix of farming patterns will shift to labour requirements of 0.6 manpower units/ha, as presently represented by SGU 3;

Scenario 4 assumes that the total mix of farming patterns will shift to labour requirements of 0.8 manpower units/ha, as presently represented by SGU 4.

Table 2.3/1 Possible Increments of Irrigated Crop Production (in ha)

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1995	30,200	16,600	17,700	- 1,500
2005	62,700	34,500	45,200	36,900
Total Increment	92,900	51,100	62,900	35,400

Table 2.3/1 shows clearly that rapid changes in the mix of farming systems, particularly in the before-dam situation, would not allow for outstanding expansions of irrigated cropped areas. A change of pattern as presently represented by SGU 4 which is determined by high labour demands from large scale estates and medium-scale banana farms would even decrease the potential command area in the before-dam situation and would allow for a total increment of only 35,400 ha until 2005.

A shift of average labour requirements to the pattern presently represented by SGU 3 would allow for an increase of irrigated areas under crop production of 17,700 ha until 1995 and of further 45,200 until 2005 making up a total increment of 62,900 ha.

The labour force additionally available for farming activities allows for an expansion of irrigated areas under crop production between 16,000 and 30,000 ha until 1995, and between further 35,000 and 62,000 ha until 2005, depending on labour intensity of cropping patterns and farming systems implemented.

The interpretation of these figures has to consider two aspects which are not taken into account (and have contradictory effects on the total area that can be brought under cultivation with the available labour force):

- above figures concern additional labour potentials assuming that they are not absorbed i.e. in rainfed farming but can entirely be mobilized for the expansion of irrigated crop production

- above figures concern additional areas which can be brought under cultivation with the additional labour force; they do not consider conversion processes, i.e. of deshek/levee into irrigated cultivation, which do not require additional labour force

- the figures do not reflect changes that are related to major population movements (e.g. resettlement); additional labour force potentials from outside the Study Area will slightly increase the area development potential.

Furthermore, it has to be considered that the preceding and following estimates are based on the analysis of present labour allocation patterns which are subject to change in the future, i.e. increasing labour supply to farming activities.

In order to arrive at a more refined picture on the level of Socio-Geographic Units, assumed changes in farming patterns, labour requirements and their relation to the available amount of manpower in 1995 and 2005 will be described according to the crop production development concept as proposed in the Masterplan.

Whereas changes in the deshek/levee farm system and irrigated crop production are clearly defined, the expansion of areas under rainfed cultivation is a major variable. On the one hand, it can be assumed that the rainfed population will partly shift to irrigated crop production; on the other hand, population increases in rainfed areas will lead to the expansion of farm land. The probable extent of the latter is difficult to assess. Therefore, the following estimates entail both a minimum and a maximum assumption on cropped rainfed area. The first assumes that the area per SGU will not change, the second that the area will increase according to the increase of farm households (assuming that average farm sizes will not change in future (see also ANNEX 4, Crop Production).

Table 2.3/2 illustrates assumed farming patterns and farm labour potentials in 1995 for six major Socio-Geographic Units. It clearly shows that labour in quantitative terms will not be a limiting factor for the development of irrigated crop production in the before-dam situation if it is implemented as envisaged by the Masterplan development concept for the crop production sector.

Major changes in the before-dam situation will take place in SGU 1, 2 and 3 with an increase of irrigated areas under crop production of 3,500 ha, 3,400 ha and 2,000 ha respectively. In SGU 2 and 3 this expansion will mainly take the form of converting deshek/levee cultivation.

Table 2.3/2 Farming Patterns and Labour Potentials 1995

SGU	FS	Annually cropped ha	MD ha/year	MU1	MU2	MU2/ MU1	MU1/ ha
SGU 1	R1	21,000-30,000	107	7,200-10,300			
	SI1	3,500	100	1,100			
	SI2	2,500	163	1,300			
		27,000-36,000		9,600-12,700	12,300		1.0-1.3
SGU 2	R1	7,000-10,600	107	2,400-3,600			
	D	4,300	140	1,900			
	SI2	5,000	163	2,600			
		16,300-19,900		6,900-8,100	12,300		1.5-1.8
SGU 3	R2	2,300-2,900	81	600-800			
	D	1,700	140	800			
	SI1	2,200	100	700			
	LI	7,800		6,400			
		14,000-14,600		8,500-8,700	12,400		1.4-1.5
SGU 4	R2	7,000-8,400	81	1,800-2,200			
	SI1	2,000	100	600			
	BI	3,400	595	6,500			
	LI	600		600			
		13,000-14,400		9,500-9,900	19,000		1.9-2.0
SGU 5	R1	36,000-46,800	107	12,300-16,100	11,700		0.7-1.0
SGU 6	R2	7,700-9,400	81	2,000-2,400	7,100		3.0-3.6

FS = Farming system
R1 = Rainfed farming system 1
R2 = Rainfed farming system 2
D = Deshek/Levee cultivation
MU2 = Manpower units available
SI1 = Irrigated crop production on vertisoils, land preparation by tractor
SI2 = Irrigated crop production on levee land, land preparation by tractor
BI = Banana irrigation farms
LI = Large scale irrigation
MD = Labour requirements in man-days
MU1 = Manpower units required

Particularly in SGUs where rainfed farming systems do not dominate and the expansion of irrigated crop production will take the form of conversion labour supply problems will hardly occur. In comparison to the present situation, the elasticity between labour requirements and statistically available labour force even slightly increases in SGUs 2, 3 and 4. In SGU 1 no labour strains can be foreseen with respect to the envisaged development of irrigated crop production; labour stresses, however, would occur if the acreage under rainfed cultivation would expand according to population increases. In SGU 5 labour stresses were already identified for the present stage of development. This situation will continue if labour productivity and labour supply will not be raised by the improvement of health conditions and supply of basic needs in rainfed areas.

Table 2.3/3 illustrates assumed farming patterns and farm labour potentials in 2005 for six major Socio-Geographic Units.

Table 2.3/3 Farming Patterns and Labour Potentials 2005

SGU	FS	Annually cropped ha	MD ha/year	MU1	MU2	MU2/ MU1
SGU 1	R1	21,000-53,400	111	7,500-19,000		
	SI1	5,000	115	1,800		
	SI2	2,500	170	1,400		
		38,000-60,900		10,700-22,200	17,500	0.8-1.6
SGU 2	R1	7,000-16,900	111	2,500-6,000		
	SI2	10,000	170	5,400		
		17,000-26,900		7,900-11,400	16,400	1.4-2.1
SGU 3	R2	2,300-4,000	98	700-1,300		
	SI1	3,500	115	1,300		
	LI	9,500		7,700		
		15,300-17,000		9,700-10,300	16,600	1.6-1.7
SGU 4	R2	7,000-11,300	98	2,200-3,500		
	SI1	5,000	115	1,800		
	BI	5,000	595*	9,500		
	LI	2,000		1,100		
		19,000-23,300		14,600-15,900	25,300	1.6-1.7
SGU 5	R1	36,000-68,400	111	12,800-24,300	15,700	0.7-1.2
SGU 6	R2	7,700-12,500	98	2,400-3,900		
	SI1	4,900	115	1,800		
	BI	2,100	595*	4,000		
		14,700-19,500		8,200-9,700	9,500	1.0-1.2

* Note: 595 man-days/ha/year are assumed by AHT 1984; 274 man-days/ha/year by USBR 1987.

In the with-dam situation major changes will occur in SGU 2 with an expansion of irrigated crop production of 5,000 ha, in SGU 4 with an expansion of small-scale irrigation of 3,000 ha and of 1,600 ha banana cultivation, and in SGU 6 (mainly Homboy Area) with an expansion of 4,900 ha small-scale irrigation and of 2,100 ha banana cultivation.

In general, it can be concluded, that the expansion of irrigated crop production envisaged in Table 2.3/3 according to the Masterplan crop production development concept can be easily coped with by the available labour force in 2005.

The elasticity between labour requirements and the statistically available labour force (MU2/MU1) will not change significantly compared to 1995. An exception is SGU 6 in which a rapid development of small-scale irrigation and banana schemes is envisaged absorbing almost all labour potentials in this area. Labour stresses, however, will not occur because SGU 6 faces presently the highest degree of labour surplus.

It was mentioned before that above estimates are supposed to identify a rough order of magnitude concerning available manpower for future development. Various assumptions made are definitely subject to discussion and change on the basis of improved data and information.

Considering these vagaries, the above figures allow for the conclusion that labour potentials are sufficient for a sound development or irrigated crop production, mainly oriented towards small-scale farmers.

Apart from those farmers, major population groups which will have to be addressed are households being engaged in subsistence farming and employed in medium- and large-scale projects, and rainfed farming households particularly in SGU 5. Labour stresses occurring in both of these socioeconomic systems have to be addressed by various measures of improving economic and social conditions of subsistence farming.

APPENDIX

Discussion of Population Estimates

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Discussion of Population Estimates

1. National Population Statistics

The present data situation is determined by the results of the 1975 Census, since almost all recent population estimates refer to this source. It is assumed that on the basis of the 1975 Census no realistic estimate of the present population is possible, at least because of three biasing influences:

- 1975 was a year of extreme drought causing a movement of many nomads to the river valleys. Consequently, considerable distortion of census results can be assumed.

- On the other hand, the 1975 Census was combined with a mass adult education and vaccination campaign. Only participants in this campaign were enumerated. This indicates a considerable under-enumeration of official figures.

- The Ogaden conflict increased the number of refugees who were not enumerated in the 1975 Census and following estimates.

It is extremely difficult to quantify as a result of the partly contradictory influences. The TECHNITAL Study [90] estimated that only between 65 and 80% of the population living in the Juba Valley Region was covered by the 1975 Census. On the other hand, it is assumed that this study underestimated the temporary movement of nomads to the Juba Valley as well as the settlement of refugees in Gedo District.

Recent population estimates of the Ministry of National Planning of Somalia (MNP) and various international organizations show remarkable variations according to different assumptions on the annual population growth rate, the extent of international migration and refugee settlement, and the share of nomadic population in total population.

Whereas the latest population estimate of MNP in 1986 cites 8.5 million people [52] most of the recent estimates, including some publications of MNP, range from figures around 5.5 million to 6.5 million people.

Table A1 shows that the most remarkable differences in population estimates refer to the years 1980 and 1981. Estimates of the U.S. Census Bureau (F) and the Agricultural Statistical Handbook for Somalia (G) jumped from 1979 to 1981 by 1.4 million resp. 1.0 million people. In contrast to these figures, those of other international organizations and the Ministry of National Planning recorded standard growth rates, increasing the population between 200,000 and 500,000 people. These differences are mainly due to different estimates and handling of refugee figures. Whereas the lower figures do not include the refugee movement, those of the U.S. Census Bureau and the Agricultural Statistical Handbook do. The latter includes a number of refugees and net international migration of more than one million people [63].

Table A1 Population Estimates for Somalia (in thousands)

Year	A	B	C	D	E	F	G
1975	4089	4089	3722	3125		3583	3640
1979	4533		4156	4316		4872	4872
1980	4652		4272	4612		5373	5373
1981	4788		4392	4867		5912	5912
1985	5377	5384		5552	5234/5500	6542	6542

Sources: A: MNP, according to Agricultural Statistical Handbook for Somalia (ASHS), Mogadishu 1985
B: MNP, Analysis of Rural and Intercity Transportation, 2 Volumes, Mogadishu 1986
C: UNO, according to ASHS 1985
D: FAO, according to ASHS 1985
E: World Bank, Somalia: Recent Economic Developments and Medium-Term Prospects, Report No. 6542-SO, 1987; Somalia: Towards Economic Recovery and Growth, Report No. 5584-SO, Washington D.C. 1985
F: U.S. Census Bureau, according to ASHS 1985
G: Task Force No. Five, Agricultural Statistical Handbook for Somalia (ASHS), Agricultural Sector Review, Mogadishu 1985

Compared to estimates for the years between 1979 and 1981 population estimates after 1981 do not show remarkable variations and extraordinary growth rates. Generally it is assumed that the refugee movement had stopped. The Agricultural Statistical Handbook suggests that a return of net migrants to their homelands might hold the population of Somalia around 6.5 million people.

In comparison to all other sources, including sources of the Ministry for National Planning itself, its most recent publication estimating a population of about 8.5 million people in 1986 seems to be most misleading. This estimate and its employed methodology is not explainable the more as it is also based on the 1975 Census and the assumption of an annual population growth rate of 3.1%.

The quite vague and problematic national population statistics might be recalculated on the basis of the following considerations:

- The 1975 Census as the basis for further calculations has to be modified by adding an estimated under-enumeration of 15%.

- A further adjustment has to be made with regard to the under-enumeration of females. According to calculations of the U.S. Census Bureau the 1975 enumerated female population was inflated by 3.6% to yield an expected overall sex ratio of 1.045 rather than the reported one of 1.08 [102].

- An average annual population growth rate of 2.8% is adopted taking into account the extraordinary high infant mortality.

- Estimates of refugee figures will not be included because no reliable data are available, and no accurate estimate about the net return of migrants is possible.

Taking the figure of 3,492,006 inhabitants in 1975, as reported by the IMPRESIT study [33], the following re-calculation of total population in Somalia in 1987 can be made:

Recorded population in 1975	3,492,006
+ 3.6% (female under-enumeration)	3,617,718
+ 15% (general under-enumeration)	4,160,375
+ annual population growth rate of 2.8%	
Estimated population in 1987	5,794,952

Considering the vague figure of about 700,000 refugees, as assumed by the UN High Commissioner for Refugees, the population of Somalia in 1987 would be around 6.5 million people. This estimate comes near to the estimates of the U.S. Census Bureau and the Agricultural Handbook for Somalia. However, it is still about 2 million inhabitants lower than reported by the most recent official estimate of the Ministry of National Planning.

2. Population Figures on Regional and District Level

A breakdown of national population figures to the regional and district level of the Juba Valley is not possible. On the one hand, there are considerable differences in population structure and other socioeconomic conditions between the national and regional level as well as within the region itself. On the other hand, figures referring to the 1975 Census have to be handled carefully because administrative divisions changed between 1976 and 1983. The following considerations have to be made with regard to administrative changes:

- According to the administrative divisions in 1975 the entire Juba Region consisted of the regions of Lower Juba, Gedo and Bay.
- The Bay Region is not included in the present administrative division of the Juba Region. Since the former Bay Region consisted of the Dinsor and Qansadheere Districts they have to be subtracted from the former Juba Region.
- The former Lower Juba Region was divided into the regions of Lower Juba with Kismayo as its urban center and Middle Juba with Jilib as its urban center. Consequently, population figures of Jilib District has to be subtracted from the former Juba Region and to be transferred to Middle Juba.
- The Gedo Region did not change with the exception of Saakow District that was integrated within Middle Juba Region. Thus, the population of Saakow District has to be transferred to Middle Juba.
- The Middle Juba Region now consists of the districts of Jilib, Bu'aale and Saakow. The Dujuma population listed separately in 1975 has to be included into Bu'aale District. In addition, the population of Dujuma has been reduced to some 5,000 people due to large movements taking up employment in the Juba Sugar Project at Mareerey. Therefore, it is proposed to transfer this former population of Dujuma to Jilib District [63].

A source providing data on district level based on the 1975 Census is the IMPRESIT Study [33]. However, its calculation of population figures for 1985 uses an annual population growth rate of 2.4% that is considered to be too low.

Table A2shows the 1975 figures and administrative division of the IMPRESIT Study on the one side, and an 1987 population estimate calculated on the basis of an annual population growth rate of 2.8% and taking into account the above mentioned administrative changes.

Table A2 Population Estimates for the Juba Region 1975 - 1987

Region	District	1975	District	1987
	Kismayo	57,857	Kismayo	80,588
	Jamaame	63,657	Jamaame	88,666
	Afmadow	40,435	Afmadow	56,321
	Badaade	24,700	Badaade	34,403
	Jilib	59,377		
Lower Juba		246,026		259,978
			Jilib	94,329
			Bu'aale	34,345
			Saakow	54,692
Middle Juba				183,366
	Saakow	39,266		
	Bardheere	52,137	Bardheere	72,621
	Bulo Hawo	25,420	Bulo Hawo	35,406
	El Waq	23,437	El Waq	32,645
	Dolo	7,795	Dolo	10,857
	Luuq	25,286	Luuq	35,220
	Garbaharey	38,790	Garbaharey	54,030
Gedo		212,131		240,779
	Dinsor	48,305		
	Qansadheere	48,062		
Bay		96,367		
Total		554,524		684,123

Source: [33]

On the basis of the above figures the following population would be given for the Study Area:

District	
Kismayo	88,666
Jamaame	56,321
Jilib	94,329
Bu'aale	34,345
Saakow	54,692
Bardheere	72,621
Total	400,975

3. Population Estimate on the Basis of the "SAMPLING FRAME FOR SOMALIA"

The following numbers of urban and rural settled households are given in the "Sampling Frame for Somalia" (see Table A3) [50]. Population estimates are calculated on the assumption of an average household size of 5.5 persons and average annual population growth rate of 2.8%.

Table A3 Settled Population on Household Basis

District	Households			Settled Population		
	Urban	Rural	Total	1982	1985	1987
Kismayo	13,225	2,927	16,152	88,836	96,509	101,989
Jamaame	1,422	7,621	9,093	50,011	54,330	57,415
Afmadow	740	5,692	6,432	35,367	38,421	40,603
Badaade	630	2,083	2,713	14,921	16,209	17,130
LOWER JUBA	16,017	18,373	34,390	189,145	205,482	217,150
Jilib	3,408	6,425	9,833	54,081	58,752	62,088
Bu'aale (x)	2,145	1,734	3,879	21,334	23,176	24,492
Saakow	1,854	4,023	5,877	32,323	35,114	37,108
MIDDLE JUBA	7,407	12,182	19,589	107,739	117,044	123,691
Bardheere	3,483	8,250	11,733	64,531	70,104	74,085
Garbaharey	2,934	3,470	6,404	35,222	38,264	40,437
Luuq	2,524	3,230	5,772	31,746	34,488	36,446
Bulo Hawo	1,813	430	2,243	12,336	13,401	14,162
Dolo	264	500	764	4,202	4,564	4,824
El Waq	335	76	411	2,260	2,485	2,594
GEDO	11,353	15,956	27,327	150,298	163,279	172,551
Total	34,795	46,511	81,306	447,182	485,805	513,392

(x) Including 956 urban households of Dujuma

Source: [50]

In order to calculate total population per district on the basis of the above table information on nomadic population is required. In the following figures of the proportion of nomadic in total population were used which are reported by the Ministry of National Planning [4] (proportion of nomadic population in brackets) (see Table A4).

Table A4 Settled and Total Population

District	1985 Settled	1985 Total	1987 Settled	1987 Total
Kismayo (18)	96,509	117,694	101,989	124,377
Jamaame (12)	54,330	61,739	57,415	65,244
Afmadow (83)	38,421	226,006	40,603	238,841
Badaadhe (78)	16,209	73,677	17,130	77,864
LOWER JUBA (38)	205,482	331,423	217,150	350,242
Jilib (38)	58,752	96,315	62,088	101,784
Bu'aale (39)	23,176	44,569	24,492	47,100
Saakow (46)	35,114	65,026	37,108	68,719
MIDDLE JUBA (42)	117,044	201,800	123,691	213,260
Bardheere (37)	70,104	111,276	74,085	117,595
Garbaharey (90)	38,264	382,640	40,437	404,370
Luuq (72)	34,488	123,171	36,446	130,164
Bulo Hawo (55)	13,401	29,780	14,162	31,471
Dolo (27)	4,565	6,253	4,824	6,608
El Waq (92)	2,455	30,563	2,594	32,425
GEDO (65)	163,279	466,511	172,551	493,003

Source: [52]

At a glance it is not only striking that there are considerable differences between different sources but also outstanding inconsistencies between regional and sums of district figures.

Table A5 presents a synopsis of figures on district level (reference year: 1985) derived from the IMPRESIT Study [33], Ministry of National Planning [50, 51] and the household sampling frame. Inconsistencies between regional figures and corresponding sums of district figures will be indicated in brackets.

Table A5 Synopsis of Figures on District Level (Reference Year 1985)

District	Impresit	Min.of NP	Sampling Frame	
Kismayo	76,258	89,493	117,694	
Jamaame	83,902	100,123	61,739	
Afmadow	53,294	61,534	226,006	
Badaadhe	32,555	37,833	73,677	
LOWER JUBA	246,010	288,984	331,423	(479,116)
Jilib	89,261	84,295	96,315	
Bu'aale	32,500	34,591	44,569	
Saakow	51,754	23,964	65,026	
MIDDLE JUBA	173,515	142,949	201,800	(205,910)
Bardheere	68,719	72,737	111,276	
Garbaharey	51,127	55,898	382,640	
Luuq	33,328	43,471	123,171	
Bulo Hawo	33,504	18,296	29,780	
Dolo	10,274	12,469	6,253	
El Waq	30,891	34,184	30,563	
GEDO	227,843	237,055	466,511	(683,683)
Total	637,368	668,988	999,734	(1,368,709)

Source: [33, 50, 51]

It is most striking that outstanding differences between sources concern the Gedo Region in general, and Garbaharey and Luuq District of Gedo as well as Afmadow and Badaadhe District of Lower Juba in particular. The same is true with regard to inconsistencies of district and regional figures within the household data. There are only minor differences between sources with regard to Lower and Middle Juba, and district and regional figures for Middle Juba are quite consistent. Thus, inconsistencies within sources as well as differences between sources are mainly due to Afmadow, Garbaharey and Luuq District.

This gives some evidence to the assumption that data problems mainly occur in areas with a high estimate of nomadic population. A closer look to the concerned districts reveals that this is particularly true for areas not only having an outstanding share of nomadic population but also a considerable size of settled population. Since calculation of absolute numbers of nomads are based on estimates of settled population, distortion of population data may be caused by overestimations of the settled population.

The above household data show that there are two pattern of settled populations in areas which are mainly populated by nomads. The first pattern is represented by Afmadow and Badaadhe District which are characterized by almost rural settlements. Whereas urban figures are low and are consistent with population data of MNP, 5,692 and 2,083 rural households are reported for Afmadow and Badaadhe respectively. Compared to figures of MNP that reports a rural settled population of just 4,479 for Afmadow and of 4,354 for Badaadhe it can be assumed that the above household data in nomadic areas entail a clear overestimation of rural settled households.

The second pattern is represented by Garbaharey and Luuq District which are characterized by a considerable size of rural settled as well as urban settled population. 2,934 urban households are reported for Garbaharey. Compared to the corresponding population figure of only 2,832 people a considerable overestimation of urban population can be assumed. This is also true for rural settlements. Whereas 3,470 and 3,230 households are reported for Garbaharey and Luuq respectively, corresponding population data of source B are only 2,808 and 2,139 respectively.

ANNEX 4

S O M A L I A

Masterplan for Juba Valley Development

Crop Production

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List of Abbreviations

AFMET	-	Agricultural Farm Management and Extension Training Project
CIF	-	Cost, Insurance, Freight
FAO	-	Food & Agriculture Organization
FOB	-	Free on board
ONAT	-	Organisazione Nazionale Altressi Trattore
SGU	-	Socio-Geographic Unit
USBR	-	US Bureau of Reclamation

Local Terms

Beel	-	administrative subdivision of a district
Darab	-	agricultural plot (about 0.25 ha)
Der	-	rainy season; mid October to mid December
Deshek	-	natural floodplain depression
Gu	-	rainy season; mid April to mid July
Jilaal	-	dry season; mid December to mid April
Xagai	-	dry season; mid July to mid October
Yambo	-	traditional hand tool (short-handled hoe) for soil preparation

Crop Production

1. Introduction

The present document on crop production has been elaborated as an ANNEX to the Masterplan Study for Juba Valley Development. The ANNEX consists basically of two parts; an analyses of the present situation, and the proposed development scenarios for the future.

At the end of the report an analysis of farm income development, including the income farm families derive from their livestock, has been presented for the present situation as well as for the future in the before and after Bardheere dam situation. Details of labour requirements for the present and future situations are presented in the APPENDICES to this ANNEX.

For the present situation, for all the existing crop production systems; rainfed, flood recession and irrigated (small-, medium- and large-scale) crop production, a detailed analysis has been presented. The following aspects have been examined; characteristics of each cropping system, the physical production conditions, cropping patterns and yields, cultural practices and the major factors limiting agricultural productivity and production.

For the future, development scenarios have been proposed for the three crop production systems. Apart from general considerations which determine the future of each system, the following aspects have been highlighted. The expansion or reduction of the area under each production system, including the number of farm families involved, until the end of the planning period; development of cropping patterns including the introduction of green fodder production; development of crop yields and total agricultural production output of the area.

Recommendations have been presented as to how the proposed scenarios can be implemented. A major factor of consideration in the present and future development of crop production in the Development Area is the role of the agricultural production support services, such as applied agricultural research, extension and training, input supply and seasonal and medium-term credit. These subjects will be dealt with in ANNEX 5.

The present situation and future developments, proposed for irrigated crop production, have to be considered in close relation with the proposals presented in ANNEX 2.

2. Parameters of Present Crop Production in the Juba Valley

Both agriculture and livestock are at present the most important sectors of the economy in the Juba valley. It is estimated that as much as 46% of the labour force is employed in sedentary agriculture and 32% in employment related to nomadic livestock keeping (see ANNEX 3, p. 9).

There are different degrees of integration to be found between crop production and animal husbandry. In principle all farmers belonging to the traditional systems of rainfed and deshek cultivation are in addition livestock keepers. However, the importance of livestock to the river farmers is certainly less than to the pure rainfed farmers. The predominant livestock element in the planning area is nomadic livestock keeping.

Over the years, distinctly different farming systems have developed. The extent of each system is shown in Map 1. The organization of these systems constitutes a continuum ranging from cultivator owned and managed farms over various forms of sharecropping to privately and publicly owned commercial enterprises.

In Section 3 an analysis of the main characteristics of each of the identified farming systems is presented. Table 1 summarizes some of the most striking features, such as the location and the type of farming. The dynamics inherent in each system are also indicated.

In Section 4 the physical and technical aspects of each type of crop production are described and evaluated while the major constraints to increase agricultural productivity and production have been identified. Table 2 presents some of the most important information in that section in a summarized form. Here the importance of each farming system is shown with regard to the area cropped, main crops and amount of produce as well as the numbers of farmers involved in crop production.

Table 2/1 Farming Systems: Location and Characteristics

Farming System	Location	Typification	Present Development Tendency
Rainfed based farming system Subsystem 1	between dam site and Fanoole; concentrations in West Bardheere District and West Saakow District small areas in Bu'aale District	traditional rainfed cultivation with low and erratic rainfalls; low standard of production techniques; lack of any support services	low expansion related to population growth; low expectations for future conversion into irrigation schemes
Subsystem 2	between Fanoole and Yontoy in Jilib, Jamaame and (little) Kismayo District; dispersed subunits, i.e. Homboy area, Southeast Jamaame, North of and around Juba Sugar Project, South of Mogambo to Deshek Waamo	traditional rainfed cultivation with slightly better rainfall conditions; low standard of production techniques, (although somewhat higher than in subsystem 1) due to limited availability of support services	low expansion as above; but strong expectations for future irrigation
Flood recession (deshek) based farming system	between 20 km North of Saakow town and Jilib	traditional flood irrigation on the floodplain combined with rainfed farming; low standard of production techniques; no support services	tendency towards conversion into small-scale pump irrigation schemes; increased flood protection
Small-scale irrigated farming systems	concentrated in Bardheere District; lately also in Saakow and Bu'aale Districts	low standard of pump irrigation and farming techniques; market oriented production; some access to farm inputs	expansion into Saakow and Bu'aale Districts
Banana cultivation	between Kamsuma and Yontoy along the river in Jamaame District	private commercial market oriented big farms; advanced irrigation and farming techniques; strong support through SOMALFRUIT company	expansion through rehabilitation of existing schemes
State Farms - Fanoole Project	between Jilib and Kamsuma, East bank of Jilib District	gravity irrigation of rice; large scale public enterprise	low grade of implementation with low expectations for improvement
- Juba Sugar Project	between Fanoole and Kamsuma; west bank of Jilib District	pump-irrigated public enterprise; sprinkler irrigation	implementation somewhat behind schedule
- Mogambo Project	between Mogambo and Araare; West of banana plantations	pump-irrigated public enterprise; some smallholder participation	new scheme with some implementation delays

Table 2/2 Farming Systems: Cropped Land, Produce and Farm Families (1987/88)

Farming System	Farmland ha (1)	Main crops grown	Annual production t (1)	Farm families involved (1)
Rainfed based				
- Subsystem 1	95,000	Sorghum	60,000	10,300
		Maize	3,800	
		Sesame	1,100	
		Beans	300	
- Subsystem 2	27,500 (2)	Maize	8,400	11,000
		Sesame	2,600	
		Cotton	350	
		Sorghum	700	
Flood Recession (deshek) based farming system	11,400 (3)	Maize	6,700	5,450
		Sesame	3,000	
		Beans	500	
		Vegetables/ fruits, etc.	1,100	
Small-scale irrigated farming system	4,100	Onions	23,400	1,200
		Tobacco	560	
		Maize	3,840	
		Sesame	980	
		Vegetables/ fruits, etc.	2,000	
Banana cultivation	3,400	Bananas		60
		- exportable	25,000	
		- non-exportable	25,000	
State Farms				
Fanoole Project	1,000	Rice, seasonals	5,400	
Juba Sugar Project	7,000	Sugar	42,600	
Mogambo Project	1,600	Rice	4,000	300

1) Rounded figures.
2) Including Homboy area.
3) 7,000 ha of deshek and 4,400 ha of levee lands.

3. Farming Systems

3.1 Rainfed Crop Production

The rainfed farming systems in the Development Area have developed from two main socioeconomic groups, namely the traditionally sedentary cultivators who originally settled along the river and the traditionally nomadic pastoralists.

The first group started settling in the lower Juba reaches and they constitute the oldest and also the largest population group within the rainfed system. It appears that descendants of these sedentary cultivators gradually moved along the flooded, fertile lands in the depressions (desheks) near the river. Increasing shortages of this type of land seem to have forced some of the descendants of these settlers to seek land further away on the marine plains.

The second group of traditionally nomadic pastoralists settled into the areas in several waves of migration. One large thrust is said to have taken place at the turn of the century, as the result of a devastating drought in the Bay Region around Baydhabo and Dinsor [69].

Livestock keeping is the second element of the economic system of rainfed farming. As a rule each rainfed farmer builds up a herd of cows, goats and/or sheep which can be seen partly as a compensation for the risk which is connected to rainfed farming.

Two subsystems have developed within this farming system because of differences in rainfall, soils and area accessibility. Subsystem 1 is found in the northern and middle part of the valley, up to the southern borders of Bu'aale District. Subsystem 2 is predominant from here to Kismayo.

Common to both subsystems is the priority given to staple food production and keeping of livestock; cash crop cultivation has secondary consideration.

In Table 3.1/1 an assessment is made as to the distribution of rainfed farming between the districts and between the two subsystems.

Table 3.1/1 Rainfed Farming per District and Subsystem

Subsystem/ district	Farmland in ha	Annually cropped land in ha	Number of farm families	Average farm size in ha
Subsystem 1				
Bardheere	58,000	82,000	6,400	9
Saakow	35,000	44,100	3,500	10
Bu'aale	2,000	3,900	400	5
Subsystem 2				
Jilib	7,000	6,500	2,500	2.8
Jamaame	19,000	10,000	7,900	2.4
Kismayo	1,500	500	600	2.5
Total	122,500	147,000	21,300	5.8

Source: [70]

3.1.1 Subsystem 1: Bardheere, Saakow and Bu'aale Districts

The majority of farms are operated on a scale which, in an average year, will allow for sufficient production to meet the staple food requirements of the family and generates some cash income to cover the most urgent necessities. Due to the prevailing environment farm sizes, cropping patterns and to a considerable extent also productivity, are predetermined, leaving the farmer little flexibility in choosing alternative management and production strategies. The size of the cultivated area is determined by the family's own labour force, the low productivity of the land, the uncertain outcome of any cropping season and the precarious farm cash flow situation which does not allow for undertaking financial obligations at the time of planting. Few options exist for different crops, cropping patterns and crop rotations.

Agricultural activities are carried out individually, but mutual help arrangements are still existing.

Sale of produce is determined by a pronounced food security strategy, which implies that the maximum possible amount of grain is stored, and only that amount which is absolutely necessary to meet cash requirements is sold. The precarious cash flow situation of most farmers necessitates that during the time of spare labour capacity additional income is sought through off-farm employment; women contribute to cash earnings through the manufacture of simple handicrafts.

One element included in the risk reducing strategy of this vulnerable farming system is the investment in livestock, to act as an insurance against crop failures.

3.1.2 Subsystem 2: Jilib, Jamaame and Kismayo Districts

Rainfed based, fully sedentary farming systems in these districts are both on the marine plains and in the desheks, which have been protected against all but the most severe river flooding. However, flooding from the marine plains continues, but as the system no longer uses the method of flood irrigation to any great extent it is classified under the rainfed systems.

The system shares many of the characteristics of the above described Subsystem 1, with the difference that there is less livestock and the higher and more evenly distributed rainfall as well as the access to some services increase the number of crops that can be grown and widen the scope for agronomic practices. While the primary objective remains to produce the farm family's food requirements, farmers have the possibility of choice between different crops and cropping patterns in response to changes in relative prices. In contrast to the above system, farm size is not so much determined by family labour availability. Also the predominant aim here is to satisfy the subsistence requirements of the farmer's family, which can be achieved with smaller crop areas in this part of the valley. This is due to the better soil quality and more favourable rainfall patterns. The required cash income is earned partly by selling cash crops.

In addition, part of the family's labour force tends to be employed permanently in off-farm activities, such as in banana production, in the large irrigation projects or in employment offered in urban areas. Farmers' management strategies are distinctly risk-averse and agricultural operations are shared out between a number of plots. Within plots intercropping is preferred to pure stands.

3.2 Flood Recession Crop Production

Deshek farming consists of two or three subunits. Apart from the deshek land which is the land in the depression and is on average the most productive farm area, rainfed cultivation is also important. This may take place either on the levee soils or on a plot on the marine plain.

A high degree of risk is inherent in the system, as it is subject to droughts and major floods both from the river and, when excessive rains occur, also from the marine plains. The predominant management strategy is therefore to minimize risk by simultaneous cultivation of plots which are subject to different hazards. In the districts of Saakow and Bu'aale emphasis is on staple food production, restricted and predetermined by flooding, rainfall patterns and market access. In the southern district of Jilib, however, conditions are more favourable. A common feature of the system is that the farm size is normally determined by the family's own labour force and the use of hired labour is only of marginal importance.

Furthermore, most of the deshek farmers also keep small herds of animals, including some cattle, goats, sheep, donkeys and poultry. With the exception of donkeys, which are used for traction, the purpose of livestock keeping in this system is mainly to add to the generally poor diet of the families and occasionally to act as an additional source of cash income. In most cases the animals remain in the immediate vicinity of the villages.

Neighbourhood help systems are of considerable importance but are confined to the sharing of labour. Apart from on-field operations, the major communal operations are connected with flood protection.

Table 3.2/1 shows the deshek farmland, the annually cropped land and in addition the number of deshek farms and average farm sizes distributed between the districts.

Table 3.2/1 Deshek Farming per District

District	Farmland in ha (1)	Annually cropped land/ha	Number of farm families	Average farm size in ha
Saakow	1,800	3,600	1,500	1.2
Bu'aale	5,900	11,800	2,185	2.7
Jilib	3,700	7,400	1,762	2.1
Total	11,400	22,800	5,447	2.1

Source: [69]

1) The farmland area is composed by about 7,000 ha of deshek land and about 4,400 ha of levee land. The rainfed areas which many of the deshek farmers in the Saakow District cultivate in addition to deshek and levee land, are not considered here.

3.3 Small-Scale Irrigated Crop Production

Small-scale irrigated farming systems have developed over the last 10 to 15 years and are increasing in importance. The bulk of this still relatively small number of at present about 1,000 farmers is concentrated in the Bardheere District. However, there is a dynamic tendency towards the expansion of the system downstream into the Saakow and Bu'aale Districts.

A number of different management and organizational models are found in this system but the common characteristic is its market orientation. However, in all cases the family's staple food requirements will be produced on the farm, but major attention is on cash crop production, mainly of onions and tobacco.

In one of the prevalent systems (in the Bardheere District), ownership of land and irrigation pumps is combined and the farm is managed with family labour, but hired labour constitutes a substantial part of the work force. The farm unit consists typically of two subunits, where one is irrigated and the other cultivated under rainfed conditions. Payment of hired labour is on a daily basis. In the case of larger units, hired labour tends to be substituted by sharecroppers and the involvement of the farm family in farm operations may be confined to decision making on the crops to be grown, supervision, input supply and marketing. Sharecropper remuneration for irrigated and rainfed crops is 50 and 70%, respectively.

In a more recent variation of sharecropping arrangements, ownership of land and pump is in different hands. Here the pump owner delivers irrigation water to a group of farms. The decision making on crops to be grown and cropping patterns is, however, with the owner of the land. The pump owners' return is 50% of the produce. Conflicts between the land and the pump owner which could arise, as the cropping pattern chosen also directly determines the latter's income, are said to be rare. The right to market the produce is with the pump owner but the landowner takes part in price negotiations. His bargaining position is usually stronger than that of the sharecropper and more equitable arrangements are likely to prevail. In this system, labour sharing and neighbourhood help does exist but is of lesser importance compared to the more traditional systems. The pump owners are organized into an informal group, that has as its sole objective to ascertain fuel needs and to organize its supply through Government channels. Membership is said to be open to all pump owners. This group is referred to as a cooperative but this does not mean that the inherent idea of the more conventional cooperative concept is pursued.

Access to land that can be pump irrigated can no longer be through allocation by the village committee, as no free land is now available. Instead land is bought and sold, but one would not expect frequent transactions to take place.

Further South, in the Saakow and Bu'aale Districts, irrigated agriculture is of less importance but is presently also increasing in response to the facilitated access to pumps and pricing policies that make investments more attractive. In this area, during the past two to three years, a clear tendency towards converting desheks from uncontrolled flood irrigation into controlled irrigated land has been observed. This basically requires the construction of flood protection measures, after which the land owner changes to concentrate on irrigating levee land. The lighter levee soils are more suitable for irrigation than the deshek land, which continues to be cultivated under rainfed conditions as well as the usually owned plot on the marine plain.

The production strategy pursued here seeks firstly a secure level of self sufficiency in staple foods. Only the remaining land is allocated to the production of cash crops. The degree of market integration is less than in the Bardheere District, largely because of the remoteness of the area and the resulting problems in marketing and input supply.

Irrigated agriculture is exclusively organized on a sharecropping basis, where one farmer or any other person, owns the pump and water is delivered to adjacent farms as well. The pump owners' obligations vary with the different crops grown; in the case of the high cost of onion cultivation he also provides the seed. His share in the production is 50% minus the full water delivery costs and minus the cost of seed in the case of onions. Sharing is in kind for grains and in cash for all other crops. The pump owner bears the major share of the risk.

Mutual aid arrangements do exist but appear to be confined to the traditional mutual help system, to break exceptional labour bottlenecks. Forms of cooperation involving joint ownership and management of assets are not found.

In Table 3.3/1 an assessment is made of the development of small-scale irrigated farming in three districts.

Table 3.3/1 Small-Scale Irrigated Farming Per District

District	Farmland in ha	Annually cropped land in ha	Number of farm families	Average farm size in ha
Bardheere	2,500	5,000	830	3.0
Saakow	900	1,800	300	3.0
Bu'aale	700	1,400	113	6.2
Total	4,100	8,200	1,243	3.2

Source: [69], updated

3.4 Banana Production

The commercial production of bananas was first introduced by Italian farmers in the mid-1920's. Production flourished until World War II. After that it was put under rice production by the British and rebuilt by Italian farmers in the 1950's. The peak in banana production was reached in the 1970's after which, following a post independence emigration by Italian farmers, there was a decline until the early 1980s. Since that time an increase in yields and cultivated area has been observed.

Banana cultivation is a purely market oriented system, managed according to commercial principles. The cultivated areas are determined by available capital and the ability to procure inputs and hired labour. Farms are managed individually and owners as well as hired management are found.

As only part of the production can be mechanized, a steady and reliable labour supply of skilled and unskilled labour is important. A variety of different relationships between employer and employee have developed. Skilled labour is employed on a permanent basis and payment is in cash. Unskilled labour is employed both on a permanent and casual basis. Casual labourers come from the surrounding farms in search of supplementary cash income and are paid on a daily basis.

The banana sector is organized along the lines of a nucleus estate concept. The joint venture company involving the Government and the private firm SOMALFRUIT, maintains its own production facilities. While the Government is represented on the Board of Directors, the company itself is managed strictly on technical and financial principles. The company organizes input supply, provides some extension services and extends both medium- and short-term credit. It also organizes marketing for that part of the production meant for export.

Growers are organized into an association which is intended to negotiate the more important issues, such as pricing. However, the concept is fairly new and the association has as yet to learn to take advantage of the opportunities offered. For operational issues, growers act individually with company representatives. Contractual arrangements do not exist, nor is there an obligation to use the company's input supply or marketing system. However, as SOMALFRUIT has the export monopoly for bananas, alternative marketing channels are restricted to the domestic market.

Input supply of internationally and domestically procured items has worked well and provided for the necessary stable production environment. A major reason for this is that the company has direct access to part of the foreign exchange it earns.

While participation is in principle possible for all banana growers irrespective of the size of operation, smallholders are effectively excluded. This is not a result of the insurmountable rigidities in the administration of the industry, but rather of the technical, financial and organizational requirements of the crop.

In 1987 there were 61 banana farms and 54 producers in the lower Juba region, mostly private farmers, the majority having between 1 ha and 50 ha of bananas. There are 4 state farms included in the above farm number, all belonging to the Ministry of Agriculture. They have planted in total 55 ha with bananas.

Of the total nominal area of 8,300 ha only 3,315 were actually under banana cultivation in early 1987. Due to the need for a fallow period of at least one year between crops, the banana crop area of 2,280 ha occupied only 69% of the land. Almost 5,000 ha of the nominal area of banana farms is abandoned, unutilized or used for low intensity seasonal cropping, but could be redeveloped for banana production.

According to the Homboy Study [76], two different management systems can be distinguished: one employing high inputs and using a medium level of technology and the other adopting low inputs and a low level of technology. Farms which belong to the medium level technology class are well managed, following the example set by SOMALFRUIT on its own farm.

The majority of the farmers, however, are classified as belonging to the low level technology group of banana growers. They are still using more traditional farming methods characterized by a low standard of crop husbandry.

3.5 Public Enterprises

Public enterprises are managed according to the state farm concept and only recently, and in one case, has the concept of a mixed farm, involving both semi-independent settlers and state farm operations with the same scheme, been introduced.

Three large-scale projects are under implementation. The Fanoole Project is a multipurpose project which includes infrastructure, hydropower generation and agricultural development by gravity irrigation. The farming areas are located between Jilib town and Kamsuma on the left river bank in the Jilib District. Opposite on the other side of the river, the Juba Sugar Project extends over a distance of about 40 km from North to South. Sugar cane is grown under sprinkler irrigation. The Mogambo Project which is further downstream in the Jamaame District, between Mogambo and Araare has been designed as a pure state farm for rice cultivation under gravity irrigation and for possible future cotton growing under sprinkler irrigation. Meanwhile the concept has been subject to changes with regard to the cropping calendar as well as to the participation of settlers.

In the case of the Fanoole Project, an area of 7,500 ha were to be put under rice cultivation, (1983-1988); the Juba Sugar Estate was to cultivate 7,200 ha in a first phase (1976-1982) and to be extended to a maximum area of 13,500 ha and the Mogambo Project would operated on 2,215 ha under mainly rice cultivation in a first phase (1984-1986) and on an ultimate area of 6,500 ha.

Although it proved feasible to put considerable parts of the physical structure into place, the development of the cultivation areas was and still is far behind schedule. Operation and maintenance has proven to be quite problematic and bears part of the blame for the below target expansion. Each of these systems has its own individual difficulties, but the major problems and constraints are those common to public sector managed productive enterprises, compounded by an exceptional shortage of managerial, professional and technical skills, budgetary dependence on the public sector, chronic foreign exchange shortage and dubious assumptions on achievable productivity.

The original objectives pursued for designing this type of large-scale enterprise was to break labour bottlenecks and to operate on a higher level of productivity than appeared possible with smallholder production. To this end, capital intensive and foreign exchange dependent production technologies were introduced on a large scale.

It is, however, one of the characteristics of this farm type that despite the high degree of mechanization and its inherent requirements for managerial and technical skills and/or finance, there is still a very high dependency on a large amount of unskilled labour. The shortage, unreliability and fluctuations of the supply of unskilled labour has proven to be a severe constraining factor. This is based on the fact that most labourers seek income through employment in the projects only as additional cash income. Preference is given to independent small-scale farming by which subsistence and some cash requirements are satisfied.

A further typifying element is the high demand for capital investment which can usually only be met by the provision of foreign exchange. The total investments of the Fanoole Project i.e. will amount to about SoSh 10,300 million, of which 95% are in foreign currency. Investments in the Juba Sugar Project, which are budgeted at SoSh 23,900 million, are financed to 79% by foreign sources and the foreign component of the total investment in Mogambo amounting to about SoSh 3,000 million, will eventually be more than 90%.

All foreign capital is provided as soft loans or as a grant from the Governments of the donor's countries. However, despite the favourable credit conditions, experience has proven that repayment obligations are difficult to fulfill.

Foreign exchange earnings have so far only been created by the Sugar Project. If they had been available to the project, they could have contributed quite considerably to the self-financing of the project. In particular, the urgent requirements for spare parts and replacement of machinery and equipment could have been met. However, the project has had only reduced influence on budget decisions. This holds true for all three state enterprises. They completely depend on budget allocations from the Government.

In addition to this, the projects have been dependent on the Governments price policy. As far as this is concerned, it seems that the considerations according to which prices have been fixed are other than those aiming at the development of financially self-sustained enterprises.

Another characteristic inherent in the system of large-scale projects with high capital investment demand is the low flexibility with regard to changes. Once the project is designed and implementation is underway, it is hardly possible to make any major modifications such as in the cropping calendar, the irrigation method and extent, and the involvement of smallholders. This can be clearly observed in all projects in the lower Juba region. If the Fanoole Project is taken as an example, this phenomenon becomes particularly obvious. The construction of the large, long and capital intensive irrigation main canal has set the precondition for water use and the area to be developed. The same applies to the large rice mill which has been designed to cope with the requirements of processing double-cropped rice on an area of over 7,000 ha. These two existing factors make any changes in the project setup very difficult.

While the problem of low flexibility may be overcome to some extent by extremely accurate project planning, it is thought that the strong dependency on outside managerial skills is going to be long-lasting and will increase, if additional public enterprises are established. Experience has clearly shown that the prevailing type of public enterprise does not attract the already limited number of local, skilled managerial professionals. Thus the projects depend heavily on management from abroad and each newly planned project of this kind would aggravate this problem.

4. Crop Production

4.1 Rainfed Crop Production

4.1.1 Physical Conditions

Crop cultivation under rainfed conditions is carried out in the northern part of the Study Area, mainly in Bardheere District (47% of rainfed farm land), in Saakow District (29%) and in Bu'aale District (2%). This area has been referred to as Subsystem 1 of the rainfed based farming systems.

Smaller rainfed areas are to be found in Subsystem 2 which incorporates Jamaame District (15%), Jilib District including the Homboy area (6%) and Kismayo District (1%).

The climatic conditions of the northern areas are described as arid with annual rainfalls of about 400 mm. In the South, rainfall patterns are slightly more favourable with up to 750 mm p.a.

Most of the cultivation in the North takes place on the soils of the mantled limestone plain, while the southern areas are located mainly on the marine plain.

In the North there are two pronounced rainy seasons, Gu and Der, while in the lower valley the Gu season is followed by the coastal Xagai-showers which are used most years for crop growing rather than the following insecure Der season.

4.1.2 Crops and Cropping Patterns

Crop cultivation in Bardheere, Saakow and Bu'aale Districts takes place in Gu and Der seasons. However, sorghum is not always planted in the Der season. In many cases ratoon cropping is practiced which means that after a successful Gu season, the sorghum plants are left on the field for regrowth during the following Der season. This system is applied when the total production of the Gu season is sufficient to cover the food and cash requirements of the farmer's family. If Gu production does not meet such requirements, i.e. due to low rainfalls, sorghum is replanted in Der season. On average ratoon cropping of sorghum is practiced in two out of five years.

In the southern part of Jilib, in Jamaame and Kismayo Districts, crop cultivation is mainly carried out in the Gu season. Some crops like sesame and beans are cultivated at the end of the Gu season and continue together with cotton, which was planted at the beginning of the Gu season, to grow in the following Xagai season.

The crops grown in the districts of Bardheere, Saakow and Bu'aale are the same; only the cropping patterns are slightly different. The main crops are sorghum, maize, sesame and small amounts of beans for both the Gu and the Der season.

In Saakow and Bu'aale, sorghum, maize and sesame are also grown in the rainy seasons. Beans were found to be interplanted with maize and sorghum only in the Gu season.

In the districts of Jilib, Jamaame and Kismayo, maize, sesame, cotton, beans and groundnuts are grown in the Gu and the following Xagai seasons. Maize and sesame are planted as pure crops but a wide range of intercropping is also practiced, for example sesame and maize; sesame, maize and beans; cotton and beans; and maize and beans together with sesame and groundnuts.

The current cropping patterns in the rainfed areas are shown in Table 4.1/1.

Table 4.1/1 Current Cropping Pattern in Areas of Rainfed Agriculture

Bardheere District:			
Gu season:		Der season:	
Sorghum	86%	Sorghum	93%
Maize	9%	Sesame	4%
Sesame	4%	Maize	2%
Beans	1%	Beans	1%
Saakow and Bu'aale Districts:			
Gu season		Der season	
Sorghum	92%	Sorghum	96%
Maize	5%	Maize	2%
Sesame	2%	Sesame	2%
Beans	1%		
Jilib (South), Jamaame and Kismayo Districts:			
Gu/Xagai seasons:			
Maize	50%		
Sesame	36%		
Beans	10%		
Groundnuts	3%		
Cotton	1%		

4.1.3 Farming Practices

Soil Preparation

Soil preparation works are generally carried out by hand in rainfed agriculture. It is estimated that not more than 5 to 10% of the area under rainfed farming is mechanically ploughed. The portion of ploughed land is certainly somewhat higher in lower Juba than in the upper part. Nowhere draft animals are used for soil preparation. Soil preparation by hand consists of removing the crop residues from the previous season and superficial loosening of the soil with a short-handled hoe (Yambo).

Sowing

Seeds come mainly from the previous years' harvests. They are kept in baskets or stored in trees for protection against insect damage; they are not treated chemically. Sowing of the Gu crop is carried out after the first rains while in the Der season crops are sown before the onset of the Der rains. In lower Juba, sesame, beans, groundnuts and cotton are planted 6 to 8 weeks after the beginning of the Gu rains. The sowing method is the traditional one using a hoe as the only implement. All crops are sown on the flat and mainly in rows.

Inputs

Inputs in the form of improved seed, agro-chemicals and fertilizers are generally not available.

Crop Maintenance

Hand weeding is carried out for all crops. Most farmers carry out three weedings in both seasons. Weeding constitutes the main bottleneck with regard to family labour. Usually farmers have to hire labour for this operation.

Harvest and Post-Harvest

All crops are harvested by hand. Maize cobs are broken from the stems which are left on the fields to be used as fodder for their own or nomadic animals, or the maize plants are pulled out of the soil, piled into heaps and left to dry. Sorghum stalks are cut and heaped with the heads in the fields, where they are left to dry. To minimize seed losses through scattering, sesame is pulled out of the soil as the lowest pods are about to open. It is then bundled and stacked until fully dry, after which the bundles are shaken to extract the seed. Cotton picking is carried out two to three times. Beans and groundnuts, being mainly interplanted crops, are harvested together with maize and sesame.

The most common form of crop transport is the donkey cart. In the lower Juba, oxen carts are also used; in areas with nomadic influence crops are transported by camels too. Lorries and tractor/trailers are used only by a few big farmers.

Most of the grain production is stored in underground pits which are built either in the fields or in the villages next to the owners' houses. Sesame and beans are stored in bags and barrels inside the house. It is estimated that on average each farmer sells no more than 10 to 15% of his grain crops.

Diseases and Pests

The most common diseases mentioned by the farmers in the rainfed supply cropping areas are stalk-borers for sorghum and maize and leaf spot for sesame. In addition the crops are attacked by birds and animals. Sorghum is often subject to severe quelea birds' attack and crop damage by warthogs and baboons also occur.

4.1.4 Yields and Production

Due to limited rainfalls, poor farming techniques and the absence of any support system to the rainfed farmers, the yields achieved are generally low. From Table 4.1/2 it can be noted that the yields of maize and sesame in lower Juba are higher as compared to the rest of the area under consideration. This is due to higher rainfalls and a more even rainfall distribution. Table 4.1/2 also shows that the most important areas of production under rainfed conditions are located in the districts of Bardheere and Saakow/ Bu'aale with sorghum being the dominant crop. In comparison the rainfed areas in the lower Juba are small, maize and sesame being the main crops.

Table 4.1/2 Yields and Crop Production of the Rainfed Farming System (1)

District	Crop	Cropped area in ha		Yields in t/ha		Production in t		Total production in t
		Gu	Der	Gu	Der	Gu	Der	
Bardheere	Sorghum	35,000	38,000	0.6	0.4	21,000	15,200	36,200
	Maize	3,700	800	0.7	0.4	2,590	320	2,910
	Sesame	1,600	1,600	0.3	0.2	480	320	800
	Beans	400	400	0.4	0.1	160	40	200
Saakow/ Bu'aale	Sorghum	22,600	23,600	0.6	0.4	13,560	9,440	23,000
	Maize	1,200	500	0.6	0.3	720	150	870
	Sesame	500	500	0.4	0.2	200	100	300
	Beans	250	-	0.4	-	100	-	100
Jilib/ Jamaame/ Kismayo	Maize	5,000	-	1.2	-	6,000	-	6,000
	Sesame	3,600	-	0.6	-	2,160	-	2,160
	Beans	1,000	-	0.5	-	500	-	500
	Groundnut	300	-	0.5	-	150	-	150
	Cotton	100	-	0.4	-	40	-	40

Source: [70]

1) Homboy area not included.

4.1.5 Limiting Factors

The most important factors which hamper the development of rainfed agriculture in the Juba valley are related to:

- climate
- low degree of mechanization
- lack of inputs
- flooding (partly)
- lack of support services.

As has been mentioned before, rainfall is generally low and erratic, a fact which cannot be influenced. However, what can be influenced to a certain degree is the adaptation of the cropping system to the prevailing conditions. In this respect one could think of the improvement of farming techniques, i.e. by introducing water retention measures and better adapted crop varieties.

The low degree of mechanization is due to the absence of draft animals and implements for animal draft and the nonexistence of a programme for training draft animals despite a considerable interest on the part of farmers in this technology. The availability of farm machinery and equipment is likewise low.

Better access to farm inputs such as improved seeds, chemicals and implements would certainly be most beneficial to the farmers. The introduction of an input supply system should, however, in any case be connected with the establishment of a support service which would connect input supply with other related elements, as mentioned further below.

For the lower Juba flood hazards are an important constraint to receiving adequate yields in many years. Flood hazards may occasionally occur when the Juba river overflows its embankments. However the fields are more regularly flooded by rainwater coming from adjacent areas.

Lack of support services such as agricultural extension, input and credit supply, machinery service, marketing and promotion of farmers' organizations are the main constraints for development of this sub-sector. This problem is commonly shared by all small systems in the Study Area. The performance of agricultural services is analyzed in ANNEX 5.

4.2 Flood Recession Crop Production

4.2.1 Physical Conditions

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 record flood may destroy the crops. To overcome this, gates were introduced in some areas but they have mostly fallen into disuse. In other instances when desheks have been flooded and then protected against further water intrusions, a record high flood may overtop the flood bunds and cause damage to the crops.

During the past few years it was observed that up to 50% of the desheks had some form of flood protection. The extent of flood protection is increasing. Attempts are being made to completely protect desheks from flood waters by converting them into pump-irrigated schemes. However, complete protection seems to be difficult as has been experienced in the Gu floods of 1987, when practically all desheks were inundated.

Therefore the majority of the farmers in the districts of Saakow, Bu'aale and Jilib, where deshek farming is practiced, cultivate on the adjacent levee soils (in addition to deshek land plots). In Saakow District many deshek farmers have further land on the marine plains. The lands on both levee and the marine plains are cropped under rainfed conditions. The deshek farmers cultivate all types of land in both the rainy seasons, Gu and Der.

4.2.2 Crops and Cropping Patterns

Maize, sesame and beans are the main crops grown on deshek and levee land, while sorghum, some maize and sesame are cultivated on the marine plain in Saakow. Sesame is mainly grown as a cash crop. Other crops grown in the districts are, in the case of Saakow, onions and tobacco and in Jilib, tobacco and watermelons which are marketed outside the district. In all districts mango trees grow on the sandy levees while in Jilib some bananas are cultivated near the river. Only local crop varieties are grown.

The cropping patterns for each different land type of the districts where deshek cultivation is practiced are shown in Table 4.2/1.

Table 4.2/1 Cropping Patterns in Areas of Deshek Cultivation

Saakow District deshek cultivation:			
Gu season:		Der season:	
Maize	77%	Sesame	78%
Sesame	21%	Maize	16%
Vegetables	2%	Beans	6%
Saakow District levee cultivation:			
Gu season:		Der season:	
Maize	76%	Sesame	60%
Sesame	20%	Maize	32%
Beans	4%	Beans	8%
Saakow District rainfed cultivation:			
Gu season:		Der season:	
Sorghum	94%	Sorghum	94%
Maize	6%	Maize	6%
Bu'aale District, deshek cultivation:			
Gu season:		Der season:	
Maize	98%	Sesame	77%
Sesame	2%	Maize	23%
Bu'aale District, levee cultivation:			
Gu season:		Der season:	
Maize	80%	Sesame	80%
Sesame	10%	Maize	16%
Sorghum	7%	Beans	4%
Beans	2%		
Vegetables	1%		

Jilib District, deshek cultivation:

Gu season		Der season:	
Maize	79%	Maize	48%
Beans	14%	Sesame	46%
Vegetables	7%	Vegetables	6%

Jilib District, levee cultivation:

Gu season:		Der season:	
Maize	65%	Sesame	77%
Beans	22%	Maize	22%
Sesame	12%	Vegetables	1%
Vegetables	1%		

4.2.3 Farming Practices

4.2.3.1 Soil Preparation

The farming practices on deshek and levee land are similar in all districts. Soil preparation is done mainly by hand and by mechanical means on up to 20% of the area. Animal traction is not found.

Manual soil preparation consists of cleaning the fields of crop residues and loosening the soils with a short-handled hoe (Yambo).

Mechanical soil preparation consists ploughing with a disc-plough. Tractor hire is provided to a limited extent by the ONAT station in Bu'aale and by some private owners.

4.2.3.2 Sowing

Seeds are used from the previous years' crops and in the case of vegetables, onions and tobacco are purchased on the local market. Sowing is carried out by hand in rows.

4.2.3.3 Inputs

Normally, neither manure nor chemical fertilizers are used in the deshek farms. Only in rare cases chemicals are applied which have been bought in Mogadishu or provided by the Ministry of Agriculture.

4.2.3.4 Crop Maintenance

Crop maintenance consists of hand weeding and thinning of sesame only. Most farmers do three weedings on each crop grown.

4.2.3.5 Harvest and Post Harvest

Crop harvesting is also carried out by hand. Maize cobs are broken as soon as the first leaves are dry, then heaped and bagged. Sesame plants are cut or pulled out of the soil as soon as the first leaves and lowest pods turn yellow; thus they are gathered and stacked and left for about 10 days until harvesting on the field starts. Sorghum heads are cut when they have turned yellow and brought to the house. Beans have to be picked several times, whenever pods are ripening to avoid scattering. The crop is sun-dried on mats in the village. Tobacco plants are pulled out of the soil and left two to three days to sundry. Then they are bundled and brought to the house for further processing.

Transport is mostly carried out by the farmers own or hired donkey carts. Sometimes trucks are also hired to transport grain to the villages or watermelons to Mogadishu.

Storage of maize and sorghum is in underground pits. Seeds are kept inside the house, or in the case of maize, in bundles in trees or on elevated stands near the houses. In most cases maize and crop residues are used or sold for fodder, particularly in the lower Juba.

Watermelon, tobacco and occasionally onions are cultivated for sale, also sesame after a little has been withdrawn for own consumption. Maize, beans and sorghum will be sold only if at least one years requirement for the family has been stored. If the yield was good, some farmers store more than their annual consumption and sell at a later date according to their cash requirements.

4.2.3.6 Diseases and Pests

Most of the crops grown suffer from diseases and pests, causing damage of up to an estimated 25% of the yields expected. Maize is often attacked by stalk-borers, maize earworms, army worms and aphids. The sesame yields are often reduced by leaf-spot diseases and sesame leaf roolers. Tobacco and onion are attacked by sucking insects and thrips, respectively.

4.2.4 Yields and Production

In Table 4.2/2 yield figures for the crops distinguished between the districts are presented. For differences between Saakow and Bu'aale Districts no other reason can be given than the variable rainfall, because soils and agricultural practices are similar. The higher yields in Jilib District are attributable to higher and better distributed rainfalls.

Table 4.2/2 Yields of Deshek Farming

District/ crop	Gu season			Der season		
	Deshek	Levee	Rainfed	Deshek	Levee	Rainfed
	in kg/ha					
Saakow District						
Maize	700	650	620	550	350	--
Sorghum	--	--	--	--	--	380
Sesame	300	250	--	300	250	220
Beans	400	400	250	400	300	200
Vegetable/ watermelons/ onions/tobacco	4,500	4,000	--	4,500	3,000	--
Bu'aale District						
Maize	400	550	--	500	300	--
Sorghum	--	850	--	--	--	--
Sesame	350	300	--	350	250	--
Beans	400	400	--	400	300	--
Vegetables/ Watermelons/ onions/tobacco	4,500	4,000	--	4,500	3,000	--
Jilib District						
Maize	860	700	--	750	600	--
Sesame	--	450	--	400	400	--
Beans	450	500	--	400	500	--
Vegetables/ watermelons/ onions/tobacco	5,400	4,800	--	5,400	--	--

Source: [69]

In Table 4.2/3 the total crop production of deshek farming is shown. Calculations are based on the above information from this section. However, rainfed production has not been considered since the production on rainfed land is already included in Table 4.1/2. For reasons of simplicity, average cropping patterns and average yields for cultivation on deshek and levee soils have been applied.

Table 4.2/3 Crop Production of Deshek Farming

District	Crops	Cropped area in ha		Yields in t/ha		Production in t		Total production in t
		Gu	Der	Gu	Der	Gu	Der	
Saakow	Maize	1,365	425	0.675	0.450	921	191	1,112
	Sesame	380	1,240	0.275	0.275	105	341	446
	Beans	35	125	0.400	0.350	14	44	58
	Vegetables/ other	20	-	4.250	-	85	-	85
Bu'aale	Maize	5,250	1,180	0.500	0.400	2,625	472	3,097
	Sesame	350	4,600	0.325	0.300	114	1,380	1,494
	Sorghum	180	-	0.180	-	32	-	32
	Beans	60	120	0.400	0.400	24	48	72
	Vegetables/ other	60	-	4.250	-	225	-	225
Jilib	Maize	2,660	1,295	0.780	0.675	2,075	874	2,949
	Sesame	220	2,295	0.450	0.400	99	918	1,017
	Beans	670	110	0.475	0.450	318	50	368
	Vegetables/ other	150	-	5.100	-	765	-	765

Source: [69]

4.2.5 Limiting Factors

Apart from the limiting factors connected with water management and flood protection, the following problems related to crop production, prevailing in deshek agriculture, are very much the same as mentioned for rainfed farming.

Technical limitations include the absence of animal traction and the lack of machinery supply as well as the lack of inputs and implements. Farm management and farming practices are poor.

Insufficient support services include the absence of technical advice, the lack of input supply and the non-availability of farm credit or any support for establishing group initiatives.

4.3 Small-Scale Irrigated Farming

4.3.1 Introduction

Small-scale irrigated farms are presently concentrated in the Bardheere District. North of Bardheere town up to the proposed site of the Bardheere dam, the river banks are high and the floodplain is narrow, so that the irrigated fields consist of small strips. Downstream of Bardheere town the river banks are lower and the irrigated areas are wider. The irrigated fields extend over the levees adjacent to the river and the following depressions. The physiography of that part is similar to the deshek areas further downstream, with the difference that they are situated at a higher level.

An increasing expansion of small-scale irrigation takes place within the district of Bardheere and is extending into the districts of Saakow and Bu'aale.

Production of the small pump-irrigated farms is strongly market oriented, onions and tobacco being the main cash crops. It seems that Bardheere District has become the most important center for onion production. In addition maize, sesame, fruits and some other vegetables are planted for home consumption and sale.

4.3.2 Crops and Cropping Pattern

The most valuable crop produced is onions. Long growing varieties with a 5-6 months vegetation period are reported to be grown as well as varieties with a growing period of 120 days. On average a 4.5 to 5 months growth period can be assumed. Most of the seed originating from the Netherlands is imported from Kenya.

For tobacco cultivation only local varieties are sown. This applies in general also to maize and sesame. Occasionally, a new maize variety is used, introduced from the research station at Afgoi near Mogadishu. In addition, watermelons as an intercrop, as well as tomatoes and cowpeas are cropped on a minor scale. On the levees and along the irrigation canals, mango trees, bananas and papayas are planted.

The cropping patterns of an average 3 ha irrigated scheme are as follows:

Gu/Xagai seasons:	Onions	30%
	Sesame	25%
	Maize	35%
	Tobacco	10%
Der/Jilaal seasons:	Onions	35%
	Tobacco	25%
	Maize	25%
	Sesame	10%
	Watermelons Tomatoes/ other	5%

The overall cropping intensity is 200%, but may reach 270% within most advanced, market oriented enterprises. No crop rotation was practices in small-scale irrigation.

4.3.3 Farming Practices

4.3.3.1 Soil Preparation

Soil preparation is done mainly by hand or by tractor, the latter being the most preferred method. Due to the insufficient number of tractors available, mechanized field preparation does not to exceed 30% of the total land prepared for cropping. In 1987, six work oxen trained for ploughing and iron ploughs were found and many farmers expressed their readiness to use oxen for ploughing if available.

4.3.3.2 Sowing

Seeds for the annual crops are retained from the previous harvest with the exception of those for onions and occasionally those for maize. Sowing is carried out by hand only. All crops grow between or on top of the ridges, except for onions which are grown at each side of the ridge.

4.3.3.3 Inputs

Neither chemical fertilizers nor manure are used to raise yields. Plant protection measures are applied only in a few cases and is limited to onion spraying.

4.3.3.4 Crop Maintenance

Crop maintenance consists mainly of hand weeding for all crops and thinning for sesame. On average maize and sesame receive three weedings while the number of weedings for onions and tobacco is higher, with six and four weedings, respectively.

4.3.3.5 Harvest and Post-Harvest

All harvesting activities are carried out by hand. Maize and sesame are harvested as has been described in Section 4.1.3. The harvest of onions starts when the top part of the plant begins to fall over. The onions are pulled out of the soil and left for two days on the field to dry, before they are cut and bagged. Tobacco plants are pulled out of the ground and left on the fields for two to three days to be sun-dried. Then they are bundled and brought to the house for further processing.

Transport from the fields is mainly by donkey or oxcart and in exceptional cases by lorry. Maize is stored in underground pits and sesame and tobacco used for home consumption is kept inside the houses. Tobacco from the fields is made into rings by the farm families and mostly sold on the local markets. Onions are sold on the local markets to traders who transport most of the produce to Mogadishu and other places, or farmers hire lorries for their own marketing in Mogadishu.

4.3.3.6 Diseases and Pests

The most common diseases and pests for maize and sesame are as previously described in Section 4.1.3. For onions, thrips are reported to be the most common pest and downy mildew, neck rot and black mould are the main diseases. Tobacco is said to be attacked by sucking insects. Furthermore, farmers suffer from damage to crops caused by birds, rats, baboons, warthogs and even hippopotami.

4.3.4 Yields and Production

In Table 4.3/1 the yields and production for the different crops grown under pump irrigation on smallholder farms are shown.

Table 4.3/1 Crop Production of Small-Scale Irrigated Farming

Crop	Cropped area in ha		Average yield in t/ha	Production in t/ha		Total Production in t
	Gu/Xagai	Der/Jil		Gu/Xagai	Der/Jil	
Onion	1,230	1,435	9.0	11,070	12,915	23,985
Tobacco	410	1,025	0.4	164	410	574
Maize	1,435	1,025	1.6	2,296	1,640	3,936
Sesame	1,025	410	0.7	718	287	1,005
Vegetables/ fruit/ other	-	205	10.0	-	2,000	2,050

Source: Own calculation based on Table 3.3/1 and Section 4.3.2.

4.3.5 Limiting Factors

This farming system shares a number of problems with the aforementioned traditional farming systems. However, pump irrigation is no longer a purely traditional system. Farmers who belong to this group have already taken an important step from a low technology based production level to a much higher level of technology and capital investment. This is a very significant fact to consider when analyzing the system and its inherent problems.

Irrigated agriculture is not a farming system which can evolve gradually out of any of the other systems, or rather out of the smallholder systems. Its establishment is dependent on capital which could not be accumulated through the average scale farming operations. Outside support in the form of bank credits or transfers from other businesses that may be undertaken are a pre-condition. Also, input supply and pump operation and maintenance require organizational skills which are beyond the average farmer for a variety of reasons. During the field investigations it emerged quite clearly, that farmers would not consider group ownership and group management as an advantage over leasing and sharecropping arrangements, as the potential for conflicts of interest was judged to be high.

The development of the farming system towards improved efficiency has been hampered by a number of factors. The absence of a reliable input supply, that would offer seeds, fertilizers, pesticides and insecticides as well as spare parts in the required quantity and quality has imposed considerable costs on the individual farmer. It means that production technologies and therefore productivity is below the level that could be attained with the prevailing knowledge and skills. Likewise, the lack of repair facilities has led to inefficiencies and cost increases. The absence of any agronomic messages, demonstrations and extension services has led to waste of water and keeps the productivity at a much lower level than would be achievable.

4.4 Banana Cultivation

4.4.1 Physical Conditions

Bananas are grown on both sides of the river between Kamsuma and Yontoy mainly on the levee soils. Although these soils are reasonably fertile and relatively easy to cultivate, drainage problems are apparent on many farms. Salinity levels are generally low but increase with depth.

Banana species developed in the wet, humid tropics, consequently the environmental conditions prevailing in Somalia are far from ideal. The yield potential is likely to be low when compared with the traditional growing area of Central America.

Banana production in the lower Juba is additionally hampered by irrigation water shortages in the Jilaal season, as well as by floods which have occurred with increasing frequency in recent years.

4.4.2 Cultivars and Crop Rotation

The cultivar Poyo (syn. Robusta) is universally grown. Of less importance are Guande Naire (syn. Williams) and Valley. Poyo and Valley are similar, growing to 3 to 4 m and belonging to the Robusta clone in the Cavendish subgroup. Guande Naire is shorter, 2.5 to 3 m and belongs to the Giant Cavendish subgroup with the same Cavendish clone [76].

A four year crop rotation with a crop life of three years seems to be common. This would result in a fallow area of 25%. However, the area under fallow on the less well managed farms may be up to 40%.

4.4.3 Farming Practices

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

4.4.3.1 Soil Preparation

After the land levelling by bulldozer, the banana land is prepared by tractor and mould-board plough. The primary objective of ploughing is weed control, as bananas are intolerant of competition from grass roots.

4.4.3.2 Planting

Planting material used are suckers which have been collected from abandoned banana fields. Planting is carried out using a Yambo in furrows spaced at 2.5 m and planting holes 2 m apart. This spacing gives a planting density of 2,000 plants per ha. SOMALFRUIT gives the advice to place some fertilizer and Furadan in each hole before planting the sucker.

4.4.3.3 Fertilizer Application

Three types of fertilizers, urea (46% N), Di-ammonium phosphate DAP (20N:50 P_2O_5) and compound NPK (15N:7P:24K) are imported by Somalfruit and sold to the banana growers, all at the same price. The recommended application rates are 1,800 to 2,100 kg/ha at six week intervals. Most growers, however, apply lower amounts and usually less frequently.

4.4.3.4 Crop Maintenance

Pruning of suckers is normally carried out at 45 day intervals by removing them with the Yambo. Every four months a strong sucker is allowed to develop as the follower, producing future crops. In general, pruning is poorly done with the effect that maturation and fruit development are delayed.

Weed control is a serious problem until the crop canopy covers the ground. Weed growth, particularly grasses, has to be controlled at an early stage, otherwise the canopy will not become dense enough to control subsequent weed growth. On well managed farms, inter-row weeding is done by tractor and cultivator during the first three to four months until the canopy closes. After that, occasional hand-weeding is sufficient to keep weeds under control.

4.4.3.5 Harvest and Post-Harvest

First harvest of banana bunches starts from nine months after planting. The stage at which a bunch is considered ready for harvesting is determined by SOMALFRUIT's quality standards for export. The bunches are carried on headboards to the edge of the field where they are collected and transported to the packing station. The frequency of harvesting is based on the arrival of the banana ships which arrive at Kismayo every eight to ten days.

Packing is controlled by SOMALFRUIT and the standards of packing and quality of fruits is good. The harvested bananas are packed either in one of the 12 private packing stations, under the supervision of SOMALFRUIT or collected by SOMALFRUIT for grading and packing in one of its modern packing station.

4.4.3.6 Diseases and Pests

The most serious diseases which are prevalent in other banana producing countries are almost absent in Somalia. At present only occasional aerial sprayings are carried out as a prophylactic against Sigatoka, locally known as Cencospora. Apart from the post-harvest benonyl dip there are no further disease control measures. The major problems for bananas in the lower Juba, causing crop losses and shortening lifetime of the plants are two pests; the root-burrowing nematode (Radopholus similis) and the banana weevil. Control is done through application of Furadan at a recommended rate of 120 kg/year.

4.4.4 Yields and Production

According to estimates by the Homboy Study [76], the average annual yields of a banana farm at 'medium technology' level in the lower Juba amount to 20 t. Yields in the first year of production reach 14 t/ha; in the second year they reach their maximum at 28 t/ha, after which they decrease to 24 t/ha and 14 t/ha in the following third and fourth years, respectively. The study also claims that the yield figure of 28 t/ha given in previous reports, i.e. AHT [46], is to be taken as the level most growers are aiming at rather than the actual average achieved.

At present about 50% of the banana crop is estimated to be rejected by SOMALFRUIT because of not meeting export quality.

In Table 4.4/1 the export yields of bananas in the lower Juba are shown beginning in 1981.

Table 4.4/1 Yields and Exports of Bananas of Lower Juba 1981 - 1987

Year	Area planted in ha	Export yield in t/ha	Banana exports in t (1)
1981	1,804	8.3	15,000
1982	1,650	13.2	21,800
1983	2,052	13.4	27,500
1984	2,571	8.3	21,500
1985	2,010	10.1	20,400
1986	2,280	10.1 (2)	23,000 (2)
1987	2,500 (2)	10.1 (2)	25,300 (2)

Source: [76]

1) Rounded figures.
2) Estimate.

4.4.5 Limiting Factors

As indicated before, the main limiting factors to banana production in the lower Juba are related to:

- soils
- climate
- floods
- low river flow.

As to the soil quality it appears that the generally high clay content causes drainage problems for most farmers. This problem seems to be increasingly overcome by improved management and the extension of the drainage systems.

Climatic factors do not only include low annual rainfall of about 430 mm, requiring frequent irrigation. Problems are caused by heavy storms which occur in both rainy seasons bringing about destruction by flooding. This again requires adequate surface drainage to prevent plant death through water logging. Also the strong persistent winds between June and September cause scarring and bruising of developing fruits and result in lower yields caused by constant rocking of the plant and subsequent crown and root distortion. The establishment of windbreaks would help to reduce this phenomenon.

Floods constitute an increasing problem for the banana growers, due to higher flood frequencies caused by flood protection measures upstream. Flooding is very serious, as death will result if the plant stands in water for more than four days.

The effect of water stress is similarly severe. Even short periods of drought lasting two to three weeks can result in crop yield reductions of 5-10%. Low water flows occur almost every Jilaal season between January and April. Sometimes the river drys out almost completely or sea water intrudes into the river bed almost as far as the Araare bridge. With the aim of reducing water stress in banana plants, farmers often pump saline water onto their fields which has the effect of gradually increasing the salinity content of the soils.

It can be expected that future expansion of the banana plantations will take place mainly in those areas which were registered as banana land long ago and which have been partly under banana cropping.

4.5 Large-Scale Projects

4.5.1 Fanoole Project

The project is supplied by gravity from the Fanoole barrage by a 52 km long main canal which is planned to provide irrigation water for the Homboy area too. The total capacity is 33.6 m^3/sec, of which about 21 m^3/sec constitute the supply for Fanoole, the rest being for Homboy.

The project is run as a state farm under the Ministry of Agriculture, with assistance provided by the People's Republic of China. The overall project area is 8,200 ha with a net irrigable area of 7,500 ha.

Land clearing started in 1975 when 1,600 ha were cleared. However, it took until 1984 before the first area was irrigated by gravity. Up to 1985 no more than 200 ha were planted with rice. By 1987 the cultivated areas were not much larger than just over 600 ha in each season.

Although double cropping was originally intended this has so far not been achieved. The area actually irrigated is given as 1,500 ha. It has been the normal practice during the past few years to cultivate the Gu crop on about 600 to 700 ha and the Der crop with a similar cropping area size.

When compared with the aim of 7,500 ha to be put under irrigation by the end of 1988, project implementation is obviously far behind schedule.

The only variety of rice grown is IR 24. No seed dressing is practiced. According to the project management, the reason for sticking to this long growing variety is that this type of rice plant makes it more difficult for the Quelea birds to pick the grains. The sharply dented leaves and the weak stems prevent the birds resting on the plants.

As a rule, chemical fertilizers are applied with combined fertilizer drills. Pre-emergence herbicides are seldom used. More frequent however is the use of the post-emergence weed killer Probalin. Weeding is generally carried out by hand.

Harvesting starts 140 to 145 days after sowing; combined harvesters are used. Processing is in the project's own rice mill.

The yields obtained and total production of paddy rice achieved in recent seasons are shown in Table 4.5/1. According to the project management, the average yield of at present 4.3 t/ha could be increased to 5 tons if the required inputs were always available and if crop damage by Quelea birds could be reduced.

Table 4.5/1 Rice Production of the Fanoole Project

Year	Season	Cropped area in ha	Yield in t/ha	Total rice production
1985	Gu	500	4.37	2,185
1985	Der	600	4.24	2,544
1986	Gu	633	4.13	2,614
1986	Der	635	4.41	2,800
1987	Gu	850	4.40	3,740 (1)
1987	Der	850	4.40	3,740 (1)

Source: Fanoole Project.

1) Estimate.

4.5.2 Juba Sugar Project

The project is run as a state farm under the Ministry of Industries, with foreign management and technical assistance. Implementation began in 1976. According to the original plans, 7,200 ha of sugar cane under irrigation (almost all sprinkler) with a total sugar production of 65,000 tons p.a. were to be developed by the end of 1982.

The original targets could not be achieved. In 1982 only about 70% of the planned area was under cane cultivation. It can be expected that full development will only be reached by 1988 with a delay of six years. By then project implementation will have taken twice as long as scheduled.

The sugar cane of the Juba Sugar Project (JSP) matures after 12 months. Cane cutting is done by hand after the fields have been burnt. The cane is loaded mechanically onto a wheeled trailer tandem with a capacity of 10 tons and pulled by a tractor. This transports the cane to the factory. The average hauling distance is 12 km.

In general four to five harvests are obtained from one cane field; i.e. after the first cutting there are three or four ratoon croppings. The harvesting periods last from late July/ early August to the beginning of November and from early December to early April. Generally the factory is shut down for maintenance between May and July.

In Table 4.5/2 the cane areas and the cane and sugar yields from JSP are shown. The production target of 65,000 tons of sugar p.a. has not been achieved so far. It was based on the assumptions of a fully developed area of 7,200 ha, cane yields of about 100 t/ha and a 9.43% sugar extraction rate. The figures in Table 4.5/2 reveal that in particular the cane yields have been considerably below expectation. They even show a tendency to decrease. The major reason for the low cane yields has been the inadequate number of crop irrigations applied. Instead of the 23 wettings previously estimated, only a maximum of 18 are feasible (without the Bardheere dam) because of water shortages in the Jilaal season. However, in recent years not even this number could be reached because of the permanent diesel fuel shortage. For example, in 1984 only about 9 and in 1985 less than 12 wettings were applied.

Table 4.5/2 Cane Area and Cane and Sugar Production of the Juba Sugar Project, 1980 - 1987

Year	Area under cane in ha	Cane area harvested in ha	Cane harvested t/ha	Cane harvested Total in t	Sugar extraction rate in %	Sugar produced t/ha	Sugar produced Total in t
1980	(1)	1,464	84.0	122,924	6.45	5.41	7,926
1981	(1)	3,013	72.0	219,381	6.73	4.89	14,746
1982	(1)	3,324	89.6	297,744	7.46	6.68	22,213
1983	5,301	4,909	68.4	335,747	8.37	5.73	28,113
1984	6,374	4,555	63.4	289,476	9.31	5.92	26,959
1985	6,584	6,575	64.8	426,060	9.18	5.95	39,103
1986	6,818	4,538	61.4	278,243	9.87	6.05	27,450
1987	7,000	2,817	70.5	198,667	9.61	(1)	42,617

Source: [76], ANNEX 3, p. 2-13

1) No information available.
2) Harvest until April.

4.5.3 Mogambo Project

The first phase of the Mogambo Irrigation Project (MIP) including 2,050 ha of surface irrigation and 160 ha of sprinkler irrigation was completed in 1986. Cropping began in 1985.

The original concept was to run the project as a pure state farm, but this policy was 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. The first settlers were brought from Mogadishu, most of them without experience in agriculture. This approach has not proved successful and therefore, in 1986, local farmers were included in the scheme. Many of them seem to be doing very well. In 1987, 300 farmers had plots of 2 ha each in the project area, so that by then 600 ha of the total 2,200 ha of the project were occupied by smallholders.

In its initial phases, the project suffered from the non-availability of machinery. Farm operations could only be carried out with machinery hired from elsewhere. By 1987 most of the equipment and machinery had arrived.

The settlers can ask the project to carry out field operations, such as; land preparation, planting, weeding and harvesting, in return for payment.

One of the main problems in rice cultivation is attack by Quelea birds. MIP claims to have suffered losses amounting to 22% of the potential rice harvest in 1985 and 58% in 1986 due to Quelea attacks. Bird scaring was not effective and the Quelea campaign carried out by the Ministry of Agriculture in 1986 did not have the effect expected. In the maize fields the maize stem borer has proved to be the most serious pest and difficult to control.

Harvesting is carried out by combine harvesters with five meter cutter bars. The paddy rice is then transported by special trailers to the Alvan Blanch Dryers. After drying, the grain is temporarily stored and afterwards processed at Mogambo's own rice mill.

Mogambo Project's original plan was based on rice cropping under gravity irrigation and cotton with sprinkler irrigation, on most of the area, the overall cropping intensity being 150%.

This concept was altered as a result of the built-up of water table levels and soil salinity due to rice double cropping and to the inclusion of smallholders in the scheme.

Consequently a more mixed cropping system has been in use since 1986. The following Table 4.5/3 shows the cultivated areas and yields for the years 1985 and 1986.

The yields obtained so far have been relatively low and moreover there have been differences between the areas planted with rice and those actually harvested, i.e. in the Gu season of 1986, 556 ha were sown with rice and only 306 ha could be harvested. The reasons for this were that some areas were lost due to flooding or they had to be abandoned after serious bird attacks. Apart from yield reduction due to Quelea, MIP claims that the lack of fertilizers and chemicals for weed control has had a distinctly negative effect on yields.

Table 4.5/3 Cultivated Areas and Yields for 1985/86

Year	Crop	Cropped area in ha	Average yields in t/ha	Total production in t
1985/Gu	Rice	116	3.2	371
	Maize	40	1.6	64
1985/Der	Rice	119	4.6	547
	Sesame	200	0.3	60
	Cowpeas	6	0.9	5
	Mung-beans	6	0.8	5
1986/Gu	Rice	556(306) (2)	2.8	857
	Maize (1)	50	1.8	90
1986/Der	Rice	504(248) (2)	3.3	818

Source: Mogambo Irrigation Project

1) Sprinkler irrigation.
2) Area harvested in brackets.

4.5.4 Limiting Factors

One of the most crucial factors hindering technical efficiency is the severe shortage of local managerial and professional skills. While unattractive remuneration is partly responsible, it must also be recognized that there is an absolute shortage of skills in the country, ranging from the level of the operator through to technicians, accountants and higher level production and management specialists. Also, as no effective national agricultural research service exists and training opportunities in all fields are rare, schemes have to put up substantial efforts out of their own resources and are consequently slowed down in implementation.

A further limiting factor is the shortage of skilled and unskilled labour and the unreliability and fluctuation of the supply that does come forth. It cannot be expected that labour supply will substantially increase, unless of course the smallholder sector becomes increasingly marginalized, which cannot be the objective, one would think, of rural development.

Important financial issues include the lack of control over the projects' budgets and the setting of prices. There is very little scope for influencing the allocation of funds on the part of project management, in particular as to the share of foreign currency which is so desperately needed. It has been the shortage of hard currency, together with the above problems, which has hampered the implementation of the three projects in the Juba valley in the past. The result has been lack of fuel and spare parts and failure to replace machinery and equipment.

For example, it is evident that yield reductions in the Sugar Project have in many cases been caused to a large extent by the lack of diesel fuel for the pumps rather than by low river flows.

As to the setting of prices, it is obvious that in particular the low ex-factory prices for sugar allowed to the Sugar Project have prevented the estate from being run as a more independent and financially sound enterprise.

It is believed that all the natural and physical constraints mentioned in the previous section, such as drainage and salinity problems and even flood problems can be overcome to a great extent. However, the shortage of irrigation water in the Jilaal season constitutes an ever increasing constraint to future irrigation development.

5. Introduction of the Future Development of the Study Area

The purpose of this part of the ANNEX is to present the possible development scenarios for future agricultural development in the Juba valley and to describe the overall requirements which are needed to allow for their implementation.

In discussing future scenarios a number of aspects have been taken into account. The main aspects are the following:

- experience with agricultural development in the area until recently,
- other ongoing agricultural developments in the country,
- experience elsewhere with similar projects,
- the future construction of the Bardheere Dam,
- the recommendations already presented in the field of irrigation water systems planning for the Juba valley.

Whether planned or not, agricultural development has and will take place in and around the Juba valley. However, if not planned and monitored, development will take place in an uncontrolled manner. In such a case the Government will not be in a position to timely plan and implement improvements in infrastructure and agricultural production support services needed to sustain these developments (assuming these are desired developments) and serious constraints will occur.

Obviously if uncontrolled developments are undesirable developments the situation becomes even worse, particularly since such developments may be hard to reverse, to stop or to correct.

Undesirable developments in the Juba valley could be:

- uncontrolled extraction of river water for irrigation north of Fanoole, leading to increased irrigation water shortage during Jilaal for the big projects and banana growers downstream, thus endangering existing public and private investments,
- uncontrolled transformation of all levee soils and other land next to the river to irrigated crop production land, thus denying watering places to (nomadic) cattle and camel owners and destroying the last remaining gallery forests along the river,
- land positioning on land with irrigation potential by Mogadishu residents, reducing many present farmers in the valley to landless labourers.
- increased competition for arable land between rainfed and irrigated crop production farmers, due to the absence of proper land use planning.

But even the gradual extension of cultivated land and the transformation of rainfed and deshek farming into irrigated farming would ask for increased support of Government (and private) production support services, if these developments are to have a long term beneficial impact on the region.

In this context the overall importance of agricultural price policy has to be emphasized, setting the economic framework for the farmer's daily decisions and determining the profitability of his or hers farming operations. Price elasticity of agricultural supply has proved to be very high within the short period between 1982 and 1986, when prices could be established by free market forces and agricultural input supply services became liberalized.

Planning and monitoring of developments can prevent to a large extend the problems caused by uncontrolled and undesired developments. However, planning is a tool which has to be used realistically to allow for the necessary flexibility in implementation. It should not strangle agricultural development.

For instance, in the Main Report parameters are presented towards the planned development of irrigated agriculture. These include:

- areas considered for irrigation development
- regional allocation of annual and perennial crops and rice
- annual estimated development potential for new areas
- organizational and infrastructural requirements.

Yet within these parameters flexibility should be allowed. E.g. if the area north of Fanoole is allocated for seasonal crops only, this should be enforced by the Government, until such time there are sound reasons available to change this situation. However, within this limitation (seasonal crops only) the farmers will decide their own cropping pattern, e.g. in reaction to market prospects and prices. The Government however, will allow for free access to the market and fair prices. Such a flexibility will usually allow for an optimal use of land, water, labour and capital resources. Experience in many countries, including Somalia, has proved that small- and medium-scale farmers have the flexibility to adapt quickly to changes in market prospects and prices. The main reason for this behaviour that these farmers will at any moment try to maximize their returns to available production means. These farmers may decrease crop production levels to subsistence needs when they have no access to the markets or when they consider the prices they receive for their produce as not fair. Consequently, they will look elsewhere for off-farm employment. Large-scale (public) agricultural schemes usually do not show this flexibility.

In the next sections development scenarios will be presented for rainfed, deshek and irrigated crop production. However, to allow the eventual implementation of these scenarios certain conditions will have to be satisfied. These refer in particular to infrastructure, irrigation water systems management and agricultural production support services, all of which are subject of separate ANNEX.

In the next sections presenting the development scenarios for the different systems of crop production, the following strategy considerations have been applied:

- In the future, emphasis will be placed on smallholder development for all crop production systems. Experience in many countries, including Somalia, has proved that these farmers provide the best guarantee for an optimal use of available resources such as land, water, labour and capital.

- Considerable investments are foreseen within the planning period to expand and develop irrigated crop production in the future. However, in view of the large part of the population living within the area of rainfed crop production (particularly SGU 1,2 and 5), a major effort will have to be undertaken to increase agricultural productivity within this farming system. (The Equity Consideration).

- To prevent a mainly negative impact from the construction of the Bardheere Dam on the traditional deshek farming system (SGU 2), special activities have to be initiated in the before-dam period.

- In developing and expanding the area presently under irrigated crop production, care should be taken that the already existing public and private investments (SGU 3 and 4) in this farming system in the Lower Juba, are safeguarded against the negative impact from unplanned irrigation-water extraction north of Fanoole.

- In (re)allocating land which has been developed for irrigated crop production, preference should be given to locally already established (dryland) farmers, to prevent major injustices and the creation of a class of landless families. (The Equity Consideration).

- In the selection of crops for the proposed cropping patterns, first priority has been given to cover the farming families' subsistence food requirements, and to contribute to national self-sufficiency in basic staple foods. (The Food Security Consideration). Only thereafter the promotion of cash and export crops according to the countries national development objectives (The Foreign Exchange Earnings/Savings Consideration), has been considered.

- Improvements suggested to increase overall agricultural productivity in the Study Area are mainly within the low to medium technology approach. A high technology approach would not appear realistic at present or in the foreseeable future, and would not allow for replication of the development model for the Study Area to other parts of the country. (The Replication Consideration).

- In view of the importance of livestock keeping in the Study Area and the decreasing availability of natural grazing lands as a result of the expansion of crop production areas, wherever possible, the production of green forage has been introduced in the proposed cropping patterns.

6. Rainfed Crop Production

6.1 Considerations for the Future

Rainfed crop production is the prevailing crop production system in the Juba valley and surrounding areas. It has the largest area under cultivation and provides food and income to the largest number of families as compared to the other crop production systems. This is the present situation, and is expected to remain so till at least the end of the planning period (2005) (see Table 6.1/1).

Table 6.1/1 Distribution of Crop Production Systems in Study Area (1988)

Crop Production System	Total Farmland (ha)	% of Total	No. of Farm Families	% of Total
Dryland farming	122,500	81	21,300	75
Deshek farming	11,400 (1)	8	5,450	19
Irrigated small-scale farming	17,100	11	1,560	6
Total	151,000	100	28,310	100

Source: Table 2/2.

1) The total farmland of 11,400 ha include 7,000 of actual deshek land and 4,400 of levee land.

Rainfed crop production, particularly north of Jilib, is mainly geared towards the provision of family subsistence needs, and the way this crop production system has developed to date is mainly determined by the amount and distribution of seasonal rainfall. The average annual rainfall is about 400 mm, however near Luuq average annual rainfall is less than 300 mm while in the area around Jilib average annual rainfall is about 700 mm. Although annual totals over the remainder of the Juba valley do not vary much, considerable differences occur in distribution.

At Jamaame, close to the sea, the rainfall pattern is most reliable during Xagai, though this season does not bring the highest amount. Rains in Der are unreliable, occurring sometimes in September, sometimes in October. Agriculturally significant rainfall occurs only in the continuous period from April to July.

At Bardheere, rainfall during the Xagai is insignificant. The rainfall pattern of Der is similar to the pattern of Gu. The periods, during which rainfall can be expected with some reliability, are from the beginning of April to the middle of May and from middle October to the middle of December. The shortness of the rainy seasons explains why rainfed agriculture in the middle and upper Juba valley quite often fails, and makes it such a risky undertaking.

Obviously, also in the future amount and distribution of rainfall will continue to be the main factors which determine the development potential of rainfed crop production in the area.

For the districts in the lower Juba (Jilib, Jamaame and Kismayo) flood hazards are an important production constraint to rainfed crop production. Flood hazards occasionally may occur when the Juba river overflows its embankments. However, more regularly the rainfed areas are flooded from rain water coming from adjacent higher areas.

In the after-dam situation (after 1995) occasional flooding of the Juba river will still occur, as the water release in the reservoir will be in the 500 to 700 m^3/sec range for over a month period every 5 years in the Der season, to accommodate flood levels in the reservoir.

Although it has been suggested to construct the drainage system of the Homboy area to accommodate rainfall runoff from the Lower Shebelli area in the Der season into the Juba river and to minimize pressure from localized runoff on the Lower Juba reach, it is not certain that these works will be executed completely before the end of the planning period (2005).

It is apparent that farmers in the rainfed crop production system will have no direct benefit from the construction of the Bardheere dam. However, within the Masterplan a number of improvements for infrastructure and crop production support services are suggested. The following proposed actions could be of direct benefit for farmers within this farming system:

- improvement of regional infrastructure; in particular roads,

- strengthening of the extension service to reach all farmers with the appropriate extension messages,

- strengthening of adapted agricultural research, including farming systems research,

- improvement of input supply,

- improvement of access to markets and credit.

Within these proposals the elements are available to improve present rainfed crop production in the area, within the limitations set by the climatic conditions.

Credit needs are likely to be relatively low for the next 10 years, unless specific development activities were to be introduced, such as mechanized land levelling, animal drawn equipment, etc.

6.2 Increasing Crop Production

Increasing crop production in rainfed farming can basically be achieved along two lines;

- enlargement of production area
- increasing crop yields per ha

as well as by the combination of both activities.

Studies previously carried out (Rainfed Agriculture in the Juba valley, AHT, 1986) indicate that land availability is presently no constraint to increase agricultural production and that ample arable land is available to increase the present area cropped.

The future increase of the actual area under rainfed crop production is dependent on many factors. With the increased possibilities for irrigation in the after-dam situation, part of the present rainfed cropping land will be converted into irrigated cropping land. Marketing possibilities and attractive farmgate prices can strongly influence crop production, while there is also the ongoing tendency of nomads gradually changing to sedentary farming. Since these effects are hard to estimate it is assumed here that these factors will balance each other and their net effect will be negligible. However, in Table 6.2/1 an exception is made for the Homboy area irrigation scheme, which is in an advanced stage of planning already.

Therefore the expansion of the rainfed crop production area will be mainly caused by natural population growth, which is estimated for the rural settled population at an annual rate of 2.8% until 1995 and 3.0% thereafter.

As a result, at the end of the planning period about 32,000 farm families will practice rainfed crop production. This presents an increase of approximately 65% over the present number. If average farm land size remains the same, these 33,000 farm families will need approx. 193,000 ha of farmland. Large-scale introduction of animal-drawn cultivation techniques would allow for a further increase of 20-25% of this area.

Table 6.2/1 Distribution of Areas under Rainfed Crop Production

District	Present (1988)		1995		2005	
	ha	Farm Fam.	ha	Farm Fam.	ha	Farm Fam.
Bardheere	58,000	6,400	70,400	7,800	94,600	10,400
Saakow	35,000	3,500	42,500	4,200	57,100	5,700
Bu'aale	2,000	400	2,400	500	3,300	700
Jilib (1)	2,800	1,000	3,400	1,200	4,600	1,600
Jamaame	19,000	7,900	23,100	9,600	31,000	12,900
Kismayo	1,500	600	1,800	700	2,400	1,000
Total	118,300	19,800	143,500	24,000	192,900	32,400

Source: [70] and own calculations.

1) Excluding Homboy area, which is already earmarked for irrigation development.

Soil reconnaissance studies carried out in the past (USBR) [81] indicate that in general this increased demand for farmland can be coped with, without putting the present system under pressure. This is in particular true for the socio-geographic units (SGU) 1,2 and 5, where most of the rainfed crop production area is located. However it is to be expected that in the LowerJuba area (SGU 3,4 and 6) with a much higher population density than the Middle- and Upper Juba valley, increased competition for arable land will occur between dryland farmers and dryland and irrigated farmers in view of the envisaged extension of irrigated crop production during and after the Masterplan period. Without proper land use planning, there is the risk that this increased competition may force in particular dryland farmers to increasingly use soils less suitable for crop production. By giving preference to local already-established farmers when (re)allocating land for irrigated crop production, major imbalances may be prevented.

Sizes of rainfed crop production farms in the Middle and Upper Juba valley will not change much, since these are determined mainly by the availability of family labour for actual cropping activities (part of available family labour within rainfed crop production systems is also devoted to livestock keeping and other (off-farm) activities. As has been commented before, only the introduction of animal-drawn cultivation practices (or tractorization) could change this situation.

6.3 Increasing Farm Productivity

Apart from an increase of total crop production as a result of natural population growth, increases in crop production can therefore only be achieved through increased productivity, i.e. increase in crop yields per ha.

Improvements in rainfed crop productivity are, however, not expected to be spectacular in the foreseeable future. Presently little or no locally-tested, reliable research information and recommendations are available for immediate application. The effects of large-scale intensive mechanized soil preparation on the fragile ecological balance, under which rainfed farming presently is operating, are largely unknown.

Obviously there is a strong need for research programmes for the improvement of rainfed crop production, which includes animal-drawn cultivation techniques, the introduction of more suitable (drought tolerant) varieties of the main staple crops, methods of intercroppping, water conservation and wind erosion control, the understanding of the practiced fallow system, and aspects of integration of crop and livestock production.

At Bonka Dryland Research Station work is presently undertaken on some of the above mentioned aspects of rainfed crop production. Under the "Second Agricultural Extension Project" - AFMET/World Bank, financial support for this research project is envisaged for 1989, to complete its implementation. Arrangements still have to be made for its continuation after 1989. Several of the findings of the Bonka research project will be applicable to rainfed crop production in the Juba valley and its continuation after 1989 is very important.

In view of these given conditions, the development scenario for rainfed crop production could best be envisaged along a low technology approach. The aim of the low technology approach will be to consolidate and strengthen the present rainfed crop production system in a gradual way, through the introduction of simple technical improvements and a low level of external (cash) inputs.

By strengthening the present system, the production of staple food crops would be ensured to a somewhat greater extend than at present. In the long run, production might be raised in such a way that an increasing part of the farm produce can be sold on the national market.

Pending research findings, the following packages should be envisaged for introduction to improve productivity of rainfed farming.

- The increased introduction of water retention measures such as small basins in order to raise the soil moisture content at the onset of the rains. This will enable the farmers to sow earlier and make better use of the precipitation, especially during the Der season.

- Construction of small bunds in the Jilib/Jamaame/Kismayo Districts to keep flood waters from adjacent areas out of their fields. Such construction works would have to be carried out mechanically and therefore the services of ONAT or private tractor hire services would have to be available. Maintenance could be done by the farmers themselves.

- Improvement of soil preparatory and weed control activities through the use of animal-drawn equipment (oxen, donkeys).

- Improvement of seed quality. Farmers would need access to professionally produced improved seeds. The present practice of on-farm production of seed has led, for some crops, to degenerated planting material with low production potential. The practice of seed treatment would have to be introduced.

- Control of the most important pests and diseases through the introduction of improved cultural practices and possibly the use of agro-chemicals (particularly for cotton).

- Establishment of windbreaks, which would allow for the supply of firewood and animal fodder (Leucaena).

- Improved cultural practices, such as crop rotation and increased plant populations and the use of fertilizers at low-rate application.

- Increased integration of crop production with livestock keeping (mixed farming).

The combined effect of these improvements on crop yields are hard to estimate and will always be dependent on amount and distribution of rainfall, availability of inputs, etc. It is estimated that average rainfed farm productivity will increase by an approximately 20% over a period of about 10 years upon introduction of the proposed recommendations (between the years 1995 and 2005; see 1995 yield figures in Table 6.4/1).

The introduction of the use of fertilizers (which could be considered when the soil moisture conditions are improved as a result of the proposed water retention measures) and pesticides, would allow for a further increase in crop yields (see 2005 yield figures in Table 6.4/1). However, in view of the marginal conditions under which rainfed crop production has to operate, initially low rates of fertilizer application have been suggested.

6.4 Yields and Cropping Patterns

Based on the proposed improved cultural practices presented in Section 6.3 of this report, yield projections have been prepared for the major crops in the rainfed production areas. Yield increases between 1995 and the end of the planning period will be in particular the result of the combined effects of improved water retention measures and the introduction of fertilizers and pest control measures. Detailed development scenarios for all crops (including input and labour requirements, etc.) for the most important time horizons; present (1988), 1995 and the end of the planning period (2005) have been presented in APPENDIX 1 to the present ANNEX. Envisaged crop yield developments are presented in Table 6.4/1.

Table 6.4/1 Development of Yields in Rainfed Crop Production (t/ha)

Crop		Season	Present (1988)	1995	2005 (*)
Sorghum	(1)	Gu	0.6	0.75	1.0
Sorghum	(1)	Der	0.4	0.5	0.9
Sesame	(2)	Gu/Xagai	0.6	0.7	0.8
Sesame	(1)	Der	0.2	0.3	0.4
Maize	(2)	Gu	1.2	1.4	1.7
Maize	(1)	Gu	0.6	0.7	1.2
Maize	(1)	Der	0.4	0.5	0.8
Groundnuts	(2)	Gu/Xagai	0.3	0.4	0.6
Beans	(1)	Gu	0.4	0.5	0.6
Beans	(1)	Der	0.1	0.2	0.3
Beans	(2)	Gu	0.5	0.6	0.7
Cotton	(2)	Gu/Xagai	0.4	0.8	1.2
Vegetables	(2)	Gu/Xagai	2.0	3.0	5.0
Leucaena	n.a.	-	-	8.0	10.0

Source: APPENDIX 1

1) Data applicable for the Districts of Bardheere, Saakow and Bu'aale.
2) Data applicable for the Districts of Jilib, Jamaame and Kismayo.
*) Use of fertilizers and pesticides introduced.

Large-scale introduction of mechanized land preparation within the planning period is not foreseen. (It is assumed that the present 5-10% mechanically prepared rainfed land will increase slowly). There are two reasons for this assumption. The first and most important reason is the technical considerations presented in section 6.3 of the present ANNEX. The second reason is a more pragmatic one. With the simultaneous expansion of irrigated crop production and the physical and financial limitations in establishing a very large pool of tractors and equipment to several cropping systems, it is expected that priority will be given to irrigated farmers for the use of the limited available mechanization equipment.

For the design of the proposed future cropping patterns several factors have been taken into consideration.

In the rainfed crop production systems the emphasis has always been on assuring the availability of the family subsistence requirements, while crop residues play a very important role in feeding of animals kept by farm families (see ANNEX 7). These basic functions of rainfed crop production will also be respected in the future. However, the projected yield increases for grain crops will allow to gradually reduce their present dominant position in the cropping patterns. The reductions suggested, in combination with the increased yield projections, will still allow for a net increase in grain and stover output per farm unit.

In the future development of the cropping patterns for the Middle and Upper Juba valley (Table 6.4/2), it is envisaged that the area dedicated to sorghum will be slightly decreased while that for maize will be increased. A very strong increase in particularly sorghum production would anyway not be desirable, since it is expected that this is the first crop in Somalia for which national production might meet the national demand. Rural people do give increasingly preference to maize, besides sorghum, for consumption. Until present an expansion of the acreage under maize, particularly in the Der season, was hampered by the lack of soil moisture. The introduction of improved water retention measures, as has been suggested, would improve the soil moisture balance and permit an increase in the area under maize.

On the other hand, within the overall national development objectives for the country, considerable increases in the production of beans, groundnuts and cotton are expected. Given this objective, the relative importance of these crops in the future crop rotations has been increased. Sesame oil has consumer preference in Somalia over any other vegetable oil, while in the Study Area numerous small oil mills are operating, which can cope with the processing. Although in the present cropping pattern for the Middle and Upper Juba valley (Table 6.4/2) sesame is reported as a crop also grown in the Gu season, it does not so in the future cropping patterns. Additional field investigations have suggested that sesame, in these particular areas, is more suitable to grow in the Der season, with harvesting in Jilaal. However, this does not necessarily stop some farmers to grow small plots of sesame for home consumption during the Gu season. Other potential oil crops such as sunflower and safflower are presently being investigated in the country, but no suitable varieties for rainfed farming conditions are expected to be released in the foreseeable future.

An increase of the area grown under cotton and of the actual yields will lead to increased savings in foreign exchange, since considerable amounts of cotton lint presently have to be imported. The possibility of exporting in the future is presently also under consideration. However an efficient and effective pest control programme, including the enforcement of existing cotton sanitation legislation is a prerequisite to achieve this objective. According to this legislation cotton is to be planted in April/May and all stalks are to be burned by the end of February. Cotton grown as a succession crop to maize can meet these legal requirements. At present effective control of bollworm is not undertaken, leading to low yields and the production of poor quality seed cotton.

Vegetables are an important element in a well balanced family food basket. In the cropping patterns for the Middle and Upper Juba area they do not play an important role, and therefore have not been mentioned. However, as a rule they will be interplanted on a small-scale between the main food crops, for home consumption, while possible surpluses are sold. Expansion of vegetable production on any considerable scale is not envisaged, mainly because of the erratic rainfall pattern in these areas. For the Districts in the Lower Juba valley an increase of the area under vegetable production is envisaged. Higher rainfall and lower evaporation losses make market oriented vegetable production possible near the end of the Gu season. The higher population density, with a higher proportion of this population having some form of wage income, and the nearby urban centers provide for a market outlet. Vegetables to be considered are: tomatoes, okra, sweet potatoes, capsicum and leaf vegetables.

While the envisaged cropping patterns consist basically of crops presently grown in the rainfed crop production systems, the introduction of one new "crop" is proposed. Presently rainfed crop production land, particularly the vast concentration of farmlands within the Bardheere - Luuq - Dinsor area, is subject to wind erosion of the top soil, and high evapo(transpi)ration losses, which are increased by the prevailing winds.

Therefore the establishment of windbreaks or shelterbelts has been proposed, which may eventually cover about 5% of the farmland. Planting will be done in strips or borders along the farmland and at regular intervals in the farmed land. The use of Leucaena has been suggested, which is a fast growing leguminous shrub with soil improvement characteristics (N-fixation) while it also makes an excellent green forage during the rainy and dry seasons. In view of the erratic rainfall patterns, particularly in the Upper Juba valley, seedlings should first be raised in nurseries and afterwards, at the beginning of the Gu season, been transplanted in the field. The farming families can either use this fodder for their own animals or sell it.

However to implement this proposal successfully, full farmers' participation will be essential. To achieve such participation a special campaign has to be initiated by the extension service. The proposed planting of windbreaks would make an ideal activity for a "Food for Work" programme (such as sponsored by WFP/FAO) since this would be one of those very rare occasions where food aid could really lead to increased crop production.

Introduction of Leucaena in the Lower Juba Districts is not being foreseen but near the end of the planning period. Farm sizes in these Districts are considerably smaller than in the Middle and Upper Juba valley and emphasis will therefore first be placed on increasing food and cash crop production, before introduction of a fodder crop can be considered. Secondly since rainfall in the Lower Juba valley is higher than elsewhere, the necessity for windbreaks in less urgent.

In all cropping patterns maximum use of available family labour (estimated at 60 man-days/month for crop farming activities) has been envisaged.

Table 6.4/2 and 6.4/3 present the proposed cropping patterns for rainfed crop production in the Lower Juba valley and in the Middle and Upper Juba valley.

Within the cropping patterns the maturing times of the varieties are:

- Beans 70 days
- Cotton 120 days
- Groundnuts 90 days
- Maize 100 days
- Sesame 90 days
- Sorghum 90 days
- Vegetables 120 days
- Leucaena perennial

Table 6.4/2 Development of Cropping Patterns
Rainfed Crop Production Farm - 5 ha
(Bardheere/Saakow/Bu'aale Districts)

Crop	Present (1988)		1995		2005	
	Gu	Der	Gu	Der	Gu	Der
Sorghum	90%	95%	80%	90%	75%	80%
Maize	7%	2%	10%	2%	10%	5%
Sesame	2%	2%	-	4%	-	7%
Beans (1)	1%	1%	8%	2%	10%	3%
Leucaena (2)	-	-	2%	2%	5%	5%
Cropping intensity	200%		198%		195%	

Source: Own calculation

1) Interplanted in sorghum.
2) Planted in strips or in borders, perennial crop.

Figure 6.4/1 Cropping Calendar Rainfed Crop Production in 2005
(Bardheere/Saakow/Bu'aale)

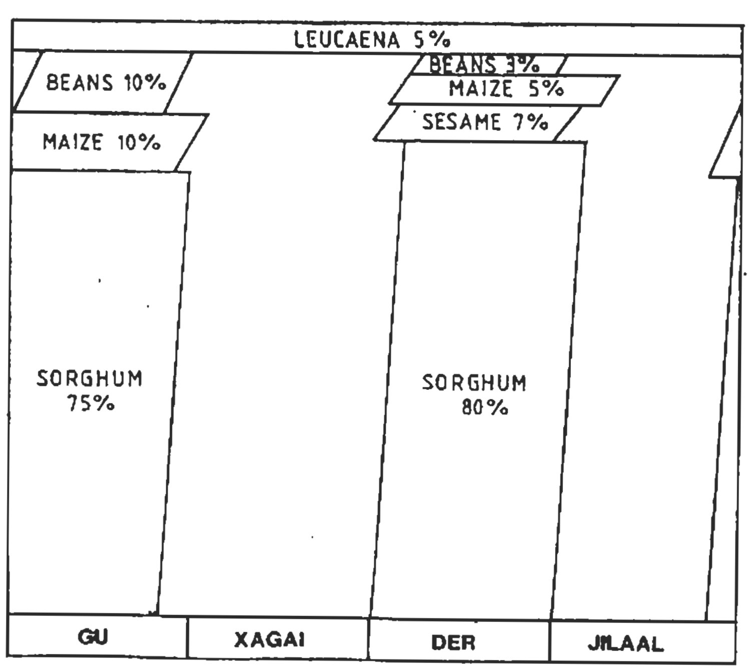


Table 6.4/3 Development of Cropping Patterns
Rainfed Crop Production Farm - 2.5 ha
(Jilib/Jamaame/Kismayo Districts)

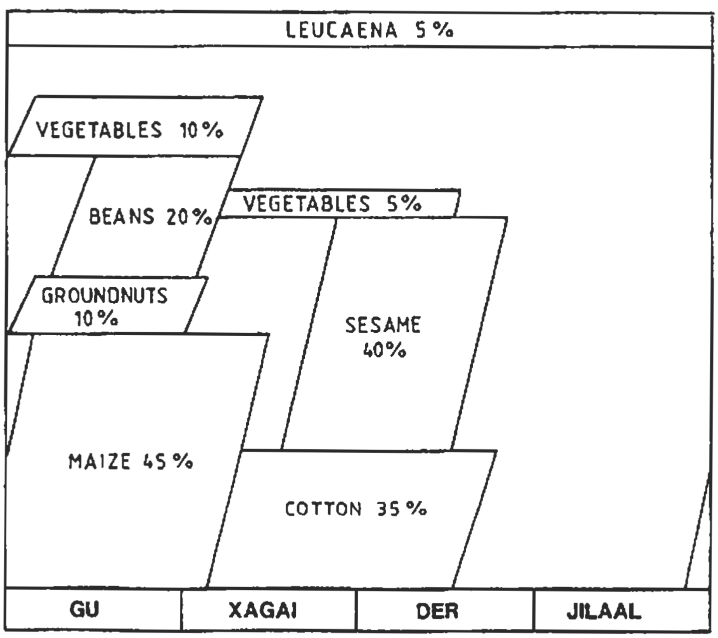
Crop	Present (1988)		1995		2005	
	Gu	Xagai	Gu	Xagai	Gu	Xagai
Maize	50%	--	50%	--	45%	--
Beans (1)	10%	--	20%	--	20%	--
Groundnuts	3%	--	10%	--	10%	--
Cotton (2)	--	1%	--	10%	--	25%
Sesame (3)	--	36%	--	36%	--	40%
Field Vegetables	--	--	5%	5%	10%	5%
Leucaena (4)	--	--	--	--	5%	5%
Cropping intensity	100%		136%		160%	

Source: Own calculation

1) Interplanted in maize.
2) Succession crop to maize.
3) Planted at end of Gu season.
4) Planted in strips or in borders, perennial crop.

Note: The construction of small bunds to keep flood waters from adjacent areas out of the fields, and the initiation of the drainage works in the Homboy area, will allow for an increased cropping intensity in the three Districts.

Figure 6.4/2 Cropping Calendar Rainfed Crop Production in 2005
(Jilib/Jamaame/Kismayo)



7. Flood Recession Crop Production

7.1 Considerations for the Future

Presently flood recession crop production is the second most important crop production system in the Juba valley. Table 7.1/1 presents the land presently used for actual deshek and levee cultivation and the estimated potential for possible future extension. These areas are all located in SGU's 2 and 3.

Table 7.1/1 Present and Potential Areas for Deshek and Levee Cultivation (ha)

District		Deshek		Levee	
		Cultivated	Potential	Cultivated	Potential
Saakow	(SGU 2)	1,500	3,000	300	1,700
Bu'aale	(SGU 2)	3,500	14,000	2,400	6,300
Jilib	(SGU 3)	2,000	4,000	1,700	4,400
Total		7,000	21,000	4,400	12,400

Source: [69]

In considering the future development scenarios for flood recession crop production the following should be noted. Although this farming system is recognized as a special system with its own characteristics, between the different desheks there are great differences. From surveys carried out in the past it has become clear that the soils of each deshek individually can deviate greatly from those soils expected according to the average standard pattern. These differences are to a large extend caused by the different topographic location of each deshek.

Therefore, to allow for the planning of the development of the individual desheks, in particular in the after-dam situation, elaboration of topographic maps and detailed soil maps per deshek, is strongly recommended. Such a more detailed assessment would allow i.a. to determine which proportion of each deshek will be permanently flooded in the after-dam situation and which proportion, apart from levee land, will be suitable for irrigation.

Although attempts have been made all along the Masterplan to catch the present deshek cultivation system in tables and statistical records, in practice the system is subject to strong seasonal and presently also more structural changes.

Desheks are not flooded every Gu and Der, and sometimes no flooding occurs for several successive years, upon which the desheks are simply used for rainfed crop production.

Apart from these seasonal fluctuations, presently more far reaching changes are taking place within the traditional flood recession crop production system. Increasingly deshek farmers are protecting their desheks from unwanted and untimely floods through the construction of bunds, which allows for (some degree of) controlled flooding for crop production, or they simply practice rainfed crop production on the deshek land. Secondly there is presently a rapid and uncontrolled conversion taking place of levee and adjacent higher situated deshek lands, into irrigated crop production land.

This uncontrolled development has to be considered an undesired development. It will eventually result into irrigation development in the form of a too small strip along the river, creating problems of right-of-way and access to water for those landowners outside the strip who would like to be included in irrigation development, for livestock owners and nomads, as well as for future irrigation development proposals, as have been envisaged within and after the period covered in the Masterplan. Moreover this development will lead to increased irrigation water shortages during Jilaal for the big irrigation schemes and banana growers downstream, in the before-dam situation.

To correct or at least stop this present trend, several recommendations have been presented in the technical report for irrigation water systems planning. These recommendations are due for immediate implementation.

Apart from the ongoing and unplanned developments as described before, the development of flood recession crop production in the future will be completely changed by the construction of the Bardheere dam.

After the Bardheere dam has been constructed, the flood flow in the Juba River will be regulated. Depending on the daily fluctuations in power demand, the discharge from the turbines will vary between 150 and 350 m^3/s. The average river level will therefore be constant throughout the year. Consequently it can be expected that the groundwater level in the floodplain will rise to this average level. The deepest parts of the deep-lying desheks might be inundated permanently. Variation in river levels will decrease and therefore the flood recession cultivation will disappear gradually.

In this respect, it can be concluded that without any development programme the impact of the construction of the dam on the existing crop production system will be negative.

As a result of these considerations the development and the actual future phasing-out of flood recession crop production will be considered in two parts; the before-dam situation (present-1995) and after-dam situation (1995-2005).

Apart from the proposed development scenarios for flood recession crop production in direct relation to the future construction of the Bardheere dam, it should be noted that within the Masterplan a number of improvements for infrastructure and crop production support services are suggested. These would also have to be available to the farmers in the flood recession crop production systems. The following proposed actions could be of direct benefit:

- improvement of regional infrastructure; in particular roads,
- strengthening of the extension service to reach all farmers with the appropriate extension messages,
- strengthening of adapted agricultural research, including farming systems research,
- improvement of access to credit,
- improvement of input supply,
- improvement of access to markets.

Within these proposals the basic elements are available for improvements in flood recession crop production and allow its eventual successful conversion into irrigated crop production. However, in view of the particular impact of the Bardheere dam on this farming system, a number of specific proposals will have to be considered.

7.2 The Before-Dam Situation (Present - 1995)

In 1984 the detailed study "Impact of the Bardheere Dam on the Development of the Traditional Agricultural System (Deshek) in the Juba Valley" was completed by AHT. This study presented development scenarios in the before and after-dam situation in relation to flood recession crop cultivation. However the study also pointed to the constraint of the absence of topographic and detailed soil maps for each deshek. Moreover since the conclusion of the afore-mentioned study new (and unplanned) developments took place, such as; the accelerated conversion from flood recession cultivation to irrigated crop production on levee soils, the development of pump/sharecropper arrangements and increased flood protection in the desheks itself.

Therefore it is strongly recommended that in the before-dam period the following action is taken in respect to the deshek cultivation system;

- preparation of topographic and soil maps for all desheks which will be influenced by the construction of the Bardheere Dam,
- identification of riverine areas to be reserved for gallery forests, access to irrigation water for irrigation development projects envisaged in the future and access to drinking places for livestock owners and nomads,
- establishment of the Saakow Deshek Pilot Project. This pilot and demonstration project should have as objective to develop agronomic practices, irrigation techniques. etc. and extension recommendations (messages) to guide the trend of change over from the present traditional flood recession crop production system to small-scale irrigated pump systems in SGU 2 and 3,
- initiation of the deshek area irrigation conversion project, based on community (farmer) organization principles, to assist farmers in obtaining ownership and operation of small pump units for levee irrigation,

- in view of the ongoing development of irrigated agriculture on levee soils, also reference is made to the following actions recommended in ANNEX 2:

  It is proposed to start urgently a "Project for Juba Immediate Land and Pump Registration", starting 1989, based on recognition of de facto water rights, issuing of water rights certificates (which include elimination of water abstraction for irrigation from the Juba river during Jilaal, until dam completion and operation); this is to be accompanied by extension measures with respect to cropping calendars, to make optimal use of the river flow during the period mid-April to mid-January and to assist in advise on cropping practices to compact cropping cycles into a 9-month period".

In the before-dam situation some modest improvements can be expected in agricultural productivity within the (controlled) flood recession and levee land irrigated crop production systems as a result of the proposed improved agricultural production support services. However, this period should mainly be seen as a transitional phase, towards the with-dam period.

In the afore-mentioned deshek study proposals have been presented towards the introduction of improved infrastructure for controlled flooding in the before-dam situation. The wisdom of a project-wise approach to introduce these proposals is somewhat doubtful.

An increasing number of deshek farmers have introduced some degree of flood control since this study was undertaken. Taking into account the usual delays in preparation and implementation, which are inherent to a project-wise approach, the cost of the improved infrastructure, and its envisaged limited life span (until the dam is operational), the feasibility of this proposal should be put to question.

7.3 The With-Dam Situation (1995 - 2005)

In the afore mentioned deshek study the following areas have tentatively been identified as suitable for controlled flood crop production before the dam is in full operation and for eventual irrigated crop production in the after-dam situation (see Table 7.3/1):

Table 7.3/1 Distribution of Potential Land According to Crop Production System (ha)

District	Controlled Flooding	Irrigation
Saakow (SGU 2)	2,100	2,100
Bu'aale (SGU 2)	9,800	8,600
Jilib (SGU 3)	2,800	4,300
Total	14,700	15,000 (1)

Source: [69] - ANNEX 4, AHT 1986.

1) Of which presently an estimated 1,600 ha are irrigated.

The proposed actions presented in section 7.2 of the present report would allow for a more accurate and detailed identification of these areas. However the full and actual impact of the Bardheere dam on flooding levels in the desheks will only be really known after the dam is in full operation. Too many factors, such as groundwater flows and levels, influence of local runoff and the effect of takeoff of irrigation water upstream, etc. are presently unknown and anyway hard to predict, unless a full hydrological study were to be undertaken, which is not recommended.

It is therefore strongly recommended that based on the proposed actions (Section 7.1.1) in the before-dam situation, a seasonal monitoring programme be established to permit an evaluation of the "behaviour" of the present deshek areas under the new river regime in the after-dam situation, thus also permitting an adjustment of proposed irrigation development programmes in these areas, when necessary.

In the deshek study specific recommendations have been made towards the creation of artificial flood waves through adjusted dam operation in the after-dam situation. Bearing the proposed action in section 7.2 in mind and pending the findings of the proposed monitoring programme, this recommendation will have to be reviewed in the after-dam situation, before implementation is to be considered.

7.4 Increasing Farm Productivity

In view of the envisaged gradual conversion of the deshek farming system into irrigated crop production, while the lower parts of the desheks might be flooded permanently, possibilities to improve productivity are considered only for the period between present and just after the completion of the dam.

Benefitting from a strengthened extension service and improved input supply organization, the following recommendations can be considered to improve productivity in the before-dam period:

- increased areas with grain or fodder legumes in the cropping patterns to improve soil fertility,
- control of those pests and diseases which are of major economic importance,
- introduction of seed dressing,
- introduction of improved seed,
- improved weed control, e.g. with the use of animal-drawn equipment,
- increased plant populations.

While the issue of flood damage and flood control has received ample attention in previous studies, it has to be pointed out that so far no on-farm research has been undertaken towards the specific requirements of flood recession crop production. As a result, apart from the recommendations presented above, presently no specific recommendations are available for this farming system.

The proposed Saakow Deshek Pilot Project would be the most obvious organization to create specific recommendations to improve productivity in flood recession cultivation. However presently (April 1988) this project has not become operational as yet. It would take several years to formulate the required recommendations , while the main task of this project is to assist in the transformation of deshek farming into irrigated farming, within a given period of time. It is therefore unlikely that in the before-dam situation a contribution of major importance towards increasing productivity in deshek farming can be expected from this project.

While the packet of recommendations presented above could lead to an average increase in productivity of about 15 to 20% over a period of 10 to 15 years after full implementation, this future situation will not be reached, because of the changes in the flood recession crop production system as a result of the construction of the Bardheere dam.

For this reason no attempt has been made to a further analysis of yield and farm income development, or other developmental aspects, during the remaining lifetime of this farming system.

The future development of irrigated crop production on levee land will be reviewed in the chapter of this ANNEX dealing with irrigated crop production.

8. Irrigated Crop Production

8.1 Considerations for the Future

Irrigated crop production, and in particular small-scale irrigated crop production, is at present of lesser importance in the area. However this situation is already subject to changes and will be changed even more drastically in the after-dam situation, when the Juba riverine area is assured of a constant irrigation water supply.

Two present ongoing developments in irrigated agriculture are unplanned and will lead to developmental constraints in the foreseeable future. These developments are the following;

- land speculation and water access positioning along the river, particularly in SGU 1 and 2,
- the risk that irrigation development will occur in the form of a too small strip along the river.

Proposals to overcome and correct these problems have been presented in the Water ANNEX (ANNEX 2) and will not be elaborated in the present ANNEX.

The envisaged development scenario for irrigated crop production, until the end of the planning period is presented in Table 8.1/1.

Table 8.1/1 Development Scenario Irrigated Crop Production

Socio - geographic Unit	Present (1988)		Before-Dam (1995)		After-Dam (2005)	
	ha	Crops	ha	Crops	ha	Crops
SGU 1	2,500	Seasonals	6,000	idem	7,500	idem
SGU 2	1,600	Seasonals	5,000	idem	10,000	idem
SGU 3	7,000	Sugar	7,000	idem	7,000	idem
	800	Rice	800	idem (1)	2,500	idem (1)
	200	Seasonals	2,200	idem	3,500	idem
SGU 4	3,400	Bananas	3,400	idem	5,000	idem
	600	Rice	600	idem (2)	2,000	idem (2)
	1,000	Seasonals	2,000	idem	5,000	idem
SGU 6	-	-	-	-	500	Rice (1)
	presently under rainfed farming				2,100	Bananas
	-	-	-	-	4,900	Seasonals
Total	17,100		27,000		50,000	

Source: ANNEX 2.

1) Double rice crop per year.
2) Rice grown in own season only (Mogambo).

Between present (1988) and 1995 the area under irrigated crop production will increase by nearly 60%. By the end of the planning period the present irrigated area will nearly be tripled. For the end of the planning period (2005) the following breakdown in farm sizes could be envisaged, depending on the scenario which will eventually be implemented by the Government. Bearing in mind the discussion presented in Chapter 5 of the present ANNEX, it has been assumed that preference will be given to smallholder development in irrigated farming.

Table 8.1/2 Envisaged Development of Farming Systems in Irrigated Crop Production

Farm System	Present (1988)		1995		2005	
	Area (ha)	Farm Families	Area (ha)	Farm Families	Area (ha)	Farm Families
Juba Sugar (SGU 3)	7,000	-	7,000	-	7,000	-
Large-scale Irr.Projects						
- SGU 3	1,000	-	-	-	-	-
- SGU 4	1,600	300	-	-	-	-
Medium-scale Irr. Banana Growers	3,400	60	3,400	60	5,000	100
Small-scale Irr. Farmers						
- SGU 1	2,500	800	6,000	2,000	7,500	2,500
- SGU 2	1,600	400	5,000	1,400	10,000	3,300
- SGU 3	-	-	3,000	1,000	6,000	2,000
- SGU 4	-	-	2,600	1,040	7,000	2,400
- SGU 6	-	-	-	-	7,500	3,000
Total	17,100	1,560	27,000	5,500	50,000	13,300

Source: Own calculation based on ANNEX 2.

Note: It is assumed that both the Fanoole and Mogambo Schemes will be reorganized into smallholder schemes by 1995. Banana production for the Homboy area has been proposed as a smallholder scheme (2.5 ha/farmer) in the MacDonald feasibility study (1987).

Apart from all the infrastructural and organizational requirements which will be needed to allow an equitable allocation and efficient use of available irrigation water, there will be a strong need for improved infrastructure (in particular roads) and strengthening of agricultural production support services. This is true for all crop production systems in the Juba valley, but in particular for irrigated crop production, in view of the high public and private investment cost required to develop arable land for irrigation.

To make irrigated crop production economically attractive, higher management skills are expected from the farmers, both for on-field water management as well as for crop production and maintenance techniques and methods. To achieve these higher levels, an efficient system of agricultural production support services has to be operational before the envisaged development scenarios for irrigated crop production can be implemented successfully.

The following actions will have to be undertaken to improve the production support services:

- strengthening of the extension service to reach all farmers with the appropriate extension messages,

- strengthening of adaptive agricultural research, including research on on-farm water management,

- improvement of access to credit,

- improvement of input supply (seeds, fertilizers, agro-chemicals),

- improved availability of such services as pump repair, etc.,

- improvement of access to markets.

It is obvious that in an irrigated crop production system security of land tenure is a prerequisite to achieve sustained high productivity and thus an acceptable return on public investments. In case a farmer is not certain of his land rights, or these land rights are guaranteed only for a (too) short period, he will minimize his investments in on-farm improvements, and exploit available production means such as land, water and infrastructure, to maximize returns on his private investments, without considering the consequences of his management practices in the long term.

These consequences are usually the following; deterioration of irrigation infrastructure, exhaustion of soil fertility and problems of waterlogging and salinity. In the end such developments do lead to the need for expensive irrigation and drainage rehabilitation projects.

8.2 The Specific Role of Extension in Irrigated Crop Production

Agricultural extension services have a tendency to concentrate their extension activities and messages on such aspects of crop production as seed quality, plant population, weed control, pest and disease control and other cultural practices. This is presently also the case with the AFMET agricultural extension programme in the Juba valley. While such orientation of the extension programme is acceptable in rainfed farming systems, it is not in irrigated crop production. This farming system distinguishes itself from rainfed crop production by its specific requirements for on-farm water management. Therefore water management extension has to be included in the packet of extension recommendations made available to farmers.

For the Juba valley this implies that with the increasing number of farm families involved in irrigated crop production, part of the extension effort will have to be reoriented towards this new situation: include water management expertise in the Subject Matter Specialist (SMS) staff, train Field Extension Agents (FEAs) in on-farm water management practices and include extension messages on on-farm water management practices in the existing extension programme for small and medium-scale irrigated farmers.

In particular the extension service has to assist and train the farmers in the following aspects in relation to on-farm water management:

- the most profitable cropping pattern to be used with the allotted amount of water,

- on-farm water distribution systems,

- interval of irrigation for different crops,

- crop water requirements and how to irrigate,

- negative effects of overirrigation such as waterlogging as well as of underirrigation, e.g. salinisation,

- soil-water-plant relationship, and where applicable, aspects of on-farm drainage works.

The extension recommendations and messages as regards on-farm water management will have to be based on the results of of the work of the proposed Bardheere Experimental Station and the Saakow Deshek Pilot Scheme.

However it is important to realize that water management extension with farmers, aimed at efficient water use at the tertiary level, cannot be successful if:

- there is no coordination with the irrigation district,

- irrigation districts or command areas are poorly operated,

- irrigation water is not available when needed,

- farmers are free to install pumps where and when they desire,

- a cropping plan at regional or district level is not made and enforced,

- water is available free of charge, and therefore a free for all input, which can be used in a wasteful manner.

Experience elsewhere has shown that in irrigated areas where sharecropper arrangements, such as presently are increasingly introduced in the Juba valley, are prevalent, motivation to increase on-farm water use efficiency is very low.

Recommendations as regards these above outlined preconditions for a successful water management extension programme have been outlined in ANNEX 2.

8.3 Increasing Farm Productivity

Total agricultural output of irrigated crop production will increase strongly as a result of the extension of the area under irrigation, particularly in the after-dam situation.

Taking advantage of the proposed strengthening of the agricultural production support services, the following recommendations are to be considered to increase the overall farm productivity in the irrigated crop production system:

Recommendations applicable to all farm systems in irrigated crop production;

- improvement of maintenance (and available maintenance services) of pumps for irrigation water,
- improvement of on-farm water management,
- improvement of land preparation or/and the introduction of mechanized equipment,
- improvement of weed control,
- improvement of pest and disease control.

Recommendations applicable in particular to small-scale farmers;

- improvement of pest and disease control in cotton,
- introduction of fertilizers,
- increase in plant densities to optimum levels,
- introduction of high(er) yielding varieties,
- improvement of access to seasonal and medium-term credit.

Recommendations applicable in particular to banana growers;

- improvement of drainage infrastructure in banana plantations,
- increased establishment of windbreaks in banana plantations.

Recommendations applicable in particular to large-scale projects;

- change from the present rice mono-cropping system to a rotation including other annual crops, in the Mogambo Irrigation Project, to control salinity levels.

The above presented recommendations should form the base for a short to medium-term programme to improve productivity in irrigated crop production, in which the agricultural extension service will play a key role.

At present not all the above suggested recommendations can be considered for immediate implementation. As mentioned before, on water management, a prerequisite for successful irrigated crop production, little or no research has been done. Recommendations for improved cultural practices are available to some extend in the Shebelli area, and could be used in the Juba valley, pending the results from on-farm field trials within the area. Future recommendations will depend on the results from the Bardheere Experimental Station. Higher yielding crop varieties are presently not readily available. The research station in Afgoi is about to release several new high-yielding maize hybrids. However these introductions can only be successful if farmers are aware of the necessity (extension service) to buy fresh seed every season, assuming seeds are available in the desired quantity and at the right time.

With two important time horizons in mind (1995; dam construction completed and 2005; end of Planning Period), the following tentative gradual productivity improvement programme for irrigated crop production could be envisaged (see Figure 8.3/1).

Figure 8.3/1 Tentative Gradual Productivity Improvement Programme

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-----------------------------------------------------------------------------
                                    Y E A R
-----------------------------------------------------------------------------
1988                 1990               1995              2000            2005
-----------------------------------------------------------------------------
- Improved maintenance service
  and maintenance of pumps
I-------------------------------------C

- Introduction of a second crop
  in rice rotation (Mogambo) I----------------------C

- Improvement of drainage and
  establishment of windbreaks in
  banana plantations
I-------------------------------------------C

- Improvement of on-farm water
  management              I---------------------------------------------------|

- Improvement of land
  preparation
I---------------------------------------------------------------------------|

- Improvement of weed
  control
I---------------------------------------------------------------------------|

- Improvement of pest
  and disease control
I---------------------------------------------------------------------------|

- Introduction of fertilizers
  for small-scale farmers             I---------------------------------------|

- Increasing plant densities
I---------------------------------------------------------------------------|

- Improvement of access to credit     I---------------------------------------|

- Introduction of high yielding
  varieties                                     I---------------------------|

-----------------------------------------------------------------------------
I = start of activity     C = activity completed     -| = activity continuing
```

8.4 Yields and Cropping Patterns

Based on the proposed improved crop husbandry practices presented in Section 8.3 of this report, yield projections have been prepared for the major irrigated smallholder crops in the Study Area. Yield increases between 1995 and the end of the planning period will in particular be the result of the combined effects of reliable and sufficient irrigation water availability, improved soil/water management and the introduction of pest control measures and fertilizers.

Although improvement of soil/water management practices in irrigated crop production is expected to take place gradually, it is not expected that a changeover from the present practice of flood/basin irrigation to a more controlled system of irrigation, such as that of furrow irrigation, will take place on a considerable scale within the planning period. Presently farmers are not familiar with these techniques, while their introduction would also lead to increased costs of land preparation. It is unlikely that the small-scale irrigated farmers will reach the management and skills level within the next 10 to 15 years, which is required to make them cope with such a higher level of irrigation management. The main motivation for farmers to adopt such techniques would be irrigation water shortages (a situation which is not expected to occur during the period 1995-2005) and increased farm incomes as a result of increased crop yields, the introduction of higher value crops and fair farmgate prices for their produce.

Increased introduction of mechanized field operations in irrigated crop production is expected to take place as of the year 1995.

Detailed development scenarios for the most important time horizons; present (1988), 1995 and the end of the planning period (2005) have been presented in APPENDIX 1 to the present ANNEX. Envisaged crop yield developments have been presented in Table 8.4/1.

Table 8.4/1 Development of Yields in Irrigated Crop Production with Small-Scale Farmers (t/ha)

Crop	Present (1988)	1995 (1)	2005 (2)
Watermelon	10.0	11.0	18.0
Vegetables (tomatoes)	6.0	8.0	13.0
Tobacco	0.4	0.5	0.9
Sesame	0.7	0.9	1.1
Onions	9.0	10.0	14.0
Maize (grain)	1.6	1.9	2.6
Maize (fodder) (3)	-	5.0	8.0
Groundnuts	0.8	1.0	1.5
Cotton	-	0.9	1.9
Beans	0.8	0.9	1.1
Alfalfa (Fodder) (3)	-	8.0	10.0

Source: APPENDIX 1

1) Mechanized land preparation has been introduced.
2) Use of pesticides and fertilizers has been introduced
3) Yield expressed in Dry Matter (DM).

For the design of the proposed future cropping patterns several factors have been taken into consideration.

Although irrigated farming has developed into a more commercially oriented farming type, in the Juba valley area the production of staple foods for subsistence requirements is still of high priority. Marketing of surpluses is still of minor importance. This particular consideration has also been adopted for the future, to some degree.

The envisaged decreases of the proportional area of maize in the cropping patterns in the period 1995 - 2005, combined with the increased yields, will, however, still result in a net increase of total maize production.

The relative importance of onions in the present cropping patterns on levee irrigated land is expected to decrease gradually. No information is presently available with respect to national demand/consumption for onions. However with the envisaged expansion of irrigated farming during the planning period, and the present high net returns on onion growing, it is to be expected that many farmers will embark on the growing of this crop, which may eventually lead to a saturation of the market and a decrease (or collapse) of farmgate prices.

The increased areas allocated to sesame, groundnuts, beans and cotton, within the cropping patterns, are motivated by the same considerations as presented for rainfed crop production (Section 6.4). The reason that sesame is cultivated in the Gu season at present, but not in 1995 and 2005, has also been explained in Section 6.4. Groundnuts have been considered in particular for irrigated crop production on levee lands which, due to their light soils, are very suitable for this crop. Equally, these soils have proved over the years their suitability for successful tobacco and vegetable production. In the future cropping patterns, initially the acreage devoted to tobacco has been decreased, due to its (present) low economic returns. However, after 1995, due to the introduction of the use of fertilizers and improved pest and disease control measures, returns on tobacco growing are expected to increase considerably (for details see APPENDIX 2) and it is assumed that the acreage allocated to tobacco production will be increased again gradually.

The only new crops envisaged in the crop rotation are fodder crops; alfalfa and fodder maize. In the Study Area presently little or no attempts are made to produce fresh fodder as a complement to crop residues and natural vegetation for the feeding of cattle and small ruminants. With the increased development of irrigated farming along the Juba River as proposed in the Masterplan, and the envisaged changes in the traditional deshek system in the after-dam situation, provision of adequate feed supplies to particularly cattle may become problematic in the foreseeable future. This would particularly be the case in areas of highly concentrated irrigation development, such as the levee lands, the development area around Saakow and in the Mogambo and Fanoole Irrigation Schemes.

To prevent fodder shortages in the future as a result from developments in crop production farming and prevent potential conflict situations between crop farmers and livestock farmers (although this division is never quite clear in the Somalia context) the introduction of fodder crops in the cropping patterns has been proposed. For the cropping pattern for vertisols based on maize preference has been given to Alfalfa (var. Hunter River). Field trials undertaken at Afgoi Research Station during the Jilaal season of 1986/87 showed promising results. Alfalfa is a perennial leguminous crop with soil improvement characteristics (N-fixation) and as such can play an important role in the cropping pattern. It needs to be replanted every 2-3 years, and after its establishment period requires relatively little maintenance. In the rice based cropping pattern the perennial alfalfa would not be feasible and instead fodder maize has been proposed as an annual fodder crop. In case an alternative annual fodder crop could be identified, in particular a legume (such as berseem), this should replace fodder maize in the proposed cropping pattern.

For the rainfed crop production systems the introduction of Leucaena as part of the cropping pattern has been proposed. In the case of irrigated crop production, planting of Leucaena (or alternative species) should be considered along roads and irrigation canals, but not within the fields.

Cropping patterns for the irrigated crop production systems applicable for the areas north of the Fanoole inlet have been designed in such a way that the abstraction of irrigation water from the river is not necessary during the Jilaal season. This in view of the irrigation water shortages in the Lower Juba irrigated areas during this season in the before-dam situation. In the after-dam situation the water supply situation is expected to improve during Jilaal. But to increase the proposed cropping intensities it would need more than water availability alone, it would also depend on the management and irrigation skills level of the farmers and the timely availability of mechanization services to intensify the use of available land and water resources.

In all cropping patterns maximum use of available family labour (estimated at 60 man-days/month for crop farming activities) has been envisaged.

Tables 8.4/2, 8.4/3 and 8.4/4 present the proposed cropping patterns for small-scale irrigated crop production in the different locations in the Study Area.

- Irrigated crop production on levee land. The levee lands are situated along the Juba river and have a texture characterized by coarse sand. They are light soils, easy to work and suitable for crops such as [redacted]

It is foreseen that the double cropping of rice in the Fanoole Scheme will continue, but in the Mogambo scheme other seasonal crops will be introduced in the existing cropping pattern, due to the problems of waterlogging and salinisation.

Table 8.4/2 Development of Cropping Patterns
Irrigated Crop Production on Levee Land
3 ha Farm

Crop	Present (1988)		1995		2005	
	Gu/Xag	Der/Jil	Gu/Xag	Der/Jil	Gu/Xag	Der/Jil
Onion	30%	35%	30%	30%	20%	20%
Sesame	25%	10%	-	20%	-	25%
Maize	35%	25%	35%	20%	30%	15%
Tobacco	-	25%	-	15%	-	20%
Vegetables	10%	-	15%	-	15%	-
Watermelons	-	5%	-	10%	-	10%
Groundnuts	-	-	15%	-	25%	-
Alfalfa (1)	-	-	5%	5%	10%	10%
Cropping intensity	200%		195%		190%	

Source: Own calculation

1) Perennial crop.

Figure 8.4/1 Cropping Calendar Irrigated Crop Production on Levee Land in 2005

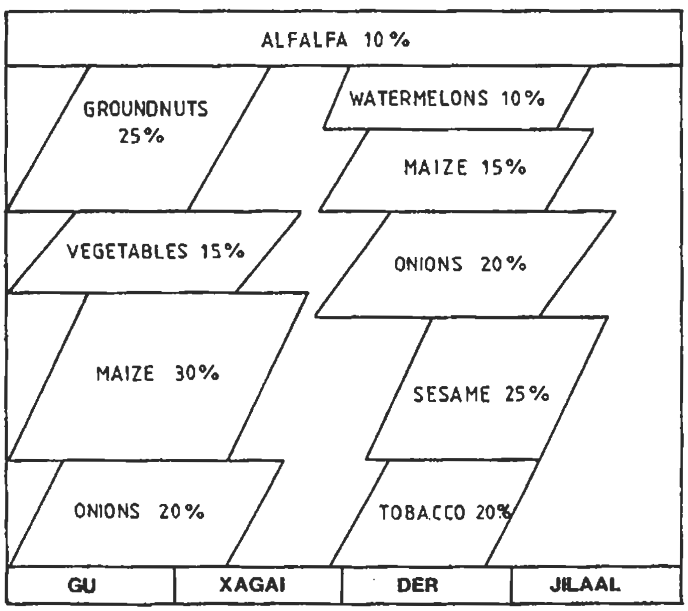

Table 8.4/3 Development of Cropping Patterns
Irrigated Crop Production on Alluvial Soils
3 ha Farm (rotation based on maize)

Crop	Present (1988)		1995		2005	
	Gu/Xag	Der/Jil	Gu/Xag	Der/Jil	Gu/Xag	Der/Jil
Maize	-	-	50%	40%	45%	25%
Sesame	-	-	-	20%	-	20%
Vegetables	-	-	5%	-	5%	-
Watermelons	-	-	-	5%	-	5%
Cotton (1)	-	-	-	20%	-	30%
Beans (2)	-	-	30%	-	35%	-
Alfalfa (3)	-	-	5%	5%	10%	10%
Cropping intensity	-		175%		175%	

Source: Own calculation

1) Succession crop to maize.
2) Interplanted in maize.
3) Perennial crop.

Figure 8.4/2 Cropping Calendar Irrigated Crop Production on Alluvial Soils in 2005

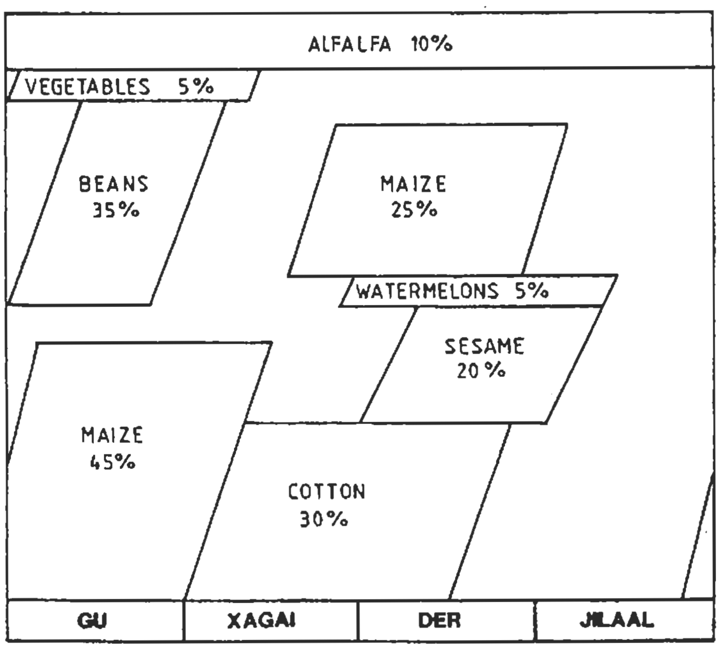

Table 8.4/4 Development of Cropping Patterns
Irrigated Crop Production on Alluvial Soils
2 ha Farm (rotation based on rice)

Crop	Present (1988)		1995		2005	
	Gu/Xag	Der/Jil	Gu/Xag	Der/Jil	Gu/Xag	Der/Jil
Rice	50%	50%	50%	50%	50%	50%
Maize (grain)	-	-	50%	-	40%	-
Maize (fodder)	-	-	-	10%	10%	10%
Sesame	-	-	-	40%	-	40%
Cropping intensity	100%		200%		200%	

Source: Own calculation

The development of cropping patterns presented in Table 8.4/4 is of particular relevance for the Mogambo Irrigation Scheme, while it could also be applicable for Fanoole in the before-dam situation. However, the present and future functioning of Mogambo is presently subject to review, and eventually different cropping patterns may be recommended for implementation.

Within the cropping patterns the maturing times of the varieties are:

- Alfalfa 365 days
- Beans 70 days
- Cotton 120 days
- Groundnuts 90 days
- Maize (grain) 100 days
- Maize (fodder) 80 days
- Onions 120 days
- Rice 140 days
- Sesame 90 days
- Tobacco 70 days
- Vegetables 120 days

8.5 Large and Medium-Scale Irrigation

In Sections 8.1 to 8.4 of the present ANNEX a development scenario has been presented for irrigated crop production in the Study Area, between present and 2005, with particular emphasis on small-scale irrigated farming. As has been highlighted in the introduction, successful sustained agricultural development is usually best achieved through small and medium-scale farmers' participation. However a prerequisite to such a success are the following conditions; availability of all necessary production support services and inputs, security of land tenure, access to markets, fair prices and in the case of irrigated crop production, the timely and sufficient availability of irrigation water.

In view of the past performance of the Mogambo and Fanoole Schemes and pending the results of the (proposed) reviews of their organization and operation, a strong plea is made to transform both schemes into smallholder schemes, or at least to develop their remaining command areas as a smallholder scheme. However such a drastic move needs to be well prepared if success is to be achieved. In the after-dam situation there is no known reason not to introduce double cropping of rice in Fanoole, as had been anticipated during the design period of the project. In the period between present and 1995 it is unlikely that full double cropping with rice can be achieved, due to the Jilaal water shortages. During this period a cropping pattern as suggested in Table 8.4/4 could be considered for implementation. In view of potential salinity problems in Mogambo, an alternative cropping pattern has been proposed, for both the before and after-dam situation (see Table 8.4/4).

No extension of the Juba Sugar Project is foreseen in the planning period, but emphasis will have to be placed on increased water use efficiency. In the after-dam situation the present Jilaal water shortages are expected to be solved. Present low cane yields of 61.4 t/ha as a result of seasonal water shortages can increase in the direction of the anticipated 100 t/ha as envisaged during the design period of Juba Sugar. The rate at which this development will take place depends much on the management and skills level of the project staff and the timely and sufficient availability of inputs such as fertilizers, diesel and electrical power.

If expansion of the area under cane is to be considered in the future, consideration should be given to involve small farmers as out-growers of sugar cane. If cane in their fields is not burned, the tops will also supply a valuable fresh forage for cattle. If expansion is indeed considered, including the establishment of an out-growers scheme, a full feasibility study will be required, while most probably the proposed water allocation in the present Masterplan scenario will have to be adjusted.

The area presently grown with bananas in the Lower Juba (3,400 ha), is expected to increase to 5,000 ha by the end of the planning period. Another 2,100 ha with bananas will be grown in the Homboy Project area, under a smallholder scheme.

Although in the present report it has been assumed that banana development will be based on medium-scale farms, this does not necessarily have to be the case. As has been proposed in the feasibility study for Homboy, banana production in the Lower Juba could also be based on smallholders participation. Such a development would than require extra support from Somalfruit and from the extension service for small farmers.

In the after-dam situation the banana growers are not expected to suffer anymore from the Jilaal irrigation water shortages, as they do at present. Proposed improvements in drainage infrastructure could be completed between 1995 and 2000. These improved production conditions may be expected to lead to increased yields. However the highest increase in net returns for banana growing is expected to come from an improvement in the ratio between bananas for export and bananas for the national market, the latter being rejects for export. At present only 50% of the bananas produced on the farms meet export quality standards. Improved quality of harvested bananas, e.g. through the proposed increased establishment of wind breaks to prevent wind damage, and better training of farmers and farm labourers in harvesting and crop maintenance operations is expected to lead to a strong increase in net returns on banana growing.

9. Development of Crop Production Output in the Study Area

Table 9/1 presents a comparison of total crop production output in the Study Area, for the representative crops in the cropping patterns as have been suggested in the development scenarios in the present report. Comparisons are made for the most important time horizons; present (1987 data), 1995 and the end of the Planning Period (2005).

Table 9/1 Development of Annual Crop Production Output in the Study Area (Production in 1,000 tons)

Crop	Present (1987)	1995 (1)	2005
Alfalfa	-	10.0	45.0
Bananas (2)	25.0	31.0	85.0
Beans	n.a. (3)	13.8	29.6
Seed cotton	0.7	5.7	31.4
Groundnuts	n.a.	2.0	6.0
Maize (grain)	22.0	70.1	135.0
Maize (fodder)	-	0.7	8.0
Leucaena	-	19.0	97.6
Onions	n.a.	36.0	56.0
Rice (4)	7.0	8.0	35.0
Sesame	8.0	13.6	29.3
Sorghum	87.4	124.6	230.5
Sugar cane (5)	48.0	53.0	60.0
Tobacco	n.a.	0.5	1.8
Vegetables	2.4	23.4	71.1
Watermelons	2.0	17.4	49.5

Source: Own calculation.

1) For 1995, production figures for desheks are still included
2) Following average exportable yields have been assumed per ha; 1987: 10t; 1995: 12t and 2005: 16t.
3) n.a. = data not available.
4) Following average yields have been assumed per ha; 1987: 3t; 1995: 3.5t and 2005: 4.4t.
5) Following average yields have been assumed per ha; 1987: 70t: 1995: 75t and 2005: 85t.

10. Land Use Development for Crop Production

In Table 10/1 a comparison has been made between the development of the areas under the different crop production systems, with the arable land actually available in the Study Area. This comparison has been made for the SGUs 1-6 only, since agricultural development activities, as proposed in the Masterplan, will be concentrated mainly in those SGUs. The balance thus obtained indicates that in general there is sufficient arable land available for crop production development as envisaged during the planning period.

Table 10/1 Agricultural Land Use Development in Study Area (ha)

Item	1988	1995	2005	Ultimate Development
Arable Land				
Irrigable	360,000	360,000	360,000	360,000
Other	210,000	210,000	210,000	210,000
Sub-total	570,000	570,000	570,000	570,000
Land Use				
Irrigation	17,100	27,000	50,000	120,000
Rainfed	122,500	143,500	192,900	449,000 (1)
Flood Recession (2)	11,400	11,400	-	-
Permanently Flooded	-	-	1,000	1,000
Sub-total	151,000	179,900	243,900	570,000
Net Balance	423,400	399,500	326,100	-

1) Rainfed cropping area determined as balancing item.
2) Excluding the 4,400 ha levee land usually included in the deshek crop production.

However differences between the various SGUs do occur. In particular in the area covered by the SGUs 3, 4 and 6 (Lower Juba), with a higher population density than the Middle and Upper Juba Districts, competition for arable land may be expected to increase. To prevent major imbalances and social injustice within the proposed development scenario for the Study Area, the need for integrated land use planning is evident. Moreover it will be important to give preference to local already established farmers, when (re)allocating land for irrigated crop production, before considering the import of farmers from other areas or Mogadishu residents.

However, the most important conclusion from Table 10/1 is that between 1988 and 2005, about 100,000 ha of uncultivated land, which is presently available for grazing of livestock, will be brought under crop production. While the crop residues from this newly developed land will well cover the loss of natural grazing sources, it will certainly restrict the movements of nomad owned livestock and camel herds.

11. Agro-Economic Analysis

11.1 Calculation Assumptions

This section covers the financial price calculations and assumptions applied for agricultural inputs and produce. Wherever possible, financial prices have been based on relevant border parity values. They apply CIF prices for imported inputs and crop produce which replaces imports, and FOB prices for commodities which will be exported. World market prices have been taken from the World Bank Commodity Price Forecasts (October 1986). Values for labour, agricultural inputs and produce, for which world market prices are either not available or not appropriate have been based on existing local market prices.

The calculations are based to a great extend on previous studies, such as the two studies on deshek cultivation [46] and [52], and the study on rainfed farming [53], undertaken in 1986. The official exchange rate in the second half of 1986 (at SoSh 90 = US $ 1) did not reflect the free market rate of SoSh 160 per US $ 1. Therefore for border price calculations an average shadow foreign exchange rate of SoSh 130 = US $ 1 was assumed to take adequate account of the scarcity value of foreign exchange in the Somali economy. This information has been updated in mid-1987 with regard to prices and costs.

The reintroduction of the policy of administered prices in February 1988 has not been taken into account in setting up development scenarios for the agricultural sector. It is assumed that the Government will return to a market-oriented price policy for agricultural commodities, to prevent counter-productive effects on national production, and will formulate a suitable agricultural price policy which will correspond to the high price elasticity of supply in the agricultural sector.

At present it is not possible to make any reliable assumptions about future price policy decisions, therefore the favourable conditions of mid-1987 were selected as calculation basis.

For the various crops the following per kg farmgate prices have been applied:

- maize	SoSh 19
- sorghum	SoSh 17
- beans	SoSh 25
- sesame	SoSh 47
- groundnuts	SoSh 45
- cotton	SoSh 45
- onions	SoSh 50
- tobacco	SoSh 75
- vegetables (tomatoes)	SoSh 30
- watermelons	SoSh 13

The yields of crop by-products (stover and other crop residues which are used as fodder) were estimated at 300% of the main product for maize and sorghum, at 200% for sesame, 100% for beans and 50% for groundnuts. The remaining crops do not produce residues suitable for fodder. While prices for these different crop residues mainly depend on the availability of fodder from natural vegetation which in its turn depends on the erratic seasonal rainfall patterns, there are also huge regional price differences within the Study Area.

The lowest average annual prices for stover are reported from the Upper Juba valley with SoSh 1-2 per kg. In its lower parts, especially around a big urban center like Kismayo, the highest prices with SoSh 5-6 per kg were found. Seasonal shortages, after drought periods, lead to considerable price increases, far above the figures mentioned. In the Masterplan a unit price of SoSh 4 per kg is adopted as an overall annual average.

On-farm losses were estimated at 25% for onions, tobacco, vegetables and watermelons and at 5% for all other crops, taking into account the good local storage facilities.

Seed prices have been valued at 1.5 times output values. Cotton seed is presently provided free of charge to growers by Somaltex; however, it is assumed that this policy will be discontinued with increasing supplies from national production. Therefore a cotton seed price of SoSh 50 per kg was estimated, taking into account the different values for lint and seed cotton with a ratio of 1:2. (1)

Seed prices for onions, tomatoes and watermelons are based on Mogadishu retail prices, being SoSh 5,000 per kg for onions and watermelons and SoSh 3,000 for tomatoes. No price could be obtained for tobacco seed; it has been assumed to be equal to that of tomato seed. For alfalfa seed the farmgate price for imported seed from Kenya (SoSh 922/kg CIF Mogadishu) was applied at SoSh 1,200 per kg.

The price of a unit of fertilizer nutrient (1 kg) as presented in the Agricultural Development Scenarios (APPENDIX 1), is based on the average of an assumed fertilizer mixture ($N:P_2O_5$ = 2:1). Based on information received from FAO Mogadishu the following nutrient prices were adopted:

1 kg N	=	SoSh 57
1 kg P_2O_5	=	SoSh 47

The resulting price of a unit of fertilizer nutrient is SoSh 54 per kg (2).

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1) 3 kg seed cotton is equal to 2 kg seed and 1 kg of lint. The value of 2 kg seed is equivalent to the one of 1 kg of lint. Applying farmgate prices for seed cotton the following calculation was set up: 3 kg x 45 SoSh = 135 SoSh.
2 kg cotton seed represent 50% of total value = SoSh 34/kg + quality premium of 50% = SoSh 50/kg.

2) (2 x SoSh 57 + 1 x SoSh 47) : 3 = SoSh 54.

For agro-chemicals, the price of the most commonly used pesticide, Basudin 10% was selected as the reference price. According to market investigations, a farmgate price of SoSh 970 per kg was applied.

Land preparation services by tractor are either offered by the Government (ONAT), Government owned companies like Somaltex, or private enterprises and individual tractor owners. Government tractor hire rates per hour are relatively low, due to high subsidies, and do not reach any satisfying cost recovery level. With SoSh 600 to 1,000 per hour private tractor hire rates are higher. Due to the high proportion of Government operated tractors among the total tractor fleet in the Study Area an average rate of SoSh 700 per hour is assumed here.

Pumping costs for irrigated farming have been determined by the following assumptions:

- investment costs of a small pump to irrigate 4 ha	300,000 SoSh
- depreciation (20 % p.a.)	60,000 SoSh
- maintenance and repair (20 % p.a.)	60,000 SoSh
- annual use for 4 ha	1,200 hours
- fuel consumption (1.2 l diesel/hr at SoSh 25/l)	36,000 SoSh
- pumping costs per ha p.a.	39,000 SoSh

At an annual rate of SoSh 39,000 per ha full cost recovery including capital costs can be achieved. The pumping costs for the different irrigated crops are calculated on the basis of the different crop growth periods, as have been presented in the present report, and have been adjusted for these crops which are mainly grown in the dry season.

Labour costs are considered in the farm budget calculations by valuing the annual labour requirements with an average annual wage rate, representative for the Study Area: Daily wage rates for unskilled and semiskilled labour vary considerably, not only between the large scale projects and the various banana plantations but also between the different cropping seasons.

From July to March average rates amount to SoSh 80 per day while in the Gu season due to the peak labour demand average daily rates rise at about SoSh 200. Since the seasonal wage rates vary considerably it can be assumed that they represent realistically the opportunity costs of labour at the different times of the year. Based on the above figures an annual weighted average rate of SoSh 135/day is applied.

The application of these assumptions on the Agricultural Development Scenarios as outlined in APPENDIX 1 of this ANNEX lead to the calculation of crop- and farm budgets (see APPENDICES 2 and 3).

In addition to the calculation of income from crop production an attempt has been made to include the potential income from livestock production in the farm budget calculations.

The dry matter production on a typical model farm determines the carrying capacity on the cultivated farm area. It is assumed that present on-farm production of dry matter (see APPENDIX 3) represents only 2/3 of total dry matter intake, 1/3 being provided by grazing. The latter is expected to remain at least stable in absolute terms, taking into account the increasing land pressure in the future. The calculated number of Tropical Livestock Units (TLU) is broken down to the number of cattle and small ruminants. A herd of small ruminants is assumed to consist for 2/3 of goats and 1/3 of sheep. Based on the production parameters as outlined in ANNEX 2 the production value of meat and milk was calculated. A uniform milk price for goat and cow milk of SoSh 50 per liter was applied. Productivity increases, such as higher offtake rates, increased meat and milk production as a consequence of animal health improvements and the introduction of new breeds have been considered in the calculation.

APPENDIX 4 summarizes in detail the calculation for the different time horizons. An estimation of the production costs and labour requirements per animal is presented in Table 4, APPENDIX 4.

11.2 Labour Requirements

Agricultural labour requirements are presented per crop and per production cycle. In the Bardheere, Saakow and Bu'aale Districts labour requirements for the same crop are different between the Gu and Der seasons in rainfed crop production. This difference is caused mainly by the differences in rainfall between the two seasons (less rain in the Der season). In the Lower Juba valley rainfall figures are higher than for the Middle and Upper valley resulting in higher yields, but also in higher labour requirements, mainly due to a higher demand for weeding activities.

The decrease in labour requirements in irrigated crop production as of 1995 is the result of the assumed introduction of mechanized land preparation.

Details of labour requirements for the different farm operations (land preparation, planting, weeding etc.) are presented in APPENDIX 1. The data are presented for the three most important time horizons: present (1988), 1995 and the end of the planning period (2005).

In the financial analysis no distinction has been made between family and hired labour. However, in ANNEX 3 an in-depth analysis of family farm labour availability, in relation to overall farm labour requirements has been conducted.

From this report it also appears that for crop production activities, on average, 60 man-days per month are available (720 man-days per year).

Tables 11.2/1 and 11.2/2 present a summary of labour requirements for rainfed and irrigated crop production, respectively.

Total annual labour requirements are considered in the crop budget calculations (APPENDIX 2). The financial return per labour day allows a direct comparison of the relative profitability of individual crops with regard to different labour inputs.

Table 11.2/1: Labour Requirements in Rainfed Agriculture (in man-days per ha)

Crop	Present		1995		2005	
Bardheere/Saakow/Bu'aale	Gu	Der	Gu	Der	Gu	Der
Sorghum	56	51	57	53	61	57
Maize	58	53	59	54	64	58
Sesame	-	50	-	52	-	54
Beans	35	18	36	20	38	26
Jilib/Jamaame/Kismayo	Gu	Xagai	Gu	Xagai	Gu	Xagai
Maize	62	-	63	-	67	-
Beans	36	-	37	-	39	-
Groundnuts	68	-	71	-	81	-
Cotton	-	39	-	48	-	64
Sesame	-	55	-	56	-	58
Vegetables	92	-	93	-	104	-

Source: APPENDIX 1

Table 11.2/2: Labour Requirements in Irrigated Agriculture (in man-days per ha)

Crop	Present	1995 (1)	2005 (1)
Maize	71	56	63
Beans	41	30	32
Groundnuts	90	79	85
Cotton	-	55	71
Sesame	68	56	58
Tobacco	107	91	100
Onions	123	107	113
Vegetables	129	115	123
Watermelons	79	64	72

Source: APPENDIX 1
1) Lower figures for future time horizons indicate the introduction of mechanized land preparation.

11.3 Crop Budgets

In this section a comparison is presented between the financial returns from the major crops grown in the Study Area. The differences in returns are presented per season, and per district. A further distinction is made between rainfed and irrigated farming. In addition, the development of the returns per ha and per man-day is shown for the present, the before-dam and for the after-dam situation.

The results of the individual crop budget calculations (APPENDIX 2) are summarized in Tables 11.3/1, 11.3/2 and 11.3/3.

In the rainfed farming systems of Bardheere, Saakow and Bu'aale maize is presently the most profitable crop with regard to total returns per ha as well as per man-day. Sorghum follows as second best crop with only a minor difference. While beans show relatively low returns, they are competitive with regard to returns to labour in the Gu season. They are, however, still grown in the Der season, to cover the family's food requirements. Cultivation of sesame is attractive in the Der season, giving similar returns as maize and sorghum.

The projected increases in productivity do not affect the relative order of the crops. Although maize shows slight losses in the before-dam situation (1995), its economic attractiveness rises considerably in the after-dam situation. Therefore an expansion of the area cropped with maize to the debit of sorghum is expected after 1995. However, sorghum remains the major crop in this area, since it provides highest food security under the prevailing climatic conditions. Compared to other areas of the Juba valley absolute returns are lower due to unfavourable production conditions, i.e low and erratic rainfall.

In 1995 the net returns for maize and sorghum will be 20-30% higher, in 2005 even 60-110% higher compared to the present situation. Sesame and especially beans show increases about twice as high in the same period. These high growth rates are mainly possible as a result of the present very low productivity levels, and indicate the high growth potential in these areas under improved cultural practices.

Table 11.3/1: Comparison of Financial Returns in Rainfed Agriculture (in SoSh)
(Bardheere/Saakow/Bu'aale Districts)

Crop	Present		1995		2005	
	Gu	Der	Gu	Der	Gu	Der
Sorghum						
- net return	16,661	11,031	21,814	13,769	26,334	23,519
- return to labour	298	216	383	260	432	413
Maize						
- net return	17,859	11,849	20,693	14,683	34,100	22,188
- return to labour	308	224	351	272	533	383
Sesame						
- net return	-	10,248	-	15,443	-	19,198
- return to labour	-	205	-	297	-	356
Beans						
- net return	10,650	2,475	13,425	5,175	15,230	6,943
- return to labour	304	138	373	259	401	267

Source: APPENDIX 2, Tables 3, 4, 10, 11, 15, 17, 18.

Table 11.3/2: Comparison of Financial Returns in Rainfed Agriculture (in SoSh)
(Jilib/Jamaame/Kismayo Districts)

Crop	Present		1995		2005	
	Gu	Xagai	Gu	Xagai	Gu	Xagai
Maize						
- net return	35,775	-	41,728	-	48,963	-
- return to labour	577	-	662	-	731	-
Beans						
- net return	13,425	-	16,200	-	18,005	-
- return to labour	373	-	438	-	462	-
Groundnuts						
- net return	12,275	-	15,875	-	23,855	-
- return to labour	181	-	224	-	295	-
Cotton						
- net return	-	16,100	-	32,510	-	48,970
- return to labour	-	413	-	677	-	765
Sesame						
- net return	-	31,308	-	36,503	-	40,258
- return to labour	-	569	-	652	-	694
Vegetables						
- net return	44,400	-	66,900	-	110,120	-
- return to labour	483	-	719	-	1,059	-

Source: APPENDIX 2, Tables 2, 6, 8, 12, 16, 21.

Table 11.3/3: Comparison of Financial Returns in Irrigated Agriculture
(Gross margins in SoSh per ha and man-day, rsp.)

Crop	Present	1995	2005
Maize			
- net return	37,095	45,353	64,338
- return to labour	522	810	1,021
Beans			
- net return	14,260	17,035	21,615
- return to labour	348	568	675
Groundnuts			
- net return	24,820	31,855	52,920
- return to labour	276	403	623
Cotton			
- net return	-	23,945	66,055
- return to labour	-	435	930
Sesame			
- net return	26,943	36,703	45,723
- return to labour	396	655	788
Tobacco			
- net return	7,220	12,145	32,595
- return to labour	67	133	326
Onion			
- net return	310,820	346,920	494,870
- return to labour	2,527	3,242	4,379
Vegetables			
- net return	113,000	156,600	266,510
- return to labour	876	1,362	2,167
Watermelon			
- net return	69,660	78,710	144,910
- return to labour	882	1,230	2,013

Source: APPENDIX 2, Tables 1, 5, 7, 9, 13, 14, 19, 20, 22.

In Table 11.3/2 these differences become obvious, especially for maize and sesame. Apart from vegetables which are always highly profitable, maize dominates in the present situation and is highly competitive against all other crops. In the Xagai season cotton as a succession crop to maize is presently only of minor importance compared to sesame. This is also reflected by the higher net return, being twice as high than cotton.

The application of pesticides, as foreseen for the future will change this relation already in the before-dam situation resulting in an overproportional area increase compared to sesame. Sesame remains, however, a highly profitable crop and will even expand due to increased cropping intensities which are possible as a result of flood protection measures.

Compared with the Upper and Middle Juba River areas, the crops grown in Jilib, Jamaame and Kismayo districts show relatively smaller increases in their net returns (15-25% in 1995 and 35-90% in 2005). This is explained by the fact that present productivity levels are already higher partly due to higher rainfall. Cotton shows the highest increase in net return with 100% in 1995 and 200% in 2005, indicating its high response to better pest control measures and improved farm management.

In irrigated farming cultivation of onions shows the highest profitability. Even if future prices would fall by 50% as a result of overproduction, onions remain competitive. Other cash crops like vegetables and watermelons show also attractive returns (see Table 11.3/2).

Among the food crops maize is presently the most competitive crop. In the future its relative position remains the same with regard to return to labour, but absolute returns are lower than those of cotton.

Irrigated crops show growth rates of net returns of 17-30% in 1995 and 35-90% in 2005, and achieve the highest values in absolute terms. Compared with rainfed agriculture, where returns to labour show in all cases lower growth rates than the net returns, in irrigated agriculture the opposite situation can be found. Increases in returns to labour are at least twice as high as in the net returns and reflect the higher productivity potential in this farm type, and the results of the assumed introduction of mechanized land preparation as of 1995.

11.4 Farm Budgets

In order to understand the economic situation of farm families in the Study Area, for rainfed and irrigation production representative farm models have been selected and analyzed with regard to labour availability and income.

The large and medium-scale irrigation projects in the Study Area, producing sugar cane, rice and bananas are excluded from the agro-economic analysis, because emphasis was given to smallholder development in the Juba valley. With regard to the pending restructuring of these schemes into smallholder operated farms, separate analyses are required exceeding the given limitations of a Masterplan. Recently an appraisal of the Mogambo scheme has been undertaken by the German Bank for Reconstruction (KfW) of which the results were not available at the time of preparing Volume II of the Masterplan.

Based on the crop budgets as presented in APPENDIX 2, and the calculation of livestock income in APPENDIX 4, farm budgets have been set up according to present and future cropping patterns for rainfed and irrigated farms, located in different districts and farming on different soils.

Present cropping patterns harmonize very well with the relative economic profitability of the various crops and confirm the ability of small farmers to take rational economic decisions within a given framework, set by natural conditions, prices, labour and land availability, and the presence or the lack of production support services.

For the preparation of the future cropping patterns the expected manpower availability in the Study Area has been taken into consideration.

In the selection of crops for the future cropping patterns first priority has been given to cover the farm families' subsistence food requirements, and to contribute to national self-sufficiency in basic staple foods. Promotion of cash and export crops according to the countries national development objectives will be considered then.

The analysis of farm income concentrates on income generated by crop cultivation and potential livestock income, based on the carrying capacity of each farm size and model. Other sources of income such as earnings from off-farm employment have not been included. Additional benefits from livestock production, such as the increase of soil fertility (due to manure) or their potential for animal traction have not been valued. The value of crop residues as calculated in the crop budgets is not considered in the farm budget calculations, because in their double function as output from crop production and input for livestock production they compensate for each other.

The farm budget calculations do not pretend to present exact figures on farm income, but are meant to give a realistic illustration of their development potential in the different districts of the Study Area and to give an indication about the contribution of the different sectors (crop- and livestock production) to total farm income. These relative shares and their projected development facilitate for a decision about future agricultural development priorities and allow for their justification.

Four data are of major interest: the gross margin per farm and per man-day, the annual labour requirements and management income.

The gross margin per farm was calculated by deducting the total production costs from the total production value (gross output). The gross margin per man-day was calculated by dividing the gross margin per farm by the total labour requirements used according to the requirements calculated in the crop budgets of APPENDIX 2.

The management income was calculated by costing the total labour requirements at the rate which is paid, on average, for hired labour in the Study Area.

The farm budget calculations are presented in APPENDIX 3. Table 11.4/1 summarizes the results of the different farm budgets.

Table 11.4/1: Farm Income Development per Farm Type and District (in SoSh)

District/Farmtype	Time horizon			Increase in %		
	Present	1995	2005	Present	1995	2005
Rainfed agriculture:						
Bardheere/Saakow/Bu'aale (5 ha farm)						
- Gross margin/farm	145,883	186,954	269,948	100	128	185
- Labour requirement/year	565	568	592	100	101	105
- Return to labour	258	329	456	100	128	177
- Management income	69,676	110,301	190,021	100	158	273
Jilib/Jamaame/Kismayo (2.5 ha farm)						
- Gross margin/farm	82,761	129,176	187,635	100	156	227
- Labour requirement/year	162	219	264	100	135	163
- Return to labour	512	591	711	100	115	139
- Management income	60,944	99,667	151,993	100	164	249
Irrigated Agriculture:						
Levee Land (3 ha farm)						
- Gross margin/farm	757,345	843,452	956,788	100	111	126
- Labour requirement/year	595	510	539	100	86	91
- Return to labour	1,273	1,653	1,774	100	130	139
- Management income	677,040	774,568	883,989	100	114	131
Alluvial soils (3 ha farm)						
- Gross margin/farm	-	221,538	339,378	-	100	153
- Labour requirement/year	-	328	377	-	100	115
- Return to labour	-	676	900	-	100	133
- Management income	-	177,278	288,450	-	100	163

Source: APPENDIX 3

The per-hectare increase of farm incomes under rainfed conditions is higher than under irrigated conditions, where incomes in absolute terms per farm type exceed by far those in all the rainfed crop production areas, where farm incomes are around or below the estimated poverty line (1). The higher growth rates of rainfed farming incomes do not only reflect the present low productivity level in this farming system, but also indicate its growth potential, if adequate production support services are provided. As a result of the proposed development scenario for rainfed crop production the existing income gap between rainfed and irrigated farmers will be reduced and achieve more equity among the different districts.

In rainfed crop production in the Lower Juba (Jilib, Jamaame and Kismayo Districts) farm incomes are lowest, mainly the result of smaller farm sizes and of lower cropping intensities. Part of the household income in these Districts is acquired through off-farm employment (large-scale projects, banana farms, etc.). However according to the proposed development scenario for rainfed crop production in the Lower Juba area, income from farm activities will rise by more than 100% until the end of the planning period (2005). The expected increase in cropping intensity in the Lower Juba will strongly increase the labour requirement in this farm model. This will reduce the family labour available for off-farm employment.

On levee soils the income from irrigated agriculture is several times higher than that of rainfed agriculture. In this irrigated farm model present labour requirements will decrease in the future, due to the assumed introduction of mechanized land preparation as of 1995, resulting in increases in the returns to labour.

In irrigated crop production the income differences between the two farm models are mainly caused by differences in cropping patterns, which in turn are the result of different soil characteristics. The lighter soils of the levee lands are suitable for the production of high value crops such as onions, vegetables and watermelons. Although these crops have a much higher labour requirement than such crops as maize, cotton, sesame, etc. they provide for a return to labour which is still twice as high as that of the irrigated farm model based on maize cultivation.

Gross margins on levee soils irrigated crop production are about three times as high as on vertisol irrigated crop production. The gross margin of a vertisol 3 ha farm (SoSh 221,500 and SoSh 339,300 in 1995 and 2005, respectively) is well above an estimated poverty line for rural areas set at SoSh 156,700 per household and year (= SoSh 2,300/capita/month).

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1) In the absence of official data an attempt was made to estimate a poverty line on the basis of a desirable energy intake of 2,200 kcal per capita and day, as recommended by FAO/WHO. To calculate the cost of an average food basket 1986 Mogadishu retail prices were applied and updated to 1987 prices with the Mogadishu consumer price index for food (see APPENDIX 5). While no reliable information about urban/rural price differentials was available a price deduction of 20% for rural areas was applied. For non-food items a rate of 30% of total food basket value was added to arrive at a probable poverty line for farmers (SoSh 156,700/household/year).

Therefore, when the deshek conversion programme is to be initiated, it may well be considered that the irrigated farm models to be developed for levee soils should be based on 1 ha farms, thus permitting more families to farm on levee soils, and still allowing them an acceptable income.

The projected increases in annual labour requirements on the different farm models do not exceed the amount of annual labour, available within the farm families. However, at times of peak labour demand the employment of hired labour may become necessary.

In all farm models, at any time horizon, returns to labour exceed the average annual wage rate of SoSh 135 per day.

Analyzing the composition of farm incomes, the high proportion from livestock production becomes apparent.

Table 11.4/2: Gross Margins from Livestock Production and Percentage of Total Gross Margin per Farm

District/Farmtype	Present		1995		2005	
	SoSh	%	SoSh	%	SoSh	%
Rainfed agriculture:						
Bardheere/Saakow/Bu'aale	66,548	46	86,907	46	139,447	52
Jilib/Jamaame/Kismayo	27,928	34	34,013	26	48,753	26
Irrigated agriculture:						
Levee land	46,861	6	58,360	7	84,950	9
Alluvial soils	-	-	88,587	40	123,306	36

Source: APPENDIX 3 and 4

Presently potential livestock income would account for 25 to 50% of total farm income under rainfed conditions while in irrigated agriculture on levee soils its income contribution ranges below 10%. Future projections foresee a stable income proportion in Bardheere, Saakow and Bu'aale districts, while in the areas of Jilib, Jamaame and Kismayo declining shares are expected due to the productivity increases in crop production.

After 1995 the assumed farm models set up on vertisols show with 40% also a high share of livestock income which is expected to decline due to productivity increases in crop production.

With the exception of irrigated levee land these figures underline not only the economic importance of livestock production for the farmers in the Study Area, but support a policy to promote the integration of crop and livestock production and justify further research activities in these fields. From a regional point of view priority should be given to rainfed areas, especially in the Upper Juba valley due to its high contribution in securing subsistence needs with high quality food items (milk, meat).

APPENDIX 1

Agricultural Development Scenarios

Table 1: Development Scenarios for Beans - Irrigated

Crop:	Beans intercropped with maize
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0,8	0,9	1,1
	By-products (t/ha)	0,2	0,9	1,1
Inputs:	Seed (kg/ha)	12	12	12
	Fertilizer (kg unit/ha)			
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	13	4	4
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d) (2)	10	8	8
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)			
	Pest control (m-d)	0	0	1
	Harvest (m-d)	8	8	9
	Transport (m-d)	1	1	1
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	58	58	58
Summary:	Man-days	41	30	32
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
2) In addition to requirements of maize
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 2: Development Scenarios for Beans - Dryland

Crop:	Beans intercropped with maize
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Jilib/Jamaame/Kismayo
Applicable in season(s):	Gu

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.5	0.6	0.7
	By-products (t/ha)	0.5	0.6	0.7
Inputs:	Seed (kg/ha)	12	12	12
	Fertilizer (kg unit/ha)			
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	13	13
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	9	9	9
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)			
	Pest control (m-d)	0	0	1
	Harvest (m-d)	8	8	9
	Transport (m-d)	1	1	1
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	36	37	39
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
2) In addition to requirements of maize
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 3: Development Scenarios for Beans - Dryland - Gu

Crop:	Beans intercropped with sorghum
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Bardheere/Saakow/Bu'aale
Applicable in season(s):	Gu

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.4	0.5	0.6
	By-products (t/ha)	0.4	0.5	0.6
Inputs:	Seed (kg/ha)	12	12	12
	Fertilizer (kg unit/ha)			
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	13	13
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	9	9	9
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)			
	Pest control (m-d)	0	0	1
	Harvest (m-d)	7	7	8
	Transport (m-d)	1	1	1
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	35	36	38
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
2) In addition to requirements of sorghum
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 4: Development Scenarios for Beans - Dryland - Der

Crop:	Beans intercropped with sorghum
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Bardheere/Saakow/Bu'aale
Applicable in season(s):	Der

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.1	0.2	0.3
	By-products (t/ha)	0.1	0.2	0.3
Inputs:	Seed (kg/ha)	8	10	11
	Fertilizer (kg unit/ha)			
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	7	8	9
	Planting (m-d)	3	4	6
	(a-d)			
	Weeding (m-d)	5	5	7
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)			
	Pest control (m-d)	0	0	1
	Harvest (m-d)	2	2	2
	Transport (m-d)	1	1	1
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	18	20	26
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
2) In addition to requirements of sorghum
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 5: Development Scenarios for Cotton - Irrigated

Crop:	Cotton, succession crop to maize
Farm type:	Irrigated
Tractor use:	Yes (for maize)
Applicable in districts:	All
Applicable in season(s):	Gu

Planning horizon		P	W(1)	W(2)
Yield:	Seed cotton (t/ha)	-	0.9	1.9
	By-products (t/ha)			
Inputs:	Seed (kg/ha)	-	23	25
	Fertilizer (kg unit/ha)	-	10	20
	Pesticide (1)	-	2	5
	Land preparation (T-hr)			
	(m-d)			
	Planting (m-d)	-	4	4
	(a-d)			
	Weeding (m-d)	-	28	31
	(a-d)			
	Irrigation (m-d)	-	3	3
	Fertilizing (m-d)	-	1	1
	Pest control (m-d)	-	2	5
	Harvest (m-d)	-	12	21
	Transport (m-d)	-	2	3
	Irrigation system maintenance (m-d)	-	3	3
	Pumping (hrs)	-	98	98
Summary:	Man-days	-	55	71
	Animal-days	-	0	0
	Tractor-hours	-	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 6: Development Scenarios for Cotton - Dryland

Crop:	Cotton, succession crop to maize
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Jilib/Jamaame/Kismayo
Applicable in season(s):	Gu/Xagai

Planning horizon		P	W(1)	W(2)
Yield:	Seed cotton (t/ha)	0.4	0.8	1.2
	By-products (t/ha)			
Inputs:	Seed (kg/ha)	20	23	25
	Fertilizer (kg unit/ha)	0	10	20
	Pesticide (1)	0	2	5
	Land preparation (T-hr)			
	(m-d)			
	Planting (m-d)	4	4	4
	(a-d)			
	Weeding (m-d)	25	27	30
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	1	1
	Pest control (m-d)	0	2	5
	Harvest (m-d)	8	12	21
	Transport (m-d)	2	2	3
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	39	48	64
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 7: Development Scenarios for Groundnuts - Irrigated

Crop:	Groundnuts
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha) (1)	0.8	1.0	1.5
	By-products (t/ha)	0.4	0.5	0.8
Inputs:	Seed (kg/ha)	20	30	30
	Fertilizer (kg unit/ha)	0	10	20
	Pesticide (2)	0	0	1
	Land preparation (T-hr)	0	1	1
	(m-d)	16	5	5
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	26	23	25
	(a-d)			
	Irrigation (m-d)	4	4	4
	Fertilizing (m-d)	0	1	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	32	34	36
	Transport (m-d)	3	3	4
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	74	74	74
Summary:	Man-days	90	79	85
	Animal-days	0	0	0
	Tractor-hours	0	1	1

1) unshelled
2) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table B: Development Scenarios for Groundnuts - Dryland

Crop:	Groundnuts			
Farm type:	Dryland			
Tractor use:	No			
Applicable in districts:	Jilib/Jamaame/Kismayo			
Applicable in season(s):	Gu/Xagai			
Planning horizon		**P**	**W(1)**	**W(2)**
Yield:	Main product (t/ha) (1)	0.3	0.4	0.6
	By-product (t/ha)	0.2	0.2	0.3
Inputs:	Seed (kg/ha)	20	30	30
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (2)	0	0	1
	Land preparation (T-hr)			
	(m-d)	14	15	15
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d) (2)	22	23	25
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	24	25	30
	Transport (m-d)	2	2	3
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	68	71	81
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) unshelled
2) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 9: Development Scenarios for Maize - Irrigated

Crop:	Maize
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	Gu

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	1.6	1.9	2.6
	By-product (t/ha)	4.8	5.7	7.8
Inputs:	Seed (kg/ha)	10	12	12
	Fertilizer (kg unit/ha)	0	0	20
	Pesticide (1)	0	0	1
	Land preparation (T-hr)	0	1	1
	(m-d)	13	4	4
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	29	23	26
	(a-d)			
	Irrigation (m-d)	3	3	3
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest + threshing (m-d)	14	14	15
	Transport (m-d)	3	3	4
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	82	82	82
Summary:	Man-days	71	56	63
	Animal-days	0	0	0
	Tractor-hours	0	1	1

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 10: Development Scenarios for Maize - Dryland - Gu

Crop: Maize
Farm type: Dryland
Tractor use: No
Applicable in districts: Bardheere/Saakow/Bu'aale
Applicable in season(s): Gu

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.6	0.7	1.2
	By-product (t/ha)	1.8	2.1	3.6
Inputs:	Seed (kg/ha)	6	12	12
	Fertilizer (kg unit/ha)	0	0	12
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	13	13
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	25	25	26
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest + threshing (m-d)	13	13	14
	Transport (m-d)	2	2	3
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	58	59	64
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 11: Development Scenarios for Maize - Dryland - Der

Crop:	Maize
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Bardheere/Saakow/Bu'aale
Applicable in season(s):	Der

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.4	0.5	0.8
	By-product (t/ha)	1.2	1.5	2.4
Inputs:	Seed (kg/ha)	6	12	12
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	11	12	12
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	22	22	23
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest + threshing (m-d)	12	12	13
	Transport (m-d)	2	2	2
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	53	54	58
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 12: Development Scenarios for Maize - Dryland - Gu

Crop:	Maize
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Jilib/Jamaame/Kismayo
Applicable in season(s):	Gu

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	1.2	1.4	1.7
	By-product (t/ha)	3.6	4.2	5.1
Inputs:	Seed (kg/ha)	10	12	12
	Fertilizer (kg unit/ha)	0	0	15
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	13	13
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	27	27	28
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest + threshing (m-d)	14	14	15
	Transport (m-d)	3	3	3
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	62	63	67
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 13: Development Scenarios for Onions

Crop:	Onions			
Farm type:	Irrigated			
Tractor use:	Yes			
Applicable in districts:	All			
Applicable in season(s):	All			
Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	9.0	10.0	14.0
	By-product (t/ha)			
Inputs:	Seed (kg/ha)	0.2	0.2	0.2
	Fertilizer (kg unit/ha)	0	0	20
	Pesticide (1)	0	0	1
	Land preparation (T-hr)	0	2	2
	(m-d)	17	5	5
	Planting (m-d) (2)	40	40	40
	(a-d)			
	Weeding (m-d)	36	32	34
	(a-d)			
	Irrigation (m-d)	10	10	10
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	14	14	15
	Transport (m-d)	3	3	4
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	197	197	197
Summary:	Man-days	123	107	113
	Animal-days	0	0	0
	Tractor-hours	0	2	2

1) Expressed as equivalent to kg Basudin 10%
2) Including care of nursery.
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 14: Development Scenarios for Sesame - Irrigated

Crop:	Sesame
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	Der

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.7	0.9	1.1
	By-product (t/ha)	1.4	1.8	2.2
Inputs:	Seed (kg/ha)	4	5	5
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (1)	0	0	1
	Land preparation (T-hr)	0	1	1
	(m-d)	13	4	4
	Planting (m-d)	4	6	6
	(a-d)			
	Weeding (m-d)	35	30	30
	(a-d)			
	Irrigation (m-d)	3	3	3
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	8	8	8
	Transport (m-d)	2	2	2
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	74	74	74
Summary:	Man-days	68	56	58
	Animal-days	0	0	0
	Tractor-hours	0	1	1

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 15: Development Scenarios for Sesame - Dryland - Der

Crop:	Sesame			
Farm type:	Dryland			
Tractor use:	No			
Applicable in districts:	Bardheere/Saakow/Bu'aale			
Applicable in season(s):	Der			

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.2	0.3	0.4
	By-product (t/ha)	0.4	0.6	0.8
Inputs:	Seed (kg/ha)	4	5	5
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	11	12	12
	Planting (m-d)	4	5	5
	(a-d)			
	Weeding (m-d)	27	27	27
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	7	7	7
	Transport (m-d)	1	1	1
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	50	52	54
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 16: Development Scenarios for Sesame - Dryland - Gu

Crop:	Sesame
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Jilib/Jamaame/Kismayo
Applicable in season(s):	Gu/Xagai

Planning horizon		P	W(1)	W(2)
Yield:	Main-product (t/ha)	0.6	0.7	0.8
	By-product (t/ha)	1.2	1.4	1.6
Inputs:	Seed (kg/ha)	4	5	5
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	12	12
	Planting (m-d)	4	5	5
	(a-d)			
	Weeding (m-d)	30	30	30
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	7	7	7
	Transport (m-d)	2	2	2
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	55	56	58
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 17: Development Scenarios for Sorghum - Dryland - Gu

Crop:	Sorghum			
Farm type:	Dryland			
Tractor use:	No			
Applicable in districts:	Bardheere/Saakow/Bu'aale			
Applicable in season(s):	Gu			

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.60	0.75	1.00
	By-product (t/ha)	1.8	2.3	3.0
Inputs:	Seed (kg/ha)	9	12	12
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	13	13
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	20	20	21
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest + threshing (m-d)	16	16	17
	Transport (m-d)	2	2	2
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	56	57	61
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 18: Development Scenarios for Sorghum - Dryland - Der

Crop:	Sorghum
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Bardheere/Saakow/Bu'aale
Applicable in season(s):	Der

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.4	0.5	0.9
	By-product (t/ha)	1.2	1.5	2.7
Inputs:	Seed (kg/ha)	9	12	12
	Fertilizer (kg unit/ha)	0	0	10
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	12	13	13
	Planting (m-d)	6	6	6
	(a-d)			
	Weeding (m-d)	16	16	17
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest + threshing (m-d)	15	16	17
	Transport (m-d)	2	2	2
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	51	53	57
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 19: Development Scenarios for Tobacco

Crop:	Tobacco
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	0.4	0.5	0.9
	By-product (t/ha)			
Inputs:	Seed (kg/ha)	0.1	0.1	0.1
	Fertilizer (kg unit/ha)	0	0	20
	Pesticide (1)	0	0	1
	Land preparation (T-hr)	0	1	1
	(a-d)	16	4	4
	Planting (m-d) (2)	30	30	30
	(a-d)			
	Weeding (m-d)	30	26	28
	(a-d)			
	Irrigation (m-d)	4	4	4
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	20	20	24
	Transport (m-d)	4	4	5
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	115	115	115
Summary:	Man-days	107	91	100
	Animal-days	0	0	0
	Tractor-hours	0	1	1

1) Expressed as equivalent to kg Basudin 10%
2) Includes care of nursery
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 20: Development Scenarios for Vegetables (Tomatoes) - Irrigated

Crop:	Vegetables (tomatoes)
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	6.0	8.0	13.0
	By-product (t/ha)			
Inputs:	Seed (kg/ha)	0.2	0.2	0.2
	Fertilizer (kg unit/ha)	0	0	30
	Pesticide (1)	0	0	1
	Land preparation (T-hr)	0	2	2
	(m-d)	15	4	4
	Planting (m-d) (2)	40	40	40
	(a-d)			
	Weeding (m-d)	33	30	32
	(a-d)			
	Irrigation (m-d)	4	4	4
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	30	30	33
	Transport (m-d)	4	4	5
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	164	164	164
Summary:	Man-days	129	115	123
	Animal-days	0	0	0
	Tractor-hours	0	2	2

1) Expressed as equivalent to kg Basudin 10%
2) Includes care of nursery
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 21: Development Scenarios for Vegetables (Tomatoes) - Dryland

Crop:	Vegetables (tomatoes)
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	Jilib/Jamaame/Kismayo
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Main product (t/ha)	2.0	3.0	5.0
	By-product (t/ha)			
Inputs:	Seed (kg/ha)	0.2	0.2	0.2
	Fertilizer (kg unit/ha)	0	0	15
	Pesticide (1)	0	0	1
	Land preparation (T-hr)			
	(m-d)	15	16	16
	Planting (m-d) (2)	30	30	33
	(a-d)			
	Weeding (m-d)	30	30	30
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	15	15	20
	Transport (m-d)	2	2	3
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	92	93	104
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Expressed as equivalent to kg Basudin 10%
2) Includes care of nursery
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 22: Development Scenarios for Watermelons

Crop:	Watermelons			
Farm type:	Irrigated			
Tractor use:	Yes			
Applicable in districts:	All			
Applicable in season(s):	All			

Planning horizon		P	W(1)	W(2)
Yield:	Main products (t/ha)	10.0	11.0	18.0
	By-products (t/ha)			
Inputs:	Seed (kg/ha)	3	3	3
	Fertilizer (kg unit/ha)	0	0	20
	Pesticide (1)	0	0	1
	Land preparation (T-hr)	0	1	1
	(m-d)	15	4	4
	Planting (m-d)	4	4	4
	(a-d)			
	Weeding (m-d)	30	26	26
	(a-d)			
	Irrigation (m-d)	3	3	3
	Fertilizing (m-d)	0	0	1
	Pest control (m-d)	0	0	1
	Harvest (m-d)	20	20	25
	Transport (m-d)	4	4	5
	Irrigation system maintenance (m-d)	3	3	3
	Pumping (hrs)	98	98	98
Summary:	Man-days	79	64	72
	Animal-days	0	0	0
	Tractor-hours	0	1	1

1) Expressed as equivalent to kg Basudin 10%
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 23: Development Scenarios for Alfalfa

Crop:	Alfalfa (Var. Hunter River) - 3 years
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Forage (t DM/ha)	0.0	8.0	10.0
Inputs: (1)	Seed (kg/ha)	0	20	20
	Fertilizer (kg unit/ha)	0	10	20
	Pesticide			
	Land preparation (T-hr)	0	2	2
	(m-d)	0	7	7
	Planting (m-d) (2)	0	1	1
	(a-d)			
	Weeding (m-d)	0	15	15
	(a-d)			
	Irrigation (m-d)	0	6	6
	Fertilizing (m-d)	0	1	1
	Pest control (m-d)			
	Harvest (m-d) (3)	0	100	120
	Transport (m-d)			
	Irrigation system maintenance (m-d)	0	3	3
	Pumping (hrs)	0	300	300
Summary:	Man-days	0	133	153
	Animal-days	0	0	0
	Tractor-hours	0	2	2

1) Inputs for land preparation and planting refer to year 1 only.
2) Hand broadcasting
3) Controlled grazing if irrigation scheme allows access otherwise DM statet for 4 cuts a year.
DM = dry matter
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 24: Development Scenarios for Leucaena

Crop:	Leucaena - 10 years
Farm type:	Dryland
Tractor use:	No
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Forage (t DM/ha)	0.0	8.0	10.0
Inputs: (1)	Seed (kg/ha)	0	5	5
	Fertilizer (kg unit/ha)			
	Pesticide			
	Land preparation (T-hr)			
	(m-d) (2)	0	8	8
	Planting (m-d) (3)	0	60	60
	(a-d)			
	Weeding (m-d)	0	10	10
	(a-d)			
	Irrigation (m-d)			
	Fertilizing (m-d)			
	Pest control (m-d)			
	Harvest (m-d) (3)	0	15	18
	Transport (m-d)	0	4	5
	Irrigation system maintenance (m-d)			
	Pumping (hrs)			
Summary:	Man-days	0	97	101
	Animal-days	0	0	0
	Tractor-hours	0	0	0

1) Inputs for land preparation and planting refer to year 1 only.
2) Including care of nursery.
3) Digging holes for seedlings.
DM = dry matter
P = present situation
W(1) = situation before dam
W(2) = situation after dam

Table 25: Development Scenarios for Fodder Maize

Crop:	Fodder maize
Farm type:	Irrigated
Tractor use:	Yes
Applicable in districts:	All
Applicable in season(s):	All

Planning horizon		P	W(1)	W(2)
Yield:	Dry matter (t DM/ha)	0.0	5.0	8.0
Inputs:	Seed (kg/ha)	0	25	25
	Fertilizer (kg unit/ha)	0	20	40
	Pesticide			
	Land preparation (T-hr)	0	1	1
	(m-d)	0	4	4
	Planting (m-d)	0	7	7
	(a-d)			
	Weeding (m-d)	0	15	17
	(a-d)			
	Irrigation (m-d)	0	3	3
	Fertilizing (m-d)	0	1	2
	Pest control (m-d)			
	Harvest (m-d)	0	20	20
	Transport (m-d)	0	6	9
	Irrigation system maintenance (m-d)	0	3	3
	Pumping (hrs)	0	66	66
Summary:	Man-days	0	59	65
	Animal-days	0	0	0
	Tractor-hours	0	1	1

DM = dry matter
P = present situation
W(1) = situation before dam
W(2) = situation after dam

APPENDIX 2

Crop Budgets

Table 1: Crop Budgets for Beans Intercropped with Maize

Farm type:	Irrigated
Tractor use:	Yes (in maize)
District(s):	All
Season:	All

Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	800	900	1,100
On-farm losses	kg/ha	40	45	55
Net Production	kg/ha	760	855	1,045
Farmgate price	SoSh/kg	25	25	25
Net production value	SoSh	19,000	21,375	26,125
By-products	kg/ha	800	900	1,100
Value	SoSh	3,200	3,600	4,400
Total production value	SoSh	22,200	24,975	30,525
Variable costs:				
Land preparation	SoSh	0	0	0
Seed	kg/ha	12	12	12
Value	SoSh	450	450	450
Fertilizer	kg/ha	0	0	0
Value	SoSh	0	0	0
Pesticide	SoSh	0	0	970
Pumping	SoSh	7,490	7,490	7,490
Total costs	SoSh	7,940	7,940	8,910
Labour requirements	man-days	41	30	32
Gross margin:				
- per ha	SoSh/ha	14,260	17,035	21,615
- per man-day	SoSh/m-d	348	568	675

Source: APPENDIX 1, Table 1

Table 2: Crop Budgets for Beans Intercropped with Maize

Farm type:	Dryland
Tractor use:	No
District(s):	Jilib/Jamaame/Kismayo
Season:	Gu

Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	500	600	700
On-farm losses	kg/ha	25	30	35
Net Production	kg/ha	475	570	665
Farmgate price	SoSh/kg	25	25	25
Net production value	SoSh	11,875	14,250	16,625
By-products	kg/ha	500	600	700
Value	SoSh	2,000	2,400	2,800
Total production value	SoSh	13,875	16,650	19,425
Variable costs:				
Land preparation	SoSh	0	0	0
Seed	kg/ha	12	12	12
Value	SoSh	450	450	450
Fertilizer	kg/ha	0	0	0
Value	SoSh	0	0	0
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	450	450	1,420
Labour requirements	man-days	36	37	39
Gross margin:				
- per ha	SoSh/ha	13,425	16,200	18,005
- per man-day	SoSh/m-d	373	438	462

Source: APPENDIX 1, Table 2

Table 3: Crop Budgets for Beans Intercropped with Sorghum - Gu

Farm type:	Dryland			
Tractor use:	No			
District(s):	Bardheere/Saakow/Bu'aale			
Season:	Gu			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	400	500	600
On-farm losses	kg/ha	20	25	30
Net Production	kg/ha	380	475	570
Farmgate price	SoSh/kg	25	25	25
Net production value	SoSh	9,500	11,875	14,250
By-products	kg/ha	400	500	600
Value	SoSh	1,600	2,000	2,400
Total production value	SoSh	11,100	13,875	16,650
Variable costs:				
Land preparation	SoSh	0	0	0
Seed	kg/ha	12	12	12
Value	SoSh	450	450	450
Fertilizer	kg/ha	0	0	0
Value	SoSh	0	0	0
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	450	450	1,420
Labour requirements	man-days	35	36	38
Gross margin:				
- per ha	SoSh/ha	10,650	13,425	15,230
- per man-day	SoSh/m-d	304	373	401

Source: APPENDIX 1, Table 3

Table 4: Crop Budgets for Beans Intercropped with Sorghum - Der

Farm type:	Dryland
Tractor use:	No
District(s):	Bardheere/Saakow/Bu'aale
Season:	Der

Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	100	200	300
On-farm losses	kg/ha	5	10	15
Net Production	kg/ha	95	190	285
Farmgate price	SoSh/kg	25	25	25
Net production value	SoSh	2,375	4,750	7,125
By-products	kg/ha	100	200	300
Value	SoSh	400	800	1,200
Total production value	SoSh	2,775	5,550	8,325
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	8	10	11
Value	SoSh	300	375	413
Fertilizer	kg/ha	0	0	0
Value	SoSh	0	0	0
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	300	375	1,383
Labour requirements	man-days	18	20	26
Gross margin:				
- per ha	SoSh/ha	2,475	5,175	6,943
- per man-day	SoSh/m-d	138	259	267

Source: APPENDIX 1, Table 4

Table 5: Crop Budgets for Cotton, Succession Crop to Maize - Irrigated

Farm type:	Irrigated
Tractor use:	Yes (for maize)
District(s):	All
Season:	Gu

Time horizon:		P	W(1)	W(2)
Item	**Unit**			
Production:				
Gross production	kg/ha	0	900	1,900
On-farm losses	kg/ha	0	45	95
Net Production	kg/ha	0	855	1,805
Farmgate price	SoSh/kg	0	45	45
Net production value	SoSh	0	38,475	81,225
By-products	kg/ha	0	0	0
Value	SoSh	0	0	0
Total production value	SoSh	0	38,475	81,225
Variable costs:				
Land preparation	SoSh	0	0	0
Seed	kg/ha	0	23	25
Value	SoSh	0	1,150	1,250
Fertilizer	kg/ha	0	10	20
Value	SoSh	0	540	1,080
Pesticide	SoSh	0	0	0
Pumping	SoSh	0	12,840	12,840
Total costs	SoSh	0	14,530	15,170
Labour requirements	man-days	0	55	71
Gross margin:				
- per ha	SoSh/ha	-	23,945	66,055
- per man-day	SoSh/m-d	-	435	930

Source: APPENDIX 1, Table 5

Table 6: Crop Budgets for Cotton, Succession Crop to Maize - Dryland

Farm type:	Dryland			
Tractor use:	Yes (for maize)			
District(s):	Jilib/Jamaame/Kismayo			
Season:	Gu			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	400	800	1,200
On-farm losses	kg/ha	20	40	60
Net Production	kg/ha	380	760	1,140
Farmgate price	SoSh/kg	45	45	45
Net production value	SoSh	17,100	34,200	51,300
By-products	kg/ha	0	0	0
Value	SoSh	0	0	0
Total production value	SoSh	17,100	34,200	51,300
Variable costs:				
Land preparation	SoSh	0	0	0
Seed	kg/ha	20	23	25
Value	SoSh	1,000	1,150	1,250
Fertilizer	kg/ha	0	10	20
Value	SoSh	0	540	1,080
Pesticide	SoSh	0	0	0
Pumping	SoSh	0	0	0
Total costs	SoSh	1,000	1,690	2,330
Labour requirements	man-days	39	48	64
Gross margin:				
- per ha	SoSh/ha	16,100	32,510	48,970
- per man-day	SoSh/m-d	413	677	765

Source: APPENDIX 1, Table 6

Table 7: Crop Budgets for Groundnuts - Irrigated

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	800	1,000	1,500
On-farm losses	kg/ha	40	50	75
Net Production	kg/ha	760	950	1,425
Farmgate price	SoSh/kg	45	45	45
Net production value	SoSh	34,200	42,750	64,125
By-products	kg/ha	400	500	800
Value	SoSh	1,600	2,000	3,200
Total production value	SoSh	35,800	44,750	67,325
Variable costs:				
Land preparation	SoSh	0	700	700
Seed	kg/ha	20	30	30
Value	SoSh	1,350	2,025	2,025
Fertilizer	kg/ha	0	10	20
Value	SoSh	0	540	1,080
Pesticide	SoSh	0	0	970
Pumping	SoSh	9,630	9,630	9,630
Total costs	SoSh	10,980	12,895	14,405
Labour requirements	man-days	90	79	85
Gross margin:				
- per ha	SoSh/ha	24,820	31,855	52,920
- per man-day	SoSh/m-d	276	403	623

Source: APPENDIX 1, Table 7

Table 8: Crop Budgets for Groundnuts - Dryland

Farm type:	Dryland			
Tractor use:	No			
District(s):	Jilib/Jamaame/Kismayo			
Season:	Gu/Xagai			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	300	400	600
On-farm losses	kg/ha	15	20	30
Net Production	kg/ha	285	380	570
Farmgate price	SoSh/kg	45	45	45
Net production value	SoSh	12,825	17,100	25,650
By-products	kg/ha	200	200	300
Value	SoSh	800	800	1,200
Total production value	SoSh	13,625	17,900	26,850
Variable costs:				
Land preparation	SoSh	0	0	0
Seed	kg/ha	20	30	30
Value	SoSh	1,350	2,025	2,025
Fertilizer	kg/ha	0	0	0
Value	SoSh	0	0	0
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	1,350	2,025	2,995
Labour requirements	man-days	68	71	81
Gross margin:				
- per ha	SoSh/ha	12,275	15,875	23,855
- per man-day	SoSh/m-d	181	224	295

Source: APPENDIX 1, Table 8

Table 9: Crop Budgets for Maize - Irrigated

Farm type:	Irrigated
Tractor use:	Yes
District(s):	All
Season:	All

Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	1,600	1,900	2,600
On-farm losses	kg/ha	80	95	130
Net Production	kg/ha	1,520	1,805	2,470
Farmgate price	SoSh/kg	19	19	19
Net production value	SoSh	28,880	34,295	46,930
By-products	kg/ha	4,800	5,700	7,800
Value	SoSh	19,200	22,800	31,200
Total production value	SoSh	48,080	57,095	78,130
Variable costs:				
Land preparation	SoSh	0	700	700
Seed	kg/ha	10	12	12
Value	SoSh	285	342	342
Fertilizer	kg/ha	0	0	20
Value	SoSh	0	0	1,080
Pesticide	SoSh	0	0	970
Pumping	SoSh	10,700	10,700	10,700
Total costs	SoSh	10,985	11,742	13,792
Labour requirements	man-days	71	56	63
Gross margin:				
- per ha	SoSh/ha	37,095	45,353	64,338
- per man-day	SoSh/m-d	522	810	1,021

Source: APPENDIX 1, Table 9

Table 10: Crop Budgets for Maize - Dryland - Gu

Farm type:	Dryland			
Tractor use:	No			
District(s):	Bardheere/Saakow/Bu'aale			
Season:	Gu			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	600	700	1,200
On-farm losses	kg/ha	30	35	60
Net Production	kg/ha	570	665	1,140
Farmgate price	SoSh/kg	19	19	19
Net production value	SoSh	10,830	12,635	21,660
By-products	kg/ha	1,800	2,100	3,600
Value	SoSh	7,200	8,400	14,400
Total production value	SoSh	18,030	21,035	36,060
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	6	12	12
Value	SoSh	171	342	342
Fertilizer	kg/ha	0	0	12
Value	SoSh	0	0	648
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	171	342	1,960
Labour requirements	man-days	58	59	64
Gross margin:				
- per ha	SoSh/ha	17,859	20,693	34,100
- per man-day	SoSh/m-d	308	351	533

Source: APPENDIX 1, Table 10

Table 11: Crop Budgets for Maize - Dryland - Der

Farm type:	Dryland			
Tractor use:	No			
District(s):	Bardheere/Saakow/Bu'aale			
Season:	Der			

Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	400	500	800
On-farm losses	kg/ha	20	25	40
Net Production	kg/ha	380	475	760
Farmgate price	SoSh/kg	19	19	19
Net production value	SoSh	7,220	9,025	14,440
By-products	kg/ha	1,200	1,500	2,400
Value	SoSh	4,800	6,000	9,600
Total production value	SoSh	12,020	15,025	24,040
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	6	12	12
Value	SoSh	171	342	342
Fertilizer	kg/ha	0	0	10
Value	SoSh	0	0	540
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	171	342	1,852
Labour requirements	man-days	53	54	58
Gross margin:				
- per ha	SoSh/ha	11,849	14,683	22,188
- per man-day	SoSh/m-d	224	272	383

Source: APPENDIX 1, Table 11

Table 12: Crop Budgets for Maize - Dryland - Gu

Farm type:	Dryland			
Tractor use:	No			
District(s):	Jilib/Jamaame/Kismayo			
Season:	Gu			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	1,200	1,400	1,700
On-farm losses	kg/ha	60	70	85
Net Production	kg/ha	1,140	1,330	1,615
Farmgate price	SoSh/kg	19	19	19
Net production value	SoSh	21,660	25,270	30,685
By-products	kg/ha	3,600	4,200	5,100
Value	SoSh	14,400	16,800	20,400
Total production value	SoSh	36,060	42,070	51,085
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	10	12	12
Value	SoSh	285	342	342
Fertilizer	kg/ha	0	0	15
Value	SoSh	0	0	810
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	285	342	2,122
Labour requirements	man-days	62	63	67
Gross margin:				
- per ha	SoSh/ha	35,775	41,728	48,963
- per man-day	SoSh/m-d	577	662	731

Source: APPENDIX 1, Table 12

Table 13: Crop Budgets for Onions

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	9,000	10,000	14,000
On-farm losses	kg/ha	2,250	2,500	3,500
Net Production	kg/ha	6,750	7,500	10,500
Farmgate price	SoSh/kg	50	50	50
Net production value	SoSh	337,500	375,000	525,000
By-products	kg/ha			
Value	SoSh			
Total production value	SoSh	337,500	375,000	525,000
Variable costs:				
Land preparation	SoSh	0	1,400	1,400
Seed	kg/ha	0.2	0.2	0.2
Value	SoSh	1,000	1,000	1,000
Fertilizer	kg/ha	0	0	20
Value	SoSh	0	0	1,080
Pesticide	SoSh	0	0	970
Pumping	SoSh	25,680	25,680	25,680
Total costs	SoSh	26,680	28,080	30,130
Labour requirements	man-days	123	107	113
Gross margin:				
- per ha	SoSh/ha	310,820	346,920	494,870
- per man-day	SoSh/m-d	2,527	3,242	4,379

Source: APPENDIX 1, Table 13

Table 14: Crop Budgets for Sesame - Irrigated

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	Der			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	700	900	1,100
On-farm losses	kg/ha	35	45	55
Net Production	kg/ha	665	855	1,045
Farmgate price	SoSh/kg	47	47	47
Net production value	SoSh	31,255	40,185	49,115
By-products	kg/ha	1,400	1,800	2,200
Value	SoSh	5,600	7,200	8,800
Total production value	SoSh	36,855	47,385	57,915
Variable costs:				
Land preparation	SoSh	0	700	700
Seed	kg/ha	4	5	5
Value	SoSh	282	353	353
Fertilizer	kg/ha	0	0	10
Value	SoSh	0	0	540
Pesticide	SoSh	0	0	970
Pumping	SoSh	9,630	9,630	9,630
Total costs	SoSh	9,912	10,683	12,193
Labour requirements	man-days	68	56	58
Gross margin:				
- per ha	SoSh/ha	26,943	36,703	45,723
- per man-day	SoSh/m-d	396	655	788

Source: APPENDIX 1, Table 14

Table 15: Crop Budgets for Sesame - Dryland - Der

Farm type:	Dryland			
Tractor use:	No			
District(s):	Bardheere/Saakow/Bu'aale			
Season:	Der			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	200	300	400
On-farm losses	kg/ha	10	15	20
Net Production	kg/ha	190	285	380
Farmgate price	SoSh/kg	47	47	47
Net production value	SoSh	8,930	13,395	17,860
By-products	kg/ha	400	600	800
Value	SoSh	1,600	2,400	3,200
Total production value	SoSh	10,530	15,795	21,060
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	4	5	5
Value	SoSh	282	353	353
Fertilizer	kg/ha	0	0	10
Value	SoSh	0	0	540
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	282	353	1,863
Labour requirements	man-days	50	52	54
Gross margin:				
- per ha	SoSh/ha	10,248	15,443	19,198
- per man-day	SoSh/m-d	205	297	356

Source: APPENDIX 1, Table 15

Table 16: Crop Budgets for Sesame - Dryland - Gu

Farm type:	Dryland			
Tractor use:	No			
District(s):	Jilib/Jamaame/Kismayo			
Season:	Gu/Xagai			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	600	700	800
On-farm losses	kg/ha	30	35	40
Net Production	kg/ha	570	665	760
Farmgate price	SoSh/kg	47	47	47
Net production value	SoSh	26,790	31,255	35,720
By-products	kg/ha	1,200	1,400	1,600
Value	SoSh	4,800	5,600	6,400
Total production value	SoSh	31,590	36,855	42,120
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	4	5	5
Value	SoSh	282	353	353
Fertilizer	kg/ha	0	0	10
Value	SoSh	0	0	540
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	282	353	1,863
Labour requirements	man-days	55	56	58
Gross margin:				
- per ha	SoSh/ha	31,308	36,503	40,258
- per man-day	SoSh/m-d	569	652	694

Source: APPENDIX 1, Table 16

Table 17: Crop Budgets for Sorghum - Dryland - Gu

Farm type:	Dryland			
Tractor use:	No			
District(s):	Bardheere/Saakow/Bu'aale			
Season:	Gu			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	600	800	1,000
On-farm losses	kg/ha	30	40	50
Net Production	kg/ha	570	760	950
Farmgate price	SoSh/kg	17	17	17
Net production value	SoSh	9,690	12,920	16,150
By-products	kg/ha	1,800	2,300	3,000
Value	SoSh	7,200	9,200	12,000
Total production value	SoSh	16,890	22,120	28,150
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	9	12	12
Value	SoSh	230	306	306
Fertilizer	kg/ha	0	0	10
Value	SoSh	0	0	540
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	230	306	1,816
Labour requirements	man-days	56	57	61
Gross margin:				
- per ha	SoSh/ha	16,661	21,814	26,334
- per man-day	SoSh/m-d	298	383	432

Source: APPENDIX 1, Table 17

Table 18: Crop Budgets for Sorghum - Dryland - Der

Farm type:	Dryland			
Tractor use:	No			
District(s):	Bardheere/Saakow/Bu'aale			
Season:	Der			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	400	500	900
On-farm losses	kg/ha	20	25	45
Net Production	kg/ha	380	475	855
Farmgate price	SoSh/kg	17	17	17
Net production value	SoSh	6,460	8,075	14,535
By-products	kg/ha	1,200	1,500	2,700
Value	SoSh	4,800	6,000	10,800
Total production value	SoSh	11,260	14,075	25,335
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	9	12	12
Value	SoSh	230	306	306
Fertilizer	kg/ha	0	0	10
Value	SoSh	0	0	540
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	230	306	1,816
Labour requirements	man-days	51	53	57
Gross margin:				
- per ha	SoSh/ha	11,031	13,769	23,519
- per man-day	SoSh/m-d	216	260	413

Source: APPENDIX 1, Table 18

Table 19: Crop Budgets for Tobacco

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	400	500	900
On-farm losses	kg/ha	100	125	225
Net Production	kg/ha	300	375	675
Farmgate price	SoSh/kg	75	75	75
Net production value	SoSh	22,500	28,125	50,625
By-products	kg/ha			
Value	SoSh			
Total production value	SoSh	22,500	28,125	50,625
Variable costs:				
Land preparation	SoSh	0	700	700
Seed	kg/ha	0.1	0.1	0.1
Value	SoSh	300	300	300
Fertilizer	kg/ha	0	0	20
Value	SoSh	0	0	1,080
Pesticide	SoSh	0	0	970
Pumping	SoSh	14,980	14,980	14,980
Total costs	SoSh	15,280	15,980	18,030
Labour requirements	man-days	107	91	100
Gross margin:				
- per ha	SoSh/ha	7,220	12,145	32,595
- per man-day	SoSh/m-d	67	133	326

Source: APPENDIX 1, Table 19

Table 20: Crop Budgets for Vegetables (Tomatoes) - Irrigated

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	6,000	8,000	13,000
On-farm losses	kg/ha	1,500	2,000	3,250
Net Production	kg/ha	4,500	6,000	9,750
Farmgate price	SoSh/kg	30	30	30
Net production value	SoSh	135,000	180,000	292,500
By-products	kg/ha			
Value	SoSh			
Total production value	SoSh	135,000	180,000	292,500
Variable costs:				
Land preparation	SoSh	0	1,400	1,400
Seed	kg/ha	0.2	0.2	0.2
Value	SoSh	600	600	600
Fertilizer	kg/ha	0	0	30
Value	SoSh	0	0	1,620
Pesticide	SoSh	0	0	970
Pumping	SoSh	21,400	21,400	21,400
Total costs	SoSh	22,000	23,400	25,990
Labour requirements	man-days	129	115	123
Gross margin:				
- per ha	SoSh/ha	113,000	156,600	266,510
- per man-day	SoSh/m-d	876	1,362	2,167

Source: APPENDIX 1, Table 20

Table 21: Crop Budgets for Vegetables (Tomatoes) - Dryland

Farm type:	Dryland			
Tractor use:	No			
District(s):	Jilib/Jamaame/Kismayo			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	2,000	3,000	5,000
On-farm losses	kg/ha	500	750	1,250
Net Production	kg/ha	1,500	2,250	3,750
Farmgate price	SoSh/kg	30	30	30
Net production value	SoSh	45,000	67,500	112,500
By-products	kg/ha			
Value	SoSh			
Total production value	SoSh	45,000	67,500	112,500
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	0.2	0.2	0.2
Value	SoSh	600	600	600
Fertilizer	kg/ha	0	0	15
Value	SoSh	0	0	810
Pesticide	SoSh	0	0	970
Pumping	SoSh			
Total costs	SoSh	600	600	2,380
Labour requirements	man-days	92	93	104
Gross margin:				
- per ha	SoSh/ha	44,400	66,900	110,120
- per man-day	SoSh/m-d	483	719	1,059

Source: APPENDIX 1, Table 21

Table 22: Crop Budgets for Watermelons

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Gross production	kg/ha	10,000	11,000	18,000
On-farm losses	kg/ha	2,500	2,750	4,500
Net Production	kg/ha	7,500	8,250	13,500
Farmgate price	SoSh/kg	13	13	13
Net production value	SoSh	97,500	107,250	175,500
By-products	kg/ha			
Value	SoSh			
Total production value	SoSh	97,500	107,250	175,500
Variable costs:				
Land preparation	SoSh	0	700	700
Seed	kg/ha	3	3	3
Value	SoSh	15,000	15,000	15,000
Fertilizer	kg/ha	0	0	20
Value	SoSh	0	0	1,080
Pesticide	SoSh	0	0	970
Pumping	SoSh	12,840	12,840	12,840
Total costs	SoSh	27,840	28,540	30,590
Labour requirements	man-days	79	64	72
Gross margin:				
- per ha	SoSh/ha	69,660	78,710	144,910
- per man-day	SoSh/m-d	882	1,230	2,013

Source: APPENDIX 1, Table 22

Table 23: Crop Budgets for Alfalfa (Var. Hunter River)

Farm type:	Irrigated			
Tractor use:	Yes			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Dry matter	kg DM/ha	0	8,000	10,000
Variable costs:				
Land preparation	SoSh	0	467	467
Seed	kg/ha	0	7	7
Value	SoSh	0	8,000	8,000
Fertilizer	kg/ha	0	10	20
Value	SoSh	0	540	1,080
Pesticide	SoSh			
Pumping	SoSh	0	39,000	39,000
Total costs	SoSh	0	48,007	48,547
Labour requirements	man-days	-	128	148
Unit production costs:				
- per kg dry matter	SoSh/kg DM	-	6	5
- per man-day	SoSh/m-d	-	376	329

Source: APPENDIX 1, Table 23

Table 24: Crop Budgets for Leucaena

Farm type:	Dryland			
Tractor use:	No			
District(s):	All			
Season:	All			
Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Dry matter	kg DM/ha	0	8,000	10,000
Variable costs:				
Land preparation	SoSh			
Seed	kg/ha	0	0.5	0.5
Value	SoSh	0	free	free
Fertilizer	kg/ha			
Value	SoSh			
Pesticide	SoSh			
Pumping	SoSh			
Total costs	SoSh	0	0	0
Labour requirements	man-days	-	36	40
Unit production costs:				
- per kg dry matter	SoSh/kg DM	-	0	0
- per man-day	SoSh/m-d	-	0	0

Source: APPENDIX 1, Table 24

Table 25: Crop Budgets for Fodder Maize

Farm type:	Irrigated
Tractor use:	Yes
District(s):	All
Season:	All

Time horizon:		P	W(1)	W(2)
Item	Unit			
Production:				
Dry matter	kg DM/ha	0	5,000	8,000
Variable costs:				
Land preparation	SoSh	0	700	700
Seed	kg/ha	0	25	25
Value	SoSh	0	713	713
Fertilizer	kg/ha	0	20	40
Value	SoSh	0	1,080	2,160
Pesticide	SoSh			
Pumping	SoSh	0	8,550	8,550
Total costs	SoSh	0	11,043	12,123
Labour requirements	man-days	-	59	65
Unit production costs:				
- per kg dry matter	SoSh/kg DM	-	2.2	1.5
- per man-day	SoSh/m-d	-	187	187

Source: APPENDIX 1, Table 25

Table 26: Crop Budget for Bananas - Low Technology Level

	Unit	Rate SoSh	Value SoSh
Output			
Banana produce:			
- Export quality	10 t	15,000	150,000
- Local sale	10 t	3,000	30,000
Total output	20 t		180,000
Inputs			
Land preparation and planting	3 year crop		52,200
Furadan	30 kg	350	10,500
Fertilizer	500 kg	21	10,500
Bunch bags	-	-	-
Irrigation fuel	990 l	27	26,730
Hand weeding	4 times	1,000	4,000
Pruning	6 times	100	600
Cleaning of drains	1 time	4,400	4,400
Cleaning of canals	1 time	6,000	6,000
Chemical application	4 times	50	200
Harvesting	1 time	1,500	1,500
Transport	2 times	1,500	3,000
Supervision, drivers, mechanics			10,000
Spare parts, taxes, petrol			10,000
Management			12,000
Total inputs			151,630
Gross margin			28,370

Source [76], ANNEX 2.

Table 27: Crop Budget for Bananas - High Technology Level

	Unit	Rate SoSh	Value SoSh
Output			
Banana produce:			
- Export quality	24 t	15,000	360,000
- Local sale	4 t	3,000	12,000
Total output	28 t		372,000
Inputs			
Land preparation and planting	4 year crop		39,150
Furadan	120 kg	350	42,000
Fertilizer	1,800 kg	21	37,800
Bunch bags	2,000	3	6,000
Irrigation fuel	990 l	27	26,730
Hand weeding	20 times	1,000	20,000
Pruning	4 times	3,000	12,000
Cleaning of drains	1 time	4,400	4,400
Cleaning of canals	1 time	6,000	6,000
Chemical application	18 times	50	900
Harvesting	1 time	2,000	2,000
Transport	2 times	2,000	4,000
Supervision, drivers, mechanics			20,000
Spare parts, taxes, petrol			20,000
Management			12,000
Total inputs			252,980
Gross margin			119,020

Source [76], ANNEX 2.

APPENDIX 3

Farm Budgets

Table 1: Farm Budget for Rainfed Agriculture - Bardheere/Saakow/Bu'aale Districts - (1988) - 5 ha Farm (in SoSh)

Crop		Sorghum	Sorghum	Maize	Maize	Sesame	Sesame	Beans	Beans	Leucaena	Total
Hectares (Gu)		4.50		0.35		0.10		0.05		-	5.00
Hectares (Der)			4.75		0.10		0.10		0.05		5.00
Item	**Unit**										
Production:											
Gross production	kg	2,700	1,900	210	40	30	20	20	5	-	
On-Farm losses	kg	135	95	11	2	2	1	1	0	-	
Net production	kg	2,565	1,805	200	38	29	19	19	5	-	
Farmgate price	SoSh/kg	17	17	19	19	47	47	25	25	-	
Net production value	SoSh	43,605	30,685	3,791	722	1,340	893	475	119	-	81,629
Livestock income	SoSh										75,388
Total production value	SoSh	43,605	30,685	3,791	722	1,340	893	475	119	-	157,017
Variable costs:											
Land preparation	SoSh	0	0	0	0	0	0	0	0	-	
Seed	kg	41	43	2	1	0.4	0.4	0.6	0.4	-	
Value	SoSh	1,033	1,090	60	17	28	28	23	15	-	
Fertilizer	kg	0	0	0	0	0	0	0	0	-	
Value	SoSh	0	0	0	0	0	0	0	0	-	
Pesticide	SoSh	0	0	0	0	0	0	0	0	-	
Pumping	SoSh	0	0	0	0	0	0	0	0	-	
Livestock	SoSh										8,840
Total costs	SoSh	1,033	1,090	60	17	28	28	23	15	-	11,134
Gross margin:											
- per farm	SoSh										145,883
- per man-day	SoSh/m-d										258
Labour requirements (1)	m-d	252	242	20	5	5	5	2	1	-	565
Adjustment for labour	SoSh										76,208
Investment and Management income	SoSh										69,676

Source: APPENDIX 2 and 4
1) Including 32 days from livestock production.

Table 2: Farm Budget for Rainfed Agriculture - Bardheere/Saakow/Bu'aale Districts - (1995) - 5 ha Farm (in SoSh)

Crop		Sorghum	Sorghum	Maize	Maize	Sesame	Sesame	Beans	Beans	Leucaena	Total
Hectares (Gu)		4.00		0.50		-		0.40		0.10	5.00
Hectares (Der)			4.50		0.10		0.20		0.10	(1)	4.90
Item	Unit										
Production:											
Gross production	kg	3,200	2,250	350	50	-	60	200	20	800	
On-farm losses	kg	160	113	18	3	-	3	10	1	-	
Net production	kg	3,040	2,138	333	48	-	57	190	19	-	
Farmgate price	SoSh/kg	17	17	19	19	-	47	25	25	-	
Net production value	SoSh	51,680	36,338	6,318	903	-	2,679	4,750	475	-	103,142
Livestock income	SoSh										96,967
Total production value	SoSh	51,680	36,338	6,318	903	-	2,679	4,750	475	-	200,109
Variable costs:											
Land preparation	SoSh	0	0	0	0	-	0	0	0	-	
Seed	kg	48	54	6	1	-	1.0	4.8	1.0	-	
Value	SoSh	1,224	1,377	171	34	-	71	180	38	-	
Fertilizer	kg	0	0	0	0	-	0	0	0	-	
Value	SoSh	0	0	0	0	-	0	0	0	-	
Pesticide	SoSh	0	0	0	0	-	0	0	0	-	
Pumping	SoSh	0	0	0	0	-	0	0	0	-	
Livestock	SoSh										10,060
Total costs	SoSh	1,224	1,377	171	34	-	71	180	38	-	13,154
Gross margin:											
- per farm	SoSh										186,954
- per man-day	SoSh/m-d										329
Labour requirements (2)	m-d	228	239	30	5	-	10	14	2	4	568
Adjustment for labour	SoSh										76,653
Investment and Management income	SoSh										110,301

Source: APPENDIX 2 and 4
1) Annual crop
2) Including 36 days from livestock production.

Table 3: Farm Budget for Rainfed Agriculture - Bardheere/Saakow/Bu'aale Districts - (2005) - 5 ha Farm (in SoSh)

Crop		Sorghum	Sorghum	Maize	Maize	Sesame	Sesame	Beans	Beans	Leucaena	Total
Hectares (Gu)		3.75		0.50		-		0.50		0.25	5.00
Hectares (Der)			4.00		0.25		0.35		0.15	(1)	4.75
Item	**Unit**										
Production:											
Gross production	kg	3,750	3,600	600	200	-	140	300	45	2,500	
On-farm losses	kg	188	180	30	10	-	7	15	2	-	
Net production	kg	3,563	3,420	570	190	-	133	285	43	-	
Farmgate price	SoSh/kg	17	17	19	19	-	47	25	25	-	
Net production value	SoSh	60,563	58,140	10,830	3,610	-	6,251	7,125	1,069	-	147,587
Livestock income	SoSh										151,867
Total production value	SoSh	60,563	58,140	10,830	3,610	-	6,251	7,125	1,069	-	299,454
Variable costs:											
Land preparation	SoSh	0	0	0	0	-	0	0	0	-	
Seed	kg	45	48	6	3	-	1.8	6.0	1.7	-	
Value	SoSh	1,148	1,224	171	86	-	123	225	62	-	
Fertilizer	kg	38	40	6	2.5	-	3.5	0	0	-	
Value	SoSh	2,025	2,160	324	135	-	189	0	0	-	
Pesticide	SoSh	3,638	3,880	485	243	-	340	485	146	-	
Pumping	SoSh	0	0	0	0	-	0	0	0	-	
Livestock	SoSh										12,420
Total costs	SoSh	6,810	7,264	980	463	-	652	710	207	-	29,506
Gross margin:											
- per farm	SoSh										269,948
- per man-day	SoSh/m-d										456
Labour requirements (2)	m-d	229	228	32	15	-	19	19	4	10	592
Adjustment for labour	SoSh										79,927
Investment and Management income	SoSh										190,021

Source: APPENDIX 2 and 4
1) Annual crop
2) including 37 days from livestock production.

Table 4: Farm Budget for Rainfed Agriculture - Jilib/Jamaame/Kismayo Districts - (1988) - 2.5 ha Farm (in SoSh)

Crop		Maize	Maize	Beans	Beans	Groundn.	Groundn.	Cotton	Cotton	Sesame	Sesame	Veget.	Veget.	Leucaena	Total
Hectares (Gu)		1.25		0.25		0.08		-		-		-		-	1.58
Hectares (Iagai)			-		-		-		0.03		0.90		-		0.93
Item	Unit														
Production:															
Gross production	kg	1,500	-	125	-	24	-	-	12	-	540	-	-	-	
On-farm losses	kg	75	-	6	-	1	-	-	1	-	27	-	-	-	
Net production	kg	1,425	-	119	-	23	-	-	11	-	513	-	-	-	
Farmgate price	SoSh/kg	19	-	25	-	45	-	-	45	-	47	-	-	-	
Net production value	SoSh	27,075	-	2,969	-	1,026	-	-	513	-	24,111	-	-	-	55,694
Livestock income	SoSh														31,998
Total production value	SoSh	27,075	-	2,969	-	1,026	-	-	513	-	24,111	-	-	-	87,692
Variable costs:															
Land preparation	SoSh	0	-	0	-	0	-	-	0	-	0	-	-	-	
Seed	kg	13	-	3.00	-	1.6	-	-	0.60	-	3.6	-	-	-	
Value	SoSh	356	-	113	-	108	-	-	30	-	254	-	-	-	
Fertilizer	kg	0	-	0	-	0	-	-	0	-	0	-	-	-	
Value	SoSh	0	-	0	-	0	-	-	0	-	0	-	-	-	
Pesticide	SoSh	0	-	0	-	0	-	-	0	-	0	-	-	-	
Pumping	SoSh	0	-	0	-	0	-	-	0	-	0	-	-	-	
Livestock	SoSh														4,070
Total costs	SoSh	356	-	113	-	108	-	-	30	-	254	-	-	-	4,931
Gross margin:															
- per farm	SoSh														82,761
- per man-day	SoSh/m-d														512
Labour requirements (1)	m-d	78	-	9	-	5	-	-	1	-	50	-	-	-	162
Adjustment for labour	SoSh														21,817
Investment and Management income	SoSh														60,944

Source: APPENDIX 2 and 4
1) Including 19 days from livestock production.

Table 5: Farm Budget for Rainfed Agriculture - Jilib/Jamaame/Kismayo Districts - (1995) - 2.5 ha Farm (in SoSh)

Crop		Maize	Maize	Beans	Beans	Groundn.	Groundn.	Cotton	Cotton	Sesame	Sesame	Vegel.	Vegel.	Leucaena	Total
Hectares (Gu)		1.25		0.50		0.25		-		-		0.13		-	2.13
Hectares (Dagai)			-		-		-		0.25		0.90		0.13		1.28
Item	**Unit**														
Production:															
Gross production	kg	1,750	-	300	-	100	-	-	200	-	630	390	390	-	
On-farm losses	kg	88	-	15	-	5	-	-	10	-	32	98	98	-	
Net production	kg	1,663	-	285	-	95	-	-	190	-	599	293	293	-	
Farmgate price	SoSh/kg	19	-	25	-	45	-	-	45	-	47	30	30	-	
Net production value	SoSh	31,588	-	7,125	-	4,275	-	-	8,550	-	28,130	8,775	8,775	-	97,217
Livestock income	SoSh														38,203
Total production value	SoSh	31,588	-	7,125	-	4,275	-	-	8,550	-	28,130	8,775	8,775	-	135,420
Variable costs:															
Land preparation	SoSh	0	-	0	-	0	-	-	0	-	0	0	0	-	
Seed	kg	15	-	6	-	7.5	-	-	5.75	-	4.5	0.03	0.03	-	
Value	SoSh	428	-	225	-	506	-	-	288	-	317	78	78	-	
Fertilizer	kg	0	-	0	-	0	-	-	2.5	-	0	0	0	-	
Value	SoSh	0	-	0	-	0	-	-	135	-	0	0	0	-	
Pesticide	SoSh	0	-	0	-	0	-	-	0	-	0	0	0	-	
Pumping	SoSh	0	-	0	-	0	-	-	0	-	0	0	0	-	
Livestock	SoSh														4,190
Total costs	SoSh	428	-	225	-	506	-	-	423	-	317	78	78	-	6,245
Gross margin:															
- per farm	SoSh														129,176
- per man-day	SoSh/m-d														591
Labour requirements (1)	m-d	79	-	19	-	18	-	-	12	-	50	12	12	-	219
Adjustment for labour	SoSh														29,508
Investment and Management income	SoSh														99,667

Source: APPENDIX 2 and 4
1) Including 17 days from livestock production.

Table 6: Farm Budget for Rainfed Agriculture - Jilib/Jamaame/Kismayo Districts - (2005) - 2.5 ha Farm (in SoSh)

Crop		Maize	Maize	Beans	Beans	Groundn.	Groundn.	Cotton	Cotton	Sesame	Sesame	Vegel.	Vegel.	Leucaena	Total
Hectares (Gu)		1.13		0.50		0.25		-		-		0.13		0.13	2.13
Hectares (Dagai)			-		-		-		0.63		1.00		0.13	(1)	1.75
Item	Unit														
Production:															
Gross production	kg	1,921	-	350	-	150	-	-	756	-	800	650	650	1,300	
On-farm losses	kg	96	-	18	-	8	-	-	38	-	40	163	163	-	
Net production	kg	1,825	-	333	-	143	-	-	718	-	760	488	488	-	
Farmgate price	SoSh/kg	19	-	25	-	45	-	-	45	-	47	30	30	-	
Net production value	SoSh	34,674	-	8,313	-	6,413	-	-	32,319	-	35,720	14,625	14,625	-	146,688
Livestock income	SoSh														53,613
Total production value	SoSh	34,674	-	8,313	-	6,413	-	-	32,319	-	35,720	14,625	14,625	-	200,301
Variable costs:															
Land preparation	SoSh	0	-	0	-	0	-	-	0	-	0	0	0	-	
Seed	kg	14	-	6	-	7.5	-	-	16	-	5	0.03	0.03	-	
Value	SoSh	386	-	225	-	506	-	-	788	-	353	78	78	-	
Fertilizer	kg	17	-	0	-	0	-	-	13	-	10	2	2	-	
Value	SoSh	915	-	0	-	0	-	-	680	-	540	105	105	-	
Pesticide	SoSh	1,096	-	485	-	243	-	-	0	-	970	126	126	-	
Pumping	SoSh	0	-	0	-	0	-	-	0	-	0	0	0	-	
Livestock	SoSh														4,860
Total costs	SoSh	2,398	-	710	-	749	-	-	1,468	-	1,863	309	309	-	12,666
Gross margin:															
- per farm	SoSh														187,635
- per man-day	SoSh/m-d														711
Labour requirements (2)	m-d	76	-	20	-	20	-	-	40	-	58	14	14	5	264
Adjustment for labour	SoSh														35,643
Investment and Management income	SoSh														151,993

Source: APPENDIX 2 and 4
1) Annual crop
2) Including 18 days from livestock production.

Table 7: Farm Budget for Irrigated Agriculture on Levee Land - (1988) - 3 ha Farm (in SoSh)

Crop		Maize	Maize	Onion	Onion	Sesame	Sesame	Tobacco	Tobacco	Veget.	Veget.	Watern.	Watern.	Groundn.	Groundn.	Alfalfa	Total
Hectares (Gu)		1.05		0.90		0.75		-		0.30		-		-		-	3.00
Hectares (Der)			0.75		1.05		0.30		0.75		-		0.15		-		3.00
Item	Unit																
Production:																	
Gross production	kg	1,680	1,200	8,100	9,450	525	210	-	300	1,800	-	-	1,500	-	-	-	
On-farm losses	kg	84	60	2,025	2,363	26	11	-	75	450	-	-	375	-	-	-	
Net production	kg	1,596	1,140	6,075	7,088	499	200	-	225	1,350	-	-	1,125	-	-	-	
Farmgate price	SoSh/kg	19	19	50	50	47	47	-	75	30	-	-	13	-	-	-	
Net production value	SoSh	30,324	21,660	303,750	354,375	23,441	9,377	-	16,875	40,500	-	-	14,625	-	-	-	814,927
Livestock income	SoSh																53,261
Total production value	SoSh	30,324	21,660	303,750	354,375	23,441	9,377	-	16,875	40,500	-	-	14,625	-	-	-	868,188
Variable costs:																	
Land preparation	SoSh	0	0	0	0	0	0	-	0	0	-	-	0	-	-	-	
Seed	kg	11	8	0.18	0.21	3	1	-	0.08	0.06	-	-	0.45	-	-	-	
Value	SoSh	299	214	900	1,050	212	85	-	225	180	-	-	2,250	-	-	-	
Fertilizer	kg	0	0	0	0	0	0	-	0	0	-	-	0	-	-	-	
Value	SoSh	0	0	0	0	0	0	-	0	0	-	-	0	-	-	-	
Pesticide	SoSh	0	0	0	0	0	0	-	0	0	-	-	0	-	-	-	
Pumping	SoSh	11,235	8,025	23,112	26,964	7,223	2,889	-	11,235	6,420	-	-	1,926	-	-	-	
Livestock	SoSh																6,400
Total costs	SoSh	11,534	8,239	24,012	28,014	7,434	2,974	-	11,460	6,600	-	-	4,176	-	-	-	110,843
Gross margin:																	
- per farm	SoSh																757,345
- per man-day	SoSh/m-d																1,273
Labour requirements (1)	m-d	75	53	111	129	51	20	-	80	39	-	-	12	-	-	-	595
Adjustment for labour	SoSh																80,305
Investment and Management income	SoSh																677,040

Source: APPENDIX 2 and 4
1) Including 25 days from livestock production.

Table 8: Farm Budget for Irrigated Agriculture on Levee Land - (1995) - 3 ha Farm (in SoSh)

Crop		Maize	Maize	Onion	Onion	Sesame	Sesame	Tobacco	Tobacco	Veget.	Veget.	Watern.	Watern.	Groundn.	Groundn.	Alfalfa	Total
Hectares (Gu)		1.05		0.90		-		-		0.45		-		0.45		0.15	3.00
Hectares (Der)			0.60		0.90		0.60		0.45		-		0.30		-	(1)	2.85
Item	Unit																
Production:																	
Gross production	kg	1,995	1,140	9,000	9,000	-	540	-	225	3,600	-	-	3,300	450	-	1,200	
On-farm losses	kg	100	57	2,250	2,250	-	27	-	56	900	-	-	825	23	-	-	
Net production	kg	1,895	1,083	6,750	6,750	-	513	-	169	2,700	-	-	2,475	428	-	-	
Farmgate price	SoSh/kg	19	19	50	50	-	47	-	75	30	-	-	13	45	-	-	
Net production value	SoSh	36,010	20,577	337,500	337,500	-	24,111	-	12,656	81,000	-	-	32,175	19,238	-	-	900,767
Livestock income	SoSh																65,210
Total production value	SoSh	36,010	20,577	337,500	337,500	-	24,111	-	12,656	81,000	-	-	32,175	19,238	-	-	965,977
Variable costs:																	
Land preparation	SoSh	735	420	1,260	1,260	-	420	-	315	630	-	-	210	315	-	70	
Seed	kg	13	7	0.18	0.18	-	3	-	0.05	0.09	-	-	0.90	14	-	1.1	
Value	SoSh	359	205	900	900	-	212	-	135	270	-	-	4,500	911	-	1,260	
Fertilizer	kg	0	0	0	0	-	0	-	0	0	-	-	0	5	-	1.5	
Value	SoSh	0	0	0	0	-	0	-	0	0	-	-	0	243	-	81	
Pesticide	SoSh	0	0	0	0	-	0	-	0	0	-	-	0	0	-	0	
Pumping	SoSh	11,235	6,420	23,112	23,112	-	5,778	-	6,741	9,630	-	-	3,852	4,334	-	5,850	
Livestock	SoSh																6,850
Total costs	SoSh	12,329	7,045	25,272	25,272	-	6,410	-	7,191	10,530	-	-	8,562	5,803	-	7,261	122,525
Gross margin:																	
- per farm	SoSh																843,452
- per man-day	SoSh/m-d																1,653
Labour requirements (2)	m-d	59	34	96	96	-	34	-	41	52	-	-	19	36	-	19	510
Adjustment for labour	SoSh																68,884
Investment and Management income	SoSh																774,568

Source: APPENDIX 2 and 4
1) Annual crop
2) Including 25 days from livestock production.

Table 9: Farm Budget for Irrigated Agriculture on Levee Land - (2005) - 3 ha Farm (in SoSh)

Crop		Maize	Maize	Onion	Onion	Sesame	Sesame	Tobacco	Tobacco	Veget.	Veget.	Waterm.	Waterm.	Groundn.	Groundn.	Alfalfa	Total
Hectares (Gu)		0.90		0.60		-		-		0.45		-		0.75		0.30	3.00
Hectares (Der)			0.45		0.60		0.75		0.60		-		0.30		-	(1)	2.70
Item	Unit																
Production:																	
Gross production	kg	2,340	1,170	8,400	8,400	-	825	-	540	5,850	-	-	5,400	1,125	-	3,000	
On-farm losses	kg	117	59	2,100	2,100	-	41	-	135	1,463	-	-	1,350	56	-	-	
Net production	kg	2,223	1,112	6,300	6,300	-	784	-	405	4,388	-	-	4,050	1,069	-	-	
Farmgate price	SoSh/kg	19	19	50	50	-	47	-	75	30	-	-	13	45	-	-	
Net production value	SoSh	42,237	21,119	315,000	315,000	-	36,836	-	30,375	131,625	-	-	52,650	48,094	-	-	992,936
Livestock income	SoSh																93,240
Total production value	SoSh	42,237	21,119	315,000	315,000	-	36,836	-	30,375	131,625	-	-	52,650	48,094	-	-	1,086,176
Variable costs:																	
Land preparation	SoSh	630	315	840	840	-	525	-	420	630	-	-	210	525	-	140	
Seed	kg	11	5	0.12	0.12	-	4	-	0.06	0.09	-	-	0.90	23	-	2.1	
Value	SoSh	308	154	600	600	-	264	-	180	270	-	-	4,500	1,519	-	2,520	
Fertilizer	kg	18	9	12	12	-	8	-	12	14	-	-	6	15	-	6.0	
Value	SoSh	972	486	648	648	-	405	-	648	729	-	-	324	810	-	324	
Pesticide	SoSh	873	437	582	582	-	728	-	582	437	-	-	291	728	-	0	
Pumping	SoSh	9,630	4,815	15,408	15,408	-	7,223	-	8,988	9,630	-	-	3,852	7,223	-	11,700	
Livestock	SoSh																8,290
Total costs	SoSh	12,413	6,206	18,078	18,078	-	9,144	-	10,818	11,696	-	-	9,177	10,804	-	14,684	129,388
Gross margin:																	
- per farm	SoSh																956,788
- per man-day	SoSh/m-d																1,774
Labour requirements (2)	m-d	57	28	68	68	-	44	-	60	55	-	-	22	64	-	44	539
Adjustment for labour	SoSh																72,799
Investment and Management income	SoSh																883,989

Source: APPENDIX 2 and 4
1) Annual crop
2) Including 30 days from livestock production.

Table 10: Farm Budget for Irrigated Agriculture on Alluvial Soils - (1995) - 3 ha Farm (in SoSh)

Crop		Maize	Maize	Sesame	Sesame	Cotton	Cotton	Beans	Beans	Veget.	Veget.	Waterm.	Waterm.	Alfalfa	Total
Hectares (Gu)		1.50		-		-		0.90		0.15		-		0.15	2.70
Hectares (Der)			1.20		0.60		0.60		-		-		0.15	(1)	2.55
Item	Unit														
Production:															
Gross production	kg	2,850	2,280	-	540	-	540	810	-	1,200	-	-	1,650	1,200	
On-farm losses	kg	143	114	-	27	-	27	41	-	300	-	-	413	-	
Net production	kg	2,708	2,166	-	513	-	513	770	-	900	-	-	1,238	-	
Farmgate price	SoSh/kg	19	19	-	47	-	45	25	-	30	-	-	13	-	
Net production value	SoSh	51,443	41,154	-	24,111	-	23,085	19,238	-	27,000	-	-	16,088	-	202,118
Livestock income	SoSh														98,867
Total production value	SoSh	51,443	41,154	-	24,111	-	23,085	19,238	-	27,000	-	-	16,088	-	300,985
Variable costs:															
Land preparation	SoSh	1,050	840	-	420	-	0	0	-	210	-	-	105	70	
Seed	kg	18	14	-	3	-	14	11	-	0.03	-	-	0.45	1.1	
Value	SoSh	513	410	-	212	-	828	405	-	90	-	-	2,250	1,260	
Fertilizer	kg	0	0	-	0	-	6	0	-	0	-	-	0	1.5	
Value	SoSh	0	0	-	0	-	324	0	-	0	-	-	0	81	
Pesticide	SoSh	0	0	-	0	-	0	0	-	0	-	-	0	0	
Pumping	SoSh	16,050	12,840	-	5,778	-	7,704	6,741	-	3,210	-	-	1,926	5,850	
Livestock	SoSh														10,280
Total costs	SoSh	17,613	14,090	-	6,410	-	8,856	7,146	-	3,510	-	-	4,281	7,261	79,447
Gross margin:															
- per farm	SoSh														221,538
- per man-day	SoSh/m-d														676
Labour requirements (2)	m-d	84	67	-	34	-	33	27	-	17	-	-	10	19	328
Adjustment for labour	SoSh														44,260
Investment and Management income	SoSh														177,278

Source: APPENDIX 2 and 4
1) Annual crop
2) Including 37 days from livestock production.

Table 11: Farm Budget for Irrigated Agriculture on Alluvial Soils - (2005) - 3 ha Farm (in SoSh)

Crop		Maize	Maize	Sesame	Sesame	Cotton	Cotton	Beans	Beans	Veget.	Veget.	Watera.	Watera.	Alfalfa	Total
Hectares (Gu)		1.35		-		-		1.05		0.15		-		0.30	2.85
Hectares (Der)			0.75		0.60		0.90		-		-		0.15	(1)	2.40
Item	Unit														
Production:															
Gross production	kg	3,510	1,950	-	660	-	1,710	1,155	-	1,950	-	-	2,700	3,000	
On-farm losses	kg	176	98	-	33	-	86	58	-	488	-	-	675	-	
Net production	kg	3,335	1,853	-	627	-	1,625	1,097	-	1,463	-	-	2,025	-	
Farmgate price	SoSh/kg	19	19	-	47	-	45	25	-	30	-	-	13	-	
Net production value	SoSh	63,356	35,198	-	29,469	-	73,103	27,431	-	43,875	-	-	26,325	-	298,756
Livestock income	SoSh														134,926
Total production value	SoSh	63,356	35,198	-	29,469	-	73,103	27,431	-	43,875	-	-	26,325	-	433,682
Variable costs:															
Land preparation	SoSh	945	525	-	420	-	0	0	-	210	-	-	105	140	
Seed	kg	16	9	-	3	-	23	13	-	0.03	-	-	0.45	2.1	
Value	SoSh	462	257	-	212	-	1,350	473	-	90	-	-	2,250	2,520	
Fertilizer	kg	27	15	-	6	-	18	0	-	5	-	-	3	6.0	
Value	SoSh	1,458	810	-	324	-	972	0	-	243	-	-	162	324	
Pesticide	SoSh	1,310	728	-	582	-	0	1,019	-	146	-	-	146	0	
Pumping	SoSh	14,445	8,025	-	5,778	-	11,556	7,865	-	3,210	-	-	1,926	11,700	
Livestock	SoSh														11,620
Total costs	SoSh	18,619	10,344	-	7,316	-	13,878	9,356	-	3,899	-	-	4,589	14,684	94,303
Gross margin:															
- per farm	SoSh														339,378
- per man-day	SoSh/m-d														900
Labour requirements (2)	m-d	85	47	-	35	-	64	34	-	18	-	-	11	44	377
Adjustment for labour	SoSh														50,929
Investment and Management income	SoSh														288,450

Source: APPENDIX 2 and 4
1) Annual crop
2) Including 39 days from livestock production.

APPENDIX 4

Livestock Income

Table 1: Farm Income from Livestock Production - Present Situation (1988)

District/ Farm type: (*)		Rainfed J/J/K		Rainfed B/S/B		Irrigated Levee		Irrigated Alluvial soils	
Farm size (ha)		2.5		5.0		3.0		3.0	
Item	Unit								
Dry-matter production (DM):									
Maize	kg	4,500		750		8,640		0	
Sorghum	kg	0		13,800		0		0	
Beans	kg	125		25		0		0	
Sesame	kg	1,080		100		1,470		0	
Groundnuts	kg	12		0		0		0	
Alfalfa	kg	0		0		0		0	
Leucaena	kg	0		0		0		0	
Sub-total DM from crops	kg	5,717		14,675		10,110		0	
DM from grazing	kg	2,859		7,338		5,055		0	
Total dry matter	kg	8,576		22,013		15,165		0	
TLU requirement/year (**)	kg	2,300		2,300		2,300		2,300	
Carrying capacity	TLU	3.73		9.57		6.59		0.00	
		Small Rum.	Cattle	Small Rum.	Cattle	Small Rum.	Cattle	Small Rum.	Cattle
Herd (1)	No.	37	0	64	4	50	2	0	0
Off-take rate	%	22	10.5	22	10.5	22	10.5	22	10.5
Off-take	No.	8.1	0.0	14.1	0.4	11.0	0.2	0.0	0.0
Unit price	SoSh	2,500	12,000	2,500	12,000	2,500	12,000	2,500	12,000
Meat product. value	SoSh	20,350	0	35,200	5,040	27,500	2,520	0	0
Lactating females (2)	No.	9.3	0.0	16.1	1.3	12.6	0.7	0.0	0.0
Milk production (3)	kg	233	0	403	300	315	150	0	0
Milk product. value	SoSh	11,648	0	20,148	15,000	15,741	7,500	0	0
Sub-total product. value	SoSh	31,998	0	55,348	20,040	43,241	10,020	0	0
Total Production Value	SoSh	31,998		75,388		53,261		0	
Production costs (4)									
- drugs	SoSh	3,700	0	6,400	1,600	5,000	800	0	0
- watering	SoSh	370	0	640	200	500	100	0	0
Total production costs	SoSh	4,070		8,840		6,400		0	
Gross margin/farm	SoSh	27,928		66,548		46,861		0	
Labour requirements	m-d	19	0	32	0	25	0	0	0
Total lab. requirmt.	m-d	19		32		25		0	

Source: APPENDIX 3 and ANNEX 7
(*) J/J/K = Jilib/Jamaame/Kismayo; B/S/B = Bardheere/Saakow/Bu'aale
(**) TLU = Tropical Livestock Unit (= 250 kg)
1) Small ruminents: 2/3 goats, 1/3 sheep
2) Lactating females: 2/3 of all reproductive goats, 85 % kidding rate; 2/3 of all cattle, 50 % calving rate
3) Annual average production minus kid/calf needs: Goats: 25 ltr/a, 50 % twin births; cows: 225 ltr/a.
4) Excluding on-farm production costs of dry matter which are part of the farm budgets.

Table 2: Farm Income from Livestock Production - Situation Before Dam (1995)

District/ Farm type: (*)		Rainfed J/J/K		Rainfed B/S/B		Irrigated Levee		Irrigated Alluvial soils	
Farm size (ha)		2.5		5.0		3.0		3.0	
Item	**Unit**								
Dry matter production (DM):									
Maize	kg	5,250		1,200		9,400		15,390	
Sorghum	kg	0		15,950		0		0	
Beans	kg	300		220		0		810	
Sesame	kg	1,260		120		1,080		1,080	
Groundnuts	kg	50		0		225		0	
Alfalfa	kg	0		0		1,200		0	
Leucaena	kg	0		800		0		0	
Sub-total DM from crops	kg	6,860		18,290		11,905		17,280	
DM from grazing	kg	2,859		7,338		5,055		8,640	
Total dry matter	kg	9,719		25,628		16,960		25,920	
TLU requirement/year (**)	kg	2,300		2,300		2,300		2,300	
Carrying capacity	TLU	4.23		11.14		7.37		11.27	
		Small Rum.	Cattle	Small Rum.	Cattle	Small Rum.	Cattle	Small Rum.	Cattle
Herd (1)	No.	34	1	71	5	50	3	73	5
Off-take rate	%	24	11	24	11	24	11	24	11
Off-take	No.	8.2	0.1	17.0	0.6	12.0	0.3	17.5	0.6
Unit price	SoSh	2,500	12,000	2,500	12,000	2,500	12,000	2,500	12,000
Meat product. value	SoSh	20,400	1,320	42,600	6,600	30,000	3,960	43,800	6,600
Lactating females (2)	No.	9.1	0.4	18.9	1.8	13.3	1.1	19.5	1.8
Milk production (3)	kg	238	92	497	458	350	275	511	458
Milk product. value	SoSh	11,900	4,583	24,850	22,917	17,500	13,750	25,550	22,917
Sub-total product. value	SoSh	32,300	5,903	67,450	29,517	47,500	17,710	69,350	29,517
Total Production Value	SoSh	38,203		96,967		65,210		98,867	
Production costs (4)									
- drugs	SoSh	3,400	400	7,100	2,000	5,000	1,200	7,300	2,000
- watering	SoSh	340	50	710	250	500	150	730	250
Total production costs	SoSh	4,190		10,060		6,850		10,280	
Gross margin/farm	SoSh	34,013		86,907		58,360		88,587	
Labour requirements	m-d	17	0	36	1	25	0	37	1
Total lab. requiremt.	m-d	17		36		25		37	

Source: APPENDIX 3 and ANNEX 7
(*) J/J/K = Jilib/Jamaame/Kismayo; B/S/B = Bardheere/Saakow/Bu'aale
(**) TLU = Tropical Livestock Unit (= 250 kg)
1) Small ruminents: 2/3 goats, 1/3 sheep
2) Lactating females: 2/3 of all reproductive goats, 90 % kidding rate; 2/3 of all cattle, 55 % calving rate
3) Annual average production minus kid/calf needs: Goats: 26.25 ltr/a, 50 % twin births; cows: 250 ltr/a.
4) Excluding on-farm production costs of dry matter which are part of the farm budgets.

Table 3: Farm Income from Livestock Production - Situation After Dam (2005)

District/ Farm type: (*)		Rainfed J/J/K		Rainfed B/S/B		Irrigated Levee		Irrigated Alluvial soils	
Farm size (ha)		2.5		5.0		3.0		3.0	
Item	Unit								
Dry matter production (DM):									
Maize	kg	5,760		2,400		10,530		16,380	
Sorghum	kg	0		22,050		0		0	
Beans	kg	350		345		0		1,155	
Sesame	kg	1,600		280		1,650		1,320	
Groundnuts	kg	75		0		600		0	
Alfalfa	kg	0		0		3,000		3,000	
Leucaena	kg	1,300		2,500		0		0	
Sub-total DM from crops	kg	9,085		27,575		15,780		21,855	
DM from grazing	kg	2,859		7,338		5,055		8,640	
Total dry matter	kg	11,944		34,913		20,835		30,495	
TLU requirement/year (**)	kg	2,300		2,300		2,300		2,300	
Carrying capacity	TLU	5.19		15.18		9.06		13.26	
		Small Rum.	Cattle	Small Rum.	Cattle	Small Rum.	Cattle	Small Rum.	Cattle
Herd (1)	No.	36	2	72	10	59	4	77	7
Off-take rate	%	26	12	26	12	26	12	26	12
Off-take	No.	9.4	0.2	18.7	1.2	15.3	0.5	20.0	0.8
Unit price	SoSh	2,500	12,000	2,500	12,000	2,500	12,000	2,500	12,000
Meat product. value	SoSh	23,400	2,880	46,800	14,400	38,350	5,760	50,050	10,080
Lactating females (2)	No.	10.7	0.8	21.3	4.0	17.5	1.6	22.8	2.8
Milk production (3)	kg	307	240	613	1,200	503	480	656	840
Milk product. value	SoSh	15,333	12,000	30,667	60,000	25,130	24,000	32,796	42,000
Sub-total product. value	SoSh	38,733	14,880	77,467	74,400	63,480	29,760	82,846	52,080
Total Production Value	SoSh	53,613		151,867		93,240		134,926	
Production costs (4)									
- drugs	SoSh	3,600	800	7,200	4,000	5,900	1,600	7,700	2,800
- watering	SoSh	360	100	720	500	590	200	770	350
Total production costs	SoSh	4,860		12,420		8,290		11,620	
Gross margin/farm	SoSh	48,753		139,447		84,950		123,306	
Labour requirements	m-d	18	0	36	1	30	0	39	1
Total lab. requiremt.	m-d	18		37		30		39	

Source: APPENDIX 3 and ANNEX 7

(*) J/J/K = Jilib/Jamaame/Kismayo; B/S/B = Bardheere/Saakow/Bu'aale

(**) TLU = Tropical Livestock Unit (= 250 kg)

1) Small ruminents: 2/3 goats, 1/3 sheep

2) Lactating females: 2/3 of all reproductive goats, 100 % kidding rate; 2/3 of all cattle, 60 % calving rate

3) Annual average production minus kid/calf needs: Goats: 28.75 ltr/a, 50 % twin births; cows: 300 ltr/a.

4) Excluding on-farm production costs of dry matter which are part of the farm budgets.

Table 4: Production Parameters and Production Costs for Livestock

Item	Unit	Camel	Cattle	Small Ruminants
Average liveweight	kg	300	200	25
	TLU (*)	1.2	0.8	0.1
Dry matter intake:				
- per day (= 2.5%)	kg	7.50	5.00	0.63
- per year	kg	2,738	1,825	228
Drugs per year	SoSh	500	400	100
Water requirements:				
- per day	l/d	30	25	2.5
- per year	m3/a	11	9	1
Watering costs (2)	SoSh	100	50	10
Labour requirements:				
- watering	hr/a	2	1	0.2
- milking	hr/a	6	6	0
- herding	hr/a	2	2	1
- treatment	hr/a	2	2	1
Total labour	hr/a	12	11	2.2

(*) TLU = Tropical Livestock Unit
1) Rough estimations.
2) Watering costs are assumed for a period of 3-4 month only.

APPENDIX 5

Estimation of Poverty Line

Table 1: Consumer Price Index for Food (1987)
(1977 = 100)

January	1695.74
February	1680.15
March	1812.09
April	2054.16
May	2060.03
June	2080.73
July	2060.03
August	2086.34
September	2092.45
October	2050.67
November	2146.08
December	2332.15
10 Month Average:	2012.55
Average 1986 :	1541.64
Increase '86/'87 (%):	30.5

Source: Ministry of National Planning
Directorate of Statistics
National Account Aggragates 1977-1986
Mogadishu 1987, Table 41

Table 2: Consumer Prices Mogadishu (SoSh/kg)

Item	1986	1987
Beef	167	218
Sheep	194	253
Goat	194	253
Milk	30	39
Sorghum	27	35
Maize	30	39
Rice	41	54
Beans	55	72
Sesame (oil)	162	211
Vegetables	43	56
Sugar	67	87

Source: Ministry of National Planning
Directorate of Statistics
National Account Aggragates 1977-1986
Mogadishu 1987, Table 41

Table 3: Value of an Average Food Basket per Capita at
a Desirable Energy Intake of 2,195 kcal/day (in SoSh)

Food item	kg/year	SoSh/kg	Value	in $ (1)
Meat	27.7	230	6,371	
Milk	231.0	39	9,009	
Cereals	127.0			
- sorghum (27%)	34.3	35	1,201	
- maize (43%)	54.6	39	2,129	
- rice (11%)	14.0	54	756	
- wheat (19%)	24.1	33	795	
Legumes	2.0	72	144	
Vegetable oil	4.8	211	1,013	
Sugar	13.1	87	1,140	
Other	42.5	70	2,975	
Total value/capita/year - urban			25,533	196
Total value/household/year - urban			150,643	1,159
Total value/capita/year - rural (2)			20,426	157
Total value/household/year - rural			120,514	927
Plus 30 % non-food items			6,128	
Total value/capita/year - rural			26,554	204
Total value/household/year - rural			156,669	1,205

1) 1 $ = 130 SoSh
2) Rural = 80 % of urban
Source: ANNEX 6, Table 8.1/1; ANNEX 3, Table 2