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INTERIM REPORT

Juba Valley Analytical Studies

Land and Water Resources

Somalia

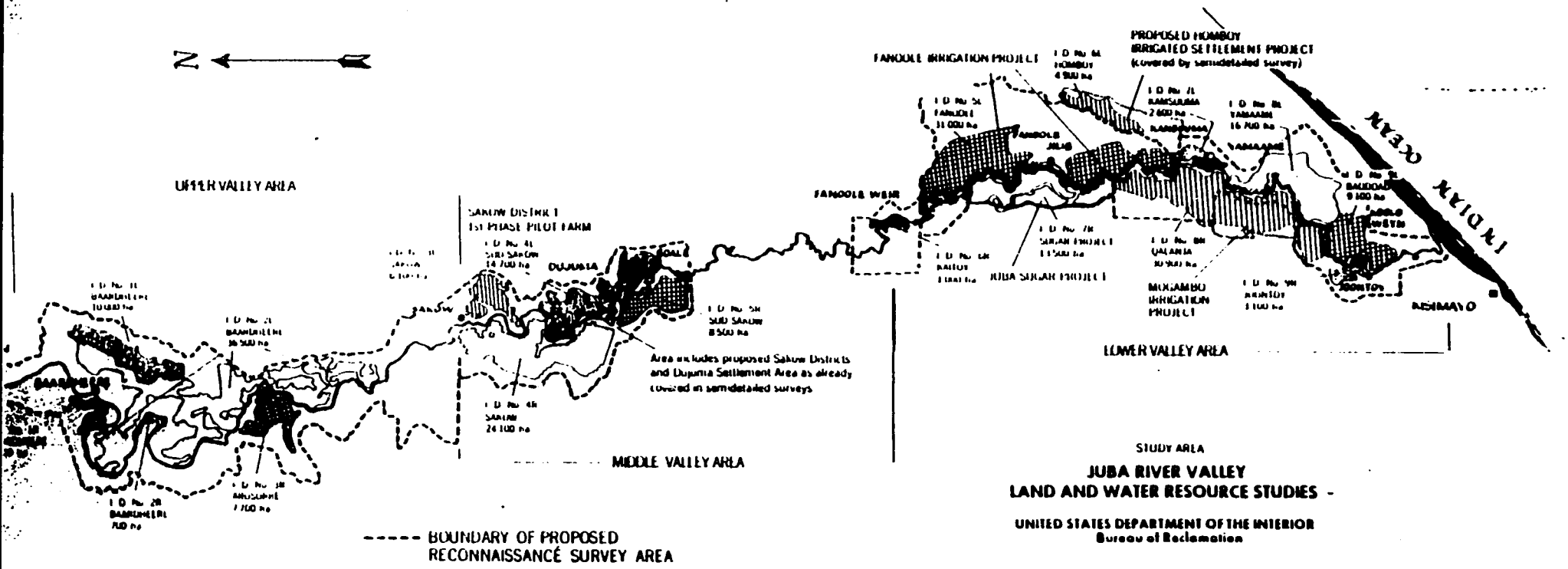
Bureau of Reclamation

U.S. Department of the Interior

Ministry of Juba Valley Development

Democratic Republic of Somalia

February, 1986



STUDY AREA

JUBA RIVER VALLEY
LAND AND WATER RESOURCE STUDIES -

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

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FRONTIS PIECE MAP

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SUMMARY

This interim report summarizes the initial findings and opinions of the Bureau of Reclamation team evaluating the land and water resources of the Juba Valley and the Lower Shebelli Valley of the Democratic Republic of Somalia.

Indications are that a water supply can be developed on the upper portion of the Juba River, suitable in both quality and volume to irrigate 120,000 to 200,000 hectares of basin lands, downstream of the proposed Baardheere Damsite.

Preliminary field evaluations have indicated that sufficient arable lands exist within the basin. These lands, however, exhibit a wide range of characteristics and their suitability for prolonged irrigated agriculture has yet to be determined.

In general, basin soils are predominantly clays, (totalling approximately 80%) with the balance (20%) occuring as coarser grained alluvial soils adjacent to the Juba River. Of the fine textured clay soils, preliminary laboratory tests have indicated residual salinity conditions in some areas as well as, some soil chemistry which could be toxic to certain plants.

Drainage problems will also be widespread throughout the basin. Without careful management and control of irrigation application and removal of excess water, water logging and salinity buildups will result. Although major portions of the basin will only be suitable for rice cultivation in the long term, some diversified cropping may be possible in the initial years. The alluvial soils encountered in the basin occur in narrow bands along the meandering course of the river. These soils are predominantly sandy clay loams, free draining and well suited to a wide range of crops. Although the lateral extent of individual parcels is not great, their inherent characteristics and proximity to the river channel make them prime for near future development.

Introduction

This interim report summarizes the findings to date of U.S. Bureau of Reclamation Team evaluating the lands, soils, and water of the Juba River basin and the Lower Shebelli River basin. The purpose of this study is to determine the potential for expansion of irrigated agriculture. Approximately 8 months of field activities have been devoted to an overview of the entire basin with a more detailed reconnaissance level evaluation of the Lower Juba area and portions of the Upper Juba area. Evaluations are based almost entirely upon field classification without benefit of detailed laboratory analyses.

In this report, opinions, observations, economic projections, and general trends suggested must be accepted as preliminary. Information generated over the many years by previous consultants was relied upon as necessary.

The land classification results as presented are based primarily upon the field evaluation of the physical soil properties and references to pre-existing soils and land class data have been made as utilized. Limited laboratory data, recently obtained, has been included in this report for informational purposes. Time has not allowed its incorporation into the presented field classification.

Basic Criteria

In the absence of definative guidelines and boundary conditions, the following limitations were established for the soils, water and land resources evaluation of the Juba Valley Analytical Studies.

Boundary Conditions

In determining boundary limitations for the study area, the proposed Baardheere Damsite was selected as the northern limit. Sine the proposed reservoir has a maximum elevation of 150 meters, this same contour elevation was selected to limit the lateral extent of the valley at the northern or upper Juba area. With increasing distance downstream from the damsite, the elevation was reduced accordingly.

Gravity Irrigation

The proposed Baardheere Dam is to be constructed with a high elevation outlet structure for irrigation purposes. Although it is doubtful that this outlet can be utilized in the near term, the costs associated with its construction as part of the dam are nominal. Several problems preclude its near future utilization. First, to maximize power production,

it will be desirable to pass all discharges through the power house facility. Secondly, the Baardheere damsite is situated about 10 kilometers upstream of the northern most lands which may prove to be suitable for cultivation. The building of a water conveyance system within the canyon reach below the damsite to serve these lands would be costly in the early years of development. Once an adequate agricultural base has been firmly established, such a conveyance system could be re-evaluated.

Pump Irrigation

In the absence of diversion structures and during the period prior to the construction and operation of Baardheere dam, irrigation by river bank pumping schemes will be necessary. In order to evaluate these potentials, 15 meters of pump lift were considered to be the maximum economical limit. To further support a pump lift of this magnitude, it is believed that the following additional criteria must also be imposed.

a) Class I, II or III lands

b) High value crops

c) Pumping costs based upon diesel (unsubsidized)

With the completion of Baardheere dam, it is assumed that downstream control structures will afford opportunities for conversion to gravity type systems. In those limited areas where pump irrigation will continue, it is assumed that the availability of reduced cost hydropower will allow further expansion.

Soil Classification

The basic criteria employed in the classification of the soils in the Juba River basin are shown on the following tabulation. Due to soil chemistry, it is doubtful that any extensive areas will qualify as Class I. The classification designated as 4S (sprinkler) will probably be incorporated into the R1, rice land category because of its very limited occurence.

PRELIMINARY

SPECIFICATIONS FOR RECONNAISSANCE IRRIGATION SUITABILITY
LAND CLASSIFICATION - [illegible] RIVER VALLEY, SOMALIA

Land Characteristics	Lands Suitable for Diversified Upland Crops: Class 1 Highly Suitable (Surface Irrigation)	Class 2 Suitable (Surface Irrigation)	Class 4S(2) Suitable (Sprinkler Irrigation)	Suitable for Wetland (Paddy) Rice: Class 4R(1) Highly Suitable (Surface Irrigation)	Class 4R(2) Suitable (Surface Irrigation)
Soil (s)					
Texture: 1/					
Surface (0 - 50 cm)	Fine sandy loam to heavy clay loam	Loamy fine sand to permeable clay	Loamy fine sand to permeable clay	Fine sandy loam to clay	Loamy sand to clay
Subsoil (50 - 100 cm)	Sandy loam to permeable clay	Loamy fine sand to permeable clay	Loamy sand to permeable clay	Loamy sand to clay	Loamy sand to [illegible]
Rooting depth 2/	More than 100 cm	More than 60 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	More than 8 cm in the 0-60 cm zone	Not applicable	Not applicable
Reaction, pH in water (1:1) 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 the 0-60 cm zone	6.0 to 8.7 in the 0-60 cm zone	5.5 to 9.0 the 0-60 cm zone
Salinity, EC_e in dS/m 4/	Less than 4.0 in the 0-100 cm zone	Less than 6.0 in the 0-60 cm zone	Less than 6.0 in the 0-60 cm zone	Less than 4.0 in the 0-60 cm zone	Less than 6.0 in the 0-40 cm zone
Sodium, SAR with irrigation 5/	Less than 8 in the 0-100 cm zone	Less than 13 in the 0-60 cm zone	Less than 13 in the 0-60 cm zone	Less than 10 in the 0-60 cm zone	Less than 16 in the 0-40 cm zone
Cation-exchange capacity at pH 8.2	More than 16 meq/100 g in the 0-100 cm zone	More than 10 meq/100 g in the 0-60 cm zone	More than 10 meq/100 g in the 0-60 cm zone	More than 16 meq/100 g in the 0-60 cm zone	More than 10 meq/100 g in the 0-40 cm zone
Topography (T)					
General slope	Less than 2 percent	Less than 4 percent	Less than 6 percent	Less than 2 percent	Less than 4 percent
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	May have relatively rough surface	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 rock or stones	Less than 20 m^3/ha	Less than 60 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.	May have moderately high clearing cost.	Low or moderately low clearing cost.	May have moderately high clearing cost.

Chapter II

Development Potentials

The amount of irrigable land in the Juba Valley will greatly exceed the available water supply. Development of these lands, therefore, may take several approaches and of course the time factor for development is nebulous. Past experience suggests that possibly 2,000 hectares annually may be optimistic. If development is undertaken by large, well financed commercial farming operations, this figure annually could be conservative.

With single crop cultivation, water could be sufficient for land in excess of 200,000 hectares, depending on crop selection, leaching requirements, and the power operation.

By multi-cropping of the lands, this same volume of water would only suffice for an additional 120,000 hectares of new lands. This broad range of development allows for much speculation. When one considers the time factor for development, it is certain that some lands will have been cultivated and in-turn gone out of production due to salinity and water logging problems, long before all the available lands have been cultivated. It is also clear that development, lacking local infrastructure and supporting supplies and services, must depend largely upon imported goods, equipment, services and technologies. With these considerations as a working base, several scenarios are presented for consideration.

Single Cropping

The cultivation of the valley lands on the basis of single crops will be limited and economically very difficult. The soils, in general, are marginally suited for irrigated agriculture. Natural fertility is low, requiring large amounts of fertilizer and chemical additives to compensate for inherent deficiencies.

The fine textured clay soils will require careful management in the application of irrigation water and removal of excess waters as a drainage control.

Water conveyance systems will be costly. Most lands will be developed initially on the basis of pump irrigation with anticipation of later conversion to total gravity systems.

The valley population, as in most of Somalia, is not comprised of farmers with generations of experience. Farming under irrigation makes the problems even more complex. Typically, the Somali farmer will want to work only during the daylight hours. Irrigation systems, therefore, must be designed and built accordingly. Delivering the required volumes of irrigation water over the shortened day will be exceedingly costly, increase system losses, and add to the drainage requirements of the area.

Double Cropping

The double cropping of most cultivated areas will be economically necessary to offset the high cost of irrigation development. In the Juba Valley, however, this approach could create early drainage and salinity problems. The soils data, as presently available, indicate that a drying period may be essential between the harvest and the following cultivation. This would allow the heavy clay soils time to dry and develop deep cracks in an effort to control the drainage and salinity buildup. The length of the drying period has yet to be determined and may prove to be a critical factor in cropping patterns. It is anticipated that the time factor may be predictable following the completion of the drainage evaluation tests.

LOWER JUBA VALLEY

The lower portion of the Juba valley, generally taken as that reach of the river between Fanoole and the Indian Ocean, is considerably more developed that the balance of the basin. In this reach, moderate development of bananas, sugar cane, rice, and a few other crops have been operated for many years. Most of these developments were initiated on the superior quality alluvial soils adjacent the river channel. As development progressed, individual irrigation systems soon expanded the areas of cultivation outward from the river.

Three major developments of the lower valley are the Fanoole Project, the Juba Suga Project, and the Mogambo Project. These developments have yet to be completed and all have large areas designated for expansion. Other developments are those of private owners and cooperatives which together comprise a significant portion of the existing development.

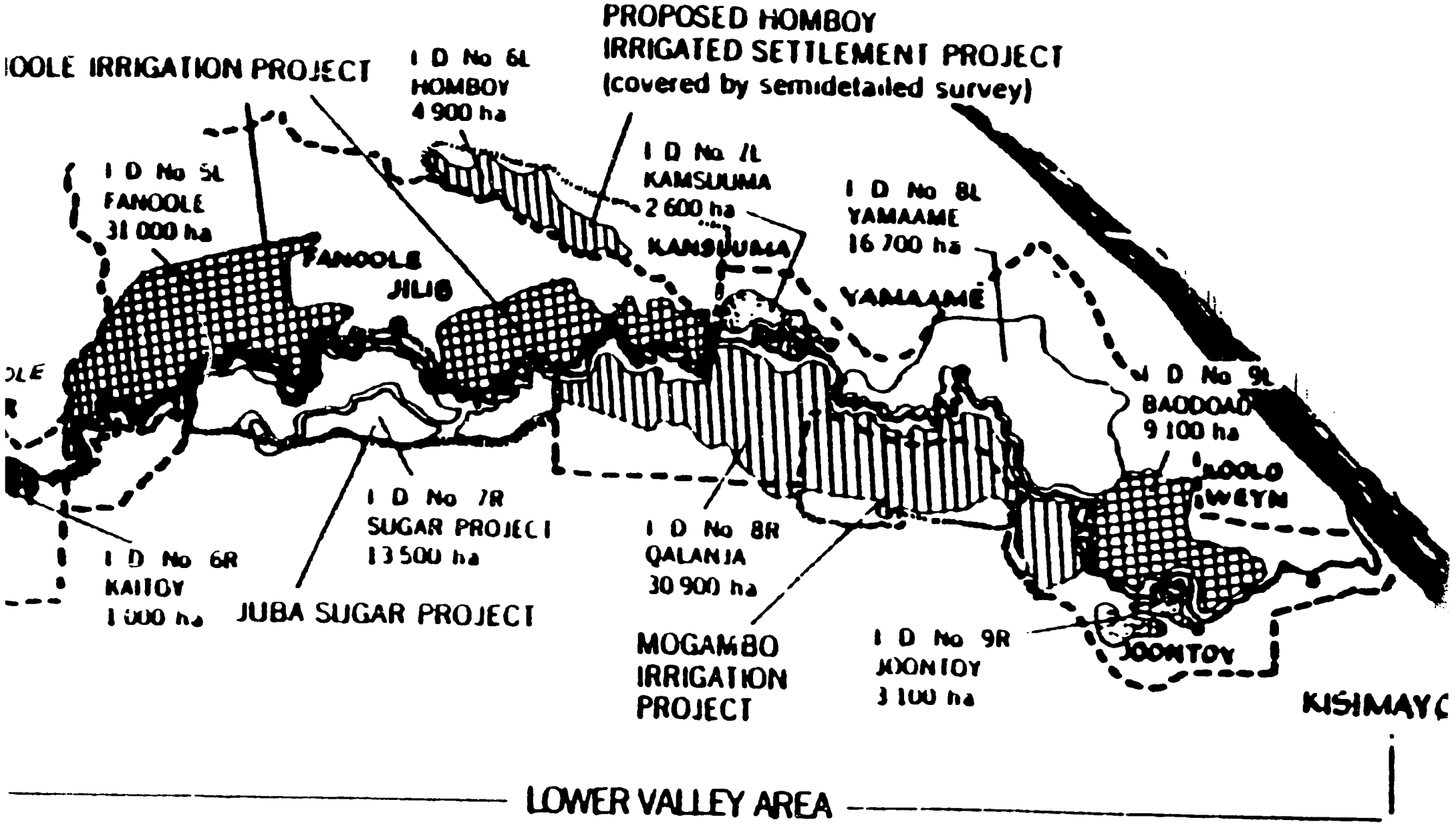
Soils work in the lower Juba valley has been directed towards the classification of the uncultivated lands, suitable for the expansion of irrigated agriculture, once river regulation is achieved. As soon as both flood control and a water supply can be guaranteed, the new lands will be a prime

attraction for further development.

Between Fanoole and Yontooy (some 95 kilometers), the Juba river gradient is very low and its channel shows distinct aggradation characteristics. The adjacent river alluvial sediments range up to 6 kilometers wide on both sides of the river. The textures range from loams to clay loams with some stratifications.

A distinct ancient river channel extends southward along the western edge of the alluvial plain from 8 kilometers upstream of Fanoole to downstream of Kamsuma. The sediments in the lower valley areas are also influenced by the Shebelli river. Southward from Jilib, marine sediments appear to underlie the alluvial sediments and are still exposed at the surface in places within the recent alluvium. The textures of the marine plain sediments also range from clay from clay loam. These soils are mostly suited for rice production but only where they are moderately saline/sodic.

To facilitate discussion and assist in the identification of land areas, this report has utilized the land area designation employed by Impressit, SpA, with modification as necessary. In the lower Juba valley, these areas were identified as follows: 5L Fanoole, 6R Kaitoy, 6L Homboy, 7R Sugar Project, 7L Kamsuuma, 8R Qalanja, 8L Yamaame, 9R Joontoy, and 9L Baodoad. These areas are shown on the following map.


PROPOSED HOMBOY
IRRIGATED SETTLEMENT PROJECT
(covered by semidetailed survey)
OOLE IRRIGATION PROJECT
I D No 6L
HOMBOY
4 900 ha
I D No 5L
FANOOLE
31 000 ha
FANOOLE
JILIB
I D No 7L
KAMSUUMA
2 600 ha
KAMSUUMA
I D No 8L
YAMAAME
16 700 ha
YAMAAME
I D No 9L
BAOOOAD
9 100 ha
BOOLO
WEYN
I D No 7R
SUGAR PROJECT
13 500 ha
I D No 8R
QALANJA
30 900 ha
I D No 6R
KAITOY
1 000 ha
JUBA SUGAR PROJECT
MOGAMBO
IRRIGATION
PROJECT
I D No 9R
JOONTOY
3 100 ha
JOONTOY
KISIMAYO
LOWER VALLEY AREA

UPPER JUBA VALLEY

For the purpose of the soils evaluation, the upper Juba valley was identified as that reach of the river between the proposed Baardheere dam site and the downstream settlement of Saacow. The initial upstream portion of this reach is confined to a narrow canyon bordered by steep talus slopes. Downstream, approximately 10 kilometers, the canyon begins to open providing the first river terraces suitable for cultivation.

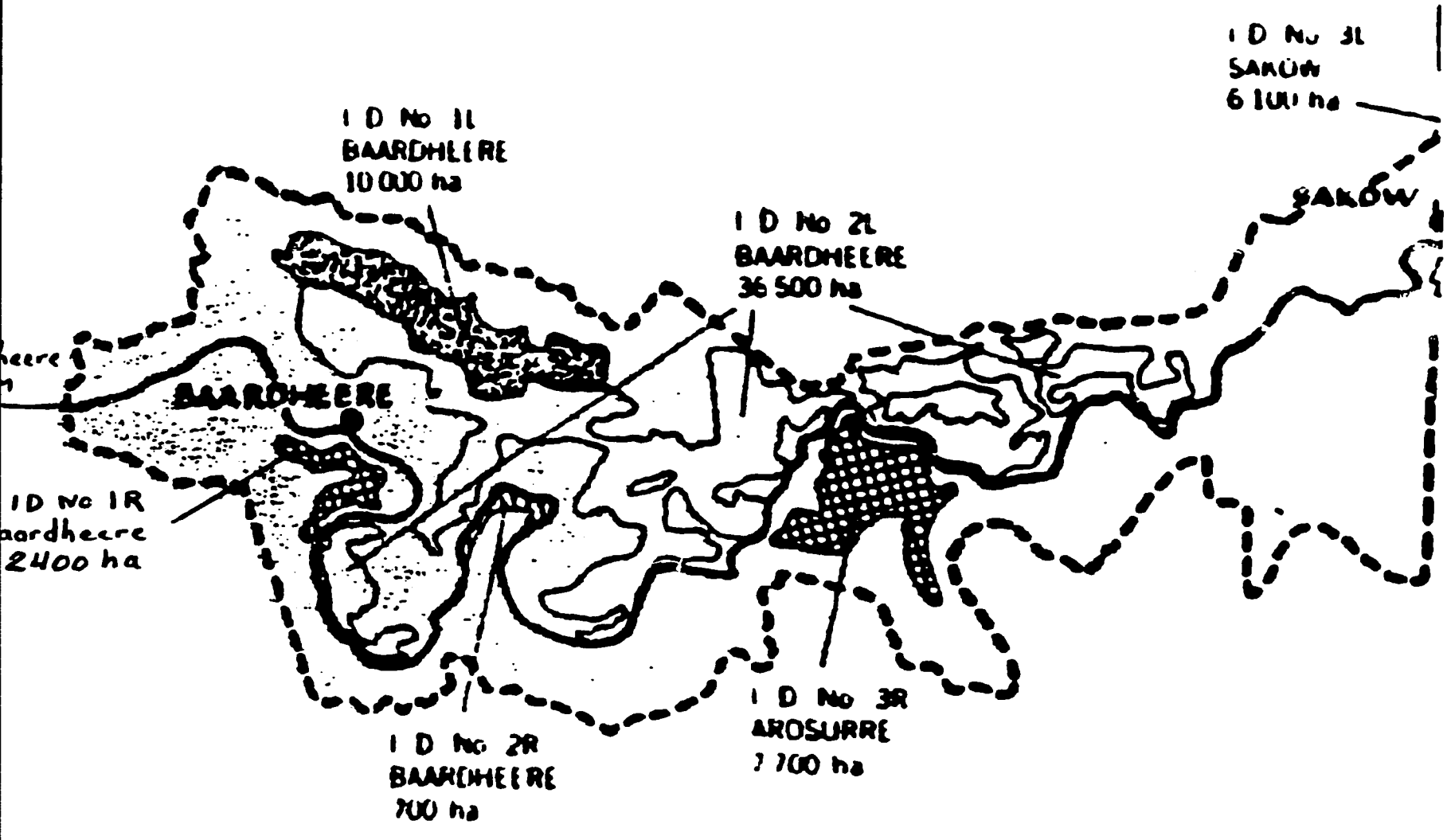
The upland or mantled limestone plain area, suitable mostly for rice production, is a thick eluvium which overlays limestone, acid crystalline rocks and basalts. The thickness of mantled cover is more than two meters except where there are isolated areas of exposed limestone and marl. Some areas are heavily cut due to sheet and gully erosion.

The soil is usually saline and sodic with strong concentrations of lime and drusses of gypsum. The textures are characteristically clay loam and clay with depth.

The flood plain lands covering both sides of the Juba river range between 2 to 4 kilometers in width and are suitable for a wide range of crops. The soil profile is characteristic of

the recent alluvial sediments. The textures range from medium to fine with small stretches of stratified 'sandy loams, loamy sands, and loams". These soils are usually non-saline and non-sodic according to Impressit S.p.A. but recent laboratory data show these soils to be slightly saline.

These upper vally lands have been previously identified with the following area designations, 1L Baardheere, 1R Baardheere, 2R Baardheere, and 3 Arossurre. These areas and their relative locations are shown on the following map of the upper Juba valley.



UPPER VALLEY AREA

MIDDLE JUBA VALLEY

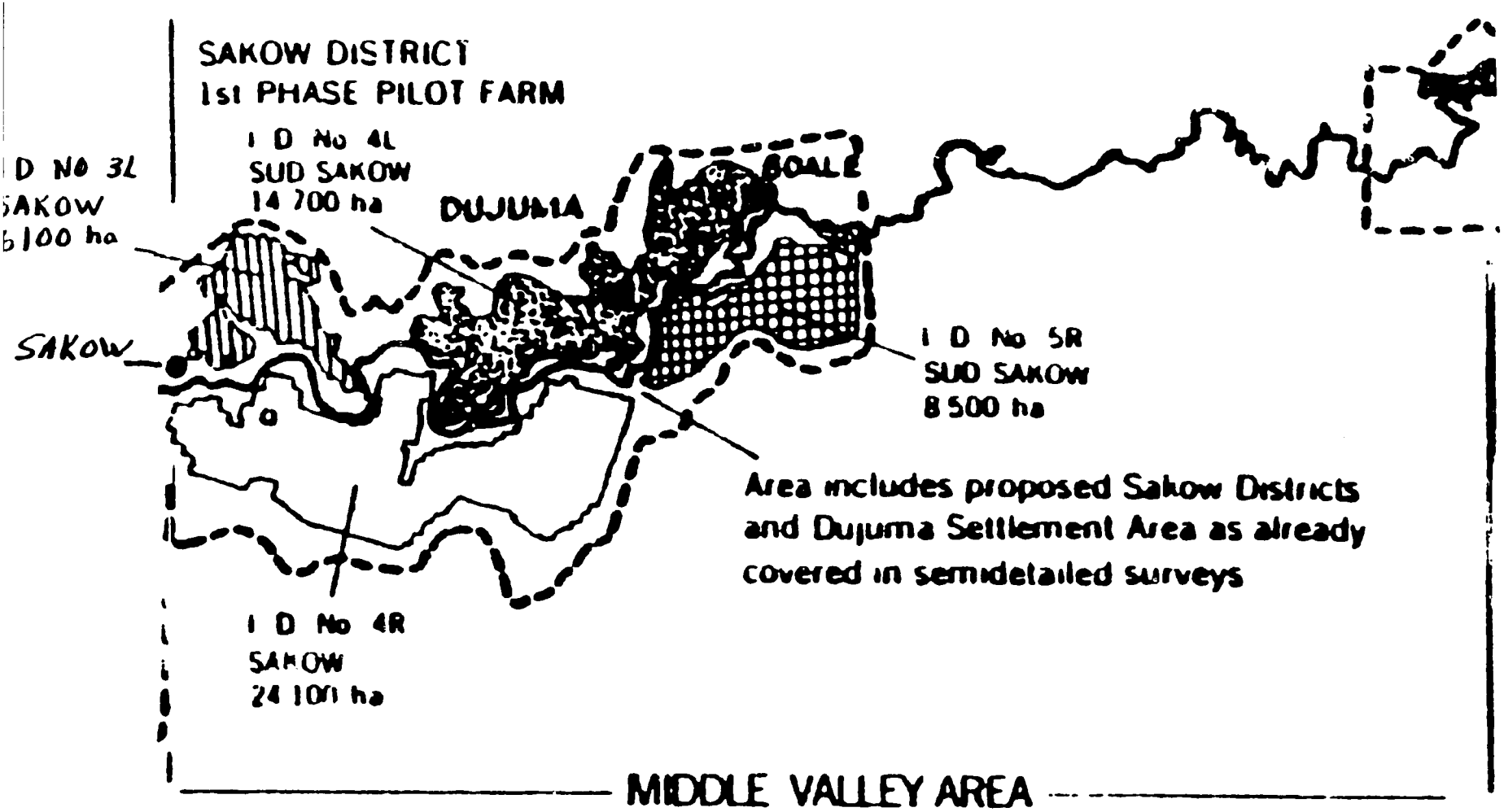
The middle Juba valley has been designated as that reach of the river between Saacow and the Fanoole diversion weir. This portion of that valley is the least developed. Lacking all weather roads and supporting infrastructure, most of the middle valley becomes isolated during the two rainy seasons, totalling about six months each year. Crops, therefore, presently cultivated or planned for the near future, must be marketable in the immediate area.

Between Saacow and Buaale (a distance of 45 kilometers) the alluvial soils adjacent to the river may range up to 4 kilometers in width. This area has more and larger "desheks" which are flood plain depressions such as oxbow lakes, cutoffs, or old river channels subject to frequent flooding.

On both sides of the river is the continuation of the mantle limestone plain soils referred to earlier. On the west side of the river across from Saacow, a large area of brown and red soils was mapped. These soils, covering an area of some 4 square kilometers, range in texture from sandy loam to clay loam. Just downstream of Buaale begins the extensive marine plain area of ancient alluvial sediments. These soils are

usually saline-sodic, slowly permeable, and suited generally for rice production. Impressits proposed irrigation districts 3L, 4R, 4L and 5R flank the river bank both sides between Saacow and Buaale. These areas are shown on the following map of the middle valley area.

Field classification in the middle valley by the Reclamation team, other than a brief overview, has not been initiated. This work has been scheduled for the 1986 field seasons and will be included in the final report.


SAKOW DISTRICT
1st PHASE PILOT FARM
I D No 4L
SUD SAKOW
14 700 ha
DUJUMA
BOALE
I D No 3L
SAKOW
6 100 ha
SAKOW
I D No 5R
SUD SAKOW
8 500 ha
Area includes proposed Sakow Districts
and Dujuma Settlement Area as already
covered in semidetailed surveys
I D No 4R
SAKOW
24 100 ha
MIDDLE VALLEY AREA

Chapter III

Land Classification

General

The Juba Valley study area as presently identified is contained on forty-one, 1:100,000 quadrangle sheets or portions thereof. Each quandrangle is approximately 36x56 kilometers giving a gross area in excess of 82,000 square kilometers. This gross area is shown on the following index sheet for the quadrangle maps.

To date, field work has been completed on over half of these complete and partial quadrangle sheets. To facilitate field mapping and data transfer, the 1:100,000 quadrangles were enlarged to 1:30,000 to correspond to the scale of the available aerial photographs.

Specifications

In the formulation of land classification specification under the broad guidelines of the U.S. Bureau of Reclamation land classification manual (Series 510, land classification techniques and standards), the initial step was the collection of available data and reports on the subject soil and water which have been prepared by others. This was basically

accomplished during the pre-reconnaissance survey of June 2, 1984.

A previous land classification by Impressit S.p.A. (1979) provides a basic coverage for most of the Juba River valley. This classification was accomplished using U.S.B.R. land classification techniques and identified the three primary factors of soil, topography and drainage. This classification is being utilized to a great degree. It has been found to be accurate and effective in saving field time. During the course of developing the specifications, the following large categories of lands have been recognized.

Methodology

A Pre-reconnaissance review of potential study areas was made during the period February 26 and May 2, 1984, to access specific areas that appeared to have those characteristics desirable for irrigated agriculture. This review made possible the elimination of certain areas from further consideration when it could be determined that from the standpoint of land characteristics alone, only limited investigations would be performed.

During the review, an inventory of aerial photographs, topographic maps, quadrangle sheets, and specific references was made to determine the type and scale of maps most suitable for the land class base map. Topographic maps, scale 1:100,000 (20 meter contours) with limited topographic data, principal drainageways, predominant land features, roads, trails and villages were selected as base maps. These maps were enlarged to a scale of 1:30,000, to correspond to the scale of the contact photos. This review allowed for the gathering and compiling of pertinent lands and logistic information to guide the land classifiers.

A Field review by a senior land resource specialist and a senior drainage engineer was also made during the period August 7 to 23 with the objective of evaluating land and drainage problems, and to advise on subsequent investigative procedures to be used during the course of the reconnaissance studies.

Field mapping is being accomplished by using the gridded 1:30,000 enlargement print. Each grid is 2 kilometers square and represents an area of 400 hectares. Numbers have been assigned to each base map and soil sampling sites with corresponding profile descriptions are identified. These numbers which will be referenced to a coordinate system.

PROJECT Somalia

12/65

BUREAU OF RECLAMATION
INTERREGIONAL SOIL & WATER LABORATORY
DIVISION OF PLANT SCIENCE SERVICES

Boring Number	Depth	Texture	Particle Size Distribution % Sand	Silt	Clay	pH 1:5 H_2O	pH 1:5 $CaCl_2$	Settling Volume	Sat %	ECe10³ Sat. Ex.	Soluble Cations me./l Ca	Mg	Na	K	Soluble Anions me./l CO_3	HCO_3	SO4	Cl	Exch. Na me./100 g.	Cation Exch. Cap. me./100 g.	Exch. K meq/100g	SAR	Gyp. me./100 g.	% Moisture Bars 1/3	15	$CaCO_3$ e/c	Boron Mg/l
12	0-12	CLAY	7.4	13.8	78.8	8.0	7.2	31.0	106.3	7.35	39.0	60.9	34.2	0.33	0	1.22	41.1	52.2	2.36	11.6	1.09	6.25	2	51.9	29.3	22.5	2.20
	12-36					8.2	7.9	28.0	95.0	13.0	102.6	Ca + Mg	115.6	0.22								20.2	3				
	36-48					8.0	7.7	15.0	72.0	7.6	3.35		14.0	0.05								10.8	0				
	48-60					8.2	7.8	23.0	69.2	12.0	69.9		120.0	0.20								20.3	3				
	60-81					8.2	7.8	25.0	72.9	16.0	75.2		125.8	0.19								20.5	3				
	81-108					8.1	7.7	25.0	76.7	15.1	68.1		119.8	0.15								20.5	0				
	0-21					8.3	7.6	21.0	59.8	2.81	32.2		8.8	0.12								2.2	1				
	21-31					8.2	7.9	19.0	27.9	9.39	27.9		85.0	0.12								22.8	0				
	31-60					8.9	7.9	20.0	59.5	17.3	65.7		159.0	0.16								27.7	3				
	60-84					8.2	7.9	23.0	72.3	13.0	59.5		118.0	0.14								23.5	3				
	0-18					8.7	7.9	26.0	80.5	14.9	36.1		135.8	0.14								32.0	0				
	18-36					7.8	7.6	23.0	69.7	7.2	19.2		13.5	0.12								8.77	3				
	36-51					8.0	7.8	25.0	82.4	5.2	18.8		108.3	0.11								35.3	2				
	51-81					8.1	7.8	25.0	90.0	17.6	72.8		139.8	0.16								23.2	2				
	0-12					8.4	7.9	27.0	83.9	17.0	59.5		141.8	0.12								26.0	0				
	12-36					8.2	7.6	25.0	66.9	0.66	3.39		6.5	0.10								1.92	0				
	36-60					8.0	7.7	26.0	45.8	1.44	1.81		12.0	0.08								12.6	0				
	60-72					8.1	7.8	27.0	82.3	18.3	48.1		102.0	0.46								22.2	1				
	72-96					8.1	8.0	28.0	84.5	20.0	76.4		180.0	0.31								28.9	3				
						8.1	8.0	27.0	84.9	19.5	90.0		170.0	0.28								30.1	3				

PROJECT SOMALIA

DATE 12/05

BUREAU OF RECLAMATION
INTERREGIONAL SOIL & WATER LABORATORY
DIVISION OF TECHNICAL SERVICES

Boring Number	Depth	Texture	Particle Size Distribution % Sand	Silt	Clay	pH 1:5 H_2O	pH 1:5 $CaCl_2$	Settling Volume	Sat. %	$EC_{e}10^3$ Sat. E	Soluble Cations me/l Ca + Mg	Na	K	Soluble Anions me/l CO_3	HCO_3	SO_4	Cl	Exch Na me/100 g	Exch Cap me/100 g	Exch Na %	SAR	Gyp me/100 g	% Moisture Bars 1/3	15		
Clock (Auger)	0-24					9.0	7.7	26.0	92.6	5.1	30.0	33.8	0.9								8.73	1				
	24-48					9.0	6.7	28.0	90.1	10.8	45.3	86.8	0.14								18.2	1				
	48-72					8.2	7.7	27.0	93.2	8.6	38.8	67.0	0.11								15.2	2				
	72-96					8.9	7.7	32.0	100.8	2.4	30.9	81.8	0.13								20.8	0				
	0-24					9.0	7.7	20.0	64.2	5.4	38.2	30.0	0.10								6.86	1				
	24-48					8.8	7.8	26.0	80.0	18.9	72.9	145.0	0.28								24.0	2				
	48-72					9.1	7.8	31.0	101.7	12.2	35.5	118.3	0.16								28.1	0				
	72-120					9.2	7.8	28.0	91.9	11.4	25.6	102.0	0.11								29.3	0				
	0-12					8.9	7.6	24.0	73.4	8.6	51.8	59.0	0.19								16.6	3				
	12-48					8.4	7.9	27.0	89.4	16.1	52.7	140.0	0.20								28.8	3				
	48-72					9.0	7.8	32.0	95.9	15.5	38.0	133.0	0.15								0.23	0				
	72-96					9.0	7.8	31.0	101.4	15.7	36.2	143.0	0.12								33.6	0				
	0-6					9.2	7.5	15.0	35.0	0.69	6.13	1.0	0.31								0.57	0				
	6-12					9.6	7.6	11.0	22.9	0.33	2.34	0.83	0.02								0.77	0				
	12-30					9.0	7.6	14.0	33.6	2.30	4.8	5.30	0.02								1.51	0				
	30-60					9.0	7.6	12.0	34.0	1.70	12.3	3.0	0.60								0.97	0				
	60-84					8.6	7.7	15.0	34.1	3.10	11.7	7.0	0.73								1.53	1				
	84-96					9.4	8.0	14.0	32.1	9.3	49.0	82.0	0.45								16.6	0				
	96-108					9.8	8.2	15.0	36.6	12.1	56.4	130.5	0.34								24.6	1				
	108-120					9.4	8.2	20.0	53.3	11.7	67.1	114.3	0.33								19.8	2				

IECT: SOMALIA

IE: 12/05

BUREAU OF RE[illegible] [illegible]
INTERREGIONAL Soil & [illegible]RATORY
DIVISION OF PLANNING SERVICES

Boring Number	Depth	Texture	Particle Size Distribution % Sand	Silt	Clay	pH 1:5 H_2O	pH 1:5 KCl	Settling Volume	Sat %	Conv. Sat.	Soluble Cations me/l Ca + Mg	Na	K	Soluble Anions me/l CO_3	HCO_3	SO_4	Cl	Exch. Na me./100 g.	Exch. Cap me./100 g.	Exch. Na %	SAR	Gyp me/100 g	% Moisture Bars 1/3	15		
Upper Zone	0-24					9.4	8.0	22.0	66.6	1.2	11.7	32.8	0.07								12.9	0				
	24-48					9.2	8.0	21.0	34.1	1.25	3.12	9.3	0.02								6.76	0				
	48-72					9.0	8.1	22.0	42.3	2.9	11.4	63.8	0.10								12.2	1				
	72-96					9.2	8.0	23.0	65.6	2.0	26.6	28.3	0.10								16.0	0				
	0-6					9.0	7.8	21.0	33.9	0.37	1.31	1.0	0.26								0.68	0				
	6-24					9.2	7.8	22.0	60.2	0.17	3.02	1.0	0.73								0.81	0				
	24-48					9.3	7.8	16.0	32.1	0.64	3.95	1.5	0.81								1.07	1				
	48-72					9.4	7.9	18.0	43.9	0.63	3.67	2.0	0.60								1.48	1				
	72-96					9.4	7.9	16.0	40.1	0.45	2.31	1.5	0.43								1.32	0				
	96-120					9.4	7.9	19.0	41.6	0.90	1.24	1.0	0.35								2.28	0				
	0-24					8.8	8.3	20.0	67.2	1.7	19.6	1.3	0.12								10.0	0				
	24-36					9.1	8.3	23.0	27.0	0.67	2.06	1.5	0.02								1.43	0				
	36-50					9.2	8.3	25.0	61.2	1.10	2.90	1.8	0.03								2.80	0				
	50-60					9.3	8.3	26.0	52.1	2.90	9.02	2.2	0.7								10.5	0				

GPO 830-000-17

By using aerial photographs of equal scale, compass courses, vehicle odometer, distance pacing, existing land features, cross trails and villages, all observation sites are being located as accurately as possible within each grid.

To determine various soil types, relief and aerial extent, photo stereoscopic photo-interpretation were employed. An autofocus projector is being used to trace land delineations from aerial photographs to land class base maps. A sketch master for opaque data bases will also be available for a similar purposes.

Initially, special efforts were being made to examine one site per grid, which later was determined to be unnecessary due to land uniformity and the inaccessability of certain areas. Where the lands are obviously nonarable due to severe erosion, unfavorable topography, rock, limestone and marl exposures, profile evaluations were done less frequently, from sampled sites, laboratory analyses will be used to support field determinations. An average of four soil samples is being collected from significant horizons of each described profile.

A number of test pits in the lower and upper Juba River

valley have been excavated for detailed sampling and complete analyses by the laboratory. These pits, based upon routine borings, have been strategically located as to represent major geomorphological units as a means of defining major land areas.

The methods being followed are in general accordance with those described by U.S.B.R. manuals. Pit descriptions are done in accordance with USDA guidelines.

Topography

The topography of the Juba River valley soils range from nearly level (2 percent or less in gradient) to gently sloping (2 percent or greater in gradient).

The area in general is predominantly nearly level. Gradients greater than 2 percent comprise only a very small amount of the total area and usually these areas are associated with the Juba River terraces occuring on both sides of the river. Other areas of relief are associated with "toggas" or drainage ways, tributary to the Juba River.

CHEMICAL CHARACTERISTICS

Based upon the limited soil chemistry currently available, the soils in the Upper Juba have a salinity range from 1.1 to 30.1 (mmhos/cm). Field observations indicate that the predominantly higher salinity values occur in the mantled limestone soils and the lower values occur in the recent alluvial soils.

In the Lower Juba, the salinity value range is from .50 to 28 (mmhos/cm). With higher values occuring primarily in the marine plain soils. The levee soils have normal salinity values for irrigation development. See Table ___ for some chemical values on the Lower Juba Valley area.

LABORATORY PROCEDURES

The methods of analyses used in the Afgoi soil and water laboratory for samples being processed for this study are standard.

Although extensive field work has been completed in the valley there remains a continuing need for considerable additional laboratory analyses to support the field land classification program.

Some of the primary methods used are listed below with the major reference for each. The number in brackets following USDA Handbook No. 60 references, is that books method description number.

1) Saturated soil paste. - Prepared according to the specifications, USDA Handbook No. 60(2).
2) Saturated extract. - Obtained by vacuum, USDA Handbook No. 60(2).
3) Electrical conductivity. - USDA Handbook 60(4b).
4) PH of saturation extract and 1 to 5 dilution with standard buffer solution.
5) Particle size analysis - Determined by sieve and pipette method.
6) Sodium absorption ration
7) Settling volume.

In addition to the standard tests listed above master-site test pit samples will include carbonates, bicarbonates, chlorides, sulfates, calcium, magnesium, sodium, potassium, exchangeable sodium, cation exchange capacity, gypsum requirement, percent calcium carbonate, boron and selected moisture tensions.

At the present time, the rehabilitation work has not been

undertaken on the laboratory and the laboratory is only operating at 20 percent of normal capacity. To date, only a few of the master site test pit analyses have been completed and there exists a 6 - month backlog of routine soil samples.

Landforms

The landform terminology used in this report was modified from that of Lockwood (GAD) 1968. Only those characteristics that are significant to irrigated agriculture have been noted.

The major landforms in the study area can be delineated from aerial photographs and on the ground in lesser detail. They have fairly consistent relief, drainage, vegetative cover, and soil characteristics.

Meander complex soils in the lower valley are essentially brown to gray brown clays and clay loams with some sandy horizons. There are lime modules in the subsoil, and structure tends to be massive with depth.

The mantle limestone and marine plain lands represent greater than 50 percent of the area with smooth to nearly level (less than 2 percent gradient) topography. Levee areas comprise the next largest group of lands which is approximately 40 percent

of total area. Beach remnants and depressional areas comprise about 10 percent of the area.

Topographically, unsuitable land areas for irrigation development are high and isolated; Small depressional areas which are costly to outlet for surface drainage; hillocks and shallow rocky areas.

The following geomorphical units should cover most of lands with the study area: alluvial plain, mantled limestone plain, eluvial plain and beach remnants.

ALLUVIAL PLAIN

These are plains of non-marine alluvial origin with recent deposits (Tertiary and Quaternary) of riverine origin. The alluvial strip, moving away from the river is composed of natural river levee, lower floodplain area.flood plain depression, meander complex (old river channels and levees) and river terraces.

Although the alluvial strip is of limited extent, it is very important for irrigation development.

In the upper valley, alluvial plain levee soils are reddish brown sandy to silt loam, often interstratified; slowly permeable

clayey layers with low soluble salts and exchangeable sodium. The lower valley alluvial plain river levee soils are reddish brown clay loam to silty clay or clay with weak - moderate structure. They are generally slowly permeable with low soluble salts and exchangeable sodium.

The flood plain soils in the upper the middle valley are dark brown clay loam to clay with strong vertical cracking (1/2 meter to 1 meter deep). They have occurrence of lime modules and gypsum crystals in the subsoil. Soluble salts and exchangeable sodium may be high below 60 cm. Conventional hydraulic conductivity tests show low permeability. In the flood-plain depressions, soils are dark gray to olive gray, silty clay to clay with weak structure. Lime occurs throughout the profile and gypsum below one meter where the structure becomes massive.

LIMESTONE PLAIN

This land form is composed of level to gently rolling plain with soil mantle of variable thickness. These soils have developed in limestone or locally derived from erosion products. The two limestone formations are the Jurassic, fine - grained limestones interbedded with bands of marl and the Cretaceous limestone, consisting of limestones, sandstones,

conglomerates, and gypsum.

Within the Jurassic limestone area, soils are typically brown to yellowish brown clay over grayish brown clay subsoil. Surfaces exhibit deep cracks and sink holes with granular structure. Subsoil has columnar or prismatic structure. The profiles exhibit a high lime content with high soluble salts and exchangeable sodium, concentrated within the subsoil. The subsoil sediments are easily puddled which is indicative of dispersion due to high sodium.

The Cretaceous limestone areas yield soils of a reddish - yellow to brown clay. Surfaces are moderately cracked with low subsoil salts and exchangeable sodium. The subsoils are yellowish brown to gray with prominent slickensides with high gypsum content. Highly soluble and exchangeable sodium is occassionally present.

ELUVIAL PLAIN

An eluvial plain, surrounding the Dujuma area, has grayish brown or pale brown sandy clay loam with shallow cracking and occassional solution holes. These soils are generally prismatic with lime nodules and gypsum crystals. The profiles are slowly permeable with high soluble salts and exchangeable

sodium in the subsoil.

MARINE PLAIN

The marine plain has no prominent feature and is underlain by marine sediments. These soils are often referred to as the lagoonal type. The surficial materials are clayey sediments with high accumulations of salts.

Marine plain soils occur extensively in the middle and lower Juba. These soils are dark gray brown fine sandy clay or clay in the surface with prominent cracking and prismatic structure to a general depth of one meter. Slickensides occur at deeper depths. Subsoils are high in lime, gypsum, soluble salts, and exchangeable sodium. The hydraulic conductivity indicates very low permeability.

BEACH REMNANT

This formation is prominent on the marine plain in the lower valley and may have developed along an ancient shoreline of the Indian Ocean. Typical soil characteristics are yellowish red to red, fine sand to sandy clay loam on the surface with finer calcarous subsurface. The profile has generally low soluble salts and exchangeable sodium. Indications are that

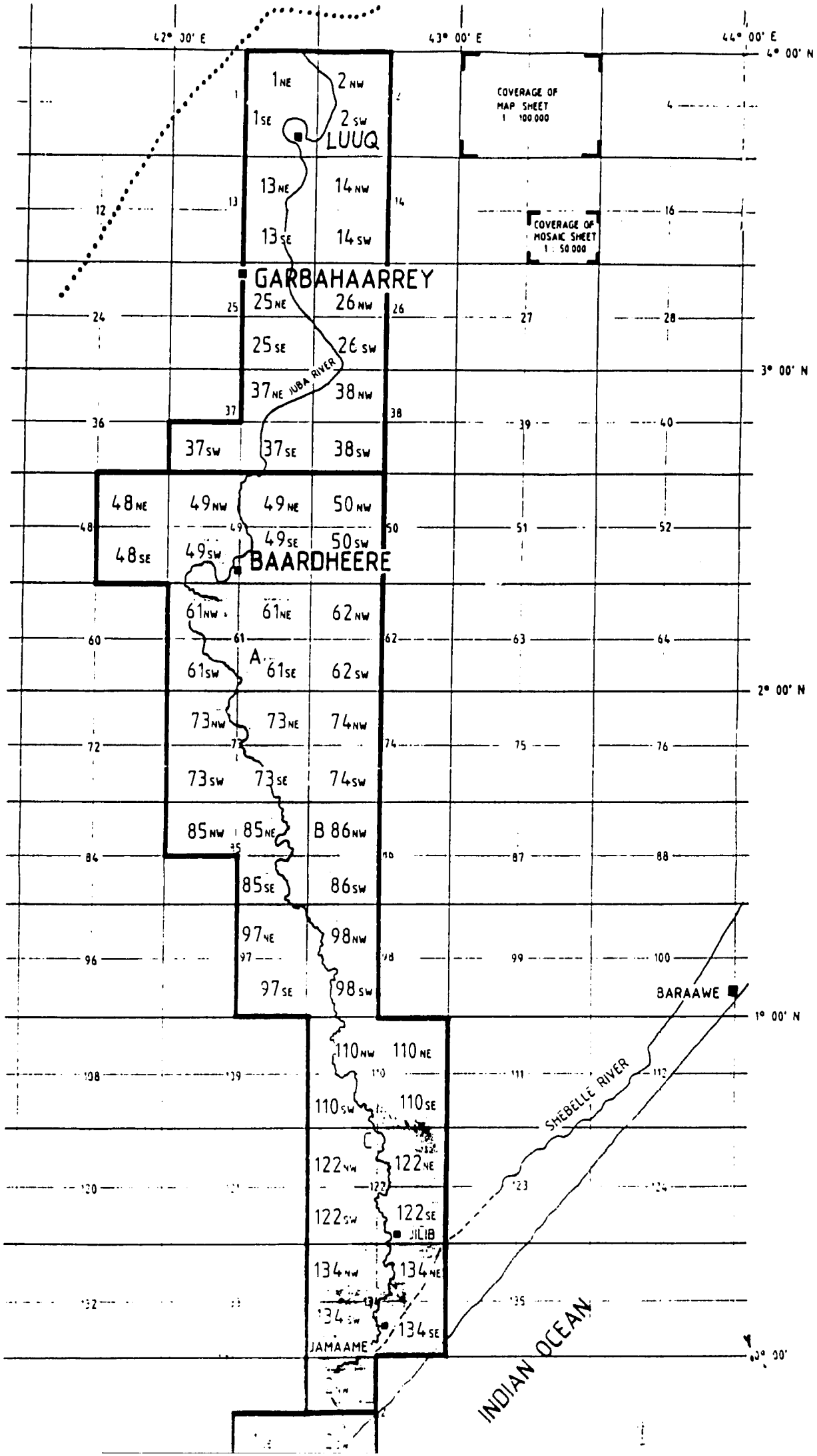
these are relatively permeable soils.

Soils

The field classification of the Juba valley soils is approximately on schedule. To date, 196,100 hectares have been classified on 22 quadrangle sheets. Most of these new lands occur in the upper Juba valley as little field work has been accomplished in the middle valley. The lower valley already exhibits extensive development along the river channel so the field work there, has been directed towards the expansion of presently cultivated areas.

There are several major irrigation projects in the lower Juba valley area and many privately owned irrigation units are located in the upper Juba valley. "Deshek" or flood recession agriculture is practiced along the Juba river from Saacow to Jilib. Several government sponsored irrigation development (100-200 hectares) are located along the valley to serve the specific interests of farmers and cooperatives. Special studies of small irrigation projects and "deshek" agriculture are being investigated by Agar Und Hydrotechnik GmbH.

An evaluation of the previous reports and information, pre-reconnaissance boring, field permeability tests and pits were used to provide the following guidelines encompassing levels of arable diversified cropland.


42° 30' E
43° 00' E
44° 00' E
4° 00' N
3° 00' N
2° 00' N
1° 00' N
0° 00'
COVERAGE OF MAP SHEET 1 : 100 000
COVERAGE OF MOSAIC SHEET 1 : 50 000
1NE
2NW
1SE
2SW
LUUQ
13NE
14NW
13SE
14SW
GARBAHAARREY
25NE
26NW
25SE
26SW
JUBA RIVER
37NE
38NW
37SW
37SE
38SW
48NE
49NW
49NE
50NW
48SE
49SW
49SE
50SW
BAARDHEERE
61NW
61NE
62NW
A
61SW
61SE
62SW
73NW
73NE
74NW
73SW
73SE
74SW
85NW
85NE
B 86NW
85SE
86SW
97NE
98NW
97SE
98SW
BARAAWE
110NW
110NE
110SW
110SE
SHEBELLE RIVER
C
122NW
122NE
122SW
122SE
JILIB
134NW
134NE
134SW
134SE
JAMAAME
INDIAN OCEAN

Class I, II, and III soils are generally suitable for a wide variety of crops. In addition, special category class R_1 and R_2 were identified as suitable for wetland (paddy) rice using surface irrigation (level basin flooding). Although, a sprinkler class was originally considered, it was later dropped due to a very small acreage. This small acreage is being evaluated in terms of Classes II and III, diversified cropland.

The Class I lands are well suited for irrigated agriculture and will produce economically, all climatically adapted crops if provided with proper management, fertilization, drainage, and irrigation facilities. These lands are flat lying and of gentle gradient. The soil profile is deep, medium to fine textured with open and stable structure, favorable for root penetration, permeable to air and water, and have good moisture retention. These soils are free of toxic elements and are anticipated to remain so at equilibrium under irrigation development.

The crops best suited for these soils are citrus, bananas, peanuts, cotton, sesame, and vegetables.

Class I lands represent a relatively small acreage adjacent to the Juba river (40,860 hectares identified by Impressit) and

are limited to the broadest levee areas.

The Class II lands would be moderately high suitability for irrigation. They have one or two significant soil, topograhic, or drainage deficiencies that may cause lower crop yields or moderately high production costs as compared to the Class I lands. These lands, when provided with the necessary cultivation practices, management and irrigation facilities, will produce economically, such crops as cotton, maize, sesame, sugar cane, tobacco and pulses. On these lands, crops sensitive to salinity and sodicity (i.e., citrus) can only be produced successfully in the better, well-drained areas. The Class II lands are found to occur on both the river alluvium and levee areas. Very little of the mantled limestone plain (especially in the Baardheere area) and eluvial plain (the Saakow to Bu'aale areas) would qualify for Class II. Impressit recognizes 48,905 hectares of Class II lands.

Class III lands would be measurably lower than Class II in suitability for irrigation development. They also will have, but to greater degree, one or more significant soil, topographic and drainage deficiencies. These lands necessitate the same requirements as the cultivation practices, management and irrigation facilities for the economical production of the crops mentioned under Class II lands. The Class III lands will occur primarily on the alluvial and levee soils.

Impressit identified 61,850 hectares of Class III lands. However, present field work suggests a large reduction of lands in this category.

Class R_1 rice lands will be highly suitable for paddy rice production being capable of producing relatively high yields of rice at reasonable costs. These lands are found on clayey soils along the Juba river, mantled limestone, eluvial, and marine plain surfaces where drainage costs for upland crops are too high. These lands occupy positions where project facilities assure adequate runoff of surface water.

Impressit identified a large Class III category of lands that will likely be identified as Class R_1 rice.

Class R_2 rice lands have been identified as those lands which have fair suitability for paddy rice under irrigated agriculture, being measurably lower that Class R_1, in overall productivity. These lands have correctable deficiencies within a reasonable cost or non-correctible deficiency but only to the degree that overall productivity will not be hampered.

Typical positions include the flood plain, marine plain

and shallow mantled limestone surfaces. Very extensive areas occur downstream from Bu'aale and fit into this category. A large portion of Impressit Class III and some Class IV pasture will occur in this classification.

PROJECT: SOMALIA

DATE: 12/85

BUREAU OF RECLAMATION
INTERREGIONAL SOIL & WATER LABORATORY
DIVISION OF PLANNING TECHNICAL SERVICES

Boring Number	Depth INCHES	Texture	Particle Size Distribution % Sand	Silt	Clay	pH 1:5 H_2O	pH 1:5 $CaCl_2$	SETTLING VOLUME	Sat. %	ECx10³ Sat. E	Soluble Cations me./l Ca	Mg	Na	K	Soluble Anions me./l CO_3	HCO_3	SO_4	Cl	Exch. Na me./100 g.	Cation Exch. Cap. me./100 g.	Exch. K m-eq/100 g	SAR	Gypsum Quantity	% Moisture Bars 1/3	15	$CaCO_3$ %	BORON Mg/l
1 UPPER TUBA	0-6	CLAY	19.0	26.6	54.4	9.0	7.6	22.0	59.6	1.75	2.33	1.62	13.0	0.10	0	2.07	0.0	15.09	2.8	32	0.97	9.17	0	37.6	19.2	32.7	2.40
	6-12	CLAY	17.6	22.0	60.4	8.9	7.8	24.0	73.8	9.45	6.47	10.5	83.8	0.10	0	1.88	11.9	82.7	7.8	28.0	0.79	28.9	0	41.9	26.7	34.3	1.92
	12-43	CLAY	13.2	19.4	65.4	8.9	7.9	27.0	91.6	10.2	4.82	8.24	97.0	0.18	0	1.29	19.6	99.4	8.1	36.2	1.06	31.9	0	47.9	23.9	30.5	13.8
	43-57	CLAY	9.6	20.0	70.4	8.7	8.0	29.0	98.9	11.8	2.42	10.7	113.5	0.24	0	1.31	20.2	100.3	10.8	41.6	1.34	40.0	0	52.9	26.0	30.0	11.4
	57-94	CLAY	7.8	31.8	60.4	8.7	8.0	32.0	127.1	9.90	1.14	7.65	94.8	0.25	0	1.42	9.79	95.6	11.0	37.6	1.39	39.0	0	55.7	27.0	28.4	0.40
2 LOWER TUBA	0-5	CLAY	14.2	26.4	59.4	8.5	7.6	24.0	71.7	0.512	3.41	0.71	1.13	0.08	0	2.15	1.90	1.04		46.6	1.45	0.34	0	45.9	24.3	14.8	1.24
	5-11	CLAY	16.4	24.6	59.4	8.9	7.6	23.0	70.4	0.400	1.49	0.32	2.89	0.03	0	2.29	0.39	1.55		41.6	0.88	1.84	0	44.1	22.6	17.0	1.36
	11-20	CLAY	14.0	25.6	60.4	8.8	7.6	20.0	71.5	0.101	0.72	0.29	3.0	0.04	0	3.01	0.0	1.27	1.4	41.6	0.72	4.22	0	45.5	25.0	15.7	1.88
	20-42	CLAY	14.4	30.2	55.4	8.7	7.6	24.0	71.5	1.86	2.97	1.13	14.0	0.05	0	1.94	1.81	11.3	3.0	37.6	0.66	9.78	0	42.5	22.8	18.3	1.28
	42-72	LOAM SANDY	33.0	41.6	25.4	8.5	7.8	17.0	46.1	15.5	10.2	32.8	119.0	0.16	0	0.74	25.3	121.1	2.51	15.6	0.13	19.1	0	27.2	11.4	17.8	0.16
	72-112	LOAM	57.9	29.2	12.9	8.1	7.9	13.0	22.9	15.2	19.0	35.1	152.0	0.20	0	0.92	23.0	122.4	1.1	7.6	0.04	29.2	0	13.4	5.5	11.7	3.16
3	0-11	CLAY	37.0	14.6	48.4	8.0	7.6	20.0	63.9	0.492	1.6	0.30	3.50	0.09	0	4.59	0.22	0.71	0.8	30.0	1.33	3.26	0	36.6	19.4	11.1	1.52
	11-29	CLAY	36.4	19.2	44.4	8.4	7.7	25.0	86.1	0.810	0.40	0.20	8.00	0.06	0.44	5.50	1.14	1.58	1.0	32.0	0.78	14.6	0	42.8	22.6	14.2	2.20
	29-36	CLAY	31.6	10.0	58.4	8.9	8.0	25.0	76.7	12.1	26.0	28.7	122.0	0.11	0	1.42	115.4	52.9	5.2	35.6	0.61	23.3	1	47.0	24.7	14.0	2.80
	36-50	CLAY	19.0	12.4	68.6	8.8	8.1	29.0	97.6	13.5	11.0	24.9	136.0	0.10	0	1.18	56.7	114.2	1.8	37.0	0.40	32.1	0	50.0	25.7	18.0	2.32
	50-62	CLAY	16.6	11.0	76.4	8.8	8.1	31.0	98.6	14.2	20.0	31.1	145.0	0.12	0	1.05	83.2	112.6	8.3	39.6	0.65	28.5	0	52.7	27.4	21.7	1.20
10	0-18	CLAY	0.6	35.0	64.4	8.8	7.6	25.0	80.9	0.420	0.92	0.15	3.00	0.05	0.17	3.34	0.46	0.15	1.76	39.0	1.02	3.62	0	43.6	24.5	31.7	0.92
	18-32	CLAY	3.4	29.2	67.4	8.8	7.7	27.0	92.4	1.26	2.2	1.59	9.25	0.08	0.09	2.62	1.50	5.64	1.8	33.6	1.01	6.90	0	46.3	25.8	28.2	2.04
	32-54	CLAY	1.2	28.4	70.4	8.3	7.6	27.0	85.1	1.75	25.0	14.6	25.5	0.24	0	1.64	11.7	19.0	1.43	40.6	0.92	5.73	1	47.5	27.7	25.2	1.72
	54-88	CLAY	5.2	17.4	77.4	8.1	7.6	28.0	91.5	6.20	31.0	20.0	33.0	0.26	0	1.33	45.6	37.3	1.0	45.0	0.84	6.53	2	50.5	28.6	27.3	2.28

Drainage Analysis

Although the USBR team has not performed any field drainage tests to date, review of published previous investigations and field reconnaissance leads to the conclusion that continued irrigation over the long term in most cases will not be possible without some combination of surface/subsurface drainage and farm crop/water management. The soils, other than those of the generally lighter textured levees close to the river, are almost uniformly heavy with massive non-drainable subsoil. The present natural mechanism which apparently prevents water - logging and accompanying salinity buildup, above the 70 to 100 cm depth, seems to depend upon the cracking and shrinking of the upper soils during the dry seasons. It is theorized that upon application of water, either through precipitation or river flooding, the more friable, heavily "microfractured" upper portion of the soil peds (blocks isolated by the large scale fractures) absorb water at a faster rate than the relatively non-microfractured ped surface at depth. Consequently the top 1/3 to 1/2 meter swells much faster than the subsoil and effectively seals itself off. Fractures below this depth tend to remain open because inadequate moisture percolates to, or reaches the underlying fracture system. Thus both the horizontal and vertical fractures at or below the 70 to 100 cm level tend to

remain open. In the Russian report (The Giuba River Scheme, Selchopromexport, Moscow 1965) the theory presented in the Soil Section is that the open horizontal fractures serves as "capillary breaks", effectively stopping the migration of salt (in most cases) above the 70 to 100 cm depth. It is very likely that under continued irrigation, these capillary breaks will eventually close and allow waterlogging and the migration of the salts upward into the root zone.

If the proposed irrigation regime incorporates continued (year round) irrigation, then subsurface drainage (i.e., spaced buried pipe drains installed no deeper than the depth of the fracture system) will be necessary. Even then the possibility exists for salinity problems because of the limited leachability of the heavier soils immediately below the top 1/3 to 1/2 meter. There is also the strong probability that the fractures may close completely, even with the installation of subsurface drains. This may not be problem on the lighter textured levee soil but it is a concern on the other irrigated soils. It may be possible through crop and water management to eliminate the subsurface drainage requirement or reduce it substantially. This would not insure the continued irrigability of the soils but would allow crop production until the time waterlogging and salinity problems force abandonment of the irrigated plots. Staged development and possibly some "checkerboard" project layout may prolong the project production period considerably.

At the present time a promising crop management scheme seems to be the incorporation of a "drying out" or fallow period to allow the surface fractures to reestablish themselves and provide leaching "pathway" down through the soil. The fallow/crackforming period could be used to grow some crop not requiring irrigation (sesame for example). It may be possible to produce two or three or more rotations of rice before a drying out period becomes necessary. Trial plots should be established to determine the actual management required.

This management scheme is a salt storage process and at some time in the future the soil salinity will build up above the 70-100 cm level into the root zone. No estimates of project life have been made, however trials plots may be the indicators. It is possible that study of very similar irrigated soils in Sudan and Australia may provide more definitive answers. A literature search is recommended and, if possible, a soil scientist and drainage engineer should make onsite observations of the soils.

If the present theory is correct (the fracture system, horizontal and vertical, allows a downward path for leaching and serve as capillary breaks, preventing upward movements of salts as the water transpires) then selection of the heavier

soils for irrigation should be based on those lands having low salt concentrations at and/or below 70-100 cm. It is hoped that the planned field work will provide sufficient evidence to either prove or disprove the validity of this hypothesis. At the least it should be the basis for either a modified or different management scheme.

SOILS LABORATORY

In support of the field classification efforts, plans were developed to rehabilitate the Agricultural Research Service laboratory (CARS) at Afgoi. Over $100,000 U.S. dollars in laboratory equipment and supplies has been furnished and partially installed at this facility. During the installation period, it was noted that both the electrical wiring and plumbing systems were inadequate to meet the needs of a fully operational facility. A rehabilitation contract was then drafted and furnished with design requirements to upgrade the entire facility. This renovation is in progress.

By increasing the laboratory work load, the existing distillation equipment, essential for the preparation of pure laboratory water, could not fulfill the needs. Equipment was then purchased and installed for reverse osmosis water treatment, capable of meeting the laboratory demands. This equipment had the basic requirements of needing nearly constant electric power and a water supply of 40 psi. Both requirements were unattainable at the laboratory and in Mogadishu proper. Lacking other options, the equipment was installed at space provided at the American Embassy, GSO compound. The power at this location is generally available and to compensate for the lack of water pressure, an in-line bladder pump was installed to boost line pressure. This facility is fully operational and provides distilled water at a rate of 30 gallons per day.

Chapter IV

Engineering Analyses

General.

Except for the items noted in the following discussion, most of the engineering work is on schedule. However, in order to maintain the schedule, the scope and detail of many of the items have been reduced. For many of these items, the necessary data and information for a more detailed or accurate analysis is not and will not be available within the time frame of this study.

For the remaining phase of the engineering analysis, it will not be possible to maintain the schedule without again reducing the scope and detail and perhaps eliminating some work items. The principal obstacle is that much of the remain engineering work requires a preliminary estimate of the area land classification, cropping patterns and drainage requirements. The determination of these last three items will depend on the results of the laboratory analysis of the soil samples. The laboratory work has not been possible because of the delay in completing the laboratory and the lack of supporting laboratory staff.

One reason for the increased time requirement for many work items was an overestimation of the amount and quality of the basic data that would be available and an underestimation of the time required to generate and assemble the data. Making estimates and analysis with limited and/or inaccurate data increases rather than decreases the time and work requirement.

The following paragraphs discuss and modify each line item of the original engineering work schedule as to (1) if it is on schedule (2) what has or has not been done, (3) and what is still planned and what has to be modified.

If the laboratory work is delayed much longer, the engineering analysis will have to be based on the Impressit report data, modified by guesses on anticipated changes in land classes and cropping patterns.

Work Items

Maps Enlargements. The enlargement of the base maps from 1/100,000 scale to 1/30,000 scale for the area, Baardheere Dam to Saacow was completed on schedule. However, the supply of film in-country was used up. An attempt was made to obtain the enlargements in Germany, but after a couple of months of effort, the arrangements fell through mainly because of the

costs and a need for hard currency. We did, however, obtain 1/50,000 scale maps of the valley. Additional film has been ordered from the US and should be available in the immediate future. This will allow the maps to be completed locally. These map enlargements are needed for the completion of the land classification work and engineering, as well as for the environmental study. If for some unforeseen reason, we cannot get the 1/30,000 scale maps, the 1/50,000 scale maps obtained from Germany, will suffice but they would not be nearly as effective.

Local Unit Construction Cost - A compilation was made of the probable unit construction costs for the Juba Valley area. The unit costs are based upon recent bids for construction projects, where these were available. Other prices were obtained from recent planning reports by other agencies or consulting firms where a consensus appeared to exist. Where local prices could not be obtained, especially for equipment, U.S. prices were used with approximated freight charges. These estimates will continue to be updated as new or more reliable data becomes available.

Preliminary Alternative Plans - This is essentially a review of Impressit's irrigation schemes and a consideration of possible alternatives.

(1) Layout - A layout of Impressit's schemes and comparison with possible alternative plans has been made for both the upper and lower Juba valley.

(2) Size Canals

(3) Trace Alignments in field

(4) Quantity and Cost Estimates. These work items would comprise an appraisal level design and cost estimate of the Impressit and alternative plans for irrigation service to the Juba valley. Only the service to Impressit areas 1L and 2L (150 km canl) have been completed to date, Design and costs estimates were made for gravity diversion from the reservoir and for an alternative canal and pumping scheme from the river. An evaluation of the gravity diversion impact on Baardheere Dam power production has not been made but will be completed when the Dam operation schedules become firm. The alternative designs for a pressure gravity system to the service area or a low line gravity canal (from the discharge level of the dam) with additional pumping were only processed to the point which indicated that they were too costly or would not have any particular advantage over other schemes.

The original concept of the preliminary studies was to com-

plete an approximation estimate to guide in the selection of the most promising scheme for each area. This scheme would then be used to evaluate irrigation and drainage service costs in more detail when the land class and cropping patterns information become available (under the work item "selected plans".) However, this concept has changed. It was found that too much time was consumed in analyzing the different alternatives. There were not adequate data readily available, without spending a prohibitive amount of office and field engineering time, to make meaningful decisions between many of the alternative plans. At present, it does not appear that there will be sufficient time available after completion of the land classification, cropping patterns, and drainage data becomes available, in which to update design and cost estimates for "selected" schemes. Therefore, the scheme to be analyzed for each area will be selected based on the apparent efficiency of the system layout.

Exceptions will be that both a gravity diversion and a pump station canal scheme will be evaluated at both Saacow and near Bu'aale. Canal alignments will be determined from the topographical maps and airphotos. Only major structure sites will be checked in the field, such as proposed sites for diversion dams, pumping plants, major siphons and wasteways.

The most critical canal reach requiring extensive field checking because of the rough topography is the gravity diversion below the proposed Baardheere Dam. This has been completed.

The Impressit areas will be used and assumed to be predominantly double cropped rice land (unless already checked by the classifier and known to be on the river levee soils). The canals and water conveyance facilities will be sized accordingly. If the land class and cropping pattern are later determined to be substantially different an adjustment factor will be applied. The separate line items as noted in the original work schedule for the appraisal estimate for "selected plans" will be eliminated.

We are currently working on the design and cost estimate of a gravity diversion near Saacow. Our estimated completion date for the design and cost estimates is June 1986 for the upper Juba and November 1986 for the lower Juba.

Hydrology and Water Requirements - With a few exceptions, the hydrology and water requirement study is completed or on-schedule. The current problem is that the data cannot be used or summarized until the land classification and cropping patterns are determined.

(1) Water Supply - The water supply estimate of 3500 M m^3/yr

was taken from the Electroconsult study. In this study the Baardheere reservoir was operated for maximum power production with irrigation using what it could of the water released for power. A new monthly river routing study was made for a typical year of operation using the power releases to meet, as near as possible, a revised irrigation requirement (predominantly double cropped rice). Irrigation return flows were also used as available for irrigation requirements and to meet river losses and minimum stream flow requirements. The new irrigation pattern increased the severity of the irrigation deficiencies which were already excessive under the Electroconsult study.

When a reasonably firm cropping pattern is established an additional operation study will be made to determine a project yield with irrigation deficiencies reduced to acceptable levels and still having minimum impact on power production.

A monthly operation for a typical year was also made for a small storage reservoir at the Saacow site. This reservoir could regulate the irrigation return flows from upstream of Saacow as well as the single purpose power releases from Baardheere reservoir. The reservoir could then divert these flows by gravity on a usable irrigation pattern. This reservoir

could be a later stage development when the Baardheere reservoir yield (under power schedule operation) is approaching full utilization and Baardheere electrical power would have a higher priority use out of the valley.

Water Requirements - A preliminary estimate was made of the water requirements of the Juba valley assuming sufficient irrigable land to utilize the full water yield potential of the river.

(1) Crops and areas - Over 80% of the irrigable valley lands are clay soils of the grey marine plain of the lower Juba or the mantle limestone plain of the upper Juba. Until the laboratory analysis and drainage studies are completed it will not be possible to determine the crops that can be grown (on a long term basis) on these soils. For a preliminary estimate, it was assumed that most of the clay soils will double cropped rice land. Although many different crops can and will be grown on the lighter levee soils, 6 crops (banana, sugar cane, citrus, maize, cotton, and soybean) were used to estimate the probable area irrigation requirement. Estimates of the crop areas of existing, under construction or proposed near term projects or developments have been updated from the latest available reports.

With the construction of the Baardheere Dam, it was projected that any rice land of the existing or proposed projects would also be double cropped. The remaining irrigable valley land would exceed the project study. Therefore, the area to be served was proportioned along the valley to areas which could potentially be served by gravity systems or by lower pumping lifts. Eighty percent of the area projected for development was assumed to be double cropped rice land.

(2) Evapotranspiration - Hydrologic data has been collected (in addition to what is available in many recent planning reports). Reference crop Evapotranspiration rates (ETO) were computed, using the additional data, for the different climatic zones of the valley compared to previous estimates used in other recent studies. The FAO (I & R 24) modified Penman method was used; Crop factors and growing seasons were selected using the FAO information and local recommendations as outlined in several recent reports concerning the Juba valley. Effective rainfall was computed for each climatic zone using the 80 percential procedure, a Reclamation standard.

(3) Leaching and Drainage - Leaching efficiencies were estimated based on the soil types. Leaching requirements

were computed based on the irrigation water salinity, percent of effective rainfall, leaching efficiencies, and crop salinity tolerances. A river routing study of irrigation diversions and return flows considering (drainage and salt returns) irrigation efficiencies and losses, was made to estimate the increase in salinity of the river flows at the various irrigation diversion points along the river. Future revisions in these estimates will be necessary if the projected cropping patterns change.

(4) Scheduling and Peaking Capacities - The estimates of crop requirements were used to determine monthly irrigation requirement and canal capacities for various cropping patterns. Project irrigation efficiencies and canal losses were based on crops grown, soil types, irrigation methods and the recommendations of local irrigation project managers. Irrigation requirements for each area include a large percentage leaching requirement, and under a reseroir power release schedule, the irrigation requirement will be difficult to meet in critical high use months unless deficiences are taken. Therefore no peaking canal capacity was included and any peaking would be provided by moving leaching capacity

to a month of lesser use. Again, a change in cropping patterns will require revision in projected canal capacities.

(5) On line storage - Estimates made to date assume 24 hour irrigation application. An estimate will be made at a later date for only daylight irrigation for all crops. This will require an estimate of on-line reservoirs for storage of night time flow. This will allow an evaluation of the financial impact of this operational procedure on a project.

Cross-drainage - Estimates have been made of the peak flows to be expected, one in 25 years, for the streams or togas which will cross the alignments of the canals.

(1) Toga Capacities - The cross sectional areas have been surveyed for several of the togas along the east side of the valley. The togas measured were selected to give a large range in drainage area and topography. The cross-sections were then used with estimated streambed conditions (hydraulic coefficients) and slope to determine bankfull flows. Where high water marks from the previous runoff season could be determined, flows for these depths were also calculated.

(2) <u>Flow Frequencies</u> - No rainfall or runoff records exist for any of the tributary drainage areas. The representative rainfall for a drainage area was assumed to be the same as for the nearest rainfall station for which a rainfall frequency relationship could be computed. Rainfall intensities and areal extent were estimated using the USBR (Design of Small Dams) method. The triangular hydrograph method was next used with the rainfall data to estimate runoff. The SCS procedure was used to estimate rainfall-runoff relationship based upon known soil and vegetation conditions. The estimated peak discharges were then compared to the bankfull and high water mark stream channel flow estimates. The 1985 rainfall season was estimated as being representative of a rainfall frequency of about once in 10-15 years. For Togas with reasonable agreement of flow from both methods (considering frequency) the results were used to determine a peak flow (25 year) versus drainage area relationships. Time permitting, a similar but short cut method will be used to estimate peak flows for the cross drainage areas of the entire Juba otherwise the same relationship will be assumed.

(3) Culvert Size - Culvert capacities and sizes have been computed for the cross drainages along the eastside canal alignments of the upper Juba. Similar curverts sizing must still be completed for the lower Juba and the west side of the upper Juba.

Floods-River - With Baardheere reservoir in operation, the one in a 100 year flow could be held below 700 $m^{3/S}$ and contained within the river bank (or levee) capacity.

(1) Juba River Flows and Frequencies - The Juba river flows and frequencies were taken from the report[1/] by AHT. The flood frequencies after Baardheere reservoir is in operation were taken from the Electroconsult report.

(2) High Water Profiles - The high water profiles along the Juba river were estimated based on a study[1/] (computer program) by AHT for calculating the propagation and deformation of flood waves downstream.

(3) Levee Requirements - Flood heights and durations will affect the drainage outlet elevations (needed for drainage

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1/ Hydrology of the Juba River - AHT - 1984

pumping, discharge, etc) for some of the better quality lower lying lands along the river. Also, the construction of possible diversion dams or reservoirs at points down the river will require an estimate of these project impacts on river flood heights. Protection by levees, or other means, for existing or proposed facilities or projects will be required. This work has been delayed until July 1986. If time becomes critical, this study will be dropped as it could be postponed to the feasibility stage investigations.

Distribution System

The design and cost estimate of the irrigation distribution system and on-farm irrigation system has been delayed. This work will be completed after the cropping patterns and drainage requirements are determined. The projected flag dates have been changed to August 1986 for the upper Juba and November 1986 for the lower Juba.

Typical System Layout

On-farm system - The layout and sizing of the irrigation distribution systems as well as that of the on-farm irrigation systems will depend largely upon the projected cropping pattern, the method of irrigation (basin, furrow, sprinkler, etc.), farming practices (extent of mechanization), and the proposed solutions to the leaching and drainage problems.

Lateral Design

Cost Estimates - The design of the laterals and structures and their cost estimates for the distribution and on-farm system will include estimates for brush clearing and land leveling.

The layout, design and cost estimates will only be made for 3 to 4 typical, different irrigation conditions. For example a lateral and on-farm system will be designed for an individual unit

of a typical rice project. This design and cost estimate will then be assumed applicable to the entire area of the rice project as well as other rice projects. Estimates of operation and maintenance costs will also be included for the various systems.

Drainage

The design and cost estimate of the drainage system has been delayed. The work will be completed after the cropping patterns and drainage requirements are determined. The project flag dates have been changed to August 1986 for the upper Juba and December 1986 for the lower Juba.

Typical System Layout

On-Farm Drainage - The layout of the drainage system and on-farm drainage will vary with the cropping patterns and soil types. For example, it will not be known until the drainage studies are completed, whether or not other crops in addition to rice can be successfully grown for long periods under irrigation on the clay soils. Nor is it known what irrigation and drainage regime (periods of fallow or leaching), if any, can be employed to allow prolonged double cropping of rice. Answers to these questions will impact the design and cost of both the irrigation distribution and drainage systems.

Drainage Design

Cost Estimates - As with the irrigation distribution system, once the drainage system has been layed-out and sized, the drains and structures will be designed and cost estimates made. The on-farm drainage system designs and cost estimates will only be made for 3 Or 4 drainage units. These units will be typical for different anticipated conditions of soil type, crops, and topographical areas. The costs per hectare will then be assumed to be the same for similar drainage requirements encountered in other areas of the valley. Cost estimates of operation and maintenance will also be included.

Report

Initial Draft - The initial draft of the engineering study will be completed by the end of February 1987. The draft will include pencil drafts of plates and tables. It is assumed that this is the termination date for the in-country activities.

Review - The review of the initial draft by both the Ministry of the Juba Valley and AID will be completed by April 1987. During this period the final copies of the plates and tables will be drafted in the U.S.

Final Report - The final report which will incorporate the recommendations of the Ministry and AID review, will be completed by July 1987.

PROGRESS OF ECONOMIC STUDIES

The Economy of Somalia

Present Condition

The economy of Somalia in the last three or four years has been in transition from a State controlled economy to a dual economy of private and public sectors. The freeing of the economy has had a noticeable effect on the goods and services available to the general public. Shops whose shelves were almost bare are now stocked with a selection of items. While the private sector is slowly gaining strength and momentum the public sector has not fared so well. Many of its projects have performed poorly leaving it with burdensome deficits and increased external debt.

In 1984 Somalia's economy did not achieve the desired gains. Its performance was hampered by the shortage of the following major ingredients.

1. Investment Capital
2. Foreign exchange to purchase needed inputs for expansion and production
3. Infrastructure for the orderly distribution of these vital inputs.

Exports in 1984 were also down creating a trade deficit of 9.9 billion shillings or about 99 million dollars.

Somalia does not have a large reserve of natural resources waiting to be developed. There are no known major metals, no located oil deposits and exploratory drilling for natural gas has been disappointing. Wood products contribute to the economy, but are limited. While agriculture and fishing are Somalia's two major natural resources, both are underdeveloped.

Agriculture

Importance in the Economy

Agriculture is the dominant sector in the economy of Somalia. In 1984, crops and livestock generated 3.6 billion shillings or 47 percent of Somalia's 7.7 billion Gross Domestic Product (GDP).

Sixty-five percent of Somalia's exports in 1984 totalling 818 million shillings came from agriculture as shown below. Over the five year period 1980-1984 agriculture exports averaged 1,206 million shillings or 85 percent of all exports.

Exports

Million Somalia Shillings

	1984	Percent	Average 1980-1984	Percent
Livestock	522	64	961	80
Banana	6	1	63	5
Other	290	35	182	15
Total	818	100	1,206	100

Agriculture exports in 1984 were 48 percent below the five year average due largely to the quarantine on livestock exports. These figures demonstrate the importance and the potential of agriculture as a producer of foreign exchange.

The performance of the agriculture sector has shown recent improvement with the freeing of price controls on cereal grains. Grain prices are now determined by market forces. The return of price incentives to producers has been accompanied by increased production.

Agriculture Subsectors

Livestock

The livestock industry has been the leading producer in the economy of Somalia. Its continued performance is vital to Somalia's economic well-being. Even though there are limits to the number of livestock that the range land can support, opportunities exist to increase production. New studies and programs are under way which will assist the livestock industry. Areas of possible improvement include better range management, improving health programs and disease control, better marketing facilities, marketing cattle earlier and over-coming the tendency to retain livestock as a savings account.

The Livestock Marketing and Health Project is planning to construct three cattle quarantine centers in Somalia over the next two years. These centers will be located relatively close to the major ports of Mogadishu, Kismayo and Berbera. To guarantee that only disease free and healthy animals will be exported,

all cattle leaving the country will be quarantined for 21 days. During this period they will be vaccinated, dipped, inspected and closely observed. These centers have the capacity to process 720,000 head of cattle per year. There are presently 4 million cattle in Somalia. With less than an optimum calving percentage, high mortality rates and requirements to ship only male animals, it is unlikely that more than 150,000 head a year can be exported in the near future.

Planners have been hopeful that this development would create a large demand for livestock feed which could best be supplied from irrigated areas. The feeding of 150,000 head of cattle for a short period of only 21 days would require only 28,600 tons of feed. This feed could be produced on 2,400 hectares of irrigated land. If only 1/3 or 800 hectares would be needed in Juba Valley it would not create a significant new market.

Under current conditions it does not appear likely that livestock could compete economically with high-value crops for the use of irrigated land.

Rainfed Agriculture

Rainfed agriculture has an important place in the economy of Somalia even though in some areas rainfall approaches the

inadequate range. Roughly 3/4 of Somalia's cultivated land is rainfed, with 11 out of 15 regions producing rainfed crops. Sorghum is the dominant dry land crop accounting for 90 percent of the rainfed production.

Increased production could come from rainfed areas through the adoption of new moisture conserving practices.

Rainfed agriculture is vulnerable to drought. Where great dependence is placed upon it farmers should be encouraged to develop a storage program in case of emergency.

The Ministry of Juba Valley Development (MJVD) is in the process of publishing the findings of a recent rainfed survey in the Juba Valley. This survey made by German consultant Agar und Hydrotech GMBH will update the rainfed statistics of the Juba area.

Irrigated Agriculture

Irrigation development in Somalia is largely confined to the two major drainages, the Shebelle and the Juba. The Shebelle area approaches the full development of its water resources if in fact the river is not already over appropriated. Reliable figures on the number of hectares irrigated do not exist. Current estimates range between 35-40 thousand hectares.

Existing irrigation along the Juba River is primarily concentrated in the Lower Juba with the Fanoole Rice Project at Jilib, Juba Sugar Project at Mareerey and the Mogambo Project and Banana Plantations in the Kamsuma-Jamaame area. In addition to the large irrigation developments many small pumps provide water for small farms along the river. The greatest concentration of pumping is in the Bardhere area.

Current estimates of irrigated land along the Juba total 26,670 hectares with a break-down by district shown below.

District	Irrigated Hectares	When Completed
Bardhere	1,522	
Saakow	1,185	
Buaale	2,206	
Jilib	1,525	
Jamaame & Kismayo		
Desheks	7,883	
Medium scale farms	4,940	
Large scale projects		
Fanoole	600*	7,500
Juba Sugar	6,370**	7,700
Mogambo	439	2,200
Total	26,670	17,400

Source

Development of the Juba Valley present situation, potential planning Agar und Hydrotechnik GMBH

*End of 1985

**End of 1984

The Juba Valley is the major area in Somalia where substantial blocks of new irrigated land could be developed. Its development would require the building of Bardhere Dam to control the floods on the Juba River and insure adequate water during dry seasons.

Farm Organization

Current farm organization in Somalia is generally of three types:

1. Subsistence farms of 1-5 hectares.
2. Large State Farms of several thousands hectares.
3. Medium to large farms in private ownership ranging from 20-200 hectares.

Subsistence Farms

Subsistence farming is effective where used. It not only provides families with their food but is also the backbone of the social structure in many villages. Subsistence farming does not maximize production. The yields and returns are low but so are the inputs. It does not require a developed infrastructure, a large number of hectares or imports of agriculture inputs which draw on scarce foreign exchange. It is as its name suggests, a method of feeding the farm family and using the small surplus produced as a source of cash to acquire

items which cannot be grown. Most of the labor can be provided by the farm family. The major exception is to custom hire the plowing of the land. Land is not a restraining factor in subsistence farming and if yields fall because of soil depletion the family moves to another plot of land.

State Farms

The performance of State Farms organized in the 1970's have been disappointing. They have required large inputs of donor capital and scarce foreign exchange and have never achieved the production envisioned at the time of their organization. The Ministry of Agriculture is conducting studies through its Agriculture Farm Management and Extension Training (AFMET) Program to find feasible solutions. It would be impractical to continue to operate State Farms unless they are put on a paying basis.

The Mogambo Project which brought its first 439 hectares into production in 1985 was originally designed as a State Farm. In the first full year of production the program was modified to include several small tenants. The tenant system has not been in operation long enough to be evaluated. Its success will depend largely on the agricultural knowledge and ability of the tenants, the economic incentives provided and whether or not they have sufficient capital to establish themselves.

Medium to Large Farms - Private Ownership

Few statistics are available on this segment of agriculture. Their continued existence speaks of their vigor. Historically these farms have been primarily banana farms averaging about 65 hectares. With the reduction of government controls in agriculture a renewed interest is anticipated in this sector of agriculture.

Crops Grown in Somalia

The climate of Somalia permits the growth of a wide range of crops. In rainfed areas sorghum is the principal crop. Some cowpeas, groundnuts and other minor crops are also grown. Under irrigation many vegetables are grown near populated areas for the local market. A partial list includes: tomatoes, potatoes, cucumbers, lettuce, grean beans and onions. Watermelon, mangoes, grapefruits, and papaya are abundant and of good quality. Major irrigated field crops include, but are not limited to: maize, rice, bananas, sesame, onions, groundnuts, cotton, coconuts, citrus, cowpeas and tobacco. Forage crops do not appear to be grown in Somalia. This is somewhat surprising considering the large livestock numbers.

Project Economic Studies

Purpose

The development of economic parameters needed for land classification is the major thrust of economic studies. As time permits other peripheral areas of economic interest of project development will be studied.

Level of Study

The agreement between the Ministry of Juba Valley Development (MJVD) and the U.S. Agency for International Development (USAID) and the agreement between USAID and the Bureau of Reclamation provide for a reconnaissance level of land classification study. Reconnaissance studies do not provide the level of detail that is expected and required in a Feasibility Report.

Data Collection

Data needed to make the project analysis has been obtained from may sources. The MJVD and their consultant Agar Und Hydro-technik GMBH have been most helpful. Officials at USAID and contractors for their various projects have shared information and given advice. Interviews have been conducted with Government Officials, District Agricultural Coordinators, World Bank personnel, Extension Officers, State Farm Managers in Jowhar Mogambo and Fanoole and with village leaders and

farmers. Officers of Somalfruit and Somaltex have granted interviews in Mogadishu, Jamaame and Balad. A review of the available literature of the much studied area has been made.

Method of Analysis

Crop Budgets

The productive ability of the various land classes would be measured using crop budget. The standard measure of land productivity is net farm income, consisting of gross farm income minus all production expenses.

Basic Assumptions

There are several fundamental agricultural inputs which must be in place before success can be obtained from new agricultural development. To begin without them invites disappointment and failure. They should be included in project planning and developed simultaneously with the project. In this analysis the basic assumption has been made that the essential inputs listed below would be available to farmers. Without them, reported results would be invalid. This is appropriate in a land classification effort. To do otherwise would classify the agricultural infrastructure and not the land. An outline of basic assumptions is shown below.

Foreign Exchange

Foreign exchange to purchase equipment, parts, fuel, fertilizer and chemicals is the need most often expressed by those associated with agriculture. The one exception is the banana industry where Somalfruit which generates a significant amount of foreign exchange can purchase and guarantee these inputs to their producers. There is considerable risk for farmers if essential inputs cannot be assured throughout the growing season.

All Season Roads

A network of all-season roads to link cities and major towns is sorely needed in the Juba Valley. The existing road between Jilib and Bardhere is impassable through extended wet periods. Without dependable roads the normal functions of agricultural marketing and supply cannot operate effectively.

Marketing Facilities

Improved marketing channels and facilities are needed to replace government procedures used when major crops were purchased by the government. This could be most effectively accomplished by the private sector.

Import Supply System

A competitive import supply system with distribution facilities readily available to the farmers would best serve agriculture. This type of system would give producers an opportunity to select products and implements best suited to their needs.

Production Credit

Farmers and especially new ones will need assistance in purchasing the elements of production.

Trained Farmers

Farmers or farm managers experienced in irrigated agriculture who are qualified to make both long term and day to day managerial decisions are perhaps the most critical need facing new projects.

Extension Service

An effective extension service to disseminate new data, teach new methods and train farmers to economically evaluate their managerial alternatives is needed in the Juba Valley. Recent advances made in extension training and improved extension service in the Middle and Lower Shebelli Regions should be extended to the Middle and Lower Juba Regions.

Communication Network

A reliable communication system to relay market, weather and supply information would greatly assist farmers.

Improved Seed Program

A seed program to assure seeds with good inherit ability and high germination rates should be given priority. The repeated use of poor quality seed causes low plant population, low yields and wastes production inputs.

Hybrid seed is not used in Somalia. The technology to manage a hybrid seed program in Somalia is perhaps 20 years into the future, but efforts should be made to move in that direction.

Land Tenure and Water Rights

Current land tenure and water rights laws do not encourage the investment of private capital in farms. This is particularly true of foreign capital. More favorable guarantees of ownership and water rights would encourage increased investment.

Double Cropping

The high cost of building irrigation projects today makes double cropping essential. Even though timing is tight it can

be achieved but it requires good management and incentives. A double cropping program should be a part of the project planning process.

Commercial Farming

Only mechanized commercial agriculture can amortize today's high irrigation development costs. Based on economics alone only new irrigation units which can pay the following costs should be included:

1. Project irrigation development cost.
2. Project annual operation, maintenance and replacement cost. (OM&R)
3. Provide a reasonable living standard for the farm family
4. Pay a water charge to assist in the repayment of Bardhere Dam.

This analysis assumes a commercial farm operation with the state of the art inputs.

It is recognized however that the MJVD in drafting a master-plan for the development of the Juba Valley may desire to serve objectives other than economic such as environmental or social objectives.

Reorganized Cotton Industry

There is no reason why Somalia could not have a healthy cotton industry, from the farm to the clothing store. This would require removing government controls on cotton and reorganizing the industry under the private sector.

Wage Rates

Managers of large projects have experienced labor shortages during critical periods. It is not known at this point if there is an acute labor shortage or if the problem is created by low wage rates. It appears that some wage rates are so low that the opportunity cost of staying home is more valuable to the individual than working. The MJVD has just gotten under way the Juba Environmental Social Study (JESS) which will address such important issues.

Crop Selection

High value crops which generate foreign exchange or substitute for imported food would be most beneficial to Somalia. Many other considerations also influence crop selection. They include crop returns, potential markets, type of soil, perishability, level of management required, processing needed, labor requirements, and whether or not the crop is being successfully

grown in Somalia. A discussion on the relative merit of crops follows:

Bananas

Bananas lead all crops in exports and are second only to livestock in the foreign exchange column. Banana production reached its peak in 1973 when 7,100 hectares produced 168,000 tons. For a period economic incentives for growers did not exist and production and number of hectares fell in 1981 to 59,000 tons on 4,100 hectares. When grower incentives returned, the banana industry began to recover and in 1984, 106,000 tons of bananas were produced on 5,500 hectares. In 1985 Somalfruit is expanding its banana plantations and is encouraging private growers to do the same. If producer incentives remain in place, bananas could reclaim their prominent place in the economy of Somalia.

Bananas will be used in this analysis to represent high value-crops which could be grown on class I land.

Maize

Maize is one of the staples in the Somali diet. It has been grown in country for many years and most farmers have had some experience in raising it.

During the 1970's and early 1980's maize production was adversely impacted by the pricing policies of the Agricultural Development Corporation (ADC) who had monopoly power over the marketing of maize. During this period of time, maize production remained fairly constant in the range of 97,000 to 110,000 tons per year. With improved pricing, production increased to 270,000 tons in 1984. Even with this substantial increase Somalia is a long way from achieving its goal of being self-sufficient in maize production. In the period from 1980 - 1984 Somalia imported an average of 100,000 tons of maize per year or 36 percent of the maize requirement. During this same period total grain imports filled about 48% of the country's needs.

Maize, because of its place in the Somali diet and its established acceptance in the Somali economy will be used in the analysis as an import substitution crop. It will be shown on both class 1 and class 2 land in rotation with other crops.

Rice

The role of rice in Somalia is expanding. The State Farms at Jowhar and Fanoole are rice projects. Jowhar has 350 hectares, 300 of which produced rice in 1985. At Fanoole 600 of the planned 7,500 hectares produced rice in the same time period. In 1985 rice was also grown on the Mogambo Project in both the Gu and the Der seasons.

The Agricultural Farm Management and Extension Training (AFMET) program has been sponsoring small rice plots of 1 to 2 hectares in the Middle and Lower Shebelli Regions for the last two years. The first year a grower plant rice, AFMET furnishes the seed, fertilizer and technical assistance without charge. In 1985, 1,150 hectares were in the program. Returns reported were higher than those from other annual crops.

Rice is an attractive crop for Somalia. Its major advantages include:

1. It is an excellent food
2. An import substitution crop
3. Yields and returns are relatively high
4. Climatically well suited for Somalia
5. It will produce on land unsuited for other crop production.

The major problem of rice culture is the migratory Quela Quela birds which cause considerable damage. When rice is seeded with a drill, they dig up the rice before it sprouts. From the flowering stage of the rice plant until the end of harvest they raise havoc in ripening rice fields. Their numbers are so great that on occasion they darken the sky. Effective control measures in Somalia have not been developed. Left unchecked they can easily destroy one half or more of

the crop. Before committing a large number of hectares to rice, some control procedures should be developed.

Somalia's recent experience in rice culture will be invaluable should they build new rice projects. However, there are some important questions which should be answered before development begins. They are:

1. Under a rice double cropping system can production and disease control be maintained over an extended period without fallowing or rotating into another crop?
2. Would the double rice crop, which may not permit deep drying and cracking of the soil, impede drainage and accelerate salinity problems?
3. Which rice variety is best adopted to conditions in Somalia?

The International Rice Research Institute of the Philippines will be contacted for research data in these areas.

Rice will be shown as an import substitution crop on land classes R-1 and R-2 in this analysis.

Cotton

The fortunes of cotton once an export crop in Somalia have been eroding. Reported cotton statistics appear overstated and will not be shown. In field tours and interviews conducted in 1985 the Reclamation Study Team was unable to find 1 hectare of cotton being grown on irrigated land. Present cotton production appears to be coming entirely from the rainfed sector and principally from the Juba Valley. Irrigated land dedicated to cotton production at Balad, Fanoole and Mogambo are not producing cotton.

The demise of cotton has been precipated by two major problems: low producer prices and low yields. Somalia's cotton yields are below those reported by other countries in Africa. Recent data on irrigated cotton yields are not available. At the time cotton disappeared from irrigated land, yields were in the range of .5 to 1.0 ton per hectare. This is about 1/3 of the yield being obtained on the Gezira and Rahad Projects in Sudan. In the 1970's several test trials on cotton growing were made in Somalia by various individuals. These trials tested varieties, time of planting, level of fertilizer input and number of irrigations. These tests reported yields ranging from .9 to 3.2 tons per hectare. The ten best varieties tested in the Der season at the Central Agricultural Research Station (CARS) in Afgoi demonstrated yields of 2.4 - 3.2 tons per hectare.

The biggest problem impeding cotton yields is the management and timing of cultural practices, particularly insect and disease control. During the time Somalia strictly enforced the Cotton Sanitation Law, including spraying and the destruction of crop residue, high production was achieved.

The cotton industry in Somalia is operated and controlled by Somaltex, a government owned company functioning under the direction of the Ministry of Industry. Somaltex administratively sets the price of cotton. Somaltex pays farmers 25 shillings per kg at the collecting stations for seed cotton. In addition they provide the seed, extension service and insect control free. A subsidized rate for tractor use and small amounts of credit are also available. Somaltex estimates these additional services as worth 8 shillings per kg if used by the growers, bringing the farmers price to 33 shillings per kg. At this price there is no economic incentive to produce cotton.

Somalia plans to import 500 tons of cotton lint from Pakistan in 1986. The estimated CIF cost in Mogadishu is $737,766 or $1,475 per ton. Converted into Somali Shillings this price would be 148 shillings per kg. Handling charges and transportation to Balad would add an additional shilling making a cotton mill price of 149 shillings per kg. Assuming a 33 percent ginning rate and subtracting transportation costs from farm to the mill would price cotton seed at 49 shillings per kg. Preliminary

studies indicate cotton production on irrigated land would be profitable at that price.

Officials at the Somaltex Textile Mill in Balad quoted a yearly plant capacity of 2,050 tons of cotton lint based on the operation of two shifts per day. In 1984, because of foreign exchange was not available to purchase fuel, dye and repair parts, the plant did not run at full capacity. They produced 4.5 million yards of fabric which is 25 percent of capacity. Somaltex estimated that 20 percent of their lint cotton was produced in country. This would place local production at about 300 tons of seed cotton in 1984. Based on field observation, that would be optimistic.

Somaltex plans in 1986 to begin weaving some fabric as a blend of cotton and synthetic. This has the potential of opening a new field as most of the local garment fabric is presently imported.

Without an indepth study of the cotton industry in Somalia it would be presumptuous to say that all problems could be easily solved. Yet on the surface they do not appear to be insurmountable. In searching for high-value crops it is difficult to by-pass cotton, not only because of the foreign exchange it would generate through import substitution, but also because of the jobs it creates as the seed cotton is

processed into fabric.

For these reasons cotton will be used in our analysis on class 1 and 2 land with the recommendation that before a project is built that its viability be demonstrated.

Other Potential Crops

A search for a high-value leguminous crop to rotate on class 1 and class 2 soil with maize and cotton is being conducted. Under considerations are cowpeas, groundnuts, and soybeans. Some the oilseed crops, though not legumes, hold some promise. These would include sesame and sunflowers. An oil producing crop would appear to be logical choice in-as-much as Somalia imported 29,000 tons of edible oil in 1984. Some of the problems associated with these crops are listed below.

Cowpeas

Cowpeas are grown on both irrigated land and in rainfed areas. They are a low-yielding crop and have a short storage life due to insects. They are the most important food legume in Somalia. In spite of this the market potential appears to be local and limited. The demand could most logically be filled by rainfed or subsistence type irrigated farms.

Groundnuts

Groundnuts are an important high-value crop. They are successfully grown under rainfed and irrigated conditions in several countries in Africa as an export crop. They have yet to be accepted as a major crop in Somalia, but would fit nicely in rotation with cotton and maize.

At this writing the market potential for groundnuts has not been fully assessed. Nor has Somalia's ability to compete in the world groundnut market been evaluated. More information is also needed on the acceptance of groundnut oil for cooking in Somalia. A concern has also been expressed about the difficulty of harvesting groundnuts in heavy clay soils.

Soybeans

Once considered a temperate zone crop, soybeans have in recent years been grown with some success in the tropics and sub-tropics. The soybean produces both protein and oil, which can be effectively used in the human and animal diets.

Soybeans have not been grown commercially in Somalia, but experimental research began early in the 1970's at CARS in Afgoi. Recent tests on 16 varieties were summarized in a 1985 report, showing yields in the range of 1-2 tons per hectare.

Additional experimental work is needed before soybeans are grown commercially. An incomplete list of questions which need to be answered are listed below:

1. Are Somalia temperatures too high for good soybean production?
2. Can detrimental effects of high temperatures on stored seed be overcome?
3. What local market could be developed for soybeans?
4. Could Somalia effectively compete in the world soybean market?
5. What are the potential markets for soybean by products?

Some potential local demand could develop for soybean meal in connection with the new dairy industry beginning in Somalia.

Soybeans would be an attractive crop for Somalia if they can compete economically with the other crops. They are not a difficult crop to grow and do not have a large water demand. Their nitrogen fixation ability would be helpful in rotation with heavy nitrogen using crops.

Sesame

Sesame produces an excellent oil and is preferred in Somalia.

It is raised under both controlled and uncontrolled irrigation. Sesame is a deep rooted plant that has the ability to extract maximum amounts of moisture from the soil. It does not require a lot of water and can mature and produce in recession areas or with one irrigation. It is intolerant to water-logged conditions. Sesame is generally raised on small farms using hand labor. It is harvested and threshed by hand. Varieties grown in Somalia have a tendency to shatter and do not lend well to mechanical harvesting. Historic yields under this system are low, ranging from about .3 to .6 tons per hectare. Under research conditions at CARS in Afgoi yields of .7 to .8 tons were obtained.

The Australian team at the Mogambo project have renewed interest in sesame. They plan to rotate it with rice letting the soil dry and crack while the sesame is growing. This they feel will facilitate the flushing of salts and length the time crops can be grown. They are searching for non shattering varieties which could be harvested by machine. The results of their study is of vital interest to the reclamation team.

Final Crop Selection

A final crop selection will be made after a more thorough search of existing data.

Status of Economic Studies

Economic studies are on schedule. Required economic data would be available as needed for the completion of the Land Classification Report.