The Republic of the Sudan

THE FEASIBILITY STUDY ON THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

MAIN TEXT

AUGUST 1991

Japan International Cooperation Agency
(JICA)

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FINAL REPORT
FOR
THE FEASIBILITY STUDY
ON
THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

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PREFACE

In response to a request from the Government of the Republic of the Sudan, the Government of Japan decided to conduct a feasibility study on the Hurga and Nur El Din Pump Scheme Rehabilitation Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sudan a study team headed Mr. Shinichi Yano, NIPPON KOEI Co., Ltd., twice between November 1990 and June 1991.

The team held discussions with the officials concerned of the Government of the Republic of the Sudan, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

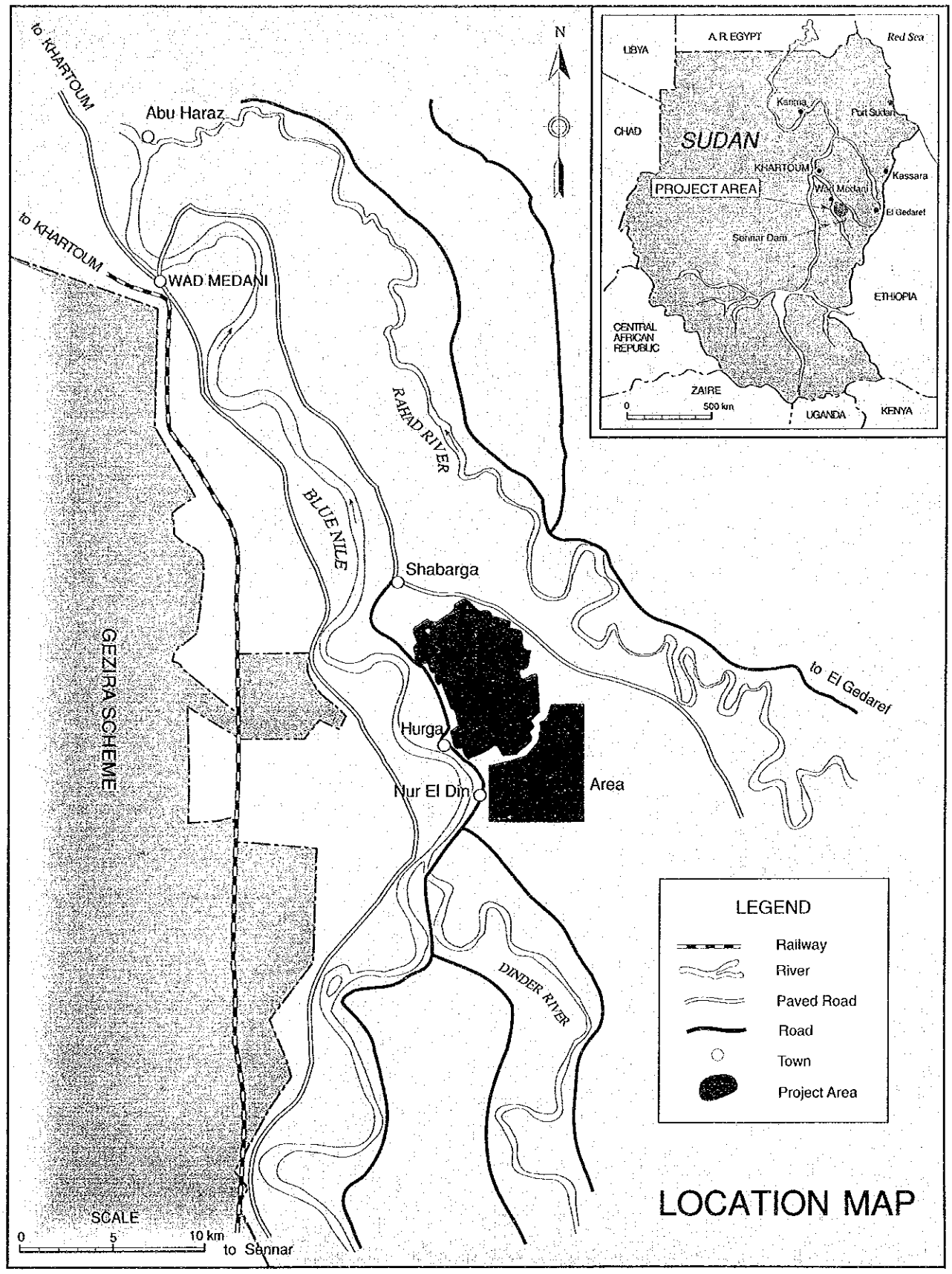
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Sudan for their close cooperation extended to the team.

August 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency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Hurga
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LEGEND
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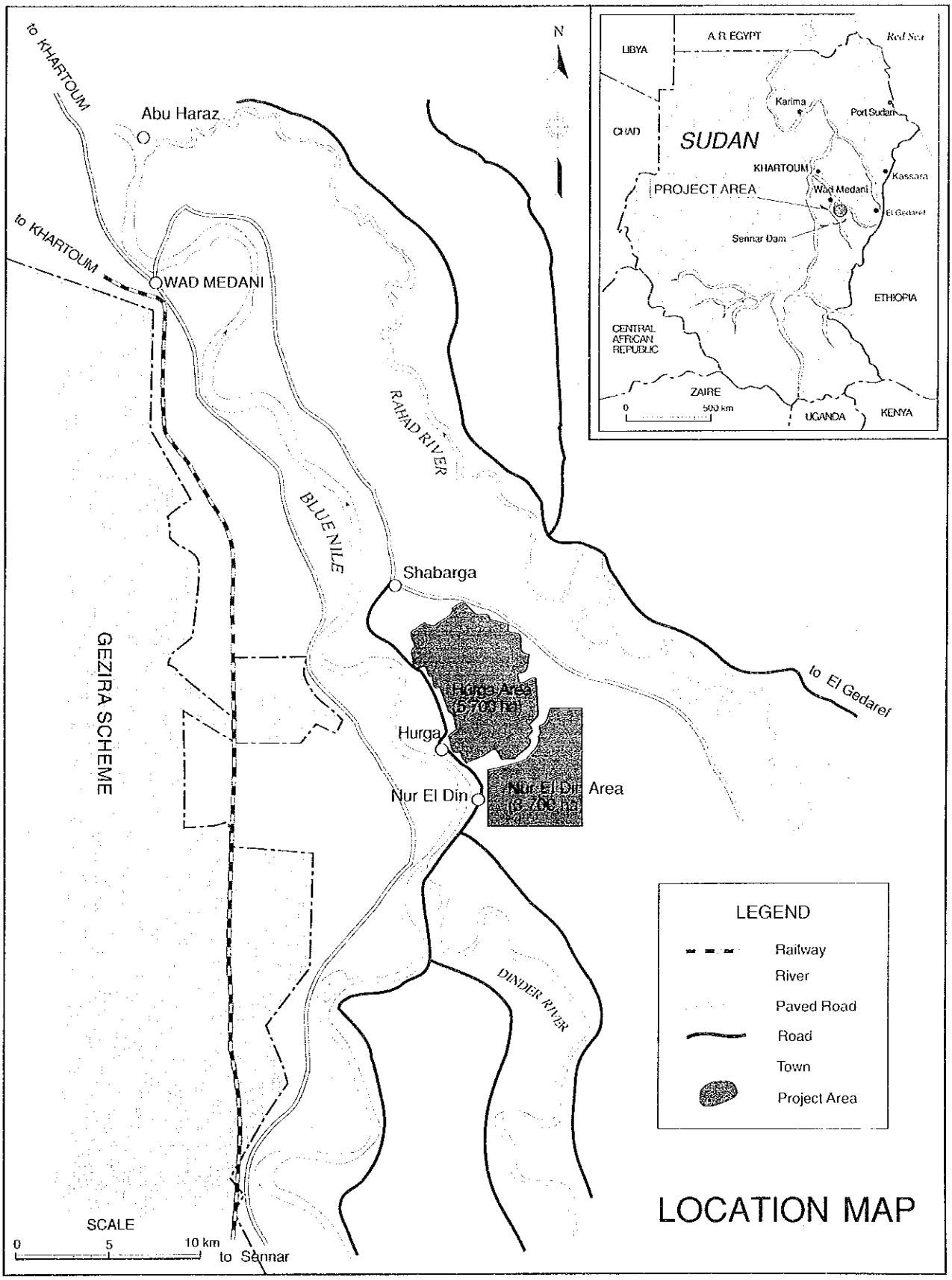
LOCATION MAP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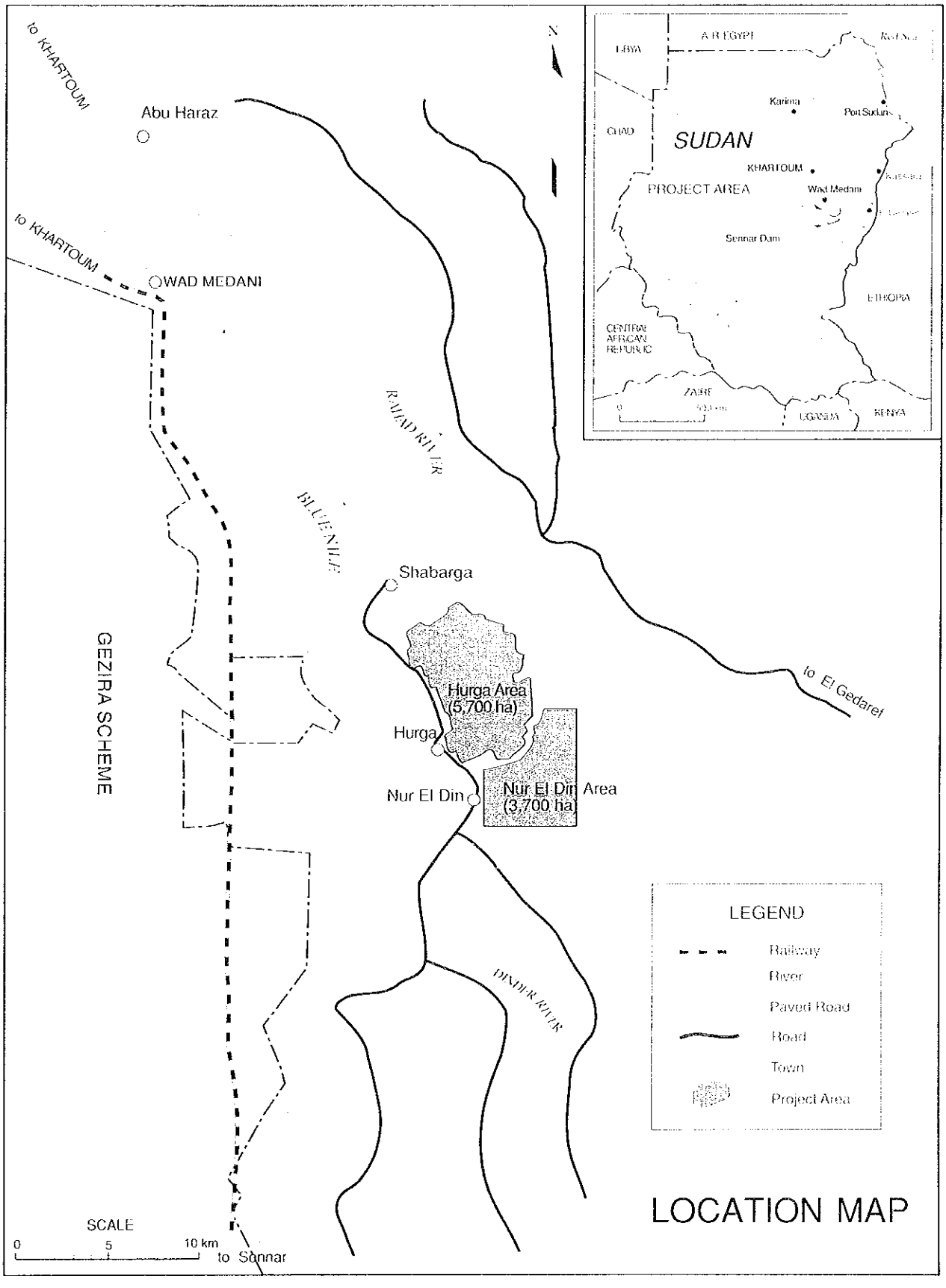
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SUMMARY

INTRODUCTION

01 This Final Report for the Feasibility Study (the Study) of the Hurga and Nur El Din Scheme Rehabilitation Project (the Project) has been prepared in accordance with the Scope of Work for the Study agreed upon between and by the Ministry of Irrigation (MOI) and the Japan International Cooperation Agency (JICA) on December 18, 1989.

02 Thé Study area covers the Hurga area of 13,900 feddans (5,840 ha) and Nur El Din area of 8,720 feddans (3,660 ha), totaling 22,620 feddans (9,500 ha). It is located about 220 km southeast of Khartoum and extends over the east bank of the Blue Nile between the Rahad river and the Dinder river.

03 The objectives of the Study were: i) to conduct a feasibility study on improvement of the Hurga and Nur El Din Pump Irrigation Schemes centered on rehabilitation of the Hurga and Nur El Din pumping facilities; and ii) to transfer technical knowledge to the counterpart personnel for the Study.

BACKGROUND

04 The per capita GDP in 1988/89 was estimated at £S 2,834.9 equivalent to US$230.5 at current market price. In 1989, Sudan's foreign trade recorded a trade deficit of £S 2,350 million. The economy of the country is dominated by agriculture. It produces 34% of the total GDP and occupies over 90% of export earnings. About 70% of the work force depends on agriculture.

05 Agriculture in Sudan is broadly categorized into four types, namely, i) irrigated, ii) rainfed mechanized, iii) rainfed traditional, and iv) livestock. Irrigated agriculture covers 7 million feddans of farm lands and mainly produces cotton, groundnuts and cereals. The Gezira-Managil Scheme with a service area of 2.1 million feddans extending over a vast central plain between the Blue Nile and the White Nile, is the largest irrigation scheme in the country. The rainfed agriculture spreads over

farm lands of some 18 million feddans, where sorghum, groundnuts, sesame, millet and gum Arabic are mainly grown.

06 Cotton, the most important industrial crop in the country, was planted in about 702,000 feddans in 1989/90, of which 358,000 feddans were covered by the Gezira-Managil Scheme. Wheat has been increasingly consumed as staple food and has been substituting for traditional staple food of sorghum recently. It was raised in the irrigated farm lands of 614,000 feddans, more than 50% of which was included in the Gezira-Managil Scheme in 1989/90. Sorghum, subsistence crop, is generally produced under rainfed conditions. Its planted area in 1988/89 reached 13 million feddans.

07 The Four Year Salvation, Recovery and Development Programme was commenced in 1988. The agricultural sector programme is directed to the rehabilitation and modernization of the existing irrigated viable schemes. Challenging self-sufficiency in wheat is one of the main objectives in the sector programme.

08 Aiming at materializing the agricultural sector programme, the Blue Nile Pump Schemes Modernization Study was carried out between July 1988 and March 1990. The study covered 62 existing pumping schemes with aggregated service areas of 284,000 feddans and extension areas of 142,000 feddans extending over both banks of the Blue Nile. The Hurga and Nur El Din schemes were included in the study and given first priority in its recommended development programme.

09 The total installed generating capacity of the National Electricity Corporation (NEC) is some 540 MW, but the actual generating capacity is about 50% of the installed one. Thus the total generation covers 75% of the potential demand. During March through August, electric power supply falls into serious shortage because of irrigation oriented operation rules of the hydropower plant at the Roseires dam, which has an installed capacity of 280 MW.

10 At present, MOI manages 19 electrical pumping stations. The power supply for those pumping stations is secured by NEC's policy of giving the top priority for irrigation use.

THE PROJECT AREA

11 The Project area extends over the flat plain on the east bank of the Blue Nile with a very gentle inclination of 20 to 25 cm/km from the southern end of EL. 411.25 m to the northern end of EL. 407.50 m.

12 The substratum of the Project area consists of sandy strata, which is overlain by thick flood deposits, more than 50 m thick. The flood deposits are broadly divided into upper and lower portions. The upper portion consists mainly of clayey materials, and has a stratification with four major strata; reddish to light brown stiff clay at the lowest, alternation of sand and clay, sandy clay, and clays at the top. While the lower one is of sandy materials.

13 The soils in the Project area are categorized as Vertisols, and characterized by dark brown to brown with a soft surface mulch and deep cracking clays with more than 60% of clay. The land suitability of the Project area is mostly categorized as moderately suitable land (S2) with vertisolic, sodicity and fertility limitations. About 20% of the land is categorized as marginally suitable (S3), because of drainage problem due to topographic reason.

14 The climate of the Project area is categorized as semi-arid with a short rainy season, and characterized by a hot summer from April to June and a cool and dry winter from November to February. Annual rainfall between 1980 and 1990 is averaged at 265 mm with a range of 440 mm in 1985 at maximum and 115 mm at minimum in 1990.

15 The monthly mean discharge of the Blue Nile varies from 386 million m^3/day in August to 9.6 million m^3/day in February. MOI forecasts the annual water demand for irrigation in the Sudan at about 19 milliard m^3 for 1995, in which water demand by the Project has been incorporated. The water level of the Blue Nile at the existing Hurga and Nur El Din pumping sites fluctuates annually over a range of 8 m on average. About one meter of water level degradation was observed during the low water stage in recent five years.

16 In 1990, only sorghum was raised in the area of 2,269 feddans or 16% of the Hurga area and 1,260 feddans or 14% of the Nur El Din area. Expecting precipitation during the rainy season, it was planted in July and harvested from the middle of November to middle of December. Available water for sorghum seemed to meet its requirement in the Hurga area but to be short in the Nur El Din area. Application of fertilizers and agro-chemicals was not practiced. Unit yield of sorghum was about 240 kg/feddan in the Hurga area and 130 kg/feddan in the Nur El Din area. Total production of the sorghum in the Project area was about 700 tons.

17 There are 18 villages which are involved in the Project. The aggregated number of households in those villages are 3,190, of which 1,512 households are beneficiary farmers of the Project. None of the beneficiary farmers are allowed to own their lands, but they are tenants. A 15-feddan tenancy is prevailing in the Project area.

18 The tenants in the Project area depend for their living mostly on off-farm income (£S 10,900) and unreliable remittances (£S 6,200). Farm income accrued from sorghum is so negligibly small as £S 800 for the Hurga and nil for the Nur El Din. The annual living expenses of the tenants is £S 16,000, which corresponds to 80% of those of the Gezira's tenants (£S 20,000). The living of the beneficiary tenants is unstable and likely to drop to a subsistence level whenever capricious remittances are ceased.

19 There are two independent pumping irrigation systems in the Project area, one each for the Hurga and Nur El Din areas. The Hurga pumping station is equipped with three units of vertical mixed flow pumps driven by diesel engines with a rated output of 450 PS/unit. The rated capacity of the pump is 90 m^3/min/unit at a rated head of 20.50 m, but at present the discharge capacity has decreased to 64% of the rated one for two units and another unit of pump is not operational. The Nur El Din pumping station has three units of horizontal shaft mixed flow volute pumps with a rated capacity of 60 m^3/min at a rated head of 21.03 m. Two units of pumps are operational and their current discharge capacity have dropped to 36% of the rated one. During the low water stage, all the pump units could not be run due to degradation of water level and so on.

20 Each of independent canal networks are composed of a main canal, a major canal (for Hurga only), several minor canals and a large number of field channels. The field channels consist of watercourses (Abu Ishreen, Abu XX) and secondary watercourses (Abu Sitta, Abu VI). Each Abu XX serves one field block with a standard area of 90 feddans, called locally "Number", which is divided into numbers of 5-feddan field plots, known as "Hawasha" by a series of Abu VIs. These canals are adequately aligned in general but their elevation is not high enough to serve their command areas in some part of the Hurga area and most part of the Nur El Din area. The existing canal systems are:

Canals	Length (km)	
	Hurga	Nur El Din
Main canal	6.2	8.2
Major canal	5.6	0.0
Minor canal	48.0	23.7

21 MOI is responsible for; i) operation and maintenance of the pumping stations and canals between the head of the main canal and the tail of the major canal, and ii) maintenance of the minor canals. Sudan Gezira Board (SGB) is responsible for operation of the minor canals and operation and maintenance of the field channels.

22 Out of 18 villages, 15 villages rely for potable water on community wells, two villages depend on canal water. Only earth roads connect inter-villages and between the Project and the Wad Medani-Gedaref highway. Public electric power supply system by the National Electricity Corporation (NEC) is not available in the Project area. The power supplies available around the Project area are; i) the terminal of a 33 KV distribution line at Shabarga village approximately 12 km north of the Project area, and ii) the terminal of a 33 KV distribution line at the El Biryab pumping station about 8 km south of the Project area.

ALTERNATIVE STUDY

23 To formulate an optimum rehabilitation/renovation plan for the Project, an alternative study of the pumping station was made. The alternative study covered the three components of: i) prime movers including electric power supply; ii) pumps and appurtenant facilities; and iii) pump houses. It was made in the following sequence:

1) Enumerate conceivable plans for each component;
2) Make first screening on the above;
3) Formulate alternative plans by assembling each of components;
4) Make comparative study on prime mover;
5) Choose promising alternative plans;
6) Make evaluation of the above plans; and
7) Choose most preferable plan.

24 Through the series of the studies, the following promising alternative plans were selected:

Alt-1e; Electrically driven vertical shaft volute pumps in individual existing pump houses with rehabilitation;

Alt-2e; Electrically driven vertical shaft volute pumps in an integrated new pump house;

Alt-3e; Electrically driven vertical shaft mixed flow pumps in an integrated new pump house.

25 Cost evaluation for the above three alternatives were made in terms of Present Value (PV) as follows:

(Unit: £S x 10^6)

Work Items	Alt-1e	Alt-2e	Alt-3e
Initial cost	48.5	49.0	51.7
Annual cost	14.3	14.6	14.6
Total PV	62.8	63.6	66.3

26 Technical feasibility of each plan was evaluated as summarized below:

Work Items	Alt-1e	Alt-2e	Alt-3e
a) Workability in construction	3	1	2
b) Reliability of structure	2	1	1
c) Suction head	3	2	1
d) Easiness of operation	3	2	1
e) Easiness of maintenance	3	2	1
f) Desilting works	1	1	3
g) Negative benefit	3	1	1

Note: 1; good, 2; fair, 3; bad

27 Considering the above economic and technical evaluations, Alt-2e has been chosen as the most preferable option of the three for the Project.

THE PROJECT

28 The objective of the Project is to improve unfavorable living conditions of the beneficiary tenants in the Project area, through revitalizing the present severely depressed agricultural production in the area. Introduction of intensive farming under irrigated condition is the basic concept of the development plan. To put this conception into shape, thorough rehabilitation and/or renovation of the existing agricultural infrastructures is needed. For attaining the goal of the Project and sustaining it over the project life, it is equally essential to provide well organized agricultural support services for the beneficiary tenants and to reorganize the existing structure for operation and maintenance.

29 Basic concepts for agricultural development are:

- To realize optimum land use;
- To introduce the crops most suitable for land and climatic conditions; and
- To establish adequate farming practices.

To achieve the above through:

- Increasing present low cropping intensity to the allowable maximum extent;
- Employing, in principle, the same cropping pattern as that used in the Gezira Scheme;
- Providing well organized agricultural support services; and
- Encouraging beneficiary tenants in introducing modernized farming practices.

30 Among preliminary selected three land use plans, i.e., i) a three-course rotation without fallow, ii) a four-course rotation with fallow, and iii) a five-course rotation with fallow, option (iii) is proposed for the Project. The crops selected for the proposed option (iii) are cotton, wheat, sorghum, groundnuts and fodder. The proposed land use plan is as follows:

(Unit; feddan)

Crops	Land Use in Each Tenancy	Land Use in Project Area
Cotton	3.0	4,524
Wheat	3.0	4,524
Sorghum	1.5	2,262
Groundnuts	1.5	2,262
Fodder	3.0	4,524
Fallow	3.0	4,524
Total	15.0	22,620

31 With introduction of the improved farming practices under stable water supply, crop yields are expected to increase substantially. The anticipated crop yields are:

Cotton	900 kg/feddan
Wheat	920 kg/feddan
Sorghum	1,000 kg/feddan
Groundnuts	1,000 kg/feddan
Fodder	1,500 kg/feddan

32 Crop production would increase gradually during the built-up period of four years after completion of the construction works. The incremental annual crop production at the full development stage is estimated as follows:

(Unit; tons)

Crop	Without Project	With Project	Incremental Production
Cotton	0	4,072	4,072
Wheat	0	4,162	4,162
Sorghum	708	2,262	1,554
Groundnuts	0	2,262	2,262
Fodder	0	6,786	6,786

33 The principal objectives of the irrigation development are to realize intensive irrigated farming by means of comprehensive rehabilitation and improvement of the existing irrigation system, drainage system and operation and maintenance (O&M) facilities. Maximum use of the existing facilities is the basic idea in the development plan, but re-arrangement of present 5-feddan farm plots (Hawasha) to 3-feddan plots is indispensable so as to match with the proposed five-course rotation.

34 The irrigation water requirements of the proposed cropping pattern were computed using Ep (Penman original) x crop factor. The peak water requirement was estimated at 8.17 m^3/sec under 18 hours/day operation for the first 10-day period of September.

35 Irrigation water would be tapped at the proposed pumping station between 0:00 and 18:00. Discharge control would be made by a combination of unit number control and operating hours. Water distribution from the minor canal to Abu XX would be done from 6:00 through 18:00 as a rule. The balance of influx into and afflux from the minor canal would be regulated in the minor canal, for which a storage capacity would be provided in addition to the ordinary design capacity. The Angaya irrigation method, a basin irrigation, is proposed for the Project.

36 O&M roads with a laterite surface would run along either side or both sides of the main, major and minor canals. A surface drainage system is

proposed to remove surface runoff caused by rainfall or over application of irrigation water.

37 MOI will be responsible for operation and maintenance (O&M) for the pumping station and the canal system between the head of the main canal and the tail of the major canal and maintenance of the minor canals, while SGB will be responsible for operation of the minor canals and O&M of the field channels.

38 The principle features of the Project works are summarized as follows:

(1) Pumping Station

- Type of pump ; vertical shaft double suction volute pump
- Rated discharge ; 148 m^3/min/unit
- Rated design head ; 24 m
- Diameter of pump ; 1,000 mm x 800 mm
- Number of pump unit ; 4 sets
- Motor output ; 750 kW

(2) Power Supply System

- 33kV distribution line ; 9.5 km
- 33 kV outdoor switchyard ; one lot

(3) Link Canal

- Length ; 450 m including a sand settling basin of 130 m long
- Design capacity ; 8.17 m^3/sec
- Bifurcation ; 5.02 m^3/sec for Hurga & 3.15 m^3/sec for Nur El Din

(4) Canal System

	Proposed Work	Hurga	Nur El Din
a)	Main canals (km)		
	- New	0.49	1.86
	- Rehabilitation	5.33	9.46
b)	Major canals (km)		
	- New	-	-
	- Rehabilitation	5.62	-
c)	Minor canals (km)		
	- New	10.40	-
	- Rehabilitation	42.01	27.09
d)	Structures (nos.)		
	- Movable weir	13	5
	- Well-head regulator	4	2
	- Cross regulator	14	2
	- Field outlet pipe	221	114
f)	Drainage canal (km)	51.35	

(5) O&M Facilities

- Field O&M office ; 300 m^2 x 1
- Residence for O&M staff ; 150 m^2 x 3
- Residence for O&M staff ; 100 m^2 x 3

39 The implementation of the Project would be carried out in 2.6 years from the last quarter 1991 through April of 1994, which include one year for detailed design. MOI would be responsible for the implementation of the Project.

40 The construction cost of the Project was estimated at £S 360 million, breakdown of which is shown below:

(Unit; £S 10^6)

Items	F/C	L/C	Total
1. Preparatory Works	11.4	7.1	18.5
2. Civil Works			
1) Pumping station	14.8	8.1	22.9
2) New canal	10.3	4.3	14.6
3) Rehabilitation canal	85.0	54.1	139.1
4) O&M Facilities	0	3.3	3.3
5) O&M Equipment	3.6	1.2	4.8
3. Mechanical and Electrical Works	87.0	2.5	89.5
4. Physical Contingency	12.5	7.8	20.3
5. Administration Cost	0	2.3	2.3
6. Engineering Cost	45.0	0	45.0
Total	269.6	90.7	360.3

PROJECT EVALUATION

41 Assuming the project life as 50 years, the economic evaluation of the Project was made in terms of economic internal rate of return (EIRR), benefit-cost ratio (B/C) and net present value (B-C) as shown below:

EIRR	13.8 %
B/C (at a discount rate of 10%)	1.38
B-C (at a discount rate of 10%)	£S 96.9 x 10^6

42 A sensitivity analysis for possible adverse changes in the future indicates that the economic viability of the Project is rather insensitive as shown below:

(EIRR: %)

Cost Overrun	Benefit Reduction	
	0%	10%
0%	13.8	12.5
10%	12.6	11.3
15%	12.1	10.8

43 The farm budget analysis demonstrates that the Project would bring about a great improvement in farm budget and thus would contribute improvement of a living standard of the beneficiary tenants considerably.

(Unit: £S)

	Item	Without Project		With Project
		Hurga	Nur El Din	
1)	Income			
	Farm income	800	0	41,600
	Off-farm income	11,600	10,200	3,200
2)	Outgoing			
	Production costs	1,400	800	11,900
	Living expenses	16,600	15,400	19,700
3)	Net Reserve	-5,600	-6,000	13,200

44 In addition to direct benefits counted in the economic evaluation, various secondary and intangible benefit and/or favorable socio-economic impact are expected from the implementation of the Project: i) increase in crop production; ii) increase in farmer's income and upgrading living standard; iii) vitalizing regional economic activities; iv) increase in employment opportunity; v) enhancement of women's activities in social activities, etc.

RECOMMENDATION

45 The Project is economically justified giving an economic internal rate of return (EIRR) of 13.8%. The sensitivity tests show that EIRR would remain at 10.8% even if combination of benefit reduction by 10% and cost increase by 15% are assumed. Thus it could be concluded that the economic viability of the Project be rather insensitive against possible adverse changes in the future.

The implementation of the Project will satisfy fundamental need for introducing intensive farming under irrigation condition for the Project area. It would smooth the way to increase considerably the unit yield of crops and cropping intensity as well. The farm budget of the beneficiary farmers, depending mostly on off-farm income and unstable remittances at

present, could be so improved that net reserve of the beneficiary tenant turn from present minus £S 6,000 into £S 13,000 per annum.

Further, various secondary and intangible benefits and/or favorable socio-economic impacts are expected from the implementation of the Project.

It is, therefore, recommended that the Project be implemented as early as possible.

Construction of a new integrated pumping station and a link canal is urgent and radical necessity to get quick return from the Project area, although no full scale operation is possible unless other rehabilitation works proposed are constructed satisfactorily.

FINAL REPORT

FOR

THE FEASIBILITY STUDY

ON

THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

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UNITS, EXCHANGE RATES AND ABBREVIATIONS

Units

1 feddan	=	0.420 ha
1 ha	=	2.38 feddan
1 kantar	=	143 kg

Exchanger Rate

Official rate

£S 1.0	=	US$0.08
US$1.00	=	£S 12.30

Free rate

£S 1.0	=	US$0.08
US$1.00	=	£S 12.30

Abbreviations

ABS	Agricultural Bank of Sudan
ARC	Agricultural Research Cooperation
ARS	Agricultural Research Station
BOS	Bank of Sudan
c.i.f.	cost, insurance and freight
CPC	Cotton Public Corporation
CWR	crop water requirement
BNAC	Blue Nile Agricultural Cooperation
ELS	extra long staple cotton
MEC	Earth Moving Corporation
FAO	Food and Agricultural Organization of the United Nations
f.o.b.	free on board
FOP	field outlet pipe
FSL	full supply level
GDP	Gross Domestic Product
GOJ	Government of Japan
GOS	Government of Sudan
HRS	Hydraulic Research Station
ITCZ	Inter-tropical Convergence Zone
JICA	Japan International Cooperation Agency
MOCT	Ministry of Commerce and Trade
MOFEP	Ministry of Finance and Economic Planning
MOANR	Ministry of Agriculture, Natural Resources and Animal
MOI	Ministry of Irrigation
MS	medium-staple cotton
NOC	National Oil Company
NEC	National Electricity Corporation
PPU	Project Preparation Unit
SCPO	Sudan Company for Processing of Oil-seeds
SGB	Sudan Gezira Board
SSA	Soil Survey Administration
SOC	Sudan Oil-seed Company

I. INTRODUCTION

1.1 Authority

This is the Final Report for the Feasibility Study on the Hurga and Nur El Din Pump Scheme Rehabilitation Project (the Study) in the Republic of the Sudan (Sudan), which has been prepared in accordance with the Scope of Work for the Study agreed upon between and by the Government of Sudan (GOS) represented by the Ministry of Irrigation (MOI) and the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan (GOJ), on December 18, 1989.

This report presents the results of the Study. The Study was completed in two parts: Work-I and Work-II. Work-I covered collection of data and information relevant to the Hurga and Nur El Din Pump Scheme Rehabilitation Project (the Project), alternative studies on the rehabilitation plan of the pumping station and formulation of the basic development plan of the Project. Work-I was carried out in Sudan between October 30, 1990 and January 27, 1991 by the JICA Study Team in close collaboration with a Counterpart Group of the GOS. The results of Work-I were compiled in the Interim Report for the Study and submitted to GOS on January 21,1991. Work-II, involving formulation of the rehabilitation plan and its technical and economical evaluation, was subsequently commenced in Japan and finished on March 28,1991 by submitting the Draft Final Report. After explanation and discussion on the Draft Final Report in June 1991 between the Steering Committee for the Project and the JICA Study Team, it has been finalized in due consideration of the comments raised by the Steering Committee.

1.2 Scope of the Study

The Project area covers the Hurga area of 13,900 feddans (5,840 ha) and Nur El Din area of 8,720 feddans (3,660 ha), totaling 22,620 feddans (9,500 ha) net, in the El Gezira Province. It is located about 220 km southeast of Khartoum, the capital of Sudan, and extends over the right bank of the Blue Nile between the Rahad river and the Dinder river.

The objectives of the Study were: i) to conduct a feasibility study on improvement of the Hurga and Nur El Din Pump Irrigation Schemes centered on rehabilitation of the Hurga and Nur El Din pumping facilities, and ii) to transfer technical knowledge to the counterpart personnel for the Study.

The Study was divided into two parts: Work-I and Work-II. Work-I was to conduct data collection, surveys, investigations and formulate basic concept of the Project. While, Work-II was to formulate the rehabilitation plan inclusive of verifying technical feasibility and economic viability of the Project.

1.3 Final Report

The Final Report is composed of the Main Text and the following ANNEXES:

MAIN TEXT

ANNEX - A	TOPOGRAPHY AND GEOLOGY
ANNEX - B	METEOROLOGY AND HYDROLOGY
ANNEX - C	SOILS AND LAND CLASSIFICATION
ANNEX - D	AGRICULTURE AND AGRO-ECONOMY
ANNEX - E	PUMPING STATION AND POWER SUPPLY SYSTEM
ANNEX - F	IRRIGATION AND DRAINAGE
ANNEX - G	IMPLEMENTATION PLAN AND COST ESTIMATE
ANNEX - H	PROJECT EVALUATION

1.4 Organization for the Study

JICA organized a Study Team headed by Mr.Shinichi Yano for implementing the Study, while, the GOS organized a steering committee chaired by Eng.Ghafar Mahgoub, Under Secretary for Irrigation Operation Gezira & Managil, MOI as a decision making organization relating to the Study and a counterpart group for smooth implementation of the Study. The members of the Study Team, steering committee and counterpart group were as listed hereunder:

(1) JICA Study Team

Mr. Shinichi Yano	Team Leader
Mr. Seiji Koyanagi	Irrigation and Drainage Engineer
Mr. Takahumi Suzuki	Hydrologist
Mr. Takeo Nakamura	Geologist
Mr. Harunobu Inoue	Agronomist/Pedologist
Mr. Sakuzo Kanazawa	Design Engineer
Mr. Akimitu Arai	Electrical Engineer
Mr. Yoshihiko Ogata	Agro-economist
Mr. Shinichi Hamada	Cost Estimator
Mr. Motoaki Tatebayashi	Engineering Geologist

(2) Steering Committee

Eng. Ghafar Mahgoub	Chairman of the Steering Committee U/Secretary for Irrigation Operation, MOI
Dr. Siddig Hussein Abbo	Acting U/Secretary for Planning, MOI
Eng. Mohamad El Hassan Taha	Director of Gezira Operation, MOI
Eng. Abdalah Babiker Saad	Assistant U/Secretary for Project, MOI
Dr. Hasim A.El Obeid	Manager for Planning & Socio-economic Research Unit, SGB
Dr. Magboul El Hadi Lazim	Head Agronomy and Crop Physiology, ARC
Dr. Osman A. Rahman	Director General for Soil Survey Administration, MOANR
Eco. Abdel Hadi Mohamad	Representative of Project Planning Unit, MOFEP
Eco. Babiker Abdalla	Representative of Agriculture Sector, MOFEP
Dr. Hashim M. Zein	Representative of Project's Loan and Grant Administration, MOFEP
Eng. Hassan Ahmed Widaa	Secretary of the Steering Committee Divisional Engineer for Project, MOI

(3) Counterpart Group

Eng. Mohamad El Hassan Taha	Director of Gezira Operation, MOI
Eng. Hassan Ahmed Widaa	Divisional Engineer for Project, MOI
Eng. Mohamad Nur El Dayem	Design Engineer for Project, MOI
Eng. Osman Abuzeid	Director, Mechanical and Electrical, MOI
Dr. Osman A. Rahman	Director General for Soil Survey Administration, MOANR
Dr. Hasim A.El Obeid	Manager for Planning & Socio-economic Research Unit, SGB
Eng. Salih A. Ellah	Chief Surveyor for Project, MOI
Hassan Mohamad Fadul	Senior Soil Scientist, Soil Survey Administration, MOANR

1.5 Acknowledgments

During the Work-I period, the Study Team received generous assistance and cooperation from the authorities, agencies and other organization concerned in collecting data and information, conducting surveys and investigations and formulating the basic development plan. Taking this opportunity, the Study Team expresses heartfelt gratitude to all individuals, authorities and agencies concerned, in particular to members of the Steering Committee and the Counterpart Group. Special appreciation is due to Dr.Siddig Hussein Abbo, Acting Under Secretary for Planning, MOI and Eng.Hassan Ahmed Widaa, Divisional Engineer for Project, MOI, who extended invaluable assistance to the Study Team throughout the Study period in Sudan.

II. BACKGROUND OF THE PROJECT

2.1 National Socio-economy

2.1.1 Land and Population

Sudan is the largest country in Africa with a land area of about 2.5 million km^2 and shares its international boundary of 7,820 km with eight neighboring countries. It is bounded on the east by the Red Sea and Ethiopia, on the south by Kenya, Uganda and Zaire, on the west by the Central African Republic, Chad and Libya and to the north by Egypt. The capital of the Sudan is Khartoum which is formed of an urban complex with Omdruman and Khartoum North, and is located at the confluence of the Blue Nile and White Nile. The other important cities are Port Sudan, Wad Medani, El Obeid, Atbara and Juba. A general map of the Sudan is shown in Fig. 2.1.

The population of Sudan in 1988 was estimated at about 24 million based on a population census carried out in 1983. The average population growth rate between 1983 and 1988 was estimated at 3.1% per annum. Sudan is one of the most sparsely populated countries in the world. The average population density in 1988 was estimated at 9.6 persons per km^2.

2.1.2 National Economy

The Gross Domestic Product (GDP) of Sudan has been almost stagnant for the last decade with minor annual fluctuations as shown in Table 2.1. Per capita GDP has been substantially declining since the early 1980s because GDP (at constant prices 1981/82) for the same period remained mostly constant although the population increased year by year. The per capita GDP in 1988/89 was estimated at £S 288.3 equivalent to US$23.8 at 1981/82 constant prices or £S 2,834.9 equivalent to US$230.5 at current market price with an exchange rate of US$1.00 = £S 12.30.

The agricultural sector plays very important role in the Sudanese economy. It accounted for about 34% of the total GDP and over 90% of export earnings in a recent five years period. About 70% of the labour force depends

on agriculture. Contributions of the industry and services sectors averaged 15 and 51% of the total GDP, respectively.

In 1989, Sudan's foreign trade recorded export earnings of £S 3,023.1 million and import expenditures of £S 5,373.4 million, resulting in a trade deficit of £S 2,350.3 million. Cotton earned £S 1,348.8 million or 44.6% of the total export value in the same year. The export earnings by other major crops are shown in Table 2.2.

2.1.3 Exchange Rates

Since 1987 the foreign exchange regime was revised ten times by the Bank of Sudan (BOS). On October 25, 1988, two main exchange rate regimes were announced and enforced. All export earnings in terms of Sudanese Pound (£S) are 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, arriving at a weighted average rate of US$1.00 = £S 6.78. On August 27, 1990, BOS announced an exceptional exchange rate for export earnings by cotton: the official and free exchange rates were to be employed for 50% each of the earnings for 1990 and 1991 seasons. 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 fully employed in both exports and imports.

On May 28, 1991, BOS enforced to employ sole exchange rate of US$1.00 = £S 12.30 for all export earnings and imported commodities without exception.

2.2 Agriculture in the Sudan

Agriculture in the Sudan is divided into four types by farming practices; i) irrigated, ii) rain-fed mechanized, iii) rain-fed traditional, and iv) livestock. Area and production of major crops by type of agriculture are shown in Table 2.3.

Irrigated agriculture covers 7 million feddans of farm lands. There are five major irrigation schemes, namely; Gezira-Managil (2.1 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 in the irrigated farm lands are cotton, groundnuts and cereals.

The cultivated areas under mechanized rainfed agriculture were 6.4 million to 10.6 million feddans between 1987/88 and 1989/90, and the cultivated areas under traditional rainfed agriculture were between 7.2 million and 11.7 million feddans during the same period. These areas grew sorghum, groundnuts, sesame, millet and gum Arabic.

The main food crops produced in Sudan are sorghum (dura), millet, groundnuts, sesame and wheat. Sorghum is the most important staple food in rural areas and one of the important cereal crops for the country's economy. Sorghum is generally produced under rainfed conditions. In 1988/89, sorghum was grown in about 13 million feddans and its production reached 4.4 million tons.

Recently, wheat has been increasingly consumed as staple food instead of sorghum especially in urban areas and the 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. Expansion of wheat production is the government policy with the aim of future self-sufficiency. Wheat planting area has been increasing year by year in recent seasons. In 1989/90, about 614,000 feddans were planted to wheat and its production increased from 247,000 tons in 1988/89 to 409,000 tons. Thus, import of wheat decreased from about 70% in 1988/89 to some 55% of the total consumption in 1989/90.

Groundnuts and sesame are the principal oil seeds crops. Groundnuts is not only the traditional foreign exchange earner but also satisfies domestic consumption need. Groundnuts is the dominant crop under rainfed traditional agriculture, particularly in North Kordofan and South Darfur. Planted areas including irrigated groundnuts were 1.3 million feddans in 1989/90.

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 cultivation. In 1988/89, sesame was planted in about 0.28 million feddans and its production was about 0.2 million tons. Its

production in 1989/90 fell to 0.14 million tons due to water logging pest and diseases.

Cotton is the most important industrial crop for earning foreign exchange. In 1989, export of cotton accounted for about 45% of the total export earnings. Cotton is produced in the large scale irrigation schemes. In the Gezira Scheme, the biggest irrigation scheme in Sudan, the cotton growing area occupies at 50% of the total planted area. Cotton production has been declining in recent years. In 1989/90, cotton was planted on about 702,000 feddans, producing 408,000 tons, and its planted area and production decreased by about 11.3% and by 20.6% respectively in comparison with those in 1988. It was reportedly attributed to: i) insect infestation, ii) inadequate supplies of water, agro-chemicals and fertilizers, and iii) shortage of labour, particularly during the picking season.

2.3 National Development Plan

With emphasis on the rehabilitation of existing production units and the removal of transport and energy bottlenecks, GOS launched and put in force the Four Year Salvation, Recovery and Development Programme in 1988. 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 a post-war development programme for the Southern Region taking into full consideration the extraordinary conditions pertaining to that region.

The main objects of the agricultural sector in the same 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 exports 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 agricultural programme is directed to the rehabilitation and modernization of viable existing irrigated schemes and self-sufficiency in wheat. Especially, regarding self-sufficiency in wheat, GOS intends to reduce import of 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 contemplated expanding the irrigated area for wheat and increasing the yield of wheat without adversely affecting other crops.

Aiming at materializing the agricultural programme stated above, the Blue Nile Pump Schemes Modernization Study was conducted between July 1988 and March 1990. The study covered 62 existing pump schemes with aggregated areas of about 284,000 feddans and extension areas of 142,000 feddans extending over both banks of the Blue Nile. The Hurga and Nur El Din schemes were included in the study and given first priority in its recommended development programme.

2.4 National Electric Power and Fuel Supply

2.4.1 National Energy Consumption

In 1988/1989, the total consumption of energy in Sudan was estimated at 1.82 million tons in terms of petroleum; equivalent to around 70 kg per capita.

At present, Sudan depends for energy source on: i) biomass such as natural forest, animal and crop residues accounting for 82% of the total energy consumption; ii) petroleum for 17%; and iii) electricity for 1%. It is predicted that the forest resources in Sudan be exhausted in 15 years if present deforestation continues. Petroleum is all imported. Now, the energy supply is thought to remain at some 80% of the potential demand.

The electric power supply covered about 332,000 consumers and the total electric power generated was 1,231 GWh in 1988/89. The suppressed demand is estimated at 25% of the total power generation.

2.4.2 Existing Power Supply System

The electric power supply system in Sudan is constructed and managed by National Electricity Corporation (NEC) under administration of the Ministry of Energy and Mining. The power supply system of NEC covers the Central Region with the Blue Nile Grid System and part of the Eastern Region with the Eastern Grid System. The total power generated in 1988/1989 was 1,231 GWh, of which 98% is consumed in the Blue Nile Grid. The main trunk line of the Blue Nile Grid is a double circuit 220 KV transmission line, connecting Kilo-X Substation in a suburb of Khartoum and Roseires hydropower station with a total route length of 436 km. The national power supply system of NEC is as shown in Fig. 2.2.

2.4.3 Existing Power Generating Plants and Conditions

At present, the total installed generating capacity of NEC is some 540 MW, of which 280 MW is occupied by hydropower plants including the Roseires power station (252 MW), and the balance is thermal plants in and around Khartoum. The actual generating capacity is always far less than the rated one, and the maximum output ever recorded was 240 MW in June 1989.

Decrease in output of power generation due to inefficient maintenance is a main cause for the thermal plants. Decreased available head for power generation at low generating capacity is the reason for the decrease in power output of Roseires power station.

Power generation at the Roseires dam is governed by reservoir operation of the dam, which is irrigation oriented. During March to May when reservoir water level goes down, discharge for power generation is restricted to secure irrigation water supply. During July and August when flood flow comes into the reservoir, inflow is spilled out directly without retarding in the reservoir. As a consequence, the available head for power generation is depressed considerably and this also decreases in power output.

During March to August, referred to as "critical months", the power supply falls into serious shortage, and NEC is obliged to conduct severe load shedding and power cuts. The full output of Roseires power station is consequently obtainable only for a quite limited period during the end of the flood season.

The monthly maximum power and energy produced in the Blue Nile Grid between 1986/1987 and 1988/1989 is shown Fig. 2.3.

2.4.4 Power Balance and Development Programme

The power demand of the Blue Nile Grid in 1988/1989 was estimated at 313 MW in peak and 1,646 GWh in total energy, while those produced was 240 MW and 1,231 GWh, respectively. The suppressed demand is estimated at 25% of total power generation.

NEC is currently planning the Generation/Transmission Development Program, in which a demand growth rate is estimated at 7.5% per annum over 1997/1998.

To cope with the present unfavorable situation and materialize the programme, NEC is promoting the augmentation of the existing plants in Khartoum North Power Station, together with the feasibility studies on large scale developments of hydro power resources; Roseires dam heightening project and Merowe dam project.

2.4.5 Electric Power Supply for Irrigation

At present, the Ministry of Irrigation (MOI) operates 19 electrical pump stations including 3 pump stations being under construction along the Blue Nile. The total installed capacity is 76 MW and unit output of pump motor ranges from 270 KW to 1,700 KW.

The power supply for these pump stations is secured by NEC policy of giving the top priority to irrigation use, even in the present power supply situation.

2.4.6 Tariff System

NEC tariff system is classified into seven categories as mentioned below:

i) Residential use
ii) Commercial use up to 100 KVA
iii) Small firm use up to 100 KVA
iv) Industrial, Big Agricultural use and Bakeries above 100 KVA
v) Bulk supply for all use other than (iv) above 100 KVA, and
vi) Street lighting.

In 1988, the total billed consumption was 1,096 GWh, of which 429 GWh corresponding to 39% of total consumption was used for categories (iii) and (iv) above, and 553 GWh for residential use. Reflecting the serious shortage of power supply, the tariff system for residential use is set at a high rate to discourage consumption to some extent, while at a low rate for productive sectors especially for (iv) sectors since agriculture is the mainstay of the Sudanese economy. The tariff system for (iv) and (v) includes seasonal rates, for critical months (March to August) and other months, and time rates for peak demand time (7:00 to 14:00 and 18:00 to 22:00 hours) and off-peak demand time. The tariff system applied for (iv) is shown in Table 2.4.

2.4.7 Fuel Supply Condition

(1) Existing Fuel Supply System

At present, the fuel supply of Sudan fully depends on imports. The total consumption is estimated at 1.82 million tons in 1988/1989. The sectorial distribution is evaluated at 75% for household, 9% for transportation, 8% for industry, 4% for service, 3% for agriculture and 1% for others. Port Sudan on the Red Sea, approximately 1,100 km from Khartoum in route distance, is the handling port for fuel imports.

Although an oil pipe line of 200 mm in diameter connects between Port Sudan and Khartoum in total length of 816 km, 80% of total transportation relies on road transportation; this is one of the major constraint on a stable fuel supply.

(2) Fuel Supply for Irrigation

At present, the Ministry of Irrigation (MOI) operates some 220 diesel pumping stations, of which 170 are on the White Nile, 40 on the Blue Nile and 8 in the Gezira Area. The total fuel consumption by these pumping stations is estimated at approximately 34,000 m^3 per annum. Although such annual amount is secured by the government policy of giving top priority to the irrigation sector, the fuel supply to distributors is unstable and sometimes falls into shortage due to delayed delivery. The fuel procurement of MOI is made through the distributors in Khartoum, or sometimes at Port Sudan, which depends on the availability of fuel at distributors. In addition, access to these pump stations makes it difficult to secure regular delivery of fuel. To cope with such conditions, 20 tankers; 4-25 kl, 6-14 kl and 10-7 kl are in operation for procurement and delivery of fuel to the pump stations.

(3) Fuel Price

The fuel price for diesel is set at £S 4.05/Gallon (£S 0.89/lit.) at government rate, and the one billed by MOI to the distributors are as follows :

- £S 5.947/gallon (£S 1.308/lit.) at Khartoum as of Dec. 16, 1990
- £S 5.747/gallon (£S 1.264/lit.) at Port Sudan as of Aug. 19, 1990

2.5 Regional Socio-economy

(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, 35,057 km^2, has an average population density of 58.1 (in 1983) persons per km^2, which is the second most densely populated province after Khartoum province.

Wad Medani town, the second largest town in the Sudan after 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 is 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.

(2) Population

The population of the El Gezira Province was reported at 2.0 millions in the 1983 census and accounted for 9.8% of the national population. A 16.9% of the population inhabit in the urban area and 81.7% in the rural area and 1.4% are nomad. In particular, the population of El Gezira Province fluctuates by temporary or seasonally in accordance with movement of agricultural laborers working in the Gezira Scheme. The number of temporary or seasonal 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 El Gezira Province in 1990 is estimated at 2.3 millions based on the average growth rate. Population aged 10 years old and over is counted as working population. In this sense it is estimated at approximately 69.2% or 1.6 millions of the population in the province.

(3) Agriculture in the Region

Administratively, the Project area falls in the El Gezira Province. El Gezira Province is economically one of the most active province for agricultural sector, which depends substantially on the Gezira Scheme lying between the Blue and White Niles.

The main crops in the Gezira Scheme are cotton, wheat, groundnuts and sorghum. The total planted area 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 46,000 feddans to vegetables.

III. THE PROJECT AREA

3.1 Location

The Project area covers farm land of 22,620 feddans (9,500 ha) net, which is divided into the Hurga area of 13,900 feddans (5,840 ha) and the Nur El Din area of 8,720 feddan (3,660 ha).

It is located at about 30 km southeast of Wad Medani and 220 km southeast of Khartoum in route distance. Administratively, the Project area falls in the El Gezira Province of the Central Region. Location map is given in Fig. 3.1.

3.2 Topography and Geology

The Project area extends over a flat plain on the right bank of the Blue Nile. It gently inclines from south to north at a gradient of 20 to 25 cm/km between an altitude of EL. 411.25 m at the southern end of the Project area and EL. 407.50 m at the northern most area. The topographic features of the right bank of the Blue Nile are broadly divided into those characterized by: i) stepped slopes seen in the upper reaches of both the Nur El Din pumping station and the Hurga pumping station; and ii) low-lying terrace formation stretching between downstream of the Nur El Din pumping station and the alternative pumping site (700 m upstream of the Hurga pumping station).

Fig. 3.2 shows the geology of the Central Clay Plain where the Project area is situated. The substratum of the Project area consists mainly of sandy layer believed to be of deposits during the Pliocene of Neogene Tertiary to Pleistocene of Quaternary Period, locally known the Umm Ruwaba Deposits. This is widely overlain by thick flood deposits, originating from igneous rocks and metamorphic rocks of Ethiopian Plateau. The flood deposits are more than 50 m thick around Wad Medani, and are broadly divided into upper and lower portions. The former one consists mainly of clayey materials, while the latter one is of sandy materials. The upper portion of the flood deposits has a stratification with four major strata; reddish to light brown stiff clay at the lowest, alternation of sand and clay, sandy clay, and clays at the top.

The groundwater level observed at alternative pumping site in June 1991 was approximately 17 m below the ground surface of EL. 410 to 411 m, and it might fluctuate in accordance with water level of the Blue Nile.

3.3 Meteorology and Hydrology

The climate in the Project area is categorized as semi-arid with a short rainy season, and characterized by a hot summer from April to June and a cool and dry winter from November to February.

Annual rainfall between 1980 and 1990 fluctuated widely from 440 mm in 1985 to 115 mm in 1990, being averaged at 265 mm. The rainy season lasts usually three months from July through September, during which about 80% of the annual rainfall is concentrated. The mean monthly temperature varies from 33.1°C in May to 23.9°C in January. Daily mean evaporation by the Penman method is 7.8 mm with a maximum one of 10.0 mm/day in June. Monthly mean maximum relative humidity varies from 83% in August to 29% in April. Meteorological records at Wad Medani Meteorological Station are shown in Table 3.1.

The mean annual discharge of the Blue Nile at Sennar dam is 30 milliard m^3. The monthly mean discharges are 386 million m^3/day at maximum in August and 9.6 million m^3/day at minimum in February. Daily discharges during the low water stage lasting November through June were generally more than five million m^3/day, those between 4-5 million m^3/day occurred occasionally for a very limited period according to the discharge records for 1970 through 1990. MOI forecasts the yearly water demand of the Sudan at 19 milliard m^3 for 1995, in which water demand by the Project has been incorporated.

The water level of the Blue Nile at the existing Hurga and Nur El Din pumping sites fluctuates annually over a range of about 8 m on average as shown in Table 3.2. About one meter degradation of water level was observed during the low water stage at the Wad El Nau gauging station in the last five years as shown in Fig. 3.3, although discharges released from the Sennar dam during the same period has not decreased significantly compared with those before it. The lowest water level was observed at the Hag Abdallah and Wad El Nau gauging stations in June 1990. The lowest water levels at the Hurga and

Nur El Din pumping sites are estimated at EL. 390.27 m and EL. 389.82 m, respectively based on those observed water levels. The highest water levels at the Hurga and Nur El Din are estimated at EL. 404.05 and EL 403.87 m, respectively.

It is to be noted that all elevations stated in this section are derived from a national datum, so called Irrigation Datum of EL. 360.00 m at Khartoum, while the values of elevation used for project works including the pumping station are based on arbitrary Bench Marks established in the Project area by MOI. It is, therefore, the values of elevation in this section should be interpreted by deducting about 80 cm for design purposes.

Annual suspended solids of the Blue Nile at the Sennar Dam are estimated at 165 million tons, which is analyzed by Hydraulic Research Station (HRS), MOI to be transported by flood discharges occurring between June and October.

3.4 Soils

The parent material of most soils of the Project area is aggradational alluvium derived from the weathering products of basaltic, igneous and metamorphic rocks of the Ethiopian Plateau.

The soils in the Project area are dark brown (10YR3/4) to brown (10YR4/4) with a soft surface mulch, wide deep cracks develop when dry. It is classified as Vertisol. It has considerable numbers of gray black calcium carbonate nodules in the surface, and soft $CaCO_3$ aggregates and gypsum usually occurs at depths below 65 cm associated with gray layer.

The land suitability of the Project area is mostly categorized as moderately suitable land (S2) with vertisolic, sodicity and fertility limitations. About 20% of the land is categorized as marginally suitable (S3), because of drainage problem due to topographic reason.

3.5 Population and Labor Force

There are 18 villages which are involved in the Project; 9 villages each for the Hurga and Nur El Din areas. According to the statistics prepared by SGB,

populations of 9 villages each for the Hurga and Nur El Din areas in 1981 were some 18,200 and 7,400 persons, respectively. Assuming that the average family size is 8 person per family, the number of the household of the respective areas are estimated at 2,270 for the Hurga and 920 for the Nur El Din. Of these households, the number of beneficiary tenants for the Hurga and Nur El Din areas are 882 and 630, respectively. A 15-feddan tenancy system is prevailing in both areas at present. The average labor force for agriculture is estimated at 4.8 persons per household.

3.6 Agriculture and Agro-economy

3.6.1 Agriculture

(1) Present Land Use

In 1990, only sorghum was raised in the area of 2,260 feddans or 16% of the Hurga area and 1,260 feddans or 14% of the Nur El Din area. Location and area distribution of planted area is shown in Fig. 3.4.

A three-course rotation cropping; cotton-sorghum-fallow, was originally established for the 15-feddan tenancy system in the 1950s'. From 1981/82 onward, however, tenants in the Project area have adopted a sorghum-fallow rotation in about two third of the Project area; one third each for sorghum and fallow, because of severe water shortage and topographic limit. Owing to deficit of irrigation water led by insufficient discharge capacity of the pumps and inadequate water distribution, etc., there were tenants who gave up growing sorghum before harvesting. Thus the actual planting/harvested area became far less than one third of the Project area. The remaining one third of the Project area is called locally "cut-off area", which was reportedly excluded from crop rotation due mainly to higher elevation.

(2) Crop Calender

Cropping calender for the sorghum is generally set to fall in the rainy season lasting July to September. Expecting rainfall, sorghum was planted in July and harvested from the middle of November to middle of December in 1990.

(3) Farming Practices

In the Project area, extensive farming is practiced for growing sorghum with one to four times irrigation during its growth period in the limited area. As a whole, available water for sorghum in the Hurga area seemed to meet its requirement throughout the irrigation period as a result of self-retaining planting area by the tenants and as a consequence of giving up growing sorghum on the way. As for the Nur El Din area, however, supplied water was decisively short between July and August.

Only ridging by machinery with a four row ridger is commonly practiced before sowing. Seeds are generally sown at a rate of about 3.0 kg/feddan manually with a plant density of 80 cm x 10 cm.

Application of fertilizers and agro-chemicals is not common in the Project area. Weed control is carried out manually a few times during early to middle stages of growth. Manual harvesting is common. After harvesting, threshing is done by either manpower or thresher.

(4) Yield and Production

Unit yield of sorghum in 1990 season was about 240 kg/feddan in Hurga area and 130 kg/feddan in Nur El Din area and the average yield of the Project area was about 201 kg/feddan.

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

3.6.2 Agro-economy

(1) Land Tenure and Holding

The Project area is included in field management units of Block No. 106 for Hurga area and No. 107 for Nur El Din under a block headquarters of Central Group in the Gezira Scheme.

None of the beneficiary farmers of the Gezira Scheme are allowed to own their lands, and they are tenants. The tenant can alienate the usufruct of tenancy to one of his family without dividing. Under this tenant system, the Gezira Scheme is divided into 102,000 tenancies. The 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) Land and Water Charges

A land and water charge system was established in 1981 to recover; i) annual administration and operation costs of both SGB and MOI, ii) procurement of operation and maintenance equipment, and iii) costs for emergency repairs. The land and water charges are collected by SGB from tenants growing cotton, and shared by SGB and MOI. Land and water charges for each crops, which are determined annually, for 1989/90 are:

(Unit: £S/feddan)

Cotton	Wheat	Groundnuts	Sorghum	Vegetables
157	131	104	104	175

Usually, land and water charges for all crops except for vegetables are deducted from the gross income earned from cotton production. If tenants only grow crops other than cotton in a year, they must pay for the charge after harvesting of cotton in the following year with 8% interest. Vegetable producers must pay the charges in advance as a form of deposit before planting.

Tenants in the Project area are under the management of SGB and members of the Tenants' Union for the Gezira Scheme. But, SGB has not collected the charges from them nor provided supporting services for them for the last decade because cotton was not grown in the area.

(3) Marketing

Currently GOS sets 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.

i) 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 domestic consumption is also under the control of CPC.

ii) Wheat

There are two main channels for marketing wheat. Locally produced wheat is predominantly handled by government authorities, while imported wheat and flour are channeled by the Ministry of Commerce and Trade (MOCT) from import through delivery to either private or cooperation millers. A minor part of the wheat produced locally is exceptionally handled by private traders. Imported wheat and flour are delivered by MOCT to Regional Governors for further inter-regional distribution. The regional share of wheat depends on population size and prevailing consumption.

iii) Sorghum

Sorghum is mainly traded by the private sector. The Agricultural Bank of Sudan (ABS) handles limited part of sorghum to keep the strategic buffer.

iv) Groundnuts

Private traders and the Sudan Company for Processing of Oil-seeds (SCPO) under the Sudan Oil Company (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.

(4) Present Conditions of Marketing in the Project Area

The results of the farm economic survey indicate that at present a half of the tenants in the Project area produce sorghum only for their family

consumption, and that a few tenants sell small amounts of sorghum to village merchants.

(5) Present Farm Budget

The tenants in the Project area depend for their living mostly on off-farm income and remittances. Off-farm incomes are accrued from livestock products and wage/salary for temporary or seasonal works.

Farm income of the tenants of the Project area accrued from sorghum is estimated at 2.6% of the average farm income of those in the Gezira Scheme. The annual living expenditures excluding costs for farm inputs are estimated at £S 16,600 per household for the Hurga, £S 15,400 for the Nur El Din and £S 19,700 for the Gezira area. In the case of both the Hurag and Nur El Din areas, the living of the beneficiary tenants is unstable and likely to drop to a subsistence level whenever capricious remittances are ceased.

The annual cash balance of farm households is summarized as shown below:

Item	Hurga	Nur El Din	Gezira
Income			
Farm income	800	0	31,400
Off-farm income	11,600	10,200	3,100
Expenditure			
Farm input	1,400	800	14,700
Living expense	16,600	15,400	19,700
Net reserve	- 5,600	- 6,000	100
Remittances	6,400	6,000	-

3.6.3 Agricultural Supporting Services

(1) Agricultural Research and Extension

All agricultural research on the Gezira Scheme is entrusted exclusively to the Agriculture Research Corporation (ARC) centered in Wad Medani. The Gezira Agricultural Research Station (ARS) of ARC is responsible for research

on development, testing of new varieties and new farm inputs such as fertilizer, herbicide, insecticide, etc. and practices directly related to the Gezira Scheme.

(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.

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.

Fourteen extension specialists are assigned to providing the extension services for the Gezira-Managil area. This means that each extension specialist should cover an area of 140,000 feddans or about 7,000 tenants. In these days extension programmes for village television are on the air aiming to make up insufficient extension services due to shortage of the extension specialists.

(3) Agricultural Credit

SGB practically provides the tenants with agricultural credit in such a way that: farm inputs necessary for cotton and wheat production are provided in kind for the tenants in time for cropping calender. The cost for these farm inputs is deducted forcibly by SGB from the gross sales of those crops to SGB. This system is regarded as a sort of credit for tenants. This system is only applied to 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 ABS is the only formal source of credit for the tenants. The present interest rate of ABS loans is 19% for short-term loans with a maximum loan period of 15 months and 38% per annum for medium term loans with a maximum loan period of five years.

Private money lenders are also available, but high rates of interest make their use difficult.

(4) Tenants' Union

The tenants' Union covering the tenants of the Gezira and Managil areas including the Project area has membership of 102,000 tenants. The main purpose of the Tenants' Union is to promote the living standards of tenants by providing them with necessary social infrastructures and establishing cooperations. The Gezira and Managil Tenants' Union has contributed to improving social welfare in the Project area through construction of hospitals, health centers, schoolhouses and well water supply systems, etc.

The Tenants' Union is run with membership fees and a subsidy from GOS. The membership fee accounting for 2% of the gross cotton products, is collected through SGB.

The Tenants' Union has three agricultural organizations, namely Kabro wheat mill, Malakia textile factory and fodder factory.

3.7 Irrigation and Drainage

3.7.1 General

There are two independent pumping irrigation systems for the Project area, one each for the Hurga and Nur El Din areas. Both systems were established in the late 1950s' as private cotton growing schemes with a net service area of 10,400 feddans net for the Hurga and 8,400 feddans net for the Nur El Din. After nationalization of these schemes in the early part of 1970s', they had been managed by the Agrarian Reform Corporation, and further transferred to the Blue Nile Agricultural Corporation (BNAC) for their management. In 1976 joint management for these schemes was commenced by SGB and MOI and has been continued since then.

General layout of the pumping stations and canal system are shown in Figs. 3.5 to 3.7.

3.7.2 Pumping Stations

(1) Hurga Pumping Station

The Hurga pumping station consists of three reinforced concrete suction pits built into the river bank with a building made of steel framed brick masonry walls and corrugated sheet roof. The size of each suction pit is 4.0 to 4.3 m wide and 4.5 m long, and that of the building is 20.3 m long, 12.3 m wide and 10.4 m high. Since dimensions of members under the ground could not be measured and no structural drawings were available, the structural soundness could not be examined. From visual observation and the results of non-destructive tests on reinforced concrete members, the reinforced concrete structure seems to be generally in good condition.

Three vertical mixed flow type pumps, 800 mm in diameter, are installed in the suction pits. Each pump unit has a rated discharge capacity of 1.5 m^3/sec at a rated head of 20.5 m. They are driven by diesel engines with a rated output of 600 PS through right angled gear boxes. River water is fed to the suction pits through a rectangular concrete made inlet channel.

At present two pumps and two engines are operational but are nearly worn out due to aging and heavy deterioration due to lack of financial support for procurement of spare parts. The discharge capacity of the operational pumps has decreased to 64% of their rated value. None of them could be run during the low water stage because of degradation of the Blue Nile, sedimentation in the inlet channel, and their poor condition.

(2) Nur El Din Pumping Station

The Nur El Din pumping station consists of a gravity type brick masonry dry pit (pump room) built into the river bank with a building made of steel framed brick masonry walls and corrugated sheet roof. The dry pit is divided into three sections by partition walls forming three pump rooms. The partition wall is of brick masonry made with reinforced concrete frames. The floor slab of the dry pit is of concrete made. The size of the pump room is 7.0 m long, 5.1 m wide and 8.5 m high, and that of the building is 26.5 m long, 10.9 m wide and 7.9 m high. The brick masonry walls of the dry pit becomes thicker stepwise towards the bottom but their dimensions are not known. The quality

of the bricks seems to be good but many traces of seepage are found on the walls according to visual observation. The building is in a very poor condition.

Three units of horizontal shaft mixed flow type volute pumps are installed in the pump rooms. Their rated discharge capacity is 60 m^3/min each at a rated head of 21.03 m. Each pump is driven by a diesel engine through a plain belt and pulley. The diesel engine having a rated output of 450 PS is mounted on the diesel engine floor approximately 8 m above the pump floor. Water in the river is tapped directly through suction pipes of 600 mm in diameter.

At present, two units each of pumps and diesel engines are operational, but their discharge capacity has dropped to 36% of their rated capacity. During low water, however, pumps could not be operated because the suction head exceeded their capacities.

3.7.3 Irrigation System

(1) Hurga Scheme

The canal network of the Hurga scheme consists of a main canal, a major canal, 10 minor canals and a large number of field channels. The general layout of the canals is shown in Fig. 3.7, and their length and nominal command areas are given in Table 3.3.

The field channels are composed of watercourses (Double Abu Ishreen and Abu Ishreen; Abu XX) and secondary watercourses (Abu Sitta; Abu VI). The Double Abu XX serves a few to several on-farm blocks, locally called Number, while Abu XX commands one Number, which varies from 100 to 20 feddans depending on the topographic limit. The Number is divided into numbers of 5-feddan farm plots locally known as Hawasha by a series of Abu VI branching off from Abu XX at right angles. All the canals are earthen channels with trapezoidal to semicircular cross sections. The nominal capacity of Abu XX and Abu VI is 115 lit./sec and 50 lit./sec, respectively. Actual ones, however, seem to have been decreased considerably by siltation as a whole.

These canals are adequately aligned in general, but their elevation is not high enough. Desilting was carried out for most of the canals in 1990. Over

excavation and insufficient excavation were observed in some reaches of the canals. The silt excavated was dumped and left on the canal banks without any compaction or dressing. Abu XXs exist in most of the service area.

Well-head regulators are installed at the head of the major and minor canals. Pipe regulators are provided at the head of Double Abu XX. Both well-head and pipe regulators are installed in those canals as cross regulators to control water levels in the canals. These structures are either in need of repair or total replacement. A field outlet pipe (FOP) with an outlet valve chopper gate was reportedly once installed at the head of each Abu XX to regulate flow from the minor canal. At present, however, most of the FOPs have been seriously damaged or even removed. Neither measuring devices nor staff gauges are installed.

(2) Nur El Din Scheme

The canal network of the Nur El Din scheme consists of a main canal, five minor canals and a large number of field channels. The general layout of the scheme is shown in Fig. 3.7, and the length and nominal command area of each canal are summarized in Table 3.3. The field channels are classified as Double Abu XX, Abu XX and Abu VI. All the canals are earthen channels with trapezoidal or semicircular cross-sections.

The canal alignment is adequate as a whole, but the canal elevation is not high enough to command their respective service areas except for a minor canal of Canal No.1. Abu XXs in more than 60% of the service area have never been used for more than decade and thus have been silted up totally.

The conditions of the regulating structures in the cultivated area is more or less the same for those in the Hurga area. Those in other areas have been seriously damaged.

3.7.4 Drainage System

No drainage canals were seen in the field, although drainage canals are shown on the original layout map.

3.7.5 Water Distribution

There is virtually no annual irrigation plan for the Hurga and Nur El Din schemes at present as the discharge capacity of the pumps is far less than that required for irrigating the service area. In practice, the beneficiary tenants decide on planting areas for sorghum in relatively low-lying farm plots chosen from experience.

For the same reason, indenting water from the Block Inspector of SGB to the Assistant Divisional Engineer of MOI is not practiced in the schemes. The only things practiced at present are distribution of water through well-head regulators and FOPs without measuring discharges.

3.7.6 Management of the Schemes

MOI and SGB have been managing jointly the Hurga and Nur El Din Schemes since 1976. The Mechanical and Electrical Under-secretariat of MOI is responsible for operation and maintenance of the pumping stations. The Under-secretariat for Irrigation Operation for Gezira and Managil of MOI is responsible for; i) operation and maintenance of canals and structures between the head of the main canal and the tail of the major canal, and ii) maintenance of the minor canal including FOPs.

The service area of the Gezira-Managil Scheme is divided into 107 blocks for field management, which are grouped into 14 Groups. The Hurga and Nur El Din areas fall in Block No.106 and No.107, respectively, and belong to the block headquarters of Central Group. FOPs and watercourses are under management of SGB.

3.8 Social Infrastructures

Out of 18 villages, 13 villages depend for potable water on community deep wells with water tanks and 2 villages have community deep wells with local water supply systems. There is no village with a water supply system provided by the Gezira Province Rural Water Administration. There are two villages which rely for drinking water on canal flow.

There are 5 elementary schools with a total enrollment of 1,614 students, and 5 intermediate schools with 590 students in total. There is no high school in these villages.

Only earth roads connect inter-villages and between the Project area and the Wad Medani-Gedaref highway, there is no all-weather type road.

Medical facilities available for these villagers are 8 dressing stations, 2 dispensaries, one health center and one bed clinic.

There is no post office in and around the Project area. Only two post agents are available in the villages for the Hurga area. The public telephone line is not extended to these villages, but the telecommunication system for the Gezira Scheme covers the Project area. At present, one and three radio telephones are installed at the Hurga pumping site and the Nur El Din pumping site, respectively.

The public electric power supply system by the National Electricity Corporation (NEC) is not available in the Project area. The power supplies available around the Project area are; i) the terminal of a 33 KV distribution line at Shabrga village approximately 12 km north of the Project area, which is fed from Meringan Substation located 8 km south of Wad Medani, ii) the terminal of a 33 KV distribution line at El Biryab pumping station fed from Hag Abdallah Substation. The El Biryab pumping station is located on the left bank of the Blue Nile and 8 km south of the Project area. Hag Abdallah Substation is located at 40 km southward from Wad Medani. The public electric power supply system around the Project area is shown in Fig. 3.8.

IV. ALTERNATIVE STUDY ON PUMPING STATIONS

4.1 General

Deterioration of the existing pumping stations is remarkable, and has decisively hampered agricultural production in the Project area. Thus rehabilitation or renovation of the existing pumping stations became the main issue of the Project objective to revitalize the present severely depressed agricultural production. In order to formulate an optimum development plan of the Pumping station, a thorough alternative study was made on various development plans of the pumping station including rehabilitation and renovation plans in this chapter. A feasibility level development plan was made for the most preferable plan which was chosen through the alternative study.

The alternative study covered the three components: i) prime movers including electric power supply system, ii) pumps and appurtenant facilities, and iii) pump houses.

The alternative study was made in the following sequence:

i) Conceivable plans for each component;
ii) First screening for each of component;
iii) Formulation of alternative plans;
iv) Selection of prime mover;
v) Selection of promising alternative plans;
vi) Evaluation of the alternative plans; and
vii) Selection of most preferable plan.

First of all, conceivable alternative plans for each of component were enumerated, and those plans were then roughly evaluated for first screening. Alternative plans were formulated by assembling selected plans for each component. Since alternative plans thus formulated could be divided into two groups, the plans with an electrical prime mover and those with a diesel engine, selection of the prime mover was done through comparative study on the alternative prime mover plans. Referring to the results of comparative study on the prime mover, promising alternative plans with selected prime

movers were evaluated from both technical and economical point of views, and finally most preferable plan for the Project was chosen. The general work flow for the alternative study is illustrated in Fig. 4.1.

4.2 Conceivable Alternative Plans

Aiming at formulation of the optimum rehabilitation plan, preliminary comparative study was made on all conceivable alternative plans. The main components composing the alternative plans consisted of: i) kind of prime mover of pumps; ii) type of pumps; and iii) pump house.

(1) Prime mover

Kinds of prime mover conceivable are:

A1 ;	Existing diesel engines	:	to utilize existing diesel engines
A2 ;	Diesel driven	:	to replace existing diesel engines with new ones
A3 ;	Diesel- electric driven	:	to apply electric motors driven by diesel engine generators
A4 ;	Electrically driven	:	to apply electric motors with extending existing power distribution line of NEC

(2) Pumps

Pumps are classified into three types depending on the streamline inside the pump impeller, i.e.,volute (centrifugal) type, mixed-flow type and axial-flow type pumps. The axial-flow type pump is generally employed when the discharge head is less than 4 m, and hence is not conceivable for the Project.

The remaining two types are further classified into vertical shaft and horizontal shaft types. In the case of the Project, horizontal shaft type pump were discarded at first because river water levels fluctuate annually over as wide a range as 12 m, which entails provision of gear units or belt/pulley to make the prime mover free from fear of inundation. The alternative plans conceivable for the type of pump are therefore:

B1 ; Vertical shaft volute pump
B2 ; Vertical shaft mixed-flow pump

(3) Pump Houses

Conceived are the following three cases:

C1 ;	Existing pump house	: to utilize existing pump houses with rehabilitation
C2 ;	New pump house, individual	: to construct new pump houses around the existing ones
C3 ;	New pump house, integrated	: to construct an integrated pump house

4.3 First Screening

The first screening was made on the conceivable plans enumerated above prior to formulating alternative plans by assembling each of the components.

(1) Prime Mover

A1 ; Discarded because this option would not meet the required output for any options of pumps.

A2 ; Proceed to further comparative study.

A3 ; Discarded because this option is obviously expensive compared with option A2.

A4 ; Proceed to further comparative study.

(2) Pumps

B1 ; Proceed to further comparative study in combination with option C1, C2 or C3.

B2 ; Proceed to further comparative study in combination with option C2 or C3.

(3) Pump houses

C1 ; Proceed to further comparative study.

C2 ; Discarded.

C3 ; Proceed to further comparative study.

(4) Alternative plans

Based on the results of the first screening, the following alternative plans were formulated for further comparative study:

Alt-1d ; A2+B1+C1
Alt-2d ; A2+B1+C3
Alt-3d ; A2+B2+C3
Alt-1e ; A4+B1+C1
Alt-2e ; A4+B1+C3
Alt-3e ; A4+B2+C3

4.4 Comparative Study

4.4.1 Comparative Study for Prime Mover

The six alternative plans formulated following the first screening were classified into two groups to select of the prime mover, and difference between Alt-1d and -1e (or Alt-2d and -2e, or Alt-3d and -3e) is only their prime mover as is self-explanatory above. A cost comparison between the two typical prime mover, therefore, clarified three promising alternative plans with either preferable prime mover. The cost comparison was made in terms of present value (PV) with a discount rate of 10%. The electrical prime mover was selected as the preferable option as summarized below:

Summary of Cost Comparison, PV

(Unit: £S x 10^6)

	Electric Motor	Diesel Engine
Alt-1		
- Initial cost	18.8	11.3
- Annual cost	14.3	34.9
Total	33.1	46.2
Alt-2		
- Initial cost	13.3	11.5
- Annual cost	14.6	35.0
Total	27.9	46.5
Alt-3		
- Initial cost	14.1	11.5
- Annual cost	14.6	35.0
Total	28.7	46.5

4.4.2 Promising Alternative Plans

Through the series of studies discussed above, the following promising alternative plans were selected:

Alt-1e;	Electrically driven vertical shaft volute pumps in individual existing pump houses with rehabilitation;
Alt-2e;	Electrically driven vertical shaft volute pumps in an integrated pump house;
Alt-3e;	Electrically driven vertical shaft mixed-flow pumps in an integrated pump house.

Salient features of pumps and electrical facilities for each of above alternative plans are shown in Table 4.1.

4.4.3 Rehabilitation Plan of the Existing Pump House

(1) The rehabilitation plan for the existing pump houses for the case of Alt-1e are:

i) Basic Concepts of Rehabilitation Plan

a) To meet recent degradation of the Blue Nile;

b) To minimize additional load against foundation of sub-structure;

c) To protect the electrical facilities from dust;

d) To maximize reliability of the structure.

ii) The rehabilitation plan for the Hurga pump house consists of:

- Replacement of the existing motor floor;
- Replacement of the existing front wall of the suction chamber;
- Replacement of the existing pump shed including overhead crane; and
- Reinforcement of the foundation, subject to results of detailed investigations on the foundation structure and underlying ground in the future.

iii) The rehabilitation plan of the Nur El Din pump house consists mainly of:

- Provision of motor floor;
- Replacement of the existing pump shed including overhead crane;
- Restoration of the river side brick wall of the pump room;
- Provision of protection work against leakage; and
- Provision of the slope protection after backfillling the outside of the said brick wall.

(2) The plan for the integrated pump house for Alt-2e and -3e

The foundation level of the alternative pump house was assumed to be of stiff clays or underlying stratum where the allowable bearing capacity was estimated at about 19 to 35 tons/m^2. The pump shed is designed to be dust-proof.

The pump house for Alt-2e consists of a reinforced concrete dry well (pump room) built into river bank and a reinforced concrete pump shed. Suction pipes are extended to the river and hence no suction chamber is provided.

The pump house for Alt-3e is composed of three reinforced concrete suction pits built into the river bank and a reinforced concrete pump shed. A slide gate is provided for each of suction pit for the purposes of maintenance and emergency repair of pumps. Inlet basin surfaced by concrete lining is provided. A berm is provided on a inside slope for the sake of removing sediment by heavy equipment.

(3) General Layouts of respective alternative plans are shown in Figs. 4.2 to 4.4.

4.5 Evaluation of Alternative Plans

4.5.1 Cost Evaluation

Present Values (PV) for Alt-1e, -2e and -3e are as follows:

Present Value

(Unit: £S x 10^6)

Work Items	Alt-1e	Alt-2e	Alt-3e
Initial cost	48.5	49.0	51.7
Annual cost	14.3	14.6	14.6
Total NPV	62.8	63.6	66.3

4.5.2 Technical Feasibility of Each Plan

Technical advantages and disadvantages for each of alternative plans are:

i) Alt-1e

- This plan involves uncertainties to some extent on structural strength and durability of existing concrete and brick works where left intact.

- Workability in demolishing and restoration is less than new construction works. Close attention will be required in preparation of the work schedule as well as in construction.

- Suction head of Nur El Din pumps is marginal at the lowest water level.

- No desilting work is needed at intake, but it is needed in the delivery channels.

- The pumps employed in this plan would require priming of pumps during the low water stage, which is considered to last four months from November through February for Nur El Din pumping station.

- Required unit number of pumps is double that of the other alternative plans, and different sizes of pumps, motor and appurtenant equipment are needed between Hurga and Nur El Din pumping stations. This entails inconvenient operation and maintenance works compared with other alternative plans.

- During the construction period, certain negative benefits of crops could be expected due to stoppage of irrigation water supply.

ii) Alt-2e

- Suction pipes are placed above the designed low water level and hence construction under wet conditions could be minimized. This would give a free hand to a certain extent in preparation of construction schedule compared with the other alternative plans.

- No desilting work is needed at intake, but needed in delivery channel.

- The pumps employed in this plan require priming of pumps during the low water stage, last of four months from November through February.

iii) Alt-3e

- This plan required more construction works under water.

- No priming of pumps is needed.

- Periodical desilting is required at inlet channel.

4.5.3 Preferable Alternative Plan

No difference in PV was recognized between Alt-1e and -2e, and the total PV of Alt-3e was highest but the difference between the highest and the lowest ones is as small as 5%.

Alt-1e would affect some 700 tenants, who will have to rely on water supply from the existing pumps, to grow sorghum under rainfed conditions during the implementation period.

Existing pumping stations equipped with the same type of pumps as Alt-3e suffer from heavy siltation in the inlet channel. Such unfavorable experiences suggest that priming of pumps is a better choice than periodical desilting of the channel.

From both economic and technical viewpoints, Alt-2e was considered to be the most preferable option of the three for the Project.

V. THE PROJECT

5.1 Basic Development Concept

Beneficiary tenants of the Project area, once enjoyed cotton and sorghum production, have been forced to remain at subsistence level unless capricious remittances are available because of severe depression of agricultural production.

The objective of the Project is to improve the unfavorable living conditions of the beneficiary tenants, through revitalizing the present severely depressed agricultural production in the area. Introduction of intensive farming under irrigated condition is the most favorable option to realize anticipated agricultural production from the Project area. To this end, thorough rehabilitation and/or improvement of the existing agricultural infrastructure is prerequisite.

As discussed in previous Chapters, deterioration of the existing pumping stations has been so decisive as to block the way to the goal of originally intended agricultural management, attention is apt to be directed to only rehabilitation of the pumping stations. In practices, however, it will be difficult to attain the target of the Project only by rehabilitating the pumping stations without tackling other problems and constraints which may adversely affect proper agricultural production.

For attaining the goals of the Project and sustaining it over the project life, therefore, it is equally essential to rehabilitate all the other irrigation facilities, to provide well organized agricultural support services for the beneficiary tenants and to reorganize the structure for operation and maintenance. This is because only limited tenants in the Project area have been growing only sorghum in a conventional way for the last decade, and hence modernization is required not only of the agricultural facilities but also of farming activities and operation and maintenance of the facilities.

5.2 Agricultural Development Plan

5.2.1 Agricultural Development Concepts

Basic concepts for introduction of intensive framing are:

- to realize optimal land use;
- to introduce crops most suitable for land and climatic conditions; and
- to establish adequate farming practices.

The basic concepts stated above will be achieved through:

- increasing present extremely low cropping intensity to the allowable maximum extent;
- adopting, in principle, the same cropping pattern as that well established through long experience in the Gezira Scheme to the Project area;
- providing well organized agricultural supporting services; and
- encouraging beneficiary tenants in introducing modernized farming practices.

5.2.2 Land Use Plan and Cropping Pattern

Among preliminarily selected three land use plans, i.e., i) a three-course rotation without fallow; ii) a four-course rotation with fallow, and iii) a five-course rotation with fallow, option (iii) is proposed for the Project taking into account, i) the available labor force and labor requirement, ii) benefits to be accrued, and iii) SGB's programme on land use and cropping pattern.

A high and stable return to encourage the beneficiary farmers is the basic concept for formulating the proposed cropping pattern. In view of this, the pattern proposed consists of export oriented high return cash crop, staple food crops for self-sufficiency, subsistence crops for the tenants and oil crops. The crops thus selected are extra long staple cotton (ELC cotton), wheat as recommended by ARC, sorghum and groundnuts. In addition, fodder is included in the cropping pattern in due consideration that in the Project area

livestock has been being raised traditionally and that SGB has commenced raising fodder in 1990 in line with the government policy.

The proposed land use plan is as follows:

(Unit: feddan)

Crops	Land Use in Each Tenancy	Land Use in Project Area
Cotton	3.0	4,524
Wheat	3.0	4,524
Sorghum	1.5	2,262
Groundnuts	1.5	2,262
Fodder	3.0	4,524
Fallow	3.0	4,524
Total	15.0	22,620

The proposed cropping pattern based on the above land use plan is shown in Fig. 5.1.

5.2.3 Farming Practices

Seed multiplication of cotton and wheat would be made by SGB, while that for sorghum, groundnuts and fodder would be made by the tenants themselves. When new varieties of sorghum, groundnuts and fodder are recommended for introduction to the Project area, seed authorized by ARC would at first be multiplied and distributed to the beneficiary tenants by SGB.

The following farm inputs are proposed to apply to each of crops:

(1) Fertilizer

Crop	Fertilizer	Amount	Time of Dosage
Cotton	Urea	40 kg/fd	before sowing
	Urea	40 kg/fd	one month after sowing
	Urea	40 kg/fd	two months after sowing
Wheat	Urea & TPS	40 kg/fd	before sowing
	Urea	40 kg/fd	one month after sowing
Sorghum	Urea	40 kg/fd	one month after sowing

(2) Agricultural chemicals

Crop	Chemicals	Times
Cotton	Insecticides Herbicide	5 times by aircraft before sowing
Wheat	Insecticides	1 time by aircraft
Sorghum		weeding manually
Groundnuts	Herbicide	before sowing

(3) Agricultural operation

Land preparation (plowing and harrowing) for all the proposed crops and ridging for cotton and sorghum would be contracted to the private sector. Harvesting of wheat also would be done on a contract basis by the private sector. Cotton picking and harvesting of other crops would be done manually.

The labor requirement for cultivating a 15-feddan tenancy was estimated at 353 man-days, consisting of 180 man-days for cotton, 19 man-days for wheat, 30 man-days for sorghum, 61 man-days for groundnuts and 63 man-days for fodder. Monthly labor requirements for the 15-feddan tenancy are summarized below:

(Unit: man-day)

Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
22	56	14	33	35	25	7	47	47	47	15	5	353

5.2.4 Anticipated Crop Yields and Production

Anticipated crop yields under with-project condition were estimated in due consideration of research data at ARC, present crop yields in the Gezira-Managil Scheme, proposed farming practices, etc. The estimated yield and production of the proposed crops are:

Crop	Planting 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

5.2.5 Crop Budget

Crop budgets under with-project condition were estimated based on the proposed cropping pattern, anticipated unit yields of crops, proposed farming practices,etc. Farmgate prices of cotton and wheat employed for the estimation are those fixed by GOS, and those of other crops are current free market prices. The farmgate prices of farm inputs employed are those currently employed by SGB for cotton and wheat growing. The crop budgets thus estimated are as follows:

(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	2,900	573	2,327

Since fodder was introduced tentatively in the Gezira Scheme in 1990 and the system for grazing cattle has not yet been established, it was hardly possible to estimate crop budget of fodder in terms of live stock production, and hence the crop budget of fodder was tentatively estimated as sorghum.

5.2.6 Farm Budget

The farm budgets under with-project condition were estimated based on gross farm income, costs for crop production, off-farm income such as livestock production and wage/salary, and living expenses. Gross farm income is based on the gross production value stated above, and costs for crop production are based on the production cost estimated previously. Livestock income and

wage/salary are assumed to be the same as the present averaged ones of the Gezira Scheme. Living expenses are also assumed to be the same as the present one of the Gezira Scheme. The farm budget thus estimated is as follows:

Description	Amount (£S)
Gross income	
Farm income	41,600
Off-farm income	3,200
Expenditure	
Farm input	11,900
Living expenses	19,700
Net Reserve	13,200

5.3 Irrigation and Drainage Plan

5.3.1 Basic Consideration for Planning

The principal objectives of the irrigation development are to realize intensive irrigated farming by means of comprehensive rehabilitation and improvement of the existing irrigation system, drainage system and operation and maintenance (O&M) facilities.

Basic requirements of the irrigation system are to supply stable perennial irrigation water to the Project area, to assure equitable and timely distribution of water to fields, while the basic need of the drainage system is to remove surface runoff caused by precipitation and over application of irrigation water.

The O&M facilities are prerequisite to operate the irrigation system properly and effectively in response to desirable farming practices and to maintain the functions of the irrigation and drainage systems as initially expected over the project life.

Maximum use of the existing facilities is the basic idea in the development plan, but re-arrangement of farm plots (Hawasha) will be indispensable because a 5-course rotation is proposed for the Project despite 15-feddan tenancies with three numbers of Hawashas are prevailing in the Project area. At present, a tenant in the Project area has a tenant's right to three

numbers of 5-feddan Hawasha. As there is expected to be no change in the present 15-feddan tenancy system, the present 5-feddan farm plots should be rearranged as 3-feddan farm plots so as to match with the proposed 5-course rotation. The re-arrangement would be attained by relocating the secondary watercourses (Abu VI), but the present alignment of Abu XX would be retained as a rule.

To utilize the existing canals and related structures to the maximum extent and for the convenience of construction, conventional ones are proposed based on the Design Sheet, a sort of design criteria, prepared by MOI.

The present joint management system by MOI and SGB is proposed to be followed, but complementing the existing field staff will be indispensable both for MOI and SGB portions for full swing operation.

5.3.2 Irrigation Water Requirement

The irrigation water requirements of the proposed cropping pattern were computed using Ep (Penman original) x Crop factor. Evaporation rates employed are those computed at Wad Medani meteorological observatory using data observed between 1980 and 1989. Crop factors employed are those used for the Gezira-Managil Scheme. First irrigation requirement were also considered. The effective rainfall considered is the probable rainfall with a 5-year return period. Irrigation losses involved are 10% for conveyance loss and 10% for operation loss. The irrigation water requirements for the Project are as follows:

(Unit: m^3/sec)

10-day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1st	4.83	3.61	1.09	0.00	2.65	4.66	6.34	6.45	8.17	7.05	5.32	4.50
2nd	4.54	3.18	0.00	0.00	3.26	5.69	7.86	6.50	7.44	5.98	5.26	4.73
3rd	4.14	2.12	0.00	2.23	3.84	6.49	6.60	6.87	6.75	5.89	4.18	4.90

Note; for 18 hours/day operation

5.3.3 Water Distribution and Application

(1) Water Distribution

Irrigation water would be tapped at the proposed pumping station between 0:00 and 18:00. Discharge control would be made by a combination of numbers of operating pump units and operating hours. Immediately after the pumping station, water pumped up would flow into a sand settling basin through a short link canal. Then it would be diverted into the respective main canals for the Hurga and Nur El Din areas through a bifurcation located at the end of the link canal.

The water in the main and/or major canal would be diverted to all the minor canal simultaneously through movable weirs provided at the head of each minor canals between 0:00 and 18:00. The water in the minor canals would further be distributed to the first half of the Numbers on each minor canal for five days and to the second half of the Numbers for another five days alternately. Water distribution to the Number would be started at 6:00 and finish at 18:00, as a rule. The balance of inflow into and outflow from the minor canal would be regulated in the minor canal, for which a storage capacity would be provided in addition to ordinary design capacity.

(2) Water Application at Field Level

Taking possible irrigation intensity, available soil moisture by crops, crop consumptive use (evapotranspiration), etc. into account, a 10-day irrigation interval is proposed as a standard irrigation interval for the Project.

Rotational irrigation is proposed as it is. The Numbers on each minor canal would be divided into two groups and the first group would be watered in five days and the second one would be watered in the next five days. Hawashas in the Number would also be divided into two groups and would be irrigated for two and three days alternatively for respective groups.

The Angaya irrigation method is proposed for the Project due to the reasons that:

a) Beneficiary tenants are aware of the Angaya irrigation method;

b) Probable daily rainfall with a 10-year return period was estimated at 73 mm/day. Considering this probable daily rainfall, heavy waterlogging would not take place so frequently and not last so long as to cause serious damage to the crops;

c) Raising of design water level of the canal system could be minimized because no pipe siphon is needed to deliver water in Abu XX to field; and

d) Present farm plots could be used without land levelling.

5.3.4 Irrigation System

The proposed irrigation system for the Project consists of a pumping station, a link canal including of a sand settling basin and canal networks for the Hurga and Nur El Din areas. The canal network for the Hurga is composed of a main canal, a major canal branching off from the main canal, 12 minor canals and a large number of watercourses (double Abu XX, Abu XX and Abu VI) at on-farm level. The Nur El Din canal system is composed of a main canal, five minor canals and many of watercourses.

The link canal connects the discharge basin of the pumping station and the head of respective main canals. To divert the water into the link canal, a bifurcation is located at the end of the link canal. The minor canal divert from the main canal. All the double Abu XXs and Abu XXs are branched off from the minor canals and no exception is proposed. The double Abu XX covers a few field blocks (Number), while Abu XX serves one Number. The Number is divided into a number of 3-feddan farm plots (Hawasha) by a series of Abu VI taking off from Abu XX at right angle.

Head regulators are provided at the head of the major canals, minor canals, double Abu XX and Abu XX for discharge control. Cross regulators are placed in the main, major and minor canals for regulating water level. Movable weir type head regulator is employed at the head of the major and minor canals. Well-head type regulator and field outlet pipe (FOP) are proposed at the head of the double Abu XX and at the head of Abu XX, respectively. A pipe regulator is employed as a cross regulator.

O&M roads with a laterite surface run along either side or both sides of the main, major and minor canals.

General layout of the proposed system is shown in Fig. 5.2.

5.3.5 Drainage Plan

A surface drainage system is proposed to remove surface runoff caused by rainfall or excess irrigation water. Surface runoff from the fields would be led to a minor drain through field drains. Then it would flow into a collector drain or directly a natural drainage pass. General layout of the proposed drainage system is shown in Fig. 5.2.

5.3.6 Proposed Works

(1) General

The proposed works for the Project are:

- Construction of one integrated pumping station and power supply system;
- Construction of a link canal including a sand settling basin;
- Construction of a bifurcation;
- Extension and rehabilitation of irrigation canal system including replacement and provision of related structures;
- Renovation of the drainage system.

(2) Pumping Station

One integrated pumping station for both the Hurga and Nur El Din areas is proposed to construct on the east bank of the Blue Nile at about 700 m upstream of the existing Hurga pumping station. The general layout of the pumping station is shown in Fig. 5.3.

The proposed pumping equipment and appurtenant facilities are shown in Table 5.1, and may be summarized as follows:

- Type of pump ; vertical shaft double suction volute pump
- Rated discharge ; 148 m^3/min/unit
- Rated design head ; 24 m
- Diameter of pump ; 1,000 mm x 800 mm
- Number of pump unit ; 4 sets
- Motor output ; 750 kw

Type of pump and prime mover were decided through the thorough alternative study discussed in the previous Chapter IV ALTERNATIVE STUDY ON PUMPING STATIONS. The rated discharge is based on the peak irrigation requirement under 18 hours operation per day and the characteristic curve of the pump shown in Fig. 5.4. One unit of pump is considered as a standby pump considering:

- Electric power supply condition during the "critical months" (see sub-chapter 2.4.3 Existing Power Generating Plants and Conditions), which may not secure 24 hours consecutive operation of the pumps. If no standby pump unit is provided, required discharge has to be recovered by prolonging the operating hours of the remaining two units of pumps from the designed 18 hours to 24 hours in the event of accidental failure of a pump; and

- The time necessary of procurement of spare parts.

The pump house will consist of a pump base structure for a pump room and a superstructure for a motor room, cubicle rooms and an erection bay. The base structure will be of water-proof reinforced concrete. The superstructure will be dust-proof and with brick masonry walls with reinforced concrete frames and reinforced concrete tops.

(3) Electric Power Supply System

Proposed electric power supply systems are:

a) 33 kV distribution line between El Biryab substation and the proposed pumping station, 9.5 km; and

b) 33 kV outdoor switchyard at the pumping station (pump substation), equipped with

- one set of 3,000 kV switchgear,
- one unit of 3,000 kVA transformer,
- one set of circuit breaker,
- one set of disconnecting switch,
- three lightning arresters,
- potential devices and current transformer
- one lot of 11 kV switchgear, and
- six pumps of control boards and others.

A single line diagram of the pump substation is shown in Fig. 5.5.

(4) Irrigation Canal and Related Structures

Proposed works for irrigation canals and related structures include:

a) Construction of link canal with a total length of 450 m including a sand settling basin of 130 m long located at the lower part of the link canal, and a bifurcation at the lower end of the link canal;

b) Extension of the main canals, 0.49 km for the Hurga and 1.86 km for the Nur El Din;

c) Heightening of the existing main and major canals, 10.95 km for the Hurga and 9.46 km for the Nur El Din;

d) Heightening of the existing minor canals, 42.01 km in total for the Hurga and 27.09 km in total for the Nur El Din;

e) New construction of two minor canals, 10.40 km in total length for the Hurga;

f) Demolishing all the existing canal structures;

g) Construction of the following canal structures;

Type of Structure	Hurga (Nos.)	Nur El Din (Nos.)
Movable weirs	13	5
Well-head regulators	4	2
Cross regulators	14	2
Field outlet pipes	221	114

Main features of the canals are shown in Table 5.2, and typical canal section and general layout of the canal structures are shown in Figs. 5.6 to 5.11.

(5) Drainage Canals and Related Structures

Proposed drainage canals will consist of four collector drains with a total length of 23.4 km and 15 minor drains having a total length of 51.4 km.

5.4 Institutional Plan

5.4.1 Agricultural Supporting Services

It is expected that the following services will be provided by either SGB or GRS for attaining the target agricultural production from the Project area:

- Delivering farm inputs such as seed, fertilizer, herbicide, etc. necessary for growing cotton and wheat to the beneficiary tenants;
- Spraying insecticide for cotton and wheat;
- Providing the tenants with extension services, especially technical on well established farming practices for cotton, wheat, groundnuts;
- Training Ghaffirs;
- Delivering seed for fodder crop to the tenants;
- Researches on behavior of soil moisture under irrigation for wheat, groundnuts and sorghum; and establishing proper irrigation intensity and irrigation intervals for these crops; and

- Assigning one Extension Worker each for Hurga and Nur El Din areas, and one Field Technical Worker for crop protection for each area.

5.4.2 Operation and Maintenance

(1) O&M Works

i) Operation

Indent for water would be made to the Chief Engineer for the new pumping station by the Assistant Divisional Engineer for the Hurga and Nur El Din every 10 days. The quantity of the indent would be computed based on crop consumptive use and actual planted area.

The Chief Engineer would decide the operating hours and unit number of pumps to be operated in response to the indent from the Assistant Divisional Engineer. The pumps would be run by pump operators in conformity with instructions of the Chief Engineer.

Gates of the bifurcation, movable weirs, well-head regulators and pipe regulators would be adjusted in timing with pump operation by the Section Engineer under instruction of the Assistant Divisional Engineers. Theoretically, magnitude of the opening of these gates could be adjusted once every 10-days, however minor adjustment should be made from time to time.

The gates of the FOPs would be opened at 6:00 in the morning and closed at 18:00 in the evening every day by the Ghaffir under instruction of the Block Inspector.

In order to utilize the water most effectively, close liaison will be indispensable between the Chief Engineer, Assistant Divisional Engineer and the Block Inspector.

ii) Maintenance

Maintenance works required for the Project are those for the pumping station and the canal system.

The maintenance works for the pumping station would consist of daily, weekly, monthly and annual maintenance, which would be carried out by the Electrical Division of the Mechanical and Electrical Under Secretariat. Preventive maintenance work is essential, it would be attained by conducting careful regular maintenance.

The maintenance works for the canal system would be: i) removal of silt and sand from the sand settling basin, ii) weed clearance from the canal sections, iii) maintenance of O&M roads, and iv) maintenance of metal works such as greasing and painting of metal works. Work items (i) to (iii) above are expected to be carried out by Earth Moving Corporation (EMC) on a contract basis, and (iv) would be conducted by MOI on a force account basis.

(2) Field Organization for O&M of the Project Facilities

It is proposed that present joint management by MOI and SGB be retained.

O&M of the new pumping station is proposed to be made under the responsibility of Electrical Division of Mechanical & Electrical Under Secretariat instead of Mechanical Division which is responsible for O&M of the existing pumping station. The proposed organization structure for O&M of the pumping station is shown in Fig. 5.12.

For O&M of the canal system to be conducted by MOI, two Section Engineers are proposed to be assigned under the Assistant Divisional Engineer. The proposed organization for O&M of the canal system is shown in Fig. 5.13.

For management of field level facilities, the following field staff is proposed to be assigned by SGB:

- 2 Block Inspectors (First Inspector);

- 2 Second Inspectors;
- 1 Third Inspector; and
- 18 Ghaffirs, 11 Ghaffirs for Hurga and 7 for Nur El Din.

(3) O&M Facilities

As daytime pump irrigation is proposed for the Project, timely operation of the pumps and gates is primarily needed for effective and proper water supply. To this end, close liaison among field staff of SGB, Irrigation Operation Under Secretariat MOI and Mechanical and Electrical Under Secretariat MOI will be indispensable. It will be equally important that field staff be stationed near their job site. In this regard, construction of a field office is proposed near the pumping station for joint use of MOI and SGB staff. In addition, provision of residences for pump operator, Section Engineers and Field Inspectors are proposed.

VI. IMPLEMENTATION PLAN AND SCHEDULE

6.1 Organization for Implementation

Implementation of the Project would be administrated by MOI. MOI would establish a project office for implementation of the Project and appoint a Project Manager for the project office. The Project Manager would be responsible for execution of all Project works and would undertake necessary coordination among relevant government agencies in connection with implementation of the Project.

6.2 Implementation Schedule

The Project works are expected to be implemented for three and half a years from the last quarter of 1991 through April of 1994. The first 12 months would be allotted for the detailed design including bidding. The construction would be commenced in the last quarter of 1992 by mobilizing staff and construction equipment and materials for construction. Substantial construction of both the pumping station and the canal systems would be started simultaneously at the beginning of 1993, and completed by the first quarter of 1994 for the pumping station and by April of 1994 for the canal systems. It would take about one year for procurement of pump equipment and electrical facilities including design, manufacturing, transportation and delivery to the site. Proposed implementation schedule is shown in Fig. 6.1.

The basic consideration for preparation of the implementation schedule is that:

- Substructure of the pumping station be constructed during the low water stage of the Blue Nile as much as possible so that the works under wet condition could be minimized;
- Earth work be suspended during the rainy season from July to September; and
- Electric power supply system be constructed in the Project under supervision of NEC.

VII. COST ESTIMATE

7.1 Basis for Cost Estimates

The costs for implementation of the Project consist of direct construction costs, administration costs, engineering service cost and contingencies. The costs were estimated on the basis of preliminary design of the project facilities and unit costs estimated based on the following assumptions:

i) All the costs were estimated at the price level of December 1990. Exchange rates employed for the estimation are:

US$1.0 = £S 12.3 = J.Yen 135.0

ii) The construction works would be carried out by contractors selected through international competitive bidding.

iii) Unit costs of the works are composed of labour cost, material cost, depreciation and operation costs of construction equipment and plant, and cost for contractor's profit and overhead.

iv) Taxes and duties on construction materials, construction equipment and plants to be imported for the Project would be exempted.

v) Physical contingencies are assumed to be 10% of the costs for civil works.

7.2 Project Costs

The Project cost comprises direct construction cost, cost for procurement of pumps and electrical equipment and facilities, engineering service fee, administration cost, and physical contingency. The total Project cost is estimated as shown in Table 7.1 , and summarized as follows:

(Unit; £S 10^6)

Items	F/C	L/C	Cost
1. Preparatory Works	11.37	7.10	18.47
2. Civil Works			
1) Pumping station	14.82	8.13	22.95
2) New canal	10.28	4.32	14.60
3) Rehabilitation canal	85.03	54.10	139.13
4) O&M Facilities	0	3.27	3.27
5) O&M Equipment	3.60	1.15	4.75
3. Mechanical and Electrical Works	87.03	2.47	89.50
4. Physical Contingency	12.51	7.81	20.32
5. Administration Cost	0	2.31	2.31
6 Engineering Cost	45.00	0	45.00
Total	269.64	90.66	360.30

7.3 Disbursement Schedule

Annual disbursement cost of the Project cost was estimated in accordance with the proposed implementation schedule and shown in Table 7.2, whose summary is tabulated below:

(Unit; £S 10^6)

Work Item	1st Year	2nd Year	3rd Year	4th Year
1. Civil Works	0.00	9.24	147.98	45.95
2. Mechanical & Elec. Works	0.00	35.80	44.76	8.95
3. Eng.Services	4.50	13.50	20.24	6.75
4. Admi. Cost	0.11	0.69	1.16	0.35
5. Contingency	0.00	0.92	14.80	4.60
Total	4.61	60.15	228.94	66.60

The fund requirement for the Project implementation is assumed for the following three price escalation rates per annum:

Case	Local Currency Portion	Foreign Currency Portion
Case - I	10%	3.5%
Case - II	20%	3.5%
Case - III	30%	3.5%

Assumed fund requirements are given in Table 7.2.

7.4 Operation, Maintenance and Replacement Costs

Annual operation and maintenance costs cover the personnel expenses, pump energy costs, fuel and lubricant costs and other expenses. The pump energy costs were estimated using the power consumption charge of £S 0.59/kWh during March through August and £S 0.27/kWh for the remaining months. In addition, monthly demand charge and service capacity charge were also incorporated in the pump energy costs.

Pump and electrical equipment, and gates have to be replaced at a certain period within a project life of 50 years.

The estimated O&M cost and replacement cost are shown in Tables 7.3 and 7.4.

VIII. PROJECT EVALUATION

8.1 General

The Project evaluation was made in view of both economic and financial feasibility. The economic feasibility of the Project was examined by means of economic internal rate of return (EIRR), benefit-cost ratio (B/C) and benefit minus cost (B-C). In addition, a sensitivity analysis of EIRR was carried out to evaluate the economic viability of the Project against possible changes in Project cost, benefits and built-up period.

Financial evaluation was also carried out by analyzing the farm budget of the beneficiary tenants.

The socio-economic impacts of implementation of the Project were examined briefly.

8.2 Economic Evaluation

8.2.1 Basic Assumption

The economic evaluation of the Project was made based on the following basis and assumptions:

i) The economic useful life of the Project is assumed at 50 years;

ii) The construction period of the Project is expected to be five years including one year for detailed design;

iii) The following exchange rate was employed;

- US$ 1.00 = £S 12.30

iv) Economic conversion factor (ECF) of 0.41 was employed for non-trade goods and services, and shadow wage rate (SWR) of 0.35 was employed for unskilled labor; and

v) All costs are expressed as constant prices at 1990 level.

8.2.2 Economic Project Cost

(1) Economic Project Cost

The economic Project cost was estimated by applying the ECF of 0.41 to local currency portion of the Project cost as follows:

(Unit: £S 10^6)

Items	F.C	L.C	Total
Direct Cost	212.1	33.0	245.1
Indirect Cost	44.9	0.9	45.8
Physical Contingency	12.5	3.2	15.7
Total	269.5	37.1	306.6

(2) Economic Annual Costs

The economic annual operation and maintenance costs (O&M costs) and replacement cost were estimated adopting ECF to the local currency portion of the financial O&M and replacement costs, as shown below:

- Annual O&M cost ; £S 2.16 x 10^6
- Replacement cost ; £S 68.05 x 10^6
- O&M Equipment ; £S 4.07 x 10^6

8.2.3 Economic Benefit

The Project benefits to be expected are defined as the difference of primary profit from crops between future with and without project. The benefits are expected to increase year by year and reaches the full benefit in and after fourth year after the completion of the Project. The benefits after the built-up period were estimated as follows:

(Unit: £S x 1,000)

Crops	Benefit
Cotton	33,754
Wheat	6,352
Sorghum	1,818
Groundnuts	6,922
Fodder	4,375
Total	53,221

8.2.4 EIRR, B/C and B-C

Based on the economic benefit and costs discussed above, EIRR, B/C and B-C were calculated as follows:

EIRR	13.8%
B/C	1.38
B-C	£S 96.9 X 10^6

8.2.5 Sensitivity Analysis

A sensitivity analysis was carried out to evaluate the soundness of the Project against possible adverse changes in future as shown below:

(EIRR; %)

Cost overrun	Case-1 Benefit Reduction		Case-2 Benefit Reduction	
	0%	-10%	0%	-10%
0%	13.8	12.5	12.3	11.2
10%	12.6	11.3	11.3	10.2
15%	12.1	10.8	10.8	9.8

Case-1 ; In the case of on schedule completion of the Project.
Case-2 ; In the case of delay of completion by one year.

8.2.6 Result of Economic Evaluation

The results of the evaluation demonstrate that the Project be economically feasible and that the economic viability of the Project is rather insensitive to possible adverse changes.

8.3 Financial Evaluation

In order to evaluate the Project from the viewpoint of farmer's economy, the farm budget analysis on a 15-feddan tenancy was made under both with and without project conditions.

After implementation of the Project, the Project will provide the basis for introduction of improved irrigation farming. As a result, a considerable increase in unit yield of crops and cropping intensity could be expected under with project condition, providing substantial improvement in farm income. On the other hand, no substantial change in farm income could be expected in future under without project conditions. The result of the farm budget analysis is summarized as follows:

(Unit: £S)

Item	Without Project		With Project
	Hurga	Nur El Din	
Farm Size (fd.)	15	15	15
1) Gross Income	(12,400)	(10,200)	(44,800)
Farm Income	800	0	41,600
Off-farm Income	11,600	10,200	3,200
2) Gross Outgoing	(18,100)	(16,200)	(31,600)
Production Cost	1,400	800	11,900
Living Expense	16,600	15,400	19,700
3) Net reserve/Capacity to Pay	-5,600	-6,000	13,200

The farm budget analysis indicates that the Project would bring about a great improvement in farm budget and thus contribute improvement of the living standard of the benefitting tenants considerably.

8.4 Impact of the Project

In addition to the direct benefits counted in the economic evaluation, various and intangible benefits and/or favorable socio-economic impacts could be expected by implementing the Project.

(1) Increase in Crop Production

The increase in crop production will improve self-sufficiency (sorghum, wheat) in the Project area as well as contribute to foreign exchange earnings (cotton, groundnuts) and will also enhance livestock production in the Project area.

(2) Increase in Farmer's Income

The farmer's income is expected to improve drastically compared with present unstable and depressed level, which will function to provide motivation for living standards. This will vitalize regional economic activities.

(3) Increase in Employment Opportunity

The Project will generate considerable employment opportunities for unskilled labour during the construction period. Most of the manpower will be supplied by the farmers in and around the Project area. In addition, the Project will create a demand for farm machinery run by private sector, which will accrue from increased farming activities due to intensive use of land.

(4) Women Activities

As the beneficiary tenants are obliged to rely for their living on off-farm income mostly, family labour force leaves his farm land to his wife and children. This present situation asks women for attending farming in addition to doing housework. Thus women in the Project area have little chance to join social activities economically and physically. After implementation of the Project, however, family labour force working outside the Project area would return to his farm land and devote himself to farming. This would enable women to share farming with her family. Moreover, mechanized farming proposed would considerably mitigate task load which will increase due to introduction of intensive farming. These future situation would give women spare time for attending social activities.

IX. ENVIRONMENTAL CONSIDERATION

Since the Project is a rehabilitation project, it is unlikely that implementation of the Project cause extremely environmental change nor adversely affect the environment in and around the Project area. It is, however, conceivable that perennial irrigation provide more favorable conditions for the vectors and intermediate hosts of water associated diseases particularly malaria and schistosomiasis.

Aiming at controlling the water associated disease of malaria, schistosomiasis and water borne diarrheal diseases in the Gezira-Managil and Rahad Schemes, the Blue Nile Health Project (BNHP) commenced in 1979. According to the report on the activities of this project, the prevalence rate of both malaria and schistosomiasis have distinctively decreased after implementation of the programme of the BNHP.

It is proposed, therefore, that the similar programme to BNHP be introduced to the Project or that the programme of BNHP be extended to the Project area after the Project start full scale operation.

X. CONCLUSIONS AND RECOMMENDATIONS

The Study demonstrates that the Project is technically sound and economically viable. Further, the Study clarified that the Project provide the beneficiary tenants with improved and stabilized living conditions. It has long been desired eagerly by all the beneficiary tenants who were obliged to stand on very fragile living basis depending on capricious remittances.

Formulating the optimum rehabilitation or renovation of the existing pumping stations was the main issue of the Project objectives. There were two ideas that the one was to rehabilitate the existing pumping stations and the other was to construct a new pumping station. Thorough alternative studies were made focusing that which idea is superior to the other. As a result, it was concluded that constructing new pumping station is more preferable for the Project.

In formulating the development plan of the pumping station, it was also discussed that whether a standby unit of pump should be introduced or not. Considering electric power supply conditions, time necessary for procuring spare parts of the pumps and appurtenant facilities, etc., one unit of standby pump was proposed for the Project.

It is not expected that the implementation of the Project cause adverse impact to the environmental conditions except for water associated diseases such as malaria and schistosomiasis. The programme on controlling such diseases has been successfully implemented in the Gezira-Managil Scheme and Rahad Scheme since 1979.

It is, therefore, recommended that the Project be implemented as early as possible.

For successful implementation of the Project, strongly recommended are well organized agricultural supporting services by SGB.

From the viewpoints of project sustainability and welfare of the beneficiary tenants, it is also recommended that controlling water associated diseases be implemented by an appropriate government authority.

TABLES

Table 2.1 ESTIMATES 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)

Table 2.2 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

Table 2.3 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 2.4 TARIFF SYSTEM

Application : This tariff is applicable for supplies of declared service capacity in excess of 100 KVA, intended to be used only for industrial, agricultural and bakeries.

1. 33 KV Supplies (2.500 KVA & Above)

(1) Base Charge

i)	Max. demand charge	: LS 3.0/KVA
ii)	Service capacity charge	: LS 1.0/KVA

(2) Consumption Charge

i)	For Critical Months,	
	Off peak rate	: LS 0.34/KWH
	Peak rate	: LS 0.98/KWH
ii)	For other Months	
	Off peak rate	: LS 0.08/KWH
	Peak rate	: LS 0.56/KWH

2. 11 KV Supplies (1.000 KVA & Above) : Omitted

3. 415 KV Supplies (100 KVA to 1.000 KVA) ; Omitted

Notes: Critical Month : March, April, May, June, July & August

Peak Hours : 7:00 to 14:00 and 18:00 to 22:00 hours

Table 3.1 SUMMARY OF METEOROLOGICAL RECORD

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Rainfall(mm/month)	0.0	0.0	0.0	0.2	17.4	25.7	65.3	92.9	49.3	11.2	2.9	0.0	264.9
Max.Temperature(C)	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
Min.Temperature(C)	14.7	16.1	19.9	21.7	24.8	25.3	23.8	23.2	22.6	22.6	18.7	15.5	20.7
Max.Relative Humidity(%)	52	42	36	29	44	61	76	83	82	64	47	49	55.4
Min.Relative Humidity(%)	19	16	14	13	21	26	37	41	38	27	20	21	24.4
Wind Speed(m/sec)	2.4	2.4	2.5	2.4	2.8	4.1	4.1	3.3	2.1	1.6	2.0	2.1	2.7
Sunshine Duration(%)	91	88	82	85	72	66	60	63	72	83	92	91	78.8
Evaporation (Penman; mm/day)	6.4	7.3	8.4	8.8	9.1	10.0	8.5	8.1	7.4	7.1	6.5	6.2	7.8

Source; Wad Medani Meteorological Station
Rainfall ; 1980 - 1990
Temperature ; 1980 - 1989
Humidity ; 1986 - 1990
Wind Speed ; 1980 - 1989
Sunshine ; 1980 - 1989
Evaporation ; 1980 - 1990

Table 3.2 SUMMARY OF MEAN WATER LEVEL (1974-1990)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
WAD EL NAU	390.66	390.59	390.62	390.90	391.03	391.63	394.87	398.40	397.36	394.66	392.18	390.96	392.82
HAG ABDALLA	395.20	395.19	395.13	395.36	395.47	396.01	398.76	402.30	400.85	398.46	396.04	395.35	397.01
HAG-WAD	4.54	4.60	4.52	4.46	4.44	4.38	3.89	3.90	3.49	3.80	3.86	4.39	4.19
NUR EL DIN	392.08	392.02	392.02	392.28	392.41	392.99	396.08	399.61	398.45	395.85	393.38	392.32	394.12
HURGA	391.87	391.82	391.82	392.09	392.22	392.79	395.91	399.44	398.30	395.68	393.21	392.13	393.94

* W.L. at gauging station & pump station are shown on Irrigation datum.

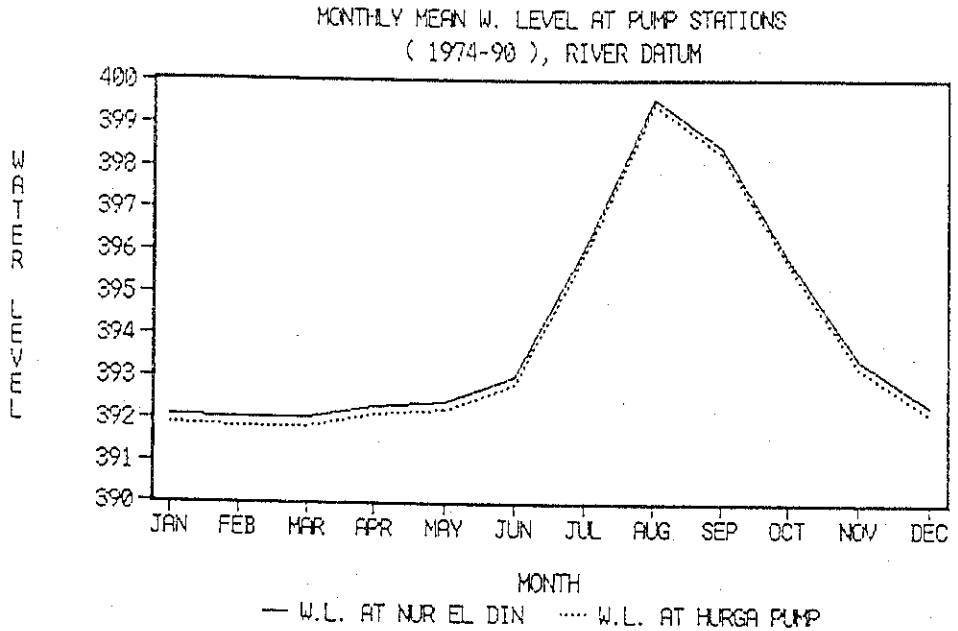


Table 3.3 EXISTING CANAL SYSTEM

1) Hurga Scheme

Name of Canal	Length of Canal (km)	Location of Canal Head	Command Area (fd)
Main Canal	6.17	Pumping Station	13,903
Major Canal	5.62	Km 0.88 of Main Canal	6,668
Gannabia No.1	2.83	Major Canal	685
Gannabia No.2	4.70	Km 0.88 of Main Canal	1,170
Gannabia No.3	2.10	Km 0.88 of Main Canal	441
Canal No.1	1.51	Km 2.49 of Major Canal	640
Canal No.2	7.20	Tail of Major Canal	1,240
Canal No.2(P)*	6.0	Tail of Major Canal	985
Canal No.3	4.13	Tail of Major Canal	1,970
Canal No.4	4.26	Km 2.91 of Main Canal	770
Canal No.5	5.60	Tail of Main Canal	1,293
Canal No.6	6.16	Tail of Main Canal	2,835
Canal No.7	3.52	Tail of Main Canal	315
D/Abu XX-3.1	1.43	Tail of Canal No.3	450
D/Abu XX-3.2	0.59	Tail of Canal No.3	170
D/Abu XX-6.1	1.11	Km 1.73 of Canal No.6	255
D/Abu XX-6.2	0.65	Km 2.49 of Canal No.6	415

* Never constructed yet

2) Nur El Din Scheme

Name of Canal	Length of Canal (km)	Location of Canal Head	Command Area (fd)
Main Canal	8.18	Pumping Sration	9,719
Canal No.1	1.96	Km 0.95 of Main Canal	608
Canal No.2	5.94	Km 4.91 of Main Canal	1,827
Canal No.3	6.70	Tail of Main Canal	3,753
Canal No.4	6.50	Km 2.88 of Canal No.3	2,385
Canal No.5	2.58	Tail of Main Canal	1,407
D/Abu XX No.1	1.04	Km 1.73 of Canal No.2	270
D/Abu XX No.2	0.89	Km 2.62 of Canal No.5	360

Table 4.1 SALIENT FEATURES OF PUMPS AND ELECTRICAL FACILITIES

(1) Salient features of tentatively proposed pumps

Description	Hurga	NurElDin	Integrated	
Type of pump	B1*	B1	B1	B2**
Design head (m)	21.0	21.5	22.0	22.0
Rated discharge (m3/min/set)	100	65	160	160
Q'ty of pump (set)	3	3	3	3
Dia. of pump (mm)	900 x 700	700 x 600	1,000 x 800	1,100
Required output (kW/set)	500	350	800	800
(PS/set)	700	500	1,200	1,200

* ; vertical shaft double suction volute pump
**; vertical shaft mixed-flow pump

(2) Salient features of tentatively proposed electrical facilities

Description	Hurga	NurElDin	Integrated
a) Distribution line, 33 kV	95 mm2 x 10.5 km		95 mm2 x 9.5 km
b) Substation equipment			
- Switchgear, 33 kV	1 lot	1 lot	1 lot
- Main transformer	33/3 kV 2,000 kVA	33/3 kV 1,500 kVA	33/3 kV 3,000 kVA
- Cubicle, 3.3 kV(set)	6	6	6
- Control panel(set)	3	3	3
- Service transformer(set)	1	1	1
- AC-DC panel(set)	1	1	1
- Battery and charger(set)	1	1	1

Table 5.1 MAIN FEATURES OF PUMPING EQUIPMENT

1. PUMP

Type of Pump	: vertical shaft double suction volute pump
Diameter of Pump	: 1,000 mm X 800 mm
Rated Discharge	: 148 m3/min. per unit
Rated Design Head	: 24 m
Specific Speed	: 460 rpm-m
Quantity	: 4 sets

2. MOTOR

Type	: totally enclosed self-cooling vertical shaft squirrel cage induction motor
Output	: 750 kW
Voltage	: 11 kV
Number of Pole	: 10 poles
Speed	: 580 rpm (including 3% slip)
Quantity	: 4 sets

3. OVERHEAD CRANE

Type	: electrically operated,wire rope hoist with travelling and transverse gear unit
Capacity	: 15 tons
Quantity	: 1 set

4. SUCTION PIPE

Type	: concrete encased welded steel pipe
Diameter	: 1,100 mm to 1,000 mm
Length	: approx. 22 m
Quantity	: 4 lanes

5. DISCHARGE PIPE

Type	: concrete supported welded steel pipe with manifold type confluence pipe
Diameter	: 800 mm,900 mm,1,500 mm,and 1,800 mm
Length	: approx.60 m
Quantity	: 4 lanes for each pump unit and 1 lane of confluence discharge pipe

6. SUCTION VALVE

Type	: manually operated sluice valve
Diameter	: 1,000 mm
Quantity	: 4 sets

7. DISCHARGE VALVE

Type	: electrically operated butterfly valve
Diameter	: 800 mm
Quantity	: 4 sets

8. CHECK VALVE

Type	: swing type check valve
Diameter	: 800 mm
Quantity	: 4 sets

Table 5.2 MAIN FEATURES OF CANALS

1) Link Canal

	Name of Canals	Length of Canal (km)	Command Area (fd)	Design Discharge (m3/s)	Max. Storage (m3)
1	Linkcanal	0.45	22,622.2	8.17	-

2) Hurga Scheme

	Name of Canals	Length of Canal (km)	Command Area (fd)	Design Discharge (m3/s)	Max. Storage (m3)
1	Main Canal	5.82	13,903.0	5.02	-
		0.49	13,903.0	5.02	-
		2.08	5,523.0	1.99	-
		3.25	4,688.0	1.69	-
2	Major Canal	5.62	6,668.0	2.41	
		0.60	6,668.0	2.41	-
		1.89	6,167.0	2.23	-
		3.13	4,605.0	1.66	-
	Minor Canal				
3	Gannabia No.1	2.83	810.0	0.29	6,299
4	Gannabia No.2	4.70	1,235.0	0.44	9,603
5	Gannabia No.3	2.10	477.0	0.17	3,709
6	Gannabia No.4 (P)	4.40	501.0	0.18	3,896
7	Canal No.1	1.51	752.0	0.27	5,848
8	Canal No.2	7.20	1,455.0	0.52	11,314
9	Canal No.2 (P)	6.00	1,180.0	0.42	9,176
10	Canal No.3	4.13	1,970.0	0.71	15,319
11	Canal No.4	4.26	835.0	0.30	6,493
12	Canal No.5	5.60	1,293.0	0.47	10,054
13	Canal No.6	6.16	2,885.0	1.04	22,434
14	Canal No.7	3.52	510.0	0.18	3,966
	D/Abu XX				
15	D/Abu XX - 3.1	1.43	450.0	0.16	-
16	D/Abu XX - 3.2	0.59	170.0	0.06	-
17	D/Abu XX - 6.1	1.11	255.0	0.09	-
18	D/Abu XX - 6.2	0.65	415.0	0.15	-

3) Nur El Din Scheme

	Name of Canals	Length of Canal (km)	Command Area (fd)	Design Discharge (m3/s)	Max. Storage (m3)
1	Main Canal	11.32	8,719.2	3.15	-
		1.86	8,719.2	3.15	-
		4.46	8,111.2	2.93	-
		5.00	3,753.0	1.36	-
	Minor Canal				
2	Canal No.1	1.46	608.0	0.22	4,728
3	Canal No.2	5.94	1,904.5	0.69	14,809
4	Canal No.3	4.97	1,368.0	0.49	10,638
5	Canal No.4	7.65	2,385.0	0.86	18,546
6	Canal No.5	7.07	2453.7	0.88	19,080
	D/Abu XX				
7	D/Abu XX No.1	1.04	270.0	0.10	-
8	D/Abu XX No.2	0.89	360.0	0.13	-

Table 7.1 SUMMARY OF PROJECT COST

Item	Foreign Currency	Local Currency	Total
A. Direct Cost			
I. Civil Works	125,100	78,071	203,171
	(1,373.0)	(856.9)	(2,229.9)
1. Preparatory Work	11,373	7,097	18,470
	(124.8)	(77.9)	(202.7)
2. Pumping Station	14,821	8,127	22,948
	(162.7)	(89.2)	(251.9)
3. Canal System (New)	10,278	4,326	14,604
	(112.8)	(47.5)	(160.3)
4. Hurga Canal System	52,365	34,278	86,643
	(574.7)	(376.2)	(950.9)
5. Nur El Din Canal System	27,333	18,469	45,802
	(300.0)	(202.7)	(502.7)
6. Drainage System	5,330	1,357	6,687
	(58.5)	(14.9)	(73.4)
7. O & M Facility	0	3,267	3,267
	(0.0)	(35.9)	(35.9)
8. O & M Equipment	3,600	1,150	4,750
	(39.5)	(12.6)	(52.1)
II. Mechanical & Electrical Works	87,031	2,474	89,505
	(955.2)	(27.2)	(982.4)
1. Pumping Equipment	84,124	2,256	86,380
	(923.3)	(24.8)	(948.1)
2. Power Supply System	2,907	218	3,125
	(31.9)	(2.4)	(34.3)
Sub-Total (A)	212,131	80,545	292,676
	(2,328.2)	(884.1)	(3,212.3)
B. Indirect Cost			
1. Engineering Services	44,994	0	44,994
	(493.8)	(0.0)	(493.8)
2. Administration Expenses	0	2,309	2,309
	(0.0)	(25.3)	(25.3)
Sub-Total (B)	44,994	2,309	47,303
	(493.8)	(25.3)	(519.1)
C. Physical Contingency	12,510	7,807	20,317
	(137.3)	(85.7)	(223.0)
Project Cost [Total (A+B+C)]	269,635	90,661	360,296
	(2,959.3)	(995.1)	(3,954.4)

Notes : 1) Exchange Rate, US$ 1.0 = LS 12.30 = J.Yen 135.00
2) Unit : LS 1,000
(J.Yen 1,000,000)

Table 7.2 ANNUAL DISBURSEMENT SCHEDULE

Description	Total			1 st			2 nd			3 rd			4 th		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Cost															
I. Civil Works	125,100	78,071	203,171	0	0	0	5,687	3,549	9,236	92,656	55,330	147,986	26,759	19,194	45,953
	(1,373,049)	(856,877)	(2,229,926)	(0)	(0)	(0)	(62,418)	(38,952)	(101,370)	(1,016,956)	(607,280)	(1,624,236)	(293,697)	(210,665)	(504,362)
1. Preparatory Work	11,373	7,097	18,470	0	0	0	3,687	3,549	9,236	5,687	3,549	9,236	0	0	0
	(124,826)	(77,894)	(202,720)	(0)	(0)	(0)	(62,418)	(38,952)	(101,370)	(62,418)	(38,952)	(101,370)	(0)	(0)	(0)
2. Pumping Station	14,821	8,127	22,948	0	0	0	0	0	0	13,339	7,314	20,653	1,482	813	2,295
	(162,670)	(89,199)	(251,869)	(0)	(0)	(0)	(0)	(0)	(0)	(146,404)	(80,276)	(226,680)	(16,266)	(8,923)	(25,189)
3. Canal System (New)	10,278	4,326	14,604	0	0	0	0	0	0	10,278	4,326	14,604	0	0	0
	(112,807)	(47,480)	(160,287)	(0)	(0)	(0)	(0)	(0)	(0)	(112,807)	(47,480)	(160,287)	(0)	(0)	(0)
4. Hurga Canal System	52,365	34,278	86,643	0	0	0	0	0	0	36,656	23,995	60,651	15,710	10,283	25,993
	(574,738)	(376,222)	(950,960)	(0)	(0)	(0)	(0)	(0)	(0)	(402,322)	(263,360)	(665,682)	(172,427)	(112,862)	(285,289)
5. Nur El Din Canal System	27,333	18,469	45,802	0	0	0	0	0	0	17,766	12,005	29,771	9,567	6,464	16,031
	(299,996)	(202,709)	(502,705)	(0)	(0)	(0)	(0)	(0)	(0)	(194,993)	(131,762)	(326,755)	(105,004)	(70,946)	(175,950)
6. Drainage System	5,330	1,357	6,687	0	0	0	0	0	0	5,330	1,357	6,687	0	0	0
	(58,500)	(14,894)	(73,394)	(0)	(0)	(0)	(0)	(0)	(0)	(58,500)	(14,894)	(73,394)	(0)	(0)	(0)
7. O & M Facility	0	3,267	3,267	0	0	0	0	0	0	0	1,634	1,634	0	1,634	1,634
	(0)	(35,857)	(35,857)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(17,934)	(17,934)	(0)	(17,934)	(17,934)
8. O & M Equipment	3,600	1,150	4,750	0	0	0	0	0	0	3,600	1,150	4,750	0	0	0
	(39,512)	(12,622)	(52,134)	(0)	(0)	(0)	(0)	(0)	(0)	(39,512)	(12,622)	(52,134)	(0)	(0)	(0)
II. Mechanical & Electrical Works	87,031	2,474	89,505	0	0	0	34,813	989	35,802	43,516	1,237	44,753	8,703	248	8,951
	(955,200)	(27,154)	(982,354)	(0)	(0)	(0)	(382,094)	(10,855)	(392,949)	(477,615)	(13,576)	(491,191)	(95,521)	(2,721)	(98,242)
1. Pumping Equipment	84,124	2,256	86,380	0	0	0	33,650	902	34,552	42,062	1,128	43,190	8,412	226	8,638
	(923,300)	(24,761)	(948,061)	(0)	(0)	(0)	(369,329)	(9,900)	(379,229)	(461,656)	(12,380)	(474,036)	(92,327)	(2,480)	(94,807)
2. Power Supply System	2,907	218	3,125	0	0	0	1,163	87	1,250	1,454	109	1,563	291	22	313
	(31,900)	(2,393)	(34,293)	(0)	(0)	(0)	(12,765)	(955)	(13,720)	(15,959)	(1,196)	(17,155)	(3,194)	(241)	(3,435)
Sub-Total(A)	212,131	80,545	292,676	0	0	0	40,500	4,538	45,038	136,172	56,567	192,739	35,462	19,442	54,904
	(2,328,249)	(884,031)	(3,212,280)	(0)	(0)	(0)	(444,512)	(49,807)	(494,319)	(1,494,571)	(620,856)	(2,115,427)	(389,218)	(213,386)	(602,604)
B. Indirect Cost															
1. Engineering Services	44,994	0	44,994	4,499	0	4,499	13,498	0	13,498	20,247	0	20,247	6,749	0	6,749
	(493,837)	(0)	(493,837)	(49,379)	(0)	(49,379)	(148,149)	(0)	(148,149)	(222,223)	(0)	(222,223)	(74,074)	(0)	(74,074)
2. Administration Expenses	0	2,309	2,309	0	115	115	0	693	693	0	1,155	1,155	0	346	346
	(0)	(25,343)	(25,343)	(0)	(1,262)	(1,262)	(0)	(7,606)	(7,606)	(0)	(12,677)	(12,677)	(0)	(3,798)	(3,798)
Sub-Total(B)	44,994	2,309	47,303	4,499	115	4,614	13,498	693	14,191	20,247	1,155	21,402	6,749	346	7,095
	(493,837)	(25,343)	(519,180)	(49,379)	(1,262)	(50,641)	(148,149)	(7,606)	(155,755)	(222,223)	(12,677)	(234,900)	(74,074)	(3,798)	(77,872)
C1. Physical Contingency	12,510	7,807	20,317	0	0	0	569	355	924	9,266	5,533	14,799	2,676	1,919	4,595
	(137,305)	(85,687)	(222,992)	(0)	(0)	(0)	(6,245)	(3,896)	(10,141)	(101,700)	(60,728)	(162,428)	(29,371)	(21,062)	(50,433)
Project Cost [Total(A+B+C1)]	269,635	90,661	360,296	4,499	115	4,614	54,567	5,586	60,153	165,685	63,255	228,940	44,887	21,707	66,594
	(2,959,391)	(995,061)	(3,954,452)	(49,379)	(1,262)	(50,641)	(598,906)	(61,309)	(660,215)	(1,818,494)	(694,261)	(2,512,755)	(492,663)	(238,246)	(730,909)
C2. Price Contingency															
(1) F/C : 3.5 % , L/C : 10.0 %	28,679	32,196	60,875	157	12	169	3,887	1,173	5,060	18,013	20,937	38,950	6,622	10,074	16,696
	(314,770)	(353,371)	(668,141)	(1,723)	(132)	(1,855)	(42,662)	(12,874)	(55,536)	(197,704)	(229,796)	(427,500)	(72,680)	(110,568)	(183,248)
(2) F/C : 3.5 % , L/C : 20.0 %	28,679	71,836	100,515	157	23	180	3,887	2,458	6,345	18,013	46,050	64,063	6,622	23,305	29,927
	(314,770)	(788,444)	(1,103,214)	(1,723)	(252)	(1,975)	(42,662)	(26,978)	(69,640)	(197,704)	(505,427)	(703,131)	(72,680)	(255,787)	(328,467)
(3) F/C : 3.5 % , L/C : 30.0 %	28,679	119,895	148,574	157	35	192	3,887	3,854	7,741	18,013	75,716	93,729	6,622	40,290	46,912
	(314,770)	(1,315,921)	(1,630,691)	(1,723)	(384)	(2,107)	(42,662)	(42,300)	(84,962)	(197,704)	(831,029)	(1,028,733)	(72,680)	(442,207)	(514,887)
Fund Requirement (1) [Total(A+B+C1+C2)]	298,314	122,857	421,171	4,656	127	4,783	58,454	6,759	65,213	183,698	84,192	267,890	51,509	31,781	83,290
	(3,274,161)	(1,348,432)	(4,622,593)	(51,102)	(1,394)	(52,496)	(641,568)	(74,183)	(715,751)	(2,016,198)	(924,057)	(2,940,255)	(565,343)	(348,814)	(914,157)
Fund Requirement (2) [Total(A+B+C1+C2)]	298,314	162,497	460,811	4,656	138	4,794	58,454	8,044	66,498	183,698	109,305	293,003	51,509	45,012	96,521
	(3,274,161)	(1,783,505)	(5,057,666)	(51,102)	(1,514)	(52,616)	(641,568)	(88,287)	(729,855)	(2,016,198)	(1,199,688)	(3,215,886)	(565,343)	(494,033)	(1,059,376)
Fund Requirement (3) [Total(A+B+C1+C2)]	298,314	210,556	508,870	4,656	150	4,806	58,454	9,440	67,894	183,698	138,971	322,669	51,509	61,997	113,506
	(3,274,161)	(2,310,982)	(5,585,143)	(51,102)	(1,646)	(52,748)	(641,568)	(103,609)	(745,177)	(2,016,198)	(1,525,290)	(3,541,488)	(565,343)	(680,453)	(1,245,796)

Notes : 1) Price Level, Dec.,1990
2) Exchange Rate, US$ 1.0 = LS 12.30 = Yen 135.00
3) Unit : LS 1,000
(J.Yen 1,000)

Table 7.3 ANNUAL OPERATION AND MAINTENANCE COST

(Unit : LS)

Item	Amount
1. Salary and Wages	
i) Staff Salary (see Table - c)	336,000
ii) Labour Wages 100 M/M x LS 700	70,000
2. Operation Cost	
i) Electric Power Consumption Cost	3,150,000
ii) Fuel,etc. for Equipment & Vehicles	150,000
3. Office Expenses	100,000
4. Repair and Maintenance Cost (0.5 % of direct construction cost)	1,463,000
Total	5,269,000

Table 7.4 REPLACEMENT COST AND USEFUL LIFE

Item	Useful Life (Years)	Replacement Cost (LS 1,000)
1. Project Facilities		
(1) Pump	25	24,275
(2) Electrical Equipment & Motor	25	27,991
(3) Transmission lines	25	3,125
(4) Irrigation Facilities (Gates & Pipes)	25	19,199
2. O & M Equipment	10	4,750

FIGURES

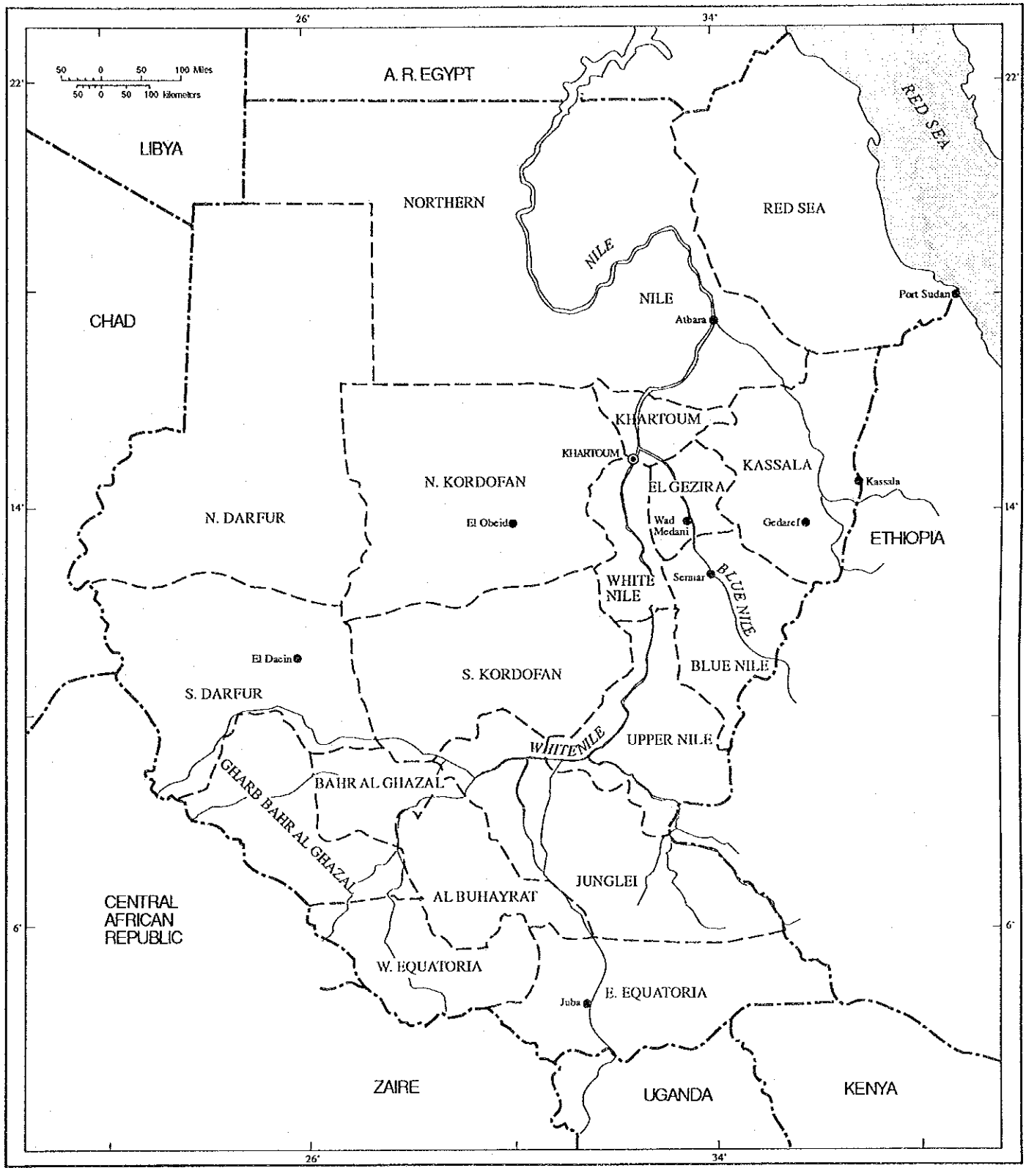


Fig. 2.1 GENERAL MAP OF SUDAN

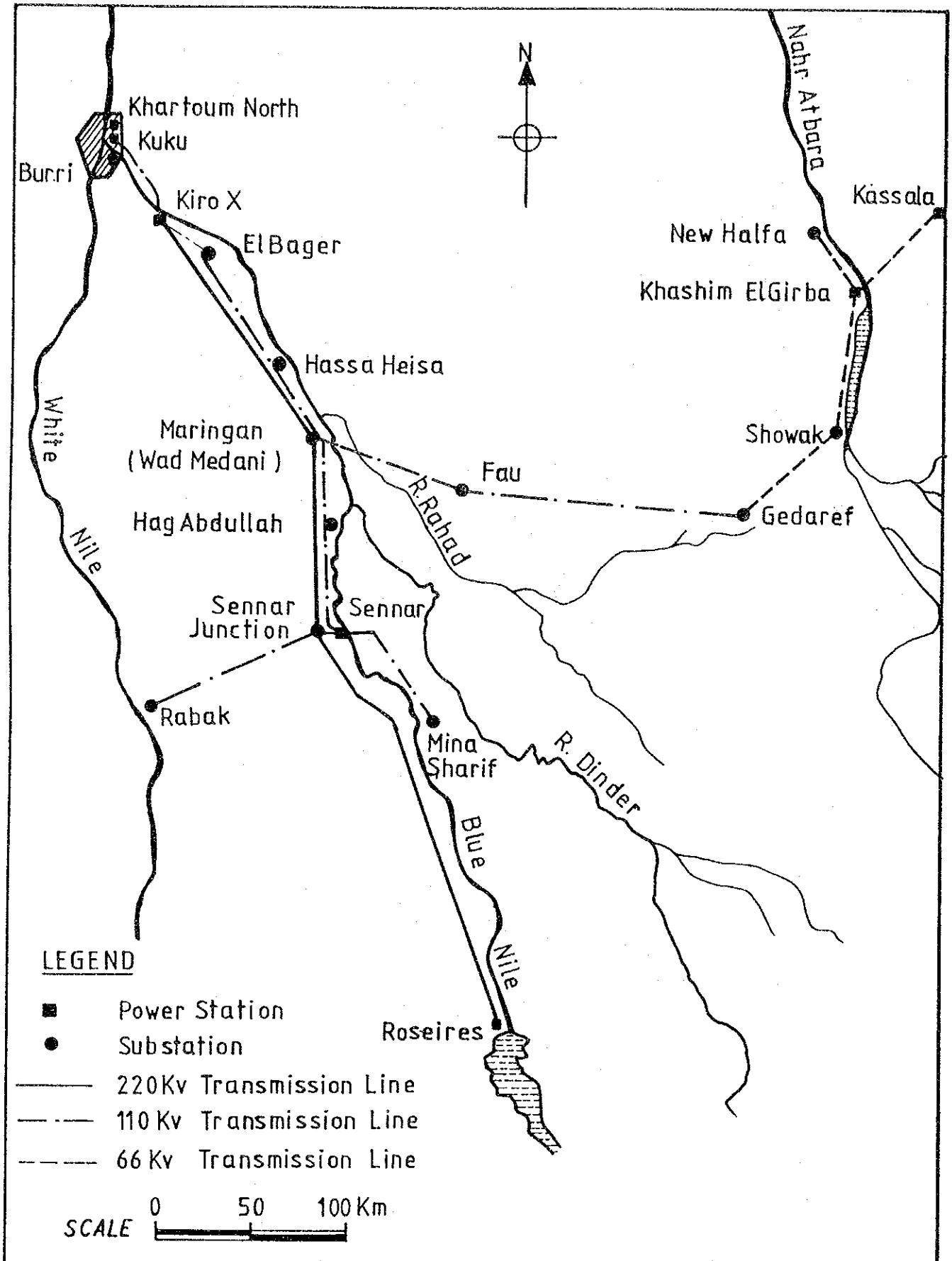
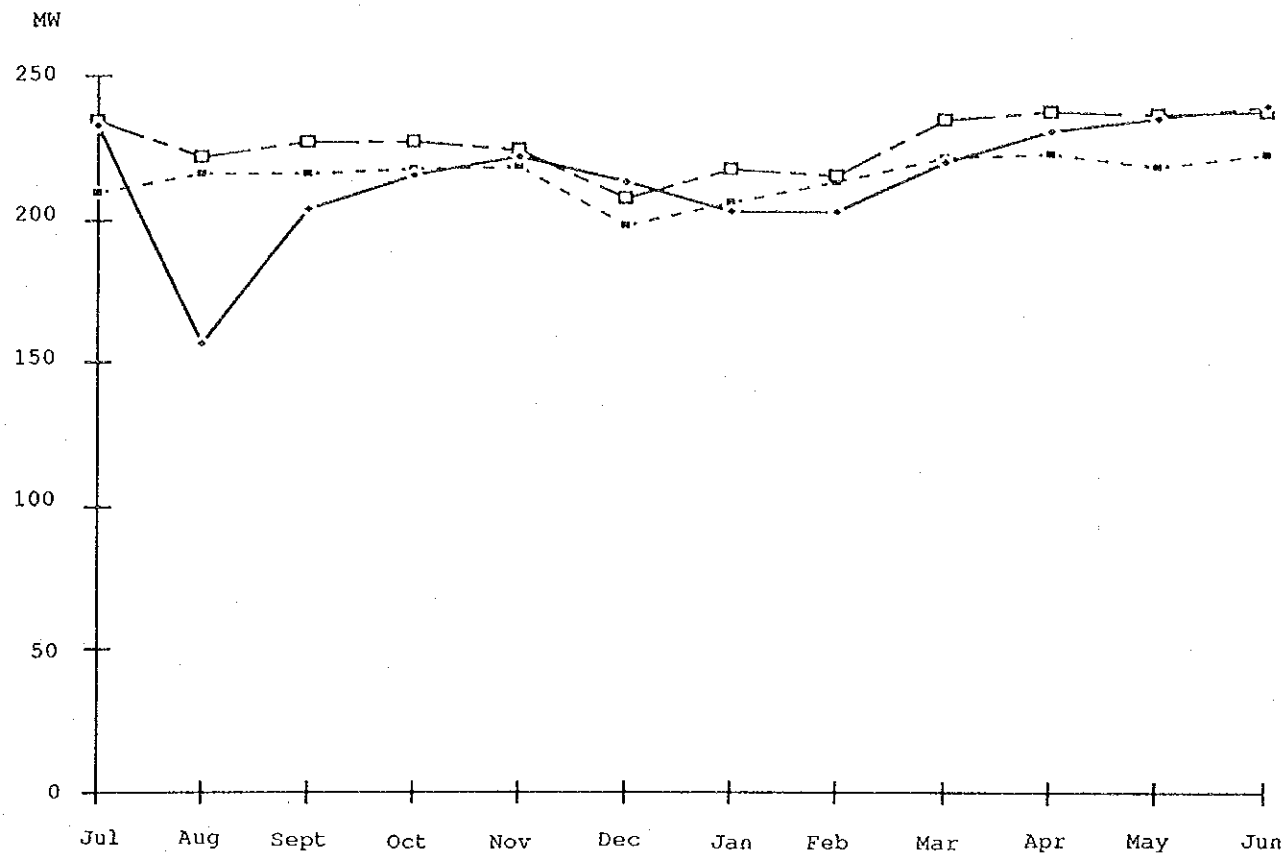
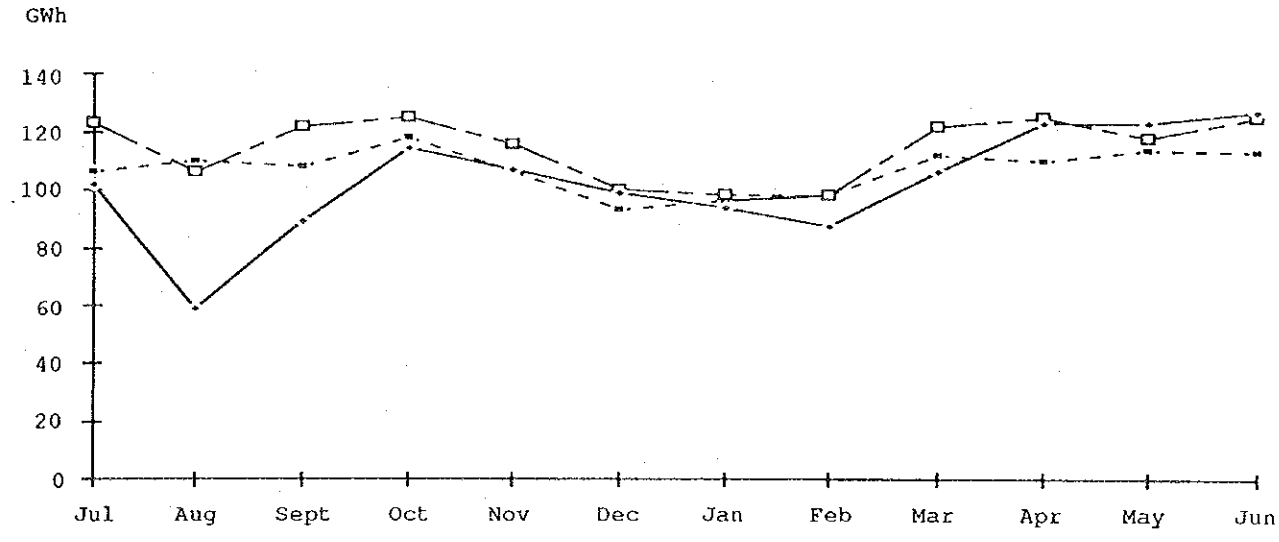


Fig. 2.2 EXISTING NATIONAL POWER SUPPLY SYSTEM



Monthly Maximum Power



Monthly Maximum Energy

NOTE:

FY 1986/1987

FY 1987/1988

FY 1988/1989

Fig. 2.3 GENERATION OF BLUE NILE GRID