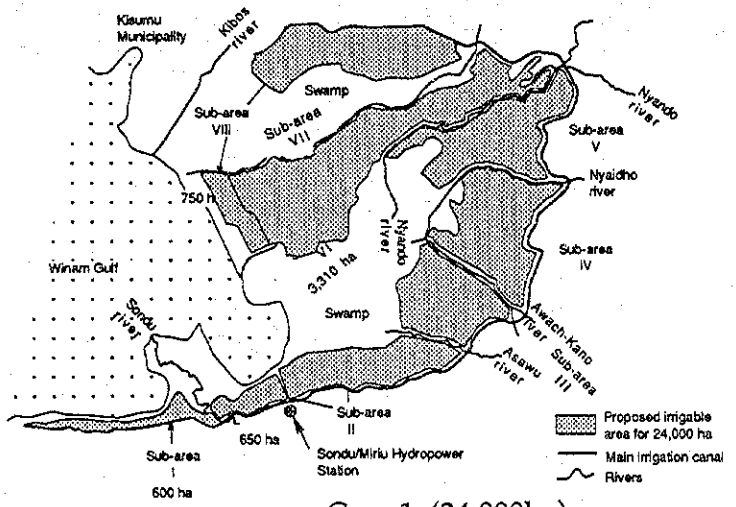
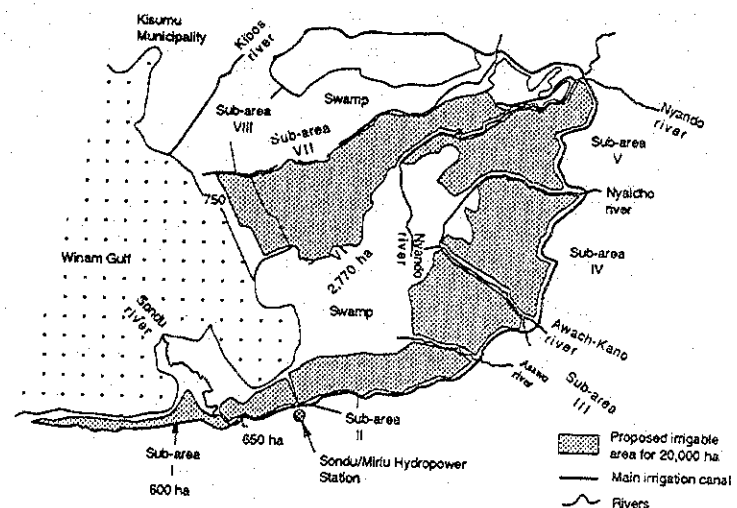
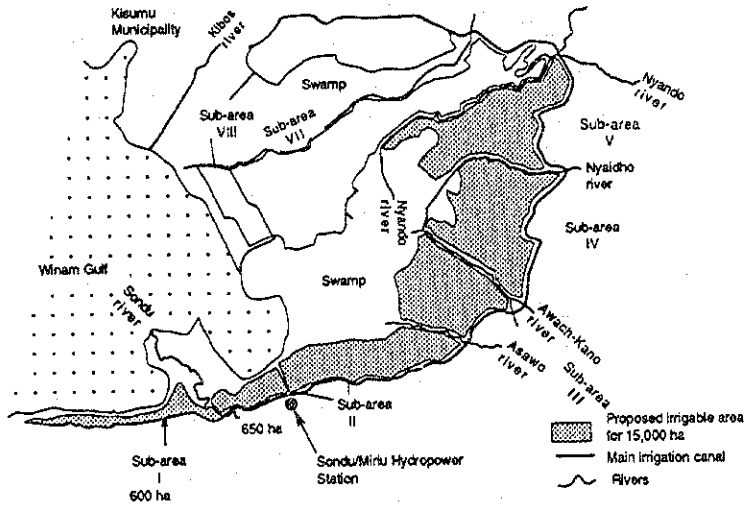


Case 1 (24,000ha)



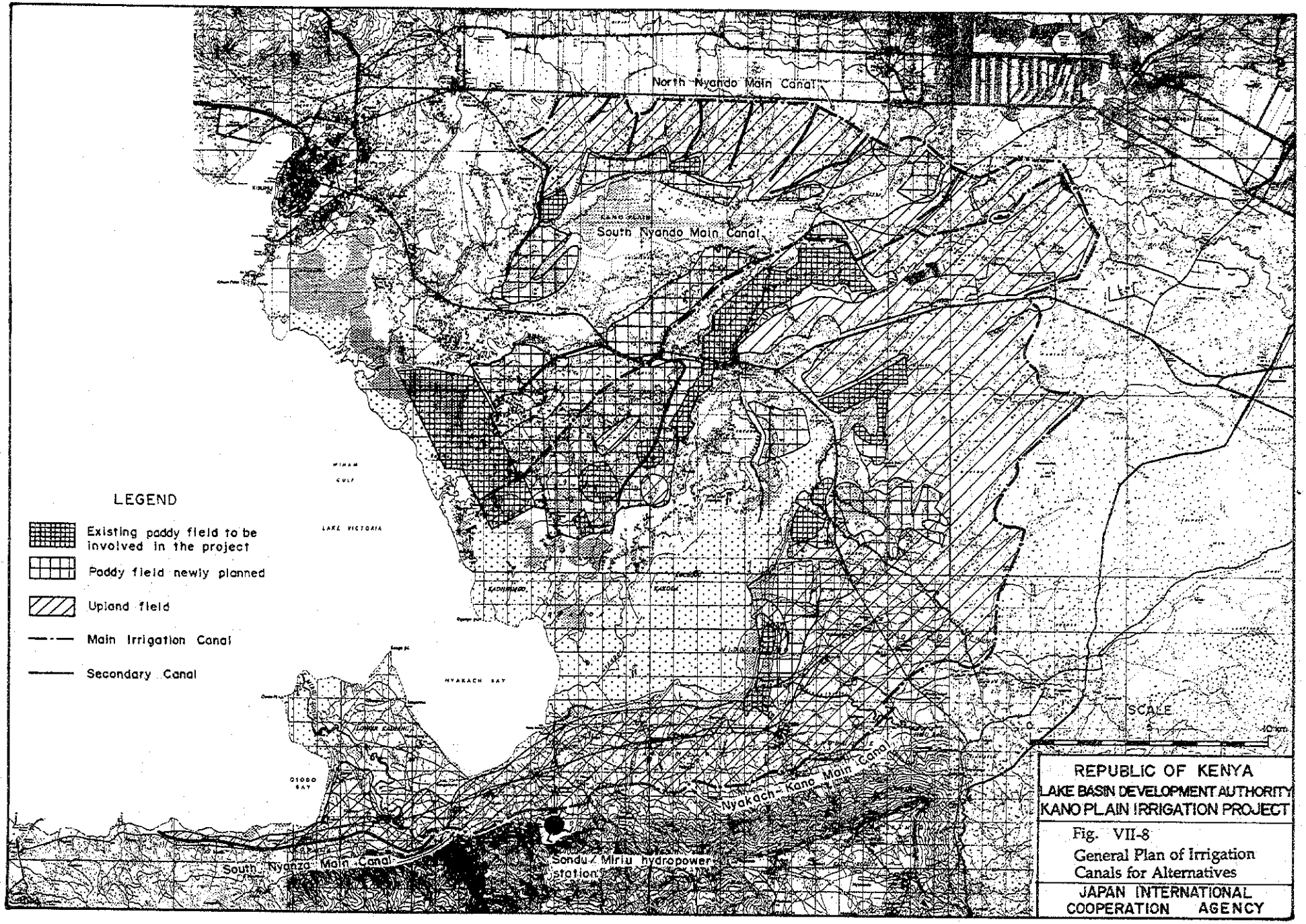
Case 2 (20,000ha)



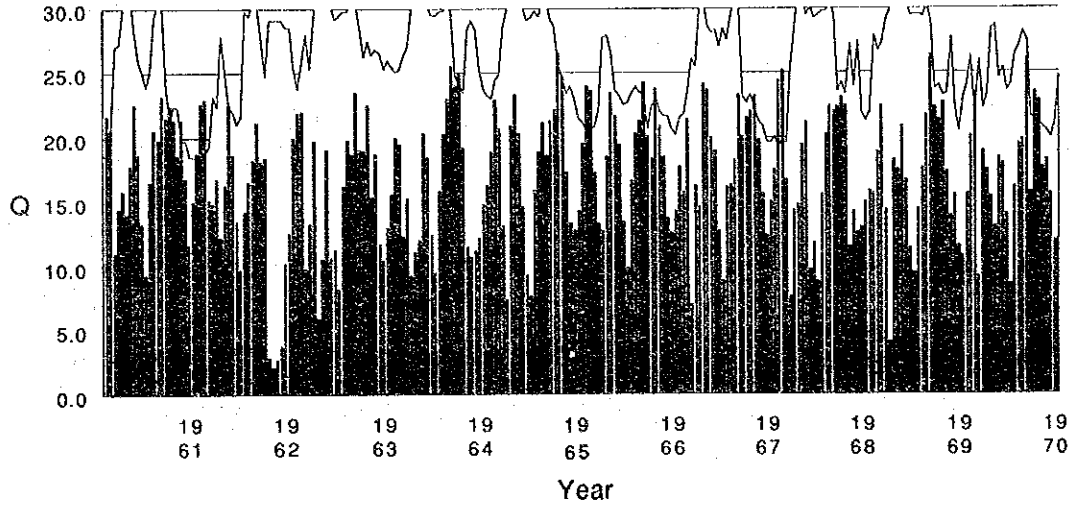
Case 3 (15,000ha)

Fig. VII-7 Location of Alternative Plans

REPUYBLIC OF KENYA
KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY


North Nyando Main Canal
South Nyando Main Canal
LEGEND
Existing paddy field to be involved in the project
Paddy field newly planned
Upland field
Main Irrigation Canal
Secondary Canal
LAKE VICTORIA
NYAKACH BAY
SCALE
Nyakach-Kano Main Canal
South Nyanza Main Canal
Sondu / Miriu hydropower station
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. VII-8
General Plan of Irrigation Canals for Alternatives
JAPAN INTERNATIONAL COOPERATION AGENCY

VII-F-8



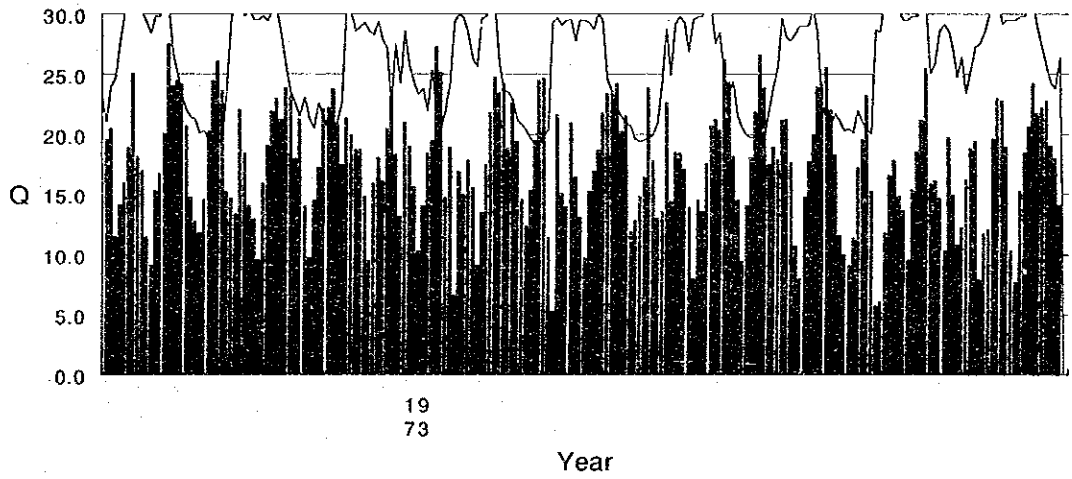
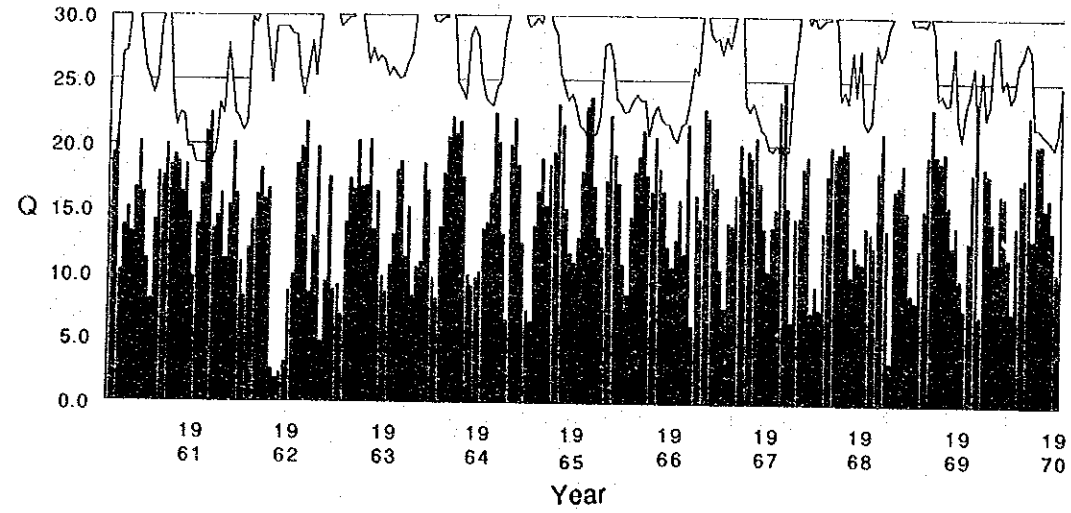


Fig. VII-9 Water Balance of Case 1

REPUYBLIC OF KENYA KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY



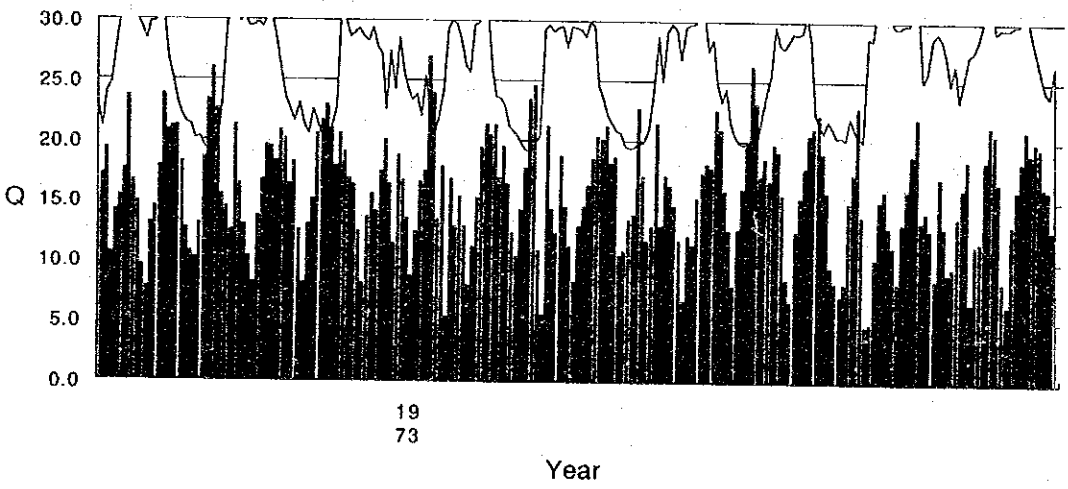
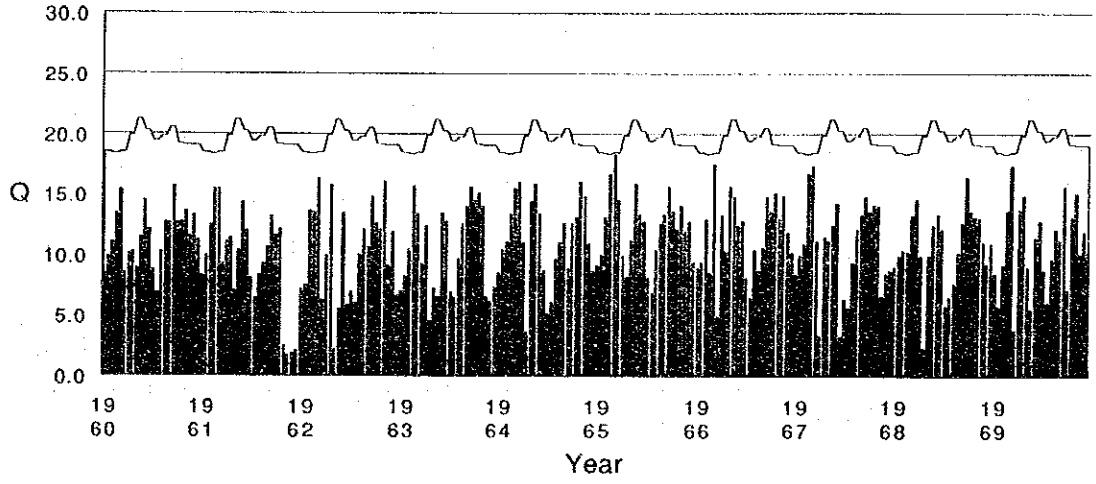


Fig. VII-10 Water Balance of Case 2

REPUYBLIC OF KENYA KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY



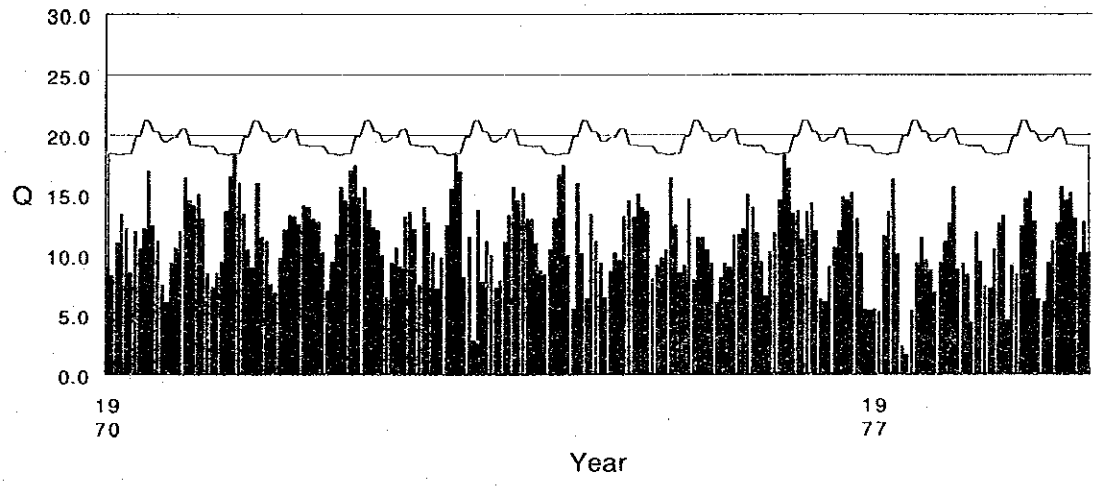
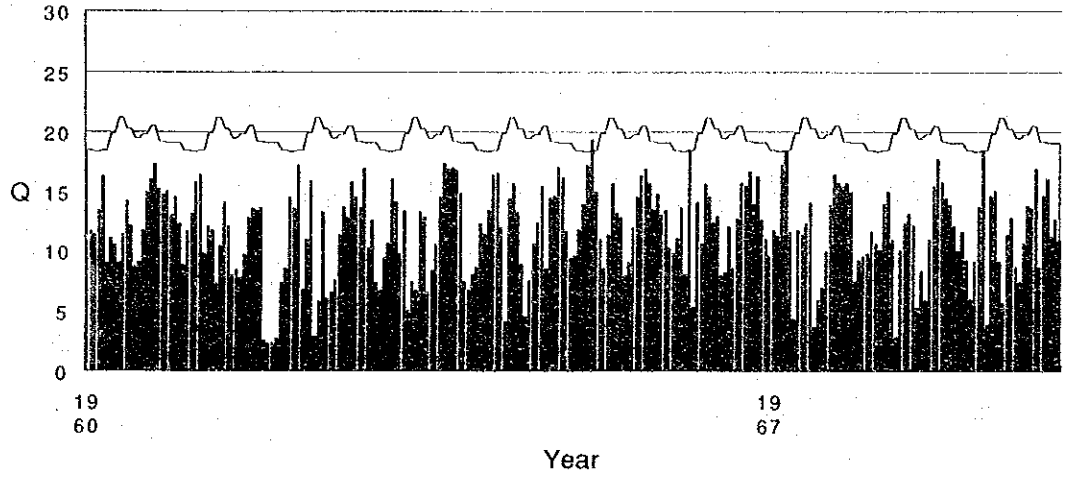


Fig. VII-11 Water Balance of Case 3

REPUYBLIC OF KENYA KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY



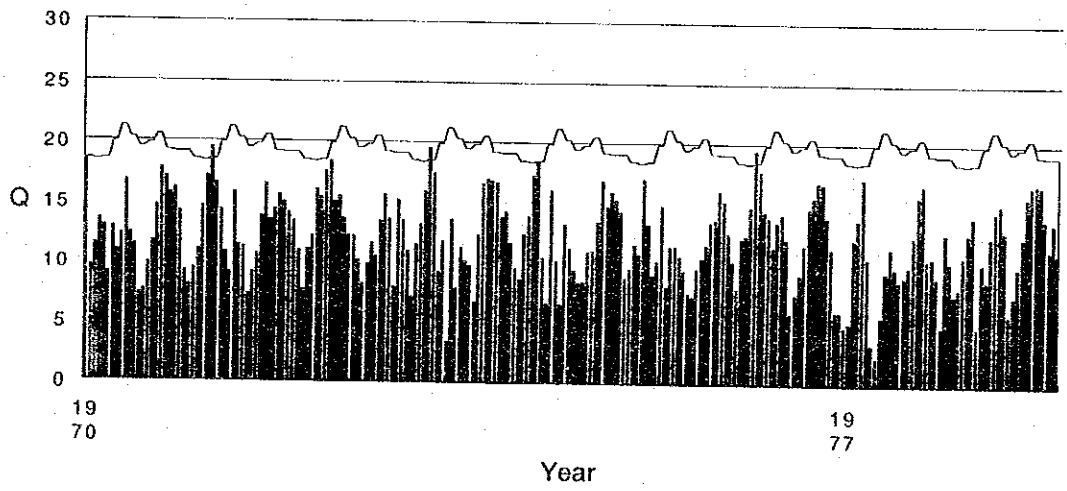
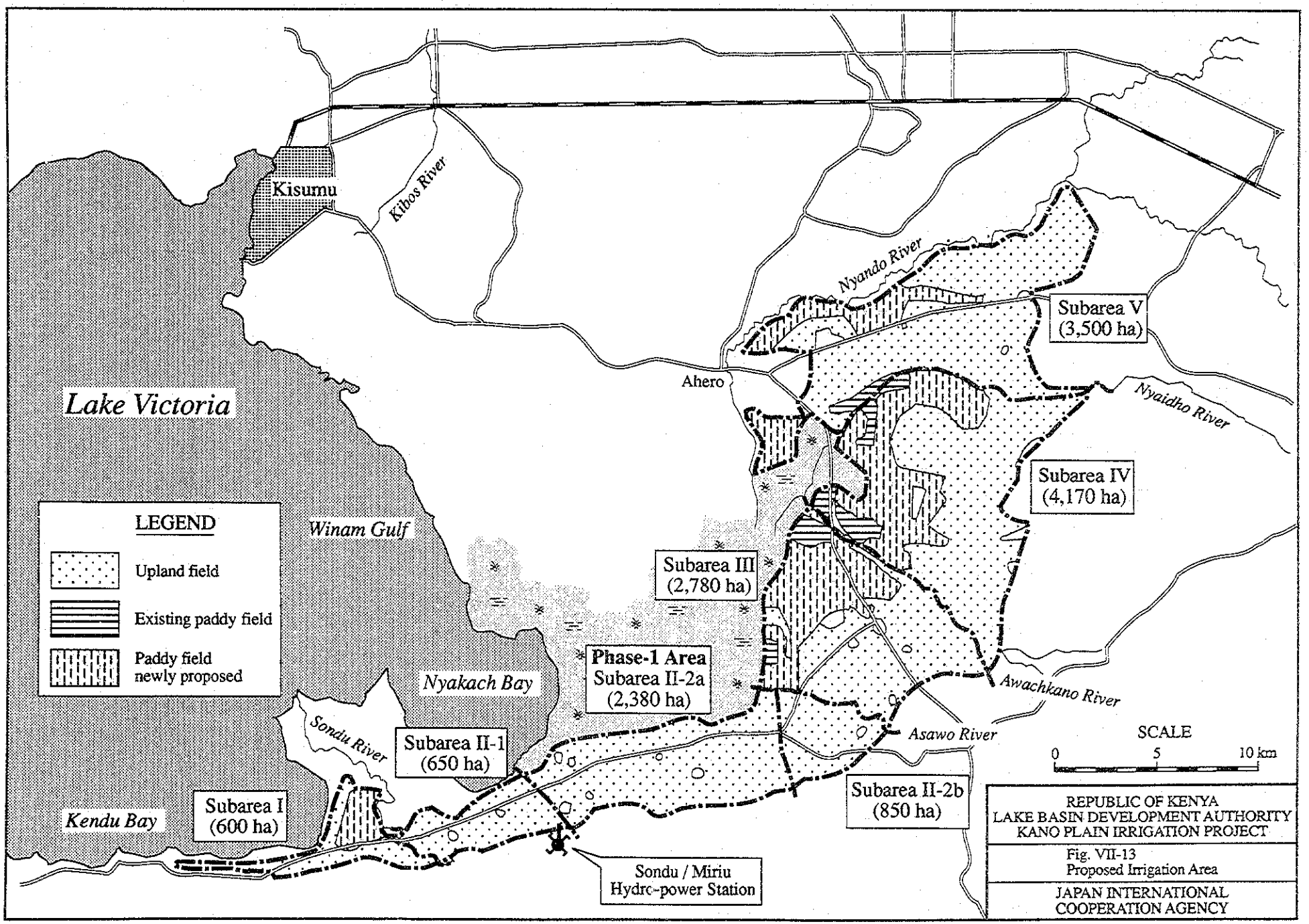
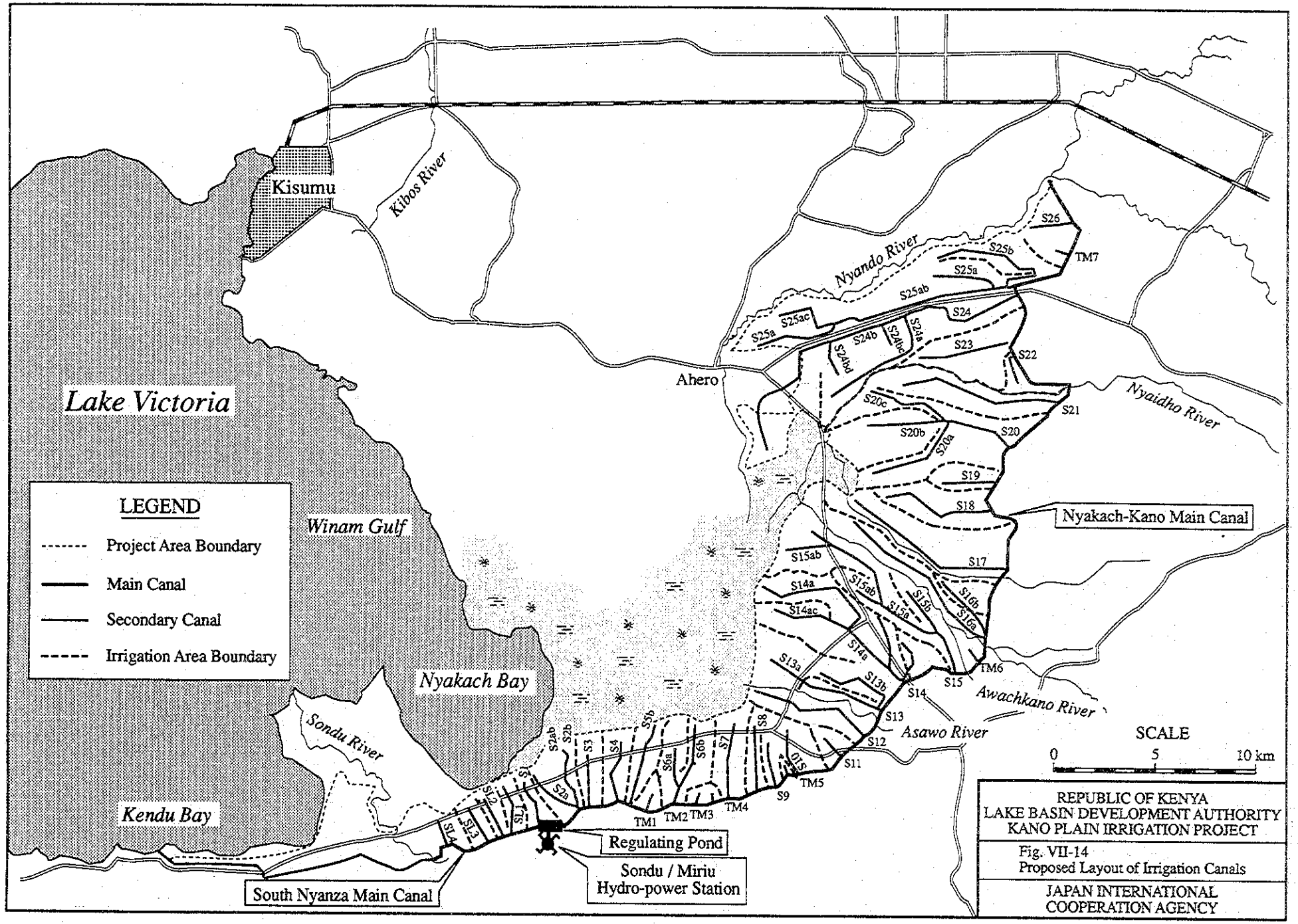


Fig. VII-12 Water Balance of the Project

REPUYBLIC OF KENYA KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY


Kisumu
Kibos River
Nyando River
Subarea V
(3,500 ha)
Ahero
Lake Victoria
Nyaidho River
Subarea IV
(4,170 ha)
LEGEND
Upland field
Existing paddy field
Paddy field
newly proposed
Winam Gulf
Subarea III
(2,780 ha)
Phase-1 Area
Subarea II-2a
(2,380 ha)
Nyakach Bay
Awachkano River
Sondu River
Asawo River
SCALE
0 5 10 km
Subarea II-1
(650 ha)
Subarea II-2b
(850 ha)
Kendu Bay
Subarea I
(600 ha)
Sondu / Miriu
Hydro-power Station
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. VII-13
Proposed Irrigation Area
JAPAN INTERNATIONAL
COOPERATION AGENCY


Lake Victoria
Kisumu
Kibos River
Ahero
Nyando River
Nyaidho River
Awachkano River
Asawo River
Winam Gulf
Nyakach Bay
Kendu Bay
Sondu River
Nyakach-Kano Main Canal
South Nyanza Main Canal
Regulating Pond
Sondu / Miriu
Hydro-power Station
LEGEND
Project Area Boundary
Main Canal
Secondary Canal
Irrigation Area Boundary
SCALE
0 5 10 km
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. VII-14
Proposed Layout of Irrigation Canals
JAPAN INTERNATIONAL
COOPERATION AGENCY

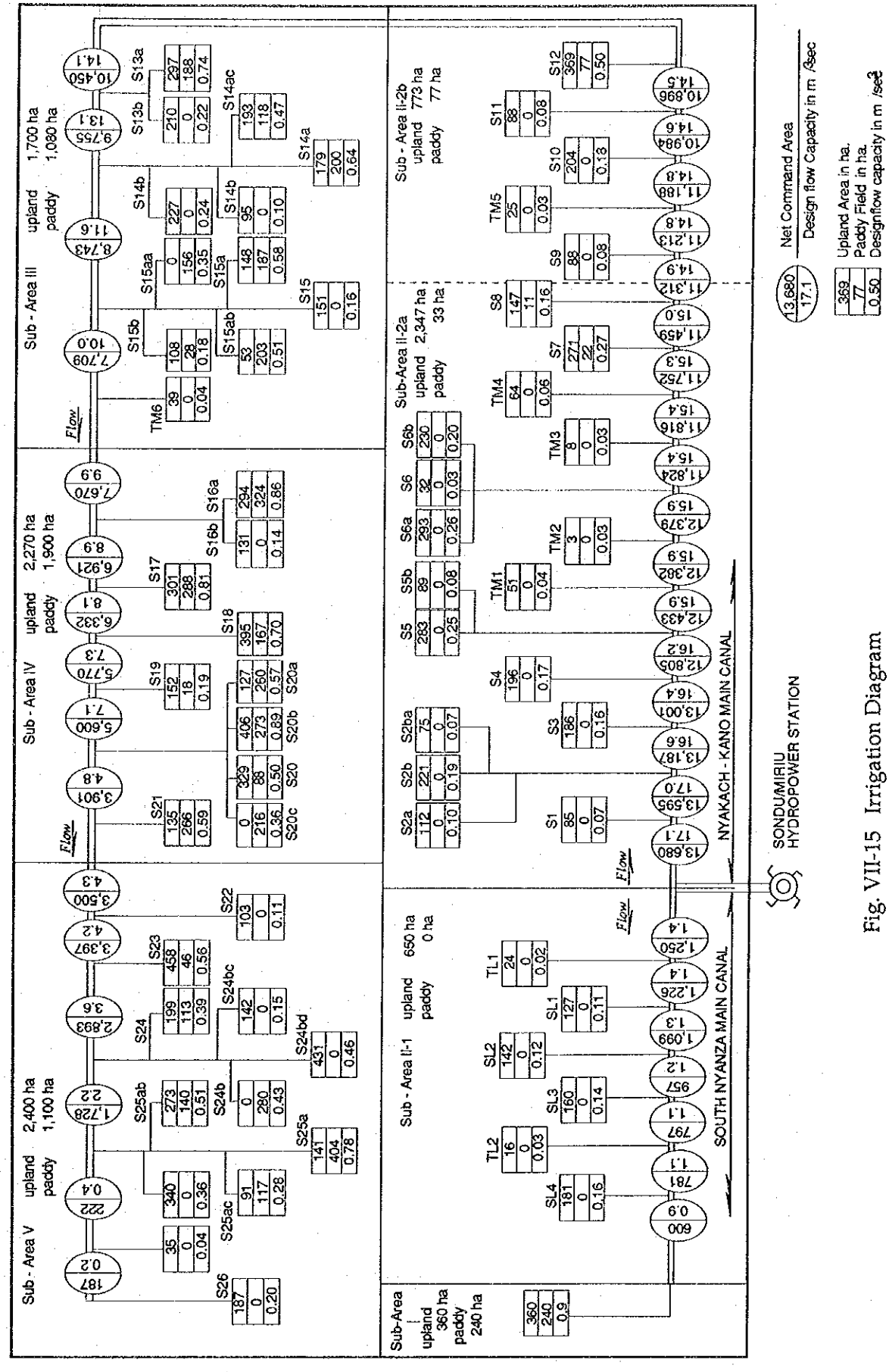
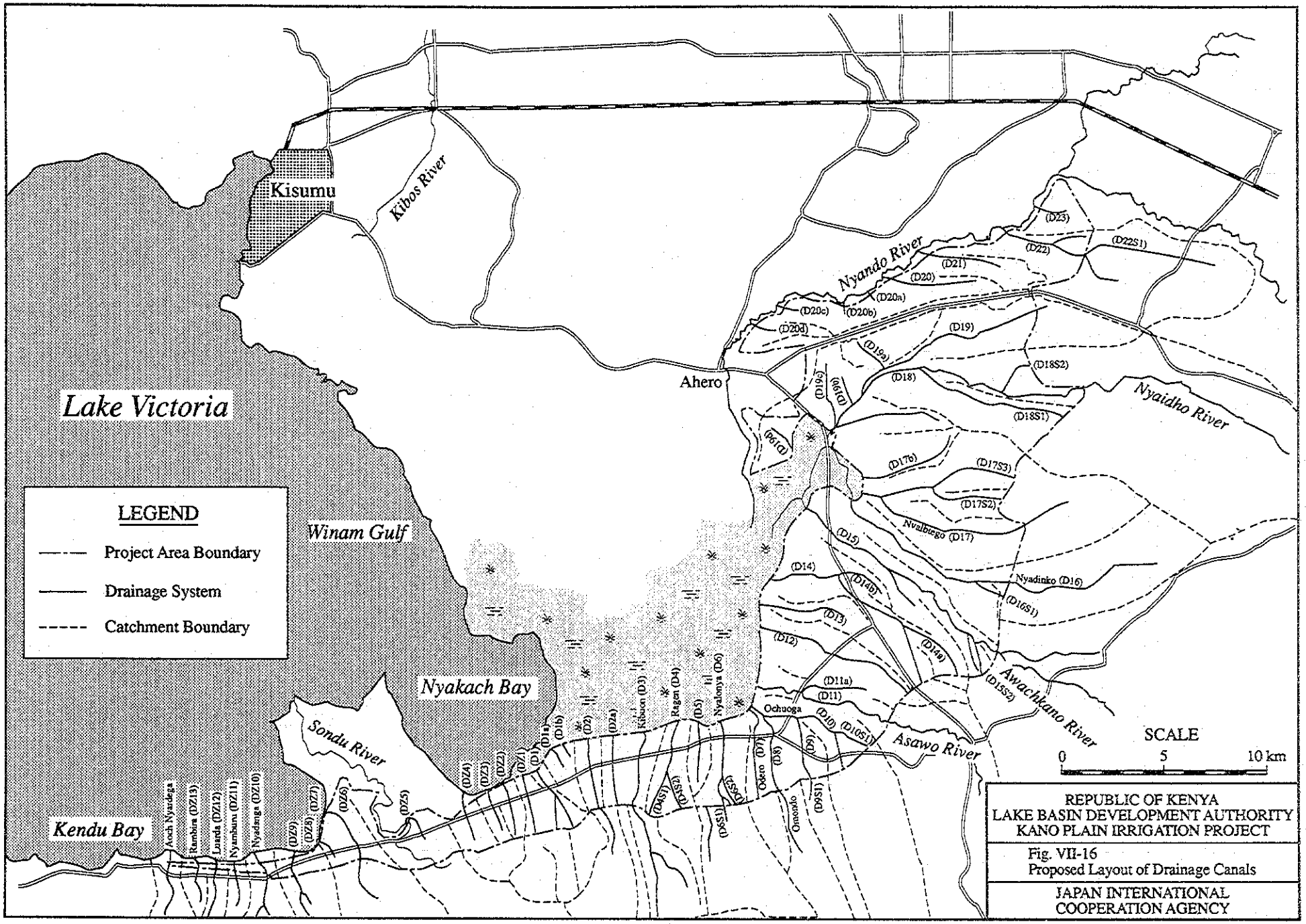


Fig. VII-15 Irrigation Diagram


Kisumu
Kibos River
Nyando River
Ahero
Lake Victoria
Winam Gulf
Nyakach Bay
Kendu Bay
Sondu River
Nyaidho River
Nyadinko (D16)
Nyalenya (D6)
Ochuoga
Asawo River
Awachkano River
Aoch Nyadega
Rambira (DZ13)
Luanda (DZ12)
Nyamburu (DZ11)
Nyadenga (DZ10)
LEGEND
Project Area Boundary
Drainage System
Catchment Boundary
SCALE
0
5
10 km
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. VII-16
Proposed Layout of Drainage Canals
JAPAN INTERNATIONAL
COOPERATION AGENCY

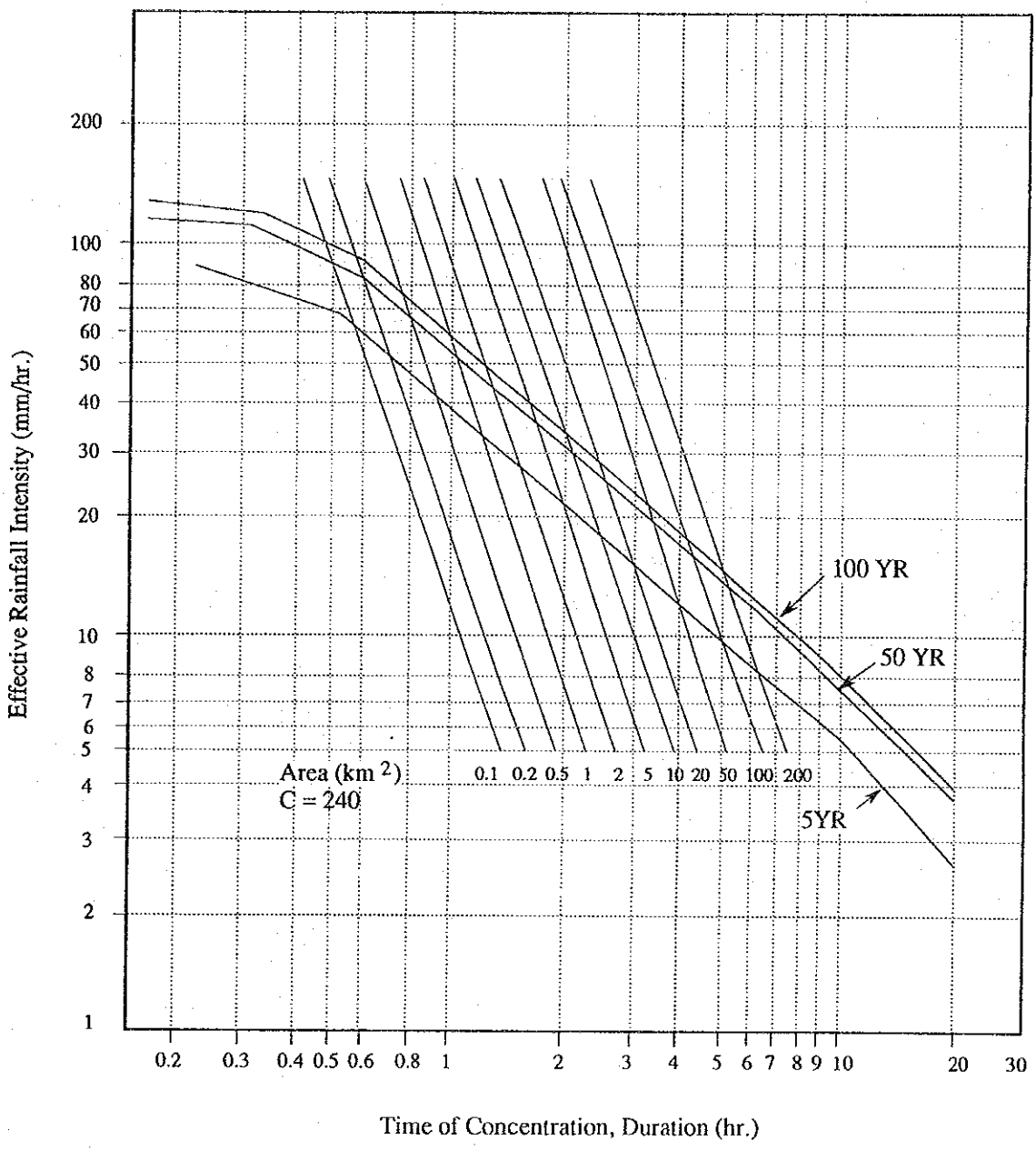


Fig. VII-17 Relationships of Effective Rainfall Intensity-Duration-Frequency and Catchment area

Annual Maximum
Three day's Rainfall

(mm)

	Station / Altitude	
	Ahero	S09034067
Year	1156	1158
1961		127
1962		91
1963		67
1964		79
1965		66
1966		92
1967		130
1968		92
1969		175
1970	77	51
1971	85	70
1972	88	59
1973	92	65
1974	111	88
1975	125	
1976	80	
1977	87	95
1978	86	60
1979	81	40
1980	98	63
1981	83	
1982	81	57
1983	79	67
1984	60	36
1985	91	
1986	73	
1987	72	
1988	142	
Average	89	79

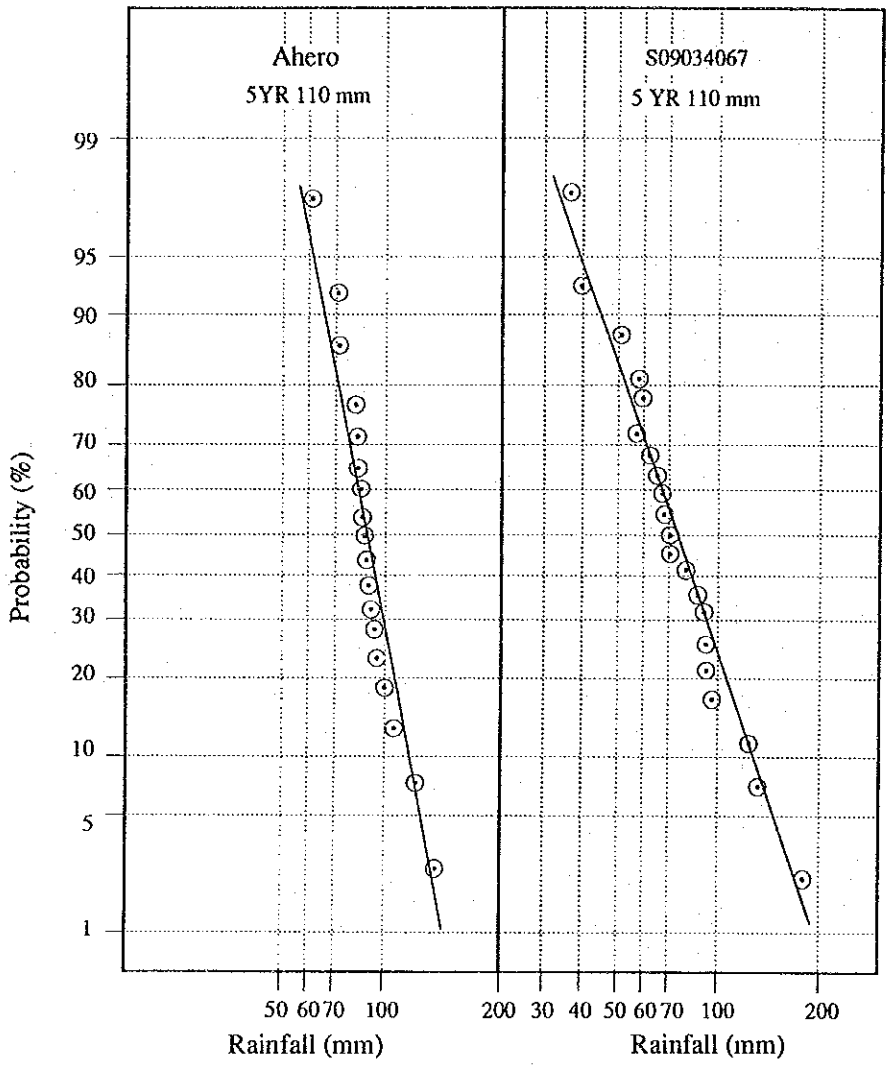


Fig. VII-18 Probability of 3 Day's Continuous Rainfall

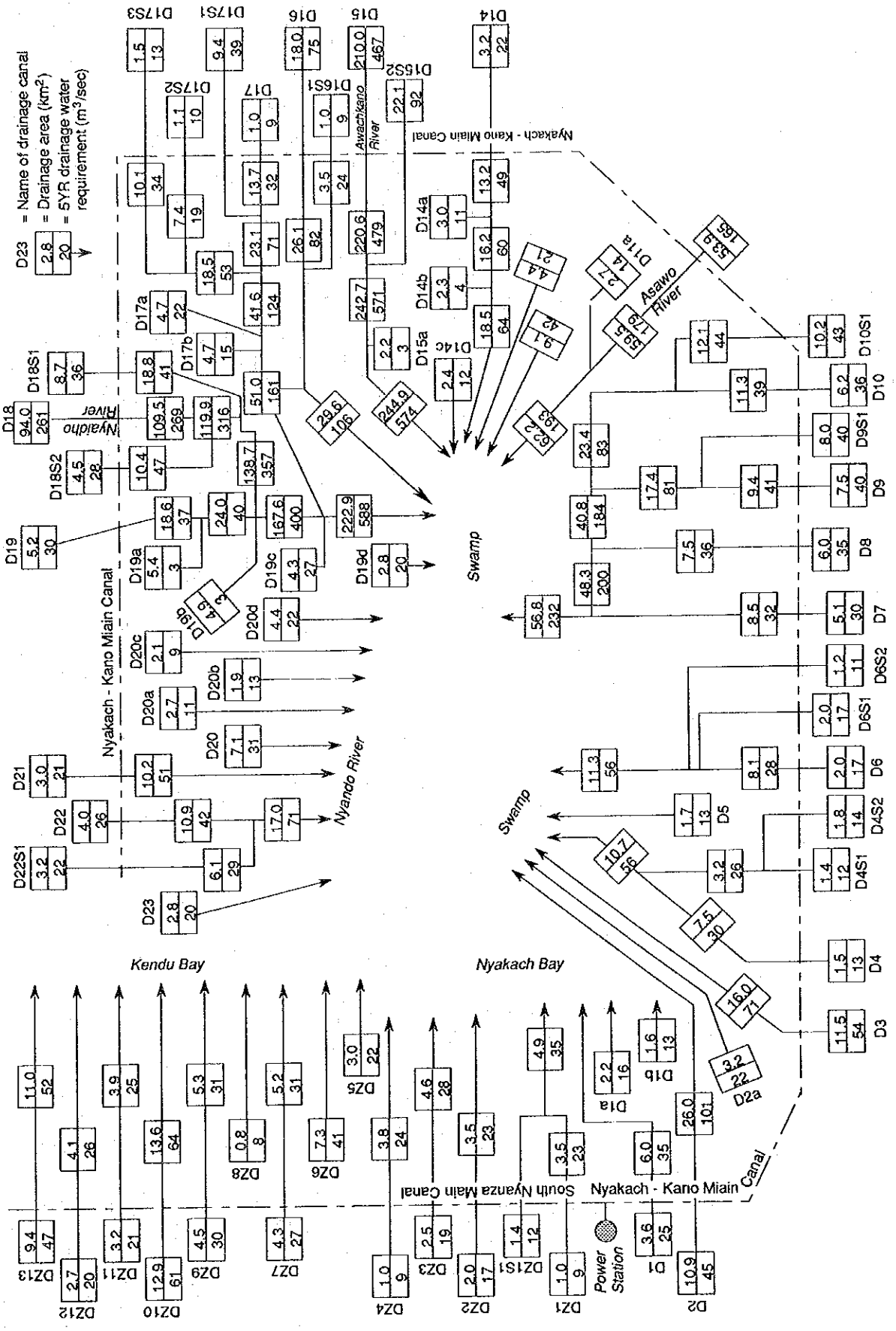


Fig. VII-19 Drainage Diagram

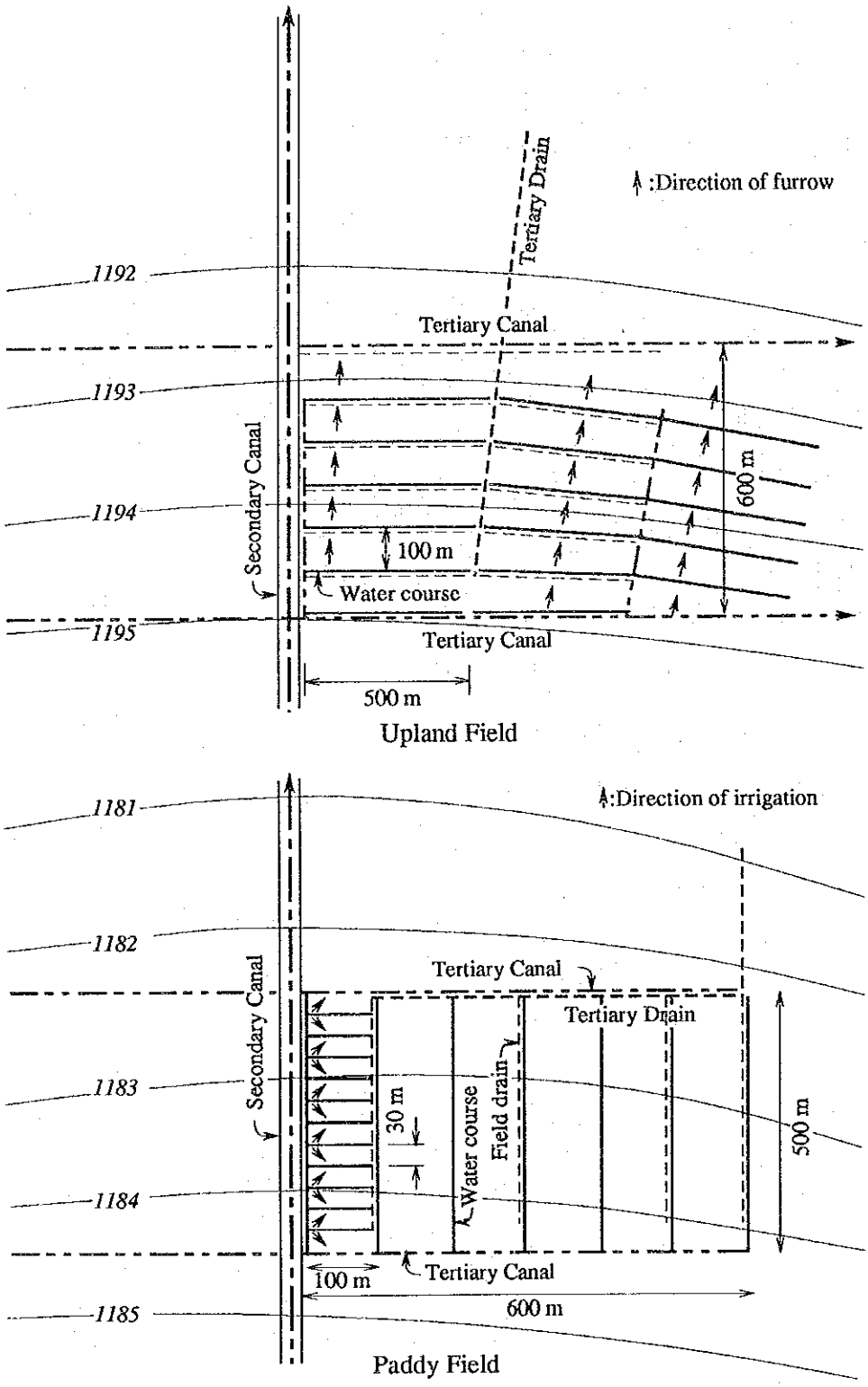


Fig. VII-20 Typical Configuration of a Tertiary System

REPUYBLIC OF KENYA KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex VIII

Construction Plan and Cost Estimate

Feasibility Study
on
Kano Plain Irrigation Project

Annex VIII
Construction Plan and Cost Estimate

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1. Construction Plan

1.1 Project Execution Time Schedule

The project is fully depend its irrigation water resources on Sondu-Miriu Hydropower Project (hereinafter called the Sondu-Miriu Project) and Magwagwa Hydroelectric Power Development Project (hereinafter called the Magwagwa Project). Construction schedule of these project should be taken into consideration in the present study. The construction work of the Sondu-Miriu Project will start in 1993 and complete middle of 1997. Detailed design work of the Magwagwa Project is considered to be started in 1993 and last to 1995. Its construction work is considered to be commenced in 1997 after loan arrangement and land acquisition. It will take five and half years. The operation of its power plant will start in 2003. Based on the above schedule, the Irrigation Project is to be constructed by stage-wise.

Available water for irrigation before construction of Magwagwa dam was estimated as shown in Table VIII-1 by using the daily discharge record at 1TG1 and mean monthly flow from the residual catchment area (Table VII-5). In the estimation, peak discharge of the power generation plants is assumed to be 39.9 m^3/sec as proposed in the Sondu-Miriu Project. Mandatory release for downstream is assumed to be 3.0 m^3/sec as described in the paragraph 3.3.1 in Annex VII Irrigation and Drainage. Diversion water requirement was estimated according to the procedure described in Annex VII. Balance between water and diversion water requirement is calculated by half-month from 1960 to 1978 as described in the paragraph 3.3.2 in Annex VII Irrigation and Drainage. The result of the water balance study is summarized as follows:

No.	Sub-areas				Total area	Nos. of season
	I	II-1	II-2a*1	II-2b*2	(ha)	of water deficit
1	-	-	2,380	-	2,380	5
2	-	-	2,380	850	3,230	7
3	600	650	2,380	850	4,480	8

*1 : II-2a consists of secondary canals from S-1 to S-8.
*2 : II-2b consists of secondary canals from S-9 to S-12.

In the above calculation Sub-area II-2 is divided into two units according to the canal system proposed. The above result was conservatively evaluated since the river flow in the Sondu would not be regulated before construction of Magwagwa dam. Eventually the area of 2,380 ha is chosen for the Phase-I development. Diversion water requirement for 2,380 ha is estimated as shown in Table VIII-2 according to the procedure described in Annex VII Irrigation and Drainage.

The remained 12,550 ha will be developed after having knowledge and experience of the operation and maintenance of irrigation facilities, water users' association and cooperatives, and irrigated agriculture in the area of Phase-I. Detailed design work will proceed the construction work of the Phase-I. Design of project facilities, preparation of tender document, environmental study, operation and maintenance plan, development of water users' association and cooperatives will be undertaken in the Detailed design stage. Irrigation area in each Phase is shown as follows:

(ha)

Phase	Sub area							
	I	II-1	II-2a	II-2b	III	I V	V	Total
I	-	-	2,380	-	-	-	-	2,380
II	600	650	-	850	2,780	-	-	4,880
III	-	-	-	-	-	4,170	3,500	7,670

The project execution time schedule is shown in Fig. VIII-1.

1.2 Construction Plan

1.2.1 Scale of the construction works

The scale of construction works are summarized as follows:

Items	Unit	Phase I	Phase II	Phase III	Total
Regulating Pond					
Excavation	x 10^3 m^3	1,070	960	-	2,030
Embankment	x 10 m^3	610	350	-	960
Reinforced Concrete	m^3	8,480	2,650	-	11,130
Irrigation Canal and Related Structure					
Excavation	x 10^3 m^3	330	1,350	1,400	3,080
Embankment	x 10 m^3	510	1,260	2,450	4,220
Reinforced Concrete	m^3	25,000	32,000	31,000	88,000
Drainage Canal and Related Structure					
Excavation	x 10^3 m^3	400	1,000	3,340	4,740
Embankment	x 10 m^3	200	610	1,910	2,720
Reinforced Concrete	m^3	41,000	74,000	138,000	253,000
Road Improvement					
Embankment and Pavement	x 10 m^3	140	280	460	880
On Farm	ha	2,380	4,880	7,670	14,930
Building	m^3	4,560	3,000	3,140	10,700

1.2.2 Workable days

Workable days are estimated as follows taking into consideration rainfall, soil condition, Sundays, and holidays.in the project area.

(days)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
22	22	22	20	19	23	23	23	24	22	22	20	262

1.2.3 Application of construction machinery and equipment

Heavy construction machineries will be used for the earth works of large volume, and manpower would be applied for small scale works. Earth works generally consist of excavation, loading and hauling, spreading and compaction. Each work is generally carried out by different machinery in the large earth works. Combination of machineries for these works will influence efficiency of the earth works. Considering the work volume and soil condition etc. the following machineries are selected.

Earth Work	Earth Materials	Proposed Equipment
Excavation	Top soil	Bulldozer
	Sand	Back-hoe shovel
	Weathered rock	Ripper dozer
	Rock	Blasting by dynamite and ripper dozer
Loading	Any kind of excavated materials	Crawler loader
		Back-hoe shovel
Hauling	Any kind of excavated materials	Damp truck
Spreading	Any kind of excavated materials	Bulldozer
		Motor grader
Compaction		Tyred roller
		Vibrating roller
		Macadam roller

Irrigation and drainage canal were made of earth. Excavation of wide space would be executed by bulldozer, and back-hoe shovel. Manpower would be adapted for the excavation of small scale work, for

example tertiary canal, ridge of paddy field, and so on. The excavation of rock would be carried out by a combination of blasting dynamite and a ripperdozer.

1.2.4 Conversion rate of earth volume

Earth volume is changeable according to the condition of soil for example, soil in the natural ground will increase its volume after excavated and decrease after compacted. These change of earth~volume should be considered in the earth moving plan. The conversion rate of earth volume was assumed as follows:

Earth Materials	in Place	Excavatcd	Embanked
Sand	1.00	1.20	0.90
Clay	1.00	1.25	0.90
Gravel	1.00	1.20	1.00
Weathered Rock	1.00	1.30	1.20
Rock	1.00	1.50	1.30

1.2.5 Earth moving plan

In principle, embankment would be made by excavated materials as far as possible taking into consideration of the cost required, effective use of natural resources, etc. Not all kind of excavated materials, however, can not be utilized for embankment due to its poor mechanical characteristics as described in ANNEX II Soil Mechanics and Engineering Geology. Black cotton soil is especially difficult to adjust its water content for adequate embankment work. Therefore, the re-useable ratio of black cotton soil is estimated at less than 50% of total excavated volume at the site.

It is necessary to excavate the Granite at in the Regulating Pond to get regulating capacity proposed. Fhe Granite excavated is suitable for pavement of road. So, the Granite excavated is to be transported from the Regulating Pond and to be used for pavement of the road in case that pavement material required is not enough from the adjacent excavation site in the Phase-I, and Phase-II. In the Phase-III, however, embankment and pavement materials are to be obtained from borrow area proposed because the distance from the borrow area to the construction site is nearer than that from the Regulating Pond.

Based on the above consideration the earth moving plan in each Sub-area are studied as shown in Table VIII-3.

1.3 Working Plan

1.3.1 Earth work

Based on earth moving plan,, the excavated materials would be sorted to materials re-used and spoiled at the excavation site. Each materials was loading by crawer loader and hauling by dump truck or cart. The water content of the embankment material should be controlled so as to keep workability and compaction effect in the embankment work. Any organic materials should not remain onto any embankment. Pavement work would be executed after compaction of embankment for road sub-base.

1.3.2 Concrete work

Concrete would be mixed by portable concrete mixer, placed by truck and manpower, and compacted by vibrators. All concrete should be cured in moist condition for a period of not less than 7 consecutive days by approved method. Forms should have sufficient strength to withstand the pressure caused by placement and vibration of the concrete.

1.3.3 Other works

Temporary drainage works would be needed in order to prevent from the surface water flowing into the on-going work site of the Regulating Pond and inverted syphons.

Gates of the irrigation facility would be installed by a truck crane.

The appurtenant structures related to the on-farm work are division boxes, field outlets, pipe culverts, drops, etc.turnout, culvert, drop, etc., which are quite small scale concrete structures.

2. COST ESTIMATE

2.1 Basic Condition

Construction cost is calculated based on the following conditions:

(1) Unit costs are calculated based on the market prices in Kenya, and were checked using "Current construction cost" issued by the Ministry of Works and Housing in September, 1990.

The unit cost of labour and materials were shown in Table XIII-6 and Table XIII-7.

(2) The exchange rate used in the calculation is as follows:

U$1.0 = Ksh. 28.0 = ¥140.0

(3) All construction works will be undertaken under the contract base. Contractors will be selected by bidding. All construction machineries and equipment are to be brought by the contractors. Only depreciation cost of machineries and equipment are taken into account.

(4) Taxes on the construction materials, machinery and equipment impored from abroad are to be exempted and not is not included in the cost estimate.

2.2 Financial Project Cost

The financial project cost was comprised of the following items.

(1) Construction cost

Construction cost is comprised with direct construction cost of facilities, cost for preparatory and temporary works, contractor's expenses. The preparatory and temporary works are assumed at about 5 to 10% of the direct construction cost. the contractor's expenss is assumed at about 20% of the direct construction cost.

(2) Operation and maintenance equipment

Price of those equipment are estimated based on the current price in Kenya. Total cost is estimated at about 44,766,000Ksh. as shown in Table VIII-8.

(3) Administration cost

Administration cost is estimated based on the required number of government staff for detailed design and construction supervision works described in the ANNEX IX. Those work will be undertaken by the Government staff with assistance and advice of the consultants. Total administration cost is estimated at Ksh.2,300,000 for detailed design work and Ksh.3,800,000 for construction supervision respectively.

(4) Land acquisition cost

About 205 ha of land will be acquired or used during the construction work. Land acquisition cost was shown in Table VIII-9.

(5) Engineering service cost

The cost for engineering service is roughly calculated the assumption that the consultants will assist and advise the Government staff in the detailed design and construction supervision. The cost is assumed at about 12% of the construction cost.

(6) Physical contingency

The physical contingency was fixed at 10% of the total for the above five items.

(7) Price contingency

The price contingency is estimated by applying the inflation rate of 2% per annum for foreign currency portion and 10% per annum for local currency portion. In the calculation assumption is made that 85% of total cost is of foreign currency and 15% is of local currency.

Summary of the Project cost is estimated at about Ksh.5,895,000 as shown in Table VIII-4. The detailed construction cost are shown in Table VIII-5.

2.3 Annual Disbursement Schedule

The annual disbursement schedule is worked out based on the construction implementation schedule. The details are shown in Table VIII-10.

2.4 Annual Operation and Maintenance Costs

The annual operation and maintenance costs were comprised with salaries of project staffs, project office expense, the materials and labour cost for repair and maintenance of project facilities and O&M equipment. The materials and labour cost for repair and maintenance of project facilities is assumed at 0.5% of the construction cost excluding preparation and on-farm works. Repair and maintenance of O&M equipment is assumed Tat 10% of the procurement cost. Total operation and maintenance cost are estimated at about 28,550,000Ksh.as shown in Table VIII-11 and Table VIII-12.

2.5 Replacement Cost

Some of the facilities, especially steel gates attached to irrigation facilities and the O&M equipment have shorter useful life than the civil works and require replacement at a certain time within the project useful life. The useful life and replacement cost of the mechanical works was shown in Table VIII-13.

Tables

Table VIII-1 Estimated Available Water from Sondu/Miriu Hydro-power Station Before Construction of Magwagwa Dam

Plant peak dischrge = 39.9 cm Mandatory release 3.0 cms
Including water from the residual basin

Year	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.	
	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last
1960	8.4	6.3	3.9	3.3	11.9	19.8	39.9	39.9	39.9	39.9	39.9	37.3	36.6	34.4	31.0	39.9	39.9	39.9	39.9	31.1	24.1	19.3	11.2	10.6
1961	5.7	2.7	2.3	1.3	1.2	2.0	4.9	9.8	19.3	24.6	14.4	12.7	13.4	8.2	21.6	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9
1962	39.9	39.9	32.8	16.1	9.8	11.1	19.5	38.4	39.9	39.9	39.9	39.9	39.9	39.9	39.9	35.0	39.9	39.9	39.9	39.9	36.3	23.8	18.1	14.3
1963	25.2	35.8	29.2	15.9	13.8	24.8	19.6	37.8	39.9	39.9	39.9	39.9	39.3	29.0	30.2	39.9	39.9	21.5	10.4	7.1	6.7	14.3	39.9	39.9
1964	39.1	19.8	11.9	10.4	29.9	18.1	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	26.5	14.6	9.2	9.0
1965	9.7	5.7	4.9	2.5	1.0	1.6	5.5	31.4	39.9	39.9	28.5	14.5	11.6	15.0	13.1	15.6	18.2	12.0	6.7	12.1	32.2	28.9	20.6	20.5
1966	10.8	6.8	8.5	9.6	13.2	36.9	39.9	39.9	39.9	39.9	26.9	37.7	22.5	27.5	19.4	25.7	39.9	39.9	28.5	17.1	20.7	21.9	12.1	7.3
1967	4.5	3.5	2.6	0.6	0.5	1.2	10.4	24.5	39.9	39.9	39.9	39.9	39.9	39.9	39.9	32.4	35.6	24.1	15.7	14.6	16.4	22.7	39.9	39.9
1968	17.3	9.5	8.2	21.5	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	31.7	17.4	14.4	17.7	29.3	39.9	39.9
1969	20.9	21.5	35.8	32.5	35.0	34.5	31.9	25.2	33.9	37.9	23.2	21.2	15.7	8.6	10.1	19.7	25.3	37.1	14.6	9.6	6.7	7.7	5.8	2.9
1970	7.1	17.0	25.2	16.1	25.2	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	37.9	39.9	39.9	39.9	39.9	39.9	39.9	31.7	19.9	12.0	7.6
1971	6.9	9.5	5.3	3.0	2.2	1.6	3.2	14.6	37.0	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	34.4	18.6	11.3	8.8	7.4
1972	9.5	6.3	6.9	6.7	5.3	4.6	4.1	6.2	17.5	39.9	39.9	39.9	39.9	39.9	36.1	39.9	31.8	18.7	12.7	23.2	39.9	39.9	39.9	32.2
1973	22.3	39.9	24.0	37.5	25.3	11.9	6.5	14.0	28.7	33.0	39.9	39.9	37.0	23.3	36.7	39.9	39.9	39.9	39.5	24.0	27.4	30.5	14.2	8.4
1974	5.7	3.4	1.5	2.1	2.8	3.4	38.1	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	35.5	28.9	16.6	10.5	7.0
1975	4.2	3.0	2.2	1.2	1.5	4.1	4.7	36.3	25.8	34.3	39.9	39.9	32.8	39.7	39.9	39.9	39.9	39.9	39.9	39.9	39.9	24.8	15.6	9.2
1976	6.9	6.1	3.0	4.2	2.8	2.6	4.4	7.5	12.5	29.0	39.9	36.7	39.9	39.9	39.9	39.9	39.9	39.9	25.1	15.3	9.5	8.5	7.2	6.2
1977	8.4	10.3	29.2	13.9	13.0	10.7	36.1	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	25.8	23.9	39.9	39.9	39.9	39.9
1978	26.8	28.7	18.1	27.5	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.8	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	39.9	33.5	22.8	30.7
Average	14.7	14.5	13.4	11.9	14.4	16.2	22.5	29.7	34.4	37.8	36.4	35.7	34.1	32.8	33.5	36.1	37.3	34.9	29.2	26.4	26.5	23.5	21.4	19.6
Minimum	4.2	2.7	1.5	0.6	0.5	1.2	3.2	6.2	12.5	24.6	14.4	12.7	11.6	8.2	10.1	15.6	18.2	12.0	6.7	7.1	6.7	7.7	5.8	2.9

Table VIII-2 Diversion Water Requirement in Phase 1

Cropping pattern	Area (ha)
LrPaddy/Beans	33
Maize-1/SrPaddy	0
Maize-1/Groundnut	0
Maize-1/Greengram	0
Vegetable	827
Maize-2/cotton	380
Maize-3/Greengram	380
Sugarcane	0
Napiar and other grass land	225
Passion fruit	534
Total	2379

Diversion Water Requirement by Year

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.	
Year	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last	First	Last
1960	1.3	1.5	1.6	1.8	1.9	1.4	1.5	1.1	0.9	1.2	1.6	1.4	1.1	1.4	2.0	2.3	2.4	3.0	3.0	2.3	2.4	2.0	2.4	2.0
1961	1.2	1.4	1.7	2.0	1.9	1.5	1.7	1.2	0.7	1.0	1.6	1.4	1.0	1.4	1.2	1.2	1.5	1.9	2.0	1.7	0.2	0.1	0.2	0.2
1962	1.0	1.2	1.9	1.8	2.0	1.1	1.5	1.8	0.2	0.5	1.5	0.5	0.8	1.3	1.6	1.7	1.5	2.1	2.1	1.7	2.3	1.2	1.7	0.9
1963	1.0	1.3	1.5	2.0	1.6	1.5	1.8	0.3	0.7	0.6	1.5	1.5	0.8	1.4	1.5	1.8	2.1	2.3	2.5	2.2	2.0	0.8	0.8	1.0
1964	1.2	1.5	1.6	1.8	1.9	2.3	1.7	0.3	1.7	1.8	1.5	0.9	0.6	1.3	1.5	1.5	1.8	1.2	2.1	1.9	2.3	2.1	1.5	1.2
1965	1.4	1.5	1.8	2.1	2.3	2.2	1.5	0.8	1.2	1.8	1.5	1.5	1.0	1.4	1.6	1.8	2.0	2.3	2.3	1.7	2.0	1.7	1.8	1.3
1966	1.4	1.4	1.8	1.4	2.1	0.9	2.0	1.1	1.8	1.6	1.3	1.5	1.0	1.4	1.6	1.1	1.5	2.1	2.3	2.2	1.8	2.1	1.7	1.4
1967	1.4	1.5	1.6	2.1	2.1	1.8	0.7	1.2	1.2	1.3	1.6	0.2	0.7	1.2	1.4	1.7	2.0	2.1	2.3	2.0	2.0	0.8	1.1	1.2
1968	1.4	1.4	1.5	1.5	1.6	2.2	1.5	0.2	1.1	1.3	1.5	1.4	0.6	1.4	1.1	1.4	1.8	2.4	2.3	1.9	1.8	1.5	1.3	1.6
1969	1.3	1.0	1.4	1.8	2.1	0.8	2.0	1.7	0.9	0.5	1.2	1.5	1.1	1.3	1.5	1.7	1.6	2.3	1.3	1.9	2.1	1.4	1.7	1.4
1970	1.3	1.3	1.6	1.8	1.5	1.4	1.8	1.1	1.3	2.0	1.3	1.3	0.9	1.3	1.4	1.4	1.7	2.4	2.5	2.0	2.1	1.8	1.1	1.0
1971	1.3	1.4	1.9	2.1	2.3	2.3	2.0	1.1	0.9	1.8	1.2	1.3	0.9	1.4	1.5	1.7	2.0	1.9	2.1	2.0	2.0	1.8	1.8	1.4
1972	1.0	1.4	1.6	2.0	1.8	2.5	2.5	1.7	1.8	1.5	1.3	1.4	1.3	1.4	1.4	1.4	1.2	1.9	2.3	1.7	0.9	2.0	1.8	1.4
1973	1.0	1.5	1.7	2.0	2.3	2.5	1.3	1.2	0.3	1.5	0.7	1.3	1.3	1.5	1.1	1.5	2.0	2.3	2.5	2.2	1.8	1.8	1.5	1.2
1974	1.2	1.5	1.8	2.1	2.1	1.6	0.9	1.9	1.1	0.6	1.5	1.3	1.2	1.4	1.3	1.4	1.3	1.9	2.5	1.9	2.1	2.0	2.0	1.1
1975	1.4	1.5	1.5	2.1	1.5	1.4	1.4	1.7	0.8	1.2	1.2	1.1	1.2	1.3	1.2	1.2	1.2	1.6	2.0	1.7	2.1	2.0	1.7	1.3
1976	1.0	1.4	1.6	1.9	2.3	2.5	2.0	1.5	1.2	1.5	1.6	1.4	0.7	1.3	1.4	1.4	1.7	2.1	2.5	2.2	1.8	1.4	0.7	0.7
1977	0.7	0.8	1.6	1.8	2.0	1.6	0.6	0.1	0.5	0.9	1.2	1.0	1.1	1.4	1.4	1.5	1.8	2.3	1.6	1.2	1.0	0.5	1.7	1.3
1978	1.1	1.2	1.5	1.7	1.6	0.9	1.4	0.8	1.3	1.6	1.7	1.5	0.7	1.3	1.4	1.5	1.8	2.3	2.5	2.2	1.8	1.4	1.8	1.4
Average 1.5	1.2	1.3	1.6	1.9	1.9	1.7	1.6	1.1	1.0	1.3	1.4	1.2	0.9	1.3	1.4	1.5	1.7	2.1	2.2	1.9	1.8	1.5	1.5	1.2

Table VIII-3 (1) Earth Moving Plan (Sub-area-I)

(unit: m3)

Description	Total	Secondary Irrigation Canal		Drainage Canal	Bank	Road Improvement		Spoil Area
		Embankment (101,400)	Pavement (3240)	Embankment (35,160)	Embankment (240,000)	Embankment (23,800)	Pavement (11,900)	
Secondary Irrigation Canal								
Top Soil	68,000							68,000
Sand		(19,890)						
	22,100	22,100						
Drainage Canal								
Sand		(9170)		(24,040)				
	36,900	10,190		26,710				
Weathered Rock			(3,240)	(11,120)				
	15,800		2,700	9,270				
SubArea II2(b)								
Sand		(21,640)			(199,900)	(11,900)		
	259,370	24,040			222,110	13,220		
Weathered Rock		(50,700)			(1870)			
	43,810	42,250			1,560			
Rock					(38,280)	(7,300)	(11,900)	
	44,640				29,410	6,080	9,150	

Remark:
Figure in the brakets is a volume designed.

Table VIII-3 (2) Earth Moving Plan (Sub-area-II-1)

(unit: m3)

Description	Total	Main Irrigation Canal		Canal from R/P to M/C			Secondary Irrigation Canal		Drainage Canal	Road Improvement		Spoil Area
		Embankment (114,600)	Pavement (2,360)	Embankment (5,250) (w. rock)	Embankment (3,300) (sand)	Pavement (1,770)	Embankment (54,400)	Pavement (1,700)	Embankment (35,200)	Embankment (25,700)	Pavement (11,900)	
Main Irrigation Canal												
Top Soil	76,400											76,400
Sand		(32,310)										
	35,900	35,900										
Weathersed Rock		(35,680)	(2,360)									
	31,700	29,730	1,970									
Rock		(29,690)					(27,200)	(1,700)		(2,640)		
	47,100	22,840					20,920	1,310		2,030		
Canal from R/P to M/C												
Top Soil	2,200											2,200
Sand					(3,300)							
	5,200				3,470							1,730
Weathersed Rock												
Rock				(5,250)		(1770)						
	5,400			4,040		1,360						
Secondary Irrigation Canal												
Top Soil	36,500											36,500
Sand							(10,620)					
	11,800						11,800					
Drainage Canal												
Sand		(16,980)							(17,600)	(12,850)		
	52,700	18,870							19,550	14,280		
Weathered Rock									(17,600)	(10,210)	(11,900)	
	36,900								14,670	8,510	9,920	
SubArea II2(b)												
Sand							(11,980)					
	13,310						13,310					

Source : Prepared by JICA Study Team

Table VIII-3 (3) Earth Moving Plan (3) Sub-area II-2a

(unit: m3)

Description	Total Excavation	Main Irrigation Canal			Reguration Pond			Canal from R/P to M/C			Canal from P/S to R/P		Raod Improvement		Drainage Canal		Secondary Irrigation Canal		Spoil Area
		Embank-ment (71,500)	Pave-ment (3,300)	Clay (2,000)	Embank-ment (573,200)	Pirprap (13,100)	Pave-ment (4,700)	Embank-ment (16,340)	Pave-ment (8,900)	Pave-ment (2,200)	Backfill (4,300)	Pave-ment (700)	Embank-ment (94,200)	Pave-ment (47,100)	Embank-ment (188,600)	Pave-ment (15,800)	Embank-ment (299,500)	Pave-ment (9,600)	
Main Irrigation Canal																			
Top Soil	123,600																		
Sand		(37,750)																	123,600
	236,400	39,720															(167,440)		
Clay				(2,000)													186,040		10,640
	43,150			2,200													(36,840)		
Black Cottom Soi	29,500																40,930		
Weathered Rock		(35,750)	(3,300)																29,500
	32,600	29,790	2,750																
Regulation Pond																			60
Top Soil	102,100																		
Sand					(46,750)														102,100
	397,600				51,940														
Weathered Rock					(185,100)		(4,700)					(700)	(47,100)		(55,440)				345,660
	244,200				154,250		3,920					580	39,250		46,200				
Rock					(341,350)	(13,100)													
	273,500				262,580	10,920													
Canal from R/P to M/C																			
Top Soil	3,400																		
Sand									(8,900)										3,400
	16,800								9,890										
Weathered Rock								(1,910)		(2,200)									6,910
	10,800							1,590		1,830								(9,600)	
Canal from P/S to R/P																		7,380	
Top Soil	2,500																		
Sand											(4,300)								2,500
	12,200										4,780								
Weathered Rock																			7,420
Rock								(14,430)											
	11,100							11,100											
Drainage Canal																			
Sand													(47,100)		(94,300)		(36,810)		
	198,000												52,330		104,780		40,900		
Weathered Rock														(47,100)	(38,860)	(15,800)			
	84,800													39,250	32,380	13,170			
Secondary Irrigation Canal																			
Top Soil	201,100																		
Sand																			201,100
	64,900																(58,410)		
																	64,900		

Source : Prepared by JICA Study Team

Table VIII-3 (4) Earth Moving Plan (4) Sub-area II-2b

(unit: m3)

Description	Total Excavation	Main Irrigation Canal			Secondary Irrigation Canal		Regulation Pond			Drainage Canal		Road Improvement		SubArea			Spoil Area
		Embankment	Pavement	Clay	Embankment	Pavement	Embankment	Pirprap	Pavement	Embankment	Pavement	Embankment	Pavement	I	II-2	III	
		(68,400)	(2,000)	(28,800)	(107,000)	(3,420)	(335,320)	(13,200)	(4,800)	(71,300)	(6,000)	(33,700)	(16,800)				
Main Irrigation Canal																	
Top Soil	73,700																73,700
Sand		(34,200)		(2,070)	(21,240)												
	63,900	38,000		2,300	23,600												
Clay				(26,730)													
	29,700			29,700													
Black Cotton Soil	65,300																65,300
Weathered Rock	400																400
Secondary Irrigation Canal																	
Top Soil	71,800																
Sand					(20,880)												71,800
	23,200				23,200												
Regulation Pond																	
Top Soil	102,200																102,200
Sand							(46,800)										
	397,700						52,000							259,370	18,420		67,910
Weathered Rock		(34,200)			(64,880)	(3,420)	(46,800)		(4,800)		(6,000)	(16,850)	(16,800)				
	244,300	28,500			54,070	2,850	39,000		4,000		5,000	14,040	14,000	43,810		39,030	
Rock							(239,720)	(13,200)									
	273,600						184,400	10,150						47,710		31,340	
Drainage Canal																	
Sand										(35,650)		(16,850)					
	74,900									39,610		18,720					16,570
Weathered Rock			(2,000)							(35,650)							
	32,100		1,670							29,710							720

Table VIII-3 (5) Earth Moving Plan (5) Sub-area III

(unit: m3)

Description	Total Excavation	Main Irrigation Canal			Secondary Irrigation Canal		Drainage Canal			Road Improvement		Spoil Area
		Embankment	Pavement	Clay	Embankment	Pavement	Embankment		Pavement	Embankment	Pavement	
		(41,700)	(2,340)	(3,300)	(390,700)	(13,620)	(194,300)		(17,000)	(110,100)	(55,000)	
Main Irrigation Canal												
Top Soil	74,500											74,500
Sand		(20,850)			(139,610)					(7,840)		
	187,000	23,170			155,120					8,710		
Clay				(3,300)	(24,330)							
	30,700			3,670	27,030							
Black Cotton Soil					(10,410)							
	25,700				12,850							12,850
Weathered Rock												
Secondary Irrigation canal												
Top Soil	282,000											282,000
Sand					(52,830)							
	58,700				58,700							
Drainage Canal												
Sand					(161,910)		(97,150)			(47,210)		
	340,300				179,900		107,940			52,460		
Weathered Rock		(3,560)	(2360)				(97,150)		(17,000)		(55,000)	
	145,900	2,970	1,970				80,960		14,170		45,830	
SubArea II2(b)												
Weathered Rock										(46,840)		
	39,030									39,030		
Rock		(17,290)			(1,610)	(13,620)				(8,210)		
	31,340	13,300			1,240	10,480				6,320		

Source : Prepared by JICA Study Team

Table VIII-3 (6) Earth Moving Plan Sub-area IV

(unit: m3)

Description	Total Excavation	Main Irrigation Canal			Drainage Canal		Secondary Irrigation Canal		Road Improvement		Spoil Area
		Embankment	Pavement	Clay	Embankment	Pavement	Embankment	Pavement	Embankment	Pavement	
		(610,800)	(5,230)	(19,080)	(1,244,800)	(33,000)	(440,500)	(15,360)	(165,100)	(82,600)	
Main Irrigation Canal											
Top Soil	196,000										196,000
Sand		(63,000)		(10,620)							
	81,800	70,000		11,800							
Clay				(8,460)							
	9,400			9,400							
Black Cotton Soil							(10,400)				
	23,100						11,550				11,550
Weathered Rock		(65,930)	(5,230)								
	59,300	54,940	4,360								
Drainage Canal											
Sand		(242,400)			(688,240)		(163,140)		(82,550)		
	1,307,000	249,300			264,710		181,270		91,720		
Weathered Rock					(556,560)	(33,000)				(82,600)	
	560,100				463,800	27,500				68,800	
Secondary Irrigation Canal											
Top Soil	317,900										317,900
Sand							(59,670)				
	66,300						66,300				
Borrow Area 3											
Top Soil	363,100										363,110
Gravel		(239,490)					(207,290)	(15,360)	(82,550)		
	544,670	239,470					207,290	15,360	82,550		

Table VIII-3 (7) Earth Moving Plan Sub-area V

(unit: m3)

Description	Total Excavation	Main Irrigation Canal			Drainage Canal		Secondary Irrigation Canal		Road Improvement		Spoil Area
		Embankment	Pavement	Clay	Embankment	Pavement	Embankment	Pavement	Embankment	Pavement	
		(285,100)	(4,370)	(17,800)	(603,500)	(23,900)	(493,000)	(17,190)	(138,600)	(69,300)	
Main Irrigation Canal											
Top Soil	137,800										137,800
Sand		(7,560)									
	8,400	8,400									
Clay											
Black Cotton Soil				(8,900)			(24,030)				
	53,400			9,900			26,700				16,800
Weathered Rock		(10,750)	(4,370)								
	12,600	8,960	3,640								
Drainage Canal											
Sand					(293,950)		(368,160)		(47,580)		
	726,500				266,560		409,070		52,870		
Weathered Rock					(309,550)	(23,900)				(40,220)	
	311,400				257,960	19,920				33,520	
Secondary Irrigation Canal											
Top Soil	355,800										355,800
Sand							(16,780)				
	74,200						74,200				
Borrow Area 3											
Top Soil	79,460										79,460
Gravel		(110,290)		(8,900)							
	119190	110,290		8,900							
Borrow Area 4											
Top Soil	192,730										192,730
Gravel		(156,500)					(34,030)	(17,190)	(91,020)	(29,080)	
	327,820	156,900					34,030	17,910	91,020	29,080	

Source : Prepared by JICA Study Team

TableVIII-4 Summary of the Project Cost

(Ks. million)

		Detailed design			Phase I			Phase II			Phase III			Project as a whole		
		L/C	F/C	Total	L/C	F/C	Total	L/C	F/C	Total	L/C	F/C	Total	L/C	F/C	Total
1.	Construction Cost															
	Preparation				20.5	23.6	44.1	37.5	47.7	85.2	52.9	63.2	116.1	110.9	134.5	245.4
	Regulating Pond				49.9	114.5	164.4	30.3	76.3	106.6	0.0	0.0	0.0	80.2	190.8	271.0
	Irrigation Facility				73.2	74.2	147.4	126.9	186.3	313.2	136.4	276.5	412.9	336.5	537.0	873.5
	Drainage facility				110.5	76.2	186.7	247.5	235.7	483.2	418.2	363.9	782.1	776.2	675.8	1,452.0
	Road Improvement				2.8	10.0	12.8	9.1	33.9	43.0	9.8	35.2	45.0	21.7	79.1	100.8
	On-farm				17.6	18.4	36.0	53.6	62.2	115.8	94.8	112.4	207.2	166.0	193.0	359.0
	Office and Quarter				6.0	6.0	12.0							5.6	5.9	11.5
	Sub-Total	0.0	0.0	0.0	280.5	322.9	603.4	504.9	642.1	1,147.0	712.1	851.2	1,563.3	1,497.1	1,816.1	3,313.2
2.	O & M Equipment	0.3	3.5	3.8	3.7	37.0	40.7	0.0	0.0	0.0	0.0	0.0	0.0	4.0	40.5	44.5
3.	Administration Cost	4.6	0.0	4.6	15.2	0.0	15.2	7.5	0.0	7.5	11.5	0.0	11.5	38.8	0.0	38.8
4.	Engineering Cost	3.4	135.6	139.0	5.3	212.7	218.0	40.1	60.0	100.1	50.0	60.0	110.0	98.8	468.3	567.1
5.	Land Acquisition	1.0	0.0	1.0	3.0	0.0	3.0	4.0	0.0	4.0	0.0	0.0	0.0	8.0	0.0	8.0
	Sub-Total	9.3	139.1	148.4	307.7	572.6	880.3	556.5	702.1	1,258.6	773.6	911.2	1,684.8	1,647.1	2,325.0	3,972.1
6.	Physical Contingency	0.6	0.3	0.9	30.2	36.0	66.2	51.6	64.2	115.8	72.4	85.1	157.5	154.8	185.6	340.4
	Sub-Total	9.9	139.4	149.3	337.9	608.6	946.5	608.1	766.3	1,374.4	846.0	996.3	1,842.3	1,801.9	2,510.6	4,312.5
	L/C=0.15*Total cost															
	F/C=0.85*Total cost	9.9	139.4	149.3	142.0	804.5	946.5	206.2	1,168.2	1,374.4	276.3	1,566.0	1,842.3	634.4	3,678.1	4,312.5
7.	Price Contingency	1.8	0.2	2.0	95.5	67.7	163.2	271.3	245.1	516.4	442.8	376.8	819.6	811.4	689.8	1,501.2
	Total	11.7	139.6	151.3	237.5	872.2	1,109.7	477.5	1,413.3	1,890.8	719.1	1,942.8	2,661.9	1,445.8	4,367.9	5,813.7

L/C : Local Currency
F/C : Foreign Currency

Source : Prepared by JICA Study Team

Table VIII -5 (1) Detailed Construction Cost

---------- Regulating Pond ----------

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area II-1	(Phase II)			
	Canal from Pond to M/C			
	Earth Works	508	1,613	2,121
	Concrete Works	5,603	2,940	8,543
	Total	6,111	4,553	10,664
Sub-Area II-2a	(Phase I)			
	Earth Works	28,269	93,610	121,879
	Outlet Structures	2,364	4,536	6,900
	Canal from R/P to M/C			
	Earth Works	403	1,519	1,922
	Concrete Works	13,643	8,879	22,522
	Canal from P/S to R/P			
	Earth Works	966	3,107	4,073
	Concrete Works	4,194	2,883	7,077
	Total	49,839	114,534	164,373
Sub-Area II-2b	(Phase II)			
	Earth Works	22,016	70,007	92,023
	Outlet Structures	2,168	1,753	3,921
	Total	24,184	71,760	95,944
	Total	80,134	190,847	270,981

Source : Prepared by JICA Study Team

Table VIII-5 (2) Detailed Construction Cost

Irrigation Facility

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area I	(Phase II)			
	Secondary Canals			
	Earth Works	7,177	26,063	33,240
	Related Structures	16,945	11,776	28,721
	Tertiary Canals			
	Earth Works	360	747	1,107
	Related Structures	1,584	993	2,577
	Total	26,066	39,579	65,645
Sub-Area II-1	(Phase II)			
	Main Canals			
	Earth Works	5,335	17,492	22,827
	Related Structure	14,034	10,911	24,945
	Secondary Canals			
	Earth Works	1,455	5,381	6,836
	Related Structures	4,219	3,362	7,581
	Tertiary Canals			
	Earth Works	371	747	1,118
	Related Structures	1,714	1,074	2,788
	Total	27,128	38,967	66,095
Sub-Area II-2a	(phase I)			
	Main Canals			
	Earth Works	3,725	14,030	17,755
	Related Structures	33,986	21,600	55,586
	Secondary Canals			
	Earth Works	7,089	15,291	22,380
	Related Structures	20,662	16,641	37,303
	Tertiary Canals			
	Earth Works	1,360	2,751	4,111
	Related Structures	6,283	3,934	10,217
	Total	73,105	74,247	147,352

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area II-2b	(phase II)			
	Ms			
	Earth Works	3,889	12,343	16,232
	Related Structures	12,798	8,234	21,032
	Secondary Canals			
	Earth Works	2,453	9,077	11,530
	Related Structures	7,350	5,922	13,272
	Tertiary Canals			
	Earth Works	492	1,002	1,494
	Related Structures	2,242	1,403	3,645
	Total	29,224	37,981	67,205
Sub-Area III	(phase II)			
	Main Canals			
	Earth Works	2,440	8,895	11,335
	Related Structures	11,507	7,571	19,078
	Secondary Canals			
	Earth Works	9,293	34,389	43,682
	Related Structures	12,890	10,244	23,134
	Tertiary Canals			
	Earth Works	2,018	4,386	6,404
	Related Structures	6,332	4,348	10,680
	Total	44,480	69,833	114,313
Sub-Area IV	(phase III)			
	Main Canals			
	Earth Works	15,767	56,587	72,354
	Related Structure	11,359	7,313	18,672
	Secondary Canals			
	Earth Works	13,050	48,778	61,828
	Related Structures	15,960	12,588	28,548
	Tertiary Canals			
	Earth Works	2,994	6,526	9,520
	Related Structures	9,343	6,411	15,754
	Total	68,473	138,203	206,676
Sub-Area V	(phase III)			
	Main Canals			
	Earth Works	15,431	53,512	68,943
	Related Structure	11,274	7,736	19,010
	Secondary Canals			
	Earth Works	14,147	52,919	67,066
	Related Structures	16,349	12,982	29,331
	Tertiary Canals			
	Earth Works	2,577	5,586	8,163
	Related Structures	8,127	5,578	13,705
	Total	67,905	138,313	206,218
	Total	336,381	537,123	873,504

Source : Prepared by JICA Study Team

Table VIII-5 (3) Detailed Construction Cost

Drainage Facility

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area I	(Phase II)			
	Main and Secondary Drains			
	Earth Works	562	1,944	2,506
	Related Structures	26,466	17,129	43,595
	Tertiary Drains			
	Tertiary Drains	1,652	225	1,877
	Sondu River Bank			
	Sundu River Bank	15,998	67,387	83,385
	Total	44,678	86,685	131,363

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area II-1	(Phase II)			
	Main and Secondary Drains			
	Earth Works	782	2,811	3,593
	Related Structures	33,901	21,072	54,973
	Tertiary Drains			
	Tertiary Drains	1,808	253	2,061
	Total	36,491	24,136	60,627
Sub-Area II-2a	(Phase I)			
	Main and Secondary Drains			
	Earth Works	2,950	10,202	13,152
	Related Structures	100,758	65,094	165,852
	Tertiary Drains			
	Tertiary Drains	6,655	927	7,582
	Total	110,363	76,223	186,586
Sub-Area II-2b	(Phase II)			
	Main and Secondary Drains			
	Earth Works	1,574	5,846	7,420
	Related Structures	38,972	25,138	64,110
	Tertiary Drains			
	Tertiary Drains	2,374	337	2,711
	Total	42,920	31,321	74,241
Sub-Area III	(Phase II)			
	Main and Secondary Drains			
	Earth Works	5,873	22,547	28,420
	Related Structures	107,120	69,430	176,550
	Tertiary Drains			
	Tertiary Drains	10,209	1,825	12,034
	Total	123,202	93,802	217,004
Sub-Area IV	(Phase III)			
	Main and Secondary Drains			
	Earth Works	26,391	98,478	124,869
	Related Structures	247,861	153,983	401,844
	Tertiary Drains			
	Tertiary Drains	15,071	2,695	17,766
	Total	289,323	255,156	544,479
Sub-Area V	(Phase III)			
	Main and Secondary Drains			
	Earth Works	11,203	34,760	45,963
	Related Structures	112,496	71,632	184,128
	Tertiary Drains			
	Tertiary Drains	5,088	2,330	7,418
	Total	128,787	108,722	237,509
	Total	775,764	676,045	1,451,809

Source : Prepared by JICA Study Team

Table VIII-5 (4) Detailed Construction Cost

---------- Road Improvement ----------

Item		Local Currency	Foreign Currency	Total
Sub-Area I	(Phase II)	2,632	10,457	13,089
Sub-Area II-1	(Phase II)	734	2,658	3,392
Sub-Area I I-2a	(Phase I)	2,759	9,990	12,749
Sub-Area II-2b	(Phase II)	986	3,570	4,556
Sub-Area III	(Phase II)	4,798	17,086	21,884
Sub-Area IV	(Phase III)	4,587	16,428	21,015
Sub-Area V	(Phase III)	5,249	18,835	24,084
	Total	21,745	79,024	100,769

Source : Prepared by JICA Study Team

Table VIII-5 (5) Detailed Construction Cost

---------- On-farm ----------

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area I	(Phase II)	7,488	8,892	16,380
Sub-Area II-1	(Phase II)	4,680	4,875	9,555
Sub-Area II-2a	(Phase I)	17,572	18,454	36,026
Sub-Area II-2b	(Phase II)	7,136	7,784	14,920
Sub-Area III	(Phase II)	34,272	40,614	74,886
Sub-Area IV	(Phase III)	55,104	66,045	121,149
Sub-Area V	(Phase III)	39,720	46,380	86,100
	Total	165,972	193,044	359,016

Source : Prepared by JICA Study Team

Table VIII-5 (6) Detailed Construction Cost

---------- Office and Quarters ----------

(Unit : ksh 1,000)

Item		Local Currency	Foreign Currency	Total
Sub-Area I	(Phase II)	600	650	1,250
Sub-Area II-1	(Phase II)	70	70	140
Sub-Area II-2a	(Phase I)	2,600	2,700	5,300
Sub-Area II-2b	(Phase II)	70	70	140
Sub-Area III	(Phase II)	800	850	1,650
Sub-Area IV	(Phase III)	750	750	1,500
Sub-Area V	(Phase III)	760	800	1,560
	Total	5,650	5,890	11,540

Source : Prepared by JICA Study Team

Table VIII-6 Wage of Labour

(Unit : Ksh)

Description	Unit	Local Currency	Foreign Currency	Total
Forman A	man.day	190	-	190
Forman B	man.day	140	-	140
Common Labour	man.day	90	-	90
Skilled Labour	man.day	150	-	150
Operator A	man.day	180	-	180
Operator B	man.day	150	-	150
Driver A	man.day	160	-	160
Driver B	man.day	140	-	140
Carpenter	man.day	150	-	150
Mason	man.day	150	-	150
Plasterer	man.day	150	-	150
Plumber	man.day	150	-	150
Power Operater	man.day	160	-	160
Mechanic A	man.day	190	-	190
Mechanic B	man.day	130	-	130
Welder	man.day	150	-	150
Painter	man.day	150	-	150
Concrete Worker	man.day	110	-	110
Reinforce Worker	man.day	150	-	150

Source : Prepared by JICA Study Team

Table VIII-7 Cost of Materials

(Unit : ksh)

Description	Uint	Local Currency	Forign Currency	Total
Gasoline	lit	7.6	-	7.6
Light Oil	lit	-	-	6.7
Portland Cement	kg	1	1	2.16
Asphalt Mixture	ton	3,588	2,392	5,980
Sand	m3	440	-	440
Aggregate	m3	288	72	360
Crusher-run	m3	280	70	350
Chipping	m3	296	74	370
Gravel . Cobble	m3	216	54	270
Reinforced Bar	kg	4.7	11.1	15.8
Mild Steel (Channel)	kg	5	11.8	16.8
Mild Steel (Angle)	kg	4.7	11.1	15.8
Steel Pipe	kg	5.7	13.3	19.0
Nail	kg	6	15	21
Binding Wire	kg	13	24	37
Gabion Box (2.0*1.0*1.0)	PC	174	406	580
Gabion Box (2.0*1.0*0.5)	PC	117	273	390
Dynamite	kg	42	78	120
AN-FO Power	kg	14	26	40
Detonater	pcs	7	13	20
Timber 50*50	ton	3,460	-	3,460
Timber 125*50	ton	440	-	4,040
Timber 225*50	ton	5,390	-	5,390
Timber 100*100	ton	3,470	-	3,470
Timber 300*100	ton	4,810	-	4,810
Plywood Panel	m3	13,770	19,584	15,300
Concrete Pipi D=600	m	480	320	800
Concrete Pipi D=900	m	900	600	1,500
Concrete Pipi D=1200	m	1,500	1,000	2,500

Source : Prepared by JICA Study Team

Table VIII-8 Procurement Cost of Operation and Maintenance Equipment

(unit: Ksh x 1000)

	Item	Unit	Q'ty	Local currency Unit cost	Local currency Amount	Foreign currency Unit cost	Foreign currency Amount	Total
(1)	Heavy equipment							
	1 Backhoe shovel, 0.35m3	nos.	3	205	615	2,075	6,225	6,840
	2 - ditto - 0.6m3	nos.	1	306	306	3,094	3,094	3,400
	3 Bulldozer, 11t	nos.	1	270	270	2,730	2,730	3,000
	4 Wheeled loader ,1.2m3	nos.	1	135	135	1,365	1,365	1,500
	5 Mortor grader, 3.7m	nos.	2	270	540	2,730	5,460	6,000
	6 Raod roller, 5t	nos.	1	108	108	1,092	1,092	1,200
	7 Lorry, 12t	nos.	2	148	296	1,495	2,990	3,286
	8 Fuel tanker, 8t	nos.	1	134	134	1,353	1,353	1,487
	9 Dump truck, 8t	nos.	2	121	242	1,340	2,680	2,922
	10 Dump truck, 4t	nos.	1	60	60	610	610	670
	11 Cargo truck 6ton	nos.	5	59	295	650	3,250	3,545
	12 - ditto - with 2t crane	nos.	2	88	176	980	1,960	2,136
	13 Pick up truck 1t	nos.	5	23	115	232	1,160	1,275
	14 Jeep	nos.	4	45	180	455	1,820	2,000
	15 Station wagon (4WD)	nos.	4	27	108	273	1,092	1,200
	16 Motor cycle	nos.	15	4	60	40	600	660
	17 bicycle	nos.	30	5	150		0	150
	18 Vibrating plate, 3PS	nos.	2	4	8	40	80	88
	19 Concrete mixer, 0.12m3	nos.	2	23	46	260	520	566
	20 Submersible pump, 50mm	nos.	2	4	8	14	28	36
	21 Portable generator, 3kVA	nos.	1	8	8	94	94	102
	22 Sapre parts and tools	L.S.	1		193		1,910	2,103
	Sub total				4,053		40,113	44,166
(2)	Meteorological equipment	L.S.	1	36	36	364	364	400
(3)	Personal computor and attachment	L.S.	1	18	18	182	182	200
	Total				4,107		40,659	44,766

Source : Prepared by JICA Study Team

Table VIII-9 Cost for Land Acquisition

	Description	Area (ha)	Unit Cost (10^3 ksh)	Amount (10^3 ksh)
1.	Phase - I			
	Canal	15.0	40	600
	Regulation Pond	10.2	40	408
	1 Sub-Total	25.2		1,008
2.	Phase - II			
2-1	Sub-Area I			
	Canal	6.8	40	272
2-2	Sub-Area II-1			
	Canal	11.5	40	460
2-3	Sub-Area II-2(b)			
	Canal	14.6	40	584
	Regulating Pond	10.2	40	408
2-4	Sub-Area III			
	Canal	35.7	40	1,428
	2 Sub-Total	78.8		3,152
3.	Phase - III			
3-1	Sub-Area IV			
	Canal	51.4	40	2,056
3-2	Sub-Area V			
	Canal	49.4	40	1,976
	3 Sub-Total	100.8		4,032
	Total	204.8		8,192

Source : Prepared by JICA Study Team

Table VIII-10 Annual Disbursement Schedule

(Ksh 1,000,000)

	Detailed Design				Phase I								Phase II											
	1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		2004	
	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C
1. Construction Cost																								
Preparation					16.4	18.9	4.1	4.7	0.0	0.0	0.0	0.0	30.0	38.2	7.5	9.5	0.0	0.0	0.0	0.0	0.0	0.0		
Regulating Pond					15.0	34.4	25.0	57.3	10.0	22.9	0.0	0.0	12.1	30.5	12.1	30.5	6.1	15.3	0.0	0.0	0.0	0.0		
Irrigation Facility					14.6	14.8	36.6	37.1	22.0	22.3	0.0	0.0	31.7	46.6	31.7	46.6	31.7	46.6	31.7	46.6	0.0	0.0		
Drainage facility					0.0	0.0	22.1	15.2	55.3	38.1	33.2	22.9	0.0	0.0	0.0	0.0	99.0	94.3	99.0	94.3	49.5	47.1		
Road Improvement					0.0	0.0	0.0	0.0	1.4	5.0	1.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	17.0	4.6	17.0		
On-farm					0.0	0.0	5.3	5.5	7.0	7.4	5.3	5.5	0.0	0.0	10.7	12.4	10.7	12.4	16.1	18.7	16.1	18.7		
Office and Quarter					3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0												
Sub-Total	0.0	0.0	0.0	0.0	49.0	71.1	96.0	122.8	95.6	95.6	39.8	33.4	73.8	115.3	62.1	99.1	147.5	168.6	151.4	176.5	70.1	82.8		
2. O & M Equipment	0.3	3.5									3.7	37.0												
3. Administration Cost	2.3		2.3		3.8		3.8		3.8		3.8		1.5		1.5		1.5		1.5		1.5			
4. Engineering Cost	1.0	52.5	2.4	83.1	0.6	32.0	1.4	60.7	1.6	61.5	1.2	41.1	8.6	29.4	8.0	12.0	8.0	12.0	8.0	12.0	8.0	12.0		
5. Land Acquisition			1.0								3.0		4.0											
Sub-Total	3.6	56.0	5.7	83.1	53.4	103.1	101.2	183.5	101.0	157.1	51.5	111.5	87.9	144.7	71.6	111.1	157.0	180.6	160.9	188.5	79.6	94.8		
6. Physical Contingency	0.3	0.3	0.3	0.0	5.3	7.1	10.0	12.3	9.9	9.6	5.0	7.0	7.9	11.5	6.4	9.9	14.9	16.9	15.3	17.6	7.2	8.3		
Sub-Total	3.9	56.3	6.0	83.1	58.7	110.2	111.2	195.8	111.0	166.7	56.6	118.5	95.9	156.2	77.9	121.0	171.9	197.4	176.1	206.1	86.8	103.0		
L/C=0.15*Total cost	3.9	56.3	6.0	83.1	25.3	143.5	46.1	261.0	41.6	236.0	26.3	148.8	37.8	214.3	29.8	169.1	55.4	313.9	57.3	324.9	28.5	161.3		
F/C=0.85*Total cost																								
7. Price Contingency	0.6	0.2	1.2	0.0	11.5	9.2	27.3	20.8	30.9	22.0	23.8	16.0	33.4	31.7	29.7	30.6	75.5	66.1	91.4	76.2	43.8	40.1		
Sub-Total	4.5	56.5	7.2	83.1	36.8	152.7	73.3	281.8	72.5	258.0	50.0	164.8	71.2	246.0	59.5	199.7	130.9	380.0	148.8	401.1	72.3	201.4		

(Ksh 1,000,000)

	Phase III										Project as a whole		
											L/C	F/C	Total
1. Construction Cost													
Preparation	42.3	50.6	10.6	12.6	0.0	0.0	0.0	0.0	0.0	0.0	111	135	245
Regulating Pond	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80	191	271
Irrigation Facility	34.1	69.1	34.1	69.1	34.1	69.1	34.1	69.1	0.0	0.0	337	537	874
Drainage facility	0.0	0.0	0.0	0.0	167.3	145.6	167.3	145.6	83.6	72.8	776	676	1,452
Road Improvement	0.0	0.0	0.0	0.0	0.0	0.0	4.9	17.6	4.9	17.6	22	79	101
On-farm	0.0	0.0	19.0	22.5	19.0	22.5	28.4	33.7	28.4	33.7	166	193	359
Office and Quarter											6	6	12
Sub-Total	76.4	119.7	63.6	104.2	220.3	237.2	234.7	266.0	117.0	124.1	1,498	1,816	3,314
2. O & M Equipment											4	40	45
3. Administration Cost	2.3		2.3		2.3		2.3		2.3		39	0	39
4. Engineering Cost	10.0	12.0	10.0	12.0	10.0	12.0	10.0	12.0	10.0	12.0	99	468	567
5. Land Acquisition											8	0	8
Sub-Total	88.7	131.7	75.9	116.2	232.6	249.2	247.0	278.0	129.3	136.1	1,647	2,325	3,972
6. Physical Contingency	7.9	12.0	6.6	10.4	22.3	23.7	23.7	26.6	11.9	12.4	155	186	341
Sub-Total	96.6	143.7	82.5	126.7	254.9	272.9	270.7	304.6	141.2	148.5	1,802	2,511	4,313
L/C=0.15*Total cost	36.0	204.2	31.4	177.8	79.2	448.6	86.3	489.0	43.5	246.3	634	3,678	4,313
F/C=0.85*Total cost													
7. Price Contingency	35.4	37.5	34.1	36.3	128.2	106.3	163.2	128.0	82.0	68.8	812	690	1,502
Sub-Total	71.4	241.7	65.5	214.1	207.3	554.9	249.5	617.0	125.5	315.0			
Total	130.9	441.4	196.4	594.2	356.1	955.9	321.7	818.4	125.5	315.0	1,446	4,368	5,814
		572.3		790.6		1312.1		1140.1		440.5			

Total	4.5	56.5	7.2	83.1	36.8	152.7	73.3	281.8	72.5	258.0	50.0	164.8	71.2	246.0	130.9	441.4	196.4	594.2	356.1	955.9	321.7	818.4	125.5	315.0
		61.0		90.3		189.5		355.1		330.6		214.9		317.2		572.3		790.6		1312.1		1140.1		440.5

L/C: Local Currency
F/C: Foreign Currency

Price escalation rate
L/C= 0.1 F/C= 0.02

Source : Prepared by JICA Study Team

Table VIII-11 Annual Operation & Maintenance Cost

Item			Amount (1000ksh)
1 Slaries & Wages			
1-1	Staff Salaries		9,590
1-2	Casual Labour Wages	(300M/M @2,500ksh)	750
2 Office Expense			110
3 Operation & Maintenance Cost			
3-1	Operation, repair of O&M equipment		4,500
3-2	Project facilities		13,600
Total			28,550

Source : Prepared by JICA Study Team

Table VIII-12 O & M Staff Salary

Item	Required Number	Annual Rate	Amount (1000ksh)
Managing Staff	9	140	1,260
Technical & administration staff	87	90	7,830
Workers	10	50	500
Total			9,590

Source : Prepared by JICA Study Team

Table VIII-13 Replacement Cost

Item	Useful Life (Year)	Repolacement Cost (1000ksh)
1 Light O & M Equipment	10	15,350
2 Gate	25	17,435

Source : Prepared by JICA Study Team

Figures

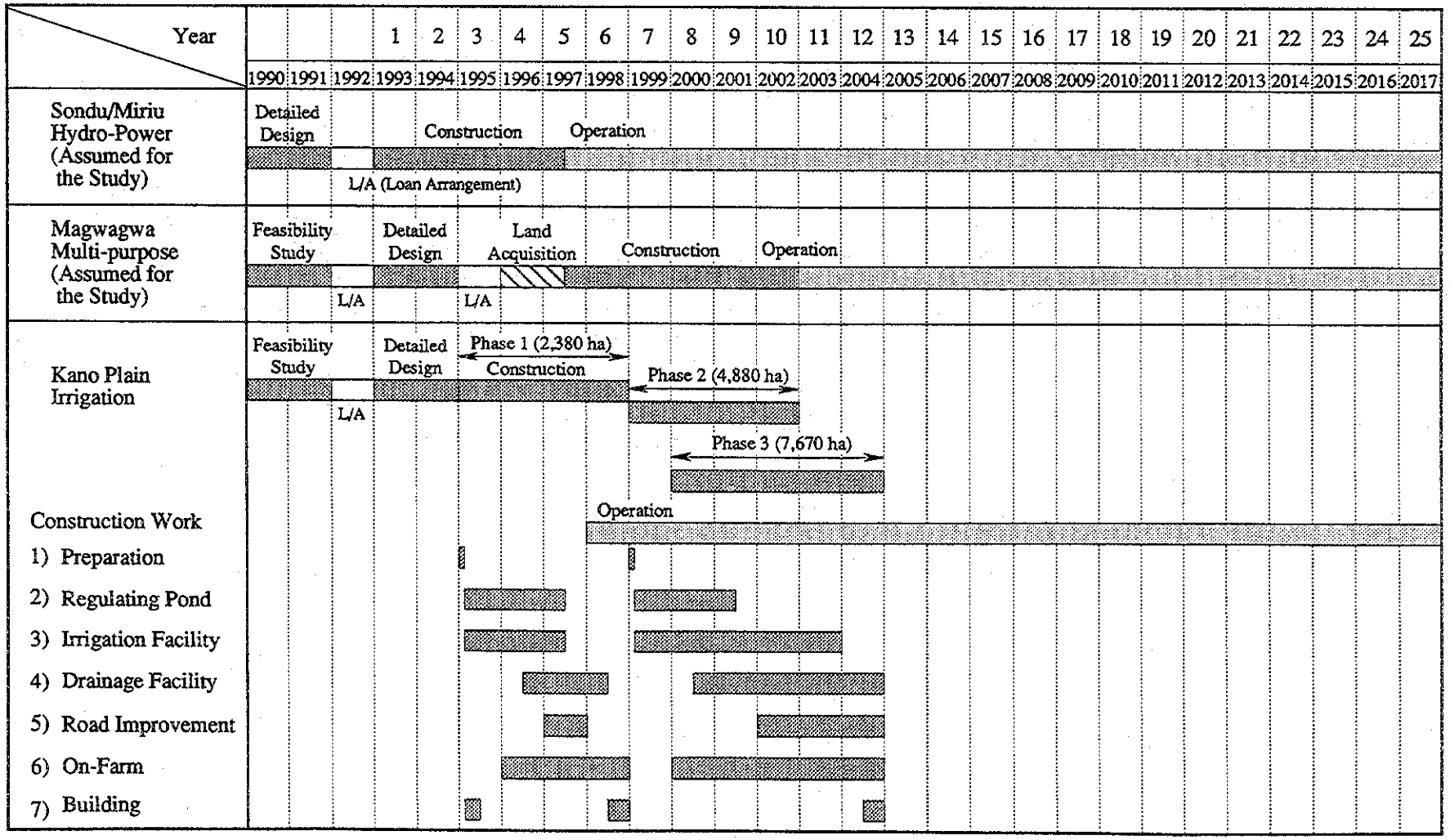

Fig. VIII-1 Project Execution Time Schedule

Annex IX

Project Organization

Feasibility Study
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Annex IX
Project Organization

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1. ORGANIZATION FOR CONSTRUCTION

1.1 Lake Basin Development Authority

The Lake Basin Development Authority (LBDA) was established under the Act of Parliament (Cap. 442) in August 1979 as the Regional Authority for the overall development of the Lake Victoria catchment area. The LBDA has been responsible to undertake planning, coordination and implementation of development project in the region. Policy matters relating to LBDA operations have been decided by the Board of LBDA, which is comprised of representatives from the Ministries and the Local Government concerned. Under the Board LBDA is headed by the Managing Director, supported by the Deputy Managing Directors for technical services and finance & administration. The LBDA has been coordinating and implementing many projects in various scale i.e. such large scale projects as West Kenya Rainfed Rice Project, Rural Domestic Water Supply and Sanitary Project, etc. Current organization of the LBDA is shown in Fig. IX-1.

The LBDA will be the executing agency of construction of the Kano Plain Irrigation Project. The managing Director of the LBDA is responsible for execution of the project. Taking into account the existing manpower in the LBDA, it is recommendable to establish a project construction office under the direct control of the Managing Director. The Managing Director of the LBDA will appoint a Project Coordinator who is responsible for operation of the Project Construction Office.

1.2 Project Construction Office

The main function of the project construction office will be as follows:

i) Design and construction supervision of the project works,

ii) Publicity work and land acquisition,

iii) Accounting and administrative management of the construction works as well as office operation.

Any contracts for the construction works will be concluded by tendering which will be monitored by the Tender Evaluation Committee being comprised of the members appointed by the Managing Director of the LBDA. The project office will be responsible to execute policy decisions of the LBDA.

The project office consists of a main office and five site offices. The main office will be established in the existing LBDA Head Quarter in Kisumu, having three divisions such as administration, survey and design, and construction supervision.

The Survey and Design Division will carry out surveys and investigations for design of the project facilities. The detailed design and preparation of tender documents will be undertaken in the detailed design stage which will start prior to the construction. On-farm work coordinators in this division will carry out coordination work between the farmers and the project in the on-farm work. The on-farm work will be undertaken in the construction stage as follows:

i) To show the farmers the detailed plan of the project and to explain importance and benefit of the on-farm work,

ii) To guide and assist farmers to organize Water Users' Association (WUA),

iii) To collect land registration from the Land Adjudication Office in Kisumu, and to investigate situation of right of cultivation traditionally trusted to the farmers. The boundary of the registration will be drawn on the map.

iv) To make a concrete on-farm plan including route of irrigation canals and drains, layout of field lots, land levelling work in the paddy field, etc. The plan will be made on the same map used in the above iii),

v) To measure area to be expropriated for the irrigation canals, drains, etc.

vi) To show and explain the above concrete on-farm development plan to the farmers plan,

vii) To start construction work by mutual consent,

viii) To transfer the tertiary block to the WUA after completion of the on-farm work

The Construction Supervision Division will carry out the construction supervision such as quality control, work progress, and measurement of work quantity.

The Administration Division will responsible for publicity, land acquisition, accounting, budgeting, logistics, personnel affairs, etc.

In addition to above, the project office will carry out monitoring work to assess the impact of the project to the water quality of the Lake in collaboration with the Environmental Protection and Public Health Division in the main office of the LBDA.

The site offices will take responsibility for day-to-day work of the construction supervision works such as measurement of the work quantities, records of the work progress, etc. The site offices will be established in the Sub-area I, II-2, III, IV and V. The proposed organization chart of the Project office is shown in Fig IX-2.

The required number of staffs assigned full-time for the detailed design stage and construction stage are estimated as shown in Table IX-1.

In the detailed design stage and construction stage, consultants which are comprised of foreign and local experts and specialists would have to be required to assistance and advice to the Project Office in order to cope with the shortage of experienced government staff in the irrigation project in Kenya. Their required number is shown in Table IX-2.

2. ORGANIZATION FOR OPERATION AND MAINTENANCE

2.1 General

After completion of the construction works, the project office is taken new charge of necessary services of water management and supporting works for farmers. The proposed O&M office will be in charge of overall activities necessary for project operation such as:

i) agricultural extension services for farmers,

ii) guidance and assistance of farmers' cooperatives in its establishment and operation, procurement of agricultural inputs, agricultural credit, etc.,

iii) guidance and assistance of establishment and operation of water users' association,

iv) preparation of overall operation and maintenance program of project facilities,

v) preparation of irrigation schedule and water distribution schedule,

vi) maintenance and repair of the project facilities,

vii) training of staffs and water user's association,

viii) periodical data recording,

ix) meteorological measurement, and

x) monitoring and feed back.

The project office consists of a main office and five site offices. The main office has four divisions; administration division, irrigation division and agricultural division, and monitoring division. The Administration Division will have three sections such as personnel, Account and Procurement. The Irrigation Division will have two sections such as Operation and Maintenance and Water Users' Association. The Agricultural Division will have two sections such as Extension, and Farmers' Cooperative. The monitoring division will monitor the results of the above activities and give information to other division for the feedback. The site offices will take responsibility for day-to-day operations in their responsible areas under the instructions

given by the main office. The proposed organization of operation and maintenance office is shown in Table IX-3.

The required number of staffs is shown in Table IX-1. In the operation and maintenance stage, efficient water management and supporting work for farmers are very important. There might be, however, shortage of experienced staffs for these activities. To train those staffs is to be an important aspect in the early stage of the project operation. Some foreign and/or local experts and specialists would have to be required to train project staffs.

2.2 Agricultural Extension and Supporting Services

Various aspects of the present agriculture will be changed after implementation of the project. Practices for rainfed farming will be changed for irrigation farming. Such farm inputs as fertilizers and seeds will be required in large amount. Financial capacity of the farmers has to be expanded for purchase of inputs. Large amount of farm products will be harvested and be handled.

For technical matters for irrigation farming, capacity of the present agricultural extension service would be insufficient because the present extension system is carried out based on the rainfed farming. For other aspects the farmers could not manage by individuals and cooperative societies of the farmers would be formed to manage those aspects. In this regard, the agricultural division of the project office would provide the farmers with agricultural extension services and support services for farmers through organizing cooperative societies.

2.2.1 Agricultural extension services

The project office will provide farmers with recommendation and guidance of technical practices of crops under irrigation condition and cattle under zero grazing in the project area. Recommendation and guidance include variety selection, preparation of cropping calender, dosage and application timing of fertilizers, timing of harvest, post harvest, water management of in the plots, management of demonstration plot, etc.

Those services will be planed by the agriculture officer and the livestock officer in the main office and conducted through the site offices by technical assistants under the supervision of the assistant officers.

2.2.2 Support services for farmers

The project office will assist the farmers by providing supporting services for the cooperative societies to manage procurement of farm inputs, agricultural credit and handling of farm products. Those services include guidance and training of the cooperative staffs as well as the farmers to formulate and operate cooperative societies. Those services will be planed by the cooperative officer in the main office, and carried out by the staffs of the site offices.

2.3 Water Management and Maintenance

2.3.1 Objectives

Water management and maintenance works will be undertaken by the Irrigation Division. The main objectives of the water management and maintenance works are:

i) to distribute the required irrigation water to each field equitably, certainly and timely,

ii) to maintain irrigation and drainage facilities properly and to prevent disaster on these,

iii) to collect and keep data of water management activity for further improvement of the system.

2.3.2 Basic idea of water management

To achieve the above objectives, the basic idea of the water management system is considered as follows:

i) The system is simply structured and easily known of any part by anybody,

ii) The operation is easy and any high technique is not required,

iii) The maintenance and repair works are possible to be carried out easily and quickly,

iv) Operation and maintenance cost is reasonable.

The water management and maintenance works would be divided into two aspects: one is that from regulating pond to entrance of tertiary system, the other is that from tertiary to farm level. The first one will be undertaken by the Project Office and the other one will be put in Water Users' Association.

The main work of the project office will be as follows:

i) Preparation of overall operation and maintenance program of project facilities,

ii) Preparation of irrigation schedule and water distribution schedule in each secondary canal,

iii) Maintenance and repair of the main project facilities such as regulating pond, main canal and secondary canal,

iv) Settlement of disputes between Water Users' Associations,

v) Training of staffs and water user's association,

vi) Periodical data recording,

vii) Meteorological measurement,

The general flow of the water management work is shown in Fig.IX-4.

2.4 Operation and Maintenance Equipment

The Operation and Maintenance works of project facilities are largely divided into earthworks, concrete works, and metal works, etc.

Maintenance and repair of earthworks are carried out to maintain the canals and roads to keep its function originally designed. Its main works are weeding, embankment and excavation. Weeding and small repair of small canals and roads will be carried out manually by labourers. Repair works in the regulating pond, main canals, and secondary canals will require heavy equipment.

As for roads are very important not only for operation and maintenance works but to communicate in and around the project area, they should be maintained periodically. A road roller and a motor grader will be provided.

For concrete works, which would be rather durable, and considering minor repairs, only a small portable concrete mixer will be provided. The metal works are mainly painting and oiling of gates of regulating pond, turnout, check, and spillway. These works require only small tools and materials. The maintenance of electric works such as transformers, electric lines, and electric control systems will be made in collaboration with Kenya Power Company Limited.

For transportation of equipment, materials, and labourers, dump trucks, ordinary trucks, etc. will be provided. For operation works and extension works, vehicles, motor bike and bicycles will be provided. These O&M equipment are listed in Table IX-4.

2.5 Office and Quarters

There will be required a main office, five site offices, watching stations, and cooperative buildings for the project. Quarters for permanent staffs are required as well. The size of these offices and quarters is approximately estimated considering the number of staffs to be engaged in the project management. Workshop will be also required for the maintenance of O&M equipment. The watching stations will be provided for gate keepers who will be in charge of gate operation of the secondary/sub-secondary canals day and night.

The cooperative building will be provided in each sub-area and have an office for staffs of the cooperative, a meeting room and store room for farm input materials of about 1000 m^3. Unit cooperative

building will also have an office for the staffs and a store room for farm inputs and farm products of 200 m^3. The following is a number of the above offices and buildings.

Item	Nos.	Unit	Quantity
Main office			
-Office	1	m^2	550
-Laboratory	1	m^2	150
-Workshop	1	m^2	200
-Quarters	10	m^2	2000
Site office	5	m^2	750
Watching stations	55	m^2	2200
Cooperative building			
-Sub area	5	m^2	3500
-primary societies	27	m^2	1350

3. FARMERS' ORGANIZATION

3.1 Cooperative Societies

After implementation of the project, farmers will establish cooperative societies to perform their farming activities to help each other. Four to five primary societies will be established in each sub-area, and those primary societies will form one cooperative union in the project area. Cooperative union and primary societies will provided with offices and stores by the project, then these facilities will be operated and maintained by society members (farmers). Basic function of the societies are as follows:

1) Procurement of farm inputs and distribution to individual farmers,

2) Collection and handling of farm products,

3) Supply of agricultural credit,

4) Other miscellaneous functions i.e., saving, supply of daily goods.

Farm inputs will be procured by the cooperative union from Kenya Grains Growers Cooperative Union, then transferred to the store in the primary societies. Farmers will purchase farm inputs through primary societies with credit. Farm products will be collected in collection yards of the primary societies and handled to the dealer or marketing agencies. Cooperative union will collect marketing information and provide primary societies. Those activities will bring commissions and handling charges to employ cooperative staffs and to maintain facilities like offices and stores.

3.2 Water Users' Association

At the farmers' level, farmers in a irrigation block which consists of several rotation blocks will be organized a Farmers' Group. A Farmers' Group will be responsible for water distribution and maintenance of the tertiary canal and water courses and its related structures such as division boxes and farm outlets, etc.

A Water Users' Association (WUA) will be organized by several Farmers Groups in each secondary/sub-secondary canal.system for its operation and maintenance. The WUA should have a regular meeting to discuss water distribution program in its command area and to elect a Working Group which consists of a chief, canal inspectors, water allocators, alarm men, and security guards. Water allocators will be in charge for water allocation to the tertiary canals. Alarm men will call people for maintenance work of the secondary canal. A chief represents the WUA.

In the project area, fifty-five secondary and sub-secondary canals are planned, thus fifty-five Water Users' Associations will be organized. A union (UWUA) will be organized by all associations in the project area. Five Sub-Unions will be organized by the WUAs in the Sub-area. The Sub-Union will have a regular meeting in collaboration with Site Office of the project. Working group in each WUA will attend the meeting.

4. SUPPORTING PROGRAMME IN PHASE 1

Kano Plain Irrigation Project is quite large project covering about 15,000 ha and this is the first project in Kenya to irrigate existing farm land owned by a number of small scale farmers. To achieve the objective of the project, it is necessary to introduce proper operation method of irrigation and drainage facilities as well as improved practices for irrigation farming and supporting services for farmers.

The project office will provide such services as O&M of the facilities, agricultural extension services and supporting of farmers' organization, however, LBDA as the exceuting agency and farmers in the project area have no experience of same kind of the project at present. The staff of the project office and farmers, therefore, will require technical assistance to obtain knowledge and technical know-how because this is the first experience to operate such large irrigation system to irrigate lots of small farmers.

In this regard, implementation of Phase 1 of the project would be the stage to establish the proper operation and management system which mainly consists of water management, extension service and support for farmers' organization. The operation system once established would be extended to Phase 2 and 3 afterwards.

The technical assistance would conduct supporting programmes for the project staff and farmers, and the objectives of the supporting programmes are (1) Establishment of water management, (2) Reinforcement of agricultural extension, (3) Formation of cooperative societies and (4) Monitoring of the project. Each ojective will include the following activities:

(1) Establishment of water management

i) To prerare manuals for water management such as
- Operation and maintenance of the project facilities,
- Rules of Water Users' association, etc.

ii) To prepare concrete programme to establish Water Users' Association, which includes
- to publicize water management works to the farmers,
- to support farmers organizing WUAs and electing working groupe in the WUAs, etc.

iii) To guide and train the project staff and WUAs.

(2) Reinforcement of agricultural extension services

i) To prerare and publicize guidance for irrigation farming,

ii) To select model farms for field trials and demonstration,

iii) To coordinate and carry out training activities for the project staff and farmers, which may include despatching to other irrigation project, i.e. Mwea Irrigation Project for paddy cultivation,

(3) Formation of ooperative societies

i) To make make rule and manual of cooperative such as
- Rules and regulations of the societies.
- Manual for running and accounting, etc.

ii) To assist for formation of cooperative societies and unions,

iii) To guide and train staff of societies on its operation and management.

(4) Monitoring of the project

i) To monitori the above activities such as water management, reinforcement of agricultural extension services, formation and performance of cooperative societies, farm economy,

ii) To feedback the above results into operatation,

The supporting programmes will be planned in deatil during the detailed design stage. It will start from the construction stage of the Phase 1 and continue during opration stage of the Phase 1.

Tables

Table IX-1 Number of Project Staffs

	Project staff	Detailed design stage	Construction stage	Operation & maintenance stage
1	Project coordinator	1	1	1
2	Irrigation engineer	1	1	1
3	Assist. irrig. engr (Site office in charge)	-	-	5
4	Design engineer	2	1	1
5	On-farm engineer / coordinator	-	5	-
6	Construction engineer (site office in charge)	-	5	-
7	Cartographer	1	1	1
8	Computer operator	1	1	1
9	WUAs expert	-	1	1
10	Canal master	-	-	5
11	Assistant gate master	-	-	10
12	Agricultural officer	-	-	1
13	Livestock officer	-	-	1
14	Assistant agricultural officer	-	-	5
15	Assistant livestock officer	-	-	5
16	Agricutural technical assistant	-	-	25
17	Animal technical assistant	-	-	25
18	Cooperative expert	1	1	1
19	Administrator	1	1	1
20	Administrator (land acquisition)	1	1	-
21	Accountant	1	1	1
22	Clerk/Typist	2	2	2
23	Operator of heavy equipment	-	-	3
24	Workers	-	-	10
	Total	12	22	106

Remarks: Drivers and some other workers are not counted.

Source : Prepared by JICA Study Team

Table IX-2 Number of Consultants Required

	Staff	Detailed design work	Construction supervision work	Operation & maintenance work
1	Team leader	1	1	-
2	Irrigation / drainage engineer	1	1	-
3	Design engineer	4	1	-
4	On-farm design engineer	1	1	-
5	Topographic engineer	1	1	-
6	Architect	1	1	-
7	Geo-technical engineer	1	1	-
8	Cost estimator	1	-	-
9	Environmentalist (water quality)	1	-	-
10	Specification writer	1	-	-
11	Agro-economist	1	-	-
12	Construction engineer	-	2	-
13	Quantity surveyor	-	3	-
14	O&M / WUA adviser	1	-	1
15	Extension service adviser (agriculture)	-	-	1
16	Extension service adviser (livestock)	-	-	1
17	Cooperative adviser	-	-	1
	Total	15	12	4

Remarks: Office supporting staffs such as clerks, typists, draftmen, computer operators, laboratory technicians, etc. are not counted.
- Topographic survey and geo-technical investigation will be undertaken by other agencies
- Not all consultant saffs will be assigned the whole each work period through.

Source : Prepared by JICA Study Team

Table IX-3 List of Operation and Maintenance Equipment

	Item		Unit	Quantity
(1)	Heavy equipment			
	1	Backhoe shovel, 0.35m3	nos.	3
	2	- ditto - 0.6m3	nos.	1
	3	Bulldozer, 11t	nos.	1
	4	Wheeled loader ,1.2m3	nos.	1
	5	Mortor grader, 3.7m	nos.	2
	6	Raod roller, 5t	nos.	1
	7	Lorry, 12t	nos.	2
	8	Fuel tanker, 8t	nos.	1
	9	Dump truck, 8t	nos.	2
	10	Dump truck, 4t	nos.	1
	11	Cargo truck 6ton	nos.	5
	12	- ditto - with 2t crane	nos.	2
	13	Pick up truck 1t	nos.	5
	14	Jeep	nos.	4
	15	Station wagon (4WD)	nos.	4
	16	Motor cycle	nos.	15
	17	bicycle	nos.	30
	18	Vibrating plate, 3PS	nos.	2
	19	Concrete mixer, 0.12m3	nos.	2
	20	Submersible pump, 50mm	nos.	2
	21	Portable generator, 3kVA	nos.	1
	22	Sapre parts and tools	L.S.	1
(2)	Meteorological equipment		L.S.	1
(3)	Personal computor and attachment		L.S.	1

Source : Prepared by JICA Study Team

Figures

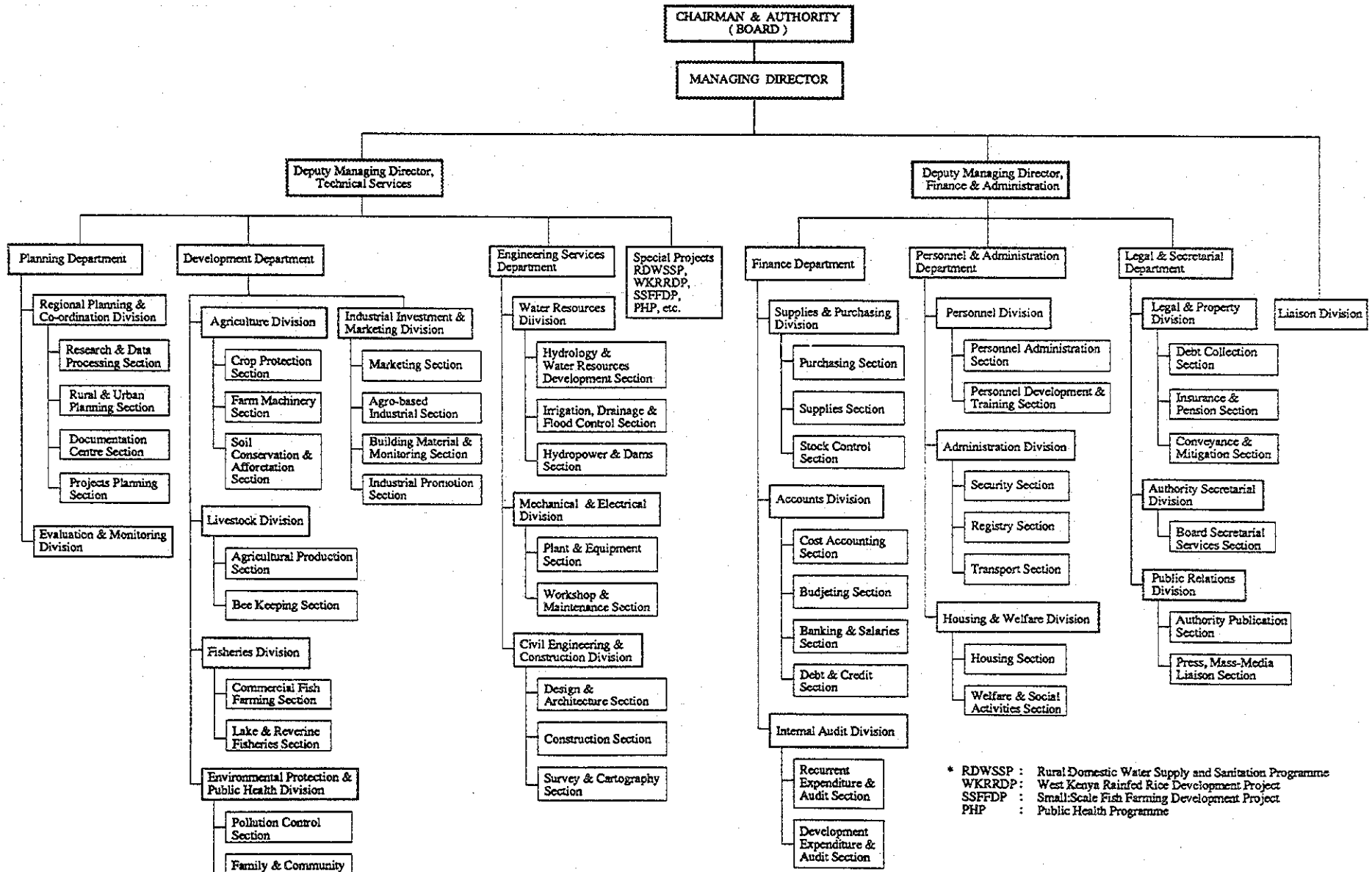

Fig. IX-1 Organization of the Lake Basin Development Authority

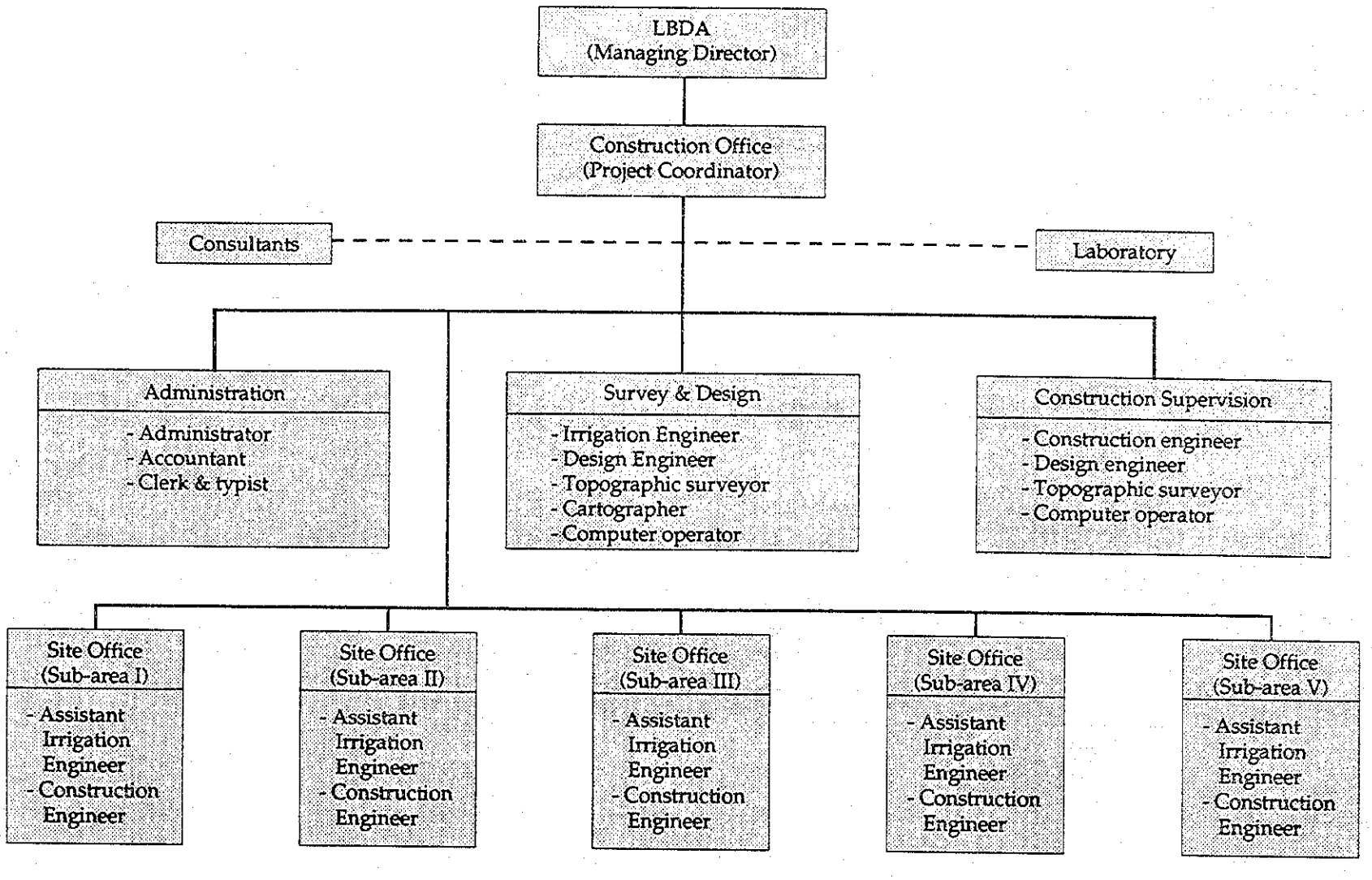

Fig. IX-2 Organization of the Detailed Design Stage and Construction Stage

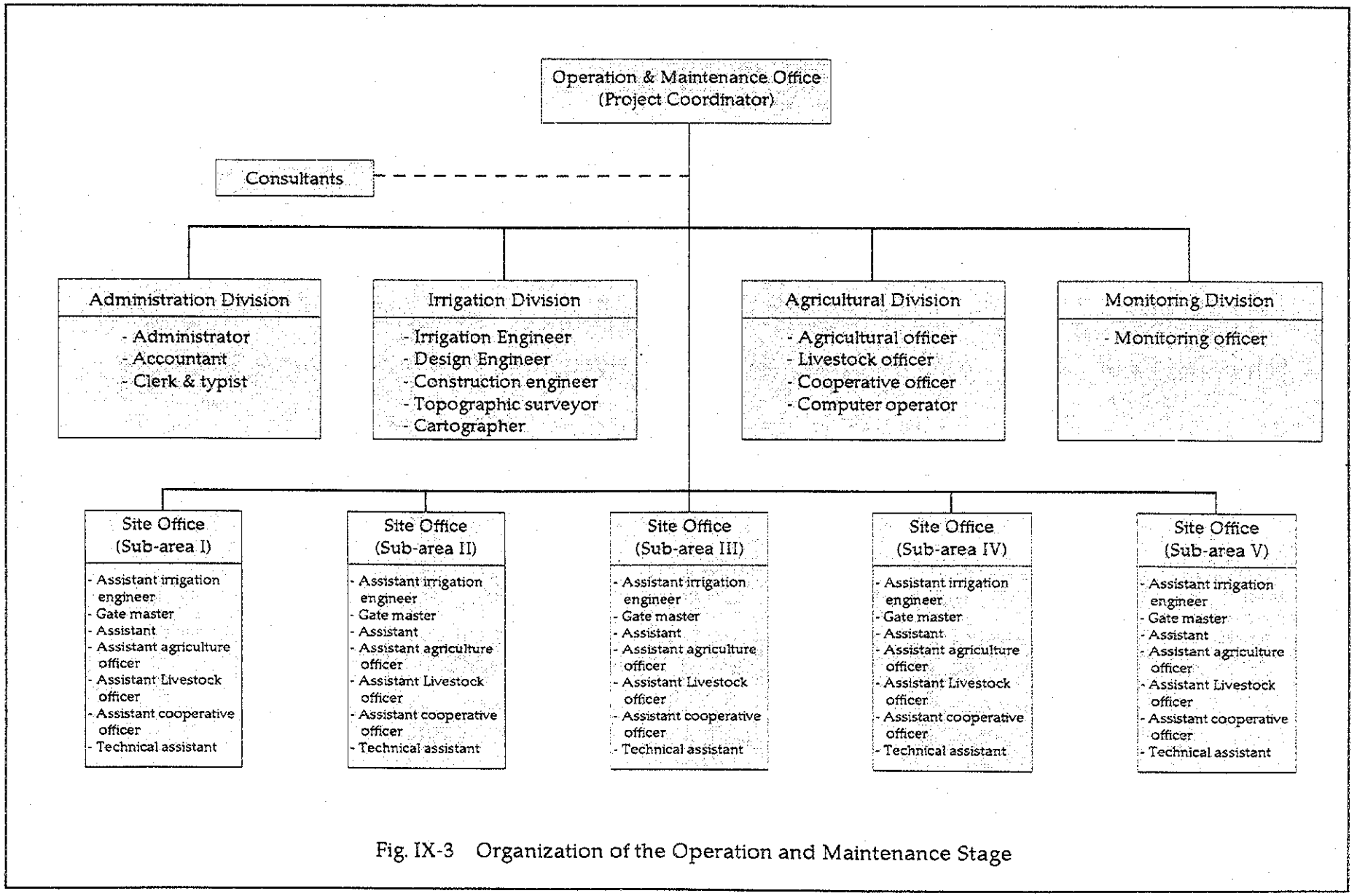

Fig. IX-3 Organization of the Operation and Maintenance Stage

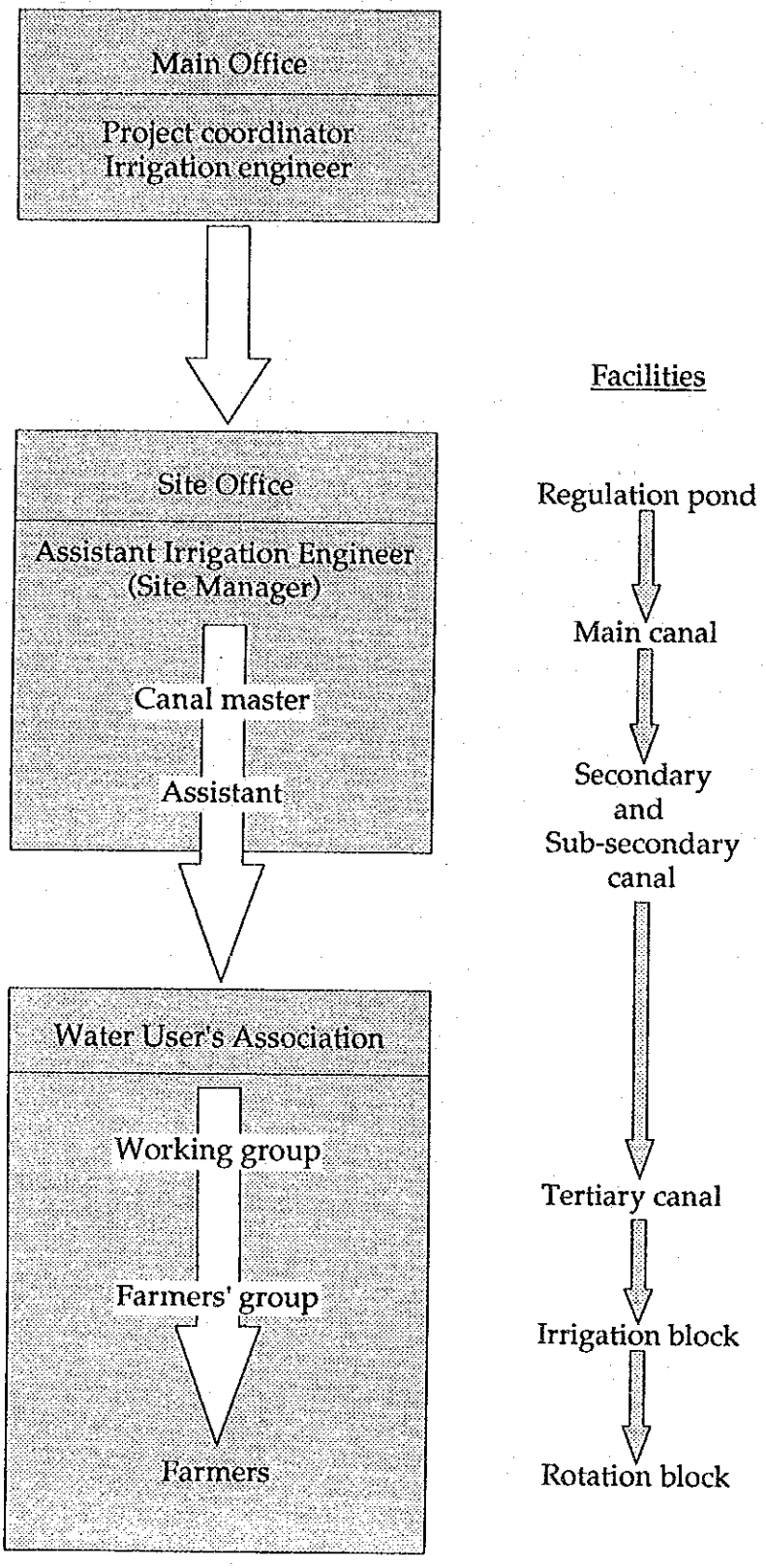

Fig. IX-4 General Work Flow of Water Management System

Annex X

Project Evaluation

Feasibility Study
on
Kano Plain Irrigation Project

Annex X
Project Evaluation

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1. INTRODUCTION

The preliminary project evaluation is carried out for 3 alternative development options in terms of the development scale. It is concluded in the main text that the Case 3 with 14,930 ha of irrigable area is the optimum development scale through examination of project economy and environmental impact on water quality of the Nyakach Bay.

The project covers 14,930 ha and supplies irrigation water from Magwagwa Dam through Sondu-Miriu Hydropower Station throughout a year. After implementation of the project, total annual cropping area expands from 4,140 ha at present to 22,460 ha, and cropping intensity increases from 28% to 150%. In this annex, project evaluation is discussed for the selected case.

The project evaluation involves making an assessment of the project feasibility in view of economic, financial and socio-economic aspect. The economic feasibility is evaluated by calculating the internal rate of return (IRR), difference between benefit and cost (B-C) and benefit/cost ratio (B/C) at the discount rate of 10%. Sensitivity analyses are also made in order to elucidate the economic viability of the project against the changes in benefits, construction period, project costs. Financial evaluation is carried out by analysing the effect of the project on the farm economy for typical type of farmers and preparing the repayment schedule of the anticipated project fund. The socio-economic impacts from the implementation of the project is also briefly studied.

2. ECONOMIC EVALUATION

2.1 Basic Assumption

The economic evaluation is made on the following basic assumptions:

(1) The economic useful life of the project is 50 years.

(2) The construction periods is 18 years including the period of detailed design and preparatory works.

(3) All prices are expressed in constant 1991 prices.

(4) The exchange rate of US$1.00 = Kshs.28.00 = ¥150 is applied.

2.2 Economic Factors

2.2.1 Standard conversion factor

Tariff and trade regulations introduce a distortion in the price relationship between trade goods and non-trade goods. In order to evaluate the project costs and benefits with respect to world market prices, a standard conversion factor (SCF) is applied to the price of non-trade goods and services. SFC is calculated at 0.82 on the basis of the export and import statistics for the years of 1987 and 1988, as shown in Table X-2.1.

2.2.2 Economic prices of agricultural outputs and inputs and opportunity cost of farm labour

Economic prices of farm products and farm inputs are estimated on the basis of the projected international market prices forecasted for the year of 2005 by IBRD in the long term range in 1985 constant US dollar. The forecasted prices are adjusted to constant 1991 price level using the factor of 1.5345 based on manufacturing unit value (MUV) index computed by IBRD. The domestic components are adjusted by SFC of 0.82.

Current labour price is Kshs. 25/man-day. Economic farm labour is priced at Kshs. 15/man-day by applying shadow wage rate of 0.6, in considering unemployment conditions.

2.3 Economic Benefit

Irrigation benefit is estimated as the difference of the annual net production values between under with and without project conditions. Net production value is defined as the difference between gross production value and crop production cost. Net production values under with and without project conditions are summarized as follows (for details, see Tables Annex VI):

(1) Net production value under with-project condition

Long Rainy Season	Short Rainy Season	Unit Net Production Value (Kshs./ha)	Total Area (ha)	Total Net Production Value (Kshs.mil.)
Paddy	Beans/Greengrams	43,670	2,690	117.5
Maize	Paddy	48,910	1,740	85.1
Maize	Cotton/Beans	37,960	1,530	58.1
Vegetable	Vegetable	80,900	1,570	127.0
Sugarcane		47,010	5,130	241.2
Managed Fodder for Dairy		26,810	760	20.4
Pasture for Working Cattle		25,190	510	12.8
Fruit Tree		25,300	1,000	25.3
Total			14,930	687.4

(2) Net production value under without-project condition

Crop	Unit Net Production Value (Kshs./ha)	Total Area (ha)	Total Net Production Value (Kshs.mil.)
Paddy	16,280	420	6.8
Maize	5,280	1,490	7.9
Sorghum	2,260	940	2.1
Beans	4,550	490	2.2
Tuber	1,800	360	0.6
Cotton	2,120	430	0.9
Sugarcane	18,620	40	0.7
Pasture	2,240	10,760	24.1
Total		14,930	45.4

(3) Increment of net production value (unit:Kshs.million)

	Net production value		
	With Project Condition	Without Project Condition	Net Incremental Benefit
(1) - (2)	687.4	45.4	642.0

It is assumed that during build-up period the irrigation benefit will be expected at 65% of full benefit in 1st year after completion of the construction work, and at 80% in 2nd year, 90% in 3rd year, 95% in 4th year, finally 100% in 5th year.

2.4 Economic Cost

The financial project cost consists of (1) construction cost for project facilities including preparatory work, contractor's overhead, profits and contract tax, (2) procurement cost of O&M equipment, (3) administrative expenses, (4) expenses for engineering services, (5) cost for land acquisition, compensation and resettlement, (6) physical contingencies and (7) price contingencies. The financial costs are converted into the economic costs by applying standard conversion factor as follows:

(unit : Kshs. million)

Cost components	Financial cost	Economic cost
(1) Construction cost	3,313	2,716
(2) O&M equipment	45	37
(3) Administrative expenses	39	32
(4) Engineering services	567	465
(5) Land acquisition	8	0
(6) Physical contingencies	341	284
(7) Price contingencies	1,501	0
Total	5,814	3,534

Economic annual O&M cost includes salaries and wages of the project staff, office expense, but excludes depreciation cost of O&M equipment. Annual O&M cost is estimated at Kshs.23.5 million at the full stage of development. Replacement cost includes O&M equipment and gates to be replaced periodically.

2.5 Internal Rate of Return

The economic internal rate of return is calculated on the basis of the flows of economic benefit and costs as shown in Table X-2.2. The calculated result is:

IRR = 13.2%

2.6 B-C and B/C

B-C and B/C at the discount rate of 10% are calculated on the same assumptions mentioned above:

(unit Kshs. million)

Net Present Value			
Benefit	Cost	B-C	B/C
2,395	1,757	638	1.36

2.7 Sensitivity Analysis

In order to evaluate soundness of the project against possible adverse changes in future economic condition, sensitivity analyses are made for the following cases:

Case 1: Project cost increases 20% due to unexpected escalation of construction cost.

Case 2: Benefit decreases 20% due to unexpected decrease in forecasted prices of farm products and unit yield.

Case 3: Project cost increases 10% and benefit delays 2 years due to inefficiency in O&M, agricultural extension and farmers support.

The effect of these changes in IRR are as follows:

Case	IRR
Case 1	11.2%
Case 2	10.8%
Case 3	10.2%

2.8 Results of Economic Evaluation

From the above results, the project could be justified economically with IRR of 13.2%, B-C of Kshs. 638 million and B/C of 1.36. The sensitivity analysis indicates that economic viability of the project is rather insensitive to the possible adverse effect.

3. FINANCIAL ANALYSIS

3.1 Farm Budget Analysis and Capacity to Pay

In order to evaluate the project from financial aspect of farmers, farm budget analyses made under both with and without project conditions.

Payment capacity is recognized as the ability of the project benefited farmers to bear the expenses required for operation and maintenance of the project facilities as well as for repayment of capital cost.

The payment capacity of average farm size (3.1 ha) under the project at the full operation stage is estimated as follows:

(unit:Kshs.)

Sub-area	Gross Income: Farm Income	Gross Income: Non Farm Income	Gross Income: Total	Gross Outgo: Farm Expenditure	Gross Outgo: Living Expenses	Gross Outgo: Total	Net Reserve
Without project							
	23,000	5,100	28,100	2,400	23,200	25,600	2,500
With project							
I	189,900	5,100	195,000	59,100	34,800	93,900	101,100
II-1	220,700	5,100	225,800	69,600	34,800	104,400	121,400
II-2	232,900	5,100	238,000	73,600	34,800	108,400	129,600
III	146,400	5,100	151,500	36,200	34,800	71,000	80,500
IV	131,400	5,100	136,500	33,200	34,800	68,000	68,500
V	128,900	5,100	134,000	28,700	34,800	63,500	70,500

The increased net reserve would offer the better living conditions and welfare to the farmers and also incentives for farm re-investment and further development. The substantial payment capacity would enable the farmers to make some payments for irrigation water, which is estimate at about Kshs. 8,000 per farm household (equivalent to O&M cost per household of the project).

3.2 Repayment of Project Cost

It is assumed that the initial investment required for the project implementation will be arranged under the following conditions:

(1) 85% of the capital is financed by bilateral or international organization with an interest rate of 2.5% for repayment period of 30 years including 10 years of grace period.

(2) For remaining of local currency portion, the capital is arranged by the Government budget allocation with no repayment.

Based on the above conditions, the repayment schedule for fund is prepared as shown in Table X-3.1.

3.3 Result of Financial Evaluation

The project will bring about a great improvement in farm budget and give an incentive to farmers with respect to further investment for agricultural production. The project could be justified from the farmer's viewpoint.

The average amount of repayment, loan interest and replacement cost is Kshs.129 million per annum during repayment period of 50 years for foreign loan. This amount corresponds to Kshs.27,000 per farm household per annum (4,800 farm household), or 21% to 40% of the above mentioned payment capacity per farm household per annum.

4. SOCIO-ECONOMIC IMPACT OF THE PROJECT

In addition to direct benefit counted in the economic evaluation, various secondary and intangible benefit are expected from the project. The major socio-economic impacts are described as follows:

(1) Increase of employment opportunity

Employment opportunity to the local people will be increased by the implementation of the project, and favourable impacts to the regional economy will be expected through the increased monetary movements. The employees and farmers will gain more experience, technical know-how, skillfullness in various work fields. These accumulation of working techniques would be applied to the future development in the region.

Irrigation will improve the present low land productivity and cropping intensity, and increase crop production in the project area. The increased crop production will accelerate further development of agro-based industries and marketing activities in the surrounding areas. It will also increase the employment opportunity.

(2) Foreign exchange saving

After completion of the project, significant increase in rice and sugarcane production is expected. The increased production would largely reduce the import of rice and contribute to the foreign exchange saving.

(3) Demonstration effect

Implementation of the project will accumulate experience, technical knowledge and skills for the irrigated agricultural project. Those knowledge and skills would be extend to surrounding area where PIU and LBDA have been promoting a number of small scale irrigation project.

(4) Increase of land value

Economic value of the land will surely increase with the project implementation. It means that the value of land assets as a mortgage will become higher and the land owners will have the larger monetary power when they will expand their business. It will also accelerate the economic activities in the region. During certain period after completion of the project, land transactions in the project area will have to be controlled by the government in order to achieve the social justice in the present system of land transactions.

(5) Improvement of local transportation

Existing road network is damaged due to flood and inundation during rainy season. The project will provide such structures as bridges and culverts to improve existing road net work, and also provide roads for operation and maintenance. Those roads will not only enhance agricultural activities but also contribute overall economic activities of the project area.

(6) Mitigation of flood damage

The downstream area of the Nyando river and the area surrounding the swamp are suffered by flood and inundation every year. The project will improve drainage condition of small rivers and rivulets in the project area. This will reduce damage of public and private facilities by flood and inundation, and provide improvement of living condition such inconvenience of accessibility and sanitary.

(7) Improvement of rural water supply

The construction of irrigation canal system will provide the farmers with easy access to domestic water supply through year-round supply of the fresh water and washing steps provided in the main and secondary canals.

(8) Fishery production

Irrigation water will exist in the regulation pond and the main canals throughout a year. Paddy field will be submerged from land preparation to harvest. Those conditions will allow fishery production such mud fish and cat fish. It is expected that the farmers can catch those fish and serve their meals or sell to the local people to gain cash income.

(9) Improvement of health and sanitary condition

Increased production of farm products will enable the local people to take enough foods like vegetables, milks and beef. This will improve nutrition condition and health situation of the local people. Sanitary condition will be improved by mitigation of flood and inundation. Public health services will easily access the project area through improvement of road network. In total, malaria and Schistosomiasis cases would be reduced during a certain period after implementation of the project.

Tables

Table X-2.1 Standard Conversion Factor

(Unit:K£ million)

Year	Export value (X)	Import value (M)	Export tax (Tx)	Import tax (Tm)	Standard conversion factor (SCF)
1984	754.81	1,050.22	27.04	267.73	0.88
1985	785.10	1,153.98	39.64	324.13	0.87
1986	957.97	1,276.03	33.88	362.48	0.87
1987	753.41	1,346.33	16.46	480.18	0.82
1988	917.72	1,654.32	25.30	554.50	0.83
Average 1987/88	835.57	1,500.33	20.88	517.34	0.82

Source: Statistical Abstract 1989, Central Bureau of Statistics, Ministry of Planning and National Development.

Note:

1. Export value includes domestic exports only and, excludes re-exports.
2. Import value includes commercial imports only and, excludes government imports.
3. Import tax includes import duties and sales tax on imports. Figures are refered from "Economic Classification of Revenue, 1984 - 1988".
4. Standard conversion factor is caliculated by the (SCF) following formula:
   SCF={(X)+(M)}/[{(X)- (Tx)}+{(M)+(Tm)}]

Table X-2.2 Economic Cost and Benefit Flow

IRR = 13.9%

		Const. cost	O & M	Replace-ment	Total cost	Benefit	Balance
1	1993	59.6	0.0	0.0	59.6	0.0	-59.6
2	1994	56.2	0.0	0.0	56.2	0.0	-56.2
3	1995	119.0	0.0	0.0	119.0	0.0	-119.0
4	1996	212.8	0.0	0.0	212.8	0.0	-212.8
5	1997	188.6	0.0	0.0	188.6	0.0	-188.6
6	1998	82.8	2.5	0.0	85.3	47.4	-37.9
7	1999	190.0	3.7	0.0	193.7	82.1	-111.6
8	2000	363.5	3.7	0.0	367.2	94.8	-272.4
9	2001	477.8	3.7	0.0	481.5	102.1	-379.4
10	2002	749.7	3.7	0.0	753.4	107.6	-645.8
11	2003	633.7	15.6	0.0	649.3	317.9	-331.4
12	2004	278.4	19.6	0.0	298.0	434.6	136.6
13	2005		23.5	0.0	23.5	551.6	528.1
14	2006		23.5	0.0	23.5	594.1	570.6
15	2007		23.5	0.0	23.5	626.1	602.6
16	2008		23.5	2.3	25.8	636.7	610.9
17	2009		23.5	0.0	23.5	642.0	618.5
18	2010		23.5	0.0	23.5	642.0	618.5
19	2011		23.5	0.0	23.5	642.0	618.5
20	2012		23.5	0.0	23.5	642.0	618.5
21	2013		23.5	10.3	33.8	642.0	608.2
22	2014		23.5	0.0	23.5	642.0	618.5
23	2015		23.5	0.0	23.5	642.0	618.5
24	2016		23.5	0.0	23.5	642.0	618.5
25	2017		23.5	0.0	23.5	642.0	618.5
26	2018		23.5	2.3	25.8	642.0	616.2
27	2019		23.5	0.0	23.5	642.0	618.5
28	2020		23.5	0.0	23.5	642.0	618.5
29	2021		23.5	0.0	23.5	642.0	618.5
30	2022		23.5	0.0	23.5	642.0	618.5
31	2023		23.5	14.4	37.9	642.0	604.1
32	2024		23.5	0.0	23.5	642.0	618.5
33	2025		23.5	0.0	23.5	642.0	618.5
34	2026		23.5	0.0	23.5	642.0	618.5
35	2027		23.5	0.0	23.5	642.0	618.5
36	2028		23.5	12.5	36.0	642.0	606.0
37	2029		23.5	0.0	23.5	642.0	618.5
38	2030		23.5	0.0	23.5	642.0	618.5
39	2031		23.5	0.0	23.5	642.0	618.5
40	2032		23.5	0.0	23.5	642.0	618.5
41	2033		23.5	10.3	33.8	642.0	608.2
42	2034		23.5	0.0	23.5	642.0	618.5
43	2035		23.5	0.0	23.5	642.0	618.5
44	2036		23.5	0.0	23.5	642.0	618.5
45	2037		23.5	0.0	23.5	642.0	618.5
46	2038		23.5	2.3	25.8	642.0	616.2
47	2039		23.5	0.0	23.5	642.0	618.5
48	2040		23.5	0.0	23.5	642.0	618.5
49	2041		23.5	0.0	23.5	642.0	618.5
50	2042		23.5	0.0	23.5	642.0	618.5
	Total	3,412.1					

Discount rate	10%
Benefit	2,395
Cost	1,665
B-C	730
B/C	1.44

Source : Prepared by JICA Study Team

Table X-3.1 Financial Cash Flow Statement

(Unit:Kshs.million)

		Outflow						Inflow						
		Project cost	O&M cost	Replacement cost	2.5% Loan interest	Loan repayment	(A) Total outflow	Foreign loan	Gov't budget	Gov't subsidy	Water charge	(B) Total inflow	Balance (B)-(A)	Accumulated loan
1993	1	77.5	0.0	0.0	1.6	0.0	79.1	62.6	14.9	1.6	0.0	79.1	0.0	62.6
1994	2	76.7	0.0	0.0	3.1	0.0	79.8	61.8	14.9	3.1	0.0	79.8	0.0	124.4
1995	3	165.4	0.0	0.0	6.5	0.0	171.9	135.3	30.1	6.5	0.0	171.9	0.0	259.6
1996	4	306.3	0.0	0.0	12.9	0.0	319.2	255.9	50.4	12.9	0.0	319.2	0.0	515.6
1997	5	281.2	0.0	0.0	18.8	0.0	300.0	235.0	46.2	18.8	0.0	300.0	0.0	750.6
1998	6	132.3	3.0	0.0	21.4	0.0	156.7	107.3	25.0	21.4	3.0	156.7	0.0	858.0
1999	7	314.6	4.6	0.0	28.0	0.0	347.2	263.5	51.1	28.0	4.6	347.2	0.0	1,121.5
2000	8	607.3	4.6	0.0	41.0	0.0	652.9	516.8	90.5	41.0	4.6	652.9	0.0	1,638.2
2001	9	830.4	4.6	0.0	58.7	0.0	893.7	710.0	120.4	58.7	4.6	893.7	0.0	2,348.2
2002	10	1,357.4	4.6	0.0	87.9	0.0	1,449.9	1,166.6	190.8	87.9	4.6	1,449.9	0.0	3,514.8
2003	11	1,196.9	19.1	0.0	107.4	250.5	1,573.9	1,031.4	165.5	357.9	19.1	1,573.9	0.0	4,295.6
2004	12	549.2	23.9	0.0	112.7	250.5	936.4	464.8	84.4	363.3	23.9	936.4	0.0	4,509.9
2005	13	0.0	28.7	0.0	106.5	250.5	385.7	0.0	0.0	357.0	28.7	385.7	0.0	4,259.3
2006	14	0.0	28.7	0.0	100.2	250.5	379.5	0.0	0.0	350.8	28.7	379.5	0.0	4,008.8
2007	15	0.0	28.7	0.0	94.0	250.5	373.2	0.0	0.0	344.5	28.7	373.2	0.0	3,758.2
2008	16	0.0	28.7	2.8	87.7	250.5	369.7	0.0	0.0	341.0	28.7	369.7	0.0	3,507.7
2009	17	0.0	28.7	0.0	81.4	250.5	360.7	0.0	0.0	332.0	28.7	360.7	0.0	3,257.1
2010	18	0.0	28.7	0.0	75.2	250.5	354.4	0.0	0.0	325.7	28.7	354.4	0.0	3,006.6
2011	19	0.0	28.7	0.0	68.9	250.5	348.1	0.0	0.0	319.4	28.7	348.1	0.0	2,756.0
2012	20	0.0	28.7	0.0	62.6	250.5	341.9	0.0	0.0	313.2	28.7	341.9	0.0	2,505.5
2013	21	0.0	28.7	12.6	56.4	250.5	348.2	0.0	0.0	319.5	28.7	348.2	0.0	2,254.9
2014	22	0.0	28.7	0.0	50.1	250.5	329.4	0.0	0.0	300.7	28.7	329.4	0.0	2,004.4
2015	23	0.0	28.7	0.0	43.8	250.5	323.1	0.0	0.0	294.4	28.7	323.1	0.0	1,753.8
2016	24	0.0	28.7	0.0	37.6	250.5	316.8	0.0	0.0	288.1	28.7	316.8	0.0	1,503.3
2017	25	0.0	28.7	0.0	31.3	250.5	310.6	0.0	0.0	281.9	28.7	310.6	0.0	1,252.7
2018	26	0.0	28.7	2.8	25.1	250.5	307.1	0.0	0.0	278.4	28.7	307.1	0.0	1,002.2
2019	27	0.0	28.7	0.0	18.8	250.5	298.0	0.0	0.0	269.3	28.7	298.0	0.0	751.6
2020	28	0.0	28.7	0.0	12.5	250.5	291.8	0.0	0.0	263.1	28.7	291.8	0.0	501.1
2021	29	0.0	28.7	0.0	6.3	250.5	285.5	0.0	0.0	256.8	28.7	285.5	0.0	250.5
2022	30	0.0	28.7	0.0	0.0	250.5	279.2	0.0	0.0	250.5	28.7	279.2	0.0	0.0
Total		5,895.2	581.0	18.2	1,458.3	5,011.0	12,963.7	5,011.0	884.2	6,487.5	581.0	12,963.7		
								85%	15%					

Foreign loan :85% of total cost, annual interest of 2.5% for repayment period of 30 years including grace period of 30 years.

Source : Prepared by JICA Study Team

Annex XI

Assessment of Environmental Impact

Feasibility Study
on
Kano Plain Irrigation Project

Annex XI
Assessment of Environmental Impacts

Table of Contents

PART 2 ECOLOGY AND VECTOR BORNE DISEASE

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1. INTRODUCTION:

Two main aspects in the environment are assessed in this feasibility study. One is possible pollution of water quality in the lake by the project and the other is an ecology in the swamp and a possible increase of vector borne diseases.

The result of the study of the former is compiled in the Part 1 in this Annex and the latter is in the Part 2, respectively.

PART 1 WATER QUALITY IN THE LAKE

1. GENERAL

1.1 Objectives

The objectives of this water quality analysis for the Kano Plain Irrigation Project (Project) are as follows:

- To assess an impact on water quality and evaluate its magnitude caused by the selected alternatives by each,
- To provide basic information for optimizing the development scale of the Project from the viewpoint of water quality, and
- To recommend possible countermeasures and further studies.

1.2 Approach of the Study

In general, an agricultural development with irrigation scheme brings about an increase of water pollution load due to a change of land use pattern and an application of fertilizers in the project area. In addition to this, since the Project plans to use diverted water from the Sondu river for irrigation, a drastic change of the existing water flow regime is envisaged and it may cause an impact on the water quality in the downstream water bodies. Therefore, a quantitative approach focusing on pollution load is taken to assess the water quality degradation caused by the Project. This approach is considered effective not only to compare with proposed alternatives for deciding an optimal scale of the Project, but also to provide basic information for preparation of the Environmental Impact Assessment (EIA) for the Project.

In order to attain the objectives mentioned in the previous section, the following works are carried out in this study:

- Collection of the existing data and document related to the water quality and pollution load,
- Implementation of water sampling and analysis at eight stations in and around the Project area,
- Calculation of the present pollution load and future pollution load by each alternative plan,
- Evaluation of the impact on the water quality of the Nyakach Bay (the Bay) and Winam Gulf (the Gulf), and
- Consideration of proper countermeasures to reduce the magnitude of impacts.

1.3 Alternatives

The following alternatives are considered for evaluation of the magnitude of impact on the water quality of the Gulf and the Bay caused by the Project:

Alternative	Irrigation Area (ha)	Water Requirement (mil. m^3/year)	Return Flow Rate (%)
Case-1	24,220	520 (=16.5m^3/s)	32.0
Case-2	20,240	467 (=14.8m^3/s)	36.7
Case-3	14,930	372 (=11.8m^3/s)	41.4

2. EXISTING WATER QUALITY CONDITIONS

Water sampling and water quality analysis was carried out in this study though several water quality data are available in and around the Project, because more specific and recent data are needed to assess the impacts on water quality caused by the Project. Based on the results of the water sampling and the existing data, the conditions of water quality around the Project area are briefly described in this chapter. The location of sampling stations and the results of water quality analysis are shown in Figure XI-1.1 and Table XI-1.1, respectively.

2.1 Sondu River

The Sondu river originates from the western slope of the Mau escarpment and drains the total area of 3,470 km^2. The Sondu river flows down westwards gathering such major tributaries as the Yurith and Kipsonoi rivers, and finally drains into the Winam Gulf through flood plains consisting of alluvial deposits. According to "the Integrated Regional Development Master Plan, 1987, JICA", the annual mean runoff recorded of the Sondu river amounts to about 1,221.6 million m^3.

All analysed physio-chemical parameters show clean river water quality although its colour is light brown. Water temperature is almost 20^oC, and Suspended Solid (SS) is rather high due to existence of fine sediments in water. Dissolved Oxygen (DO) is almost saturated level, and other biodegradable items such as Chemical Oxygen Demand (COD) are low, showing that there is no severe threats of organic pollution in the river at present.

2.2 Nyando River

The Nyando river, which has about 3,450 km^2 of basin area, originates in the western slope the Mau escarpment. The river takes its route from nearly to the southwest direction and finally flows into the Nyakach Bay through the Nyando swamp. The annual runoff of the Nyando river at the said station is estimated at about 510.9 million m^3 based on the record from 1956 through 1984.

The water quality of the Nyando river is under serious conditions compared with that of the Sondu river. Very high concentration of SS, almost ten times of the Sondu river, and heavily polluted by biodegradable substances can be found in the river mainly due to the discharge of waste water from several agro-processing factories located in the upstream area.

2.3 Winam Gulf and Nyakach Bay

Winam Gulf of the Lake Victoria is a rather closed water body and has water surface area of approximately 1,400 km^2 with its basin area of 12,000 km^2. The Sondu river, Nyando river and Awach river are the major inputs of water to the Gulf beside direct rainfall, and the approximate annual inflow to the Gulf is estimated about 2,731.0 million m^3 based on the hydrologic result of the Project and "the Integrated Regional Development Master Plan, 1987, JICA". The Nyakach Bay has about 36 km^2 of surface area and its annual inflow is considered to be almost the same to the annual runoff of the Nyando river which is about 510.9 million m^3.

"Winam Gulf Baseline Study" conducted from 1984 to 1985 provides recent and comprehensive water quality data of the Gulf. Secchi depths to measure the transparency of water were low in the Gulf: about 1.6 to 2.4 m at the centre of the Gulf, 0.8 m at the eastern lakeshore area of the Gulf, and 0.3 to 0.4 m in Nyakach Bay. This indicates considerably very low transparency of the Bay, which is mainly due to suspended sediment load from the Nyando river and blue-green algae blooms in the Bay. Dissolved Oxygen (DO) in the eastern part of the Gulf is generally high, and close to saturation near the surface. Ammonia nitrogen (NH4-N) is ranging from 0.02 to 0.03 mg/l, Nitrite nitrogen (NO2-N) is about 0.01 mg/l, Nitrate nitrogen (NO3-N) is from 0.09 to 0.18 mg/l in the mean values, and Total nitrogen (T-N) is from 0.50 to 0.63 mg/l. Total phosphorus (T-P) is slightly high ranging 0.02 to 0.04 mg/l. And the mean values of Chlorophyll-a ranges about 0.02 mg/l in the Gulf, but the values of Chlorophyll-a content in the Bay would be considerably high taking its low transparency into account.

Although the Winam Gulf and the Nyakach Bay are considered eutrophic on the basis of conventional trophic state indices, i,e., secchi depth, T-P, and chlorophyll-a, the Gulf seems to be in moderately eutrophicated conditions compared with the Bay. The bloom - causing algae (Cyanophyta) predominate in the Gulf region.

These are potentially troublesome for water treatment facilities which abstract water from this area. Sporadic cyanophyte surface bloom occurs within the Gulf. Microcystis aeruginosa was the dominant algae species during the period of investigation.

3. ASSESSMENT OF WATER QUALITY CHANGE CAUSED BY THE PROJECT

3.1 Setting up Basic Data

1) Hydrological Conditions

Three (3) alternatives which have different irrigable areas as described in the previous chapter are selected for considering an optimal scale of the Project. Basic data about hydrological conditions of the alternatives are summarized on Table XI-1.2 with a general feature of the Winam Gulf and Nyakach Bay based on the existing reports and documents related to hydrology and water quality in and around the Project area. Several key points of the basic data are explained hereunder:

- The surface area and annual inflow of the Gulf and Bay were quoted from "the Integrated Regional Development Master Plan, 1987, JICA" and the average depth of them were from "The Winam Gulf Baseline Study, 1985".

- The volume of diverted water from the Sondu river for irrigation is set by each alternative, namely 520 million m^3/y (16.5 m^3/s) in Case-1, 467 million m^3/y (14.8 m^3/s) in Case-2 and 372 million m^3/y (11.8 m^3/s).

- Annual precipitation and evapotranspiration in the Gulf and Bay would be currently considered to be well balanced.

- An evapotranspiration and permeability rate of the proposed irrigation area is assumed 4 mm/day. Thus the volume of loss water is assumed 354 million m^3/y in Case-1, 296 million m^3/y in Case-2 and 218 million m^3/y in Case-3.

- Annual inflow to the Gulf in a case of with-project conditions is calculated by subtracting the volume of loss water from the existing inflow volume.

- The area where a return flow comes into the Bay is assumed 18,240 ha (Sub-area I to VI, about 75 % of the proposed irrigation area) in Case-1, 17,700 ha (Sub-area I to VI, about 87 % of the proposed irrigation area) in Case-2 and 14,930 ha (Sub-area I to V, all the proposed irrigation area) in Case-3. Thus, the actual return flow to the Bay of each alternative is calculated by multiplying estimated return flow and area coverage ratio mentioned above.

At present, a retention time (annual inflow/storage volume) of the Gulf is about 0.33 times per year and it will be changed to about 0.28 times per year in Case-1. This means that the Project will prolong the time for replacing all water in the Gulf by 6.5 months. On the other hand, it will shorten the time in the Bay by 15 days in Case-1.

2) Water Quality Data

COD, T-N and T-P are selected as the indices to assess the impacts on the water quality by the Project, because these items have been commonly used in this purpose and the data related to load units of them (kg/ha/day) are considered available in Kenya.

Water quality data of COD shown in Table XI-1.1 are the results of water sampling in this study. T-N and T-P data are obtained from the results of water sampling and the existing data described in "The Winam Gulf Baseline Study".

3) Water Pollution Load

Based on the results of water quality analysis and the existing data, the conditions of water pollution load about COD, T-N, and T-P of the Gulf and Bay are calculated by multiplying each water quality values and inflow data shown in Table XI-1.2. The result is summarized in Table XI-1.3.

The pollution loads entering to the Bay are about 2,146 t/y in COD, 608 t/y in T-N and 51 t/y in T-P. While, the loads coming from the Bay to the Gulf are about 1,328 t/y in COD, 317 t/y in T-N and 20 t/y in T-P. Thus, the purification capacity of the Nyakach Bay would be estimated about 30 to 60 % of the total inflow load, approximately.

4) Estimation of Pollution Load from Irrigation Area

A non-point source of pollution load normally depends on the existing land use pattern. Since the Project will bring about the land use changes by introducing irrigation facilities, it is necessary to estimate the change of pollution load caused by the Project. The current and future pollution loads were calculated by multiplying a load unit to an area of land use change, and the increment of pollution loads caused by the Project are estimated based on these inputs. The results are summarized hereunder and the details are shown in Table XI-1.4 to 1.6.

Item			Case-1	Case-2	Case-3
COD	increment load	(t/y)	1,581.0	1,338.0	1,085.0
T-N	increment load	(t/y)	90.4	76.4	62.0
T-P	increment load	(t/y)	46.7	39.5	32.0

The unit pollution loads of T-N (e.g. 8.8 Kg/km^2/day in irrigated area) in Table XI-1.5 and T-P (e.g. 0.88 Kg/km^2/day in irrigated area) in Table XI-1.6 were verified by the data described in the existing reports, namely "A Survey of Eutrophication and Water Pollution Load's in Four Rivers of the Northern Half of the LBDA, 1983" and "The Manual for Integrated Water Quality Management of Lakes, 1987, Japan Civil Engineering Research Centre".

While, the unit pollution loads of COD (e.g. 28.0 Kg/km^2/day in irrigated area) in Table XI-1.4 was set by adjusting usual pollution load units in Japan through the discussion with the environment experts of LBDA considering the results of water quality analysis, because no reliable data were obtained in Kenya at present.

5) Unit Pollution Load and Fertilizer Application

Impacts on water quality and pollution load caused by fertilizer use need to be assessed properly. Table XI-1.7 shows the fertilizer consumption in the proposed irrigation area by each alternative and cropping pattern. Ammonium sulphate contains 21 % of nitrogen and TSP (Tri-super Phosphate) contains 46 % of phosphorus. Thus, their net amount range from 1,604 t/y (Case-3) to 2,414 t/y (Case-1) in nitrogen and 869 t/y (Case-3) to 1,736 t/y (Case-1) in phosphorus.

The increment load of nitrogen and phosphorus shown in Table XI-1.5 and Table XI-1.6 is about 4 % of the net nitrogen amount of fertilizer consumption and about 3 % of the net phosphorus amount. It is usually estimated that a runoff ratio of fertilizer is less than 10 % of the consumption amount. Therefore, it is considered that the estimated increment load includes the load coming from fertilizer use.

3.2 Assessment of Water Quality Deterioration

3.2.1 Change of water quality of the gulf and bay

Based on the data described in the previous chapter, a degree of water quality change in the Gulf and Bay is estimated by a complete dilution model method and the results are shown in Table XI-1.8.

1) Nyakach Bay

Levels of water quality change of the alternatives range from 2.3 (Case-3) to 3.2 mg/l (Case-1) in COD, 2.71 (Case-3) to 4.02 mg/l (Case-1) in T-N, and 0.05 (Case-3) to 0.06 mg/l (Case-1) in T-P. Case-1 shows the worst quality of all items and Case-3 is the best among the alternatives.

Since the levels of water quality change of all items are rather high even in Case-3, the water quality deterioration in the Bay could be accelerated by the implementation of the Project. The Bay is under moderately eutrophicated conditions at present, so the proliferation of aquatic weeds and water bloom by phytoplanktons might be found frequently after the completion of the Project. The expected water quality is summarized hereunder.

Item	Unit	Existing	Case-1	Case-2	Case-3
COD	(mg/l)	2.6	5.8	5.3	4.9
T-N	(mg/l)	0.62	4.64	4.07	3.33
T-P	(mg/l)	0.04	0.10	0.10	0.09

A retention time of the Bay will be shortened about 15 days by the inflow of the diverted water to the Bay. This shows that the water quality of the Bay mostly depending on the quality of the Nyando river and drained water from the proposed irrigation area. Therefore, the minimum use of water and fertilizer for irrigated agriculture is recommendable to alleviate the impacts on the water quality in the Bay.

2) Winam Gulf

Levels of water quality deterioration caused by the Project range from 0.59 (Case-3) to 0.93 mg/l (Case-1) in COD, 0.07 (Case-3) to 0.11 mg/l (Case-1) in T-N, and 0.01 (Case-3) to 0.02 mg/l (Case-1 and 2) in T-P.

Very few differences of the increase level of water quality concentration would be expected in the Gulf among alternatives. The levels of deterioration of water quality of the Gulf would not be serious in comparison with that of the Bay. Possible reasons of this are considered that a big storage volume of water in the Gulf will dilute the increment pollution loads caused by the Project and a volume of water loosed by irrigation will be very small compared with the storage volume of the Gulf. The expected water quality is summarized hereunder.

Item	Unit	Existing	Case-1	Case-2	Case-3
COD	(mg/l)	1.8	2.7	2.6	2.4
T-N	(mg/l)	0.47	0.58	0.56	0.54
T-P	(mg/l)	0.02	0.04	0.04	0.03

It is natural that the water quality around the border area between the Nyakach Bay and Winam Gulf would be higher than that of the centre of the Gulf because the water quality deterioration caused by the Project would spread from the Bay to the Gulf. The approximate maximum influence area of the Gulf could be the area of about 8.5 km distance from the transect section between the Gulf and the Bay in Case-2, about 80 km^2, by using the following equation.

Nitta Equation: $\log(r^2 \times a/2) = 1.226 \log Q + 0.086$

where:

r : expected distance to be influenced by input water,
a : angle of dilution (a= /2 in this case),
Q : volume of discharged water (m^3/day)
Case-1= 1.75 mil. m^3/day,
Case-2= 1.81 mil. m^3/day,
Case-3= 1.82 mil. m^3/day)

3.2.2 Possibility of eutrophication

Possibility of eutrophication is one of measures for evaluation of the magnitude of water quality change of the Gulf and Bay. A preliminary evaluation of eutrophication is conducted by using Vollenweider model.

A potential of eutrophication normally depends on inflow of nutrients and a feature of water body. Since the nitrogen and phosphorus ratio (N/P) in the centre of the Gulf and the Bay are more than 10, phosphorus is considered a limiting nutrient. In this condition, Vollenweider model focused on a concentration of phosphorus is a common and simple method to assess the possibility of eutrophication of the concerned water body. The model is given by the following equation:

$$Lc=Pc(Z \times @ + Z \times Vp)$$

where:

$Lc(gP/m^2.y)$	:	Annual phosphorus surface load,
$Pc(g/m^3)$	:	Concentration of total phosphorus of inflow,
$Z(m)$	:	Average depth, given by V/A,
$V(m^3)$	:	Storage volume of a water body,
$A(m^2)$	:	Surface area of the water body,
@(times/y)	:	Retention time, given by Q/V,
$Q(m^3/y)$	:	Annual inflow to the water body,
Vp(m)	:	Sedimentation velocity coefficient, normally given by 10/Z,

Results are shown in Table XI-1.9 and Figure XI-1.2, and no obvious differences about possibility of eutrophication could be found among the alternatives.

The possibility of eutrophication of the Bay will rise due to the inflow of additional pollution loads of phosphorus caused by the Project. However, it seems to be not so serious because the Bay is now under moderately eutrophicated condition and some amount of pollution load caused by the Project would be purified by the swamp area located in the downstream of the drainage canals.

As for the Winam Gulf, no drastic change of the possibility of eutrophication would not be identified and no serious impacts could be considered in the Gulf.

3.3 Consideration of Countermeasures

Two principal and possible countermeasures can be considered for reducing the impacts on the water quality caused by the Project. One is to minimize a volume of drained water from the irrigation area. The other is to use a purification capacity of paddy field and swamp area.

3.3.1 Minimization of deteriorated waste water discharge

In order to minimize the discharge of deteriorated waste water from irrigation area, the following measures are to be taken in this Project:

1) To minimize the drained water by applying a plot-to-plot irrigation and protecting the water leakage from a levee of paddy field during the periods discharging heavily deteriorated waste water especially puddling period, transplanting period and additional dressing period,

2) To reuse irrigation water as maximum as possible by arranging a layout of paddy field for receiving drained water from another cultivation lands,

3) To minimize the utilization of fertilizer by effective application of additional fertilizer dressing, and

4) To return a sedimented soil in the bottom of canals, which contains high concentration of organic substances, to the paddy field.

3.3.2 Full ese of purification capacity of swamp area

About 3,000 ha of swamp area are located in the downstream of the proposed irrigation area. This swamp area is likely to have high purification capacity of pollution load coming from upstream areas. In Japan, its purification capacity (ratio) is normally 10 - 50 % in COD and T-N, and 10 - 60 % in T-P. The capacity in Kenya could be higher than that of in Japan because of rather high mean water temperature. Thus, the swamp area is considered large enough to purify large portion of the estimated pollution loads caused by the Project because of rather low surface area load values.

Assuming that a purification capacity of the swamp area is about 40 %, the expected water quality of the Nyakach Bay in Case-3 is estimated as follows. A conspicuous reduction of water quality can be found in COD and T-P, though it is very little in T-N due to its high concentration of the diverted water from the Sondu river. Thus, the purification capacity of swamp area would directly alleviate the potential of eutrophication of the Bay.

Item	Unit	Existing	No Capacity Considered	40% Capacity Considered
COD	(mg/l)	2.6	4.9	3.9
T-N	(mg/l)	0.62	3.33	3.28
T-P	(mg/l)	0.04	0.09	0.06

Although no data are available to obtain an accurate purification capacity of the swamp area at present, the important points for the design of the Project are i) to widen the end side of drainage canals for diminishing water flow velocity, ii) to disperse discharge water by arranging drainage canals properly, and iii) to arrange a layout of drainage canals for releasing waste water in the swamp area effectively.

4. CONCLUSION AND RECOMMENDATION

4.1 Optimal Project Scale from the Viewpoint of Water Quality

1) The proposed Project would cause more significant impacts to the water quality of the Nyakach Bay than that of the Winam Gulf because the water quality of the Bay would mostly depend on the quality and quantity of the Nyando river and the drained water from irrigation area. Thus, more careful attention needs to pay to the water quality in the Bay.

2) Although there might be some uncertainty on the dynamic system of water quality in the Project area, Case-3 (14,930 ha of irrigation area) is recommendable to avoid high magnitude of impact on water quality of the Bay. As for the Winam Gulf, however, no drastic change of water quality would be considered mainly due to its dilution effect by the huge storage volume of the Gulf.

4.2 Impact on Water Quality Caused by the Project

1) This study revealed that to use water irrigation is to degrade water quality of the downstream water body, especially the Nyakach Bay. The Bay, however, is likely to be under critical conditions at present because of rich nutrient inflow from the Nyando river, as described in the previous section 2.2. Therefore, the magnitude of impacts caused by the irrigation project on water quality in the Bay would not be so substantial.

2) The large swamp area located in the downstream of the proposed irrigation area has no doubt an important function of pollution load purification. A layout of drainage canals in particular, should be designed by taking the effective utilization of the purification capacity of the swamp area into account.

3) The degree of eutrophication in the Nyakach Bay could be accelerated by the Project, even in Case-3. However, it could be sufficiently alleviated by using a purification capacity of the swamp area. While, in the Winam Gulf, no serious problems would be caused by the Project. Thus, the Project would be acceptable from the viewpoint of water quality premising the effective use of the purification capacity of the swamp area.

4) At present, no data available to verify the purification capacity of the swamp area. So, a further study for clarifying an effective use of its capacity is to be recommended. It is also emphasized that the conservation of the swamp area should be put high priority for reduction of the load caused by the Project. A study is recommended in the detailed design state to quantify the purification capacity.

5) Establishment of the efficient water management is strongly recommended to avoid unnecessary water quality deterioration in the downstream area. Since farmers in the area are not well familiar with the irrigated agriculture, it seems to be preferable to develop the project step by step to attain efficient water management system and practice.

6) Polluted water from the Nyando river has been degrading the water quality of the Nyakach Bay. The pollution of the Bay may degrade the Winam Gulf in turn. Since the Gulf is considered a semi-closed lake, it would be very difficult to retrieve a clean condition as it was if the water quality of the Gulf would be once degraded. Thus, a comprehensive approach for pollution control is recommended to avoid further water quality deterioration of the Bay and Gulf.