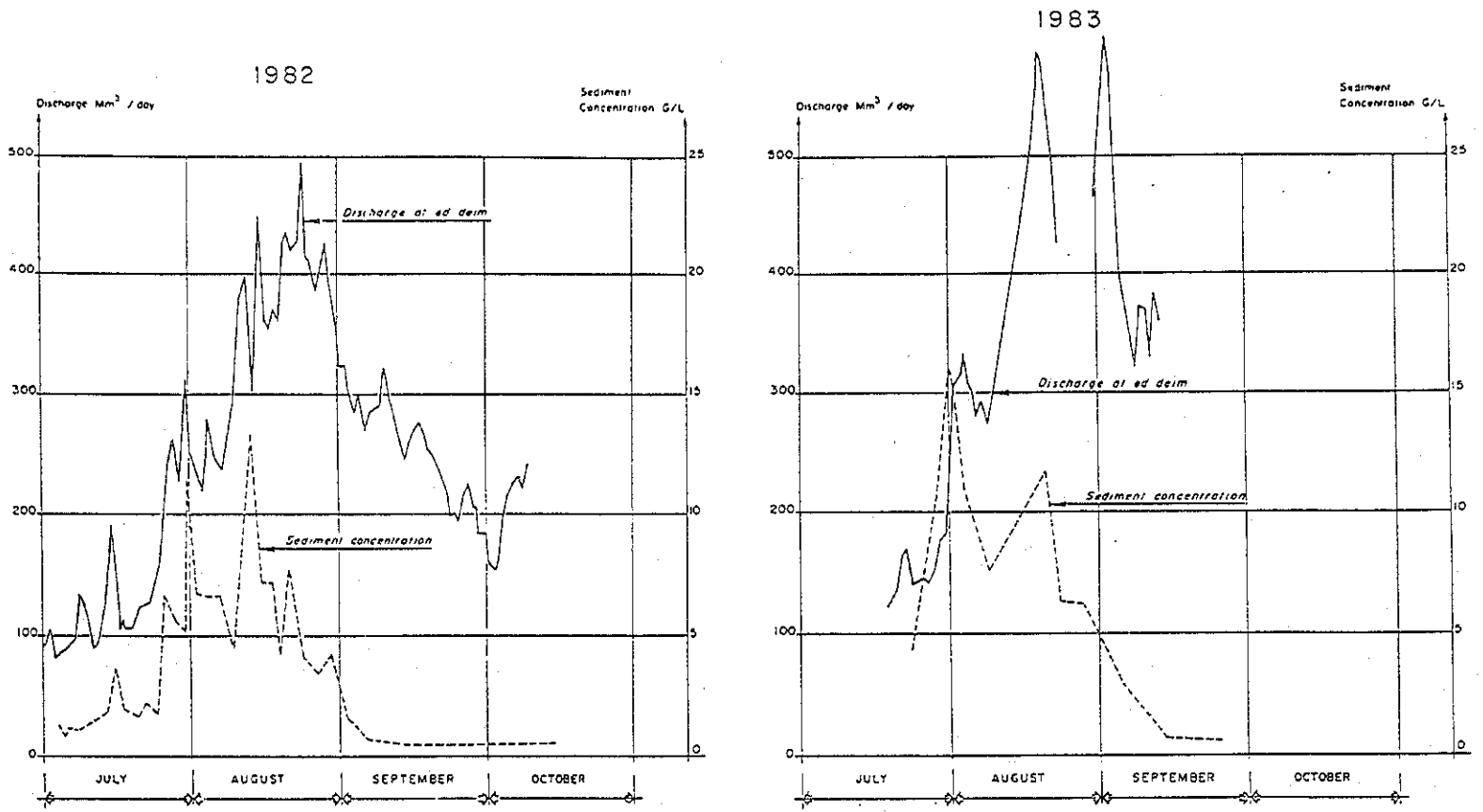
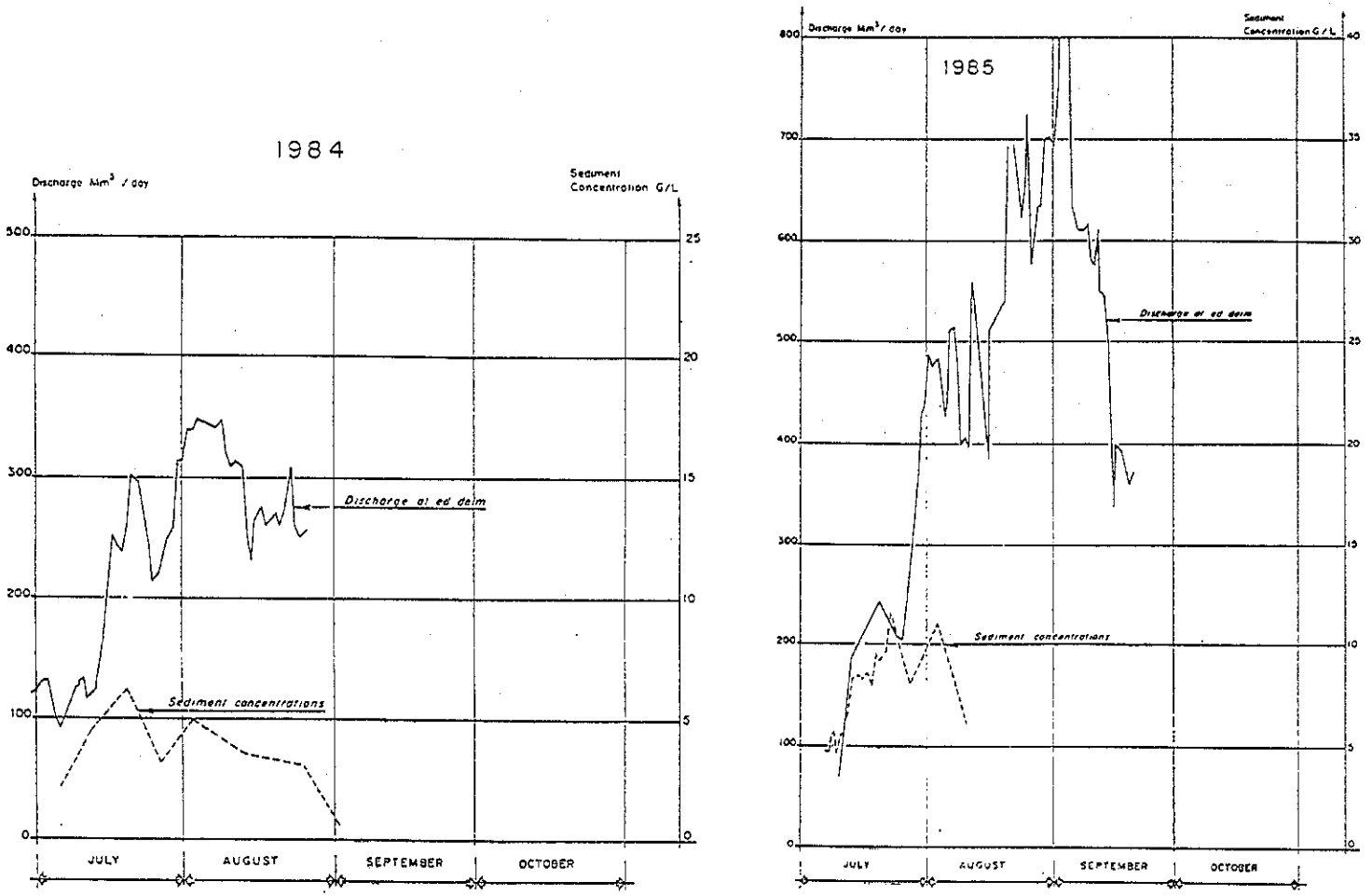


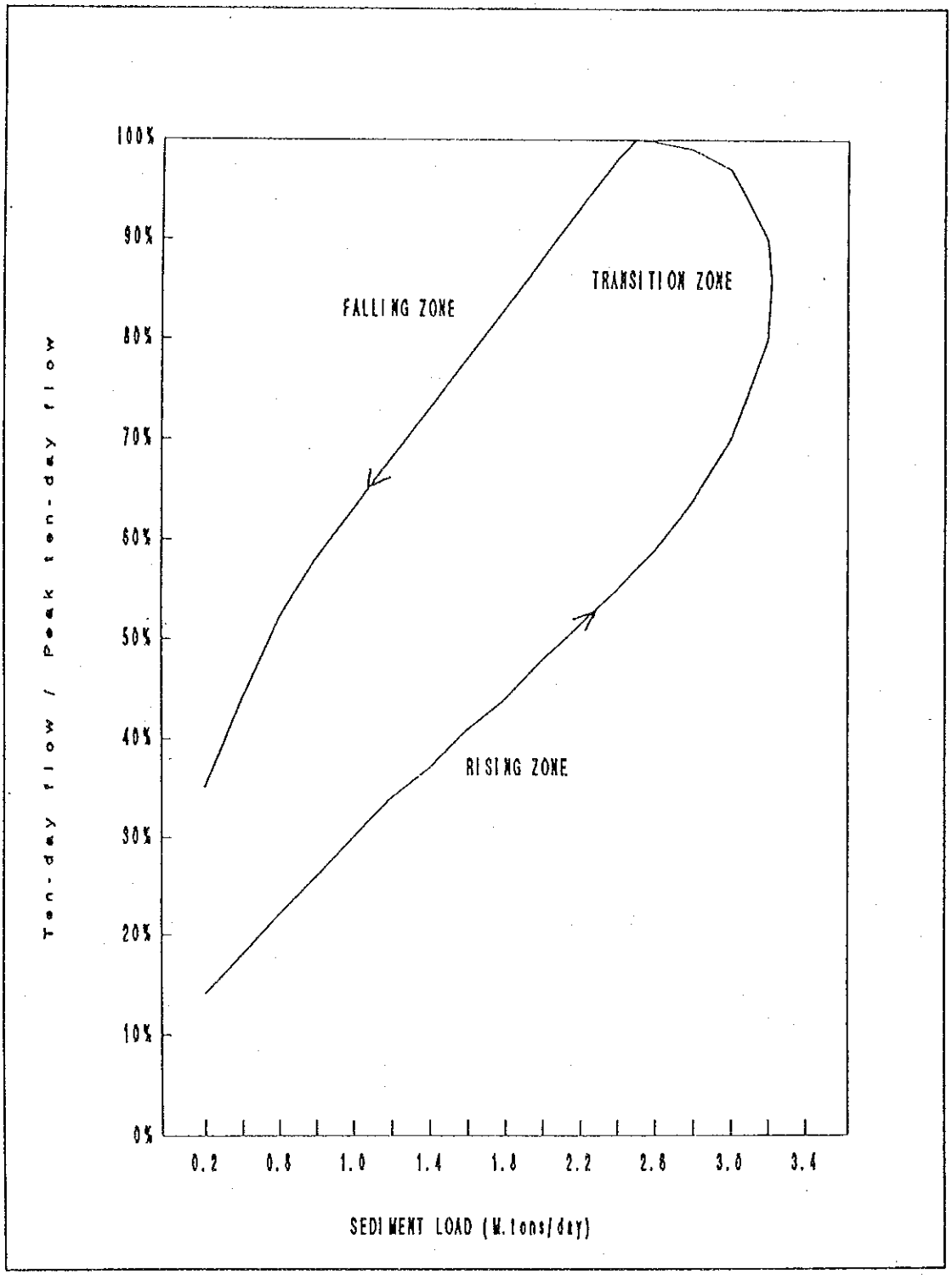
BLUE NILE SEDIMENT CONCENTRATIONS
(Downstream ROSEIRES DAM in deep sluice channel)
COB / SAGP - January 1986

Fig. 5.3 BLUE NILE SEDIMENT CONCENTRATION



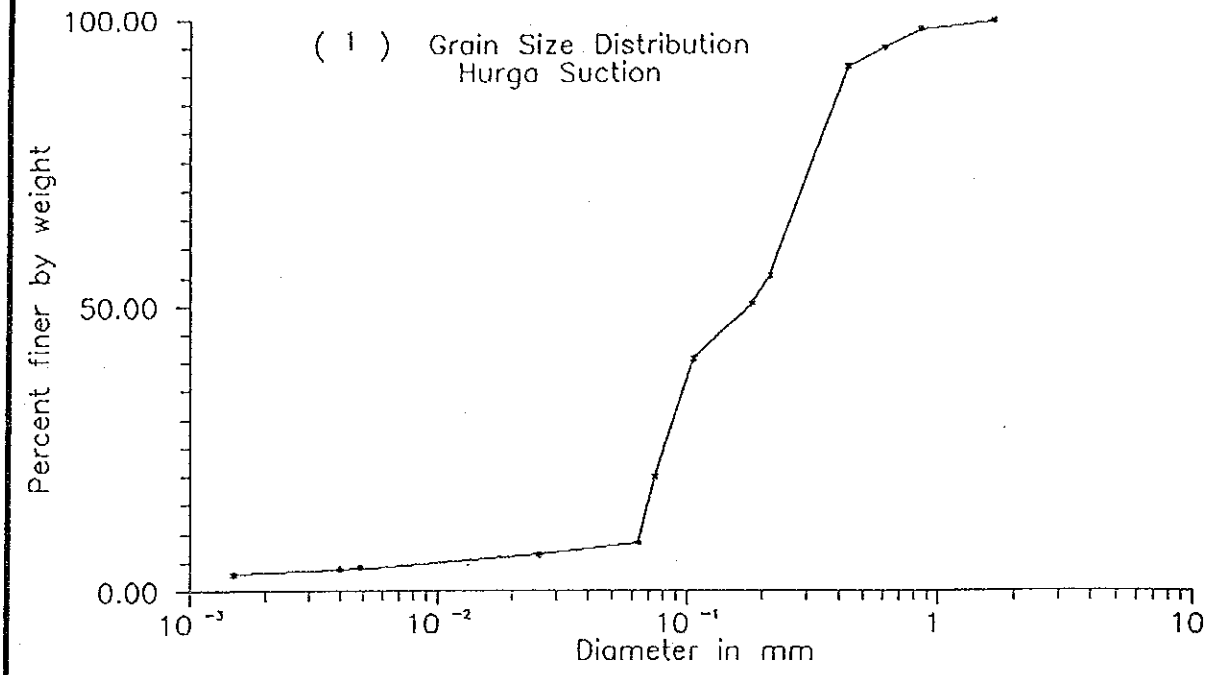
BLUE NILE SEDIMENT CONCENTRATIONS
(Downstream ROSEIRES DAM in deep sluice channel)
COB / SAGP - January 1986

Fig. 5.4 BLUE NILE SEDIMENT CONCENTRATION



Source : Updating of the Feasibility Study for the Heightening of the Roseires Dam

Fig. 5.5 SEDIMENT YIELD RATING



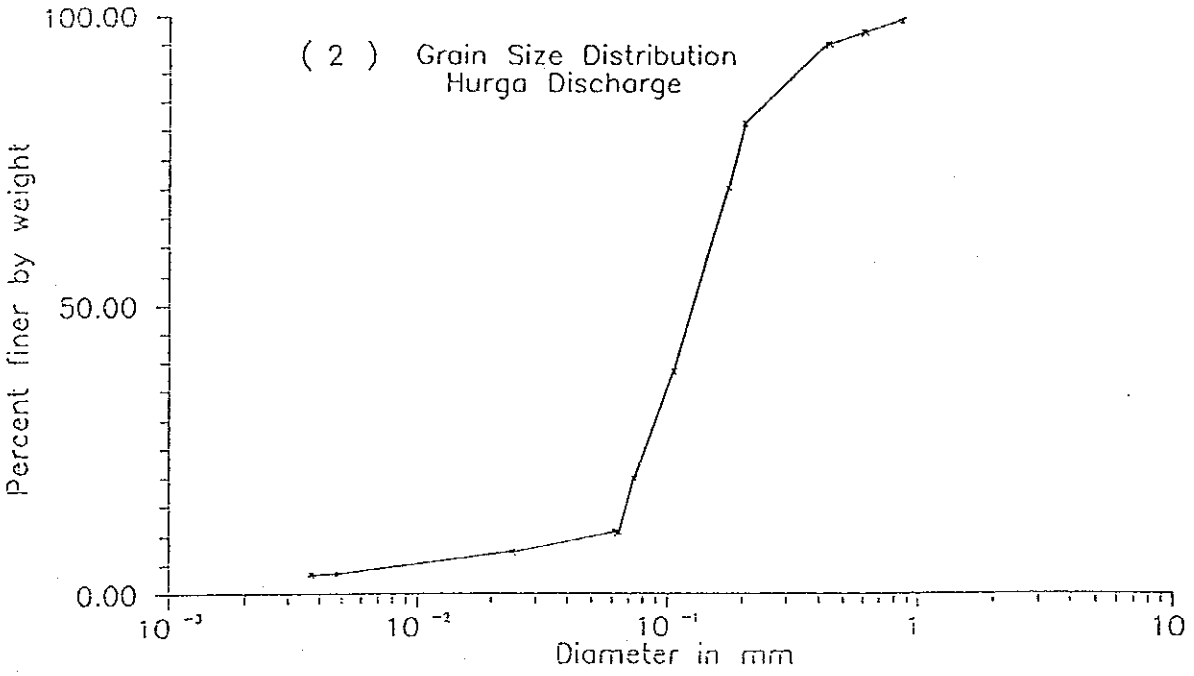
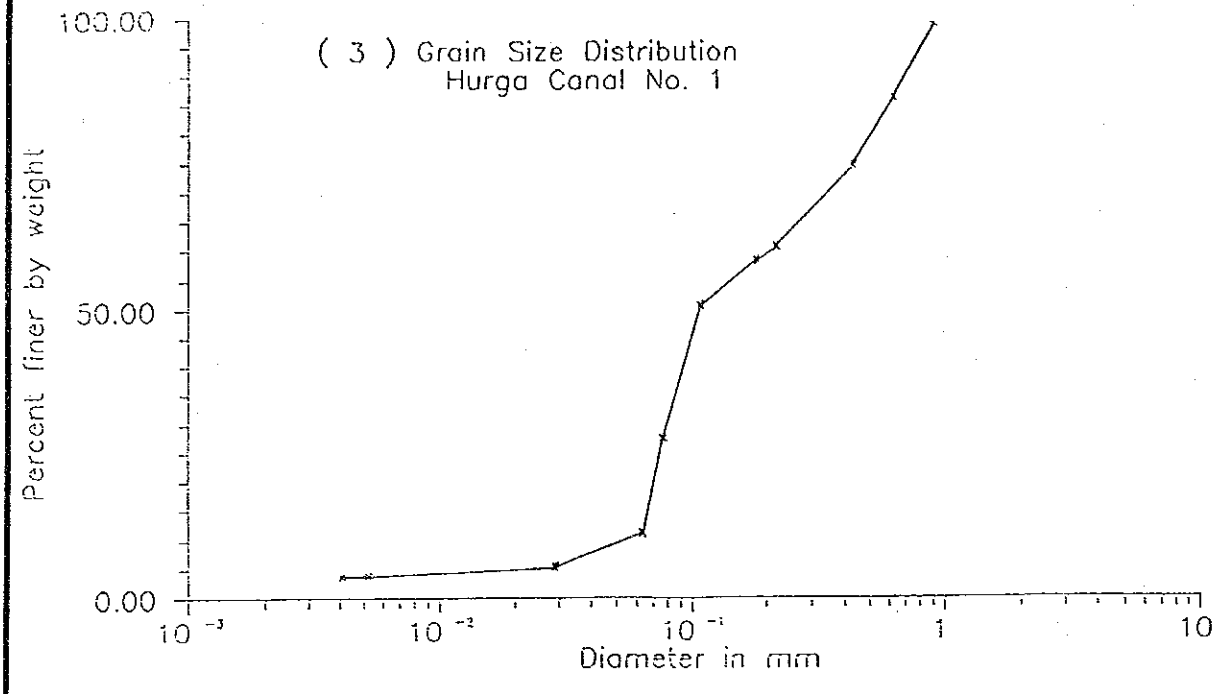
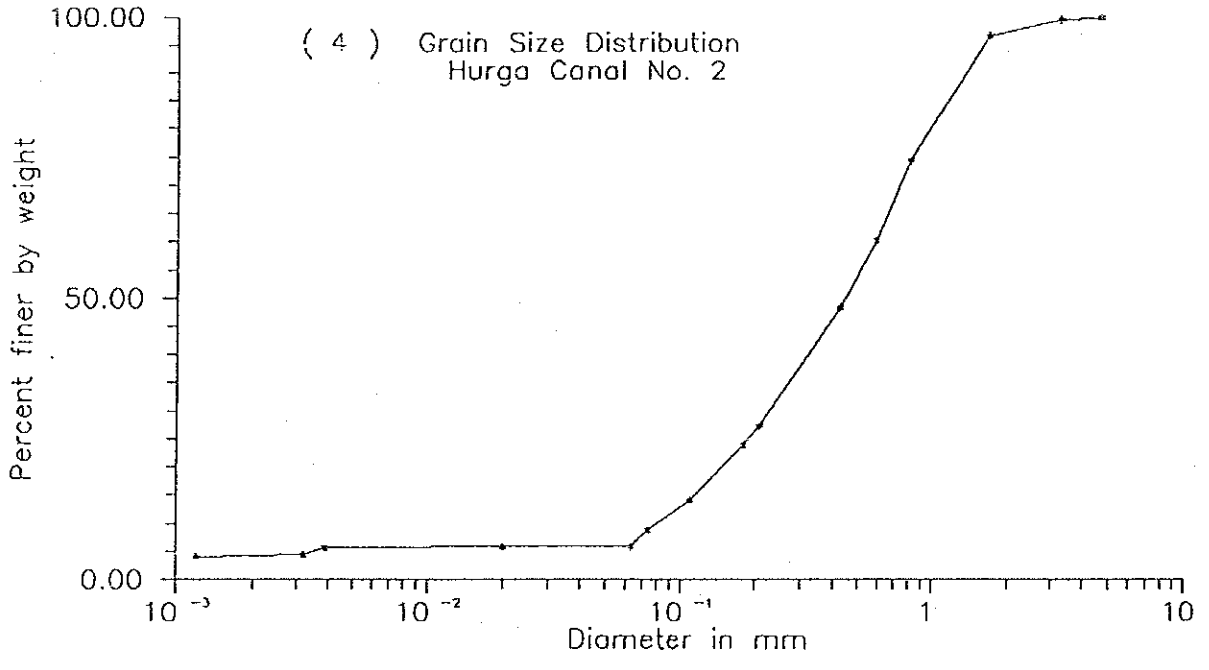


Fig. 5.6 GRAIN SIZE DISTRIBUTION





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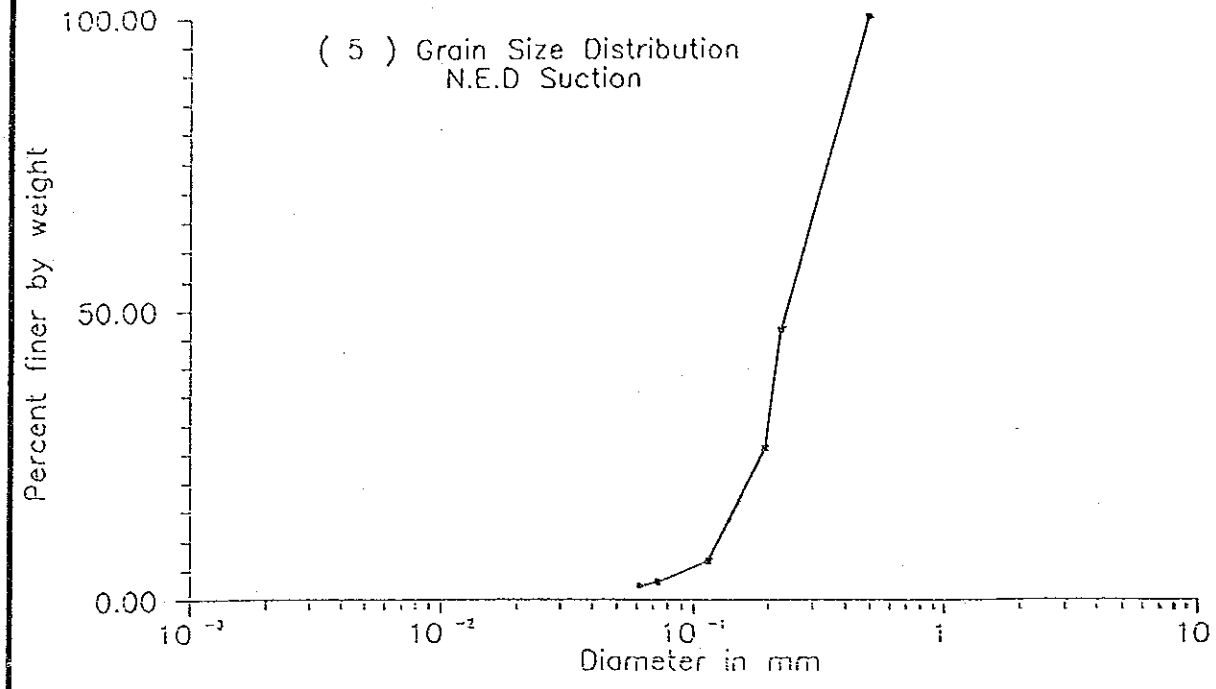


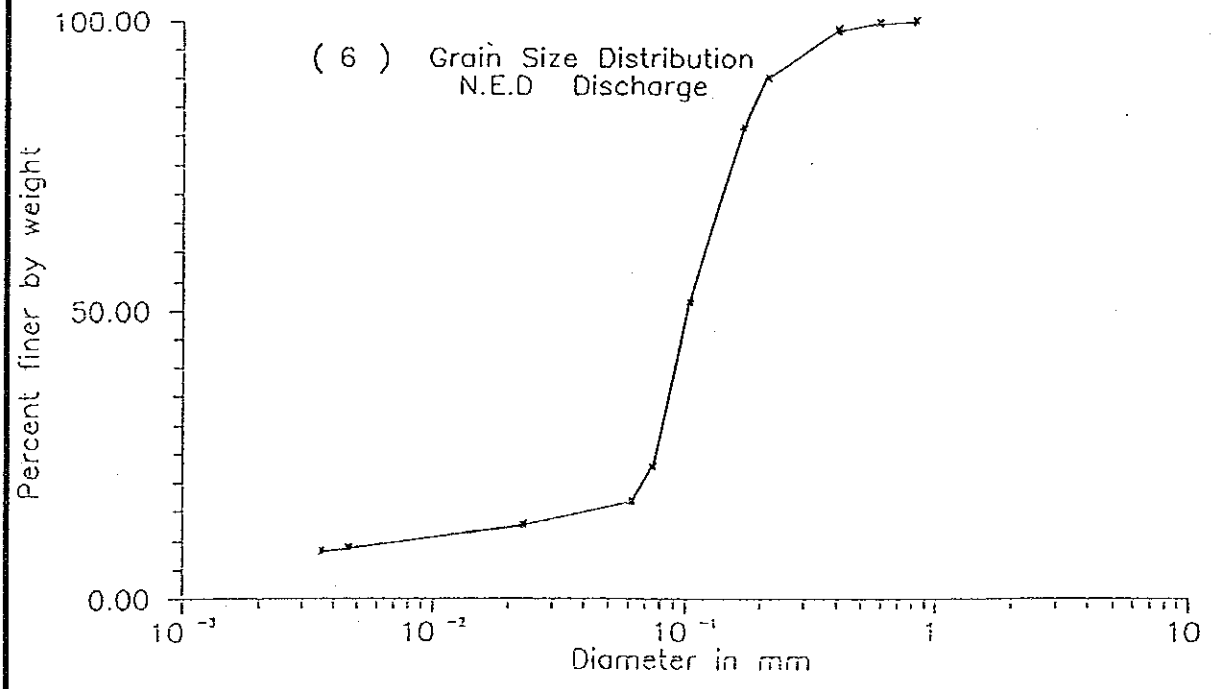
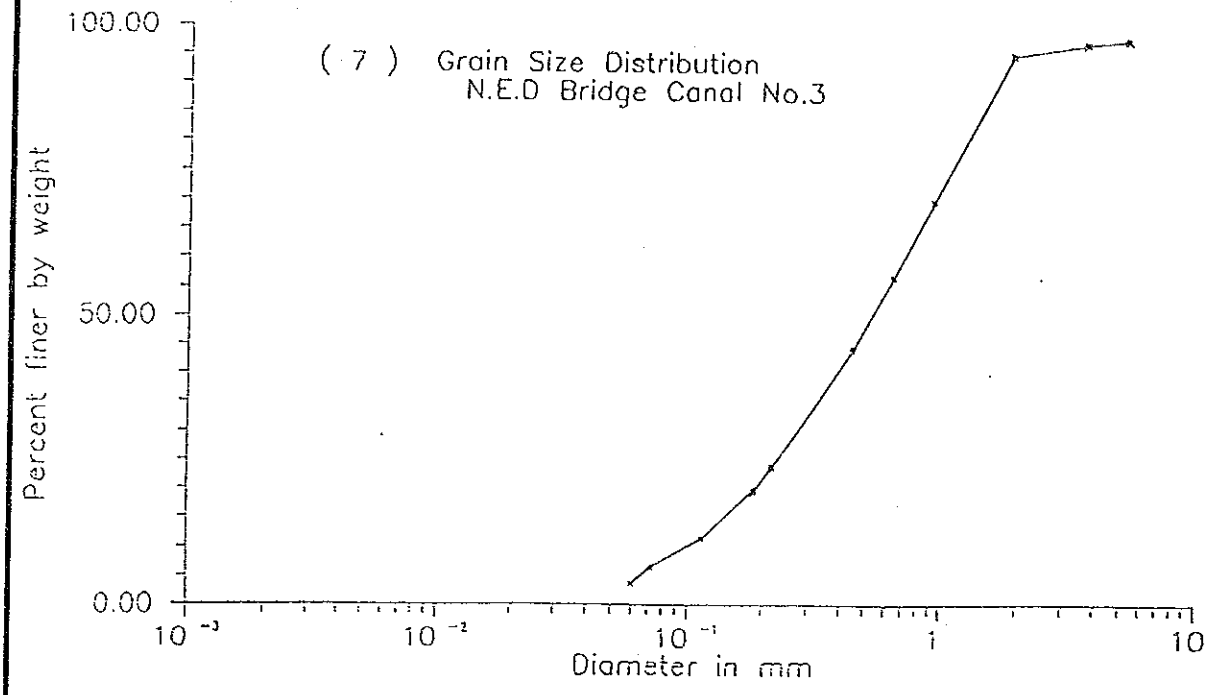


Fig. 5.8 GRAIN SIZE DISTRIBUTION



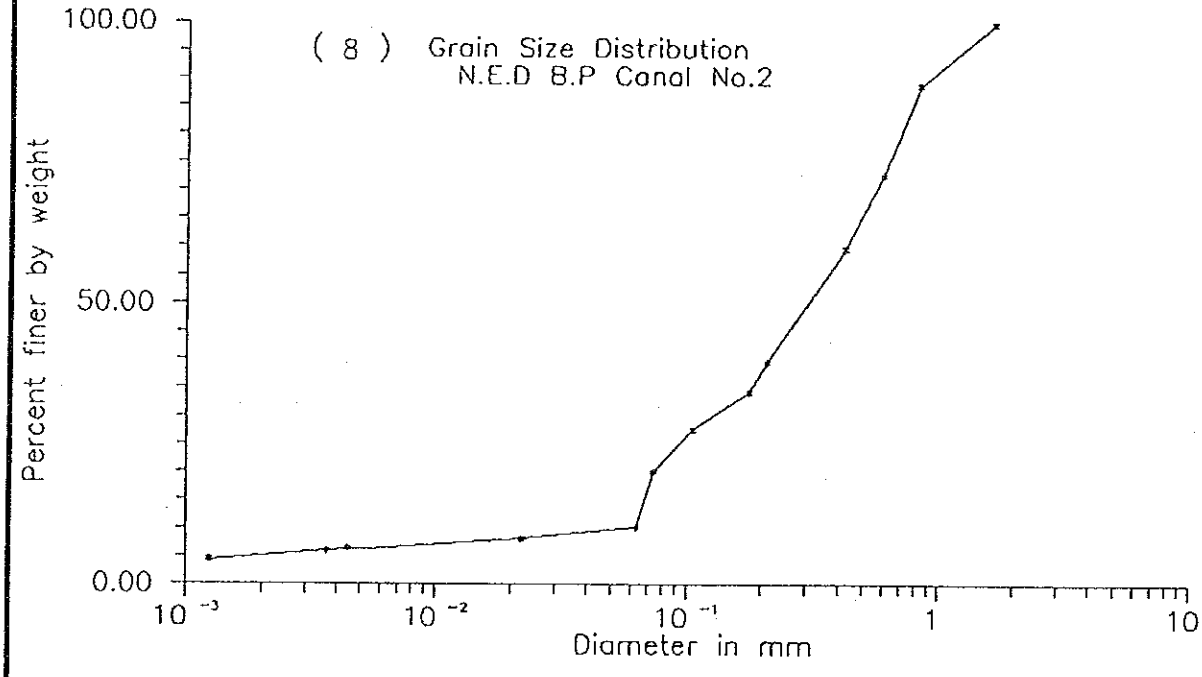


Fig. 5.9 GRAIN SIZE DISTRIBUTION

APPENDIX

BIBLIOGRAPHY

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HM-004	Nile Waters Study, Coyne et Bellier, Sir Alexander Gibb & Partners, Hunting Technical Services Limited and Sir M Macdonald & Partners
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HM-006	Daily Discharge at Sennar Dam, MOI
HM-007	Daily Gauge Reading at Downstream of Sennar Dam
HM-008	Daily Gauge Reading at Wad El Nau
HM-009	Daily Gauge Reading at Hag Abdallah
HM-010	Daily Gauge Reading at Wad El Haddah
HM-011	Daily Gauge Reading at Wad Medani
HM-012	10-day Mean Discharge and Gauge Reading of Nile Basin in the limited period
HM-013	Annual Report of Blue Nile Health Project, Ministry of Health, 1989

ANNEX-C

SOILS AND LAND CLASSIFICATION

FINAL REPORT

FOR

THE FEASIBILITY STUDY

ON

THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

ANNEX C: SOILS AND LAND CLASSIFICATION

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1. GENERAL BACKGROUND

1.1 Survey Area

Hurga and Nur El Din Pump Scheme (the Project area) is located between the Blue Nile and the Rahad river, about 30 km south-east of Wad Medani. It covers a total area of 26,435 feddans (11,100 ha).

Physiographically, the Project area is nearly a flat plain with very gentle slope from south to north. The Project area ranges in elevation from about EL. 411 m at south-eastern boundary of Nur El Din to EL. 408 m at southern boundary of Hurga with an overall gradient of about 0.20 m/km.

1.2 Review of Existing Data

The Project area was firstly involved in the semi-detailed soil surveys with land classification for irrigation under the Roseires Soil Survey Study conducted between 1964 and 1965. Soil and land classification maps on a scale of 1:50,000 was prepared based on it.

The land suitability classification of the Roseires Soil Survey was revised and compiled on the maps on a scale of 1:50,000 in the course of the Blue Nile Water Study in 1978.

Further, the revised land classification map was updated in the Blue Nile Pump Schemes Modernization Study conducted between November 1988 and March 1990. General reconnaissance soil survey and soil auger survey at three sites in the Hurga and one site in the Nur El Din area were conducted for the Project area during the current study period. The soil and land classification map updated is quoted in Fig. 1.1. In this Study, description of the soils follows the FAO Guideline for Soil Description. The soil classification was conformed to the United States System Soil Taxonomy, 1975 (Ref.No. SL-006), while land suitability classification was made in accordance with the Manual for Land Suitability for Agriculture (Ref.No. SL-005).

According to Fig.1.1, soil auger survey was conducted at only three sites at northeast end of the Hurga area and no auger survey was carried out in the Nur El Din area before the Blue Nile Pump Schemes Modernization Study. Thus, auger survey conducted by that time were six sites for the Hurga area and one site for the Nur El Din area, which seemed to be not sufficient for a feasibility level study.

Soil Survey Administration (SSA) in Wad Medani carried out the detailed soil survey in the Gezira Scheme including the Project area under the context of Gezira Rehabilitation Program in the period between March and April 1989. In this survey, soil samples were obtained at 147 auger boring sites and nine soil pits. To complement soil data obtained by SSA, JICA Study Team carried out soil pit survey at four pitting sites.

1.3 Methodology

1.3.1 Method of the Soil Survey

As stated above, the detailed soil survey for the Project area was conducted by SSA in 1990 and complemented by the JICA Study Team. The procedure and methodology of the soil survey jointly carried out are:

- Determination of the density of auger survey
- Auger survey
- Laboratory tests on soil samples obtained by auger survey
- Analysis of the tests results and classification of the soil
- Confirmation of the said classification by soil profile survey

Oriented coordinate square grids of 180 feddans (68.4 ha) each were superimposed on the layout map at a scale of 1:20,000 produced by MOI in 1978. Then auger boring sites were determined to be at the center of respective grids accounting for 147 in number accordingly. The sampling density thus determined is considered to be enough for the feasibility study purpose.

At each auger boring site, four (4) soil samples were taken from pre-fixed depth of 0-25, 25-50, 50-75, 75-100 cm for physical and chemical analyses. Based on the results of the physical and chemical analyses on these soil samples, soils in the Project area were classified into seven soil units labelled as MU50, MU51, MU52, MU53, MU70, MU71 and MU72.

In order to obtain soil data by genetic horizon, soil samples were further taken by genetic horizon at nine profile pits with a depth of about 2.0 m (three pits in MU50 and one each in other units) representing each soil unit. Physical and chemical analyses of the soil samples obtained were made by SSA main laboratory. The analytical method of soil samples are shown in APPENDIX-I, and the results of laboratory analyses of the soil samples are given in APPENDIXES-II and -III. Description of the soils is based on the FAO Guidelines for Soil Profile Descriptions (FAO 1974).

1.3.2 Method of Infiltration Rates Tests

Infiltration rates (Intake Rate) were observed by the cylinder infiltration method and the ponding method in a furrow at three sites, representing dominant soil in the Project area during December 2 to 4, 1990. Location of test sites is shown in Fig. 1.2. A steel made cylinder (30 cm in diameter, 60 cm in height) was driven into the soil to a depth of 30 cm for the former, and plates (75 cm wide, 40 cm in height) were driven into the soil to a depth of 30 cm at both upstream and downstream sides of a furrow of 25 cm wide and 100 cm long. Results of the cylinder method were used only to evaluate the vertical entry of water into soil and shown in Table 1.1.

2. SOILS OF THE PROJECT AREA

2.1 Parent Material of Soils

In general, the parent material of most soils of the Project area is believed to be of aggradational alluvium derived from the weathering products of the basaltic igneous and metamorphic rocks of the Ethiopian Plateau. These were transported and deposited by the Blue Nile during the past pluvial periods.

2.2 Soil Classification

(1) Criteria for Soil Classification

The soil classification system which has been used in the survey is the USDA Soil Taxonomy system (1975). Criteria used to classify the soils in the Project area is provided in Appendix IV.

(2) Soil Classification

Based on the result of the soil survey, the soils in the Project area are classified into Vertisols. Clay content of the soils is 50 - 70%. At suborder of the category level, the soils are categorized as Usterts, based on their ustic soil moisture regimes as inferred from the number of their cracking days (more than 3 months of the year). The Color Chroma of the soils is more than 1.5 at the Great Group level. At the sub-group level, these soils are grouped into Entic Chromusterts (Color value is more than 3.5). They consist of members of very fine, montmorillonitic and isohyperthermic family.

The soils in the Project area are locally called Suleimi soil, which are similar to the soils in the Gezira Scheme. The Suleimi series, which is one of the most extensive deep cracking clays, is dark brown (10YR 3/4) to brown (10YR 4/4) with a soft surface mulch and wide, deep cracks when dry (at 100 cm, 1 cm wide in June). It has considerable numbers of gray black calcium carbonate nodules in the surface, decreasing in number with depth. In the Suleimi series, there is often a melanic horizon "gray layer" that varies in depth; phases are recognized. The soil is calcareous and gypsum usually occurs at depths below about 65 cm associated with the gray layer and the lower substratum. The soil is very alkaline throughout. The textual composition of the soil is usually uniform throughout, clay ranges from 50 to 70%. Neither soluble salts nor exchangeable sodium are present in harmful amounts. Explanation about Sodic and Saline Soil is given in Appendix IV.

2.3 Soil Mapping Units

Based on the field and laboratory analyses, soils in the Project area were classified into seven (7) soil mapping units labelled as MU50, MU51, MU52, MU53, MU70, MU71 and MU72 as discussed previously. The physical and chemical characteristics of each soil mapping units are

summarized in Table 1.1 and explained hereunder. Area distribution of each mapping unit is shown in Fig. 1.2 and tabulated below.

Soil Units	Area (fd.)	Area Proportion (%)
MU 50	12,990	49.1
MU 51	114	0.4
MU 52	4,704	17.8
MU 53	1,195	4.5
MU 70	4,479	16.9
MU 71	1,047	4.0
MU 72	1,907	7.2
Total	26,435	100.0

(1) MU50

This mapping unit is the major soils in the Project area. It covers about 49% of the total Project area and occupies a flat plain (less than 2% slope).

The top soil is brown to dark brown with cracks up to 80 cm depth, very sticky and plastic when wet, with 5 cm mulch, moderately well drained. Plow layer has moderate coarse prismatic structure defined by the cracks.

The subsoil has weak coarse prisms with common platy parallelopiped components with slickensides and pressure faces. The melanic horizon (10YR3/1) at 70 cm depth associated with accumulation of gypsum.

This soil is calcareous and soil reaction is moderately to strongly alkaline in the subsoil. Substratum is mottled with heterogeneous clay loams.

pH (paste) : 8.3 in top 15 cm and ranges from 7.6 to 8.8 in subsoil

salinity : Top 50 cm is non-saline, underlain by a slightly saline subsoil

sodicity : Top 40 cm is non-sodic to slightly sodic, underlain by a moderately sodic subsoil

Profiles : 12, 13, 28, 29, 30 represent this mapping unit.

(2) MU51

This unit, eroded phase of map unit 50, comprises a very small area (about 0.4% of the total Project area) at the western boundary where the topography is inclined towards the Blue Nile (slope 2-5%).

The soil is mulch cracking clay with brown to dark brown in top 50 cm deep and dark gray in shallow melanic horizon (10YR3/1). This soil structure and consistency are similar to MU 50. In the gray layer, $CaSO_4$ is abundant, $CaCO_3$ as gray nodules and in powdery form is also common. This soil reaction is mildly to moderately alkaline.

pH (paste)	:	7.6 in top 10 cm and ranges from 7.5 to 7.9 in subsoil
salinity	:	Top 50 cm is non-saline, underlain by a moderately saline subsoil
sodicity	:	Top 10 cm is non-sodic, underlain by a slightly sodic subsoil
Profile	:	31 represents this mapping unit.

(3) MU52

This mapping unit comprises about 18% of the total Project area and occupies almost flat to very gently sloping topography (2% slope).

The soil is brown to dark brown at top 80 cm depth, the gray layer (10YR3/1) below 80 cm in depth.

The soil is clay, sticky and plastic in consistency when wet, moderate to weak subangular blocky structure. Platiness components and slickensides are dominant at the top 50 cm depth. This soil is calcareous through-out. The melanic horizon is associated with calcium sulfate in white crystal forms. The soil reaction is moderately alkaline. In general, this mapping unit is similar to the mapping unit 50 except that it is very slightly sloping that could be reflected in the fine texture.

pH (paste)	:	7.6 in top 8 cm and ranges from 7.8 to 8.1 in subsoil
salinity	:	Top 65 cm non-saline, underlain by a moderately saline subsoil
sodicity	:	Top 32 cm non-sodic to slightly sodic, underlain by a moderately sodic subsoil
Profile	:	27 represents this mapping unit.

(4) MU53

This mapping unit comprises about 5% of the total Project area and occupies almost flat plain.

The soil is brown to dark brown in top 35 cm in depth, dark brown below 35 cm depth. The soil is cracking, very fine clay with 3 - 5 cm mulch, very sticky and plastic when wet.

The soil has moderate to weak coarse subangular blocky structure with platy components with slickensides. Melanic horizon is deep (below 100 cm depth), and the soil matrix is calcareous through out, with common $CaCO_3$. Gray nodules at surface and white soft patches of common $CaCO_3$ are in addition to $CaSO_4$. This soil reaction is moderately alkaline. This soil is an intergrade from the brown soil to the gray soil group.

pH (paste)	:	7.8 in top 35 cm and ranges from 7.5 to 8.1 in subsoil
salinity	:	Top 80 cm non-saline, underlain by a slightly saline subsoil
sodicity	:	Top 80 cm slightly sodic, underlain by a moderately sodic subsoil
Profile	:	11, 33 represent this mapping unit.

(5) MU70

This mapping unit comprises about 4% of the total Project area and occupies an almost flat to slightly concave land form with few pot holes.

The soil is dark, grayish brown (10YR4/2), cracking clay and moderately to somewhat imperfectly drained soils with shell fragments.

Top 50 cm depth has a moderate medium and fine subangular blocky structure overlying massive soil body. $CaCO_3$ is common as nodules, concrete and white patches, the soil matrix is calcareous through-out. Gypsum crystals are also common. This soil reaction is strongly alkaline.

pH (paste)	:	7.9 in top 10 cm, ranges from 7.7 to 8.3 in subsoil
salinity	:	Top 33 cm is non-saline, underlain by a moderately saline subsoil
sodicity	:	Top 33 cm is slightly sodic, underlain by a moderately sodic subsoil
Profile	:	14, 25 represent this mapping unit.

(6) MU71

This mapping unit comprises about 7% of the total Project area and occupies lowlying topography with gilgai and potholes.

The soil is deep dark grayish brown, cracking clay, and somewhat imperfectly drained. Mottles are common below 1 m depth, many $CaSO_4$ on various forms.

The soil reaction is moderately alkaline at top, strongly alkaline below 40 cm. The soil is strongly calcareous and sodic.

pH (paste)	:	7.8 in top 17 cm and ranges from 7.5 to 8.4 in subsoil
salinity	:	Top 45 cm is non-saline, underlain a moderately saline subsoil
sodicity	:	moderately sodic throughout
Profile	:	26 represents this mapping unit.

(7) MU72

This mapping unit comprises about 17% of the total Project area and occupies an almost flat topography with potholes.

The soil is dark grayish brown with a top soil (10 cm depth) having brown to dark brown cracking clay and moderately well drained.

The soil structure is strong granular at top soil and moderate to weak below. Melanic horizon (10YR3/1, below 1 meter) associated with common gypsum. The matrix is calcareous throughout, and soil reaction is moderately alkaline.

pH (paste)	:	Ranges from 7.8 in top 10 cm and 7.6-8.1 in subsoil
salinity	:	Top 80 cm is non-saline, underlain by a moderately saline subsoil
sodicity	:	Top 40 cm is non-sodic to slightly sodic, underlain by a moderately sodic subsoil
Profile	:	32 represents this mapping unit.

3. LAND SUITABILITY

3.1 The Land Suitability Classification

The Land Suitability System being presently used by the SSA is adopted for land classification of the Project area. It was established based on the FAO Framework for Land Evaluation of the Sudan Soils by W. Van Der Kevie (Ref. No. SL-005). The standard of soil suitability classification of the System is shown in Table 3.1. The soil mapping units in the Project area have been examined and evaluated in line with the System to determine and predict levels of suitability under irrigated agriculture with high capital intensity.

The Land Suitability System has two orders:

Order "S": Suitable Land

Land on which sustained use in the defined manner is expected to yield benefits that will justify the required capital and recurrent inputs.

Order "N": Unsuitable Land

Land having characteristics which preclude its sustained use in the defined manner because of an unacceptable level of recurrent or development inputs required.

They are further classified into five (5) classes. They are:

Class "S1": Highly Suitable Land

Land which is expected to be highly productive for the defined use and yield high benefits, justifying the required capital and recurrent inputs. There are no significant limitations that will reduce crop yields or increase recurrent costs for production or conservation.

Class "S2": Moderately Suitable Land

Land which is expected to be moderately productive for the defined use, yielding moderate benefits, which are sufficiently high to justify the required capital and recurrent inputs. There are moderately severe limitations likely to reduce crop yields and/or increase recurrent costs for production and conservation.

Class "S3": Marginally Suitable Land

Land which is expected to have a low productivity for the defined use, and yield benefits that are just high enough to justify recurrent costs and capital inputs. There are limitations which, in the aggregate, are sufficiently severe to reduce crop yield and/or to increase recurrent costs for production and conservation.

Class "N 1": Currently Unsuitable

Land with very severe limitations which at present cannot be improved economically and which preclude successful sustained manner.

Class "N 2": Permanently Unsuitable

Land with very severe limitations precluding any possibility of successful use of the land for agricultural production.

All soil mapping units in the Project area were categorized into Class."S2"; moderately suitable land. There are no S1 land in the Project area.

3.2 Land Suitability for Crops

Each crop needs specific condition for normal growth e.g. climate, soils, management, etc. Cotton, wheat, sorghum, groundnut, and fodder are selected for this Project. Each for the classes of the abovementioned land suitability is further subdivided by employing a subclass reflecting the kind of the major limitations to each crops (see APPENDIX V). The main influencing factors for them on the Project area are fertility, alkalinity and a high content of clay rather than topographic condition.

Each soil unit has a fertility limitation, which would be improved by applying an adequate amount of fertilizer at right time under the intensive farming condition.

(1) Cotton

Soils that are easily water-logged are not suitable for cotton as yields will be considerably depresses if water stands on the surface for more than 2 days. Cotton prefers neutral to mildly alkaline soils. Cotton is relatively tolerant to salinity or alkalinity. The crop is probably only slightly affected by an ECs and/or an ESP. Cotton is tolerant to high ECs, yield decrease by 10, 25, 50% at 10, 12, 16 mmhos/cm, respectively (Ref.No. SL-008). Cotton is tolerant to high ESP, 50 % yield reduction is at ESP 35%. Most Mapping Units are moderately suitable for cotton.

(2) Wheat

Wheat is sensitive to waterlogging and requires good drainage for optimum yields. Wheat is moderately tolerant to saline and sodic soils, though less than cotton, but more than sorghum. The yield decreases by 10, 25, 50% at 7, 10, 14 mmhos/cm, respectively and 50% yield reduction is at ESP 15-25% (Ref.No. SL-008). All Mapping Units are moderately suitable for wheat.

(3) Sorghum

Sorghum has high tolerance to stagnant water for short periods. Sorghum is slightly tolerant to salinity and sodicity (less than cotton and wheat). Yield decrease by 10, 25, 50% at 5.5, 7, 9 mmhos/cm, respectively and 50% yield reduction is at ESP 15-25% (Ref.No. SL-008). All Mapping Units are moderately suitable for sorghum.

(4) Groundnut

There was an erroneous belief that the heavy clay soils of Gezira were not suited for groundnut production up to the 1960', because groundnuts require a loose, friable medium texture soils into which the pegs can penetrate easily. But Vertisols has a characteristics "self-mulching" when dry in the field, the clay breaks down into granular mulch, several centimeters thick. This is a valuable property allowing good seed-bed preparation and facilitating the harvesting of groundnuts. Groundnuts are very susceptible to waterlogging and slightly tolerant to salinity and sodicity (less than cotton, wheat and sorghum). Yield decrease by 10, 25, 50% at 3.5, 4.1, 4.9 mmhos/cm, respectively (Ref. No. SL-00). And the value of 50% yield reduction by ESP is lower than that for cotton, wheat and sorghum. All Mapping Units are moderately to poorly suitable for groundnut.

(5) Fodder

Leguminous crops which are suited for the conditions of soil and climate in the Project area are adopted for fodder. They are more tolerant to salinity and sodicity than groundnuts. Most Mapping Units are moderately suitable for fodder.

The results of the land suitability for each of above crops in the Study area are shown in Tables 3.2 and 3.3.

TABLES

Table 1.1 SUMMARY OF THE SOIL PHYSICAL AND CHEMICAL CHARACTERISTICS

Land Characteristic		Mapping Unit						
		50	51	52	53	70	71	72
Available Water	Topsoil	10.0	-	8.5	8.8	7.7	7.7	10.5
Hoalding Capacity	Subsoil	31.3	-	27.3	30.6	27.4	25.2	43.9
(cm water in depth)								
Chemical Soil Fertility (0-25 cm)								
pH(paste)		8.2	8.0	8.4	7.8	8.5	8.3	8.1
Organic carbon (%)		0.437	0.525	0.434	0.338	0.476	0.503	0.421
Nitrogen (%)		0.045	0.047	0.043	0.046	0.042	0.040	0.041
Phosphate (Olsen, ppm)		4.8	4.7	4.7	4.2	4.9	4.8	5.1
CEC (meq/100 g)		57	58	59	61	55	66	58
Exch. K (meq/100g)		1.09	0.65	0.94	1.87	0.96	1.28	1.07
Conditions for Seedling		fine, medium	fine, medium	fine, medium	fine, medium	fine, medium	fine, medium	fine, medium
Establishment (0-15 cm)		subangular	subangular	subangular	subangular	subangular	subangular	subangular
Salinity(mmhos/cm)	ECe(0-25 cm)	0.73	0.60	0.64	0.68	0.67	0.71	0.68
	ECe(25-100 cm)	4.35	5.07	4.15	2.85	4.50	5.44	3.33
Sodicity	ESP(0-25 cm)	15	17	16	13	16	19	16
	SAR(0-25 cm)	6	5	5	4	6	5	6
	ESP(25-100 cm)	24	27	24	21	27	25	25
	SAR(25-100 cm)	14	18	15	11	17	20	13
Soil drainability for irrigated								
agriculture	Basic Infiltration							
	Rate(cm/hr)	0.289	-	0.259	-	0.340	-	-
	Permiability(cm/hr)	0.06	-	0.08	0.04	0.03	0.07	0.04
	(depth of least permiable horizon)	(35-60 cm)		(85-125 cm)	(56-80 cm)	(130-170 cm)	(105-125 cm)	(40-80 cm)

A number; 1, 2, 3, 4 is cprresponds with good, moderate, poor or very poor for agriculture in general

Source: SSA and JICA Study Team

Table 3.1 STANDARD OF SOIL SUITABILITY CLASSIFICATION

Land Characteristic		Class			
		1 (good)	2 (moderate)	3 (poor)	4 (very poor)
1. Available water	(0-30 cm)	> 4	> 3	> 2	> 1
hoalding capacity	(30-120 cm)	> 12	> 9	> 6	> 3
(cm water in depth)					
2. Chemical soil fertility (0-30 cm)					
pH(paste)		6.0-8.0	8.0-9.0		
Organic carbon (%)		> 2.25	0.75-2.25	0.15-0.75	< 0.15
Nitrogen (%)		> 0.15	0.05-0.15	0.01-0.05	< 0.01
Phosphate (Olsen, ppm)		> 15	15-5	< 5	
CEC (meq/100g)		> 20	10-20	3-10	< 3
Exch. K (me/100g soil)		> 0.4	0.2-0.4	0.1-0.2	< 0.1
3. Conditions for seedling establishment (0-15 cm)		fine crumb, moderate fine subangular blocky; loose or very friable moist	coarse crumb, moderate medium subangular blocky;friable to slightly firm moist	coarse subangular blocky,weak fine and medium subangular blocky, massive,platy or weak prismatic; slighlly hard dry, firm to very firm	strong coarse angular blocky, massive, platy or or strong prismatic; very hard to extremely hard dry; exremely firm
4. Salinity (mmhos/cm)					
ECe	(0-30 cm)	< 4	4-8	8-16	> 16
ECe	(30-90 cm)	< 6	6-12	12-24	> 24
5. Sodicity					
ESP	(0-30 cm)	< 10	10-20	20-35	> 35
SAR	(0-30 cm)	< 8	8-18	18-38	> 38
ESP	(30-90 cm)	< 20	20-35	35-50	> 50
SAR	(30-90 cm)	< 18	18-38	38-68	> 68
6. Soil drainability for irrigated agriculture					
Basic infiltration rate (cm/h)		> 2	0.8-2	0.3-0.8	< 0.3
Permiability (cm/h)		0.2-0.5	0.05-0.2	< 0.05	-
(depth of least permiable horizon)					

Source: Van Der Kevie Ed. (1976), Available phosphate : Landon, J.R. (1984)

Table 3.2 ESTIMATION OF THE MAXIMUM CURRENT LAND SUITABILITY CLASSES AND SUBCLASSES FOR IRRIGATED AGRICULTURE HIGH CAPITAL INTENSITY

Land Qualities	Mapping Unit						
	50	51	52	53	70	71	72
- Moisture availability	1	1	1	1	1	1	1
- Chemical soil fertility (f)	2	2	2	2	2	2	2
- Condition for Seedling establishment	1	1	1	1	1	1	1
- Drainge in the growing season (w)	1	1	1	1	2	2	1
- Possibility for mechanization	1	1	1	1	1	1	1
- Salinity	1	1	1	1	1	1	1
- Sodicity (a)	2	2	2	2	2	2	2
- Soil drainability (v)	2	2	2	2	2	2	2
- Posibilities for rational layout of farm plot (t)	1	2	1	1	1	1	1
Classes	S2	S3	S2	S2	S3	S3	S2
Subclasses	vaf	tvaf	vaf	vaf	vawf	vawf	vaf
Area (feddan)	12,990	114	4,704	1,193	4,479	1,047	1,907
Area Propotion (%)	49.1	0.4	17.8	4.5	16.9	4.0	7.2

Source: Van Der Kevie Ed. (1976), Landon, J.R. (1984), SSA

Table 3.3 CROP SUITABILITY RATINGS FOR SPECIFIC CROPS PER MAPPING UNITS

Mapping Unit	Crops				
	Cotton	Wheat	Sorghum	Groundnuts	Fodder
50	2	2	2	2 / 3	2
51	2	2	2	2 / 3	2
52	2	2	2	2 / 3	2
53	2	2	2	2 / 3	2
70	2 / 3	2	2	3	2 / 3
71	2 / 3	2	2	3	2 / 3
73	2	2	2	2 / 3	2

1: High Suitable
2: Moderately Suitable
3: Poorly Suitable
4: Unsuitable

Source: Van Der Kevie Ed. (1976), Landon, J.R. (1984), SSA

FIGURES

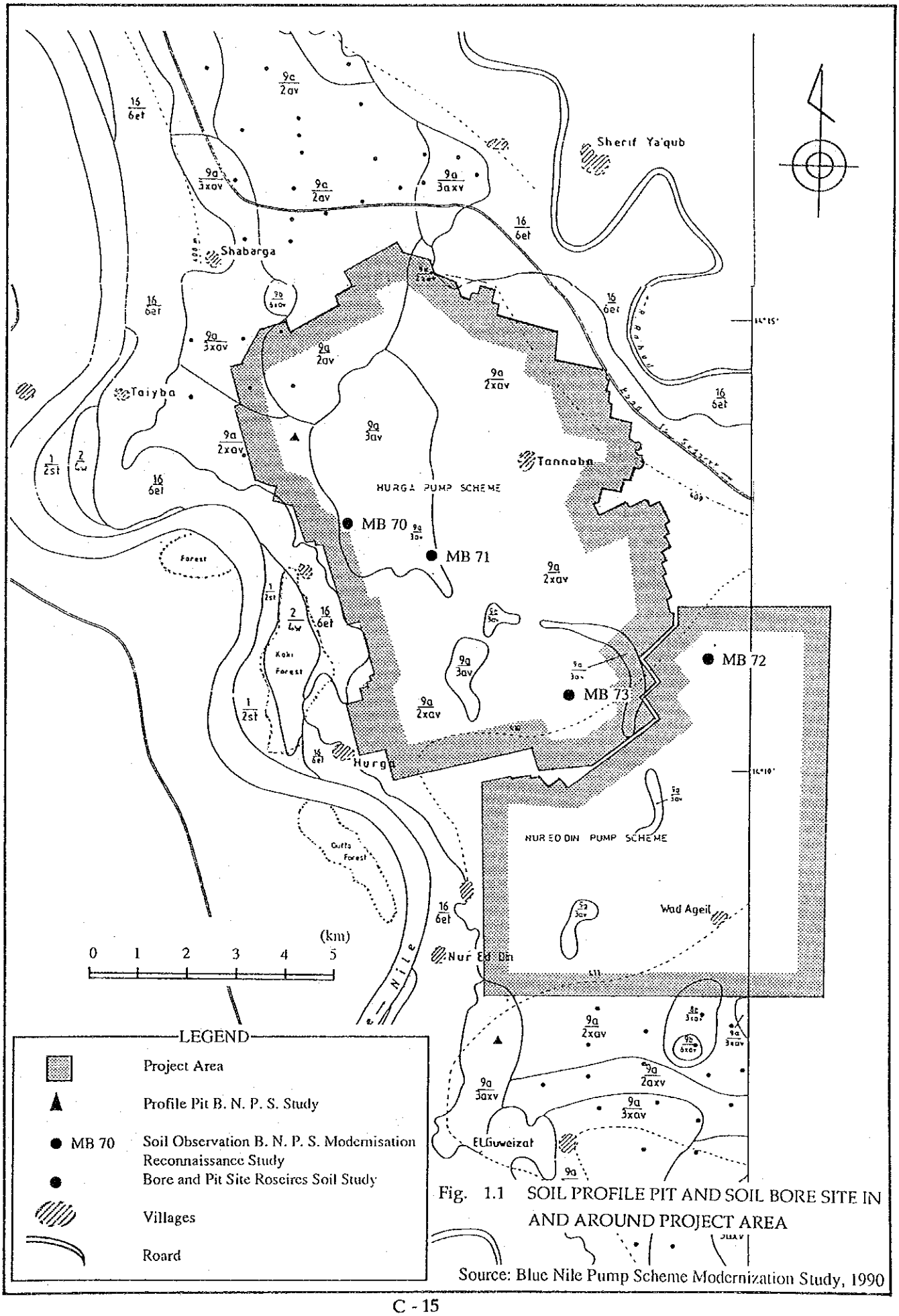

Fig. 1.1 SOIL PROFILE PIT AND SOIL BORE SITE IN AND AROUND PROJECT AREA

Source: Blue Nile Pump Scheme Modernization Study, 1990

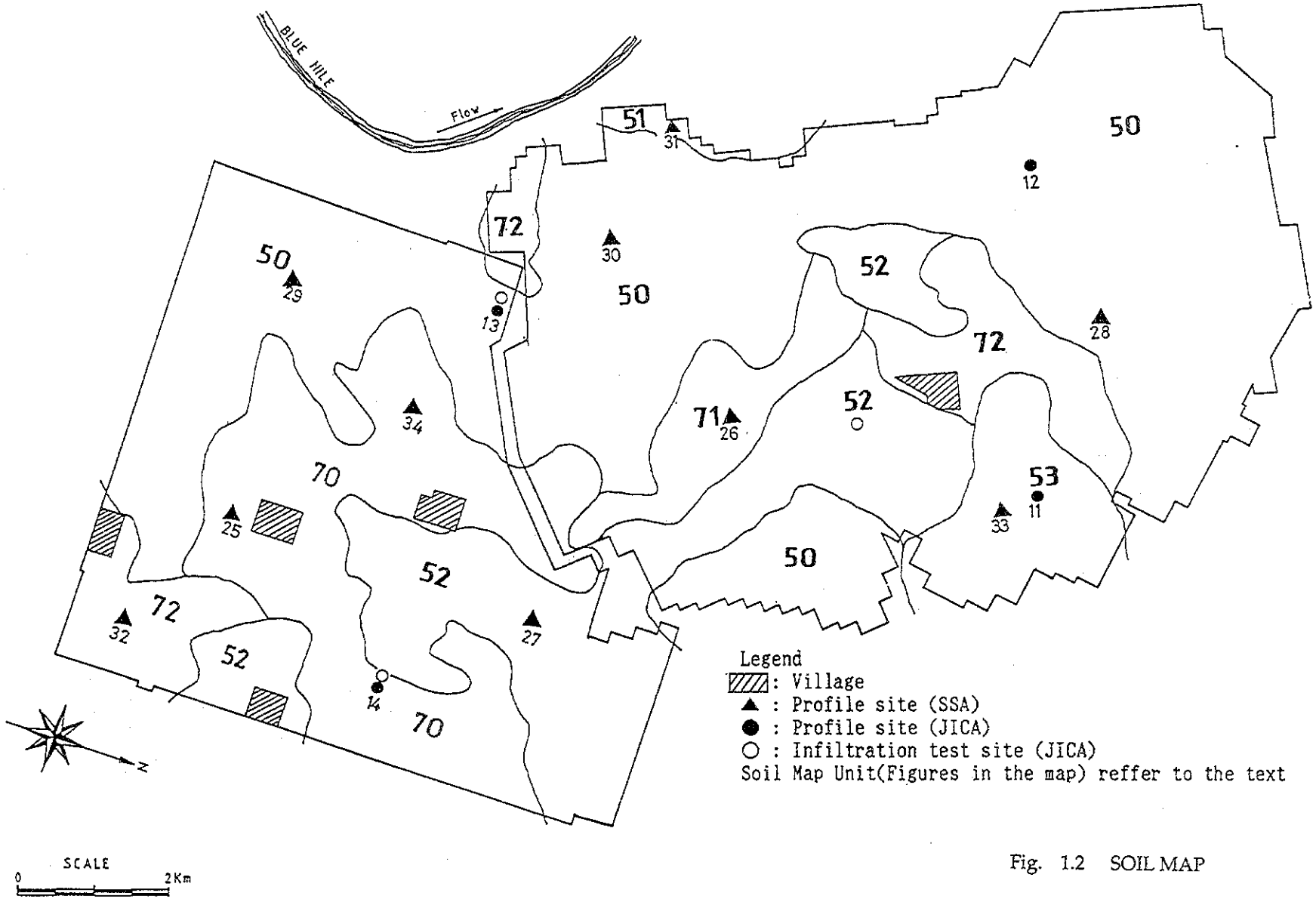

Fig. 1.2 SOIL MAP

APPENDIX

ANALYTICAL METHOD OF SOIL

(1) Hydraulic Conductivity :

By the constant head method on disturbed soil samples from each horizon of soil profiles.

(2) Mechanical analysis :

All results refer to oven dry soil. The soil is treated with HCl acid. The excess acid is neutralized by NaOH. The soil is saturated with sodium ions using NaCl for two nights, and dispersed by calgon. The pipette method is used for clay fraction wet sieving for fine sand and coarse sand fractions. Silt is determined by difference.

The fractions are:

Coarse sand	2-0.2 mm
Fine sand	0.2-0.05 mm
Silt	0.05-0.002 mm
Clay	less than 0.002 mm

(3) Bulk Density :

On natural soil clods coated with a water repellent(seran solution) and weighed in air as well as under water. The bulk density is determined on air dry clods and moist clods at 1/3 bar tension.

(4) pH :

pH is determined by glass/calomel electrode on saturation extract.

(5) CaCO3 :

CaCO3 is determined by titration. The soil is boiled with 1N-HCl. The excess acid is titrated versus 1N-NaOH using phenol-phthalane as an indicator.

(6) Organic carbon : Modified Walkley and Black method.

(7) Nitrogen : Modified micro kjeldahl method.

(8) C.E.C. :

C.E.C is determined by washing the soil in sodium acetate (pH 8.2) washed with ethanol. The absorbed ions were extracted with ammonium acetate (pH 7.0).

(9) Exchangeable Na and K :

Na and K are extracted with 1N- ammonium acetate (pH 7.0) and then determined by flame photometer. Exchangeable K is thus equal to extracted K, as water soluble K is negligible. Exchangeable Na is equal to that extracted Na minus soluble Na.

(10) Exchangeable Ca + Mg :

Exchangeable Ca + Mr are calculated by difference from C.E.C. due to the calcareous soil.

(11) Soluble cations and anions :

Soluble cations and anions are determined in the saturation extract mentioned above in item (3) - soluble Na is determined by flame photometer, while Ca+Mg, carbonate, bicarbonate and chloride by titration.

(12) Available phosphate : Olsen's method

SOIL PHYSICAL DATA

Soil Physical Data in Nur El Din

Pit No. : 25
M.U.: 70

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 10	38.8	21.8	1.23	1.75	17.0	25.3	1.06
10 - 33	40.3	22.7	1.17	1.76	17.6	25.8	0.15
33 - 55	37.2	21.4	1.08	1.73	15.8	22.2	1.27
55 - 100	46.8	25.3	1.05	1.76	21.5	30.2	0.52
100 - 130	56.5	29.7	1.02	1.76	26.8	37.3	0.08
130 - 170	59.5	27.7	1.03	1.82	24.8	45.3	0.03
170 - 190	49.8	26.6	1.00	1.86	22.2	33.2	0.03

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)		AWC (in cm)
0 - 33	25.6	0.43	per 30 cm	7.7
33 - 130	30.6	0.40	per 90cm	27.4

Pit No. : 27
M.U.: 52

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 8	40.4	22.3	1.02	1.66	18.1	24.3	1.66
8 - 32	45.0	24.0	1.05	1.77	21.0	29.6	0.29
32 - 65	40.8	22.1	1.07	1.73	18.7	26.2	0.56
65 - 85	47.5	25.7	1.00	1.79	21.6	30.4	0.58
85 - 125	51.0	26.5	1.02	1.74	24.5	33.8	0.08
125 - 160	51.5	26.7	1.02	1.86	24.8	35.7	0.13
160 - 190	46.1	24.4	1.01	1.83	21.7	30.8	0.94

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)		AWC (in cm)
0 - 32	28.3	0.63	per 30 cm	8.5
32 - 125	30.4	0.76	per 90cm	27.3

Source: Soil Survey Administration

Soil Physical Data in Nur El Din

Pit No. : 29
M.U.: 50

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 12	54.6	27.9	1.06	1.74	26.7	37.4	0.70
12 - 43	58.2	30.0	1.10	1.81	28.2	41.0	0.05
43 - 65	49.6	25.3	1.02	1.75	24.3	33.7	1.56
65 - 90	44.7	23.6	1.04	1.73	21.1	29.2	0.35
90 - 123	48.8	25.2	1.05	1.81	23.6	33.7	0.98
123 - 151	45.1	24.2	1.12	1.91	19.9	31.7	0.22
151 - 178	47.1	24.5	1.07	1.84	22.6	32.9	0.08

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)
0 - 43	40.0	0.23
43 - 123	32.3	0.76

	AWC (in cm)
per 30 cm	12.0
per 90cm	30.1

Pit No. : 32
M.U.: 72

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 10	46.3	23.6	1.14	1.73	23.3	32.6	2.50
10 - 40	51.2	26.3	1.13	1.73	24.9	35.6	0.53
40 - 80	52.3	26.9	1.16	1.78	25.4	37.3	0.04
80 - 101	47.6	24.9	1.15	1.76	22.7	33.0	1.31
101 - 140	52.9	26.8	1.14	1.78	26.1	38.1	0.18
140 - 180	55.9	29.6	1.16	1.79	26.3	38.8	0.03
180 - 200	-	-	-	-	-	-	-

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)
0 - 40	34.8	1.02
40 - 140	36.7	0.36

	AWC (in cm)
per 30 cm	10.5
per 90cm	43.9

Source: Soil Survey Administration

Soil Physical Data in Hurga

Pit No. : 26
M.U.: 71

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 17	37.2	20.1	1.23	1.74	17.1	25.4	0.51
17 - 45	38.4	20.6	1.09	1.79	17.8	25.6	0.36
45 - 75	39.4	21.3	1.05	1.77	18.1	25.5	0.56
75 - 105	46.4	24.5	1.01	1.82	21.9	31.0	0.09
105 - 125	45.4	24.7	1.01	1.81	20.7	29.2	0.07
125 - 155	46.5	24.8	1.02	1.88	21.7	31.5	0.22
155 - 180	51.3	26.9	1.00	1.86	24.4	34.9	0.03

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)
0 - 45	25.5	0.87
45 - 125	28.5	0.21

	AWC (in cm)
per 30 cm	7.7
per 90cm	25.2

Pit No. : 28
M.U.: 50

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 13	40.7	21.3	1.04	1.64	19.4	26.0	1.59
13 - 35	44.0	22.7	1.05	1.80	21.3	30.4	0.14
35 - 60	54.8	27.2	1.10	1.82	27.6	40.3	0.06
60 - 80	52.4	27.8	1.12	1.81	24.6	36.0	0.48
801 - 105	55.8	28.6	1.03	1.76	27.2	37.9	0.33
105 - 135	61.0	31.9	1.06	1.71	29.1	40.3	0.06
135 - 180	58.3	30.6	1.04	1.79	27.7	39.2	0.05

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)
0 - 35	28.7	0.68
35 - 135	38.9	0.21

	AWC (in cm)
per 30 cm	8.6
per 90cm	34.5

Source: Soil Survey Administration

Soil Physical Data in Hurga

Pit No. : 30
M.U.: 50

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 17	44.3	23.5	1.04	1.67	20.8	28.2	1.72
17 - 45	47.2	24.2	1.11	1.75	23.0	32.9	0.10
45 - 79	44.8	23.0	1.16	1.73	21.8	31.5	0.08
79 - 107	48.0	25.2	1.12	1.81	22.8	33.4	0.62
107 - 134	48.6	24.8	1.03	1.83	23.8	34.0	0.17
134 - 170	48.3	25.0	1.08	1.80	23.3	33.6	0.22
170 - 190	48.3	24.9	1.16	1.86	23.4	35.3	0.07

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)		AWC (in cm)
0 - 45	31.1	0.71	per 30 cm	9.3
45 - 125	29.3	0.26	per 90cm	29.3

Pit No. : 33
M.U.: 53

Depth (cm)	Moist. Ret. 1/3 atm	Moist. Ret. 15 atm	Bulk Density 1/3 atm	Bulk Density 15 atm	AWC DW %	AWC V/V %	Hyd. Cond. cm/hr
0 - 35	45.5	25.4	1.14	1.78	23.1	29.3	0.47
35 - 56	51.5	26.2	1.13	1.79	25.3	36.9	0.06
56 - 80	51.3	26.2	1.11	1.74	25.1	35.8	0.04
80 - 100	48.3	25.0	1.10	1.73	23.3	33.0	0.46
100 - 135	52.2	27.2	1.15	1.78	25.0	36.6	0.10
135 - 175	53.5	27.9	1.16	1.77	25.6	37.5	0.21
175 - 190	49.1	25.3	1.17	1.74	23.8	34.6	3.00

Depth	Average AWC (v/v%)	Average Hyd. Cond (cm/hr)		AWC (in cm)
0 - 35	29.3	0.47	per 30 cm	8.8
35 - 135	34.3	0.16	per 90cm	30.6

Source: Soil Survey Administration

SOIL CHEMICAL ANALYSIS DATA

Soil Physical and Chemical Data in Nur El Din

Pit No. : 25 M.U.: 70

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	ppm
0 - 10	13	7	35	45	7.9	8.6	0.035	0.593	17	6.4
10 - 33	12	7	23	58	8.3	9.1	0.040	0.608	15	3.8
33 - 55	15	6	24	55	7.7	8.4	0.035	0.499	14	4.2
55 - 100	10	5	14	71	7.9	8.6	0.045	0.430	10	4.4
100 - 130	8	5	16	71	7.8	8.5	0.040	0.530	13	4.0
130 - 170	6	5	29	60	8.1	8.9	0.040	0.312	8	4.4
170 - 190	5	5	14	76	8.2	8.8	0.035	0.343	10	4.6

Depth (cm)	CaCO3	Exchangeable Cation				CEC	Base. Sat
		Na	K	Ca	Mg	meq/100g	%
0 - 10	4.8	3.54	1.10	-	-	60	82
10 - 33	6.0	10.35	0.87	-	-	53	83
33 - 55	6.8	14.73	0.97	-	-	55	91
55 - 100	6.8	14.01	0.95	-	-	57	110
100 - 130	9.0	14.75	0.83	-	-	63	107
130 - 170	9.4	15.46	0.79	-	-	63	114
170 - 190	9.2	17.73	0.83	-	-	62	116

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3	mmhos/cm		
0 - 10	4.3	-	1.5	0.0	1.6	3.4	0.48	5	10
10 - 33	5.4	-	1.5	0.0	2.0	4.1	0.63	6	19
33 - 55	20.5	-	2.5	0.5	2.4	2.9	2.50	17	32
55 - 100	79.7	-	18.5	6.5	4.8	1.8	8.60	23	25
100 - 130	70.1	-	14.0	7.0	5.4	1.7	7.80	22	23
130 - 170	45.0	-	5.0	2.0	6.0	1.9	5.00	24	30
170 - 190	29.0	-	3.8	1.5	5.2	2.5	3.60	18	29

Source: Soil Survey Administration

Soil Physical and Chemical Data in Nur El Din

Pit No. : 27 M.U.: 52

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P ppm
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	
0 - 17	10	8	33	49	7.6	8.3	0.050	0.343	7	6.2
17 - 45	9	4	26	61	8.1	9.2	0.040	0.608	15	5.2
45 - 75	10	5	19	66	8.1	8.7	0.045	0.328	7	4.4
75 - 105	7	3	20	70	7.9	8.5	0.045	0.421	9	6.0
105 - 125	4	3	18	75	7.9	8.5	0.045	0.593	13	6.4
125 - 155	4	10	14	72	7.8	8.4	0.045	0.468	10	5.2
155 - 180	10	7	18	65	8.1	8.7	0.045	0.468	10	4.4

Depth (cm)	CaCO3	Exchangeable Cation				CEC meq/100g	Base. Sat %
		Na	K	Ca	Mg		
0 - 10	4.8	7.00	1.09	-	-	69	94
10 - 33	2.0	10.65	0.93	-	-	57	84
33 - 55	5.6	17.01	0.85	-	-	62	94
55 - 100	5.8	15.11	0.69	-	-	65	94
100 - 130	4.2	20.81	0.74	-	-	74	98
130 - 170	7.4	15.63	0.81	-	-	58	104
170 - 190	4.8	10.28	0.85	-	-	60	102

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC mmhos/cm	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3			
0 - 10	5.4	-	1.0	0.5	1.6	3.4	0.69	6	10
10 - 33	6.4	-	1.5	0.5	1.2	3.3	0.72	6	19
33 - 55	14.0	-	1.5	0.0	7.6	2.6	1.60	16	27
55 - 100	81.8	-	17.5	6.5	10.8	1.5	9.00	24	32
100 - 130	46.0	-	4.0	2.0	10.8	1.6	5.50	27	28
130 - 170	53.2	-	7.5	2.5	11.0	1.9	6.30	24	27
170 - 190	16.0	-	2.5	0.5	4.0	2.1	2.20	13	17

Source: Soil Survey Administrarion

Soil Physical and Chemical Data in Nur El Din

Pit No. : 29 M.U.: 50

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	ppm
0 - 12	7	8	28	57	8.3	8.7	0.045	0.468	10	5.8
12 - 43	6	7	27	60	8.3	8.6	0.045	0.390	9	4.2
43 - 65	4	6	25	65	7.8	8.4	0.040	0.484	12	4.4
65 - 90	8	5	21	66	7.6	8.2	0.050	0.452	9	5.2
90 - 123	2	5	24	69	7.8	8.4	0.050	0.608	12	4.4
123 - 151	9	9	21	61	7.8	8.3	0.045	0.437	10	4.4
151 - 178	10	12	21	57	7.8	8.3	0.075	0.406	5	4.2

Depth (cm)	CaCO3	Exchangeable Cation				CEC	Base. Sat
		Na	K	Ca	Mg	meq/100g	%
0 - 12	5.6	7.20	0.91	-	-	58	74
12 - 43	5.4	12.10	0.75	-	-	60	75
43 - 65	4.6	16.24	0.73	-	-	67	91
65 - 90	4.6	14.26	0.63	-	-	65	82
90 - 123	5.0	18.41	0.68	-	-	71	105
123 - 151	3.8	8.05	0.75	-	-	66	94
151 - 178	3.8	7.73	0.78	-	-	61	75

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3	mmhos/cm		
0 - 12	4.3	-	1.5	0.0	1.2	3.0	0.58	5	12
12 - 43	5.0	-	1.0	0.5	2.2	3.2	0.60	6	20
43 - 65	35.0	-	5.0	0.0	6.8	1.9	4.40	22	24
65 - 90	21.0	-	4.5	1.0	5.4	2.0	2.90	13	22
90 - 123	51.0	-	7.5	3.5	7.4	2.0	6.20	22	26
123 - 151	29.0	-	8.5	3.0	13.2	1.9	3.90	12	12
151 - 178	5.4	-	1.5	0.5	2.4	2.7	0.79	5	13

Source Soil Survey Administration

Soil Physical and Chemical Data in Nur El Din

Pit No. : 32 M.U.: 72

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	ppm
0 - 10	6	8	20	66	7.8	8.6	0.040	0.406	10	4.4
10 - 40	8	5	17	70	7.9	8.7	0.045	0.437	10	4.0
40 - 80	6	6	23	65	8.1	8.9	0.040	0.374	9	4.0
80 - 101	4	5	21	70	7.6	8.1	0.045	0.437	10	6.6
101 - 140	4	4	15	77	7.7	8.1	0.050	0.515	10	7.4
140 - 180	3	3	18	74	7.8	8.5	0.050	0.546	11	6.6
180 - 200	3	6	17	74	7.6	8.1	0.040	0.312	8	6.0

Depth (cm)	CaCO3	Exchangeable Cation				CEC	Base. Sat
		Na	K	Ca	Mg	meq/100g	%
0 - 10	4.0	4.10	1.25	-	-	70	80
10 - 40	4.2	8.85	1.10	-	-	64	79
40 - 80	3.8	13.15	0.93	-	-	64	79
80 - 101	4.0	11.51	0.83	-	-	61	105
101 - 140	4.4	16.85	0.78	-	-	66	112
140 - 180	4.4	17.09	0.79	-	-	56	122
180 - 200	5.6	12.91	0.73	-	-	62	111

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3	mmhos/cm		
0 - 10	5.0	-	1.5	0.0	1.8	2.9	0.53	6	6
10 - 40	5.6	-	1.5	0.5	1.6	3.3	0.60	6	14
40 - 80	7.6	-	1.5	0.0	2.4	2.9	0.94	9	21
80 - 101	65.0	-	17.5	6.5	8.8	1.8	7.70	19	19
101 - 140	48.0	-	6.5	3.5	13.0	2.0	5.80	21	26
140 - 180	38.0	-	7.5	0.5	13.4	1.7	5.00	19	31
180 - 200	49.0	-	11.0	5.5	15.0	1.4	6.50	17	21

Source: Soil Survey Administration

Soil Physical and Chemical Data in Hurga

Pit No. : 26 M.U.: 71

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	ppm
0 - 17	16	9	16	59	7.8	8.4	0.045	0.499	11	5.4
17 - 45	15	10	13	62	8.2	9.1	0.045	0.390	9	5.2
45 - 75	15	6	27	52	8.1	8.7	0.050	0.328	7	5.2
75 - 105	10	6	16	68	8.4	8.9	0.050	0.343	7	6.2
105 - 125	9	6	16	69	7.5	8.1	0.045	0.328	7	5.2
125 - 155	6	5	25	64	7.7	8.4	0.045	0.234	5	6.2
155 - 180	2	6	35	57	7.7	8.4	0.045	0.359	8	5.8

Depth (cm)	CaCO3	Exchangeable Cation				CEC	Base. Sat
		Na	K	Ca	Mg	meq/100g	%
0 - 17	8.6	6.48	1.25	-	-	-	77
17 - 45	8.0	11.60	1.00	-	-	53	81
45 - 75	8.2	15.86	1.00	-	-	49	98
75 - 105	7.2	16.46	0.97	-	-	-	113
105 - 125	7.6	20.16	0.99	-	-	-	113
125 - 155	8.6	20.19	0.84	-	-	-	105
155 - 180	4.6	-	1.03	-	-	-	77

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3	mmhos/cm		
0 - 17	5.0	-	1.5	1.0	2.2	3.7	0.68	4	-
17 - 45	10.6	-	1.5	0.0	3.2	3.1	1.20	12	22
45 - 75	-	-	17.5	6.5	4.0	1.8	-	24	32
75 - 105	-	-	16.0	7.0	4.0	1.8	-	26	-
105 - 125	-	-	16.5	7.5	4.0	1.6	-	26	-
125 - 155	-	-	18.5	9.0	4.0	1.6	-	23	-
155 - 180	6.0	-	1.5	0.5	3.2	3.4	0.79	6	-

Source: Soil Survey Administration

Soil Physical and Chemical Data in Hurga

Pit No. : 28 M.U.: 50

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P ppm
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	
0 - 13	14	7	15	64	8.7	9.2	0.045	0.390	9	4.4
13 - 35	14	16	8	62	8.3	8.9	0.050	0.421	8	4.4
35 - 60	13	15	15	57	8.8	9.3	0.045	0.374	8	4.0
60 - 80	8	9	18	65	8.1	8.6	0.045	0.468	10	4.8
801 - 105	9	11	21	59	8.1	8.5	0.050	0.452	9	4.0
105 - 135	8	8	19	65	8.2	8.8	0.045	0.359	8	4.6
135 - 180	16	12	35	37	8.2	8.6	0.050	0.468	9	4.8

Depth (cm)	CaCO3	Exchangeable Cation				CEC meq/100g	Base. Sat %
		Na	K	Ca	Mg		
0 - 13	5.4	5.33	0.85	-	-	59	83
13 - 35	5.2	8.95	0.75	-	-	56	83
35 - 60	6.6	4.23	0.86	-	-	67	82
60 - 80	6.2	10.75	0.86	-	-	61	93
801 - 105	6.2	5.23	1.03	-	-	58	94
105 - 135	5.2	2.98	1.04	-	-	-	98
135 - 180	5.4	5.65	1.03	-	-	58	-

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC mmhos/cm	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3			
0 - 13	3.8	-	1.5	0.5	1.2	2.9	0.53	4	9
13 - 35	4.1	-	1.5	0.5	1.1	3.6	0.53	4	16
35 - 60	17.5	-	2.5	1.0	2.8	2.1	2.00	13	6
60 - 80	32.0	-	8.5	2.5	4.7	1.7	4.40	14	18
801 - 105	3.8	-	1.5	0.0	1.2	3.2	0.52	4	9
105 - 135	4.1	-	1.5	0.0	1.4	2.8	0.55	5	-
135 - 180	5.8	-	1.5	0.5	1.2	3.6	0.77	6	10

Source: Soil Survey Administration

Soil Physical and Chemical Data in Hurga

Pit No. : 30 M.U.: 50

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P ppm
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	
0 - 17	5	10	23	62	7.9	8.5	0.045	0.468	10	5.0
17 - 45	4	10	23	63	7.5	8.1	0.040	0.452	11	4.0
45 - 79	5	9	22	64	7.6	8.2	0.040	0.390	10	5.2
79 - 107	3	8	26	63	7.8	8.5	0.045	0.484	11	4.2
107 - 134	3	8	25	64	7.5	8.1	0.050	0.515	10	6.2
134 - 170	5	8	20	67	7.6	8.2	0.075	0.343	5	5.2
170 - 190	3	9	33	55	7.9	8.5	0.045	-	-	-

Depth (cm)	CaCO3	Exchangeable Cation				CEC meq/100g	Base. Sat %
		Na	K	Ca	Mg		
0 - 17	4.0	4.76	0.91	-	-	68	76
17 - 45	4.2	8.95	0.90	-	-	72	73
45 - 79	3.8	15.13	0.78	-	-	73	81
79 - 107	3.6	12.25	0.73	-	-	73	99
107 - 134	3.6	11.86	0.73	-	-	65	103
134 - 170	5.8	12.18	0.75	-	-	65	94
170 - 190	5.6	11.78	0.80	-	-	58	97

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC mmhos/cm	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3			
0 - 17	3.6	-	1.5	0.5	1.4	2.9	0.50	4	7
17 - 45	4.0	-	1.5	0.0	1.8	2.5	0.51	5	12
45 - 79	17.5	-	2.5	1.0	6.6	2.6	2.20	9	21
79 - 107	55.3	-	17.5	7.5	10.8	1.4	6.90	16	17
107 - 134	41.0	-	11.0	5.0	11.0	1.7	5.20	14	18
134 - 170	23.4	-	3.5	1.5	9.0	1.9	3.00	15	19
170 - 190	27.0	-	5.5	3.0	8.0	1.6	3.70	13	20

Sourcr: Soil Survey Administration

Soil Physical and Chemical Data in Hurga

Pit No. : 33 M.U.: 53

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	ppm
0 - 35	10	6	15	69	7.8	8.7	0.045	0.312	7	4.0
35 - 56	10	5	22	63	8.1	8.9	0.045	0.359	8	4.0
56 - 80	8	6	17	69	7.8	8.5	0.045	0.343	8	4.0
80 - 100	11	6	14	69	7.9	8.8	0.035	0.406	12	-
100 - 135	6	6	12	76	7.6	8.4	0.040	0.406	10	5.8
135 - 175	6	6	21	67	7.5	8.2	0.045	0.421	9	6.0
175 - 190	18	22	10	50	7.7	8.5	0.045	0.312	7	6.4

Depth (cm)	CaCO3	Exchangeable Cation				CEC	Base. Sat
		Na	K	Ca	Mg	meq/100g	%
0 - 35	3.8	7.83	0.83	-	-	60	76
35 - 56	3.2	12.20	0.73	-	-	65	71
56 - 80	3.2	12.10	0.61	-	-	78	80
80 - 100	3.0	15.66	0.58	-	-	69	97
100 - 135	4.8	16.73	0.71	-	-	68	102
135 - 175	5.8	15.88	1.25	-	-	75	105
175 - 190	6.0	4.13	0.65	-	-	46	73

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3	mmhos/cm		
0 - 35	4.5	-	1.0	0.5	1.2	3.1	0.50	5	13
35 - 56	4.0	-	1.0	0.5	0.8	3.2	0.50	5	19
56 - 80	4.5	-	2.5	1.5	1.4	3.4	0.60	3	16
80 - 100	17.5	-	2.0	0.0	3.2	2.5	2.50	18	23
100 - 135	43.0	-	8.5	3.5	9.8	2.3	5.00	18	25
135 - 175	29.0	-	5.0	2.0	10.8	2.0	3.70	16	21
175 - 190	12.5	-	1.5	1.0	4.8	2.8	1.40	-	9

Soil Physical and Chemical Data in Hurga

Pit No. : 31 M.U.: 51

Depth (cm)	Particle Size Destribution (%)				pH		Nitrozen and Carbon			Avail. P
	CS	FS	Si	Clay	paste	H20	N %	C %	C/N	ppm
0 - 10	8	10	23	59	7.6	8.1	0.040	0.577	14	5.8
10 - 27	9	10	22	59	7.8	8.3	0.050	0.546	11	4.6
27 - 50	8	9	20	63	7.8	8.3	0.040	0.499	12	4.2
50 - 90	5	6	23	66	7.5	8.1	0.035	0.577	16	-
90 - 120	4	6	21	69	7.6	8.2	0.040	0.593	15	6.4
120 - 150	2	6	35	57	7.5	8.1	0.045	0.109	2	6.0
150 - 190	7	10	20	63	7.9	8.5	0.035	0.234	7	4.4

Depth (cm)	CaCO3	Exchangeable Cation				CEC	Base. Sat
		Na	K	Ca	Mg	meq/100g	%
0 - 10	5.8	3.08	0.95	-	-	66	78
10 - 27	4.4	7.53	0.85	-	-	63	79
27 - 50	5.0	10.35	0.76	-	-	67	81
50 - 90	2.6	10.86	0.70	-	-	56	81
90 - 120	3.8	3.80	1.05	-	-	59	89
120 - 150	7.0	9.73	0.68	-	-	50	101
150 - 190	7.4	11.74	0.78	-	-	-	87

Depth (cm)	Soluble Cations and Anions meq/L in Saturation						EC	SAR	ESP
	Na	K	Ca	Mg	Cl	HCO3	mmhos/cm		
0 - 10	3.3	-	1.5	0.5	1.4	2.7	0.47	3	5
10 - 27	-	-	1.0	0.5	1.0	2.9	-	-	12
27 - 50	4.7	-	1.0	0.5	1.6	3.7	0.60	5	15
50 - 90	57.5	-	18.5	7.0	5.4	1.7	7.10	16	19
90 - 120	8.2	-	6.5	1.5	2.8	1.9	1.50	4	6
120 - 150	68.0	-	16.0	6.0	17.4	1.8	7.70	-	19
150 - 190	37.0	-	4.5	1.5	21.4	1.9	4.60	21	24

Source: Soil Survey Administration

CRITERIA FOR THE SOIL CLASSIFICATION BY AMERICAN SOIL TAXONOMY (1975)

1. Criteria used to classify the soils down to the series level

a) Clay %, Cracks and slickensides, and/or wedge-shaped peds

b) Soil moisture regime
Ustert: cracks persist for more than 3 months (> 90 cumulative days)
Udert : cracks do not persist for more than 3 months (< 90 cumulative or < 60 consecutive days)

c) Color chroma
Chromustersts: chroma moist 1.5 or more
Pellusterts: chroma moist of less than 1.5

d) Color value
Typinc: color value moist less than 3.5
Entic: color value moist 3.5 or more

e) Particle size class
Minerology class
Fine: clay content less than 60 % (in control section)
Very fine: clay content 60 % or more (in control section)

Soil temperature regime
Iso: soils with < 5 °C difference between summer and winter
Thermic: 15-22 °C mean annual temperature
Hyperthermic: > 22 °C mean annual temperature

f) Depth of melanic horizon calcareous

2. Criteria used at the phase level

a) Sodicity (ESP):

Soil Phase	Sodicity level	
	at 0-25 cm depth	at 25-100 cm depth
non-sodic	<10	<20
slightly sodic	10-20	20-35
moderately sodic	20-35	35-50

3. Soil Salinity

1) Sodic Soil

A soil that contains sufficient sodium to interface with the growth of most crop plants, and in which the exchangeable sodium percentage is fifteen (15) or more.

2) Saline Soil

A non sodic soil containing a concentration of neutral soluble salts sufficient to seriously interfere with the growth of most plants. The electrical conductivity of a saturated extract ESP is more than 4mmhos/cm. Less than fifteen (15) % of the cation exchange capacity is occupied by sodium ions and the pH usually is below 8.5. ESP is calculated as follow:

ESP=(Exchangeable Sodium)÷(Cation Exchangeable Capacity)x100

Thus ESP is measure of the degree to which the exchange complex is saturated sodium. The adverse influences of exchangeable sodium are moderated by levels of calcium and magnesium. The best measure of potential hazards from high sodium levels have shown that best measurement of potential hazard from high sodium levels is a cation ratio that take calcium and magnesium as well as sodium into consideration. This ratio, called the sodium absorption ratio (SAR), is defined as

$$SAR=(Na^{+}) \div \sqrt{(Ca^{2+}) + (Mg^{2+})}$$

Where (Na^{+}), (Ca^{2+}) and (Mg^{2+}) are the concentration of these ions in a soil extract in millimoles per litter

THE SUBCLASS LIMITATION FOR LAND SUITABILITY

The Land Suitability System adopted subclasses that are subdivisions of the classes reflecting the kind of major limitations. The subclass limitations used in this study are as follow.

c: climate
limitation caused by adverse climatic conditions (climate too wet or too dry or adverse temperature regime)

t: unfavorable topography
limitation due to unfavorable relief (macro or micro) or relative elevation limiting its use

e: erosion
limitation caused by erosion hazards or past erosion damage

w: wetness
limitation due to water logging caused by a high water table, slow permeability or slow surface drainage, or a combination of these

i: inundation
limitation caused by inundation (flooding) of the land from rivers

s: salinity
limitation due to high content of soluble salts

a: alkalinity
limitation due to alkaline soil reaction (pH) and high exchangeable sodium percentage

f: fertility
limitation due to low chemical fertility (soils have low content of plant nutrients)

m: moisture deficiencies
land with moisture deficiencies due to soil conditions

v: vertisols
limitation due to a high content of swelling clay

g: surface gravel or stones
limitations due to occurrence of gravel or stones covering the surface, hampering cultivation and seeding establishment

p: physical soil deficiencies
limitations due to adverse physical soil properties (other than mentioned under v)

d: depth and stoniness
limitation due to shallowness or stoniness or both, restricting root development

w: wetness
drainage condition in the growing section lowlying areas

x: pest and disease
limitations caused by the occurrence of pest and disease

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ANNEX-D

AGRICULTURE AND AGRO-ECONOMY

FINAL REPORT

FOR

THE FEASIBILITY STUDY

ON

THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

ANNEX D: AGRICULTURE AND AGRO-ECONOMY

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I. GENERAL BACKGROUND

1.1 National Socio-economy

1.1.1 Land and Population

Sudan is the largest country in Africa with an area of about 2.5 million km^2. It is bounded by eight (8) countries, namely, Egypt, Ethiopia, Kenya, Uganda, Zaire, Central African Republic, Chad and Libya and it shares the total international boundary of 7,820 km. The capital of the country is Khartoum, forming the urban complex with Omdruman and Khartoum North. The other important cities are Port Sudan, Wad Medani, El Obeid, Atbara and Juba.

The population of Sudan was estimated at about 24 million in 1988 (see Table 1.1), based on the population census carried out in 1983 when the population was 20.6 million. The annual population growth rate was estimated at 3.1% between 1983 and 1988. Sudan is one of the least densely populated country over the world. The average population density in 1988 was estimated at 9.6 person per km^2.

1.1.2 National Economy

Table 1.2 shows annual Gross Domestic Product (GDP) of Sudan between 1981/82 and 1988/89 and GDP projection of 1989/90 at 1981/82 constant price. As shown in the Table, GDP has been fluctuated unstably and improved in 1988/89 so drestically as an increment of 11.6% compared with the previous year. But, the government of Sudan forecasted that it would turn into a negative growth rate of 5.9% again in 1989/90. The growth of GDP between 1981/82 and 1989/90 was estimated at about 1.0%, indicating that the economic growth during the period has been stagnant in the least. The per capita GDP has continued declining from early 1980s, and the one in 1988/89 was estimated at £S 288.3 or US$23.8 at 1981/82 constant price or, £S 2,834.9 or US$230.5 at current market price with an exchange rate of US$1.00=£S 12.30.

The sectoral GDP percent is shown Table 1.3, which indicates that the agricultural sector plays a very important role in the Sudanese economy. It accounted for about 34% of the total GDP and over 90% of export earnings for recent five years. About 70% of the labour force depends on agriculture. According to the Ministry of Finance and Economic Planning (MOFEP), no drastic change in such industrial structure is forecasted and Agricultural sector will continue to play a vital role in the Sudan's economy. Contribution of the industry and service sectors averaged at 15 and 51% of the total GDP, respectively.

In 1989 the Sudan's foreign trade recorded export earnings of £S 3,023.1 million and import expenditure of £S 5,373.4 million, producing a trade deficit of £S 2,350.3 million. Cotton earned £S 1,348.8 million or 44.6% of total export value as shown Table 1.4.

(£S million)

Item	1987	1988	1989
Export Value	1,497.1	2,290.9	3,023.1
(% Charge)	(+79.7)	(+53.0)	(+32.0)
Imports Value	2,612.9	4,892.8	5,373.4
(% Change)	(+8.8)	(+87.3)	(+9.8)
Total Balance	-1,115.8	-2,601.9	-2,350.3
(% Charge)	(+28.8)	(-133.2)	(+9.7)

Source: Bank of Sudan

1.1.3 Exchange Rates

Since 1987, foreign exchange market system was revised ten times by Bank of Sudan (BOS). On the 25th of October 1988, two main exchange rate regimes were established. The regime is such that all export earnings in terms of £S is converted into US$ with an official exchange rate of US$1.00 = £S 4.50 for 70% of the earnings and a free exchange rate of US$1.00 = £S 12.10 for the rest, resulting in a weighted average rate of US$1.00 = £S 6.78. On the 27th of August 1990, BOS announced an exceptional exchange rate for export earnings by cotton that: the official and free exchange rates were to be employed for each 50 % of the earnings for 1990 - 1991 season. As for the main strategic imported commodities including wheat, wheat flour, sugar, petroleum products, machinery and all agricultural inputs, however, the official exchange rate has been employed constantly. On the 21st of May 1991, BOS announced the repeal of the plural exchange rate regimes and employment of single exchange rate, and on the 28th of May it was enforced. Now, only sole exchange rate of US$1.00 = £S 12.30 is adopted for all export earnings and imported commodities without exception. Changes in the official and free exchange rates of the Sudanese pound to US$ for recent three years are shown Table 1.5.

1.1.4 National Development Plan

After the 1982/83-1984/85 Three-year Public Investment Programme placing an emphasis on the rehabilitation of existing production units and the removal of transport and energy bottlenecks, GOS launched the Four-Year Salvation, Recovery and Development Programme 1988/89- 1991/92.

During 1982/83-1984/1985, real GDP declined annually by 0.4%, 2.9% and 12.8% under the influence of a slump in agricultural sector. Owing to recovery of agricultural sector, however, GDP turned on the rise thereafter and marked an increase by 11.8% in 1885/86 and by 4.3% in 1986/87.

In view of the unsatisfactory achievement of the previous Three-Year Programme, GOS planed another Four-Year Development Programme successively. The Four-Year Salvation, Recovery and Development Programme aimed to address the immense inherited problem facing the present Government, in a systematic and comprehensive way. The major objectives of The Four-Year Salvation, Recovery and Development Programme are:

1) Inspiration and stimulation of the patriotic spirit and the sanctity of work;

2) A GDP average growth rate not less than 5 %per annum;

3) Provision of basic needs in respect of food, water, clothing, shelter, security, health, education, and transport;

4) Food security for rural and urban populations;

5) Social justice through reduction of disparities in income and wealth;

6) Progress to be made towards balanced regional development, with emphasis on less developed regions; and

7) Formulation of post-war development programme for the Southern Region taking into full consideration the extraordinary conditions pertaining to that region.

The main objectives of the agricultural sector in The Four-year Salvation, Recovery and Development Programme are:

1) Realization of food security mainly through increasing the production of major food crops;

2) Achievement of an average annual growth rate of 5.7%.

3) Increasing production and productivity on the major agricultural commodities;

4) Promotion of export earnings at an annual growth rate of 19%;

5) Realization of a balanced growth with due emphasis on the traditional sector and the least development areas;

6) Drought and desertification control; and

7) Promotion of raw materials for the industrial sector.

The targeted agricultural production and growth rate are shown in Table 1.6.

The agricultural programme is centered on the rehabilitation and modernization of the existing irrigated viable schemes and self- sufficiency in wheat. Especially, regarding to self-sufficiency in wheat, GOS intends to considerably reduce its dependence on imported wheat by attaining self-sufficiency to a target level of around 90% by the end of the programme period. In order to achieve this target, GOS suggests expanding irrigated area for wheat and increasing yield of wheat without adversely affecting other crops. Gezira Scheme, New Halfa, White Nile and Northern Region are regarded as the potential areas for both area expansion and yield improvement.

1.1.5 Agricultural Sector

Agriculture in Sudan is broadly categorized into four types, i) irrigated, ii) rain-fed mechanized, iii) rain-fed traditional, and iv) livestock. The irrigated agriculture extends to

7 million feddans, which is dominant in Sudan and mainly consist of five major irrigation schemes namely, Gezira-Managil (2 million feddans), New Halfa (0.4 million feddans), Rahad (0.3 million feddans), Blue Nile Pump Schemes (0.26 million feddans) and White Nile Pump Schemes (0.44 million feddans). The main crops raised in the irrigated area are cotton, groundnuts and cereals.

The rain-fed mechanized and traditional agriculture covers an area of 15 million feddans, which grow sorghum, groundnuts, sesame, millet and gum Arabic. This sector also plays an important role for the food production in Sudan.

The production areas and crop productions are shown Table 1.7. The main food crops produced in Sudan are sorghum (dura), millet, groundnuts, sesame and wheat.

Sorghum is the most important staple food in rural area and one of the important cereal crops for the country's economy. Mainly, sorghum is produced under rainfed conditions. In 1988/89, sorghum was grown in about 13 million feddans and its production reached 4.4 million tons. Sudan is a sorghum surplus country and continuously exports sorghum except for drought year (1984/85).

Recently, wheat has been increasingly consumed and alternated with sorghum as staple food especially in urban areas and Northern Region. Wheat is raised only under irrigated conditions. The main wheat producing center is the Gezira Scheme accounting for about 64% of total planted area in 1989/90. In accordance with the government policy on expansion of wheat production aiming at future self- sufficiency, wheat planting area has been increasing year by year for recent seasons. In 1989/90, about 614,000 feddans was planted to wheat and its production increased from 247,000 tons in 1988/89 to 409,000 tons in 1989 / 90. Thus, import of wheat decreased from about 70% in 1988/89 to some 55% of the total consumption.

Millet (dukhn) is mainly raised in North Kordofan. Production of millet remained at only 161,000 tons due to its low yield of 43 kg/feddan, although its planted area amounted to 3.7 million feddans in 1989/90.

Groundnuts and sesame are the principal oil seeds crops. Groundnuts are not only the traditional foreign exchange earner but also satisfying domestic consumption need. Groundnuts are dominant crop of rainfed traditional agriculture, particularly produced in North Kordofan and South Dafur. Groundnuts production had showed upward trend and reached 0.6 million tons in 1988/89, but dropped to less than half of the previous year in 1989/90 due to shrinkage of planting area and fall of yield. Planting area including irrigated ones for groundnuts were 1.6 million feddans in 1988/89 and 1.3 million feddans in 1989/90, respectively.

Sesame is grown only in the rainfed area, especially in Gedaref and Damazin under mechanized rainfed cultivation and in North and South Kordofan under traditional one. Sesame also is one of the traditional export crops. In 1988/89, sesame was planted in about 0.28 million feddans and its production was about 0.2 million tons. The sesame production in 1989/90 fell to 0.14 million tons due to water logging, pest and diseases.

Cotton is the most important industrial crops for earning foreign exchange. In 1989, cotton accounted for about 45% of total export earnings. The share of the Sudan's cotton in the worldwide production was about 0.7 % in total, but about 4.5% as for the specially extra long staple (ELS) cotton in 1989. Cotton is produced under irrigated condition in such large scale schemes Gezira-Managil, New Halfa Rahad, El Suki, Blue Nile Pump Scheme and White Nile Pump Schemes. Its planted area in the Gezira-Managil Scheme occupies 50% of the total planted area. Cotton production has continued downward trend in recent years. In 1989/90, about 702,000 feddans was planted for cotton producing 408,000 tons and its producing area and production declined by about 11.3% and by 20.6 % respectively in comparison with those in 1988 as shown Table 1.8. It was reportedly attributed to: i) insect infestation, ii) inadequate supplies of water, agro-chemicals and fertilizers, iii) shortage of labour, particularly during the picking season.

1.2 Regional Socio-economy

1.2.1 Location

El-Gezira province in the Central Region is located in the center of the Sudan, between latitudes 13°30' and 15°30' and longitudes 32°30' and 34°15'. It borders on Khartoum province on the north, on the Kassala province on the east, on the Blue Nile province on the southeast and on the White Nile province on the west.

The El-Gezira province covers land area of 35,057 km^2 having an population density of 58.1 persons per km^2 in 1983, which is the second most densely populated province after Khartoum province.

Wad Medani town, the second largest town in the Sudan following Khartoum is the capital of El-Gezira province and Central region as well. Wad Medani is located at about 190 km south of Khartoum and about 800 km southwest of Port Sudan and well connected to those cities by rail and highway networks.

The Project area lies about 30 km south of Wad Medani and extends on the right bank of the Blue Nile.

1.2.2 Population

The population of the El-Gezira province was reported to be 2.0 millions in the 1983 census and accounted for 9.8% of the national population as shown in Table 1.9. A 16.9% of the population inhabit in the urban area and 81.7% in the rural area and 1.4% are normad. In particular, population of El-Grzira province fluctuates seasonally in accordance with movement of seasonal or daily agricultural laborers working in the Gezira Scheme. The number of those agricultural laborers is estimated at approximately 520,000 persons.

Between 1983 and 1990 the annual population growth rate was estimated at 3.1%. The population of the El-Gezira province in 1990 is estimated at about 2.48 millions based on the said average growth rate. Population aged 10 years old or more is counted as working population. In

this sense, labor force in the province is estimated at approximately 69% or 1.7 millions persons of the population.

1.2.3 Agriculture in the Region

El-Gezira province is economically one of the most active province for agricultural sector, which depends mostly on the Gezira Scheme and the Rahad Schmes. The Gezira Scheme, having an irrigation service area of 2.1 million feddans, lies between the Blue and White Niles.

The main crops in the Gezira Scheme are cotton, wheat, groundnuts and sorghum. The total planted area in 1989/90 was 1.26 million feddans in 1989/90, of which 404,000 feddans were devoted to cotton, 274,000 feddans to wheat, 427,000 feddans to sorghum, 111,000 feddans to groundnuts and and 46,000 feddans to vegetables. The area and production of major crops in the Gezira Scheme is shown in Table 1.10.

2. PRESENT CONDITIONS IN THE PROJECT AREA

2.1 General

2.1.1 Climate

The study area is included in arid climate zone having short rainy season in hot summer. An average annual rainfall is 280 mm and the rainy season usually lasts from July through September. Annual rainfall fluctuates so wide range as from 440 mm in 1985 to 120 mm in 1990 for recent 10 years. There is no month in which the average rainfall exceeds the evaporation. Monthly mean temperature ranges from 33.1℃ in May to 23.9℃ in January. Daily mean maximum temperature in the hottest month (May) is 41.5℃ and daily mean minimum temperature in the coldest month (Jan.) is 14.7℃. An average daily solar radiation at Wad Medani weather station is 562 cal/cm^2/day and ranges from 522 cal/cm^2/day in December to 634 cal/cm^2/day in April. Further information is given in Table 2.1.

The climate is suitable for a number of irrigated crops, e.g. sorghum, cotton, sugarcane, groundnuts and rice. Potential productivity of these crops for the Study area is quite high in respect of high solar radiation and no frost season. The main limiting factor in climatic conditions is less precipitation. This means that high yield of crop could be expected under intensive irrigated farming.

2.1.2 Population and Labor Force

The Project area consists of Hurga and Nur El Din areas and involves 18 villages. There are 9 villages in each area. No recent statistic data are available for the Project area. Only a statistic book for the Gezira Scheme of "Gezira and Managil Village Directory" issued in 1981 mentions the social conditions of Hurga and Nur El Din. According to the statistic book, population and the number of tenants belonging to 18 villages are as follows:

Village	Population (household)	Nos.of tenants
Hurga area		
Gaber	650	108
Tenouba	1,885	255
Rama	350	18
Afaya	1,000	100
Hurga	5,000	181
Fadl Alla	750	10
Gemeiab	1,200	71
Errayh	938	84
Shabarga	11,000	82
Total	18,173 (2,270)*	882
Nur El Din area		
Hereiz	1,500	94
Amara Nefeidya	290	40
Rahmanya (Ansar)	300	54
Wad Elegeil	250	55
Managa	936	157
Shadayda wad Agbna	2,000	74
Nur El Din	350	32
Abdelkarim	1,000	74
Reheimat	750	60
Total	7,376 (920)*	630

Note: *: Estimated by assumed family size of 8 person per family.
Source: Gezira and Managil Village Directory, 1981

As shown in the above table, the tenants for the Hurga and Nur El Din areas are about 40% and 70% of respective household numbers. Only either patriarch or matriarch of the household can keep and take over the tenant right.

According to Gezira and Managil Village Directory, the average size of the household in 1981 was 8 persons. But, now the average household size is estimated at 7.5 persons per household based on the farm economic survey conducted by the JICA Study Team during the current study period.

Average maximum labor force for agriculture is estimated based on the result of said farm economic survey at 4.8 persons per household including womens and children, employing assumed labor force coefficients of: i) 0.6 for male and female children in the age between 10 and 12 years old; ii) 0.7 for female farmer and farmer above 60 years old; and iii) 1.0 for male farmer in the ages between 13 and 60.

2.1.3 Land Tenure and Holding

The Project area is included in the field management units of Block Number 106 for Hurga area and Number 107 for Nur El Din under a block headquarters of Central Group in the Gezira Scheme.

All farmers in the Gezira Scheme are not allowed to own their lands, but tenant right. The tenants can take over the usufruct of tenancy to one of their family without dividing. They must follow the cropping pattern and calender for cotton and wheat decided by SGB. But, they are allowed to choose by themselves the third crop to be grown in one forth tenancy area in the case of four-course rotation. Under this tenant system, the Gezira Scheme is divided into 102,000 tenancies. Present average tenancy size is 20 feddan in Gezira area and 15 feddan in the Managil area and Hurga and Nur El Din areas.

2.1.4 Social Infrastructure in the Project area

(1) Potable Water Supply

There exists no village with a water supply system provided by the Gezira Province Rural Water Administration in and around the Project area. Out of 18 villages, 16 obtain their potable water from public deep tube wells and two villages from irrigation canals. Most of public wells have water works consisting of public deep tube wells and water tanks. Potable water supply facility available for each of villages is shown in Table 2.2.

(2) Education

There are five elementary schools in the Project area with a total enrollment of 1,614 students and there are five intermediate schools with a total enrollment of 590 students. No secondary school is available in the Project area. More detailed information is given in Table 2.3.

(3) Medical Facilities

The medical facilities in the Project area include eight dressing station (rural clinic), two dispensaries, one health center and one bet clinic. The health center is staffed by one doctor and two assistants. One assistant each manages other clinics and dispensaries Some midwife and primary care unit staff are available in the project area. Farther information is given in Table 2.2.

(4) Mail and Telecommunication Facilities

There is no post office in the Project area. Only two post agents are located in Hurga area. The public telephone line is not extended to the Project area, but the telecommunication system for the Gezira Scheme covers the area. Now four radio telephones have been installed at both Hurga and Nur El Din pumping sites under Gezira Rehabilitation and Modernization Project.

2.2 Present Land Use

Potential farm land area is 13,900 feddans net in Hurga area and 8,270 feddans net in Nur El Din area. Since there was no available data on the present land use in the Project area, thorough field reconnaissance survey was conducted during the study period. The survey revealed that only sorghum was grown in the area of 2,260 feddans or 16% of the potential farm land in Hurga and 1,260 feddans or 14% of the same in Nur El Din in 1990. Location and planted area of sorghum are shown in Fig. 2.1. The rest was left fallow or regarded as "cut-off" area where was excluded from the potential farmland for crop rotation due mainly to higher elevation. The present land use condition in the Project area is summarized as follows.

(Unit: feddan)

Category	Hurga	Nur El Din
Sorghum	2,260	1,260
Fallow	4,500	3,000
Cut off area	4,500	3,000
Others*	2,640	1,460
Total	13,900	8,720

Note: *: including the area where tenants gave up growing sorghum before harvesting.

Source: land use survey, farm economy survey and Study Team estimate

2.3 Cropping Pattern and Farming Practices

2.3.1 Cropping Pattern

A three-course rotation with a 15-feddan tenancy system; cotton-sorghum-fallow for three years, was originally established in 1950's and followed by SGB after the Project area was turned over to SGB for management in the middle of 1970's. From 1981/82 crop season onward, however, tenants in the area have adopted a sorghum-fallow rotation in about two third of the potential farm lands due to severe shortage of water and topographic limit.

Generally, cropping calender of sorghum is set to fall in the rainy season lasting from July to September. Expecting rain water, sorghum was planted in July and harvested from the middle of November to middle of December. It seems that in 1990 sorghum was planted to one third of the Project area, but large number of tenants gave up growing sorghum on the way because of limit in irrigation water and abnormal drought in rain months.

2.3.2 Farming Practices for Sorghum

Most of the varieties of sorghum introduced in the Project area are local ones which are multiplied by the tenants themselves. The major varieties are Fatarieta and Mayo.

In the Project area, extensive farming is practiced for growing sorghum with one to four times irrigation during the growth period in the very limited area. Before sowing, land preparation is kept down to the absolute minimum. Only ridging is commonly carried out by machinery with four-row ridgers. Seeds are generally sown at a rate of about 3 kg/feddan by manual at 80 cm x 10 cm spacing with two seeds per hill.

Application of fertilizer and agro-chemicals are not common in the Project area. Weed control is carried out manually in few times before heading stage. Mannual harvesting is practiced in November and December. After harvesting, threshing is made by either manpower or thresher. Details of farm inputs is shown in Table 2.4.

2.4 Agricultural Production

2.4.1 Crop Yield and Production

According to the result of farm economic survey, yield of sorghum in 1990 season was about 240 kg/feddan in Hurga area and 130 kg/feddan in Nur El Din area with an average yield of about 201 kg/feddan. It is noted that the average yields thus estimated are based on answers from the tenants who got production and those who gave up farming on the way were not reflected. In fact, among 100 samples for the farm economic survey, 42% samples answered having given up harvesting finally, details of which are shown in Table 2.5. If answers of sample tenants who gave up farming is included in the estimation, the average yield in the Project area become as low as about 100 kg/feddan. Considering the Project area has suffered from chronic water shortage for decade, the above thing seems to have been recurring.

Total production of sorghum in the project area in 1990 is roughly estimated at about 700 tons by using an average crop yield of 201 kg/feddan and planted area of 3,520 feddan.

2.4.2 Live Stock Production

There is no recent statistic data on livestock production. Only existing statistic book for the Gezira Scheme provides for the following information:

Type of Animals	Hurga	Nur El Din
Cattle	1,205	1,431
Goats	3,350	1,940
Sheep	1,900	2,120
Camel	14	23
Donkey	780	537

Source: Gezira and Managil Village Directory, 1981

According to the farm economic survey on 50 sample tenants each for Hurga and Nur El Din area, total numbers of livestocks for each of areas are estimated as follows:

Type of Animals	Hurga	Nur El Din
Cattle	1,464	1,071
Goats	4,763	3,906
Sheep	811	1,474
Camel	-	-
Donkey	829	643
Chicken	3,140	1,802

Source: Farm Economic Survey

2.5 Land and Water Charge

In 1981, a land and water charge system was established primarily for the Gezira and Managil Schame to recover: i) administration and operation costs of both SGB and MOI; ii) procurement cost for O&M equipment; and iii) rehabilitation costs. The land and water charges are collected by SGB from the tenants growing cotton, and shared by SGB and MOI. The share for SGB is fixed in terms of amount regardless kind of crops to be raised, and hence the amount of the charges to be allotted for MOI varies depending on the planting area of cotton and other crops to be grown. Land and water charges for each crops are determined based on the number of irrigations and determined each year as shown in Table 2.6.

Usually, land and water charges for all crops except for vegetables are deducted from the gross revenue by cotton. In case tenants grow crops only other than cotton in a year, they must pay for the charges after harvesting of cotton in the following year with 8% interests. Vegetable producer must pay in advance as a form of deposit before planting.

Tenants in the Project area are under management of the Sudan Gezira Board and members of the Tenants' Union in the Scheme, therefore they must pay the charges for sorghum. But, SGB collected no charge from them recently, because they haven't grown cotton.

2.6 Agricultural Supporting Services

2.6.1 Agricultural Research

All agricultural research in the Gezira Scheme is entrusted exclusively to Agriculture Research Cooperation (ARC) centered in Wad Medani. The organization structure of ARC is shown in the Fig. 2.2. Gezira Agricultural Research Station (ARS) of ARC has eight departments and is responsible for research on development, testing on new varieties and new farm input such as fertilizer, herbicide, insecticide, etc. and practices directly related to the Gezira Scheme.

2.6.2 Extension Services

The Extension Department of SGB is responsible for agricultural extension services in the Gezira Scheme, and handles advisory services, demonstration pilots, and farm level contacts. These services are provided by extension staff of the said Department. Organization structure of the Department is shown in Fig. 2.3.

The Extension Department has also organized, through the Village Production Councils, regular lectures to tenants, discussion meeting, etc. aiming at improving technical knowledge of the tenants and propagating SGB's policy and intention.

The number of extension staff members is not much enough for providing the sufficient services. Usually one extension specialist covers about 140,000 feddans involving about 7,000 tenants. Now, extension programme for village television plays an important role to compensate for the short of extension specialists. The programme is broadcasted under the responsibility of the Barakat section of the SGB Extension Department.

2.6.3 Agricultural Credit

SGB practically provides the tenants with all farming services and inputs necessary for cotton and wheat production. All the imputs are distributed to the tenants in goods by SGB in timing with the cropping calender. The cost for these farm inputs is deducted from gross revenue to be earned by selling cotton and wheat to SGB after harvest, and the tenants recieve the balance. This system is regarded as a sort of credit for tenants, and is adopted for only cotton and wheat producers, therefore such tenants who grow only sorghum as those in Hurga and Nur El Din areas have no right to get any services and inputs.

The Agricultural Bank of Sudan (ABS) which has a branch in Wad Medani is only the formal source of credit for the tenants in the Project area. The following two types of credit are provided for various farming activities through the ABS.

i) Short-term loans;

Short-term loans are applicable to meet necessary costs for seasonal crop production and marketing costs of crops, granted for a period not exceeding 15 months.

ii) Medium term loans;

Medium term loans could be utilized for purchasing farm machineries and equipment, livestock, improving of irrigation facilities, repairing farm building or establishing enterprises allied to agriculture. These loans are advanced for a period not exceeding five years.

Present interest rate of ABS loans is 19% for the short-term loans and 38% per annum for the medium term loans. One year grace period is permitted as a rule, but debtor can apply

extension of the grace period for another one year. In this case, ABS adds 10% for interest. Besides, private money lenders are available, but high rates of interest make the tenants difficult in use.

2.6.4 Tenants' Union

Tenants' Union is organized by the tenants in the Gezira and Managil areas. The total number of the members including Hurga and Nur El Din areas reaches 102,000 tenants. The Gezira and Managil Tenants' Union is managed by Board of Directors consisting of 18 representatives. The main purpose of the Tenants' Union is to promote the living standard of the tenants by providing them or their communities with necessary social infrastructures and establishing cooperations. The Gezira and Managil Tenants' Union has constructed hospitals, health centers, schoolhouses and community wells for water supply, etc. in the area and the Project area as well.

The budget of Tenants' Union consists of membership fee and subsidy from GOS. The membership fee accounting for 2% of the gross cotton products is collected through SGB.

The Tenants' Union has three agricultural cooperations, namely Kabro wheat mill, Malakia textile factory and fodder factory aiming to provide agricultural services to the tenants.

2.7 Marketing and Prices

2.7.1 Marketing

Currently GOS set producer prices for cotton, gum Arabic and wheat; floor producer prices for groundnuts, sesame and sorghum; and both the producer and consumer prices for sugar. The future directions of GOS policy on prices for major crops are expected to remain free from intervention. Marketing systems for major crops are as follows:

(1) Cotton

The marketing and export activities for cotton lint are exclusively managed by the Cotton Public Corporation (CPC) established in 1970. All cotton lint for both export and domestic consumption is also under the control of CPC. General marketing channel for cotton is shown in Fig. 2.4. Cotton lint for the local textile industry is sold at the ginnery gate. CPC has been buying all the seed cotton at fixed prices at the ginnery gate, and for cotton seed at Port Sudan for lint. The price at the ginnery gate involves costs for ginning, while that at Port Sudan covers additionally the costs for transportation to Port Sudan. Cotton seed is presently sold to the local oil industry for producing cooking oil and soap by CPC. Furthermore, cotton seed cake and meal are supplied as domestic feed. CPC imports fertilizers and farm inputs and distribute them to the cotton producers.

Cotton lint is sold on a tender basis for export or at fixed prices for domestic consumption. Local prices are fixed by CPC for each quality and type of lint taking production and demand projections into account. No private participation is allowed in ginning and marketing.

(2) Wheat

Locally produced wheat is predominantly handled by government authorities between farm gate and flour mill for domestic consumption as bread or bread flour. The Ministry of Commerce and Trade is the main channel for imported wheat and flour from import through delivery to either private or cooperation millers. Small part of wheat locally produced for self sufficiency is exceptionally handled by private traders. The Ministry of Commerce and Trade allocates wheat to Regional Governments, who subsequently allocate intra-regionally. The regional share of wheat is determined in due consideration of population size and prevailing consumption. Both imported and locally produced wheat are allocated to flour mills at a fixed price. Both imported wheat flour and locally milled flour are distributed to authorized bakeries at controlled prices. General marketing channel for wheat is shown in Fig. 2.5.

(3) Sorghum

Sorghum is mainly produced for self consumption, and hence doesn't enter the market in general. Sorghum produced under rain-fed traditional farming is mainly traded by the private sector. Traders buy sorghum at auction markets and sell to urban and rural wholesaler. In the public sector, ABS handles limited part of sorghum to keep the strategic buffer. General marketing channel for sorghum is shown in Fig. 2.6.

(4) Groundnuts

Export of groundnuts are controlled by the Sudan Oil-seeds Cooperation (SOC) established in 1974. Since the 1980/81 cropping season, private traders have been allowed to participate international market along with the Sudan Oil-seed Company (SOC), which was the sole exporter previously. This change pulled up the farm gate price of groundnuts as a result. Private traders and the newly instituted Sudan Company for Processing of Oil-seeds (SCPO), which is controlled by SOC, export groundnuts oil, cakes and meal. The local trade is made by the local village merchants and by agents working for merchants and oilcrushers in Khartoum and Port Sudan.

SOC sells groundnuts to exporters through direct negotiation or an invitation of bids, and competes with private traders for export of groundnuts. SOC recommended a floor price for farmers to the MOFEP but local merchants, who also provide credit, buy them from producers below the floor price. General marketing channel for groundnuts is shown in Fig. 2.7.

(5) Present Conditions of Marketing in the Project Area

The results of the farm economic survey indicate that at present a half of tenants in the Project area produce only sorghum for their family consumption, and that very limited tenants sell small amount of sorghum to village merchants.

No crops other than sorghum aren't produced in the Project area because of severe limitation of water supply. Tenants planting sorghum sell its residue for fodder at local markets.

2.7.2 Prices of Farm Inputs and Outputs

The current farm gate prices of farm inputs and outputs in the Project area were estimated based on data collected from SGB, MOANR, ABS and farm economic survey conducted by the Study Team. The detailed prices of farm input and output are shown in Table 2.7.

2.8 Farmer's Economy

2.8.1 Present Agricultural Production Value

Present crop production cost is estimated only for single cropping of sorghum production because sorghum is only the crop cultivated currently in the Project area. The estimation is based on the data obtained through the farm economic survey conducted by the Study Team.

The sorghum production cost is estimated in the form of primary production cost, in which land and water charges are not included because no cotton is grown in the Project area. The estimated sorghum production cost comprises mainly seed cost and hired labor and machinery costs.

The present sorghum production cost per feddan thus estimated is about £S 287 in Hurga and £S 160 in Nur El Din as shown Table 2.8. The gross production value accrued from and production cost for sorghum in the Project area under the present conditions are estimated at about £S 3,480 and about £S 1,435 in Hurga and about £S 1,885 and about £S 800 in Nur El Din, respectively as shown in the following table.

Item	Hurga	Nur El Din
Planted area (feddan)	5	5
Average yield (kg/feddan) (£S/5feddan)	240 (3,480)	130 (1,885)
Gross production value (£S/feddan)	696	377
Unit production cost (£S/feddan) (£S/5feddan)	287 (1,435)	160 (800)
Net production value (£S/feddan) (£S/5feddan)	409 (2,045)	217 (1,085)

The annual net production value under the present condition in the Project area is estimated at £S 2,045 for Hurga and £S 1,085 for Nur El Din.

2.8.2 Present Farm Budget

Tenants in the Project area rely their living on off-farm income, which occupies fairly high rate in their total income. About 99% in Hurga area and 100% in Nur El Din area of averaged total annual income in respective Hurga and Nur El Din areas are earned from off-farm income such as livestock products and wage/salary in 1990. There exist tenants in the Nur El Din area who depend their living on only off-farm income. Farm income of the tenants of the Project area accrued from sorghum is estimated at 2% of the average farm income of those in the Gezira Scheme. The annual living expenditures excluding farm inputs costs is estimated at £S 16,000 per household on an average, which corresponds to 80% of that for the tenants of Gezira Scheme. The annual cash balance of farm household is summarized as shown below:

Item	Hurga	Nur El Din	(Gezira)
Gross Income			
Farm income	821	0	31,353
Off-farm income			
Livestock Products	4,902	4,969	876
Wage/Salary	6,651	5,224	2,266
Total	12,374	10,193	34,495
Expenditure			
Farm input	1,436	800	14,735
Living expense	16,552	15,365	19,683
Total	17,988	16,165	34,418
Net reserve	- 5,614	- 5,972	77
Remittance	6,409	5,996	-

Source: Farm Economic Survey, SGB

As shown in the above table, the annual cash balance of the farm household in 1990 were the red for both Hurga and Nur El Din area, and those minus reserve were made up by capricious remittance according to the results of the farm economic survey conducted during the Study period. This demonstrates that the living of the beneficiary tenants of the Project area stands on quite fragile basis and is always confronted by a fear of falling into the subsistence level.

3. AGRICULTURAL DEVELOPMENT PLAN

3.1 Present Agricultural Constraints

(1) Present primary constraints for proper sorghum production is lack of water. The next constraints is of limitation of fertilizer dosge due to budgetary problems.

(2) Presently only sorghum is grown in very limited area. Growing cotton and groundnuts in the Project area has not been practiced since 1980/81, and the tenants in the Project area have no experience on raising wheat.

(3) For agricultural management, the Gezira Scheme is divided into 14 Groups , which are subdivided into 107 Blocks. The Hurga and Nur El Din areas fall under Block No. 106 and 107 respectivery, both of which are included in Central Group (one of the 14 groups). As shown in Fig 2.3, one Extension Specialist and one Entomologist are assigned for each of Groups in the Gezira Scheme. At the Block level, however, field workers for the extension services and crop protection are not detailed at present.

3.2 Options of Crop Rotation

The present standard crop rotation in the Blue Nile pump schemes is a three-course rotation with fallow, resulting in a cropping intensity of approximately 67%. The crop rotation in the Gezira Scheme is a four-course rotation with fallow (75% cropping intensity), while that in the Managil Scheme is a three-course rotation without fallow (100% cropping intensity). Recently, a four-course rotation with fallow (75% cropping intensity) was attempted to introduce to the Managil Scheme, but it encountered opposition by the tenants in the Scheme because of prevailing 15-feddan tenancy system. A study on the rehabilitation of the Gezira Scheme proposed a five-course rotation without fallow (100% cropping intensity), and other study on modernization of the Blue Nile pump schemes proposed a two-course rotation without fallow (100% cropping intensity). Furthermore, five-course rotation including fodder crops with fallow has been adopted in two blocks out of 14 in the Gezira-Managil Scheme in order to promote the livestock production under authorization by Crop Husbandery Committee, ARC. The five-course rotation is programmed to introduce to 103 blocks out of 107 blocks untill 1994/95 season in the Gezira-Managil Scheme. These actual and proposed land use patterns are summarized as follows:

Crop Rotation pattern	Cropping Intensity	
five-course rotation without fallow	100%	(plan)
four-course rotation with fallow	75%	(actual)
three-course rotation with fallow	67%	(actual)
three-course rotation without fallow	100%	(actual)
two-course rotation without fallow	100%	(plan)
five-course rotation with fallow	80%	(plan)

Needless to say, type of crop rotation is closely related to prevailing tenancy system in the area, and hence restructuring of either Hawasha or tenancy system is required if a proposed crop rotation dose not match existing tenancy system.

Considering crop intensification and present 15-feddan tenancy system in the Project area, a three-course rotation without fallow seems to be a recommendable option for the Project. It is also worthwhile to examine: i) a four-course rotation with fallow because land use pattern with fallow has long been practiced and is prevailing presently in the Blue Nile basin area; and ii) a five-course rotation including fodder with fallow because this type of rotation has been authorized by MOA and started introducing to the Gezira-Managil Scheme, the Project area is under the management of SGB, and is famous for raising of livestock traditionally.

In line with the above basic concepts, following three types of crop rotations were selected as altnative plans:

(Unit: fedddan)

Category	Rotation		
	3-course	4-course	5-course
Plot 1	7,540	5,655	4,524
Plot 2	7,540	5,655	4,524
Plot 3	7,540	5,655	4,524
Plot 4	-	-	4,524
Fallow	-	5,655	4,524
Total	22,620	22,620	22,620

3.3 Crop Selection for Each Option

Basic idea of the cropping patterns proposed are to provide the tenants with good and stable return. In this sense, the patterns proposed consist of export oriented cash crops, staple food crops for self sufficiency, subsistence crops for tenants and oil crops. In addition, the following are also taken into account in crop selection:

a) Crops for which technical and farm input services could be expected to SGB;
b) Crops which accord with the Government policy;
c) Crops which are recommended by the ARC
d) Crops of which residues can be used as animal fodder: and
e) Crop mix consisting of gramineous and leguminous crops.

The crops thus selected are cotton, wheat, sorghum, groundnuts and fodder (leguminous crops).

(1) Cotton

Cotton is the main cash crop grown in Sudan. Cotton production will contribute to acquisition of foreign money. The residue of cotton can be used for animal feed. Cotton producers can be provided with techinical and farm inputs services by SGB.

(2) Wheat

Wheat is one of the most important staple crops in Sudan. Wheat production can contribute to the self sufficiency of food stuffs and meets the government policy of Sudan. Its residue can be used for the feed for grazing animal. Wheat producers can be supported with technical and farm imputs services by SGB.

(3) Sorghum

Sorghum is the subsistense crop in Sudan and has long been grown in the Project area for self-support, which will contribute for saving living expenses. Sorghum hay is a valuable animal feed.

(4) Groundnut

Groundnut is a major leguminous crop in Sudan and its nitrogen fixing ability is expected to contribute to keep soil fertility of the farm land. Groundnut is one of the important cash crops for export and its foliage and hay are variable animal feeds and provide the tenants with a supplementary income.

(5) Fodder Crops

Leguminous crops are recommended by ARC for fodder crop in the Gezira and Managil area. They have much advantage compared with gramineaus crops in respect of nitrogen fixing ability. By planting gramineous and leguminous crops alternately, soil fertility could be maintained to a certain extent. Furthermore, they supply a large quantity of quality protein to livestocks.

(6) Vegetables

Some vegetables will be planted in the same Hawasha as growing sorghum/grounnuts.

3.4 Proposed Farming Practices and Farm Inputs

3.4.1 Proposed Farming Practices

(1) Seed

The certified seed of cotton and wheat would be supplied by SGB. Because of high price, cotton varieties to be introduced would be ELS cotton. Wheat varieties which are improved by the ARC will be introduced. Sorghum, groundnuts and fodder crop seed would be multiplied by tenants themselves.

(2) Fertilizer

Fertilizer would be applied to cotton (40 kg urea/feddan before sowing, 40 kg urea/feddan one and two months after planting), wheat (40 kg each of urea and TSP per feddan before sowing and 40 kg urea/feddan one month after sowing), and sorghum (40 kg urea/feddan one month after sowing). No fertilizer would be applied for groundnuts and the fodder crop.

(3) Agricultural chemicals:

1) Insecticides

Insecticides would be sprayed to cotton for five times and to wheat for one time by using of aircraft under the control of SGB.

2) Herbicide

Pre-emergence herbicide would be applied for cotton and groundnuts by machine. For sorghum, cotton and groundnuts, however weeding would be made by hand. It is not necessary for wheat and fodder crop to weed.

(4) Land Preparation

All land preparation would be done by using a tractor mounted disk plow, disk harrow, and four furrow ridger, etc.

Cotton:
Deep plowing would be done at first and harrowing and levelling would be carried out. Ridging would be done prior to sowing.

Wheat:
Plowing, harrowing and levelling would be carried out in order. Especially, wheat is so sensitive to water logging that levelling should be done carefully.

Sorghum:
Plowing and harrowing would be carried out in order. After that, ridging would be done to make irrigation water control easy.

Groundnuts:
As groundnuts prefere loose and friable soil structure, deep plowing and harrowing would be carried out. After that, ridging would be done with ridger.

Fodder:
Plowing and harrowing would be carried out in order.

(5) Agricultural Operation

Usually, agricultural operation namely weeding, fertilizer application etc. would be done by manually. However, basal application for cotton and seeding of wheat would be carried out by tractor.

Cotton:
Sowing would be carried out by hand with sticks, and resowing would be done if necessary. Top-dressing would be done by hand and hand weeding would be done according to circumstances.

Wheat:
Top-dressing would be done by hand.

Sorghum:
Sowing would be carried out by hand, and resowing and thinning would be done if necessary. Top-dressing would be done by hand and hand weeding would be done especially during the early growth period.

Groundnuts:
Sowing would be carried out by hand, and resowing and thinning would be done if necessary. Hand weeding would be done according to circumstances.

Fodder:
Sowing would be carried out by hand.

(6) Irrigation

The number of irrigation would be applied once every 10 days as a role.

(7) Harvesting

Cotton:
Cotton picking would be done by hand. It will require a great deal of labor for cotton picking because of the long picking season of ELS cotton.

Wheat:
Wheat would be harvested by combine harvester.

Sorghum:
Sorghum would be harvested by hand. After drying, threshing carried out by machine.

Groundnuts:
Lifting would be done by hand and drying would be done at the drying yeard. After drying, threshing will be carried out by hand and packed.

Fodder:
Fodder would be harvested by hand two times.

3.4.2 Proposed Farm Input and Labor Requirement

Based on the proposed farming practices mentioned above, the proposed farm inputs and labor requirement under the with project conditions are estimated and presented in Tables 3.1 and 3.2. They are designed on the basis of the farming practices under the control of the SGB. The farm inputs and labour requirement under the without project conditions is assumed that it would be no substantial changes in future.

The family labors would be used mainly for farming throughtout the year and during the peak time temporary labour would be employed. The average numbers of family labour force excluding house-wife and children is estimated 1.75 persons per tenant and the workable days per month is estimated at about twentyfour (24) days. Based on that, the labour forth per month is estimated at 42 man-day. Farm machinery will be supplied by the private sectors. Farm inputs for cotton and wheat are expected to be supplied by the SGB, and those for sorghum, groungnuts and fodder would be got by the tenants themselves with or without aid of ABS.

3.5 Anticipated Yield and Production of Crops

The anticipated yields of crops are summarized as follows:

(Unit: kg/feddan)

Crop	Without Project	With Project
Cotton	-	900
Wheat	-	920
Sorghum	201	1000
Groundnuts	-	1000
Fodder	-	1,500

The yield of sorghum under the without project conditions is estimated to be equal to that under present condition because no drastic change in conditions is expected in the future.

3.6 Selection of Cropping Pattern

3.6.1 Cropping Patterns for Each Option

Based on the land use plan and crop selection discussed above, three alternative cropping patterns are shown Fig. 3.1, which are summarized as follows:

(Unit: fedddan)

Category	Rotation		
	3-course	4-course	5-course
Cotton	5.0	3.75	3.0
Wheat	5.0	3.75	3.0
Sorghum	2.5	1.875	1.5
Groundnuts	2.5	1.875	1.5
Fodder			3.0
Fallow	-	3.75	3.0
Total	15.0	15.0	15.0

3.6.2 Proposed Cropping Patterns for the Project

In order to choose the optimum cropping pattern for the Project, an alternative study was conducted in due consideration of the following concepts:

a) Government policy on agricultural development plan,
b) prevailing tenancy system,
c) maintenance of soil fertility, and
d) tenant's wish.

The result and discussion of the alternative study are as follows:

a) The Project area belongs to the Gezira Scheme which is under control of the Sudan Government through Agricultural Research Corporation (ARC). Farming practices in the Scheme are recommended and decided by Crop Husbandry Committee which is one of the technical committees of ARC.

Recentry, ARC has decided introduction of a five-course rotation including fodder crops with fallow in the Gezira Managil Scheme in order to promote the livestock production under the Government policy.

b) Present tenancy system in the Project area is 15 feddans. If proposed land use plan dose not match existing tenancy system, it entails restructuring of present tenancy system or Hawasha.

c) From the viewpoint of maximizing returns, one hundred of cropping intensity or more is recommendable. But considering the soil nutrients, these type of land use requires dosage of much fertilizers, which seems to be inpractical in view of economic conditions of the country. In order to avoid the exhaustion of the soil, it may be preferable to keep a crop rotation with fallow.

d) There is no specific labor requirement peak for a specfic crops in four and five course rotation compared with three course rotation. The results of labor balance study for each cropping pattern are shown Table 3.3, and summarized below.

(Unit: man-day)

Month	3-course		4-course		5-course	
	Req.	Deficit	Req.	Deficit	Req.	Deficit
Jun	28.5	-	21.4	-	21.9	-
Jul	50.5	8.5	37.5	-	55.5	13.5
Aug	19.0	-	14.3	-	13.8	-
Sep	12.0	-	9.0	-	32.4	-
Oct	58.5	16.5	43.9	1.9	35.1	-
Nov	41.5	-	31.1	-	24.9	-
Dec	12.0	-	9.0	-	7.2	-
Jan	78.0	36.0	58.5	16.5	46.8	4.8
Feb	78.0	36.0	58.5	16.5	46.8	4.8
Mar	77.0	35.0	57.8	15.8	46.2	4.2
Apr	25.0	-	18.8	-	15.0	-
May	0.0	-	0.0	-	5.4	-
Total	480.0	132	360.0	50.7	351.0	27.3

e) The result of the comparative study among three options from the view point of the gross revenue demonstrates that the tree-course rotation without fallow is the most beneficial, and there is no distinct difference between four-and five-course rotations as shown below.

(Unit: £S)

Category	Rotation		
	3-course	4-course	5-course
Cotton	25,000	18,800	15,000
Wheat	13,800	10,400	8,300
Sorghum	7,300	5,400	4,400
Groundnuts	8,800	6,600	5,300
Fodder	0	0	8,700
Total	54,900	41,200	41,700

Based on the above discussion, five-course rotation with fallow is proposed for the Project.

3.6.3 Crop Production for the Five-Course Rotation

After completion of the Project, the yield of crops would increase and attain to the anticipated yield level. In order to attain the anticipated yields of crops,it is necessary to supply suitable amount of farm inputs and to carry out proper farm management under the effective agricultural support services.

The annual crop production under the with project conditions is estimated on the basis of proposed crop rotation, cropping pattern and anticipated yield and summarized below.

Crop	Harvested Area (feddan)	Unit Yield (kg/feddan)	Production (ton)
Cotton	4,524	900	4,072
Wheat	4,524	920	4,162
Sorghum	2,262	1,000	2,262
Groundnuts	2,262	1,000	2,262
Fodder	4,524	1,500	6,786

3.7 Future Crop Budget

Crop Budgets under the with project conditions presented in Table 3.4 and sumarized below.

(Unit: £S/feddan)

Crop	Gross Production Value	Production Cost	Net Production Value
Cotton	5,004	1,404	3,600
Wheat	2,760	1,107	1,653
Sorghum	2,900	573	2,327
Groundnuts	3,510	713	2,797
Fodder*1	2,900	573	2,327

*1: Fodder production is valued as sorghum production.

3.8 Future Farm Economy

In order to assess the effect of the Project on farmers' budget, future farm budget is forecasted and presented in Table3.5. The basis of the following assumptions is adopted in order to estimate future farm budget in the Project area.

1) Livestock products and wage and salary will be at the same level as the present one in the Gezira Scheme tenants.

2) Living expenses will increase to the same level as the present one of the tenants for the Gezira Scheme because of improving living standard of the tenants in the Project area.

3) Any remittance will not include in the budget.

Farm income under the with project conditions would be far higher than that under the without project conditions. The result is summarized as follows.

(5-course rotation)

Item	Amount
Gross Income	
Farm income	
Cotton	15,012
Wheat	8,280
Sorghum	4,350
Groundnuts	5,265
Fodder	8,700
Off-farm income	
Livestock Products	880
Wage/Salary	2,300
Total	44,787
Expenditure	
Farm input	11,864
Living expense	19,700
Total	31,564
Net reserve	13,224

The above table shows that the total income under with project condition would increase to as much as three times of the present level. Thus, the living standard of the tenants in the Project area would be drastically improved by the implementation of the Project.

3.9 Agricultural Supporting Services

The main objectives of the Project are to increase crop production and to improve and stabilize the tenants' economy in the Project area. In order to attain the objectives, the Project would provide pump irrigation and drainage facilities. Furthermore, as mentioned earlier,

attainment of the anticipated yields of crops needs suitable amount of farm inputs and farm management under the effective agricultural support services. Agricultural supporting services should be carried out by the government authorities. The followings are recommendations for improvement of agricultural support services related to the Project.

Extension Service

Since the beneficiary tenants of the Project area have less experiences on raising cotton, groundnuts and wheat, well organized extension services are indispensable for attaining target production.

Similarly, proper field water management is prerequisite. In this context, field staff of SGB has to be reinforced sufficiently. The proposed field staff in the Project at the Block level is:

i) Three Field Inspectors and 11 Ghaffirs for the Hurga area, and two Field Inspectors and 7 Ghaffirs for Nur El Din area;

ii) One Extension worker each for Hurga and Nur El Din areas; and

iii) One Field technical worker for crop protection for each area.

TABLES

Table 1.1 POPULATION BY AGE

(Unit thousand)

Age Group	1983			1988 (estimation)			1993 (estimation)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 4	1,539.3	1,577.2	3,116.5	2,249.7	2,165.4	4,415.1	2,521.7	2,421.8	4,943.5
5 - 9	1,456.4	1,372.2	2,828.6	1,480.1	1,514.3	2,994.4	2,176.0	2,091.3	4,267.3
10 - 14	1,362.5	1,266.1	2,628.6	1,438.9	1,354.3	2,793.2	1,464.5	1,497.1	2,961.6
15 - 19	1,222.4	1,160.4	2,382.8	1,343.8	1,247.4	2,591.2	1,421.3	1,336.7	2,758.0
20 - 24	959.4	963.9	1,923.3	1,197.9	1,137.1	2,335.0	1,319.6	1,225.3	2,544.9
25 - 29	794.9	827.9	1,622.8	935.7	940.4	1,876.1	1,171.5	1,112.5	2,284.0
30 - 34	642.0	693.0	1,335.0	773.1	804.9	1,578.0	912.9	917.1	1,830.0
35 - 39	563.8	594.9	1,158.7	621.3	671.2	1,292.5	751.0	782.2	1,533.2
40 - 44	482.8	473.5	956.3	541.4	573.6	1,115.0	599.1	649.4	1,248.5
45 - 49	411.9	372.4	784.3	458.2	453.6	911.8	516.2	551.4	1,067.6
50 - 54	328.3	271.1	599.4	383.9	352.5	736.4	429.3	431.0	860.3
55 - 59	257.1	197.2	454.3	297.7	251.5	549.2	350.3	328.5	678.8
60 - 64	202.7	140.3	343.0	223.6	176.9	400.5	260.8	227.0	487.8
65 - 69	147.3	95.2	242.5	165.4	119.2	284.6	184.1	151.8	335.9
70 - 74	79.5	57.7	137.2	109.2	74.2	183.4	124.0	93.9	217.9
75 - 79	50.7	42.4	93.1	50.2	23.8	74.0	69.9	50.5	120.4
80-	101.0	69.2	170.2	54.5	44.7	99.2	41.4	35.7	77.1
Total	10,602.0	10,174.6	20,776.6	12,324.6	11,905.0	24,229.6	14,313.6	13,903.2	28,216.8

Source: Population Projections of the Sudan 1983-2033, (1990)

Table 1.2 ESTIMATE OF GROSS DOMESTIC PRODUCT AT FACTOR COST, CONSTANT 1981/82 PRICES

(Unit: £S Million)

Sector	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90 (proj.)
1. Agriculture	2,553	2,334	2,226	1,951	2,157	2,203	1,920	2,459	2,017
2. Mining and Quarrying	7	7	6	6	6	6	6	7	7
3. Manufacturing	456	496	494	520	539	562	558	560	567
4. Electricity and Water	78	93	103	115	129	128	132	133	138
5. Construction	378	450	379	350	368	351	345	378	349
6. Commerce and Hotels	892	946	802	858	797	869	966	995	1,022
7. Transport and Communications	690	707	699	628	613	664	722	742	686
8. Finance and Real Estate	775	800	802	803	729	843	860	883	910
9. Personal Services	98	112	115	115	98	109	113	112	119
10. Government Services	586	668	789	695	693	651	653	735	778
11. GDP at Constant Factor Cost	6,513	6,612	6,416	6,041	6,129	6,387	6,275	7,004	6,592
12. GDP deflator (1981/82=100)		102	99	93	94	98	96	108	101
13. Annual Change Percentage at Constant Factor Cost	-	1.5%	-3.0%	-5.8%	1.5%	4.2%	-1.8%	11.6%	-5.9%
14. GDP at Current Market Prices	-	9,449	11,440	14,746	21,519	31,090	42,685	68,859	84,816

Source: Ministry of Finance and Economic Planning (PPU)
Bank of Sudan Annual Report

Table 1.3 SECTORAL PERCENTAGE OF GDP

(Unit: %)

Sector	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90 (proj.)
1. Agriculture	39.2	35.3	34.7	32.4	35.1	34.5	30.7	35.0	30.6
- Irrigated Agriculture	7.6	10.0	10.7	11.4	12.2	11.2	10.8	9.7	10.3
- Rainfed Mechanized Agriculture	5.1	2.3	2.5	1.2	4.6	5.0	2.1	6.1	2.4
- Rainfed Traditional Crops	7.1	4.6	3.9	2.5	5.0	4.2	3.3	5.7	3.1
- Livestock	14.9	13.8	12.7	12.1	10.3	11.1	11.5	10.6	11.7
- Forestry, Fisheries and Agricultural Services	4.5	4.6	5.0	5.2	3.0	3.0	3.0	2.9	3.1
2. Industry	14.0	15.7	15.3	16.2	17.0	16.4	16.5	15.4	16.1
- Mining and Quarrying	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
- Manufacturing	7.0	7.5	7.7	8.5	8.8	8.8	8.8	8.0	8.6
- Electricity and Water	1.2	1.4	1.6	1.9	2.1	2.0	2.1	1.9	2.1
- Construction	5.7	6.7	5.9	5.7	6.0	5.5	5.5	5.4	5.3
3. Services	46.8	49.0	50.0	51.4	47.9	49.1	52.8	49.6	53.3
- Commerce and Hotels	13.7	14.3	12.5	14.2	13.0	13.6	15.4	14.2	15.5
- Transport and Communications	10.7	10.7	10.9	10.4	10.0	10.4	11.5	10.6	10.4
- Finance and Real Estate	11.9	12.2	12.5	13.4	12.0	13.2	13.7	12.7	13.8
- Personal Services	1.5	1.7	1.8	1.9	1.6	1.7	1.8	1.6	1.8
- Government Services	9.0	10.1	12.3	11.5	11.3	10.2	10.4	10.5	11.8

Source: Ministry of Finance and Economic Planning (PPU)
Bank of Sudan Annual Report

Table 1.4 BALANCE OF TRADE

(unit: £S million)

Commodity	1986	1987	1988	1989 (proj.)
1 Export				
Cotton	366.7	455.2	978.4	1,348.8
Groundnuts	2.5	10.1	86.5	27.1
Sesame	58.9	134.8	269.0	333.3
Gum Arabic	141.7	267.1	281.6	313.0
Sorghum (Dura)	13.9	248.8	106.7	297.1
Livestock	71.5	42.9	128.0	192.5
Hides and Skins	33.7	39.0	69.5	114.4
Cake and Meal	14.2	50.5	103.0	66.9
Others	130.1	248.7	268.2	330.0
Total	833.2	1,497.1	2,290.9	3,023.1
2 Imports				
Petroleum products	292.3	497.9	1,093.1	1,082.2
Manufactured goods	481.4	501.0	930.1	1,178.5
Machinery and Equipment	405.7	484.9	776.6	826.4
Transport Equipment	434.1	368.9	509.3	786.6
Chemicals	341.2	248.1	476.8	399.1
Wheat and Flour	120.5	199.6	649.1	412.8
Tea	71.9	39.8	68.6	105.1
Coffee	12.2	4.0	24.7	122.8
Sugar	-	52.7	10.3	51.8
Other Foodstuffs	155.5	117.5	172.4	205.3
Drinks and Tabacco	14.3	13.6	56.9	39.4
Textiles	71.1	84.9	125.9	163.4
Total	2,400.2	2,612.9	4,893.8	5,373.4
Total Balance	-1,567.0	-1,115.8	-2,602.9	-2,350.3

Source: Bank of Sudan Annual Report
Foreign Trade Statistical Digest

Table 1.5 CHANGES IN THE EXCHANGE RATE OF THE SUDANESE POUND

Date	Official Rate		Parallel Rate		Free Rate	
	Dollar rate in £S	£S rate in Dollar	Dollar rate in £S	£S rate in Dollar	Dollar rate in £S	£S rate in Dollar
23, Jul. '57	0.35	2.87	-	-	-	-
8, Jun. '78	0.40	2.50	-	-	-	-
15, Sep. '79	0.50	2.00	0.80	1.25	-	-
10, Nov. '81	0.90	1.11	0.90	1.11	-	-
15, Nov. '82	1.30	0.77	1.30	0.77	-	-
6, Mar. '83	1.30	0.77	-	-	1.80	0.56
21, Oct. '84	1.30	0.77	-	-	2.10	0.47
12, Feb. '85	2.50	0.40	-	-	3.00	0.33
21, Apr. '85	2.50	0.40	-	-	3.30	0.30
25, Feb. '86	2.50	0.40	-	-	4.25	0.23
12, Mar. '86	2.50	0.40	-	-	4.10	0.25
3, Oct. '87	4.50	0.22	-	-	4.50	0.22
26, Oct. '88	4.50	0.22	-	-	11.30	0.09
13, Mar. '89	4.50	0.22	-	-	12.10	0.08
28, May '91	12.30	0.08	-	-	12.30	0.08

Source: Bank of Sudan

Table 1.6 TARGETED AGRICULTURAL PRODUCTION AND GROWTH RATE IN THE FOUR YEAR SALVATION, RECOVERY AND DEVELOPMENT PROGRAMME

Commodity	1988/89	1989/90	1990/91	1991/92
1. Crop Production (1,000tons)				
Cotton	856	917	970	865
Sorghum	3,302	3,435	3,587	4,833
Millet	311	304	330	378
Groundnuts	490	592	702	859
Wheat	202	242	287	337
Sesame	275	301	304	336
Gum Arabic	32	34	26	38
Sugar Cane	5,303	5,485	6,067	6,225
Broad Beans	54	56	59	61
Fruits	764	788	812	1,064
Vegetables	834	920	1,017	1,116
2. Animal Production (1,000tons)				
Cattle	227	239	251	263
Sheep	84	86	89	93
Goats	35	36	37	38
Camels	31	32	33	34
Poultry	18	19	20	21
Fish	34	36	38	41
Milk	1,931	1,957	1,990	2,029
Egg (1,000Ps)	536,713	557,817	584,931	626,031
Total Value of the Agricultural Production (£S million)	13,459	14,149	14,895	15,719
Grouth Rate	-	5.1	5.3	5.9

Source: The Four Year Salvation Recovery and Development Programme, Ministry of Finance and Economic Planning

Table 1.7 AREA AND PRODUCTION OF MAJOR CROPS BY SECTOR

Crop Season	Sorghum		Wheat		Groundnuts		Millet		Sesame	
	Area 000's fed.	Product. 000's MT	Area 000's fed.	Product. 000's MT	Area 000's fed.	Product. 000's MT	Area 000's fed.	Product. 000's MT	Area 000's fed.	Product. 000's MT
1987/88										
1) Irrigated	711	352	343	181	251	198	0	0	0	0
2) Rainfed Mechanized	5,315	853	0	0	0	0	36	6	1,032	121
3) Rainfed Traditional	2,043	158	0	0	1,328	234	2,573	147	1,253	112
Total	8,069	1,363	343	181	1,579	432	2,609	153	2,285	233
1988/89										
1) Irrigated	846	468	393	247	217	189	0	0	0	0
2) Rainfed Mechanized	9,747	3,317	0	0	0	0	153	24	712	61
3) Rainfed Traditional	2,686	640	0	0	1,408	398	5,525	471	2,083	133
Total	13,279	4,425	393	247	1,625	587	5,678	495	2,795	194
1989/90										
1) Irrigated	755	392	614	409	159	119	0	0	0	0
2) Rainfed Mechanized	5,830	853	0	0	0	0	139	18	966	75
3) Rainfed Traditional	2,464	291	0	0	1,136	99	3,574	143	1,656	65
Total	9,049	1,536	614	409	1,295	218	3,713	161	2,622	140

Source: Agricultural Situation and Outlook, Ministry of Agriculture and Natural Resources

Table 1.8 AREA, YIELD AND PRODUCTION OF COTTON

Producing Center	1985/86			1986/87			1987/88			1988/89		
	Area 000's fed.	Yield kantars/fd	Products 000's kantars	Area 000's fed.	Yield kantars/fd	Products 000's kantars	Area 000's fed.	Yield kantars/fd	Products 000's kantars	Area 000's fed.	Yield kantars/fd	Products 000's kantars
A. Extra Long Staple Cotton												
Gezira Scheme	387	3.5	1,355	328	4.7	1,542	238	3.9	928	223	4.0	892
White Nile	27	2.4	65	25	2.2	55	-	-	-	28	2.4	67
Tokar	25	1.1	28	30	0.6	18	16	1.8	29	22	0.4	8
Total	439	3.3	1,448	383	4.2	1,615	254	3.7	957	273	3.5	967
B. Long Staple Cotton												
Gezira Scheme	-	-	-	-	-	-	145	5.7	830	181	6.5	1,177
El Rahad	-	-	-	-	-	-	80	6.8	547	81	6.1	494
New Halfa	-	-	-	-	-	-	30	4.6	137	-	-	-
White Nile	-	-	-	-	-	-	59	2.2	130	13	2.8	36
El Suki	-	-	-	-	-	-	-	-	-	25	3.2	80
Blue Nile	-	-	-	-	-	-	-	-	-	39	4.6	179
Total	-	-	-	-	-	-	314	5.2	1,644	339	5.8	1,966
C. American Types												
Gezira Scheme	25	5.3	133	87	5.7	496	-	-	-	-	-	-
Zeidab	1	3.6	4	2	3.3	7	3	3.6	10	-	-	-
White Nile	25	2.6	65	30	3.3	99	-	-	-	-	-	-
New Halfa	68	5.5	374	73	6.2	453	46	4.0	185	60	3.0	118
Nuba Mountains	33	0.7	23	43	0.6	26	28	0.4	11	23	0.6	13
El Suki	27	2.4	65	28	3.3	92	27	2.5	65	-	-	-
El Rahad	117	5.5	644	125	6.7	838	36	5.4	193	37	5.8	215
Blue Nile	53	3.4	180	54	3.0	162	49	1.7	84	13	3.6	47
Total	349	4.3	1,448	442	4.9	2,173	189	2.9	548	133	2.9	393
Ground Total	788	3.7	2,936	825	4.6	3,788	757	4.2	3,149	745	4.5	3,326

Source: Sudan Cotton Company
Bank of Sudan Annual Report

Table 1.9 POPULATION OF EL GEZIRA PROVINCE

(Unit: Nos.)

Age Group	Urban			Rural			Normadic			Province		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 4	21,984	21,915	43,899	115,572	120,991	236,563	1,865	2,084	3,949	139,421	144,990	284,411
5 - 9	24,712	24,602	49,314	141,135	140,547	281,682	2,369	2,368	4,737	168,216	167,517	335,733
10 - 14	25,886	25,308	51,194	124,803	120,350	245,153	2,101	1,821	3,922	152,790	147,479	300,269
15 - 19	27,566	24,278	51,844	89,269	94,533	183,802	1,477	1,392	2,869	118,312	120,203	238,515
20 - 24	17,967	15,585	33,552	58,432	69,046	127,478	808	1,208	2,016	77,207	85,839	163,046
25 - 29	13,553	13,125	26,678	52,927	66,971	119,898	755	1,279	2,034	67,235	81,375	148,610
30 - 34	9,235	9,147	18,382	38,086	45,157	83,243	789	957	1,746	48,110	55,261	103,371
35 - 39	9,990	9,676	19,666	42,797	47,633	90,430	695	848	1,543	53,482	58,157	111,639
40 - 44	7,674	6,926	14,600	33,353	37,013	70,366	856	849	1,705	41,883	44,788	86,671
45 - 49	6,593	5,867	12,460	29,958	27,156	57,114	482	394	876	37,033	33,417	70,450
50 - 54	5,445	4,672	10,117	27,100	22,847	49,947	621	321	942	33,166	27,840	61,006
55 - 59	3,192	2,563	5,755	14,685	9,873	24,558	182	95	277	18,059	12,531	30,590
60 - 64	3,317	2,486	5,803	17,173	12,506	29,679	409	109	518	20,899	15,101	36,000
65 - 69	2,060	1,493	3,553	10,133	6,249	16,382	102	58	160	12,295	7,800	20,095
70 - 74	1,805	1,422	3,227	9,669	6,646	16,315	219	109	328	11,693	8,177	19,870
75 - 79	899	679	1,578	4,594	2,886	7,480	65	21	86	5,558	3,586	9,144
80-	1,394	1,174	2,568	6,773	4,726	11,499	102	43	145	8,269	5,943	14,212
Total	183,272	170,918	354,190	816,459	835,130	1,651,589	13,897	13,956	27,853	1,013,628	1,020,004	2,033,632

Source: Population and Housing Census (El - Gezira Province), 1983

Table 1.10 AREA AND PRODUCTION OF MAJOR CROPS IN THE GEZIRA SCHEME

Crop Season	Cotton (ELS and MS)		Wheat		Sorghum		Groundnuts	
	Area feddans	Product. 000'Kantar	Area feddans	Product. MT	Area feddans	Product. MT	Area feddans	Product. MT
1980 / 81	501,202	1,157	366,737	75,997	300,832	69,191	170,919	83,750
1981 / 82	435,314	1,690	267,863	87,483	343,899	89,414	264,245	97,771
1982 / 83	484,315	2,276	155,760	92,969	320,940	125,167	148,182	60,755
1983 / 84	497,729	1,482	265,865	103,100	410,791	216,076	136,611	91,529
1984 / 85	464,792	2,427	0	0	420,068	147,024	212,859	108,558
1985 / 86	411,219	1,419	242,498	97,388	578,754	318,315	102,535	55,882
1986 / 87	415,074	2,048	179,869	95,908	448,005	179,202	151,051	91,083
1987 / 88	383,037	1,752	252,314	119,568	394,457	141,287	158,728	95,897
1988 / 89	404,505	2,102	274,247	147,563	426,810	215,112	110,864	128,174
1989 / 90	357,984	1,481	392,297	235,379	443,954	216,067	79,580	42,973

Source: The Gezira Current Statistics, Sudan Gezira Boarsd

Table 2.1 METEOLOGICAL DATA AT WAD MEDANI

Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average or Total
Radiation	Avg	552	569	596	634	585	569	543	557	554	538	525	522	562
(cal/sq cm/day)	SD	46.8	24.5	33.0	31.6	27.4	26.2	25.6	28.9	16.0	27.0	18.8	29.8	18.4
	CV	8.5	4.3	5.5	5.0	4.7	4.6	4.7	5.2	2.9	5.0	3.6	5.7	3.3
Rainfall	Avg	0.0	0.0	0.0	0.2	19.2	27.5	67.9	102.1	51.4	8.2	3.2	0.0	280
(mm/month)	SD	0.0	0.0	0.0	0.7	16.9	11.7	43.8	55.0	19.1	11.0	9.7	0.0	75.9
	CV				300.0	88.2	42.5	64.5	53.9	37.2	133.8	300.0	0.0	27.1
Daily	Avg	6.4	7.3	8.4	8.8	9.1	10.0	8.5	8.1	7.3	6.9	6.5	6.2	93.4
Evaporation	SD	0.6	0.2	0.4	0.2	0.3	0.4	0.5	0.6	0.4	0.3	0.3	0.4	-
(mm/day)	CV	8.7	3.0	4.8	2.4	3.5	4.4	6.2	7.9	5.1	3.9	5.0	6.8	-
Daily Maxmim	Avg	33.1	34.5	38.3	41.0	41.5	40.0	37.1	35.7	36.4	38.7	36.6	33.2	37.2
Temparature	SD	1.6	1.9	1.5	0.8	0.8	0.4	1.5	1.6	1.5	0.7	1.0	1.7	0.4
(flC)	CV	4.8	5.5	3.9	1.9	2.0	1.1	4.1	4.4	4.1	1.9	2.7	5.2	1.1
Daily Minimum	Avg	14.7	16.1	19.9	21.7	24.8	25.3	23.8	23.2	22.6	22.6	18.7	15.5	20.8
Temparature	SD	1.8	1.6	1.2	1.0	0.7	0.6	0.8	0.8	0.5	0.6	1.1	1.6	0.4
(flC)	CV	12.2	9.8	6.2	4.5	2.9	2.5	3.3	3.4	2.2	2.7	5.7	10.2	2.1
Daily Average	Avg	23.9	25.3	29.1	31.3	33.1	32.7	30.5	29.5	29.5	30.7	27.6	24.4	29.0
Temparature	SD	1.7	1.7	1.3	0.9	0.6	0.4	1.1	1.1	0.9	0.5	1.0	1.6	0.4
(flC)	CV	7.0	6.7	4.5	2.7	2.0	1.2	3.7	3.7	3.1	1.7	3.5	6.4	1.4

1) Source: Meteological Department at Wad Medani
2) Average of 10 years from 1980 to 1989
3) Avg: Average, SD: Standard Deviation, CV: Coefficient of Variation (%)
4) Evaporation, Penman (Meteorogical Department, Wad Mesani)
5) Observation Points: 14'23" N, 33'29" E, 405m

Table 2.2 PUBLIC FACILITIES IN THE PROJECT AREA (1/2)

Name of Village	Health Service							Drinking Water				
	Dressing Station	Dispensary	Health Center	Vet Clinic	mid-wif	Visiter Health	Hospital	Average Well	Filter	From Adj. Village	Service Well	Canal
HURGA												
1 Gaber	1							1				
2 Tenouba	1				1			1				
3 Rama											1	
4 Afaya												
5 Hurga		1			1			1				
6 Fadl Alla	1							1				
7 Gemeiab	1							1				
8 Erraya					1							1
9 Shabarga		1	1	1	2	1		3				
Total	4	2	1	1	5	1	0	8	0	0	1	1
Nur El Din												
1 Hereiz	1				1			1				
2 Amara Nefeidya								1				
3 Rahmanya (Ansar)								1				
4 Wad Elegeil											1	
5 Managa	1				1			1				
6 Shadayda Wad Agbna	1				1			1				
7 Nur El Din												1
8 Abdelkarim	1							1				
9 Reheimat					1			1				
Total	4	0	0	0	4	0	0	7	0	0	1	1

Source: Gezira and Managil Village Directory

Table 2.2 PUBLIC FACILITIES IN THE PROJECT AREA (2/2)

Name of Village	Other Services													Means of Transportation				
	Social Club	Flour Mill	Backery	Market	Mosque	Electricity	Police Station	Post Agent	Post Office	Restaurant	Labour Camp	Retail Shop	TV Sets	Lorry	Bus	Pick-up	Cargo	Saloon
HURGA																		
1 Gaber					1							3	2				1	
2 Tenouba	1	1			1							4	1				4	
3 Rama												1						
4 Afaya												2					2	
5 Hurga	1	1	1		1			1				15	30	15	5		5	1
6 Fadl Alla												5	1	2		1		
7 Gemciab		1			1							4		4				
8 Erraya					1							3	1	1				
9 Shabarga	1	3	1	1	1		1	1		1			100	25	2	2		10
Total	3	6	2	1	6	0	1	2	0	1	0	37	135	47	7	3	12	11
Nur El Din																		
1 Hereiz		1			1							6	1				1	
2 Amara Nefeidya					1							5		1		1		
3 Rahmanya (Ansar)					1							2		2			1	
4 Wad Elegeil																		
5 Managa					1							3		1	1			
6 Shadayda Wad Agbna		1			1							5		3	1			
7 Nur El Din												1						
8 Abdelkarim		1			1					1		5						
9 Reheimat					1							2		5				
Total	0	3	0	0	7	0	0	0	0	1	0	29	1	12	2	1	2	0

Source: Gezira and Managil Village Directory

Table 2.3 NO. OF STUDENTS IN THE PROJECT AREA

Name of Schools	1st year		2nd year		3rd year		4th year		5th year		6th year		Total		Total
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
Elementary Schools															
1 Tinoba	37	32	31	26	30	17	28	28	28	24	24	26	178	153	331
2 Bugasa	23	23	22	27	28	22	25	28	20	18	31	12	149	130	279
3 Abdel Karim	35	36	40	28	32	27	42	24	25	19	22	20	196	154	350
4 Hurga for Boys	62		49		56		53		60		45		325	0	325
5 Hurga for Girls		70		55		59		57		44		44	0	329	329
Total	157	161	142	136	146	125	148	137	133	105	122	102	848	766	1,614
Intermedialt School															
1 Hurga for Boys	45		39		39								123	0	123
2 Hurga for Girls		45		47		49							0	141	141
3 Abdel Karim	49		46		43								138	0	138
4 Bugasa	30		40		23								93	0	93
5 Tinoba		29		41		25							0	95	95
Total	124	74	125	88	105	74							354	236	590

Source: Ministry of Education and Training

Table 2.4 FARM INPUT IN THE PROJECT AREA UNDER PRESENT CONDITIONS

(Unit: per feddan)

Description	Unit	Sorghum	
		Hurga	Nur El Din
1 Material Inputs			
1) Seed	(kg)	3.10	3.50
2) Fertilizers			
Urea	(kg)	0.00	0.00
T.S.P.	(kg)	0.00	0.00
3) Agro-chemicals			
Insecticides	(lit/kg)	0.00	0.00
Herbicides	(lit/kg)	0.00	0.00
2 Labor and Machinery Requirement			
4) Labor	(man-day)		
Land Clearing		1.30	2.20
Seedling		1.50	2.20
Weeding		5.00	0.00
Canal Maintenance		1.00	1.00
Harvesting		6.50	4.90
Threshing/Drying		0.60	1.30
Water Management		1.50	2.00
Total		17.40	13.60
5) Hired Machineries			
- Plowing		0.25	0.25
- threshing		0.40	0.00
Total		0.65	0.25

Source: Farm Economic Survey, Land Use Survey

Table 2.5 CROP YIELD AND PRODUCTION IN THE PROJECT AREA

	Unit	Hurga	Nur El Din	Total
1. Total Farm Land	(fd.)	13,900	8,720	22,620
2. Planted Area of Sorghum	(fd.)	2,260	1,260	3,520 (15.6%)
3. Unit Yield	(kg/fd.)	240	130	201
4. Estimated Production	(ton)	542	164	706

Source: Farm Economic Survey, Land Use Survey

Table 2.6 LAND AND WATER CHARGE

(Unit: £S/feddan)

Crop Season	Crops				
	Cotton	Wheat	Groundnuts	Sorghum	Vegetables
1981 / 82	28.50	18.00	14.00	7.00	25.00
1982 / 83	28.50	18.00	14.00	7.00	25.00
1983 / 84	38.00	23.00	19.00	19.00	33.25
1984 / 85	50.00	31.00	25.00	25.00	44.00
1985 / 86	65.00	40.00	32.00	32.00	57.00
1986 / 87	80.00	49.00	40.00	40.00	70.00
1987 / 88	101.00	60.00	50.00	50.00	96.00
1988 / 89	120.00	95.00	55.00	55.00	120.00
1989 / 90	157.00	131.00	104.00	104.00	175.00

Source: SGB

Table 2.7 FARMGATE PRICE OF FARM INPUT AND OUTPUT (1/2)

Crop Season	Crop	Cotton (ELS) Grade (£S/Kantar)								
		1	2	3	4	5	6	7	8	9
1985/86		235	230	225	220	215	210	205	200	195
1986/87		273	268	263	258	248	238	228	218	208
1987/88		338	328	318	308	293	278	263	248	233
1988/89		722	702	682	662	642	622	502	582	562
1989/90		873	817	787	747	727	707	687	667	647

Crop Season	Crop	Cotton (MS) Grade (£S/Kantar)						Wheat (£S/ 100kg)	Sorghum (£S/ 100kg)	Groungnuts (£S/ 100kg)
		1	2	3	4	5	6			
1985/86		210	205	200	195	190	185	70	42	112
1986/87		228	223	218	213	203	193	77	35	123
1987/88		263	253	243	233	218	203	100	120	140
1988/89		463	443	403	383	363	323	240	135	140
1989/90		603	572	532	511	492	472	300	290	351

Source: SGB, Farm Economic Survey, Land Use Survey

Table 2.7 FARMGATE PRICE OF FARM INPUT AND OUTPUT (2/2)

	Description	Unit	Price (£S)
Farm Inputs			
1)	Seeds		
	Cotton	(kg)	3.1
	Wheat	(kg)	3.0
	Sorghum	(kg)	2.9
	Groundnuts	(kg)	6.0
2)	Fertilizer		
	Urea	(50kg)	68
	TSP	(50kg)	64
3)	Agrochemical Apprication		
	Insecticide	(times)	67
	Hervixcide	(times)	36
4)	Hired Labor	(man/day)	25
5)	Hired Machinery		
	Tractor	(hr)	200
	Harvestor	(hr)	300
	Thresher	(hr)	120
6)	Empty Sack	(piece)	7

Source: SGB, Farm Economic Survey, Land Use Survey

Table 2.8 PRODUCTION VALUE OF SORGHUM IN HURGA AND NUR EL DIN

(Unit: feddan)

Item	Unit	Unit Cost	Hurga		Nur El Din	
			Quantity	Amount	Quantity	Amount
1. Gross Production Value						
- Unit Yield	(kg/fd)		240.00		130.00	
- Unit Price	(£S/100kg)			290		290
- Unit Value	(£S/fd)			696		377
1. Seed*1	kg	2.9	3.50	0	3.50	0
2. Fertilizer						
- Urea	50kg	68	0.00	0	0.00	0
- TSP	50kg	64	0.00	0	0.00	0
3. Hired Labors	man/day	25	7.71	193	4.40	110
4. Hired-machine						
- Landpreparation		200	0.26	51	0.25	50
- Threshing		120	0.36	43	0.00	0
Total				287		160
Ner Production Value				409		217
(per 5feddan)				(2,044)		(1,085)

Remarks

*1 Self-support

Table 3.1 PROPOSED FARM INPUT REQUIREMENT

(Unit: per feddan)

Description	Unit	Cotton	Wheat	Sorghum	Groundnuts	Fodder
Farm Input						
1) Seed	(kg)	12	60	5	30	5
2) Fertilizers						
Urea	(kg)	120	80	40	0	0
T.S.P.	(kg)	0	40	0	0	0
3) Agro-chemicals						
Insecticides	(times)	5	1	0	0	0
Herbicides	(times)	1	0	0	1	0

Table 3.2 PROPOSED LABOUR AND MACHINE REQUIREMENT

(Unit: per feddan)

Description	Unit	Cotton	Wheat	Sorghum	Groundnuts	Fodder
1) Labor	(man-day)					
Land Preparation		0.0	0.0	0.0	0.0	0.0
Seedling		1.8	0.0	2.4	2.4	1.8
Fertilizing		2.4	1.6	0.8	0.0	0.0
Weeding		1.8	0.0	3.2	14.0	0.0
Spraying		0.0	0.0	0.0	0.0	0.0
Canal Maintenance		0.0	0.0	0.0	0.0	0.0
Harvesting		42.0	0.0	3.0	5.6	6.0
Threshing/Drying/		0.0	0.0	1.8	10.0	0.0
Post Harvest		5.0	1.0	5.0	5.0	10.0
Transporting		0.0	0.0	0.0	0.0	0.0
Water Management		6.8	3.6	3.6	3.2	3.2
Total		59.8	6.2	19.8	40.2	21.0
2) Hired Machineries	(hr)					
- Plowing		1.00	0.40	0.40	0.54	0.40
- Harrowing		0.20	0.20	0.20	0.20	0.20
- Ridging		0.60		0.40	0.40	
- Raising of Field Cannals		0.30	0.30	0.50	0.50	0.50
- Levelling		0.44	0.40			
- Fertilizer/seedling application		0.20	0.44			
- Harvesting			0.40			
- Threshing				0.40		
Total		2.74	2.14	1.50	1.64	1.10

Table 3.3 LABOR REQUIREMENT AND BALANCE FOR EACH ALTERNATIVE CROPPING PATTERN

(Unit: man-day)

Month	per feddan						3-cource rotation							4-cource rotation							5-cource rotation						
	Cot	Whe	Sor	Gro	Fod	Total	Cot	Whe	Sor	Gro	Fod	Total	Deficit	Cot	Whe	Sor	Gro	Fod	Total	Deficit	Cot	Whe	Sor	Gro	Fod	Total	Deficit
	1	1	1	1	1		5	5	2.5	2.5	0	15		3.75	3.75	1.88	1.88	0	11.3		3	3	1.5	1.5	3	12	
Jun	0.4	0.0	0.4	10.2	1.6	12.6	2.0	0.0	1.0	25.5	0.0	28.5	-	1.5	0.0	0.8	19.1	0.0	21.4	-	1.2	0.0	0.6	15.3	4.8	21.9	-
Jul	3.0	0.0	6.4	7.8	8.4	25.6	15.0	0.0	16.0	19.5	0.0	50.5	8.5	11.3	0.0	12.0	14.6	0.0	37.9	-	9.0	0.0	9.6	11.7	25.2	55.5	13.5
Aug	2.6	0.0	1.6	0.8	0.8	5.8	13.0	0.0	4.0	2.0	0.0	19.0	-	9.8	0.0	3.0	1.5	0.0	14.3	-	7.8	0.0	2.4	1.2	2.4	13.8	-
Sep	1.6	0.0	0.8	0.8	8.4	11.6	8.0	0.0	2.0	2.0	0.0	12.0	-	6.0	0.0	1.5	1.5	0.0	9.0	-	4.8	0.0	1.2	1.2	25.2	32.4	-
Oct	1.6	0.4	3.8	15.6	0.0	21.4	8.0	2.0	9.5	39.0	0.0	58.5	16.5	6.0	1.5	7.1	29.3	0.0	43.9	1.9	4.8	1.2	5.7	23.4	0.0	35.1	-
Nov	0.8	1.6	6.8	5.0	0.0	14.2	4.0	8.0	17.0	12.5	0.0	41.5	-	3.0	6.0	12.8	9.4	0.0	31.1	-	2.4	4.8	10.2	7.5	0.0	24.9	-
Dec	0.8	1.6	0.0	0.0	0.0	2.4	4.0	8.0	0.0	0.0	0.0	12.0	-	3.0	6.0	0.0	0.0	0.0	9.0	-	2.4	4.8	0.0	0.0	0.0	7.2	-
Jan	14.8	0.8	0.0	0.0	0.0	15.6	74.0	4.0	0.0	0.0	0.0	78.0	36.0	55.5	3.0	0.0	0.0	0.0	58.5	16.5	44.4	2.4	0.0	0.0	0.0	46.8	4.8
Feb	14.8	0.8	0.0	0.0	0.0	15.6	74.0	4.0	0.0	0.0	0.0	78.0	36.0	55.5	3.0	0.0	0.0	0.0	58.5	16.5	44.4	2.4	0.0	0.0	0.0	46.8	4.8
Mar	14.4	1.0	0.0	0.0	0.0	15.4	72.0	5.0	0.0	0.0	0.0	77.0	35.0	54.0	3.8	0.0	0.0	0.0	57.8	15.8	43.2	3.0	0.0	0.0	0.0	46.2	4.2
Apr	5.0	0.0	0.0	0.0	0.0	5.0	25.0	0.0	0.0	0.0	0.0	25.0	-	18.8	0.0	0.0	0.0	0.0	18.8	-	15.0	0.0	0.0	0.0	0.0	15.0	-
May	0.0	0.0	0.0	0.0	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	5.4	5.4	-
Total	59.8	6.2	19.8	40.2	21.0	147.0	299.0	31.0	49.5	100.5	0.0	480.0	132.0	224.3	23.3	37.1	75.4	0.0	360.0	50.6	179.4	18.6	29.7	60.3	63.0	351.0	27.3

Table 3.4 CROP BUDGET OF MAJOR CROPS UNDER WITH PROJECT CONDITION

Description	Unit	Unit Price (£S)	Cotton Amount /fd	Cotton £S /fd	Wheat Amount /fd	Wheat £S /fd	Sorghum Amount /fd	Sorghum £S /fd	Groundnuts Amount /fd	Groundnuts £S /fd	Fodder Amount /fd	Fodder £S /fd
1 Gross Production Value												
1) Unit Yield	(kg/fd)		900		920		1,000		1,000		1,000	
2) Unit Price	(£S/100kg)			556		300		290		351		290
3) Unit Value	(£S/fd)			5,004		2,760		2,900		3,510		2,900
2 Production Cost												
1) Seed*1	(kg)		12	38	60	180	5	15	30	180	5	15
2) Fertilizers												
Urea	(kg)	1.36	120	163	80	109	40	54	0	0	40	54
T.S.P.	(kg)	1.28	0	0	40	51	0	0	0	0	0	0
3) Agro-chemicals												
Insecticides*1	(times)	67	5	335	1.0	67	0	0	0	0	0	0
Herbicides*2	(times)	36	1	36	0	0	0	0	1	36	0	0
4) Labor	(man-day)											
Land Preparation		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Seedling		0	1.8	0	0.0	0	2.4	0	2.4	0	2.4	0
Fertilizing		0	2.4	0	1.6	0	0.8	0	0.0	0	0.8	0
Weeding		0	1.8	0	0.0	0	3.2	0	14.0	0	3.2	0
Spraying		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Canal Maintenance		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Harvesting		0	42.0	0	0.0	0	3.0	0	5.6	0	3.0	0
Threshing/Drying/		0	0.0	0	0.0	0	1.8	0	10.0	0	1.8	0
Post Harvest		0	5.0	0	1.0	0	5.0	0	5.0	0	5.0	0
Transporting		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Water Management		0	6.8	0	3.6	0	3.6	0	3.2	0	3.6	0
Total			59.8	0	6.2	0	19.8	0	40.2	0	19.8	0
5) Hired Machineries	(machine-hr)											
- Plowing		200	1.00	200	0.40	80	0.40	80	0.54	108	0.40	80
- Harrowing		200	0.20	40	0.20	40	0.20	40	0.20	40	0.20	40
- Ridging		200	0.60	120		0	0.40	80	0.40	80	0.40	80
- Raising of		200	0.30	60	0.30	60	0.50	100	0.50	100	0.50	100
Field Cannals				0		0		0		0		0
- Levelling		200	0.44	88	0.40	80		0		0		0
- Fertilizer/seedling		200	0.20	40	0.44	88		0		0		0
application				0		0		0		0		0
- Harvesting		300		0	0.40	120		0		0		0
- Threshing		120					0.40	48			0.40	48
Total			2.74	548	2.14	468	1.50	348	1.64	328	1.50	348
6) Land and Water Charge				157		131		104		104		104
7) Others (10% of (1)-(5))				128		101		52		65		52
Unit Production Cost				1,404		1,107		573		713		573
3 Net Income (per fd)				3,599		1,653		2,327		2,797		2,327

*1 Unit Price of Seed (Unit: £S/kg)

Cotton	3.1
Wheat	3.0
Sorghum	2.9
Groundnuts	6.0
Fodder	2.9

Table 3.5 FARM BUDGET UNDER WITH PROJECT CONDITIONS

Item	Unit Value (£S/fd.)	Area (fd.)	Amount (£S)
1. Gross Income			
Farm Income			
1) Cotton	5,004	3.0	15,012
2) Wheat	2,760	3.0	8,280
3) Sorghum	2,900	1.5	4,350
4) Groundnuts	3,510	1.5	5,265
5) Fodder	2,900	3.0	8,700
Livestock Products			880
Wage/Salary			2,300
Total			44,787
2. Gross Outgo			
Farm input			
1) Cotton	1,404	3.0	4,212
2) Wheat	1,107	3.0	3,321
3) Sorghum	573	1.5	860
4) Groundnuts	713	1.5	1,070
5) Fodder	573	3.0	1,719
6) Hired Labor			683
Living Expence			19,700
Total			31,564
Net Reserve			13,224

FIGURES

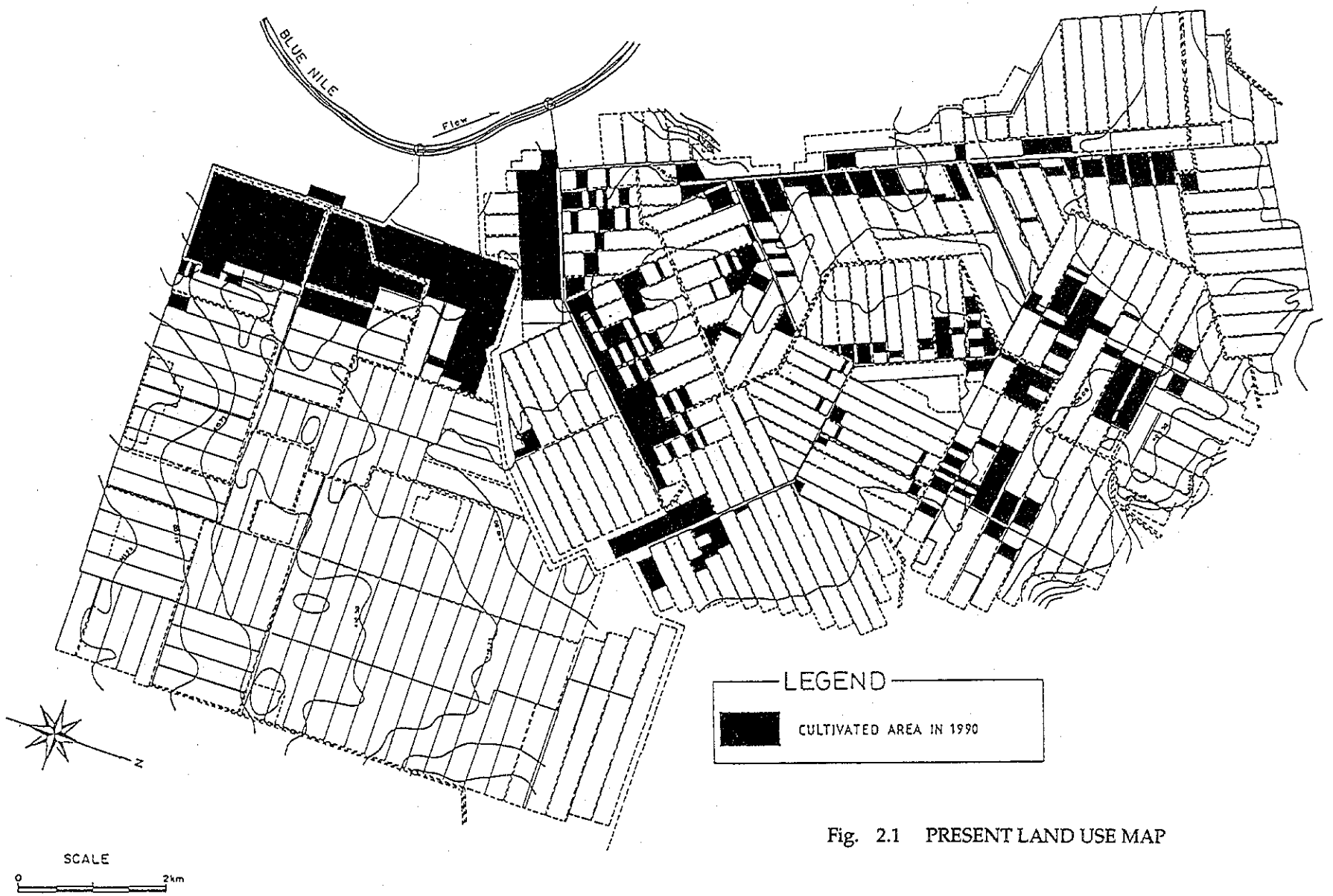

Fig. 2.1 PRESENT LAND USE MAP

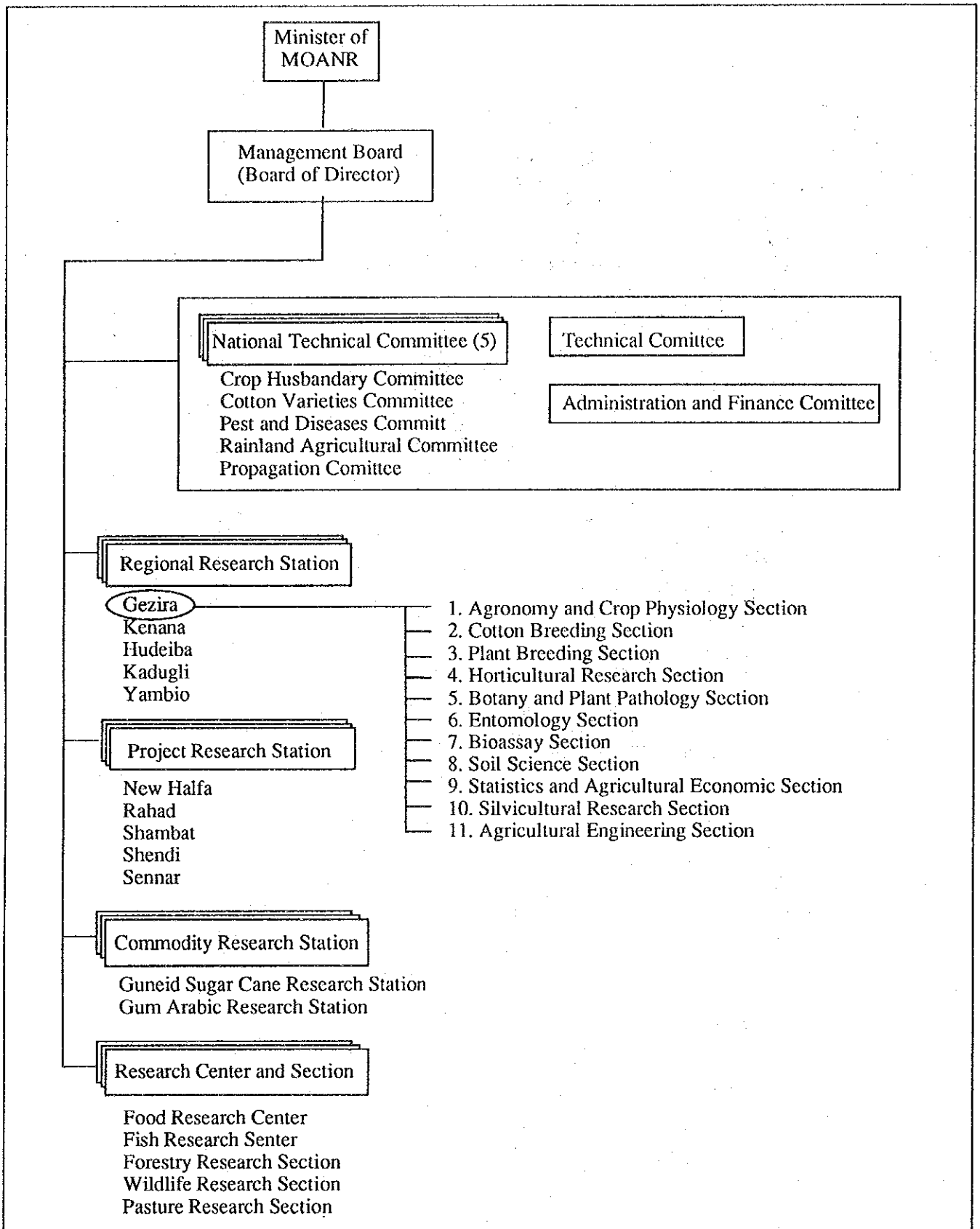

Fig. 2.2 ORGANIZATION STRUCTURE OF ARC

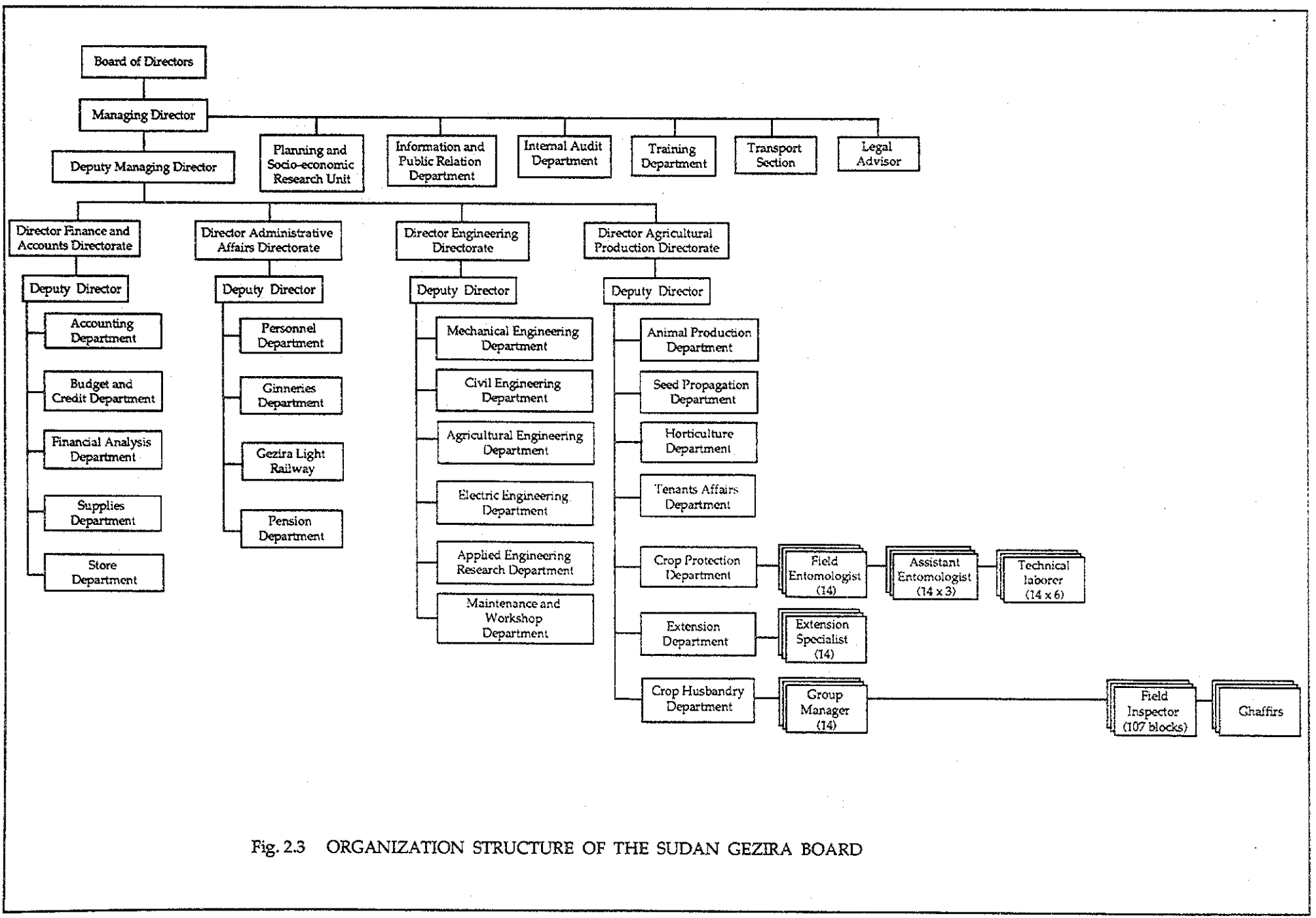

Fig. 2.3 ORGANIZATION STRUCTURE OF THE SUDAN GEZIRA BOARD

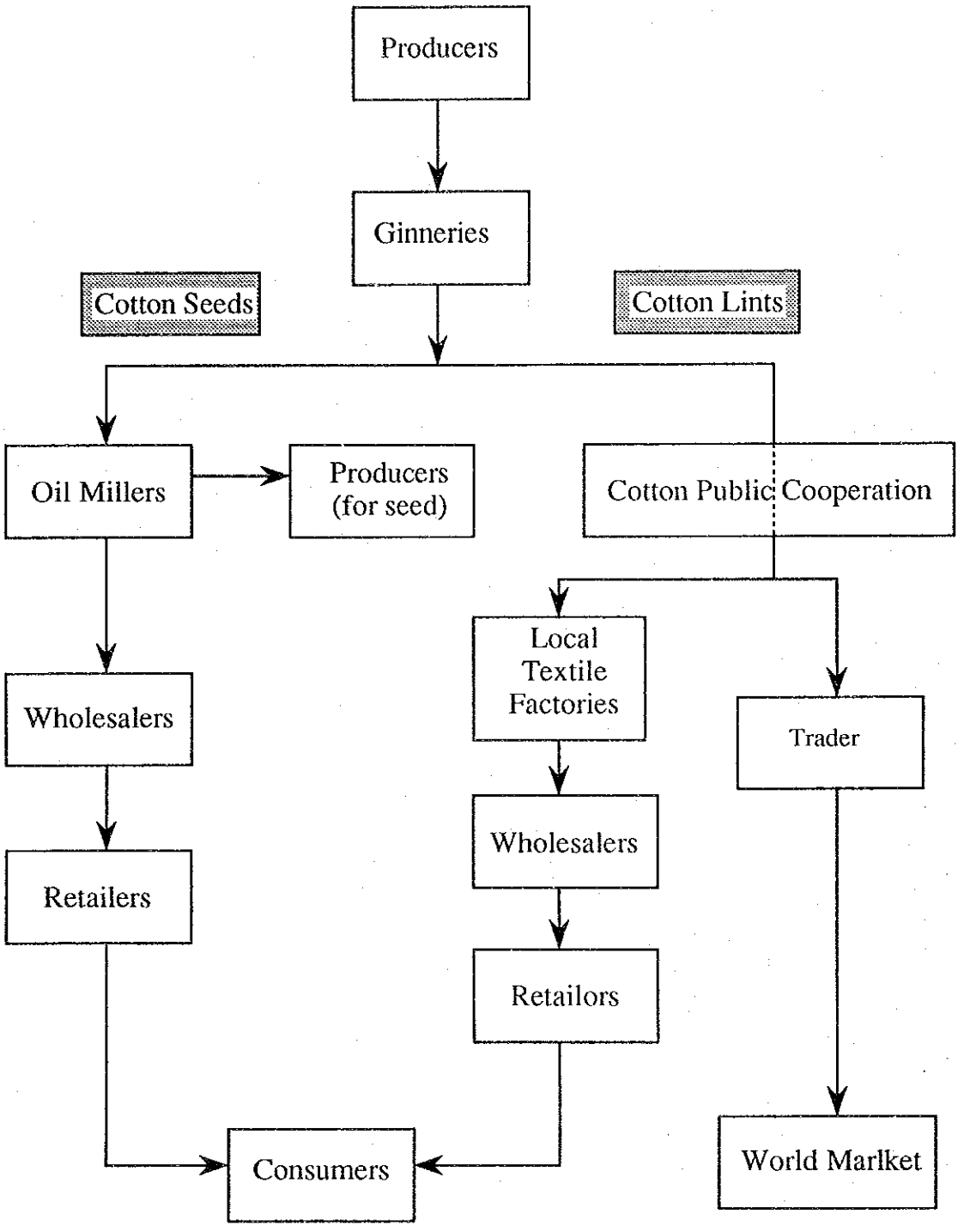

Fig. 2.4 MARKETING STRUCTURE OF COTTON

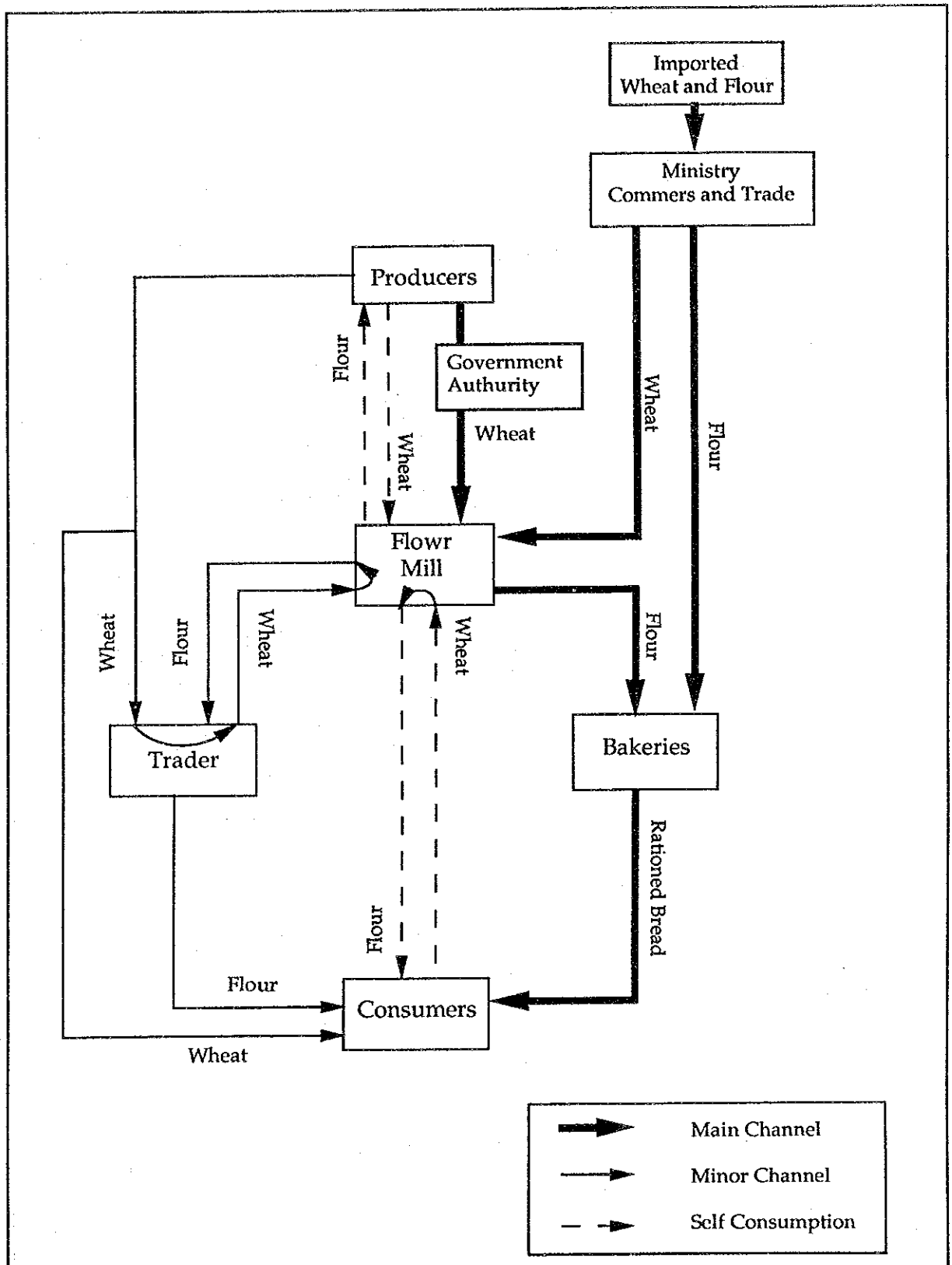

Fig. 2.5 MARKETING STRUCTURE OF WHEAT

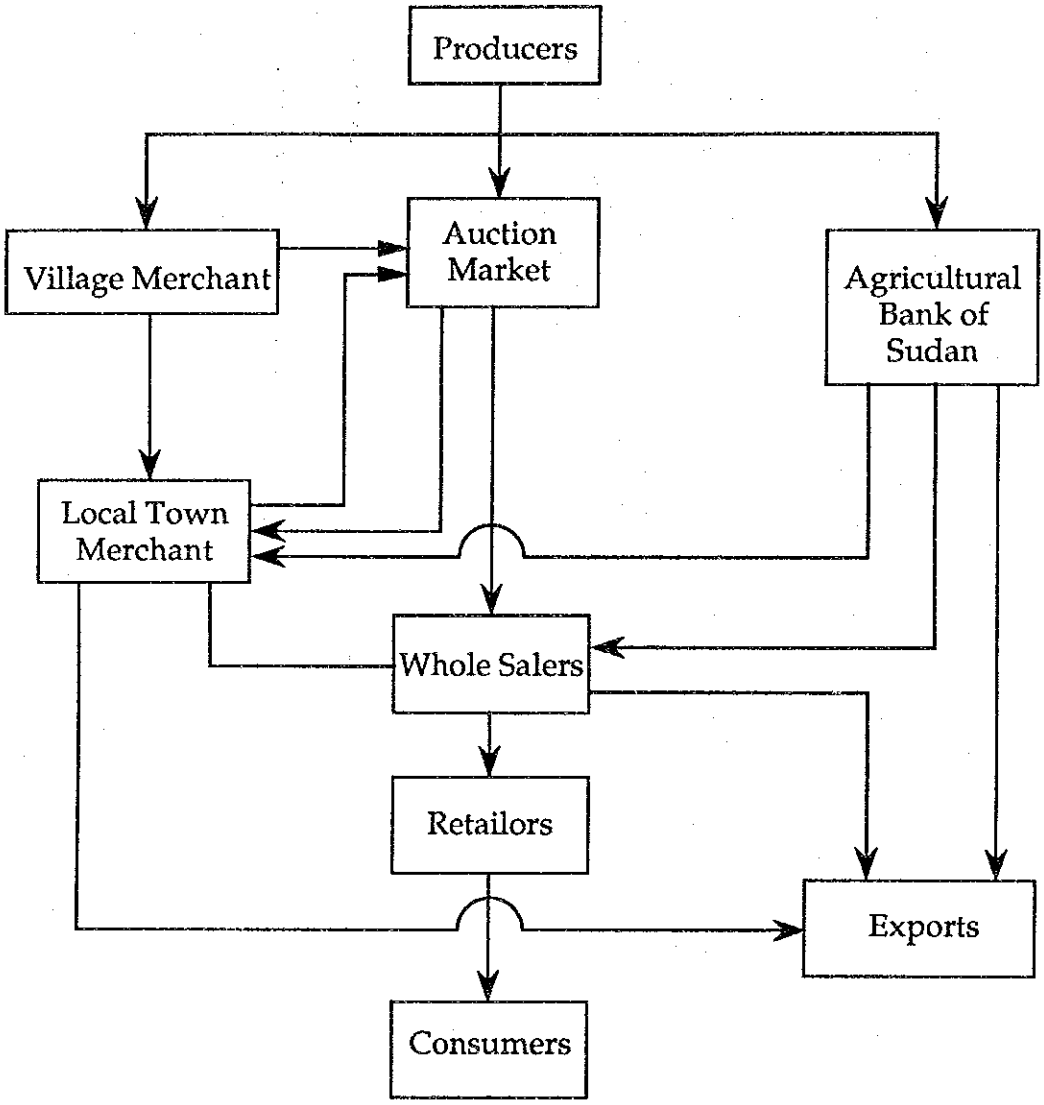

Fig. 2.6 MARKETING STRUCTURE OF SORGHUM

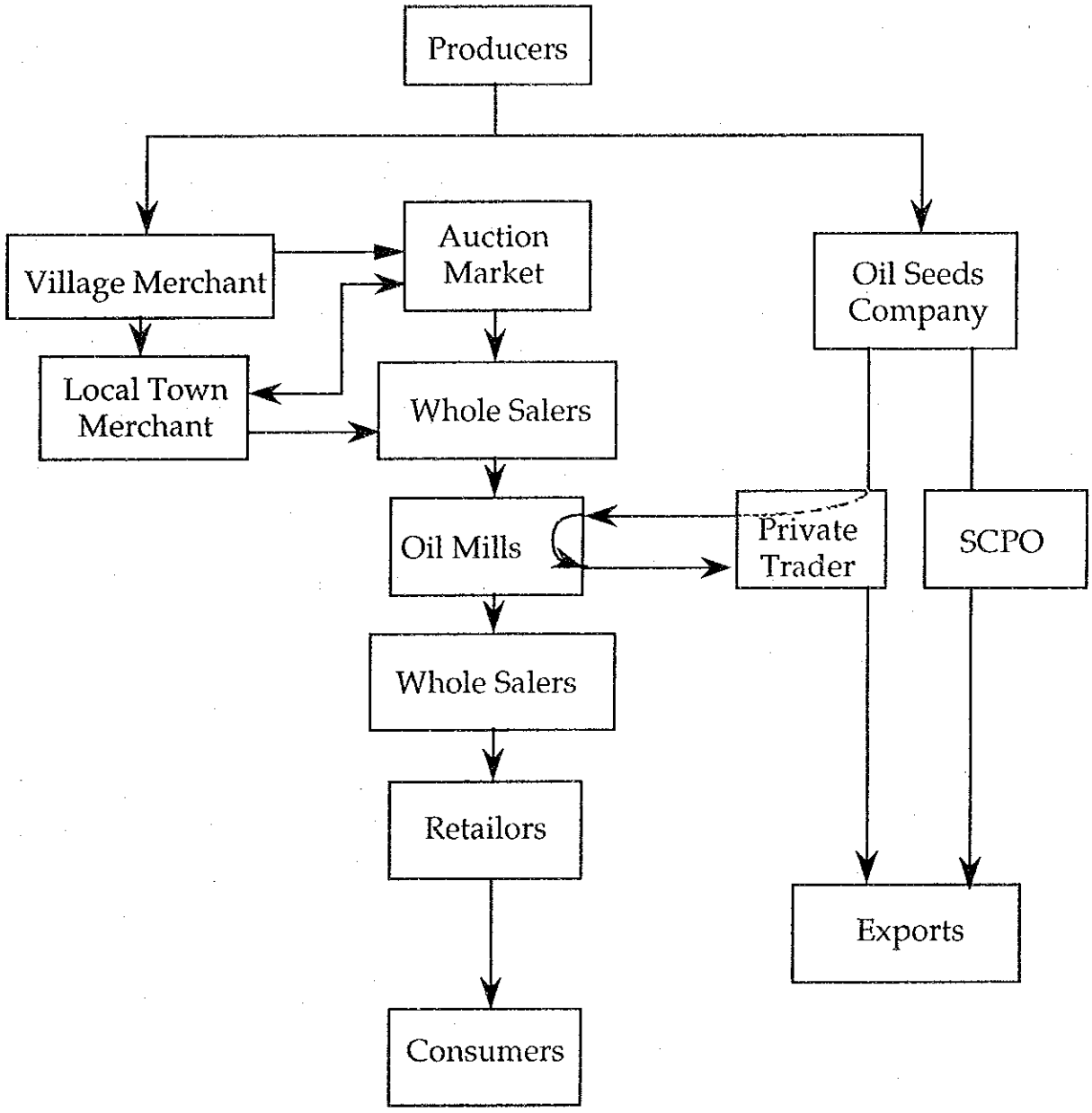

Fig. 2.7 MARKETING STRUCTURE OF GROUNDNUTS

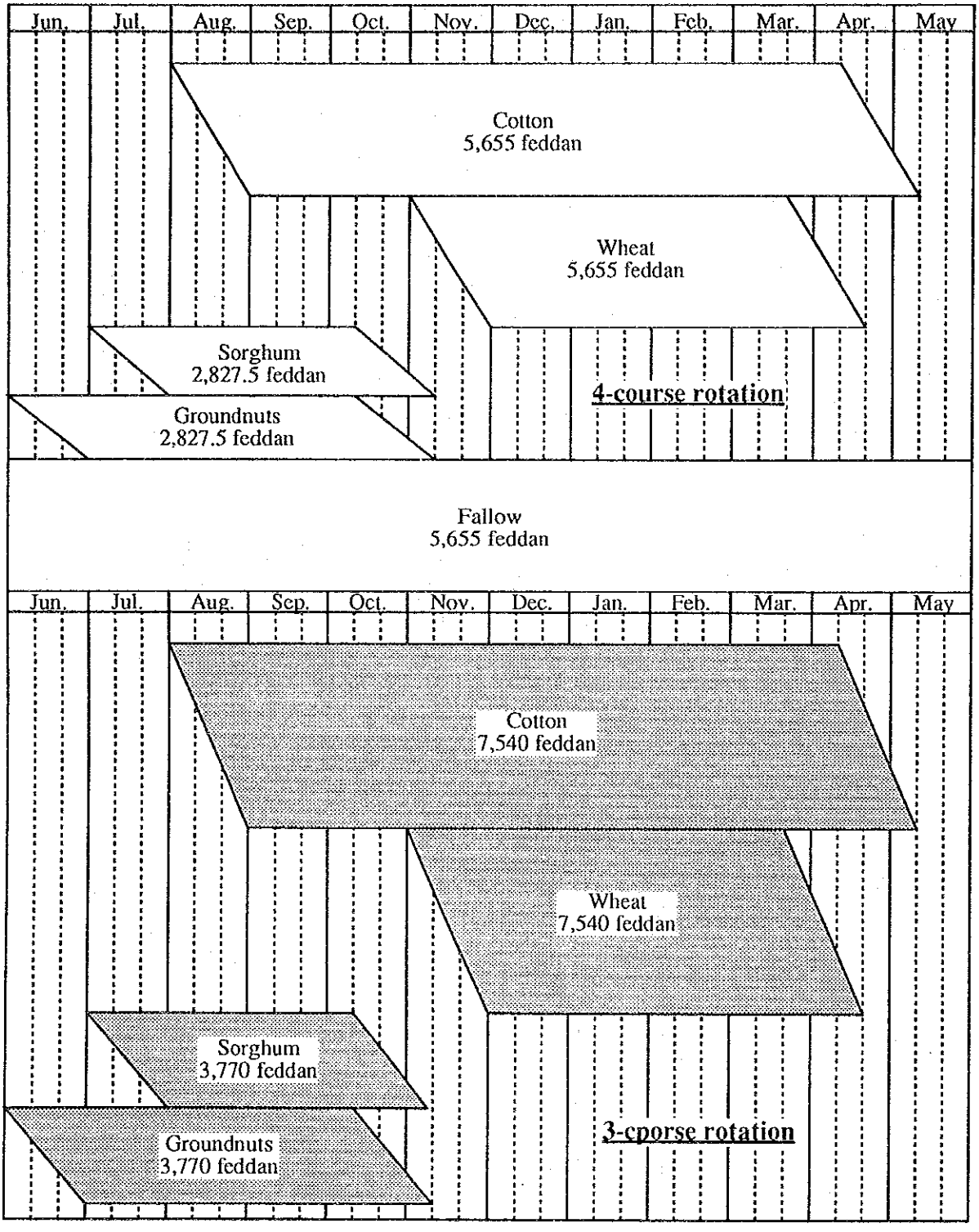

Fig. 3.1 PROPOSED CROPPING PATTERNS (1/2)

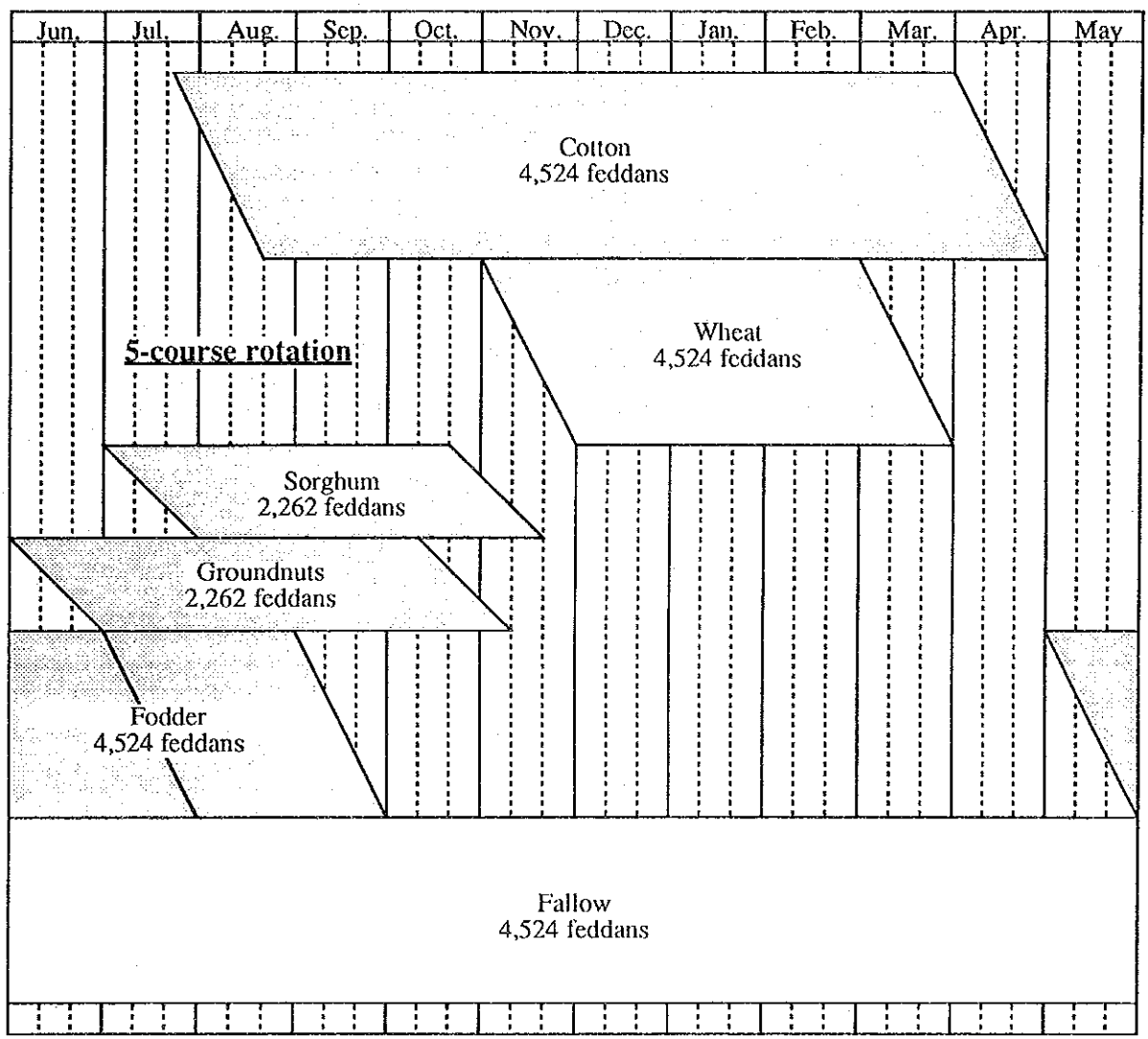

Fig. 3.1 PROPOSED CROPPING PATTTERNS (2/2)

APPENDIX

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ANNEX-E

PUMPING STATION AND POWER SUPPLY SYSTEM

FINAL REPORT

FOR

THE FEASIBILITY STUDY

ON

THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

ANNEX E : PUMPING STATION AND POWER SUPPLY SYSTEM

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1. PRESENT CONDITION

1.1 Data Collection and Field Survey

(1) Data Collection and Survey for Pumping Station

Except for a few drawings for installation of pump equipment for the Hurga Pumping Station (P/S), which was used only for referential purpose in this Study, neither any drawings nor design data for the Hurga and Nur El Din P/Ss are available.

The following drawings and data were collected and used for reference:

- General layout drawing of Es Suki P/S,
- General layout drawing of Abu Banat P/S,
- Operation record of Hurga and Nur EL Din P/Ss, and
- Record of pump operation tests of Hurga and Nur El Din P/Ss

The following surveys were conducted at both P/Ss and their vicinity:

- Visual clinical survey of the pumping station,
- Dimension survey of the pump house,
- Survey on material of the structure,
- Non-destructive tests on hardness of concrete,
- Survey on siltation in the intake structure, and
- Disassembling and visual inspection of pumping equipment and appurtenant facilities.

(2) Data Collection and Survey for Electric Power Supply

The data relevant to overall condition of electric power supply were mainly obtained at National Electricity Corporation (NEC) in Khartoum, and those of in and around the Project area were at NEC Wad Medani.

In addition, the following reconnaissance surveys and investigations were carried out in and around the Project area:

- Route of existing 33 kV distribution line and their terminal points;
- Route distance of 33 kV distribution line to be extended between existing terminal points and the Project site;
- Measurement of conductor size of 33 kV outgoing feeder of Hag Abdallah Substation for El Biryab Pumping station; and
- Measurement of typical pole arrangement for 33 kV distribution line.

1.2 Pumps and Appurtenant Facilities

1.2.1 Present Status

Hurga and Nur El Din pumping stations were constructed in 1950s' by private cotton production syndicates. Both pumping stations are located on the right bank of the Blue Nile in series between the confluences of the Dinder and Rahad rivers. The Nur El Din pumping station is at 2 km upstream from the Hurga one.

The Hurga pumping station is equipped with three (3) diesel driven vertical shaft mixed-flow type pumps having a rated discharge capacity of 90 m^3/min each at a rated head of 20.5 m. The pumps are installed in wet suction pits divided by partition wall. River water is directly fed to the suction pit through an inlet channel. The diesel engine is a horizontal shaft, 4-cycle, 8 cylinders with a rated output of 600 PS, and coupled with a pump shaft through a bevel gear unit.

The Nur El Din pumping station is equipped with three (3) diesel driven horizontal shaft mixed-flow type volute pumps having a rated discharge capacity of 60 m^3/min each at a rated head of 21.03 m. The pumps are installed in a dry type chamber and river water is fed through respective suction pipes. The diesel engine has a horizontal shaft, 4-cycle, 6 cylinders with a rated output of 450 PS, and mounted on the diesel floor approximately 8 m above the floor of the pump room. The pump is driven by the diesel engine through a plain belt and pulley.

The detailed specifications of pumps, engines and appurtenant facilities are shown in Table 1.1. The present status of pump and appurtenant facilities of both stations is summarized as follows:

i) Restriction of annual operating period of the pumps;
ii) Decrease of discharge capacity of the pumps; and
iii) Deterioration of pump and appurtenant facilities.

1.2.2 Annual Operation Period

The monthly operating record of the Hurga and Nur El Din pumping stations during 1980 to 1990 is shown in Table 1.2. As can be seen in the Table, the operation of the pumps in both pumping stations was limited to a period from July through October, when the Blue Nile remains at high water level. This is mainly caused by:

i) Degradation of water level of the Blue Nile, affecting both pumping stations;
ii) Siltation accumulated in the intake channel of the Hurga pumping station.

According to the specific speed of the pumps and existing installation drawings of the pumps for the Hurga pumping station, the lowest low water level for the existing pumps are judged to be originally designed at EL. 390.9 m for the Hurga pumping station and EL. 392.6 m for the Nur El Din.

As clarified in ANNEX B; METEOROLOGY AND HYDROLOGY, an average water level during low water stage of the Blue Nile between 1985 and 1990 has decreased by about 1 m from the one before 1982. This is quite indicative that progressive degradation of the Blue Nile entailed limiting the operational period of the pumps consequently.

As for the Hurga pumping station, siltation has accumulated to some three to four meters in the inlet channel for years and made smooth influx of river water into the same difficult during the low water stage.

1.2.3 Discharge Capacity

The discharge measurement tests of the pumps were conducted for both pumping stations in September 1990 by Hydraulic Research Station, MOI. The results of tests are as follows:

(1) Hurga Pumping Station

Date	Unit No.	Discharge (m^3/s)	Suction WL (EL)
Sept. 23	1 & 3	2.249	396.24
Sept. 24	1 & 3	2.569	396.51
Sept. 26	3	1.165	396.33

(2) Nur El Din Pumping Station

Date	Unit No.	Discharge (m^3/s)	Suction WL (EL)
Sept. 23	2	0.42	396.38
Sept. 24	2&3	0.868	396.61
Sept. 25	2&3	0.889	396.32
Sept. 26	2&3	0.892	396.42

At the time of measurement, discharge head of Hurga and Nur El Din pumps were 14.7 m and 14.5 m, respectively, which corresponded to about 70% of the rated discharge head. Judging from the typical characteristic curve of a specific speed at 600 (m-min.) shown in Fig. 1.1, the discharge capacity of the pump at a discharge head of 70% ought to have increased to around 125% of the rated discharge i.e., 1.875 m^3/s per unit for the Hurga pumps and 1.25 m^3/s per unit for the Nur El Din pumps. Nevertheless, the average of measured discharge was 1.2 m^3/s per unit for the Hurga pumps and 0.45 m^3/s per unit for the Nur El Din pumps. This means that present discharge capacity of the pumps has decreased to 64% for the Hurga pumps and 36% for the Nur El Din pumps.

1.2.4 Deterioration of Pump and Appurtenant Facilities

The Hurga and Nur El Din pumping stations have been operated and maintained by MOI since 1976 when these pumping stations were turned over to MOI from the Blue Nile Agricultural Corporation (BNAC). Despite disassembling inspection and maintenance works have been made every year for the Hurga and at 4-5 year intervals for the Nur El Din, the pumps and appurtenant facilities have been seriously worn out due to superannuation and heavily deteriorated due to lack of financial supports required for essential maintenance works, especially for procurement of spare parts. At present the available spare parts are 12 sets of pistons and cylinder liner assembly, and 4 sets of exhausts and inlet values for the diesel engine, all of which were purchased in 1982.

The present conditions of pumps and appurtenant facilities are outlined hereunder:

(1) Hurga Pumping Station

a) Pump

Out of three pump units, No. 2 pump unit is in unserviceable condition due to lack of intermediate shaft stay rings, which were removed and appropriated to other pump units.

The disassembling inspection for No.1 pump unit revealed that:

Impeller; (repair welded 5 years ago)

- Breakages and cracks in all impeller blades at outlet. The maximum area of breakage extended to approximately 90 cm^2 (19 cm in length and 8 cm in depth)
- Crack in all impeller blades at inlet
- Holes in all impeller blades, 8 numbers in total. The maximum size is approximately 5 cm in diameter.
- Pittings developed on impeller blade caused by cavitation. The maximum depth observed is 2.5 mm (Refer to Fig. 1.2).

Diffuser Vane:

- Heavy erosion on all inlet edges (Refer to Fig. 1.3).

Pump Shaft:

- Abrasion of shafts at grand packing. The maximum abrasion is 6.5 mm in diameter.
- Cracks of shaft coupling at key groove in 10 cm long.

Shaft Stay Ring:

- Breakages at rim end of all stay rings.

b) Engine

The diesel engine for No.2 pump unit is also inoperable due to water leakage from copper element tubes of heat exchanger. The rivetted steel made storage tank is generally sound condition, but cracks are observed in its foundation structures.

c) Gear Unit

The condition of gear teeth of No.1 pump unit is generally sound condition, but roller bearings sound abnormal noise.

d) Overhead Crane

The contact surfaces of hoisting worm gear and travelling helical gears are heavily worn out.

e) Discharge Pipe

The entire surface of discharge pipes are heavily corroded inside and outside. The hole having 5 mm in diameter is observed in No.3 discharge pipe. The condition of outside surface of discharge pipes is shown in Fig. 1.4. Besides, the flap valves provided at outlet end of No.1 and No.3 discharge pipes can not be fully closed due to abrasion of their hinge pins.

(2) Nur El Din Pumping Station

Out of three pump units, No.1 pump unit is in unserviceable condition due to breakages of setting bolts for casing cover (3 pieces are broken out of 8 pieces in total). The suction pipes are heavily damaged and it makes impossible to prime pumps with water.

Some parts are removed from the diesel engine for No.1 pump unit and are appropriated to other diesel engines.

Cracks are observed in almost all hoisting helical gears of overhead crane, and some of them reach up to their roots.

The discharge pipes are heavily corroded to the same extent as those of the Hurga pumps as shown on Fig. 1.5.

There is no safety means for plain belts having 1 m wide and 1 cm thick, and hence there is a possibility to cause injurious accident during operation.