THE SOMALI REPUBLIC

THE GIUBA RIVER SCHEME

SECTION I

GENERAL REPORT

SELCHOZPROMEXPORT

MOSCOW, 1965

C O M P O S I T I O N

C O N T E N T S

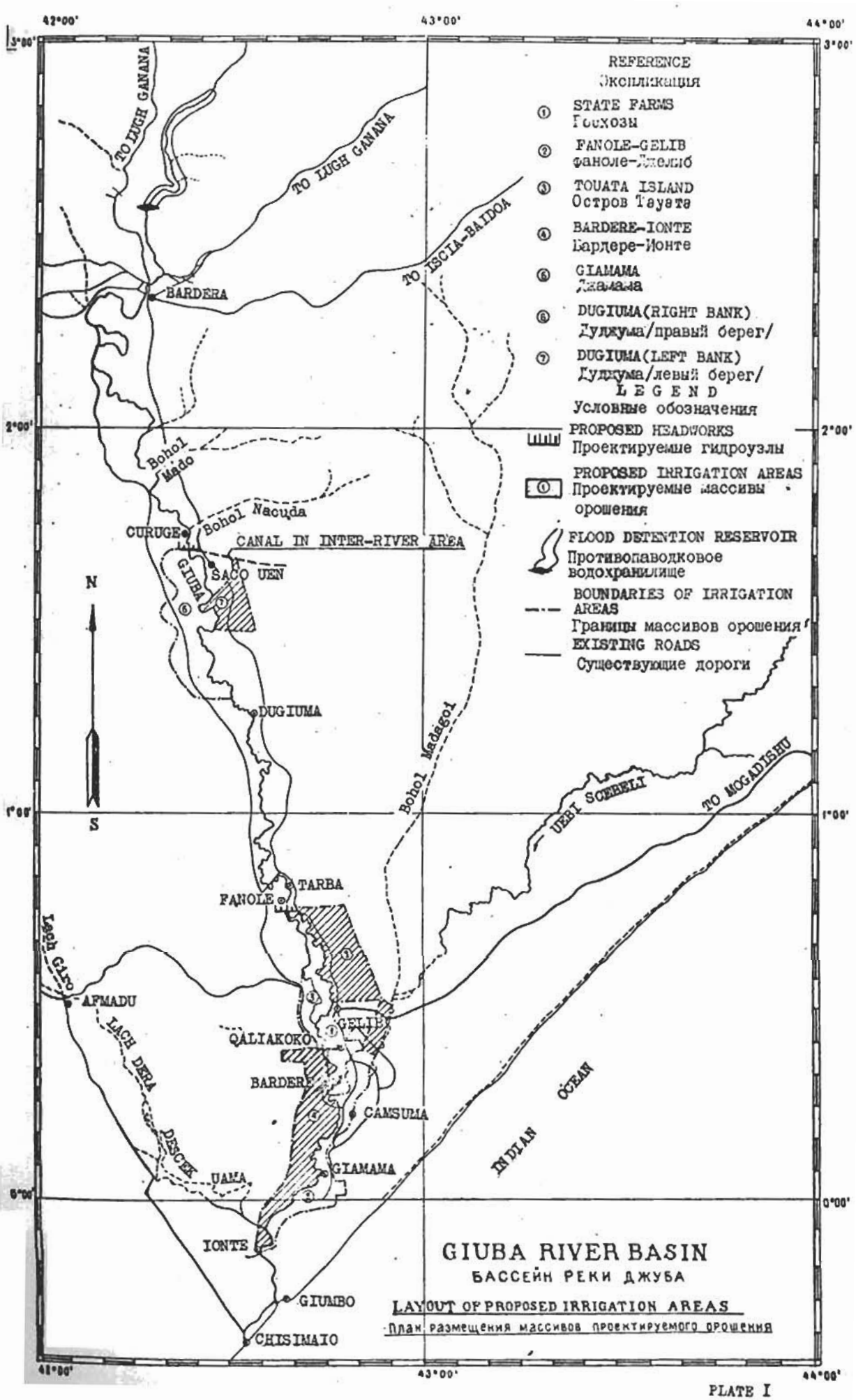

PLATE I
Формотка

I N T R O D U C T I O N

The Giuba River basin is one of the most important regions of the economic development of the Somali Republic. There are vast areas of lands suitable for the cultivation of valuable irrigation crops as well as water resources necessary for the irrigation development in the Giuba basin. As a result of the implementation of the irrigation developments envisaged by the present Scheme the country will be able to meet its domestic requirements in food products, raw materials for the cotton industry as well as to expand the export of the most important kinds of the agricultural raw materials.

The lands and water resources of the Giuba basin have been insufficiently developed. About 27 thous.ha of lands are irrigated in the basin, of this hectarage 21 thous.ha are irrigated by flooding two times a year during the flood periods. The dry arable lands are not taken into consideration as there are no data on their hectarage. The rest irrigated lands are under banana, citrus, coconut palms and other crops. The volume of water used for irrigation is about 0.28 km. The natural conditions of the basin are rather complicated. The flat topography typical of the Lower Giuba area necessitates the construction of canals in fills to ensure the command over the irrigated fields.

The river banks are low and the channel cannot pass the flood discharges. The maximum discharge of 5% probability equals 1800 cumecs. The discharge capacity of the river channel does not exceed 600÷700 cumecs. Floods usually occur each other year and therefore flood control is the necessary measure for the development of the agricultural production and for the general economic development of this area.

There are no local power resources in the Giuba basin. The possibilities for power generation are limited by the unfavourable distribution of the river flow and by the lack of the required storage capacities for the flow regulation. Therefore to find the possibilities for gravity irrigation is very important.

The Giuba flow of the 75% probability year is 4.9 cu.km, its distribution within a year being rather uneven. The water discharges fluctuate from 5 to 430 cumecs, the mean discharge being 155 cumecs. The irrigation capacity of the river under the non-regulated flow distribution does not exceed 106 thous. ha of lands during the first cropping season (April-July) and 49 thous.ha during the second cropping season (September- January).

The study of the data of soil investigations performed by the expedition of the Special Fund, FAO UNO, shows that the land resources of the Giuba basin exceed the irrigation capacity of the river and make up over 220 thous.ha. These lands are quite suitable for the cultivation of irrigation crops.

In order to prevent the floods in the Lower Giuba area it is proposed to construct a dam upstream Bardera and a flood detention reservoir whose total storage capacity equals 1.6cu.km. The reservoir shall permit to reduce the maximum flood discharges occurring once per 20 years from 1780 to 700 cumecs and to eliminate the flood danger.

Besides its main purpose, the reservoir may be used for the detention of some portion of the flood flow with its further utilization for the irrigation and power needs in low-flow months. The volume of the regulated portion of the 75% probability flood is equal to $368 \cdot 10^6$ cu.m. Hence, the reservoir can increase the irrigation capacity of the river.

The calculations have proved that, if the irrigation system is recharged from the reservoir in the low-flow period, it will be possible to irrigate 148.6 thous.ha with the Giuba water. These lands are undoubtedly suitable for the irrigation of the majority of crops.

For the irrigation of the above-mentioned lands the Scheme provides for the construction of 6 irrigation systems and 3 diversion headworks on the Giuba River to ensure the command over the irrigation systems. The upper headworks at Saco Uen is planned to take water and divert it to the Giuba-Uebi Scebeli inter-river area. The irrigation systems of Fanole-Gelib and Touata will be supplied with water from the Fanole head -

works which is to be constructed to irrigate the lands of the cotton and oil crops state farms.The construction cost of the irrigation systems with due regard for all expenditures within the river basin will total So.732 mill.The average construction cost per 1 ha of irrigated lands equals So.5300.The latter does not include the cost of boscalia clearing.The Somali Side states that this cost will be successfully paid back by the cost of charcoal.The cost of boscalia clearing and rough land levelling makes up from So.430 to So.690 per ha.Besides the expenditures on the construction of the irrigation systems, about So.23 mill. will be required for the agricultural development of lands.This sum includes the expenditures on the land organization,construction of road network,planting of perennial plants and forest belts,production facilities,etc.The unit cost of development of 1 ha of irrigated land will approximate So.170 The total cost of 1 ha of irrigated lands is about So.5.5thous. (average for all areas),the expenditures on the construction of peasants' houses and purchase of agricultural machinery being not included.The construction of the irrigation systems and the flood detention reservoir as well as the development of lands under irrigation are to be completed within 30years.The annual expenditures on the construction and development will average So.25mill.After the development of all the areas under proposed irrigation the country will receive the following amount of agricultural production(thous.quintals per year): cotton - 671,rice - 979.2,castor beans - 139,maize - 1078,vegetables - 94,grasses and green manure crops - 1654,silage crops - 2191,grain fodder crops - 639,legumes - 412,coconuts - 8,banana - 2400,sugar cane - 5600,fruits - 300.The efficiency of the capital investments in the construction of the irrigation systems is rather high.The justification period varies from 2 years(Bardere-Ionte)to 7 years(Fanole-Gelib).The Scheme of utilization of the Giuba River for the irrigation has been prepared on the basis of the initial data given by the Somali Side.The use has been made of mainly the materials and data of the soil investigation,topographic survey and hydrologic observation of the expedition of the Special Fund,FAO UNO.

I. Climate and Hydrology

1. Climate. The Giuba River basin is characterized by the moderately hot climate of semi-arid deserts. There are two wet seasons ("Gu" in March-June and "Der" in September-November) and two dry seasons ("Gilal" in December-March and "Haggai" in June-August) in the year.

The mean annual air temperature in the Somali part of the river basin varies from 27.0°C in the south to 29.1°C in the north.

The annual amount of rainfall within the basin varies from 800 mm at the river head to 250-450 mm in the lower reaches of the river. Within the Somali part of the basin about 40-50% of the annual amount of rainfall occur in Gu season and about 20-30% - in Der season.

The air humidity in the basin is rather high. The mean annual relative humidity in the Somali part of the basin ranges from 54% in the north to 79% in the south. The driest months are December-March when humidity is 41-78%.

In the Somali Republic the prevailing winds are south-western monsoon "Kos" and the north-eastern monsoon "Asnab".

The average wind velocity on the coast is 4-6 m/sec., the maximum wind velocity being 30 m/sec.

The evaporation from the water surface varies from 1500 to 2000 mm per year.

2. Hydrology. The Giuba River originates in Ethiopia and this name is applied to the river from the junction of three rivers - Uebi Gestro, Genale Doria and Daua Parma at Dolo. The length of the Giuba River from Dolo to the mouth is 800 km and from the river head of the Uebi Gestro to the mouth - 1306 km.

3. The river flow depends on the rainfall. The Giuba flow is mainly formed in the mountainous part of the basin. From Lugh Ganana to Bardera the flow increases by 13-14% due to the lateral inflow. From Bardera to Caitoi the flow increases only by 3-5% due to the accumulation, evaporation and seepage losses in the flooded depressions. The rate of annual flow somewhat decreases downwards, i.e. from 1.06 l/sec./sq.km at Lugh Gana-

Table 1

Giuba River Flow

Site	Parameters of probability curve				Probability, %							
	Mean annual discharge, cu - mecs	Flow rate, l/sec per sq.km	C_v	C_s	10	25	50	75	80	90	95	97
Lugh Ganana	190	1.06	0.36	0.72	284	230	181	141	132	109	98	83.6
Bardera	217	1.00	0.36	0.72	322	260	208	163	150	128	110	95.4
Caitoi	222	0.94	0.36	0.72	328	266	212	166	154	131	112	97.7

Table 2

Monthly Giuba Flow Distribution by Years (April-March)

Sites	Years	Probability, % of the year	Probability, % of limiting periods VI-VII	Probability, % of limiting periods I-III	Mean Discharges, cumecs Apr.	May	June	July	Aug.	Sept	Oct	Nov	Dec	Jan	Feb	Mrch	Annual
Bardera	design	50	50	50	113	257	115	187	324	226	547	396	161	45.6	19.2	9.6	200
	1952-1953, actual	60.4	72.1	95.5	66.0	260	94.1	118	268	438	697	352	42.4	9.4	4.8	4.7	196
Caitoi	design	50	50	50	114	261	117	190	329	229	555	402	163	46.3	19.5	9.7	203
	1952-1953, actual	60.4	72.1	95.5	66.6	262	95.1	119	270	442	704	556	42.8	9.5	4.8	4.7	198
Bardera	design	75	75	75	96.7	223	74.8	120	249	172	421	305	124	23.7	9.1	5.5	152
	1953-1954, actual	72.1	46.5	88.3	30.0	187	73.8	279	536	183	263	384	61.8	16.0	4.0	4.0	166
Caitoi	design	75	75	75	98.6	227	76.3	123	253	175	430	311	127	24.2	9.3	5.6	155
	1953-1954, actual	72.1	46.5	83.3	30.4	193	75.5	285	519	187	269	394	63.1	16.1	4.0	4.0	170
Bardera	design	90	90	90	80.7	187	47.3	78	192	134	323	234	94.7	13.9	5.6	2.8	116
	1955-1956, actual	81.4	88.3	72.1	31.0	99.2	14.0	57.3	228	315	491	218	51.1	24.8	14.0	4.6	129
Caitoi	design	90	90	90	82.8	191	48.6	80.0	197	137	331	240	97.1	14.3	5.7	2.9	119
	1955-1956, actual	81.4	88.3	72.1	31.2	100	14.0	57.8	229	317	496	220	51.5	25.0	14.0	4.7	130

na and 1.00 l/sec./sq.km at Bardera to 0.94 l/sec./sq.km at Caitoi.

The flow rate and mean annual Giuba discharges of various probabilities at different sites are given in Table 1.

Table 2 shows the Giuba flow distribution within a year at Caitoi for the design years(April-March), whose flow is of the same probability per year, for the main season (August-March) and for the dry semi-seasons (June-July and January-March). The flow distribution at Caitoi has been calculated on the basis of the mean annual discharge at the site and flow distribution (in %) at Lugh Ganana.

4. The maximum Giuba discharges of various probabilities have been calculated from the short-term records at Lugh Ganana. As for Bardera and Caitoi the maximum discharges have been taken from the correlation curves of maximum discharges at these sites and at Lugh Ganana. These data are tabulated below.

Table 3

Maximum Discharges

Site	Parameters of probability curve			Maximum discharges, cumecs				
	Mean max.discharge, cumecs	C_v	C_s	Probability, %				
				1	2	3	5	10
Lugh Ganana	909	0.40	1.76	2150	1940	1785	1620	1391
Bardera	(965)	-	-	(2380)	(2060)	(1950)	(1760)	(1505)
Caitoi	(982)	-	-	(2430)	(2097)	(2000)	(1800)	(1540)

The design hydrographs of the Giuba floods of 1 and 5% probabilities at Bardera have been plotted by the models of the autumn floods of 1951 and 1961 at Lugh Ganana. The design flood hydrographs have the same probability of the maximum discharges and flow volumes both for the whole multi-peak flood with the duration of 100 days and for its one-peak part lasting 50 days.

5. Silt runoff of the Giuba River was studied only for Caitoi in 1963. The maximum water turbidity was recorded in May, it reached 11.3 kg/cu.m. The mean annual water turbidity, ρ, was 2.37 kg/cu.m. The sediment load runoff, R, in 1963 was 438 kg/sec. or 13.8 mill.cu.m.

The mean many-years' runoff of the sediment load in the Giuba River at Caitoi equals 18.5 mill.tons (or R_0=590 kg/sec.; ρ_0 = =2.66 kg/cu.m), at Bardera it equals 20.2 mill.tons (or R_0=640 kg/sec., ρ_0=2.95 kg/cu.m).

The major portion of the sediment load (92%) consists of dusty and clayey particles, sand making up only 8%.

The drift load runoff has been adopted as 7% of the sediment load runoff.

6. During the flood periods the Giuba water mineralization is rather high (500-1000 mg/l) and even very high (>1000mg/l), during the rest of the year the water mineralization is average (200-500 mg/l). In the lower reaches of the Giuba River the maximum water mineralization can be as high as 1600 mg/l.

II. Economic Prerequisites

1. The Somali Republic has taken the road of development after it gained its independence in 1960. It is quite understandable that during this short period the country could not overcome its economic backwardness. The Somali Republic is a poorly developed agricultural country. The existing industrial enterprises mainly process agricultral products. The agriculture is of limited specialization as until recently attention was paid only to the export crops. A considerable amount of food and industrial commodities is imported though they can be produced within the country. They make about 40% of the total import and include: textile goods - 18%, grain and food - 10%, fruits and vegetables - 6%, sugar - 4%.

In 1957-1961 the main itemsof export were bananas making 46% of the total, livestock - 23%, hides and skins - 10%.

2. During almost the whole post-war period the country experienced a trade deficit. This deficit should be reduced

and eliminated due to the reduction of the imported goods which could be produced in the country and due to the increase of the export of cotton, oil crops, citrus, animal products. The agricultural development of 148.6 thous.ha of new lands will contribute to the solution of this problem. This problem was put under solution by organizing the cotton and oil crops state farms on the area of 10.1 thous.ha.

III. Land Resources and Their Use

/ 1. No data on the use of the lands in the Giuba basin are available except 27.5 thous.ha of irrigated lands, including 6 thous.ha of lands regularly irrigated and the lands irrigated by overflooding, i.e. the lands are flooded twice a year during the flood periods. Bananas, citrus and other crops are cultivated on the lands under regular irrigation. Cotton, maize, peanuts, sesame and other crops are grown on the lands where native methods of irrigation (overflooding) are applied. /

At some farms, where single or regular irrigation is practised, the yields of crops are as follows: maize - 10-20 quintals/ha, interrow beans - 1-2 quintals/ha, peanuts - 10-20quintals/ha, sesame - 2-8 quintals/ha, raw cotton - 2-8 quintals/ha, bananas - 200-400 quintals/ha. But the yields within the country as a whole are much lower.

2. Animal husbandry is the main accupation and the only source of existence of the majority of the population in the country. Tentatively, in 1961 the horned cattle numbered 1.5-2 mill. heads, camels - 4-5 mill.heads, goats and sheep - 12-13 mill. heads. The animal husbandry is poorly developed. The cattle is low productive. The animal production is of low quality.

/ 3. The present Scheme envisages irrigation of six land areas in the Lower Giuba covering 163.3 thous.ha, gross, or 138.5 thous.ha, net. The land areas and their hectarage are given below.

Table 4

Areas of Proposed Irrigation

Nos.	Areas	Hectarage, net
1.	Fanole-Gelib	23985
2.	Touata Island	13300
3.	Bardere-Ionte	32200
4.	Giamama	20025
5.	Dugiuma(right bank)	34000
6.	Dugiuma(left bank)	15000
	Total	138510

Besides, 10.1 thous.ha of the lands under the state farms will be irrigated.

4.The climatic conditions of the Republic permit to cultivate crops all year round. According to the rainfall there exist two cropping seasons (vegetation periods). These seasons have been historically established. The first season coincides with the rainy period "Gu". It begins in March-April and ends in August-September. The second season coincides with the rainy period "Der". It begins in September-October and ends in February-March. The second season is more favourable for the cultivation of crops whose water consumption is high and the vegetation period is long.

5. The major crops which can be cultivated on the irrigated lands are: cotton, rice, castor beans, sugar cane, bananas, cocoanut palms, tropical fruits. Maize, legumes and fodder crops can be recommended for cultivation as supplementary crops.The areas under major crops have been determined with due regard for the country's requirements in this or that product and with regard for the expansion of export.

Cotton and castor beans are planned to be the major crops on the areas of Fanole-Gelib, Touata Island, Bardere-Ionte and Giamama. Considerable area will be under maize, besides 15 th.ha are allotted to year-round crops. The Fanole-Gelib area makes an exception. Rice cultivation is proposed on the Dugiuma area (right and left banks). Because of the insufficient amount of water the lands of these areas are not used during the first season. Three large mechanized state farms of the main crops will be organized on the areas of proposed irrigation. In the districts of Gelib and Giamama the cotton and oil crops state farms are being founded. It is recommended to establish a rice show-trial state farm.

6. The yields gained at some farms prove that a farmer can crop high yields if the main agrotechnical methods are used. The following yields have been adopted for the year of complete development:

raw cotton	- 18 quintals/ha
paddy	- 30 - " -
maize	- 35 - " -
legumes	- 20 - " -
grasses, green manure crops (hay)	- 50 - " -
non-shelled castor beans	- 15 - " -
silage crops	- 350 - " -
grain-fodder crops	- 35 - " -
bananas	- 480 - " -
sugar cane	- 800 - "" -
fruits (on the average)	- 150 - " -

The seasonal land distribution under crops is as follows:

Table 5

Crops	Area, ha				
	1st season		2nd season		total hectarage
	ha	%	ha	%	
1	2	3	4	5	6
Cotton	-	-	37285	26.9	37285
Rice	-	-	32640	23.6	32640

Table 5
(contd.)

1	2	3	4	5	6
Castor beans	-	-	9270	6.7	9270
Maize	8225	9.2	22575	16.3	30800
Vegetables	185	0.2	335	0.2	670
Grasses, green manure crops	33090	37.0	-	-	33090
Silage crops	6260	7.0	-	-	6260
Grain-fodder crops	17510	19.5	785	0.6	18235
Legumes	-	-	20620	14.9	20620
Non-irrigated fallow lands	9270	10.3	-	-	9270
Year-round crops, total	15000	16.8	15000	10.8	15000
incl.:					
coconut palms	1000	1.1	1000	0.7	1000
bananas	5000	5.6	5000	3.6	5000
sugar cane	7000	7.8	7000	5.1	7000
fruits	2000	2.3	2000	1.4	2000
Grand total	89510	100.0	138510	100.0	

IV. Technical Measures for Irrigation Development

1. Water Studies

1. In accordance with the Contract the Giuba River Scheme should be based on the utilization of the natural river flow. As the fluctuation of the river flow both for the observed years and within each year is considerable, the flow of the theoretical year of 75% probability has been accepted as a design one. The data are given below.

Table 6

Monthly Flow Distribution of Design Year

April			May	June	July	Aug.	Sept.	Oct.
1-10	11-20	21-30						
8.3	23.5	261	227	76.3	123	253	175	430

Nov.	December			Jan.	Feb.	March	Average per year	
	1-10	11-20	21-31				Q	Flow 10^9 cu.m
311	207	144	30.0	24.2	9.3	5.6	155	4.9

The Table shows that the flow fluctuates within the wide limits, the maximum discharge being in October, the minimum one in March. The low-flow period lasts from the end of December till the end of April. Such flow distribution hampers the designing of irrigation with the use of the natural flow. The climatic conditions make it possible to use the irrigated lands twice a year but the water deficit in the certain period of the year prevents it.

2. The land resources of the Giuba River basin many times exceed the irrigation capacity of the river. The reclamation evaluation of the soils in the Lower Giuba area is given by the Giprovodhoz experts on the basis of the data of the UN Special Fund (UNO/FAO). The data on the land resources in the areas under the proposed irrigation are tabulated below.

Table 7

Lands of Proposed Irrigation in Lower Giuba Area

Areas	Total area, ha	Soil-reclamation groups						
		I	II	III	IV	V	VI	W
Fanole-Gelib	53990	12740	15440	8750	16440	-	-	620
Touata Island	16420	15650	-	350	420	-	-	-
Bardere-Ionte	39670	10300	27600	-	1770	-	-	-
Giamama	40240	14660	12140	11860	500	-	1080	-
Dugiuma: right bank)	40000	-	-	40000	-	-	-	-
Dugiuma (left bank)	18000	-	4000	14000	-	-	-	-
Total	208320	53350	59180	74960	19130	-	1080	620
Irrigation areas of state farms	16397							
Grand total incl. state farms	224717							

Note: W - lands inundated during flood periods

The soils of Groups I and II are suitable for irrigation of any crop, except rice, without tile drainage. The soils of Group III are more suitable for rice as these soils have fine texture. Taking into consideration the fact that the cost of the drainage construction in the Giuba area is high, provision is made in the Scheme for the development of the soils of Groups I and II as well as of Group III for rice.

3. The irrigation capacity of the river under the natural conditions is not high. The Giuba flow of the 75% probability year will permit to irrigate 106 thous.ha of lands during the

first cropping season (April-July) and 49 thous.ha during the second cropping season (September-January). The flood detention reservoir of Bardera which is to be constructed will permit to partially regulate the flood flow and consequently, to increase the irrigation capacity of the river. The reservoir can cover the water deficiency amounting to 311.10^6 cu.m in the design year. This will allow to irrigate 148.6 thous.ha of lands, including: 15 thous.ha under perennial crops, 85.6 thous.ha under seasonal crops with two times sowing, 49 thous.ha under crops included in the rice crop-rotation (once a year).

4. The water consumption of the adopted crops has been determined in Section III. The calculations are based on Blaney-Criddle's method. Table 8 shows the gross amount of water to be taken to the areas under the proposed irrigation. The following efficiencies of the irrigation systems have been adopted when calculating the water consumption:

a) rice irrigation systems - 0.75

b) other irrigation systems - 0.65

The higher efficiency of the rice irrigation systems can be explained by the fact that the field losses are taken into account when determining the water consumption of crops.

In the water studies besides the main water consumers, such as irrigation and power generation, account is taken of the water amounts necessary for the Uamo reservoir feeding and for the water diversion to the Giuba - Uebi Scebeli inter-river area. The water deficiency is covered by the Bardera reservoir.

5. In the water studies there has been established the dam hydropower plant operations at Fanole for the two periods of development:

1) after the construction of the headworks and the irrigation systems of the state farms - under the natural conditions;

2) after the completion of the Bardera flood detention reservoir - under the conditions of the partial flow regulation.

In the first case the hydropower plant will not operate 5months a year, i.e. from December to April. In the second case the hydropower plant will not operate only 1.5 month when high flood discharges are passed.

Table 8

Gross Water Consumption of Areas under Proposed Irrigation

(cumecs)

Water consumer	Irrigation area, net ha	April 1-10	April 11-20	April 21-30	May	June	July	Aug.	Sept.	Oct.	Nov.	December 1-10	December 11-20	December 21-31	Jan.	Feb.	March
Panole-Gelib	23985	-	5.22	I2.53	I5.52	I8,09	II.40	2.I4	9.52	I4.67	22.I8	20.20	I7.53	I2.64	9.29	0.05	0.05
incl. a state farm	5037	0.85	I.82	I.98	2.76	3,08	2.56	0.88	0.85	0.85	2.85	3.45	3.78	4.09	3.73	I.63	-
Touata Island	I3300	I.2	2.93	6.06	7.29	8,9I	6.06	2.56	6.47	8.I5	II.60	I0.25	I0.00	8.5I	6.35	I.89	I.8I
Giamama	26093	2.76	6.I2	I0.I9	I2.44	I5,38	I2.04	6.02	I0.69	I4.53	20.66	26.34	I8.62	I6.42	I2.3I	4.46	3.82
incl. a state farm	5068	-	0.57	I.26	I.87	2,76	2.40	0.75	-	I.04	2.44	3.I9	3.69	3.39	3.I5	0.64	-
Bardere-Ionte	32200	7.09	I0.30	I4.80	I5.80	I9,00	I6.00	II.50	I7.45	22.40	28.20	24.80	24.35	2I.50	I8.20	I0.95	9.72
Uamo reservoir	-	-	-	I2.0	I2.0	-	I2.0	I2.0	I2.0	I2.0	I2.0	I2.0	I2.0	-	-	-	-
Dugiuma(right bank)	34000	-	-	-	-	-	-	6I.90	65.0	58.8	4I.8	20.26	I2.50	-	-	-	-
Dugiuma(left bank)	I5000	-	-	-	-	-	-	27.3	28.6	26.0	I8.45	8.95	5.52	-	-	-	-
Water diversion to inter-river area	-	5.0	5.0	I0.0	I0.0	8.0	I0.0	I0.0	I0.0	I0.0	I0.0	I0.0	I0.0	5.0	5.0	5.0	5.0
Total	I486I5	I6.9	3I.4	67.6	75.8	72.5	70.06	I34.3	I60.6	I67,4	I67.7	I29.3	II4.3	68.2	54.9	23.9	20.4
Giuba River flow		8.3	23.5	26I	227	76.3	I23	253	I75	430	3II	207	I44	30.0	24.2	9.3	5.6
Deficiency		8.6	7.9	-	-	-	-	-	-	-	-	-	-	38.2	30.7	I4.6	I4.8

However the hydropower plant wil . reliable even at the firs: stage of development for the prime cost of electricity, generated by the hydropower plant will be half as much as that, generated by a diesel power plant.

2. Diversion Sites

1. The outline for water supply of the areas to be irrigated is based on water diversion at three sites where the headworks are to be constructed. Among those the Fanole headworks is under execution. The proposed areas of Fanole-Gelib, the Touata Island and the lands of both state farms will be under the command of the Fanole headworks. The construction of the Qaliakoko headworks with two-sided water taking has been proposed to divert water to the Bardere-Ionte and Giamàma areas. It is planned that at the last stage of development after the construc - tion of the Qaliakoko headworks the lands of the oil crops state farm and a part of the Gelib area (4 thous.ha) will be under the command of the Qaliakoko headworks. The Dugiuma areas(left and right banks) will be under the command of the headworks which is to be located upstream Saco Uen. A supply canal will run from the Saco Uen headworks to the Giuba-Uebi Scebeli inter-river area.

2. The total amount of the water taken with regard for all water consumers is shown by the water discharges below.

Table 9

Headworks	Water discharge, cumecs	
	right bank	left bank
Fanole	12.7	33.8
Qaliakoko	40.6[x)]	21.7
Saco Uen	92.0	40.6[xx)]

x) Including 12 cumecs for the Uamo reservoir feeding

xx) Including 10 cumecs for the water diversion to the inter-river area.

3. Irrigation Systems

1. The lands under proposed irrigation in the Giuba basin form six independent areas, each of them will have a separate irrigation system. The irrigation system comprises a main canal, distributors, minor canals and a collecting-drainage network. The lay-out of the systems is given on plans in Section II.

2. The Fanole-Gelib area is located on the left bank of the river and stretches from Fanole to Qaliakoko. The total net area is 34440 ha, including 10455 ha of the irrigated lands of the state farms. The Fanole-Gelib area will be developed by stages. It is proposed that at the first stage the lands located to the left of the canal will be developed. These lands are protected from floods by the canal bunds. A strip of land restricted by the river and the canal can be developed only after the completion of a flood detention reservoir. Three big collectors are planned to divert waste water from the area. Two collectors will divert waste water by gravity to Farta Tuoulle. The third collector will divert waste water by pumping.

3. The irrigation system of the Touata Island should serve the lands located on the Touata Island and on the right bank upstream the Qaliakoko site. The total net area is 13300 ha, including 4600 ha of the right-bank lands. About one third of the lands is under dry crops. A protecting collector, 3-4 m deep and about 30 km long runs along the levee that protects the area from flooding. The Uebi Iero branch forming the island has a cofferdam at the head and a dyke at the tail. To supply the villages located along the banks of the branch with water it is proposed to feed the branch with water taken from the main canal. It is planned to spill the rainstorm water from the branch to the downstream of the Qaliakoko headworks with the help of a collector (CT-1).

4. The Bardere-Ionte area stretches along the right bank of the river from Qaliakoko as far as Ionte. At present the riverside land strip 1.5-2.0 km wide is either under banana plantations and dry crops or is being developed for the agricultural use.

The rest part of the area is grown with brush and trees. An escape channel to the Uamo depression crosses the area. It is proposed that the Uamo reservoir should be recharged from the main canal. In high-flow months the recharge will be equal to 12 cumecs.

The Bardere main canal line will run along the western boundary of the area. Its length is about 51 km. A branch-off canal to Uamo is designed at km 41.

5. The Giamama area is located on the left bank of the river. From Camsuma to Giamama the area forms a narrow land strip adjoining the river and farther on it widens up. The total area of the irrigated lands will be 25143 ha, net, provided the oil crops state farm and a part of the Fanole-Gelib area are fed from the Qaliakoko headworks. From the east side of the fartas the area is protected with the levee.

The irrigation system of the area includes the Giamama main canal, four big interfarm distributors, innerfarm canals and collecting-drainage network. The latter has two interfarm collectors C-1 and C-2.

6. To the north of Dugiuma there are two areas located on either side of the river. Here rice plantations are to be organized, the soil of Group III will be used. The area under proposed irrigation covers 34 thous.ha on the right bank and 15th. ha on the left bank. The organization of the rice plantations on these lands is favourable as it is possible to divert water to the river by gravity and to reuse the waste water on the lands located downstream.

As there are no topographic maps of the area only plans of the major canals have been prepared. Elevations are not shown. The volumes of works have been adopted by the analogy with the Bardere-Ionte system as being most similar both according to the water discharges in canals and according to the topography.

7. The main data on the irrigation systems are given below.

Table 10

Irrigation systems	Canal length, km	Number of structures, pcs	Volume of work		
			fill, th.cu.m	excavation th.cu.m	rainforced concrete, cu.m
Fanole-Gelib	3834	6644	4110	7070	9176
Touata Island	2136	3698	2142	3999	4105
Bardere-Ionte	5025	8877	4615	9212	10979
Giamama	3208	5571	6275	6517	9650
Dugiuma (right bank)	5314	9385	5121	9786	12649
Dugiuma (left bank)	2345	4139	2269	4338	5442
Total	21863	38314	24532	40922	52001

4. Flood Control

1. The Giuba River is a typical rainfed river. The floods are mainly formed beyond the boundaries of the country on the territory of Ethiopia. The maximum discharges increase by 10% on the stretch Lugh Ganana - Caitoi. The Giuba floods are characterized by the following maximum discharges:

Table 11
(cumecs)

Site	Probability, %			
	1	5	10	50
Bardera	2380	1760	1505	870
Caitoi	2430	1800	1540	880

2. The discharge capacity of the Giuba River does not exceed 700÷750 cumecs at the Fanole site and 550÷600 cumecs at the Giamama site. The comparison of the above figures with the data of the Table 11 shows that because of the insignificant discharge capacity of the river channel floods often result i· inundations. On an average each other year floods occur.

Vast territories in the Lower Giuba area are flooded.Fields, villages, towns and enterprises are inundated. The major part of the river valley is subject to flooding. During the flood of 1960-1961 the greater part of the banana plantations was damaged.

3. There are no depressions that could be used for the relief of floods. The storage capacities of the available depressionsare insignificant. The biggest depression is the Uamo reservoir, its storage capacity being $200 \cdot 10^6$ cu.m.An escape channel with a head regulator designed for the discharge of 100cumecs approaches the reservoir. The rest depressions ("desceks") are very small and are used as irrigation areas during seasonal floods except the Rededi descek which serves as a drinking source.

4. The proposed development of irrigation in the Giuba basin necessitates the detailed studying of this problem and the working out of the protection of the irrigation systems against floods. Two alternatives of flood control have been considered in the present Scheme: the flood regulation by reservoirs and the construction of levees along the flooded stretch from Dugiuma to Ionte. As a result of the engineering and economic evaluation of both alternatives the preference has been given to the alternative with a flood detention reservoir. Under the alternative the cost of main structures equals So.36 mill., while the cost of levee construction reaches So.92 mill.

5. A dam of the flood detention reservoir has been proposed at the Arrento site located 35 km above Bardera. The F.S.L. being 40.00 m the total storage capacity of 1.6 cu.km is limited by the topography. The useful storage capacity is 1.26 cu. km. The main dimensions of the dam are as follows: height-42 m, length along the crest - 800 m. The dam is of a rock-filled ty-

pe with the core of loam. A tube escape with the maximum discharge capacity of 1100 cumecs and an open bank emergency escape for the discharge of 950 cumecs have been proposed at the dam. The construction of the headworks totals So.47.6 mill.

6. The reservoir has been proposed to transform the maximum flood discharges of 5% probability to the value of 700 cumecs. This amount of water can be discharged through the Giuba channel without overflowing the banks. The partial regulation of the flood flow at its recess has been planned in order to use the water for the feeding of the irrigation systems during dry months and to ensure power releases. The volume of the regulated flow by the year of 75% probability equals 311.10^6 cu.m.

5. Cost and Priority of Construction

1. The construction cost has been determined with the use of the unit costs given in the estimates for various projects namely, the Project Report on Irrigation of Lands under the Cotton and Oil Crops State Farms in the Republic of Somali and other.

2. The total cost of the Scheme with regard for all production costs is shown in Table 12.

The cost of the flood detention reservoir has been allocated to the irrigation systems proportionately to the areas under the proposed irrigation. The cost of levee construction at the Farta Tuculle has been included in the cost of the Fanole-Gelib and Giamama irrigation systems. Besides, the main production facilities, the cost of the irrigation systems includes the capital invested in the preparatory works, in the construction of auxiliary facilities and temporary dwellings.

3. The unit costs of the irrigation systems are tabulated below.

Table 12

Costs of Irrigation Facilities

(thous.So.Sh.)

Expenditures \ Systems	Fanole-Gelib	Touata	Bardere-Ionte	Giamama	Dugiuma		Total
					right bank	left bank	
Preparatory works	4852.6	2787.2	7132.8	5006.8	8740.1	3850.6	32370.1
Cost of major irrigation facilities	81233.6	46658.5	119405.3	83816.5	146312.3	64459.9	541886.1
Cost of auxiliary facilities	3899.3	2239.6	5731.4	4023.2	7023.0	3094.1	26010.6
Temporary buildings and construction mechnisms	9448.5	5426.9	13888.3	9748.9	17017.9	7497.5	63028.0
Management of the enterprise under construction	596.6	342.7	876.9	615.6	1074.5	473.4	3979.7
Design and investigation works	1988.7	1142.2	2923.2	2051.9	3581.9	1578.0	13265.9
Unforeseen expenditures	5101.0	2929.8	7497.9	5263.1	9187.5	4047.7	34027.0
Total	107120.3	61526.9	157455.8	110526.0	192937.2	85001.2	714567.4
Fanole headworks	11481.3	6050.4	-	-	-	-	17531.7
Grand total	118601.6	67577.3	157455.8	110526.0	192937.2	85001.2	732099.1

Table 13

Systems	Total cost, thous.So.Sh.	Irrigation area, thous.ha	Cost of 1 ha, So.Sh.
Fanole-Gelib	118602	24.0	4940
Touata Island	67577	13.3	5080
Bardere-Ionte	157456	32.2	4890
Giamama	110526	20.0	5500
Dugiuma(right bank)	192937	34.0	5680
Dugiuma(left bank)	85001	15.0	5670
Total	732099	138.5	5280

The cost of the irrigation systems referred to 1 ha of the irrigation areas is low in the Giuba basin as compared to the similar projects in Tanzanya, where this cost varies from So. 4400 to So.8000 per 1 ha.

4. The priority of development of the irrigation areas under consideration depends on a number of factors. One of the main factors affecting the irrigation development on the Giuba River is frequent floods in the river basin. It should be noted that the problem of rice production is necessarily to be solved. Viewing the above said the following priority of irrigation construction has been suggested:

a) Development of the lands under the command of the Fanole headworks located to the left of the Gelib main canal.

b) Construction of the dam at the Bardera flood detention reservoir.

c) Development of the irrigated lands on the Touata Island and on the left bank between the river and the Gelib main canal.

d) Establishment of rice irrigation on the Dugiuma areas and erection of the Saco-Uen headworks.

e) Construction of the Bardere-Ionte and Giamama irrigation systems and the Qaliakoko headworks. The complete period of development of all the lands is planned to be 30 years.

V. Economic Feasibility

1. The development of the water and land resources in the Giuba basin will provide the Somali Republic with agricultural products in quantities quite sufficient to meet the domestic requirements of the country and to extend export. The proposed total yield of the agricultural production is given in Table 14.

Table 14

Cultivation Areas and Total Yield of Agricultural Production by Year of Complete Development

Crops \ Areas	Fanole-Gelib	Touata-Island	Bardere-Ionte	Giamama	Dugiuma right bank	Dugiuma left bank	Total
1	2	3	4	5	6	7	8
Cotton							
Hectarage - 2nd season	11995	5760	11370	8160	-	-	37285
Total yield, th.quintals	215.9	103.7	204.7	146.9	-	-	671.2
Rice							
Hectarage - 2nd season	-	-	-	-	22650	9900	32550
Total yield, th.quintals	-	-	-	-	681.2	298.0	979.2
Castor beans							
Hectarage - 2nd season	830	1920	3800	2720	-	-	9270
Total yield, th.quintals	12.5	28.8	57.0	40.8	-	-	139.1
Maize(grain)							
Hectarage - 1st season	4705	1870	-	1650	-	-	8225
2nd season	6325	1870	3670	2680	5570	2460	22575
Total yield, th.quintals	386.1	130.8	128.4	151.6	195.0	86.1	1078.0

Table 14
(contd.)

1	2	3	4	5	6	7	8
Vegetables							
Hectarage -							
1st season	50	30	60	45	-	-	185
2nd season	50	30	60	45	100	50	335
Total yield, th.quintals	18.0	10.8	21.6	16.2	18.0	9.0	93.6
Grasses, green manure crops							
Hectarage -							
1st season	10380	3840	11370	7500	-	-	33090
Total yield, th.quintals	519.0	192.0	568.5	375.0	-	-	1654.5
Silage crops							
Hectarage -							
1st season	2000	970	1930	1360	-	-	6260
Total yield, th.quintals	700.0	339.5	675.5	476.0	-	-	2191.0
Grain-fodder crops							
Hectarage -							
1st season	6020	2870	5540	3050	-	-	17480
2nd season	785	-	-	-	-	-	785
Total yield, th.quintals	238.2	100.5	193.9	106.8	-	-	639.4
Legumes							
Hectarage -							
2nd season	4000	1920	3800	2720	5680	2500	20620
Total yield, th.quintals	80.0	38.4	76.0	54.4	113.6	50.0	412.4
Non-irrigated fallow lands							
Hectarage -							
1st season	830	1920	3800	2720	-	-	9270
Perennial crops							
Hectarage including:	-	1800	9500	3700	-	-	15000

Table 14
(contd.)

1	2	3	4	5	6	7	8
Coconut palms, ha	-	100	700	200	-	-	1000
Copra, total yield th.quintals	-	0.8	5.6	1.6	-	-	8.0
Banana							
Hectárágé -	-	500	2500	2000	-	-	5000
Total yield, th.quintals	-	240.0	1200.0	960.0	-	-	2400.0
Sugar cane							
Hectarage	-	1000	4900	1100	-	-	7000
Total yield, th.quintals	-	800.0	3920.0	880.0	-	-	5600.0
Fruits (average)							
Hectarage	-	200	1400	400	-	-	2000
Total yield, th.quintals	-	30	210.0	60.0	-	-	300.0

2. Fodder crops will produce 990 thous.quintals of feed units of coarse and succulent food. This amount of fodder will permit to have the following population of the horned cattle within the irrigation areas:

	(thous.heads)	
	Total	Including
Fanole-Gelib	40.1	cows - 16.0
Touata Island	16.4	do - 6.6
Bardere-Ionte	42.1	do - 16.8
Giamama	28.4	do - 11.4
Total	127.0	cows - 50.8

Table 15

Total Animal Production by
Year of Complete Development

(thous.quintals)

Nos.	Areas	Animal production	
		milk	meat
1.	Fanole-Gelib	160.0	44.6
2.	Touata Island	66.0	18.2
3.	Bardere-Ionte	168.0	46.8
4.	Giamama	114.0	31.6
	Total	508.0	141.2

The development of new irrigation areas will require about So.23.0 mill. of the capital investments.

The main investments are allocated to:

a) the construction of the road network - So.9.7 mill.

b) planting of forest belts - So.6.8 mill.

c) perennial plantings - So.1.5 mill.

d) land organization - So.0.8 mill.

e) production facilities - So.2.1 mill.

f) other expenditures - So.2.0 mill.

3. The capital invested in the irrigation construction and agricultural development will total So.751.1 mill. They will be justified by the profit gained annually starting from the year of complete development and in the third year for all areas.The justification of the capital investments in separate areas is shown below.

Table 16

(thous.So.Sh.)

Nos.	Areas	Total investments	Profit	Period of justification
1.	Fanole-Gelib	121941	16859	7
2.	Touata Island	69654	23228	3
3.	Bardere-Ionte	163383	87069	2
4.	Giamama	114125	41153	3
5.	Dugiuma(right bank)	198271	70625	3
6.	Dugiuma(left bank)	87358	31175	3
	Total	754732	270109	3

The justification period within the Fanole-Dugiuma area is the largest one as the main crop accepted here is cotton, the least economically attractive crop in the Somali Republic at present as compared to such perennial plants as banana, sugar cane, as well as rice. However, cotton is necessary to meet the domestic demands of the country and it is believed that the measures will be taken to increase the perchasing prices of cotton to interest the cotton growers.

Conclusions

1. The Giuba River basin is one of the most important regions of irrigation development in the Somali Republic. There are vast land areas suitable for cultivation of valuable irrigation crops as well as non-developed water resources required for irrigation.

2. If the natural non-regulated Giuba flow is used, about 100 thous.ha of land in the Lower Giuba area can be irrigated within the boundaries stipulated by the Contract.

3. It is possible to irrigate 49 thous.ha more, provided the flood detention reservoir is created, whose storage capacity does not exceed 1.6 cu.km by the topographic conditions at the only site above Bardera. According to the soil survey data these lands are proposed to be above Dugiuma beyond the area stipulated by the Contract.

4. The studies on the Bardera reservoir and the area of Du-

giuma have been done above the Contract. They are based on the insufficient survey data. However, the main subject of the studies, i.e. the irrigation area, cropping pattern, water requirements, reservoir storage capacity, flood flows, has been determined accurately enough at the level of Scheme.The Projects' components, that is canals, the dam and structures have been outlined sketchily.

5. As a result of the irrigation development in the Giuba River basin the country will be provided with all necessary products which are imported at present. Besides, the export of important agricultural raw materials will be extended.

6. The justification period in separate areas varies from 2 to 7 years, averaging 3 years. The expenditures on the construction of peasants' houses and the purchase of agricultural machinery are not included in the justification calculations.

7. Because of the insufficient data on the natural conditions in the Giuba River basin the studies and conclusions given in the present Scheme should be regarded as tentative and specified at the next stage of designing.

VI. Recommendations on Future Design and Investigation Works

It has been already mentioned that the natural conditions in the Giuba River basin have been poorly studied. The irrigation construction on the Giuba River should be preceded with investigation works. These works are to be performed according to the stages of irrigation development and erection of structures.

The investigation works and their priority are as follows:

1. Hydrology. It is necessary to continue the observations over the water levels, measurements of water discharges and silt runoff at the established staff gauges. Special attention should be paid to the measurements of maximum discharges.

2. Irrigation areas:

a) Topographic survey with the use of photoplans;

b) Geologic and hydrogeologic surveys and exploration of local construction materials;

c) Detailed soil survey with a view to determine the soil varieties within the boundaries of the irrigation areas, to obtain the data on the quality of the soil varieties and soil classification.

3. Flood detention reservoir

a) The survey of the reservoir based on the traverses to plot the plan at a scale of 1:50000 with the use of photoplans;

b) The survey of the headworks site at a scale of 1:2000;

c) The engineering and geologic survey at the dam site and in the reservoir basin;

d) The exploration of construction materials.