6.5.4 Layout of irrigation canal

Two (2) main canals are aligned along elevated contour lines as far as possible, originating from the regulating pond which is proposed in the due proximity of the tail race of the Sondu-Miriu Hydropower Station.

The Nyakach-Kano Main Canal of about 44.2 km long originates from the regulating pond and follows its trace firstly nearly eastwards along skirts of hilly ranges until the vicinity of the Asawo river. After crossing the Awach-Kano river, the canal takes its trace nearly northwards and finally debouches into the Nyando river. This main canal commands totally 13,680 ha under the Nyakach and Kano Plains. Twenty six (26) numbers of secondary canals branch off from this main canal and seven (7) tertiary canals directly branch off from the main canal.

The South Nyanza Main Canal extends about 7.0 km from the said Power Station. After branching off from the regulating pond, this main canal extends almost westwards until the right bank of the Sondu river. After crossing the Sondu river with inverted siphon, the canal follows its trace further westwards along or in parallel with the Road Route C19, and finally debouches into the Aoch Nyandega river. Five (5) secondary canals branch off from this main canals.

Fig.6.4 illustrates the irrigation canal layout for the entire project area, and the irrigation diagram is shown in ANNEX-VII. The proposed discharge for each main canal section in each sub-area can be summarized as given below:

	Section of Main Canal	Sub-Area	Command Area	Proposed Discharge
1)	South Nyanza	I	650	0.9
2)	South Nyanza	I, II-1	1,250	1.5
3)	Nyakach-Kano	V	3,500	4.3
4)	Nyakach-Kano	V, IV	7,670	9.9
5)	Nyakach-Kano	V, IV, III	10,450	14.1
6)	Nyakach-Kano	V, IV, III, II-2	13,680	17.1

6.5.5 Drainage improvement

(1) Layout of drainage system

Flood control and river training along rivulets and torrents developed across the project area from the east to the westwards would be essential from maintenance of the proposed irrigation canal facilities. In addition, the flood control of such torrents is essential from soil conservation viewpoint as well, because farm land around the torrents has been seriously eroded by habitual rush of floods at present.

Thirty one (31) rivers and rivulets were identified for the flood control and drainage improvement through field works. Based on this identification, and in due consideration of recommendation by water quality conservation study, a drainage improvement plan is envisaged so as to drain the drainage water from the project area into the Nyakach Swamp as far as possible for purification of polluted water by irrigated agriculture.

Sixty nine (69) main and secondary drainage canals would be proposed; out of them,fourteen (14) main and secondary drainage canals are aligned westward from the Power Station, while fifty five (55) main and secopndary drainage canals, northeastward from the

Station. The total catchment area is estimated to be about 859 km^2 Only eighteen (18) drainage canals, the catchment area of which being 110 km^2,directly drain into Nyakach bay.

Most of them debouch directly into the Nyakach Swamp. Fig. 6.5 illustrates the layout of the entire drainage canal. The total length of the proposed draiange canals reaches about 260 km.

(2) Flood discharge and drainage reqirement

The data of six (6) rain gauge stations are collected for estimate of probable rainfall in and around the Kano and Nyakach Plains. Probable rainfall with 5-year and 50-year return period is estimated to be 103.7 mm and 134.7 mm respectively. Based on the 50-year probable rainfall, flood discharge in each watershed of natural creek is estimated by empirical formula for preliminary design of the drainage canals,while based on the 5-year probable rainfall, drainage requirement for upland field is also estimated by the same empirocal formula.

Runoff from paddy field is much specific due to its large retension capacity and flatness in paddy plots. Continuous rainfall directly affects the runoff of paddy area. Based on 5-year probable rainfall of 3-day continuous rainfall and drainage area,drainage requirement for each drainage canal in the paddy field is eastimated by using an empirical formula specially developed for the runoff of paddy area.

(3) Drainage works

Drainage improvement works would be classified into two categories; one is river trainaing of natural creeks and the other is excavation works of newly proposed drainage canals. The river trainaing works would be further sub-divided into two categories;category-i is excavation of riverbed and embankment work therein with the excavated materials,and category-ii is embankment work with borrow materials. The categry-i would be proposed along ephemeral flow channel and the category-ii ,along perennial flow channel. Newly proposed drainage canals are unlined and have a trapezoidal section with a side slope of 1 to 1.5 in principle. The proposed main and secondary canals are 263 km long in total.

6.5.6 Field irrigation plan

(1) Depth of irrigation application

Depth of irrigation application is defined as the water depth that can be stored in root zone for growing of crop. Total available amount of water stored in soil is generally given by soil moisture content at field capacity (FC, pF1.5 to 1.7) to temporary wilting point to wilting point (TWP, WP, pF3.9 to 4.2). Water holding capacity of soils in the study area is not known so far. General information are therefore applied for this study.

Not all soil water in the root zone held between FC to TWP is readily available. Depth of water readily available is generally defined as RAM (Readily Available Moisture). The RAM is dependent on crops. Soil Moisture Extraction Pattern (SMEP) in root zone of the crops is different from crop to crop. Since there is no data available about SMEP of the crops proposed in the project,the reference data in FAO publication are employed in this study.

(2) Application interval

Irrigation application interval is theoretically calculated by dividing TRAM by evapotranspiration of crop. Evapotranspiration of crops, ETcrop, varies from 1.5 to 5.5 mm per day as mentioned in the previous section. The TRAM of crop shows quite different value from sandy soils to loamy and clayey soils. Irrigation interval is therefore varied by crops in sandy soils, and loamy to clayey soils as shown in Table 6.5.

Making reference to the above and in due consideration of water management aspect, the irrigation interval by crop and soil is determined as given below:

Crop	Sandy Soil	Loamy to Clay
- Cotton, Maize, Sugarcane	7 days	7 days
- Groundnuts, Onion, Peas, Vegetable, Tomato, Cabbage	2 days	4 days

(3) Application depth

Net application depth would be obtained by multiplying ETcrop with irrigation interval;gross application depth would be estimated by multiplying the net application depth with application coefficiency (70%). The gross application depth by each proposed crop is calculated as given in ANNEX-VII, and then classified into four (4) categrories according to soil and crop,as summarized below; the application depth ranges from 14 mm for vegetables on sandy soil to 52 mm for cotton, maize, and sugarcane on sandy soil.

Crop	Sandy Soil	Loamy to Clay
- Cotton, Maize, Sugarcane	52 mm	50 mm
- Groundnuts, Onion, Peas, Vegetable, Tomato, Cabbage	14 mm	26 mm

(4) Field irrigation method

Field supply is primarily determined by those of depth and interval of irrigation and by irrigation method on field. The method of irrigation is determined by factors such as type of crop, soil type, topography, and cost. According to infiltration test, soil in the study area is classified into the optimum to the marginal suitable to surface irrigation. Considering topographic condition and cost required, furrow irrigation is proposed in the project.

All crops proposed in the project other than fruit tree are suitable for furrow irrigation. In some areas in which land slope is rather steep, furrow should be made diagonally or parallel to slope. Irrigation water supply to field would be made from the water course which branches off from tertiary canal. No direct supply from major canal system would be principly made in order to attain more effective water management for the entire irrigation system.

(5) Furrow stream and length

Stream size depends mainly on type of soils or infiltration rate and slope of filed. Flow of water per furrow should be large enough to reach end of run, and small enough not to cause erosion, flooding and tail losses. No field data is available at present on furrow stream and furrow. Allowable furrow stream by soil and furrow gradient,therefore,is assumed as 0.3 l/sec for 2% gradient and 0.6 l/sec for 1% gradient,making reference to relevant technical publication. The optimum furrow length by crop,soil,and gradient can be classified as tabulated below:

Optimum Furrow Length (m)

Item	Sandy Soil		Loamy to Clay	
Furrow Gradient	1%	2%	1%	2%
- Cotton, Maize, Sugarcane	70	50	150	100
- Grondnuts, Onion, Peas, Vegetable, Tomato	50	30	100	70

(6) Furrow irrigation requirement and operation hours

In order to supply the application depth previously mentioned,per-hectare furrow irrigation requirement is estimated on the basis of the various components such as allowable furrow stream,furrow length,furrow space, number of furrow to be simulateniously operated,and daily operation time. The detail computation is given in ANNEX-VII. The following is the summary of computation of the furrow irrigation requirement per hectare by soil and crop.

Item	Sandy Soil		Loamy to Clay	
Furrow Gradient	1%	2%	1%	2%
- Cotton, Maize, Sugarcane (l/sec)	12	9	12	9
- Groundnuts, Onion, Peas, Vegetable, Tomato (l/sec)	12	6	12	6

In order to obtain simmilar furrow requirement by soil and crop,operation hours by soil and crop are adjusted in the course of the computation of the requirement as given below. The optimum operation hour ranges from about 3 hrs for vegetable on the sandy soil with 1% gradient, to about 16 hrs for cotton, maize, and sugarcane on sandy soil with 2% gradient.

Item	Sandy Soil		Loamy to Clay	
Furrow Gradient	1%	2%	1%	2%
- Cotton, Maize, Sugarcane (hrs)	12.0	16.1	11.6	15.4
- roundnuts, Onion, Peas, Vegetable, Tomato (hrs)	3.3	6.5	6.0	12.0

6.5.7 Tertiary canal system

Rotational irrigation would be practiced in tertiary canal system in accordance with field irrigation development plan discussed in the preceding section. Terminal block or rotational block would be proposed to be four (4) to five (5) ha in principle. Following the irrigation interval applied for the irrigation plan,one irrigation block consists of seven (7) blocks, the area of which being about 30 ha. One tertiary block would be composed of plural irrigation blocks. Fig. 6.6 ilustrates a typical layout of the tertiary system for upland and paddy field.

(1) Typical layout of tertiary system

Typical layout of tertiary system in upland and paddy field would be emvisaged on the following bsasic concepts;

i) One tertiary or sub-tertiary canal would be aligned at least in tertiary irrigation block,
ii) One water course would command one rotational block in principle,
iii) About six water courses would branch off from the tertiary canal,
iv) Field drain would be aligned in pararrel with water course,
v) Tertiary drain would be aligne at end side the tertiary block,
vi) Farm ditch would branch off from the water course as required.

(2) Canal dimension of tertiary system

Length of tertiary irrigation canal would be ranged from one km to 1.5 km, and limited to 2.0 km in the maximum;length of water course would be also limited to about 1.5 km in the maximum in due consideration of water management viewpoint. Farm road of four (4) m wide would be provided along tertiary canal and water course. Design discharge of the tertiary irrigation canal and irrigation water course range from 30 l/sec to 70 l/sec depending upon their command area. Side slope of the canal and the course would be 1 to 1.0.

Tertairy and field drains have drainage area of about 40 ha and 5 ha on an average respectively. Design discharge of the drains is estimated at 0.12 l/sec/ha for upland field and 4.24 l/sec/ha for paddy field. Bottom width of the tertiary and field draiange canal ranges from 0.2 m to 1.2 m and canal depth of both canals ranges from 0.2 m to 1.4 m.

Division box,drop structure, and pipe culvert would be proposed on the tertiary irrigation canal. Farm culvert and field access also would be proposed on the irrigation water course. Meanwhile, drop structure, cross drain, and drainage culvert would be provided as required on the tertiary drain.

6.5.8 Improvement of existing road

Existing roads in the project area are low-embanked and rather deteriorated by habitual floods inundations. In order to make the roads all-weathered,the embankment work would be proposed at the portion of roads in the low-lying area. In addition,laterite pavement also would be proposed as required according to soil mechanic condition.

The existing roads are not fully networked due to lack of crossing structures spanning natural creeks and rivulets. This is one of the crucial constraints for daily traffics and transportation of farm inputs and products. Proper number of bridges and causeways would be proposed to traverse main perennial and seasonal streams.

7. PROPOSED PROJECT WORKS

On the basis of the layout of irrigation and drainage system described in the preceding chapter, all the irrigation and drainage facilities are disposed at proper site and location in order to make the system for 14,930 ha fully function. The main facilities consist of i) regulating pond, ii) main irrigation canal, and its related structures, iii) secondary canal and its related structures, iv) drainage canal, and v) farm road. Details of project facilities are presented in the Annex VII and illustrated in Drawings.

7.1 Regulating Pond

Fluctuated discharge released to the tail race from the Sondu-Miriu Hydropower station would be regulated by proper size of detention storage. Based on the secondary discharge from the power station and irrigation water demand, the maximum regulating capacity of about 634,000 m^3 is calculated during a period of early March (detail calculation would be given in Annex -VII).

Topographically, there is no site suitable for construction of such a large capacity of pond in the proximity of the power station. Therefore, 1.1 km of the head reach of the main canal would be widened and deepened to get the required capacity.

The pond would be divided into two portions by the transmission line which has been provided by the Sondu-Miriu Hydropower Project. In order to unify and jointly function, the two ponds would be connected with an open channel at the outlet side of the pond. Both ponds have a trapezoidal section with a side slope of 1 to 2.0 and those are 130 m and 120 m wide respectively at the bottom and 2.5 m deep.

In spite of sharp fluctuation of 2.5 m in the depth of the regulating pond, the water level in the Nyakach-Kano and South Nyanza main canals should be seasonally maintained at almost same level. For this operation, special regulators would be installed between the pond and the two main canals.

7.2 Main Irrigation Canal

Two main irrigation canals are proposed to command the area of 14,930 ha; one is Nyakach-Kano Main Canal which commands 13,680 ha under Sub-Area II-2, III, IV, and V, while the other is South Nyanza Main Canal which commands 1,250 ha under Sub-Area I and II-1.

The design discharge of the Nyakach-Kano Main Canal ranges from 17.1 m^3/sec to 4.3 m^3/sec and that of the South Nyanza Main Canal ranges from 1.4 m^3/sec 0.9 m^3/sec. The entire reach of both main canals are trapezoidal with a side slope of 1 to 1.5 (vertical to horizontal); the distribution of longitudinal gradient of the Nyakach-Kano Main Canal ranges from 1/7,000 to 1/3,000, while that of the South Nyanza Main Canal, 1/5,000 to 1/3,000.

7.3 Related Structures to Main Canal

Nine (9) kinds of related structures to the main canal are proposed for the full function of conveyance, regulation, and protection of the canal system. The proposed related structures are categorised as follows:

	Function	Related Structures
(1)	Conveyance	i) Inverted Siphon, ii) Culvert & Bridge,
(2)	Regulation	i) Turnout, ii) Check
(3)	Protection	i) Spillway, ii) Drop, iii) Cross Drain,
(4)	Others	i) Washing Step, ii) Inspection Road

The numbers of related structures are listed in Table 7.1.

7.4 Secondary Canal and its Related Structures

Fifty seven (57) numbers of secondary canals of 213 km in total length branch off from the two (2) main canals. All the secondary canals are unlined and trapezoidal like the main canal; the side slope of channel is 1 to 1.5.

Functionally and structurally, the structures related to the secondary canals would be almost similar to those to the main canal. Turnouts and measuring devices would be equipped at rearend of the said structures for equitable water distribution and effective water management. The numbers of related structures are listed in Table 7.1.

7.5 Drainage Facilities

Drainage as well as irrigation is much important particularly in the lowlying area extended close to the Nyakach swamp. Sixty nine (69) numbers of drainage canals of 263 km in total length would be aligned to drain excess water from the entire project area. The numbers of related structures are listed in Table 7.1.

Drainage improvement can be classified into two categories, i.e. improvement of existing natural creek and new excavation of drainage canal. The improvement works would be made by cut-and-embank for intermittent flow channel (wadi) and by embankment only for perennial flow channel.

Drainage canal is classified as i) main drain, ii) secondary drain, iii) tertiary drain, and iv) field drain. The principal dimension of the proposed drainage canal can be summarized as tabulated below:

	Drain	Discharge (m^3/sec)	Bottom Width (m)	Depth (m)
i)	Main & Second.	12.5 to 225	3.0 to 20.0	1.5 to 2.8
ii)	Tertiary	0.03 to 4.9	0.5 to 1.2	0.7 to 1.4
iii)	Field	0.03 to 0.8	0.2 to 1.2	0.2 to 1.3

7.6 Improvement of Existing Road

Existing roads in the project area are rather deteriorated by habitual floods and inundations due to low embankment of road. The road improvement works would comprise embankment as required and laterite-pavement with a thickness of 10 cm.

Existing farm roads are not fully networked due to lack of crossing bridges. This is a crucial constraints for daily traffics and transportation of farm products. Proper numbers of bridges and cause ways would be proposed to traverse major perennial streams and intermitted flows respectively.

Table 7.1 is the summary of the main canals and their related structures.

7.7 Construction Plan

7.7.1 General

Construction works to be undertaken in the project consist of earth-moving works for irrigation and drainage canals, concrete and masonry works for related structures, and miscellaneous works. The following are the major structures to be constructed in the project:

1) Regulating pond,
2) Irrigation canals and their related structures,
3) Drainage canals and their related structures,
4) Improvement of existing roads, and
5) On-farm development works.

Stagewise execution would be applied for the proposed project taking into account of project scale, development stage of water resources,and experience of execution body, etc. The execution of construction works would be divided into three (3) phases as listed below in accordance with the sub-area:

Phase	Availability of Water Resources	Sub-Area	Hectareage
I	With Sondu-Miriu Project	Part of II-2	2,380
II	With Sondu-Miriu & Magwagwa	I,II-1, part of II-2, II	4,880
III	-ditto-	IV, V	7,670

According to construction plan, the Sondu-Miriu Hydro-power Project is scheduled to commence its operation in July, 1997. Phase-I of the project should be implemented keeping pace with the implementation of the Sondu-Miriu project.in order to divert irrigation water from the hydro-power plant. Based on the result of the water balance study as given in ANNEX-VII, the area of 2,380 ha under Sub-Area-II is allocated for Phase-I. After completion of the construction of Magwagwa dam and upon financial arrangement, the construction of Phase-II and -III will be commenced in sequence. Fig. 7.1 illustrates a tentative execution time schedule for the project, together with those for the Sondu-Miriu Hydro-power project and the Magwagwa multi-purpose project.

7.7.2 Basic assumption for construction plan

1) Workable days

Suspension days to be caused by rainfall would be assumed in due consideration of soil mechanical condition in the project area. Then, average monthly workable days are estimated at 21 days on the basis of the assumed suspension days and the daily rainfall records in Kisumu for past 25 years.

2) Conversion rate of earth materials

Prior to lay-out of earth-moving plan, conversion rate of earth materials is assumed as listed below:

Materials	Excavated	Embanked
i) Sand	1.20	0.90
ii) Clay	1.25	0.90
iii) Gravel	1.20	1.00
iv) Weathered Rock	1.30	1.20
v) Rock	1.50	1.30

7.7.3 Application of construction machinery and equipment

Mechanized execution would be applied for earth works for main and secondary irrigation canals and main drainage canals taking into account of earth work volume and construction schedule. Proper construction equipment should be selected in accordance with soil and geological conditions. The following is a list of equipment required for various kinds of earth works under various soil and geological conditions.

Earth Work	Earth Materials	Proposed Equipment
1) Excavation	Top soil	Bulldozer
	Sand	Backhoe shovel
	W.Rock	Ripper dozer
	Rock	Blasting,Ripper D.
2) Loading	For all the materials	Crawler loader, Backhoe shovel
3) Hauling	ditto	Dump truck
4) Spreading	ditto	Bulldozer, Motor grader
5) Compacting	ditto	Comp.roller

7.7.4 Earth moving work plan

Earth moving work plan should be established by proper method on the basis of the following basic concepts:

i) Excavated materials should be re-used for embankment works as much as possible in the proximity of the excavation site,

ii) Balance of materials between excavation and embankment should be made within sub-area for irrigation system as far as possible,

iii) Use of soil and its foundation should be considered based on soil and geological information such as impermeability and stability as described below,

iv) Shortage of embankment material which is caused by poor quality of excavated materials should be supplemented by borrow materials,and

v) Granite rock which is to be excavated at the site of the regulating pond should be reused for road pavement, riprap,and masonry.

Excavation work for main and secondary canals at wide space would be executed by bulldozer and backhoe shovel; the excavation work for tertiary canal, water course,and field drain at narrow space, by manpower. The excavation of rock at the site of the regulating pond would be made by blasting and ripper dozer.

Embankment works for canal would be executed together with construction of maintenance road. Spreading of materials would be made by bulldozer and compaction would be mace by bulldozer and/or compactor (or roller). In case the materials would be obtained from borrow area, excavation and loading would be made by backhoe, and hauling would be made by dump trucks. In order to keep better workability and high compaction, special attention should be paid to the moisture control of the embankment materials.

7.7.5 Concrete works

Most of the related structures for canal and crossing structures for roads would be mainly of reinforced concrete. Concrete would be processed by proper size of portable mixer according to scale of structure. Placing of concrete would be made by manpower and compaction, with proper size of vibrator. Wooden form and shutter would be used for concrete placing. Fine and coarse aggregates would be obtained at river side along the middle reach of the Sondu river.

7.8 Cost Estimate

7.8.1 General

Unit price analyses are made on the current price basis prior to construction cost estimate. For the analyses and estimate,following assumption is made:

1) Conversion rate among Kenyan shilling (Ks), US dollar ($),and Japanese yen (¥) is assumed to be US$1.0 = Ks.28.0 = ¥140.0, referring to the current exchange rate,

2) All the construction work would be executed by contract basis. Machinery and equipment required for construction works would be provided by contractors themselves. Depreciation cost of machinery and equipment, therefore, would be accounted in construction cost instead of the procurement cost.

3) Taxes on the imported construction machinery, equipment, and materials would be exempted from construction cost.

4) The construction cost integrated by unit costs are divided into foreign and local currency portions. The local currency portion is estimated on the basis of the current price in Nyanza Province in 1991; the foreign currency portion, on the basis of CIF Monbasssa referring to FOB prices in Japan as of 1991.

5) In order to incorporate in the construction cost, physical contingency of 10% is assumed in the estimate in consideration of depth of preliminary design works. While, for future price escalation of the construction cost, price contingency for foreign currency and local currency also is assumed at 2% and 10% per annum respectively.

7.8.2 Project cost

Table 7.2 shows an itemized breakdown of the anticipated total project cost, and Table 7.3 further specifies a breakdown of the construction cost by phases. Both Tables can be summarized as tabulated below:

(Unit: million Ks)

Item	Whole Project	Phase-I	Phase-II	Phase-III
Local C Portion	1,446	249	478	719
Foreign C Portion	4,368	1,012	1,413	1,943
Total Amount	5,814	1,261	1,891	2,662

Note: Figure in parenthesis indicates "million U.S dollar"

The total project cost is estimated at Ks. 5,895 million or about US$210 5 million equivalence, comprising Ks.1,611 million of the local currency portion and Ks.4,284 million (about US$153 million) of the foreign currency portion.

7.8.3 Operation and maintenance cost

Operation and maintenance cost comprises salaries of the staffs, materials and casual labour cost for repair and maintenance of the project facilities, operation cost for O&M equipment and running cost of all of the project facilities. The operation and maintenance cost annually required for the whole project is estimated at Ks.28.55 million at financial basis as summarized below.

(Unit: 1000 Ks.)

Item	Amount
1) Salaries and Wedges	9,590
2) Office Expenses	750
3) O/M Cost for Equipment and Facilities	18,100
Total	28,550

7.8.4 Replacement cost

Mechanical works proposed in canal system have usually shorter durable life than constructed civil works and therefore, would be replaced at several times within the project life according to their durability. The replacement cost is estimated financial basis as given below:

(Unit: 1000 Ks)

Item	Useful Life	Replacement Cost
Light O/M Equipment	10 years	15,350
Gates	25 years	17,350
Total		32,700

8. PROJECT ORGANIZATION AND AGRICULTURAL SUPPORT SERVICES

8.1 Lake Basin Development Authority (LBDA)

Lake Basin Development Authority (LBDA), which was established under the Act of Parliament (Cap.442) in August, 1979 as a basin development authority, is responsible for the development of the Lake Victoria basin under close coordination with relevant ministries.

Policy matters relating to LBDA operations have been decided by Board of LBDA, which comprises representatives from the Ministries and the Local Government concerned. Under the Board, LBDA, the head office located in Kisumu, has been managed and operated by Managing Director and Deputy Directors for technical services and finance & administration. The current organization of the LBDA is shown in Fig. 8.1

The LBDA would become an executing agency for construction of the Kano Irrigation Project. The Managing Director of the LBDA would take a responsibility for execution of the project. Taking into account of the existing manpower in the LBDA, it would be recommendable to establish a project construction office under the direct control of the Managing Director; the project construction office would be installed as an independent organization from the LBDA, and managed and operated by the project coordinator who will be appointed by the Managing Director of the LBDA.

8.2 Organization for Project Implementation

The proposed organization chart of the project office is as illustrated in Fig.8.2. The project office comprises a head office and five (5) site offices. The head office is established in the existing LBDA head quarter in Kisumu, having three (3) divisions such as administrative, survey and design, and construction supervision.

The Survey and Design Division takes a responsibility for surveys and investigations for the project facilities. The Construction Supervision Division takes a responsibility for execution of construction works such as schedule control, quality control, and cost control. Meanwhile, the Administration Division takes responsibility for publicity, land acquisition, accounting, budgeting, logistics, personnel affairs etc.

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

The Site Offices would take a responsibility for day-to-day work of the construction works such as measurement of work quantity, checking of work progress, and collection of various engineering records. The Site Office would be set up for Sub-area I and II-1, II-2, III, IV, and V respectively. Table 8.1 lists the staffing requirement for the operation of the office and the engineering assistance.

8.3 Organization for Operation and Maintenance

8.3.1 Proposed O&M office

After completion of the construction works, the project office is taken new charge of necessary services of water management and supporting farmers. The project office consists of a main office and five (5) site offices. The main office has four (4) divisions such as Administrative Division, Irrigation Division, Agricultural Division and Monitoring Division. The Administrative Division commands three sections, such as personnel, accounting and logistics; the Irrigation Division commands two sections, such as operation and maintenance section and water user' association managing section; the Agricultural Division also commands two sections, such as extension section and farmers' cooperative supervising section; the Monitoring Division monitors project activity and performance.

The site office would take responsibility for day-to-day operations under the instruction by the main office. Fig.8.3 illustrates the organization of the proposed Operation and Maintenance Office.

8.3.2 Water management

The water management for the project is broadly divided into two aspects: one is the operation and maintenance of the major irrigation and drainage facilities, the other is the water management at on-farm level in the irrigated area;the former aspect would be undertaken by the O&M Office and the later aspect, by the Water Users' Associations. The main objectives of the water management and O&M works would be, (1) Equitable, steady, and timely distribution of irrigation water, (2) Proper maintenance of irrigation and drainage facilities, and (3) Monitoring of water supply activities for future improvement of the system.

In order to achieve the above objectives, the following concepts would be essential for the operation and maintenance works:

i) Development of simple system,
ii) Operation by low technique,
iii) Easy and quick repair works, and
iv) Low operation and maintenance cost.

The following would be the major works of the proposed O&M office:

i) Preparation of overall O/M program,
ii) Preparation of irrigation schedule,
iii) Execution of repair works for main canal system,
iv) Settlement of water disputes among Water Users' Association,
v) Training of office and Water Users' Association staff,
vi) Record and collection of field data, and
vii) Record of meteorological and hydrological data.

8.3.3 Operation and maintenance equipment

Maintenance and repair works for major canal system consist of eathwork, concrete work, metal works with painting, etc. The major repair works would be executed by proper construction equipment; the minor works would be made by common labour. In accordance with the anticipated repair works, the equipment required for the repair works is selected as listed in Table 8.2. In addition to the repair equipment, proper number of vehicle and some units of stationery also are selected for the operation of the canal system, as listed in the same table.

8.3.4 Office and quarters

Following the organizational setting-up, one main office and five (5) site offices for five (5) sub-areas would be constructed as the construction offices in early stage of the implementation of the project; these offices would be renamed as the O&M offices after completion of the project. The floor spaces required for the offices are estimated at about 6,000 m^2 in total. In addition, five (5) cooperative buildings and 27 of unit cooperative buildings, which would be occupied by cooperatives and water user' associations, would be constructed at the operation and maintenance stage of the project. The floor spaces required for the buildings are estimated at about 5,000 m^2.

8.4 Farmers' Organization

8.4.1 Water users' association

At on-farm level, farmers' group would be responsible for operation and maintenance from tertiary canal system to dwonstreamward. Water users' association (WUA) would be organized by several farmers' groups based on the unit of secondary or sub-secondary canal system. The member of the WUA would mutually elect the working group which consists of one chief, canal inspectors, water allocators, alarm men, and security guards.

According to the number of secondary and sub-secondary canals, fifty five (55) WUAs would be organized. Five (5) sub-unions of WUA would be composed based on the several WUAs in the sub-area, and these sub-union would be supervised by one union of the WUAs.

8.4.2 Cooperative societies

In the operation stage of the project, the farmers concerned to the project would establish cooperative societies for mutual assistance in the course of farming activities. Four (4) to five (5) primary societies would be established by sub-area basis; these societies would organize one cooperative union in the project area. The following is the major function of the societies:

1) Procurement of farm inputs and distribution to members,
2) Collection and handling of farm products,
3) Supply of agricultural credits, and
4) Others.

The Cooperative Union would procure the farm inputs from Kenya Grains Growers Cooperative Union, and then transfer to the primary societies. The farmers concerned would purchase the farm inputs through the primary societies with credits. The primary societies would collect the farm products in the harvest season, and handle to dealers or market agencies. In this process, the Cooperative Union would collect market information and provide it to the respective primary societies.

8.5 Agricultural Extension and Support Services

Since small holders are dominant in the project area and the agriculture production mainly depends on the rainfed condition at present, various aspects of the present agriculture are changed after implementation of the project. It is therefore necessary to reinforce the present supporting system for technical extension and to organize farmers for supply of farm inputs and marketing of products unless the maximum benefit could be expected from the project. In this regard, task of the O&M office includes to reinforce agricultural extension and to provide assistance for organizing farmers.

8.5.1 Extension services

The project office would provide farmers with recommendation and guidance of technical practices of crops under irrigation condition and cattle under zero grazing in the project area. The recommendation and guidance include selection of variety, preparation of cropping calender, dosage and application of fertilizer, harvesting practices, post harvest, application of water, management of demonstration farm, etc. These services would be laid out in the main office and executed under supervision of the assistant officers of the site office.

8.5.2 Support services

The project office would assist farmers by providing such support services through cooperative societies as procurement of inputs, agricultural credits, and handling of farm products. These services would be planed by the cooperative officers in the main office and carried out by the staff of the site office. Meanwhile, the project office would execute guidance and training of the cooperative staff as well as the farmers concerned.

8.5.3 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 as mentioned in Annec IX.

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.

9. PROJECT EVALUATION

9.1 General

Project evaluation is made in order to ascertain project feasibility in view of economic, financial, and socio-economic aspect. Economic feasibility is evaluated by calculating internal rate of return (IRR), Benefit minus Cost (B-C) and Benefit by Cost ratio (B/C) at the discount rate of ten percent (10%). Sensitivity analysis is furthermore made in order to elucidate economic viability of the project against possible changes in the estimated benefits, costs, and the proposed construction period.

Financial analysis is also carried out in order to grasp the effects of the project on farm economy, and to clarify the fund requirement and the government subsidy for the implementation of the project on the basis of balance of financial cash flow statement. In addition, socio-economic impacts caused by the implementation of the project is also studied in due consideration of the effects of the project on the regional economy in the Lake Victoria basin.

9.2 Economic Evaluation

9.2.1 Basic assumption

Economic evaluation is made on the following basic assumptions:

1) The economic useful life of the project is 50 years after commencement of construction,

2) The construction period is limited to 12 years including detailed design works and preparatory works,

3) All prices are expressed in 1991 constant prices, and

4) The exchange rate between the local currency and the foreign currency is fixed as US$1.00=Ks.28.0=¥140.

9.2.2 Economic factors

1) Standard conversion factor

Tariff and trade regulation introduce a distortion in the price relationship between trade goods and non-trade goods. In order to evaluate the project costs and benefits with respects to world market prices, a standard conversion factor (SCF) is applied to the price of non-trade goods and services. The SCF is computed at 0.82 on the basis of the export and import statistics for the years of 1987 and 1988. The details are given in ANNEX-X.

2) Economic prices of agricultural outputs and inputs

Economic prices of farm products and farm inputs are estimated on the basis of the projected international market prices forecast for the year of 2005 by IBRD in the long term range in 1985 constant US dollar. The forecasted prices are adjusted to the 1991 constant price level. The domestic components are adjusted by the SCF of 0.82.

3) Economic opportunity cost of farm labour

Current labour price is Ks.25 /man-day. Economic farm labour is priced at Ks.15/man-day by applying shadow wage rate of 0.6 in consideration of unemployment condition in and around the project area.

9.2.3 Economic benefit

The direct project benefit is accrued only from agricultural production. Economic benefit is estimated as difference of annual net production value between under with-and-without project conditions; the net production value is defined as gross production minus crop production cost. In accordance with these definitions, net incremental benefit of the project is estimated at Ks.642 million per annum on the basis of the net production value under the with-project condition of Ks.687 million and the without project condition of Ks.45 million.

Build-up period of five (5) years is assumed in due consideration of current agricultural production level and its future improvement; the benefit accrued during the build-up period is estimated to be 65% of the full benefit in 1st year, 80% of them in 2nd year, 90% of them in 3rd year, and 95% of them in 4th year.

9.2.4 Economic cost

The financial cost estimated in Chapter 7 is converted into the economic cost as listed below by applying the standard conversion factor (SCF) Total economic cost for the whole project area amounts to Ks.3,412 million or US$121.9 million equivalence. Per-hectare economic cost is also estimated at US$8,162 equivalence.

(Unit : Ks. million)

Cost Components	Financial Cost	Economic Cost
1) Direct Construction Cost	3,313	2,716
2) O/M Equipment	45	37
3) Administration Cost	39	32
4) Engineering Services Cost	569	465
5) Land Acquisition Cost	8	0
6) Physical Contingency	341	284
7) Price Contingency	1,501	0
Total	5,814	3,534

Economic annual operation and maintenance cost is estimated at Ks.23.5 million by applying the same conversion factor on the basis of the financial O&M cost of Ks.28.55 million per annum which is estimated in Chapter 7.9. The replacement cost estimated at financial basis also is converted into economic basis and is periodically disbursed according to durability of each equipment.

9.2.5 Evaluation

1) Economic Internal Rate of Return

Using the economic cost and benefit mentioned above, cost and benefit flow is prepared covering the full period of the project life, and then, economic internal rate of return is computed to be 13.2%. Table 9.1 shows an economic cash flow to compute the IRR.

2) Benefit minus Cost (B-C) and Benefit by Cost ratio (B/C)

In order to get net present value of economic benefit and economic cost respectively, those values in the benefit and cost flow are accumulated by 10% of discount rate. The net present value of the benefit and the cost is estimated at Ks.2,395 and Ks.1,757 respectively. Thus, the B minus C and B by C is estimated at Ks.638 million and 1.36 respectively. Table 9.1 shows an economic cash flow to compute the net present value of the benefit and the cost.

9.2.6 Sensitivity analysis

In order to evaluate soundness of the project against possible adverse changes in future economic condition, sensitivity analysis is made under the following condition:

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

Case 2: Project benefit decreases by 20% due to unexpected decrease in forecast prices of farm products and unit yields.

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

According to the result of analysis, the internal rate of return (IRR) under is decreased to 11.2% under Case 1, 10.8 % under Case 2, and 10.2% under Case 3. Further details are given in ANNEX-X.

9.2.7 Outcome of evaluation

The evaluation above fully testifies that the project is economically feasible with the IRR of 13.2%, the B minus C of Ks.638, and the B by C of 1.36. Furthermore, the sensitivity test also clarifies that the project is rather insensitive to the various possible adverse effects, and economically viable.

9.3. Financial Evaluation

9.3.1 Farm budget analysis and capacity to pay

In order to evaluate the project from financial viewpoint, farm budget analysis is made under with project condition. Net reserve in farm budget with an average size of 3.1 ha is estimated under the with project condition. he following is the summary of the estimate of net reserve;further details are given in ANNEX-X.

(Unit:Ks./farm household per annum)

Sub-Area	Gross Income	Gross Outgo	Net Reserve
I	195,000	93,900	101,100
II-1	225,800	104,400	121,400
II-2	238,000	108,400	129,600
III	151,500	71,000	80,500
IV	136,500	68,000	68,500
V	134,000	63,500	70,500
Mean	180,133	84,866	95,267

The net reserve under the without project condition is estimated at only Ks. 2,500. In comparison with this present net reserve, the future net reserve under the with project condition skyrocketedly increases ranging from about 27 times to 52 times.

The increase net reserve would contribute to better living conditions, welfare to farmers, and incentive for farm re-investment for the beneficiary farmers. In addition to these contribution, the net reserve substantially provides a capacity to pay for irrigation water charges which is estimated at about Ks.8,000 per farm household.

9.3.2 Repayability of project fund

It is assumed that the initial project cost required for the project is arranged under the following conditions:

1) 85% of the project cost is financed with foreign currency by bilateral or international monetary organization with an interest rate of 2.5% for repayment period of 30 years including 10 years of grace period.

2) The remaining 15% of the capital cost is arranged with local currency by the government budget allocation without repayment.

3) A government subsidy is assumed at income flow side in order to make a balanced cash flow statement and attain re-payment of the financed loan amount.

Based on the above assumptions, a financial cash flow statement is prepared in order to clarify the repayability of the project as shown in Table 9.2. The outflow and inflow in the statement are fully balanced on the assumptions above.

9.3.3 Outcomes of evaluation

The project brings about a great improvement in farm budget and gives an much incentive to farmers with respect to further investment for agricultural production. From farmers economy viewpoint, the project would be financially justified.

As shown in Table 9.2, total government expenses of Ks.8,444 million for 50 years of the project life, comprising government budget of Ks.900 million, government subsidy of Ks.6,389 million ,and accumulated annual water charges of about Ks.1,155 million can be fully compensated with a portion of the net reserve of Ks.25,423 million to be accrued in the whole farmers in the project area during 50 years;the government expenses are equivalent to 30% only of the net reserve in the project area. In this regards, it is concluded that the project is surely repayable.

9.4 Socio-Economic Impacts

In addition to the direct benefit counted in the economic evaluation, substantial secondary benefits steming from the project outputs and induced by the project inputs, and favourable intangible socio-economic impacts are expected from the implementation of the project.

1) Increase of employment opportunity

Employment opportunity to local people is increased by the implementation of the project, and favourable impacts to regional economy is expected through increased monetary movements. The employees and farmers 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 improve the present low productivity of land and cropping intensity, and increase crop production in the project area. The increased crop production accelerates further development of agro-based industries and marketing activities in the surrounding areas. It also increases 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 import of rice and contribute to foreign exchange saving.

3) Demonstration effect

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

4) Increase of land value

Economic value of land surely increases with the project implementation. It means that the value of land assets as a mortgage becomes higher and the land owners have larger monetary power when they expand their business. During certain period after completion of the project, land transactions in the project area have to be controlled by the government in order to achieve 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 the rainy season. Upon completion of the project, local transportation is highly improved by construction of farm road networks in the project area. These road improvement works are not only enhance agricultural activities but also contribute to overall economic activities in the project area through the improvement of local transportation.

6) Mitigation of flood damage

The downstream area of the Nyando river and the surrounding area of the existing swamp have been habitually suffered by flood and inundation. Betterment of drainage conditions along small rivers and rivulets in the project area mitigates damage of public and private facilities.

7) Improvement of domestic water supply

The construction of irrigation canal system substantially contributes to domestic water supply owing to washing steps provided in the main and secondary canals. Sufficient domestic water consumption through the canals would much improve sanitary condition of rural people in around the project area.

8) Improvement of health and sanitary condition

Increased production of farm products enable the local people to take enough foods like vegetables, milks, beef and fish. The increased production improves nutrition condition and health situation of local people. Sanitary condition is improved by mitigation of flood and inundation. Public health services easily accesses the project area through improvement of road network. In total, in the case that control programmes for malaria and Schistosomiasis start in future, good results would be expected after the implementation of the project.

10. ENVIRONMENTAL CONSERVATION

10.1 Impacts on Water Quality of Surrounding Water Bodies

10.1.1 General

The main objectives of the study on water quality around the project area are firstly to assess an impact on water quality and to evaluate its magnitude caused by the project. Generally, irrigated agricultural development may bring about an increase of water pollution load due to up-grading of land use and intensive application of fertilizer and/or chemicals. In addition, water flow regime of the Sondu and Nyando rivers is drastically changed due to full use of the endowed water resources, and it may cause an impact on water quality in Nyakach Bay and Winam Gulf. Therefore, a quantitative approach would be taken for the assessment making focus on pollution load.

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

i) Collection of existing data and documents concerned,
ii) Water sampling and analysis in rivers, bay and gulf concerned,
iii) Calculation of present and future pollution loads,
iv) Evaluation of impacts on water quality of bay and gulf concerned, and
v) Recommendation of countermeasures for reduction of magnitude of impacts.

10.1.2 Existing water quality

Water sampling and analysis are made in this study in order to obtain more specific and recent data for the assessment. The existing conditions of water quality of rivers, bay, and gulf are summed as hereinafter on the basis of the collected data and information, and the water quality analysis.

The Sondu river, of which the basin is extended to about 3,470 km^2, originates from the western slope of the Mau Escarpment and drains into Winam Gulf; the annual runoff amounts to about 1,221.6 million m^3. All analysed physico-chemical parameters of the Sondu river show clean water quality in spite of its light brown colour. The water temperature is almost 20 °Celsius, and the suspended solid (SS) is rather high due to existence of fine sediments in water; the dissolved oxygen (DO) is almost at saturated level, and the other biodegradable items such as chemical oxygen demand (COD) are rather low. It is, therefore, imagined that there is no threats of organic pollution in this river at this moment.

The Nyando river, the basin of which is extended to about 3,450 km^2, originates in the western slope of the Mau Escarpment and drains into Nyakach Bay through the vast Nyando swamp; the annual runoff is estimated at about 510 million m^3. The existing condition of the water quality of the Nyando river is much serious compared with that of the Sondu river. The SS concentration is very high-nearly 10 times of that of the Sondu river. Besides, heavy water pollution caused by biodegradable substances can be seen along the lower reach of the river due mainly to drainage from several agro-processing factories which are located along the middle reach of the river.

The Winam Gulf of the Lake Victoria is rather isolated water body with an extremely narrow mouth at the westward. The Gulf, of which the water surface extends to about 1,400 km^2, collects the runoff from catchment basin of about 12,000 km^2 or about 9 times equivalence of its water surface. The Sondu, Nyando, and Awach rivers are the major inflow for the Gulf; the annual inflow to the Gulf is roughly estimated at about 2,731.0 million m^3.

The "Winam Gulf Baseline Study" conducted during a period of 1984 thru 1985 provides recent and comprehensive water quality data of the Gulf. Secchi depths---a scale for transparency of water--- are low in the Gulf;about 1.6 to 2.4 m at the central part of the Gulf, 0.8 m at the eastern lakeshore, and 0.3 to 0.4 m in Nyakach Bay. This low transparency of water is due mainly to suspension loads from the Nyando river and blue-green algae blooms in the Bay. The dissolved oxygen (DO) in the eastern part of the Gulf is generally high and is almost close to saturated condition near the surface water of the Gulf. Total nitrogen (T-N) ranges from 0.50 to 0.63 mg/lit. and the total phosphorus (T-P) slightly highly ranges from 0.02 to 0.04 mg/lit. The mean value of Chlorophyll-a indicates about 0.02 mg/l in the Gulf.

The Gulf and the Bay seem to be rather eutrophic on the basis of conventional trophic state indices such as secchi depth, T-P, and chlorophyll-a. However, the Gulf itself seems to be moderately eutrophicated compared with the Bay. The bloom causing algae is predominant in the Gulf region.

10.1.3 Assessment of water quality

(1) Setting-up of Basic Data

Hydrological Condition

Table 10.1 shows water regime of Winam Gulf and Nyakach Bay, and irrigation data of three alternatives. As given in Table 10.1, a retention time (annual inflow/storage volume) of the Gulf is about 0.33 times per year at present and it is changed to about 0.30 times per year with implementation of the project ; in other ward, it means that full replacement of water takes about 3.6 months longer than that at present condition.

Water Quality Data

COD, T-N, and T-P are selected as the predominant indices for the assessment of the impacts on the water quality caused by implementation of the project. COD values given in Table 10.2 are water analysis undertaken in this study. In the meantime, T-N and T-P values are obtained making reference to the available data in the "Winam Gulf Baseline Study" as well as the said water analysis.

Water Pollution Load

Water pollution load, such as COD, T-N, and T-P of the Gulf and the Bay are calculated as shown in Table 10.2, by multiplying each water quality values with the inflow data in Table 10.1. The pollution loads drained into the Bay are estimated at about 2,146 ton per annum of COD, 608 ton per annum of T-N, and 51 ton per annum of T-P, meanwhile, the loads sifted from the Bay to the Gulf are also estimated at about 1,328 ton per annum of COD, 317 ton per annum of T-N, and 20 ton per annum of T-P. Thus, the purification capacity of the Bay would be roughly estimated to be about 30 to 60 % of the total inflow load.

Pollution Load from Irrigation Area

Current and future pollution load is calculated by multiplying a load unit with a change of land use under with- and without-project conditions. The increment of the pollution loads caused between both conditions is estimated in order to confirm the environmental impacts after implementing the project. The following is a summary of the estimate, and the further details would be compiled in the Annex-XI

	(Unit : ton/year)
Increment Load	With Project
a) COD	1,085
b) T-N	62.0
c) T-P	32.0

Unit Pollution Load and Fertilizer Application

Impacts on water quality and pollution load caused by fertilizer application would be properly assessed making reference to the agricultural development plan. The incremental load of nitrogen and phosphorus is estimated to be 4% of the net nitrogen amount of and about 3% of the net phosphorus amount of fertilizer application respectively. The details of estimate would be compiled in the Annex-XI. It is usually estimated that a runoff ratio of fertilizer is less than 10% of the application. It is, therefore, considered that the estimated incremental load includes the load originated from the fertilizer use.

(2) Water Quality Deterioration

Change of Water Quality in Gulf and Bay

A degree of water quality change in the Gulf and the Bay is estimated by a complete dilution model method as given in Table 10.3. The levels of water quality change of all items are rather high in the Bay. The expected water quality in the Bay under the current and with-project conditions can be summarized as given below:

		(Unit : mg/l)
Index	Current	With Project
i) COD	2.6	5.0
ii) T-N	0.62	3.25
iii) T-P	0.04	0.09

The retention time of about 15 days of the Bay is shortened by the annual inflow of the drained water to the Bay. This means that the water quality of the Bay mostly depends on the Quality of the Nyando river and drained water from the proposed irrigation area.

The deterioration itself in the Gulf is not so serious in comparison with that in the Bay. The expected water quality in the Gulf caused by the implementation of the project can be summarized as given below:

		(Unit : mg/l)
Index	Current	With Project
a) COD	1.8	2.4
b) T-N	0.47	0.54
c) T-P	0.02	0.03

Purification Effect by Swamp Area

Swamp areas located in and around the project area are likely to have high purification capacity of water pollution load coming from the upstream area. Data on purification capacity of swampy area is unavailable in Kenya. It is, therefore, almost impossible to assess such a capacity in the study area for the time being. The purification capacity of the swampy area seems to be essential for mitigation of the water quality deterioration in the Bay; special attention therefore should be paid to the conservation of the swampy area in the vicinity of the Bay

Possibilities of Eutrophication

Eutrophication is also one of indices for the assessment of the water quality deterioration in the Gulf and the Bay. A preliminary evaluation of eutrophication is made by using Vollenweider model. Table 10.4 and Fig.10.1 give the preliminary evaluation in the Gulf and the Bay by the respective Alternatives.

There is no distinct difference of the eutrophication between the Existing condition and the with-project condition . The eutrophication of the Bay may be gradually increased due to the inflow of additional pollution loads of phosphorus caused by the implementation of the irrigation project. Actually however, it is not so serious, because the Bay is still under moderately eutrophicated condition. Besides, a considerable pollution load would be purified by the vast swampy area. As far as the Gulf is concerned, it is concluded that there is no drastic change in the eutrophication in the future.

(3) Conclusion

i) The proposed Kano irrigation project might cause more significant impacts on water quality of the Nyakach Bay than that of Winam Gulf.

ii) A smaller irrigation area would be recommendable so as to avoid high magnitude of the impact on water quality of the Bay.

iii) Eutrophication in the Bay might be gradually accelerated by the implementation of the project. Meanwhile, there is less acceleration of the eutrophication in the Gulf even by the implementation of the project,

iv) This assessment reveals that irrigation might cause degradation of water quality in the downstream water body. Hence, curtailed use of irrigation water through proper water management and effective use of rainfall water would be strongly recommendable from water quality conservation viewpoint.

v) The swampy area extended between the Bay and the project area has important function for purification of pollution load. All the main drainage canals should be so aligned as to directly debouch into the swamp for the effective use of its purification capacity. At the same time, high priority should be given to the conservation of the swampy area for reduction of pollution load

vi) The water quality in the Bay is likely to be rather serious, because of rich nutrient inflow from the Nyando river. Moreover, since the Gulf is isolated with a narrow mouth, it might be very difficult to retrieve the clean water quality once it would be polluted. It is therefore essential for the project to establish environmental management and monitoring plan for the water quality in and around the project area

10.2 Ecology and Vector Borne Disease

10.2.1 General

This study aims at making an assessment concerning whether the project may cause any adverse affect on the environmental and ecological aspects, and to provide available information to decision makers. To attain the purpose, the following would be carried out:

1) To study existing natural and social environmental conditions in the project area,

2) To execute Environmental Impact Assessment (EIA) for evacuating magnitude of impacts,

3) To propose countermeasures for mitigating the magnitude of impacts, and

4) To evaluate acceptability of the project from the environmental viewpoint.

Screening and scoping approaches would be applied for the study. The screening is made based on the existing guidelines related to the EIA in Kenya, and the scoping is made by considering Initial Environmental Examination (IEE) for the project. The IEE is essentially an initial examination of the environmental effect potentials for the proposed project, and it is therefore the first approach of the EIA.

10.2.2 Existing environmental conditions

The study area has a high potential for woodland due to relatively much rainfall, but most of the area has been modified by grazing, burning, and cultivating. Trees are therefore found in relatively small patches. Acacia-themeda and combretum-hyparrhenia mainly cover these patches. The vegetation of the study area is rather poor .

There expand swampy areas, so called Kano and Nyando swamps, in the study area. The Kano swamp is a very extensive lowlying area in the middle of Kano Plain. The Nyando swamp is spread over the mouth of the Nyando river, covering about 7,000 ha, and extending as far as the Nyakach bay. Papyrus is the most common constituent of the lake side swamp, but many other plants are associated with it. Furthermore, many floating and submerged plants are visible.

The study area is quite favourable for avifaura especially for waterbirds; there are collected about 79 species from a few days field survey. The are seems to provide a favourable habitat condition for avifauna, and there is further possibility for the increase of species of birds.

The study area has been cultivated and populated, and is not suitable for habitat of wildlife. There is no information about habitation of small animals such as squirrel, mongoose, hare, and vervet monkey. It is noteworthy that there are few species of water related animals even in the swamp.

Information about fish production in the Gulf and rivers have been collected from inquiries and questionnaires survey. The survey reports that the introduced Nile perch has increased in the Gulf whereas other indigenous species such as the tilapias, Labeo victorianus and Barbus spp., have decreased due to predation by Nile perch and fishing pressure. The ecosystem and species composition of the fish in the study area is still undergoing change at present.

Nile cabbage is commonly seen floating on the lake and widely along the lakeshore blown by the wind. These weeds sometimes contribute to nuisance for fishes. The dominant species of plankton are aphanocapsa sp., anabena circinalis, lyngbia linetia, morismopedium, etc..These blue-green algae are generally found under nutrient enriched water and tendency of eutrophicated conditions. The plankton biomass would be controlled by transparency.

The Kano plain is classified by WHO as a holoendemic malarial zone with a high prevalence of malaria cases. Anopheles gambiae is the main vector of malaria around the study area and it breeds mainly in marshy land, and open sunshine pools. Main protection of maralia is house-spraying by the Authority concerned to Public Health, using chemical of permethrin, DDT, fenitrotion, and propoxur. Meanwhile, the NIB also has tried the maralia control by applying high spread maralia oil, introducing predator fish, spreading lava control, and distributing mosquito net.

Most of the study area is classified as schistosomiasis infected area. Out-patient morbidity in Kisumu district and South Nyanza district is not so high at present;the rate os less than 1%. Intermediate snails hosts for this disease belong to genus biomphalaria group and bulinus africanus group. Out of them, the bulinus africanus group host snails have an extensive distribution below 1,800 m above MSL;they have the vide range of the habitats in such as canals, furrows, reservoir, pools, and depressions. The main protection method for this disease carried out by the Authorities concerned is moulluscividing using cropper sulphate and niclosomide.

10.2.3 Initial environmental examination (IEE)

IEE is the first approach of environmental impact assessment by scoping. A check list method is applied as a basic tool for IEE in this study, and is prepared by using items of environmental effects as stages and area. The expected effect is evaluated from A to C for each item

Effect	+ :	positive (better) effect expected
	- :	negative (adverse) effect expected
	= :	no relation with the project considered
	x :	neutral effect expected (not positive and not negative), there may be a change but such change will neither beneficial nor harmful
Magnitude	A :	effect which has relatively high level of magnitude
	B :	effect which has relatively medium level of magnitude
	C :	effect which has relatively low level of magnitude

In order to specify the location of impacts expected by the project, range of area is defined as ecological regions as follows, and shown in Fig.10.2:

Region 1	: Irrigated area: This region is the irrigated area under the project.
Region 2	: Nyando river and swamp area This region includes the downstream of Nyando river and the swamp area extended in the river mouth of the river.
Region 3	: Lake area (Winam Gulf and Nyakach Bay) This region is the open lake area including Winam Gulf and Nyakach Bay

10.2.4 Results of IEE

Seven (7) environmental items are selected as follows in consideration of the existing environmental condition and the collected information:

i) Agricultural chemical use,
ii) Soil erosion,
iii) Sedimentation,
iv) Resettlement of inhabitants
v) Fisheries,
vi) Ecosystem of swamp, and
vii) Vector borne disease.

The preliminary results of IEE on each environmental item are summarised in Table 10.5. The following is the brief discussion on the IEE :

Agricultural Chemical Use

Dosage and application of chemicals would be limited to high value crops such as vegetable and cotton. In addition, pest-resistant varieties for proposed crops and low-toxicitive and decompositive chemicals would be selected in order to reduce the negative effects on water quality.

Soil erosion and sedimentation

Soil erosion might occur at the ecological region-1 due to construction of regulation pond and headreach canal which are considerably large scaled. If special attention is paid to the construction work, the soil erosion caused by the construction works is not so serious as expected. In connection to the protection of soil erosion, sedimentation in canals and rivers also is not so harmful from environmental viewpoint.

Soil erosion is caused under irrigated farming, especially farming of beans and maize. But it is possible to reduce the soil erosion through better water and farm management. Sedimentation may be caused by in connection to the soil erosion. Proper canal velocity would prevent the sediments from canals, and the paddy field area which is extended in the alluvial plain in the vicinity of river mouth, can protect runoff of sediments into the river mouth. Thus, the negative effects caused by soil erosion and sedimentation are rather negligible in the operation stage.

Resettlement of inhabitant

Resettlement of people who stay in the area planned to construct the facilities under the project such as the regulation pond and canals will be expected. However, the canal routes are planned to avoid the resettlement, and the present condition of the area of regulation pond will be changed during construction stage of Sondu-Miriu Hydropower station. Therefore, resettlement will not cause severe problem.

Fisheries and ecosystem of swamps

Fisheries and ecosystem of swamps are suspected to have some level of effects by the project during construction stage. The negative effects on the fisheries and ecosystem of swamps are mainly caused by deterioration of water quality and sedimentation of water body in the project area. As above mentioned, sedimentation caused by the soil erosion would be quantitatively limited, and these negative effects also is not so serious.

Water quality deterioration and eutrophication may be increased due to use of fertilizer and agro-chemicals in the project area. Such ecological situation may affect behaviour of fish and fisheries.

All of the environmental changes may affect ecosystem of swamps directly and indirectly. The ecosystem of swamps plays an important role for environment of the Gulf and Bay such as purification of nutrients, reduction of sediments, breeding, hiding, and feeding of fishes and various animals. Generally, ecosystem is both tolerant and sensitive to environmental changes, but the swamps extending at the mouth of river have strong tolerance to the nutrients and sedimentation owing to their location.

Vector borne disease

Under the present condition, Kisumu district is a holoendemic malarial zone with high prevalence of malaria cases. Furthermore, schistosomiasis is widely spread over the study area.

In the case that during the construction stage a number of construction labours are recruited from the neighbouring area where water borne diseases has not been spread at this moment, the labours might be infected with the water borne disease such as maralia and schistosomiasis. In this regards, the construction labour would be basically recruited within the project area in order to protect the infection during the construction stage. In the operation stage, vector of malaria and schistosomiasis may increase gradually, and may cause the relevant diseases in the project area unless proper control progromme for disease is carried out.

10.2.5 Conclusion and recommendation

1) Conclusion

Several items are expected to cause negative effects on the environmental aspect through the IEE. It is concluded that only the effects on vector borne diseases such as malarial and schistosomiasis would reach critical conditions among the several items. Proper countermeasures should be made for these diseases accordingly. Effect on fisheries and ecosystem of swamps also may be substantially expected, but the magnitude of the impacts would be relatively low. Appropriate countermeasures would be taken accordingly.

2) Recommendation

Fisheries and ecosystem of swamps

In order to prevent the water contamination in and around the project area, it is recommended that the farmers in the project area should use less fertilizer and chemicals as far as possible and to pay special attention to ecological condition in the Gulf, Bay, and swamps. In addition, it is recommended to execute monitoring survey on phytoplankton in order to conserve the water quality in around the project area. The swamps have an important function for purification of nutrients and sediments. It is therefore recommended that the existing swamps should not be reclaimed for agricultural production and should be carefully conserved for the natural and balanced ecosystem.

Vector borne diseases

The study area is one of the high prevalence zone of both malaria and schistosomiasis in Kenya and the following is the recommendable countermeasures for the prevention of these diseases:

i) Canal lining with concrete or masonry to prevent erosion and growth of water weeds,

ii) Cleaning of canals to remove water weeds and,

iii) Introduction of chemoprophylaxis and chemotherapy for inhabitants in the project area,

iv) Dispatch of professional staff such as parasitologist, microbiologist,

v) Elimination of water pools for mosquito control,

vi) Application of mallusciding and insecticiding or oiling for breeding sites,

vii) Educational campaign for public health,

viii) Regular house spraying of insecticide in the extended area,

ix) Biological control by introducing predator fishes,

x) Distribution of mosquito nets by the Authorities concerned, and

xi) Use of long rubber shoes.

11. CONCLUSION AND RECOMMENDATION

1) Needs of Irrigation Development

Pressing needs of irrigation development in the Kano and Nyakach plains would be envisaged from the following viewpoint:

i) Intensive agricultural development for improvement of regional disparity in per capita income,

ii) Attainment of intensified land use through vertical expansion of low productive existing agricultural land,

iii) Production increase of strategic crops in view of regional food security, and

iv) Nomination in the 6th National Development Plan as one of the most favourable irrigation potential area due to its endowed abundant land and water resources and favourable climatic condition.

2) Scale of Development

The optimization study on the development scale concludes that the project area should be delineated within the extent between the Kendu Bay in the south and the left bank of the Nyando river in the north in view of environmental conservations as well as project economy. Further development in the right bank basin of the Nyando river should be considered after the habitual inundation condition in the right bank basin will be mitigated with implementation of flood control project in the near future.

3) Spill-over effects of Development

Implementation of the Kano Irrigation Project would bring about the following spill-over effects on both regional and national economy:

i) Crop diversification stipulated in the national development plan,

ii) Contribution to self-sufficiencies of food crops,

iii) Saving of foreign exchange through reduction of import of maize, rice, cotton, sugar, etc.

iv) Creation of employment opportunity through introduction of irrigated agriculture,

v) Activation of regional market through increase of agricultural production, and

vi) Activation of regional economy and contribution to regional economic growth.

4) Implementation Sequence of Development

Following the implementation schedule of the Sondu-Miriu hydropower project and the Magwagwa dam project, the Kano Irrigation Project would be implemented dividing into three

(3) phases;the 1st Phase of 2,380 ha depending its irrigation water resources on the secondary discharge of the Sondu-Miriu hydropower project would be implemented keeping pace with the implementation of the hydropower station. The remaining area of 12,000 ha would be further divided into tow (2) phases in accordance with the size and contents of the project works.

5) Organizational Set up for Implementation of the Project

LBDA would be a substantial project owner, but in the light of the project scale and the experience of professional staff in LBDA, it seems to be difficult for LBDA to manage the project directly. The organization for implementation of the project would be established independently from LBDA but being managed under LBDA.

6) Project Impacts on Environment

The project might cause significant impacts on water quality conservation of the Nyakach Bay and the Winam Gulf, more or less. From water quality conservation viewpoint, less irrigation water consumption through better water management would be recommendable. Swamps extended between the bay and the project area has an important function for purification of pollution load. High priority should be given to the conservation of the swamps for reduction of the pollution load.

The Gulf is isolated from the Lake Victoria with a narrow mouth. It is therefore difficult to retrieve clean water quality once the gulf will be polluted. Environment management and monitoring plan for water quality is essential in respect to the implementation of the Kano Irrigation Project.

For prevention of water borne diseases,water weeds control should be made along irrigation and drainage canals, and in addition, regional public health improvement program also should be executed by the O/M office in collaboration with the Authority concerned. Likewise NIB, LBDA also should make an effort for the public health control through strengthening of section for environment and public health.

7) Preparation of detail design

It is recommendable that, following the conclusion of this study, and in due consideration of the implementation schedule of the Sondu-Miriu hydropower project, the detail design works for the Phase-I of the project should have been commenced by early 1993 at the latest. In the detail design stage, further in-depth study should be made on water quality conservation of the water body in and around the project and water borne diseases.

8) O&M of canal system and training of extension workers

Farming practices would be remarkably changed with the implementation of the project. New irrigated farming practices would be attained through strengthening of existing farm support services, and setting-up of the new farmers' organization which would contribute to purchase of inputs and marketing of products. In order to execute better supporting service, the project office should undertake a training of extension workers for introduction of irrigated farming and the institutional staff who would directly concern to establishment of farmers' organization.

Tables

Table 3.1 Climatological Data (1 of 2)

Parameter	TEMPERATURE(°C) MEAN MAX.				MEAN MIN.			
Station	Ahero	Chemelil	Kibos	West Kano	Ahero	Chemelil	Kibos	West Kano
Jan.	31.3	31.0	30.6	29.4	14.2	13.8	14.9	15.9
Feb.	31.4	31.5	30.9	29.4	14.6	14.2	14.7	16.3
Mar.	31.3	31.4	30.6	29.6	15.5	14.8	14.6	16.9
Apr.	29.4	29.2	29.4	28.1	15.9	15.5	15.2	17.5
May	29.0	28.1	28.5	27.7	15.9	15.2	14.9	17.0
Jun.	28.7	28.0	27.8	27.3	14.8	14.6	14.4	16.2
Jul.	28.7	27.9	28.0	27.3	14.5	14.1	14.0	15.6
Aug.	29.2	28.5	28.7	28.5	14.3	14.0	13.8	15.6
Sep.	30.4	29.4	29.1	29.6	14.1	13.5	13.8	15.3
Oct.	31.0	30.5	30.3	30.4	14.7	13.8	15.2	16.5
Nov.	30.3	29.9	29.8	28.7	14.8	14.3	15.1	16.5
Dec.	30.3	30.6	29.8	29.1	14.4	14.0	14.8	16.3
Year	30.1	29.7	29.5	28.8	14.8	14.3	14.6	16.3

Parameter	RELATIVE HUMIDITY (%)				RAINFALL (mm)			
Station	Ahero	Chemelil	Kibos	West Kano	Ahero	Chemelil	Kibos	West Kano
Jan.	63	59	63	62	84	87	87	105
Feb.	66	60	65	66	97	104	118	129
Mar.	68	62	66	66	140	125	170	179
Apr.	72	71	72	72	192	219	243	155
May	74	70	74	74	126	174	180	125
Jun.	73	73	75	73	77	120	100	99
Jul.	73	75	75	72	77	113	89	85
Aug.	70	72	72	70	75	96	125	66
Sep.	64	66	68	60	72	109	137	78
Oct.	62	63	63	55	76	95	97	75
Nov.	64	62	65	64	101	123	146	88
Dec.	65	61	68	64	87	117	103	130
Year	68	66	69	67	1,204	1,482	1,595	1,314

Source: Climatological Statistics for Kenya, Kenya Meteorological Department, 1984.
Note: Station codes and names are as follows:

Code	Name
9034086	Ahero Kano Irrigation Scheme
9035274	Chemelil Sugar Company Limited
9034105	Kibos Sugar Research
9034133	West Kano Irrigation Scheme

Table 3.1 Climatological Data (2 of 2)

Parameter	DAILY SUNSHINE (hours)				DAILY RADIATION (langleys)			
Station	Ahero	Chemelil	Kibos	West Kano	Ahero	Chemelil	Kibos	WestKano
Jan.	8.4	8.8	-	8.5	620	589	605	-
Feb.	8.1	8.5	-	8.2	620	580	616	-
Mar.	8.1	8.6	-	7.9	625	594	612	-
Apr.	7.2	7.5	-	7.4	588	534	572	-
May	7.1	7.3	-	7.6	582	499	548	-
Jun.	6.7	7.3	-	7.2	552	493	502	-
Jul.	6.8	7.0	-	7.4	533	480	527	-
Aug.	6.8	7.1	-	7.6	544	498	536	-
Sep.	7.1	7.5	-	7.9	582	530	569	-
Oct.	7.4	7.8	-	8.1	599	544	600	-
Nov.	7.1	7.2	-	7.2	581	528	568	-
Dec.	8.2	8.5	-	8.2	607	566	579	-
Year	7.4	7.8	-	7.8	586	536	569	-

Parameter	EVAPORATION (mm)				DAILY WIND RUN (miles)			
Station	Ahero	Chemelil	Kibos	West Kano	Ahero	Chemelil	Kibos	West Kano
Jan.	210	188	201	182	87.2	80.5	97.5	107.9
Feb.	203	179	199	173	91.0	84.0	92.8	113.3
Mar.	221	190	206	185	87.6	80.9	87.9	116.4
Apr.	182	150	170	155	76.4	70.4	75.1	92.7
May	163	136	170	147	65.5	63.2	74.7	82.7
Jun.	154	129	147	143	65.9	62.0	66.5	77.7
Jul.	160	130	164	141	65.3	62.3	64.1	78.8
Aug.	170	134	169	143	73.6	66.4	67.1	87.3
Sep.	181	143	167	157	79.0	68.3	73.1	95.2
Oct.	189	159	191	152	78.8	72.0	76.2	105.2
Nov.	172	150	158	162	76.2	75.5	78.1	92.1
Dec.	189	174	182	162	81.1	76.5	84.2	99.4
Year	2,194	1,862	2,124	1,902	77.3	71.8	78.9	95.5

Source : Climatological Statistics for Kenya, Kenya Meteorological Department, 1984.
Note: Station codes and names are as follows:

Code	Name
9034086	Ahero Kano Irrigation Scheme
9035274	Chemelil Sugar Company Limited
9034105	Kibos Sugar Research
9034133	West Kano Irrigation Scheme

Table 3.2 List of Existing Irigation Schemes

Name of Scheme	Location/Sub-Location	Area (ha)	Potential Area (ha)	Water Source	Year of Implementation	Agency	Cropping Calender
1. Alungo A	Ombeyi / Ramula	40	170	Oroba River	1987	PIU	Jan.-June x 2
2. Awach Kano	N. Nyakach / Wawidhi 'A'	80	300	Awach Kano River	1983	PIU	May-October
3. Kore	L.N.E. Kano / Kamagaga	90	150	Oroba and Ombeyi	1983	PIU	April-October
4. Nyachoda	N. Nyakach / Wawidhi 'B'	50	50	Awach Kano	1985	PIU	July-December
5. Nyakach	N. Nyakach / Gem Rae	90	110	Awach Kano	1983	PIU	July-December
6. Obange	S.E. Kano	80	200	Miriu	1987	PIU	June-November
7. Wasare	N. Nyakach / Jimo Middle	110	125	Asawo River	1984	PIU	July-December
8. Nyatini	N.W. & S.E. Kano / Kobura & Kakola	150	250	A.P.S. Drainage Water	1987	PIU	July-December
9. Ombaka	S.W. Kano / Kakola	20		Nyndo	1983	PIU	N / A
10. Masune	N. Nyakac/Wawidhi 'A'	250	250	Nyaidho	1986	PIU	May-December
11. Ahero Pilot Scheme	L.N.E. Kano/Irr.	870	870	Nyando River	1966	NIB	
12. West Kano	S.W. Kano	900	900	L. Victoria	1969	NIB	
13. S.W. Kano	S.W. Kano / All Loc.	200	1130	Nyando River	1990	PIU	N / A
14. Chiga	E. Kolwa / Chiga	50	400	Lielango	1986	PIU	June-December
15. Asunda	Ombeyi / Ramula	20	40	Oroba	1989	PIU	Jan.-June x 2
16. Abwao	Ombeyi / Ramula Kore	43	70	Oroba	1987	PIU	March-August
17. Kopudo	L. Nyakach / Gem Rae	30	50	Awach Kano	1989	PIU	July-December
18. Odhong	Obumba / Wanjare	30	-	Nyangeta	1987	PIU	June-December
19. Oyani	N. Nyakach / Gem Rae	30	30	Awach	1985	PIU	July-December
20. Siany	-	6.4	10	Ahol	N / A	PIU	July-December
21. Gem Rae	N. Nyakach / Gem Rae	70	70	Awach	1983	PIU	July-December
22. Obino	East Kolwa / Chiga	10	200	Riwa	1987	PIU	May-October
23. Malele	East Kolwa / Chiga	40	100	Riwa	1987	PIU	May-October
24. Ahol	East Kolwa / Chiga	20	100	Nyangeta	1987	PIU	May-October
25. Alungo B	Ombeyi / Ramula						
26.	Wang' chieng / Kamser	4	5	Lake Victoria	1980	PIU	May-November
27. Seka Bondo							

SR: Short rainy season rice
LR: Long rainy season rice
Source: LBDA

Table 3.3 Production of Crops in the Study Area (1987-1989)

	Hectarage (ha)				Yield (t/ha)			
	1987	1988	1989	Average	1987	1988	1989	Average
Maize	5,157	5,377	4,901	5,145	1.80	1.98	1.98	1.92
Sorghum	3,617	3,189	2,972	3,260	0.90	1.05	1.26	1.08
Millet	50	39	36	42	0.72	0.27	0.45	0.48
Rice	2,489	1,521	2,200	2,070	3.60	3.34	3.00	3.31
Beans	1,513	874	1,081	1,191	0.90	0.60	0.72	0.74
Greengram	155	202	156	171	0.45	0.63	0.36	0.48
Cowpea	240	340	250	277	0.45	0.32	0.36	0.38
Groundnut	198	231	156	195	0.75	1.00	0.48	0.74
Cassava	538	560	412	503	5.58	7.16	6.24	6.34
Sweet potato	1,580	1,085	718	1,128	6.00	6.54	5.88	6.10
Sugarcane	NA	800	NA	NA	40.00	62.00	55.00	52.30
Cotton	1,493	1,846	3,204	2,181	0.30	0.30	0.30	0.30
Total	16,291	14,873	15,346	15,503				

	Production (ton)				Value (1000/Ksh)			
	1987	1988	1989	Average	1987	1988	1989	Average
Maize	8,976	9,712	9,389	9,359	18,748	31,200	23,093	24,348
Sorghum	3,216	3,419	3,819	3,521	3,879	5,682	7,650	5,757
Millet	34	10	16	20	-	-	24	NA
Rice	8,514	4,827	7,201	6,850	15,097	16,360	25,949	18,235
Beans	1,369	528	779	882	6,780	2,594	3,877	4,417
Greengram	68	125	55	83	606	698	488	597
Cowpea	111	101	93	105	-	84	700	404
Sugarcane	NA	39,184	NA	NA	NA	NA	NA	NA
Cotton	448	554	961	655	1,159	1,861	3,640	2,343
Total					73,087	71,126	74,935	72,428

Source : Prepared by JICA Study Team

Table 3.4 Prices of Major Agricultural Product by Parastatal Bodies and Cooperative Unions

Item		Unit	Price (Ksh)	Unit Price (Kshs)
National Cereals and Produce Board (NCPB)				
Maize		90 kg	235.00	2.61 /kg
Rice (in husk)	Basmati	100 kg	963.20	9.63 /kg
	Sindano	75 kg	269.00	3.59 /kg
	Others	75 kg	269.00	3.59 /kg
Beans	Canadian wonder	90 kg	480.00	5.33 /kg
	Rosecoco	90 kg	480.00	5.33 /kg
	Lima	90 kg	460.00	5.11 /kg
	Mwezi moja	90 kg	460.00	5.11 /kg
	Red haricot	90 kg	440.00	4.88 /kg
	Mwitiemania	90 kg	440.00	4.88 /kg
	Other beans	90 kg	420.00	4.67 /kg
Greengram	Green	90 kg	500.00	5.55 /kg
	Yellow	90 kg	370.00	4.11 /kg
	Black	90 kg	370.00	4.11 /kg
Peas	Pegion	90 kg	370.00	4.11 /kg
	Cow	90 kg	370.00	4.11 /kg
	Dried field	90 kg	370.00	4.11 /kg
Groudnut	Nyanza type	80 kg	700.00	8.75 /kg
Sugar Company				
Sugarcane		1 ton	405.00	405 /ton
Cotton Board of Kenya				
Seed Cotton	A rank	1 kg	10.00	10.00 /kg
	B rank	1 kg	6.00	6.00 /kg
Kenya Planters Cooperative Union				
Robuster coffee	First class	1 kg	5.50	5.50 /kg
	Second class	1 kg	4.50	4.50 /kg

Source : Prepared by JICA Study Team

Table 6.1 Hectareage of Propsed Cropping Pattern

(Unit:ha)

Long Rainy Season	Short Rainy Season	Sub-area I	II-1	II-2	III	IV	V	Total
Paddy	Beans	240	0	110	1,010	910	420	2,690
Maize	Paddy	0	0	0	70	990	680	1,740
Maize	Cotton/Beans	100	200	1,010	120	60	40	1,530
Sugarcane		0	0	0	1,230	1,830	2,070	5,130
Vegetables	Vegetables	100	190	1,100	140	20	20	1,570
Fruit tree		100	190	710	0	0	0	1,000
Napier grass		60	70	300	210	360	270	1,270
Total		600	650	3,230	2,780	4,170	3,500	14,930

Beans : Field beans, Green grams and Cow peas.

Source : Prepared by JICA Study Team

Table 6.2 Changes in Land Use

(Unit:ha)

Item	Sub-area I	II-1	II-2	III	IV	V	Total
Present Land Use							
Paddy field	0	0	100	330	240	110	780
Upland field	270	300	1,470	840	1,540	1,500	5,920
Pasture	330	310	1,470	1,380	2,200	1,710	7,400
Scrub	0	40	190	230	190	180	830
Others	0	0	0	0	0	0	0
Total	600	650	3,230	2,780	4,170	3,500	14,930
Future Land Use							
Paddy field	240	0	110	1,080	1,900	1,100	4,430
Upland field	360	650	3,120	1,700	2,270	2,400	10,500
Pasture	0	0	0	0	0	0	0
Scrub	0	0	0	0	0	0	0
Others	0	0	0	0	0	0	0
Total	600	650	3,230	2,780	4,170	3,500	14,930
Change							
Paddy field	240	0	10	750	1,660	990	3,650
Upland field	90	350	1,650	860	730	900	4,580
Pasture	-330	-310	-1,470	-1,380	-2,200	-1,710	-7,400
Scrub	0	-40	-190	-230	-190	-180	-830
Others	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Source : Prepared by JICA Study Team

Table 6.3 Crop Production under without- and with-Project

Crop	Without Project			With Project		
	Area (ha)	Yield (t/ha)	Production (t/year)	Area (ha)	Yield (t/ha)	Production (t/year)
Paddy	420	3.3	1,390	4,430	6.0	26,580
Maize	1,490	1.9	2,860	3,270	5.0	16,350
Sorghum	940	1.1	1,020	-	-	-
Beans	490	0.7	340	3,455	1.5	5,183
Cassava	140	0.3	890	-	-	-
Sweet potato	220	6.1	1,350	-	-	-
Vegetable	-	-	-	3,140	20.0	62,800
Fruit tree	-	-	-	1,000	10.0	10,000
Cotton	430	0.3	120	765	2.2	1,683
Sugarcane	40	523	2,090	5,130	100	513,000
Napier grass	-	-	-	1,270	400	508,000
Total	4,170	-	-	22,460	-	-

Beans : Field Beans, Green grams, Cowpeas and Groundnuts
Source : Prepared by JICA Study Team

Table 6.4 Financial and Economic Prices for Agricultural Outputs and Inputs

(Unit: KShs./Unit)

Outputs and Inputs			Unit	Financial (1991)	Economic (2000)*1
Outputs		Rice (Import Parity)	ton	4,800	6,180 *2
		Maize (Import Parity)	ton	3,400	4,660 *2
		Cotton (Import Parity)	ton	10,000	16,910 *3
		Sugarcane (Import Parity)	ton	405	501 *3
		Beans	ton	7,250	5,950 *4
		Sorghum	ton	3,360	2,760 *4
		Millet	ton	7,200	5,900 *4
		Greengrams	ton	13,690	11,230 *4
		Cowpeas	ton	14,360	11,780 *4
		Groundnuts	ton	14,310	11,730 *4
		Cassava	ton	2,220	1,820 *4
		Sweet potato	ton	1,040	850 *4
		Tomatoes	ton	3,400	2,790 *4
		Cattle	head	4,500	3,690 *4
		Milk	ton	8,000	6,560 *4
		Robusta coffee	ton	5,500	4,510 *4
		Passion fruit	ton	5,000	4,100 *4
Inputs	(1) Seed				
		Rice	kg	6.0	4.9 *4
		Maize	kg	12.5	10.3 *4
		Beans	kg	25.0	20.5 *4
		Tomatoes	kg	1,007.3	826.0 *4
		Onions	kg	1,099.2	901.3 *4
		French Beans	kg	42.0	34.4 *4
	(2) Fetilizer				
		ASN	kg	4.1	3.3 *4
		TSP	kg	5.5	4.5 *4
		MP	kg	2.8	2.3 *4
	(3) Agro-chemicals				
		Powder	kg	90.5	74 *4
		Liquid	lit	305.3	250 *4
	(4) Labour				
		Family Labour	Man-day	25.0	15.0 *5
	(5) Oxen				
		Land preparation	time	1,890	680 *6

Note:
*1: 1991 constant price.
*2: For breakdown, see Table VI-6.3 (1/2)
*3: For breakdown, see Table VI-6.3 (2/2)
*4: Using standard conversion factor of 0.82.
*5: Using shadow wage rate of 0.6.
*6: Using shadow wage rate of 0.36.

Source : Prepared by JICA Study Team

Table 7.1 Number of Related Structures of Irrigation and Drainage Canal

Canal / Structure		Sub-area							
		I	II-1	II-2a	II-2b	III	IV	V	Total
Main Canals									
South Nyanza main canal	(km)	-	6.0	-	-	-	-	-	6.0
Nyakach-Kano main canal	(km)	-	-	8.4	5.1	6.5	13.3	12.3	45.6
Related structures									
Culvert	(nos.)	-	10	20	12	9	7	16	74
Syphon and spillway	(nos.)	-	1	4	1	1	1	1	9
Check	(nos.)	-	4	3	2	2	4	2	17
Drop	(nos.)	-	27	0	0	0	0	2	29
Turnout	(nos.)	-	6	10	5	4	5	7	37
Washibg step	(nos.)	-	6	8	5	6	13	13	51
Secondary Canals									
Length of Canals	(km)	11	6	32	11	45	51	57	213
Related structures									
Turnout	(nos.)	18	20	70	25	61	91	77	362
Check	(nos.)	10	12	39	14	41	61	52	229
Drop	(nos.)	80	43	236	84	118	133	149	843
Culvert	(nos.)	7	4	20	7	9	11	12	70
Washing step	(nos.)	10	5	31	11	45	51	57	210
Tertiary Canals									
Length of Canals	(km)	16	17	62	22	79	117	101	414
Related structures									
Division box	(nos.)	154	167	609	217	789	1161	1012	4109
Drop	(nos.)	71	77	283	101	181	268	233	1214
Pipe culvert	(nos.)	78	84	308	110	387	571	496	2034
On-farm works									
Upland field	(ha)	360	650	2,347	773	1,700	2,270	2,400	10,500
Paddy field	(ha)	240	0	33	77	1,080	1,900	1,100	4,430
Main and secondary drains									
Length of drains	(km)	11	14	46	17	35	99	44	266
Related structures				-	-	-	-		
(1) Cross drain	(nos.)	-	4	5	4	2	7	5	27
(2) Drop	(nos.)	34	40	118	44	110	243	136	725
(3) Culvert	(nos.)	12	14	40	22	34	84	53	259
(4) Canal revetment	(m2)	2400	2700	9100	5500	7200	25300	8600	60800
Tertiary drains									
Length of drains	(km)	16	17	62	22	79	117	102	415
Related structures									
(1) Drop	(nos.)	8	9	33	12	65	96	83	306
(2) Cross drain	(nos.)	8	9	33	12	65	96	83	306
(3) Drainage culvert	(nos.)	8	9	33	12	65	96	83	306

Source : Prepared by JICA Study Team

Table 7.2 Annual Disbursement Schedule

(Ksh 1,000)

	Detailed Design				Phase I								Phase II												Project as a whole		
	1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		(Ksh 1,000)		
	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	L/C	F/C	Total
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					0.0	0.0	2.6	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.6					
Sub-Total	0.0	0.0	0.0	0.0	46.0	68.1	95.6	122.5	95.6	95.6	39.8	33.4	73.8	115.3	62.1	99.1	147.5	168.6	151.4	176.5	71.6	84.4					
2. O & M Equipment	0.3	3.5									0.2	0.6															
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	20.0	40.0	20.0	40.0	4.0	10.0	4.0	10.0	4.0	10.0	4.0	10.0	8.0	12.0	8.0	12.0	8.0	12.0	8.0	12.0	8.0	12.0					
5. Land Acquisition			1.0								3.0									0.0							
Sub-Total	22.6	43.5	23.3	40.0	53.8	78.1	103.4	132.5	103.4	105.6	50.8	44.0	83.3	127.3	71.6	111.1	157.0	180.6	160.9	188.5	81.1	96.4					
6. Physical Contingency	2.3	4.3	2.3	4.0	5.4	7.8	10.3	13.3	10.3	10.6	5.1	4.4	8.3	12.7	7.2	11.1	15.7	18.1	16.1	18.8	8.1	9.6					
Sub-Total	24.9	47.8	25.6	44.0	59.2	85.9	113.8	145.8	113.8	116.2	55.9	48.4	91.7	140.0	78.7	122.2	172.7	198.6	176.9	207.3	89.2	106.0					
L/C=0.15*Total cost	10.9	61.8	10.4	59.2	21.8	123.3	38.9	220.6	34.5	195.5	15.6	88.7	34.7	196.9	30.1	170.8	55.7	315.6	57.6	326.6	29.3	165.9					
F/C=0.85*Total cost																											
7. Price Contingency	2.3	2.5	3.5	3.6	10.1	10.2	23.8	23.0	26.6	24.7	14.8	13.2	39.7	33.8	40.9	33.3	88.8	69.1	106.8	79.5	62.6	44.5					
Sub-Total	13.2	64.3	13.9	62.8	31.9	133.5	62.7	243.6	61.1	220.1	30.5	101.8	74.5	230.7	71.1	204.1	144.5	384.7	164.4	406.1	91.9	210.5					
													Phase III														
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															0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.6	6	6	12
Sub-Total															76.4	119.7	63.6	104.2	220.3	237.2	234.7	266.0	118.5	125.7	1,497	1,816	3,313
2. O & M Equipment																							3.6	36.6	4	41	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	146	240	386
5. Land Acquisition													4.0												8	0	8
Sub-Total													4.0	0.0	88.7	131.7	75.9	116.2	232.6	249.2	247.0	278.0	134.4	174.3	1,694	2,097	3,791
6. Physical Contingency													0.4	0.0	8.9	13.2	7.6	11.6	23.3	24.9	24.7	27.8	13.4	17.4	169	210	379
Sub-Total													4.4	0.0	97.6	144.9	83.5	127.9	255.9	274.1	271.7	305.8	147.8	191.7	1,863	2,306	4,170
L/C=0.15*Total cost													4.4	0.0	36.4	206.1	31.7	179.7	79.5	450.5	86.6	490.9	50.9	288.6	629	3,541	4,170
F/C=0.85*Total cost																											
7. Price Contingency													5.0	0.0	49.4	40.2	50.5	39.4	147.3	109.6	185.3	131.7	124.9	84.7	982	743	1,725
Sub-Total													9.4	0.0	85.8	246.3	82.2	219.0	226.8	560.1	271.9	622.6	175.8	373.4			
Total	13.2	64.3	13.9	62.8	31.9	133.5	62.7	243.6	61.1	220.1	30.5	101.8	83.9	230.7	156.8	450.4	226.7	603.8	391.3	966.2	363.8	833.0	175.8	373.4	1,612	4,284	5,895

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 7.3 Summary of the Project Cost

(Ksh.1,000)

	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			0	21	24	44	38	48	85	53	63	116	111	135	245
Regulating Pond			0	50	115	164	30	76	107	0	0	0	80	191	271
Irrigation Facility			0	73	74	147	127	186	313	136	277	413	337	537	874
Drainage facility			0	111	76	187	248	236	483	418	364	782	776	676	1,452
Road Improvement			0	3	10	13	9	34	43	10	35	45	22	79	101
On-farm			0	18	18	36	54	62	116	95	112	207	166	193	359
Office and Quarter			0	3	3	5	2	2	3	2	2	3	6	6	12
Sub-Total	0	0	0	277	320	597	506	644	1,150	714	853	1,566	1,497	1,816	3,313
2. O & M Equipment	0	3	4	0	1	1	0	0	0	4	37	40	4	41	45
3. Administration Cost	5	0	5	15	0	15	8	0	8	12	0	12	39	0	39
4. Engineering Cost	40	80	120	16	40	56	40	60	100	50	60	110	146	240	386
5. Land Acquisition	1	0	1	3	0	3	0	0	0	4	0	4	8	0	8
Sub-Total	46	83	129	312	360	672	554	704	1,258	783	949	1,732	1,694	2,097	3,791
6. Physical Contingency	5	8	13	31	36	67	55	70	126	78	95	173	169	210	379
Sub-Total	51	92	142	343	396	739	609	774	1,383	861	1,044	1,905	1,863	2,306	4,170
L/C=0.15*Total cost F/C=0.85*Total cost	21	121	142	111	628	739	208	1,176	1,383	286	1,620	1,905	625	3,544	4,170
7. Price Contingency	6	6	12	75	71	353	339	260	599	566	402	968	986	739	1,725
Total	27	127	154	186	699	885	546	1,436	1,982	852	2,021	2,873	1,611	4,284	5,895

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

Source : Prepared by JICA Study Team

Table 8.1 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 8.2 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

Table 9.1 Economic Cost and Benefit Flow

IRR = 13.2%

		Const. cost	O & M	Replace-ment	Total cost	Benefit	Balance
1	1993	49	0	0	49	0	-49
2	1994	73	0	0	73	0	-73
3	1995	139	0	0	139	0	-139
4	1996	252	0	0	252	0	-252
5	1997	228	0	0	228	0	-228
6	1998	141	3	0	144	47	-96
7	1999	207	4	0	211	82	-129
8	2000	360	4	0	364	95	-269
9	2001	474	4	0	478	102	-376
10	2002	746	4	0	750	108	-642
11	2003	627	16	0	643	318	-325
12	2004	238	20	0	258	435	177
13	2005		24	0	24	552	528
14	2006		24	0	24	594	571
15	2007		24	0	24	626	603
16	2008		24	2	26	637	611
17	2009		24	0	24	642	618
18	2010		24	0	24	642	618
19	2011		24	0	24	642	618
20	2012		24	0	24	642	618
21	2013		24	10	34	642	608
22	2014		24	0	24	642	618
23	2015		24	0	24	642	618
24	2016		24	0	24	642	618
25	2017		24	0	24	642	618
26	2018		24	2	26	642	616
27	2019		24	0	24	642	618
28	2020		24	0	24	642	618
29	2021		24	0	24	642	618
30	2022		24	0	24	642	618
31	2023		24	14	38	642	604
32	2024		24	0	24	642	618
33	2025		24	0	24	642	618
34	2026		24	0	24	642	618
35	2027		24	0	24	642	618
36	2028		24	13	36	642	606
37	2029		24	0	24	642	618
38	2030		24	0	24	642	618
39	2031		24	0	24	642	618
40	2032		24	0	24	642	618
41	2033		24	10	34	642	608
42	2034		24	0	24	642	618
43	2035		24	0	24	642	618
44	2036		24	0	24	642	618
45	2037		24	0	24	642	618
46	2038		24	2	26	642	616
47	2039		24	0	24	642	618
48	2040		24	0	24	642	618
49	2041		24	0	24	642	618
50	2042		24	0	24	642	618
Total		3,534					

Discount rate	10%
Benefit	2,395
Cost	1,757
B-C	638
B/C	1.36

Source : Prepared by JICA Study Team

Table 9.2 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	61	0	0	1	0	62	48	13	1	0	62	0	48
1994	2	90	0	0	3	0	93	71	19	3	0	93	0	119
1995	3	190	0	0	7	0	196	156	34	7	0	196	0	275
1996	4	355	0	0	14	0	369	297	58	14	0	369	0	572
1997	5	331	0	0	21	0	352	277	53	21	0	352	0	849
1998	6	215	3	0	26	0	243	178	37	26	3	243	0	1,027
1999	7	317	5	0	32	0	354	263	54	32	5	354	0	1,290
2000	8	572	5	0	44	0	621	484	89	44	5	621	0	1,773
2001	9	791	5	0	61	0	856	672	119	61	5	856	0	2,445
2002	10	1,312	5	0	89	0	1,406	1,123	189	89	5	1,406	0	3,569
2003	11	1,140	19	0	108	246	1,512	977	163	353	19	1,512	0	4,300
2004	12	441	24	0	111	246	821	367	73	356	24	821	0	4,422
2005	13	0	29	0	104	246	379	0	0	350	29	379	0	4,176
2006	14	0	29	0	98	246	373	0	0	344	29	373	0	3,931
2007	15	0	29	0	92	246	366	0	0	338	29	366	0	3,685
2008	16	0	29	3	86	246	363	0	0	334	29	363	0	3,439
2009	17	0	29	0	80	246	354	0	0	326	29	354	0	3,194
2010	18	0	29	0	74	246	348	0	0	319	29	348	0	2,948
2011	19	0	29	0	68	246	342	0	0	313	29	342	0	2,702
2012	20	0	29	0	61	246	336	0	0	307	29	336	0	2,457
2013	21	0	29	13	55	246	342	0	0	314	29	342	0	2,211
2014	22	0	29	0	49	246	324	0	0	295	29	324	0	1,965
2015	23	0	29	0	43	246	317	0	0	289	29	317	0	1,720
2016	24	0	29	0	37	246	311	0	0	283	29	311	0	1,474
2017	25	0	29	0	31	246	305	0	0	276	29	305	0	1,228
2018	26	0	29	3	25	246	302	0	0	273	29	302	0	983
2019	27	0	29	0	18	246	293	0	0	264	29	293	0	737
2020	28	0	29	0	12	246	287	0	0	258	29	287	0	491
2021	29	0	29	0	6	246	281	0	0	252	29	281	0	246
2022	30	0	29	0	0	246	274	0	0	246	29	274	0	0
2023	31	0	29	17	0	0	46	0	0	17	29	46	0	0
2024	32	0	29	0	0	0	29	0	0	0	29	29	0	0
2025	33	0	29	0	0	0	29	0	0	0	29	29	0	0
2026	34	0	29	0	0	0	29	0	0	0	29	29	0	0
2027	35	0	29	0	0	0	29	0	0	0	29	29	0	0
2028	36	0	29	16	0	0	45	0	0	16	29	45	0	0
2029	37	0	29	0	0	0	29	0	0	0	29	29	0	0
2030	38	0	29	0	0	0	29	0	0	0	29	29	0	0
2031	39	0	29	0	0	0	29	0	0	0	29	29	0	0
2032	40	0	29	0	0	0	29	0	0	0	29	29	0	0
2033	41	0	29	13	0	0	42	0	0	13	29	42	0	0
2034	42	0	29	0	0	0	29	0	0	0	29	29	0	0
2035	43	0	29	0	0	0	29	0	0	0	29	29	0	0
2036	44	0	29	0	0	0	29	0	0	0	29	29	0	0
2037	45	0	29	0	0	0	29	0	0	0	29	29	0	0
2038	46	0	29	3	0	0	32	0	0	3	29	32	0	0
2039	47	0	29	0	0	0	29	0	0	0	29	29	0	0
2040	48	0	29	0	0	0	29	0	0	0	29	29	0	0
2041	49	0	29	0	0	0	29	0	0	0	29	29	0	0
2042	50	0	29	0	0	0	29	0	0	0	29	29	0	0
Total		5,814	1,155	67	1,457	4,913	13,406	4,913	900	6,438	1,155	13,406		
								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

Table 10.1 Water Flow Regime of the Winam Gulf and Nyakach Bay

Existing	unit	Winam Gulf	Nyakach Bay
a) Surface area	km2	1,400	36
b) Average depth	m	6	3
c) Storage volume(a*b)	10^6 m3	8,400	108
d) Annual inflow	10^6 m3/y	2,731.0	510.9
e) Retention time(d/c)	times/y	0.33	4.73

With project condition	unit	Winam Gulf	Nyakach Bay
f) Irrigable area	ha	14,930	14,930
g) Diverted water volume	10^6 m3/y	372	372
h) Evapotranspiration and permeabi'ty	mm/day	4	4
i) Irrigable days	day	365	365
j) Loss of irrigation water (f x h x i)	10^6 m3/y	218	218
k) Return flow(g-j)	10^6 m3/y	154	154
l) Return flow rate (k/g)	%	41.4	41.4
m) Annual inflow to Gulf (d-j)	10^6 m3/y	2,513	-
n) Annual inflow to Bay (note 1)	10^6 m3/y	-	665
o) Change of inflow rate (m/d)	%	92.0	130.2
p) Retention time(m/c)	times/y	0.30	6.16

Source : Prepared by JICA Study Team

Table 10.2 Existing Conditions of Water Quality and Pollution Load

	unit	COD	T-N	T-P
Water quality				
a) Diverted irrigation water	mg/l	2.2	4.94	0.02
b) Nyando river	mg/l	4.2	1.19	0.10
c) Center of Nyakach Bay	mg/l	2.6	0.62	0.04
d) Inflow water to Gulf (assumption)	mg/l	5.0	1.00	0.06
e) Center of Winam Gulf	mg/l	1.8	0.47	0.02
Pollution load				
f) Load from Bay to Gulf	t/y	1,328	317	20
g) Inflow load to Bay	t/y	2,146	608	51
h) Purificated load in Bay (h-g	t/y	817	291	31
i) Load from Gulf to main Lak	t/y	4,916	1,284	55
j) Load from inflow water to C	t/y	13,655	2,731	164
k) Purificated load in Gulf (m-	t/y	8,739	1,447	109

Note : Concentration of COD is quoted from the sampling results, and T-N and T-P are estimated based on the existing data and the sampling results.

Source : Prepared by JICA Study Team

Table 10.3 Change of Pollution Load and Water Quality

Item	unit	Nyakach Bay COD	Nyakach Bay T-N	Nyakach Bay T-P	Winam Gulf COD	Winam Gulf T-N	Winam Gulf T-P
a) Existing annual inflow	10^6 m3/y	511	511	511	2,731	2,731	2,731
b) Existing inflow load	t/y	2,146	608	51	13,655	2,731	164
With project condition							
c) Volume of diverted water	10^6 m3/y	372	372	372	-	-	-
d) Load by diverted water	t/y	819	1,838	7	-	-	-
e) Increased load by irrig'n	t/y	1,085	61.98	32.02	1,085	61.98	32.02
f) Total inflow load(b+d+e)	t/y	4,049	2,508	91	14,740	2,793	196
g) Self purification load	t/y	817	291	31	8,739	1,447	109
h) Expected actual load(f-g)	t/y	3,232	2,217.03	59.90	6,000	1,346	87
i) Loss of irrigation water	10^6 m3/y	218	218	218	218	218	218
j) Expected annual inflow	10^6 m3/y	665	665	665	2,513	2,513	2,513
k) Expected water quality(h/j)	mg/l	4.86	3.33	0.09	2.39	0.54	0.03
l) Increased concentration	mg/l	2.26	2.71	0.05	0.59	0.07	0.01

Source : Prepared by JICA Study Team

Table 10.4 Possibility of Eutrophication of Nyakach Bay and Winam Gulf

Item	unit	Existing Condition	with Project Condition
Nyakach Bay			
a)Surface area	km2	36	36
b)Average depth	m	3	3
c)Storage volume(a x b)	10^6 m3	108	108
d)Annual inflow	10^6 m3	511	665
e)Retention time(d/c)	times/y	4.73	6.16
f)Concentration of T-P	mg/l	0.04	0.09
g)T-P surface area load(d x f/a)	t/km2.y	0.57	1.66
h)Re'tion time x Ave. depth(e x b)	times.m/y	14.19	18.47
Winam Gulf			
a)Surface area	km2	1,400	1,400
b)Average depth	m	6	6
c)Storage volume(a x b)	10^6 m3	8,400	8,400
d)Annual inflow	10^6 m3	2,731	2,513
e)Retention time(d/c)	times/y	0.33	0.30
f)Concentration of T-P	mg/l	0.02	0.03
g)T-P surface area load(d x f/a)	t/km2.y	0.04	0.06
h)Re'tion time x Ave. depth(e x b)	times.m/y	1.95	1.80

Source : Prepared by JICA Study Team

Table 10.5 Checklist of Initial Environmental Examination

Stage	Construction stage			Operation stage		
Item/ Ecological region	1	2	3	1	2	3
Agricultural chemicals region	=	=	=	=	x	x
Soil erosion	x	=	=	x	=	=
Sediment	=	x	x	=	x	x
Fisheries	=	x	x	x	-/C	-/C
Ecosystem of the swamp	=	x	x	=	-/C	-/C
Resettlement	x	=	=	=	=	=
Vector borne disease						
- Malaria	-/C	=	=	-/A	=	=
- Schistosomiasis	-/C	=	=	-/A	x	x
- Trypanosomiasis	x	=	=	x	=	=

<Effect>

+ : Positive (better) effect expected
- : Negative (adverse) effect expected
= : No relation with the project considered
x : Neutral effect expected (not positive and not negative), there may be a change but such change will be neither beneficial nor harmful

<Magnitude>

A : Effect which has relatively high level of magnitude
B : Effect which has relatively medium level of magnitude
C : Effect which has relatively low level of magnitude

<Ecological region>

1 : Irrigation area
2 : Nyando river and swamp area
3 : Lake area (Winam Gulf and Nyakach Bay)

Source : Prepared by JICA Study Team

Figures

Fig. 1.1 Work Schedule

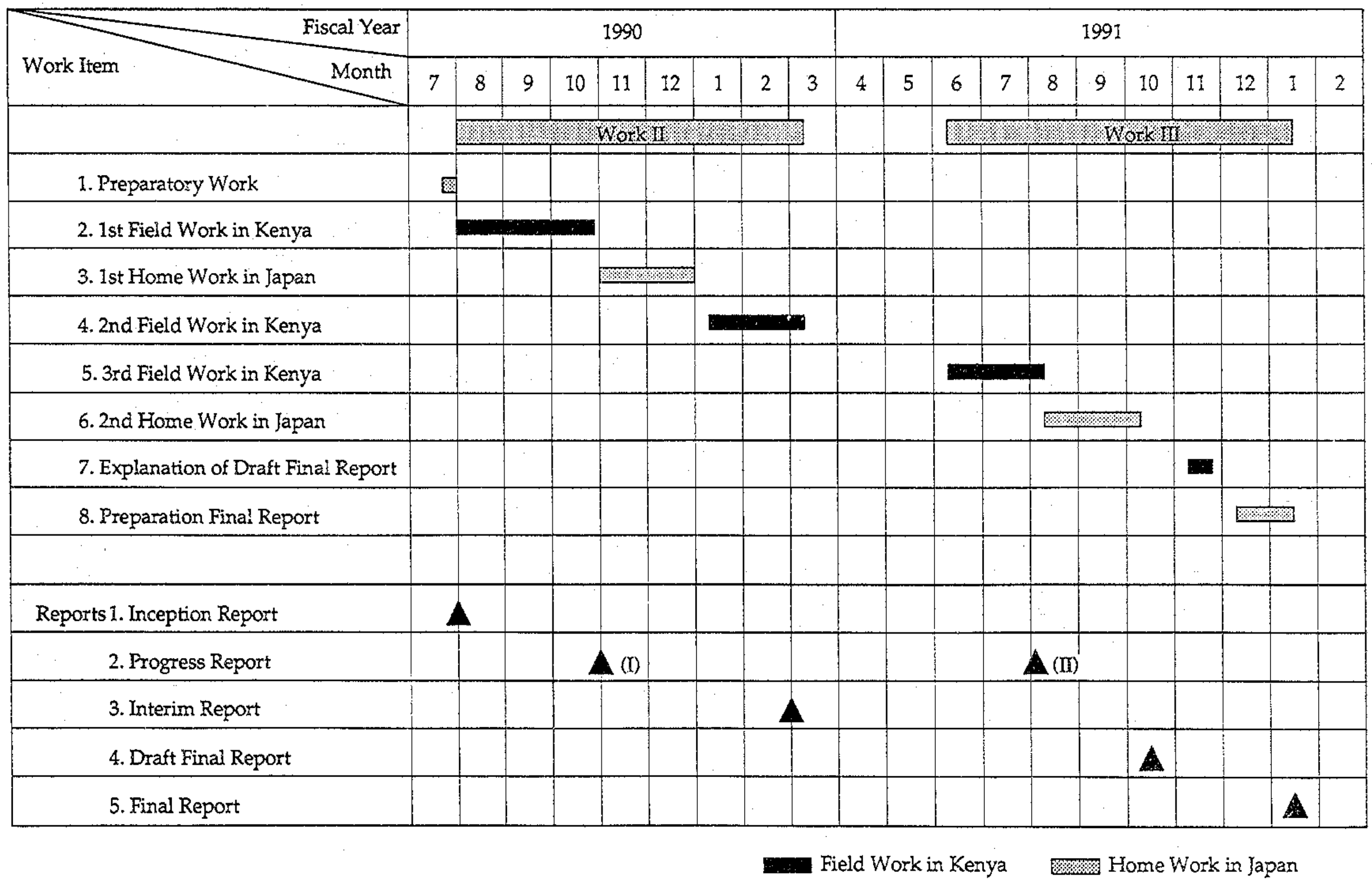


Fig. 1.2 Feasibility Study Flow Chart

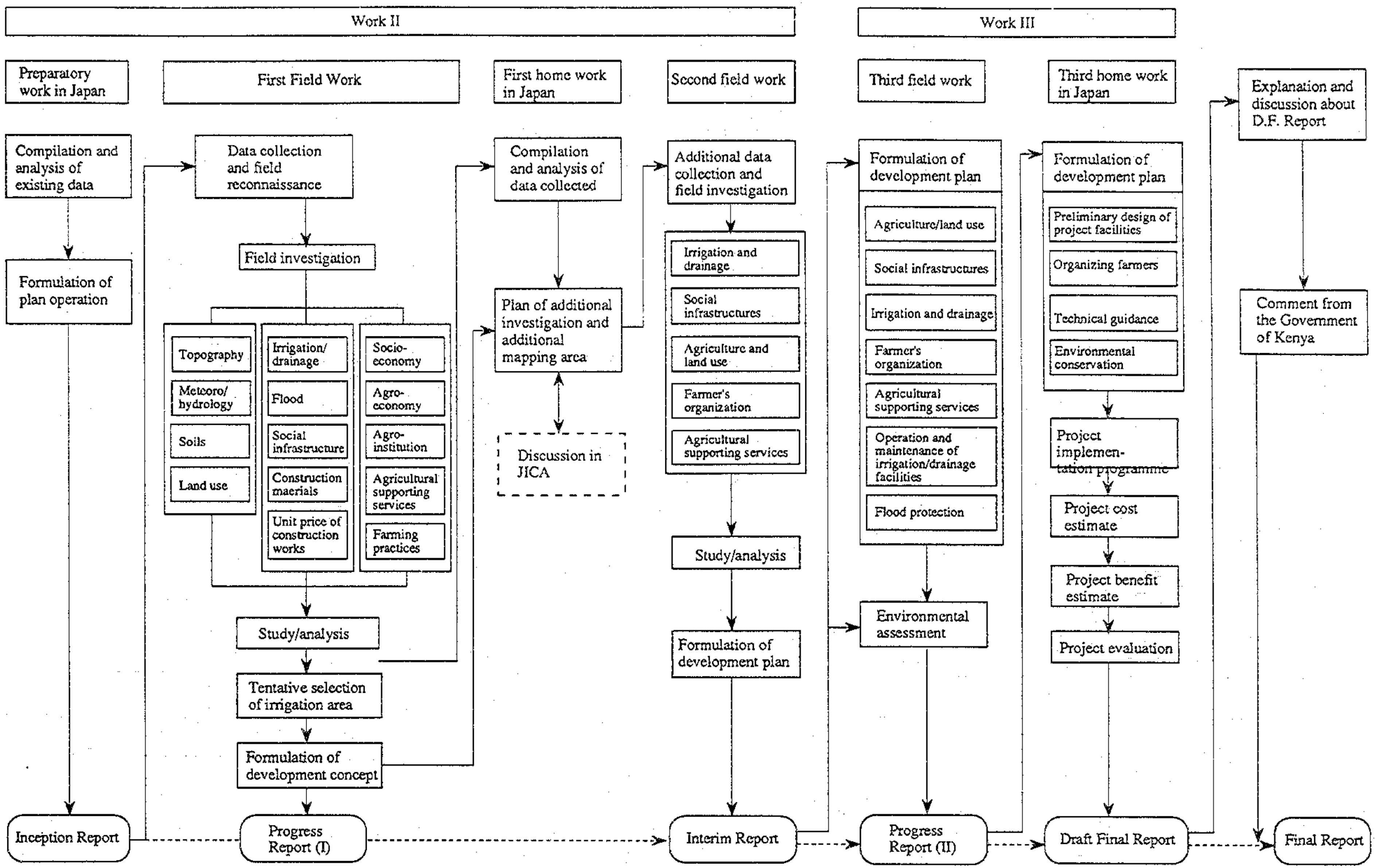
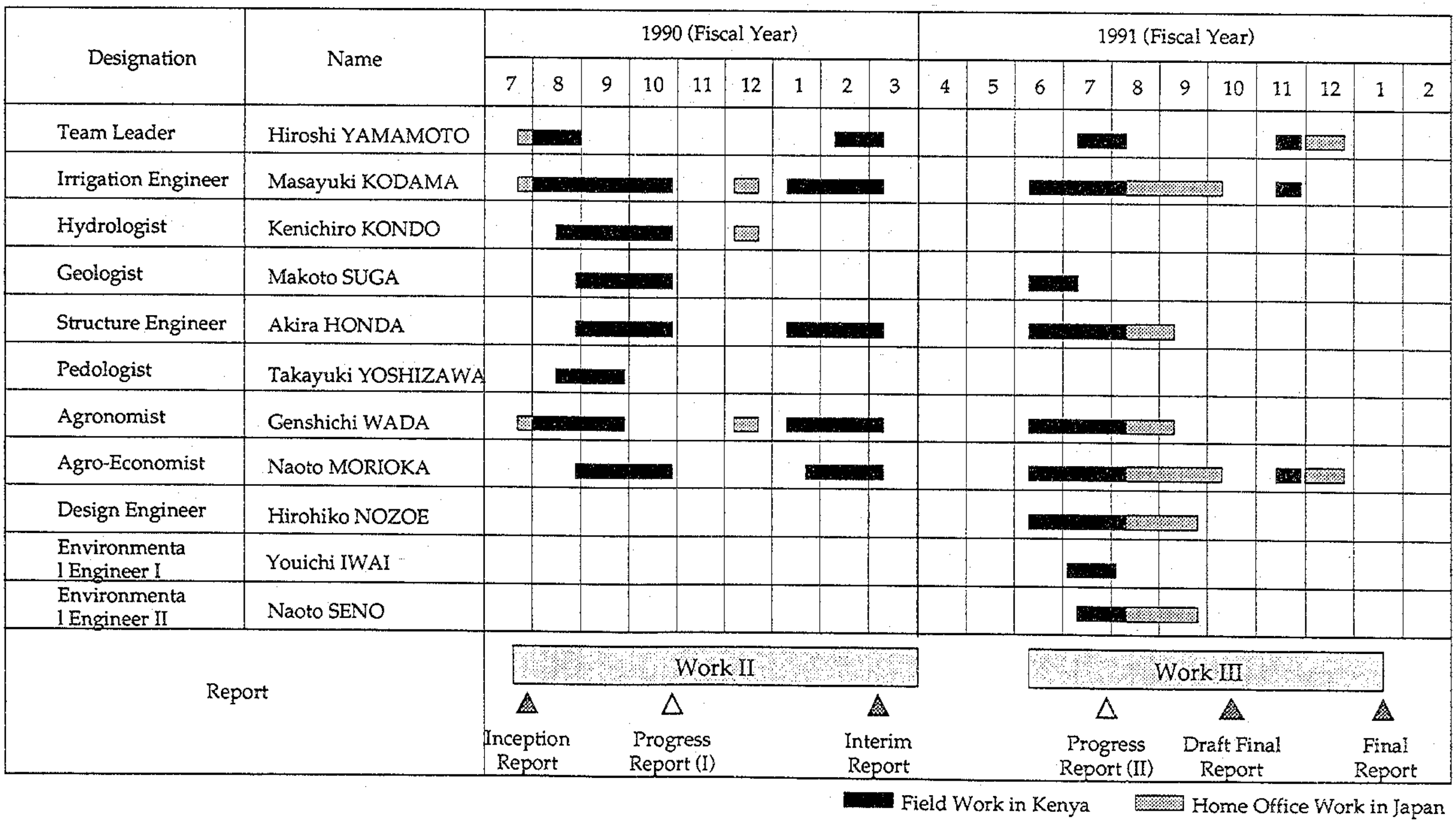
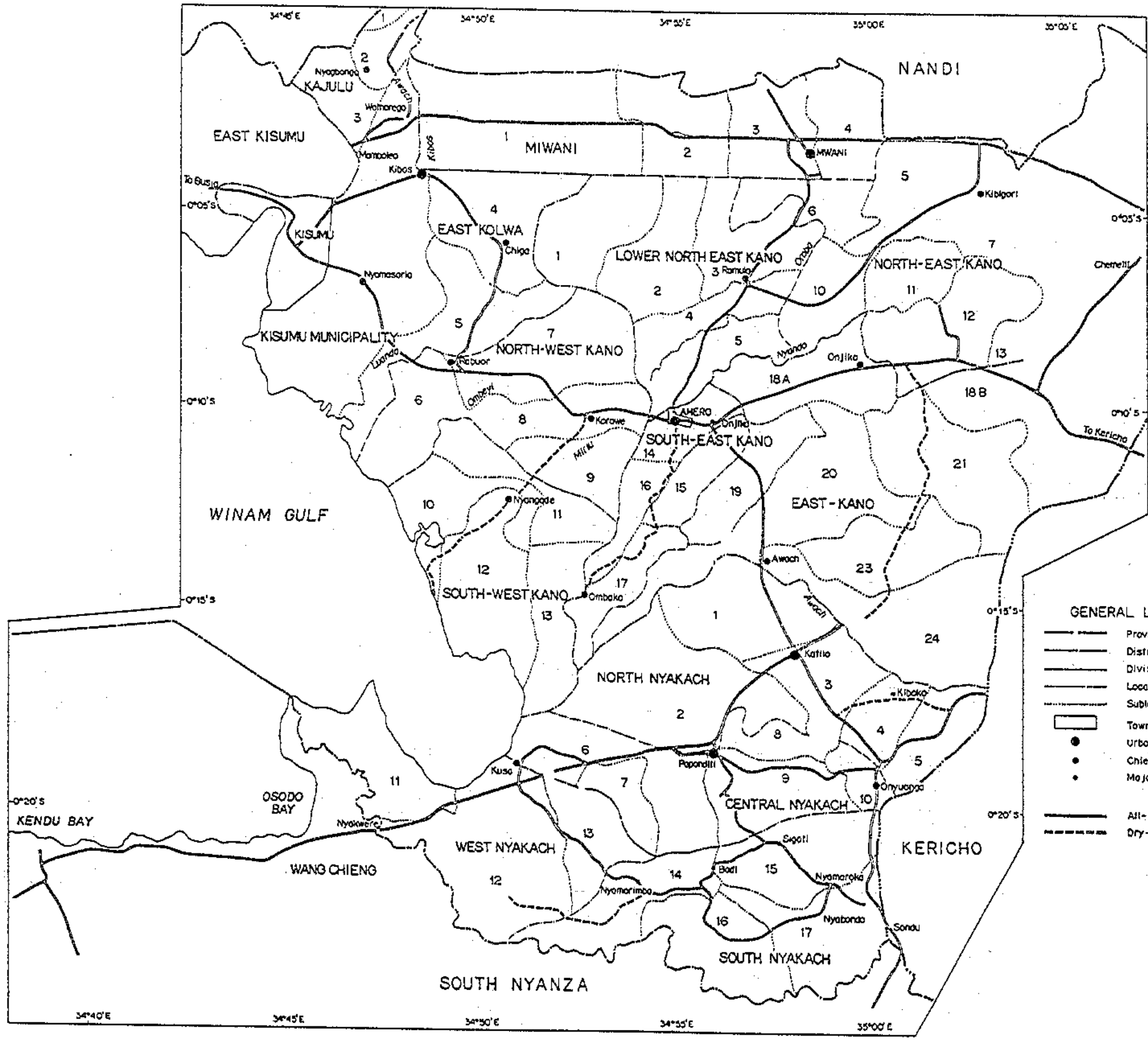


Fig. 1.3 Assignment Schedule





LEGEND TO SUBLOCATION CODE

WINAM DIVISION
KAJULU LOCATION
1. Got Nyabondo
2. Kadero
3. Konya

EAST KOLWA LOCATION
4. Chiga
5. Buoye

NORTH WEST KANO LOCATION
6. Nyamware
7. Kochieng
8. Kombura
9. Katho

SOUTH WEST KANO LOCATION
10. Kawino
11. Upper Bwanda
12. Kadhiambo
13. Lower Bwanda

NYANDO DIVISION
SOUTH EAST KANO LOCATION
14. North Kakola
15. North Kochogo
16. South Kakola
17. South Kochogo

EAST KANO LOCATION
18. Wawidhi A
19. Kokmie
20. Wawidhi C
21. Border I
22. Border II
23. Wawidhi B
24. Katolo

UPPER NYAKACH DIVISION
NORTH NYAKACH LOCATION
1. Gem Rae
2. Middle Jimo
3. West Agoro
4. Awach
5. East Agoro

CENTRAL NYAKACH LOCATION
6. West Kabodho
7. West Jimo
8. Lisana
9. East Kabodho
10. East Jimo

MUHORONI DIVISION
MIWANI LOCATION
1. West Miwani
2. Central Miwani
3. East Miwani
4. North Miwani

LOWER NORTH EAST KANO LOCATION
1. West Sidho
2. Central Sidho
3. North Komagaga
4. Irrigation Scheme

NORTH EAST KANO LOCATION
6. West Kabar
10. Wangaya II
11. North Kamswa
12. South Kamswa
13. Wangaya I

LOWER NYAKACH DIVISION
WEST NYAKACH LOCATION
11. Lower Kadianga
12. West Koguta
13. Upper Kadianga

SOUTH NYAKACH LOCATION
14. West Kadianga
15. East Koguta
16. Kajimbo
17. East Kadianga

GENERAL LEGEND :
- Provincial boundary
- District boundary
- Divisional boundary
- Location boundary
- Sublocation boundary
- Town
- Urban, Rural centers / Divisional Hq.
- Chiefs camp / Locational Hq.
- Major market centres
- All-weather roads
- Dry-weather roads

SCALE
0 1 2 3 4 5 Km

Source
Lake Basin Development Authority, RDWSSP, Map 2 Administrative Sub division (1987 Situation) Kisumu District, Sept. 1988. Modified to 1990.

REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT

Fig. 3.1
Administrative Boundary

JAPAN INTERNATIONAL COOPERATION AGENCY

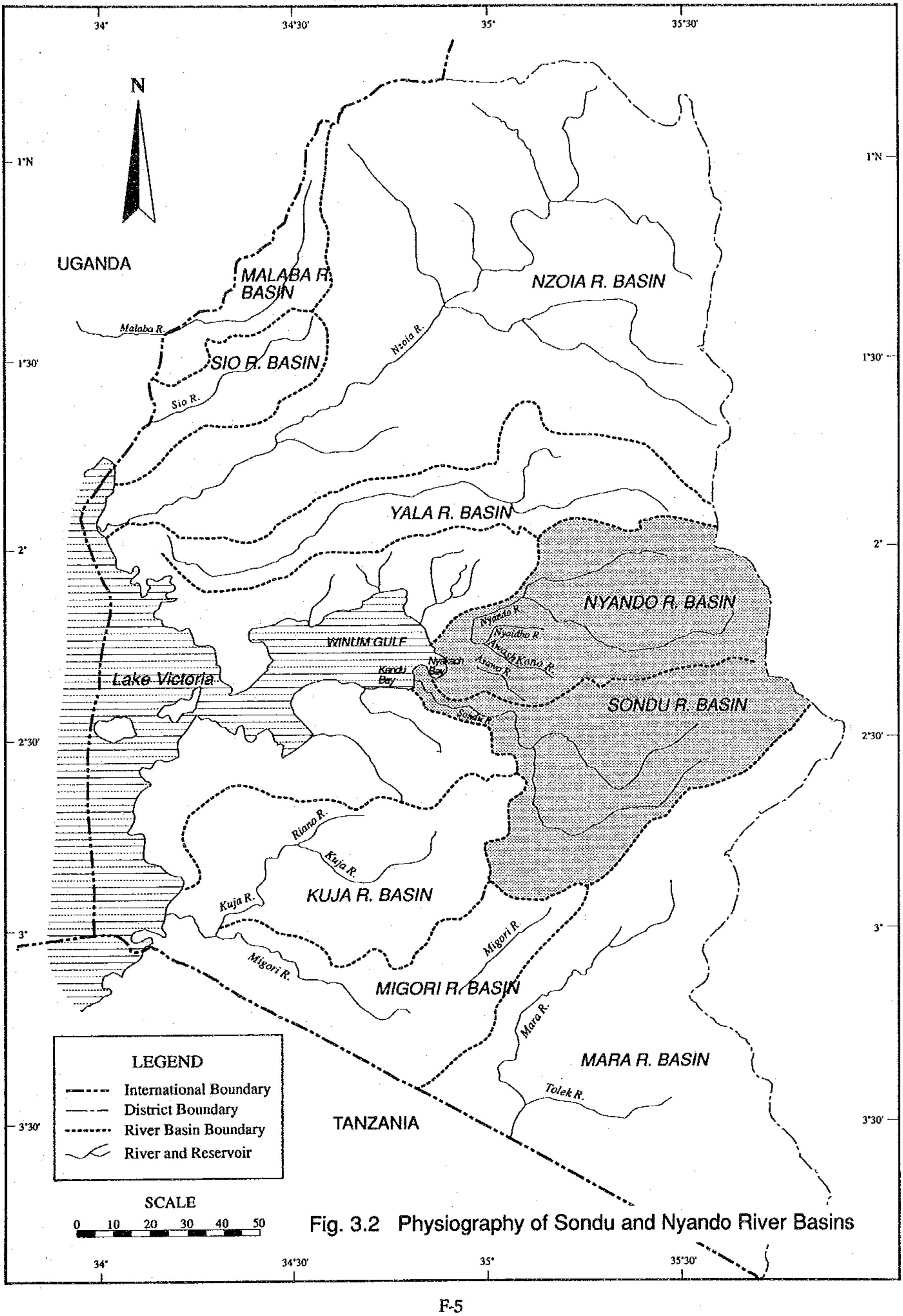
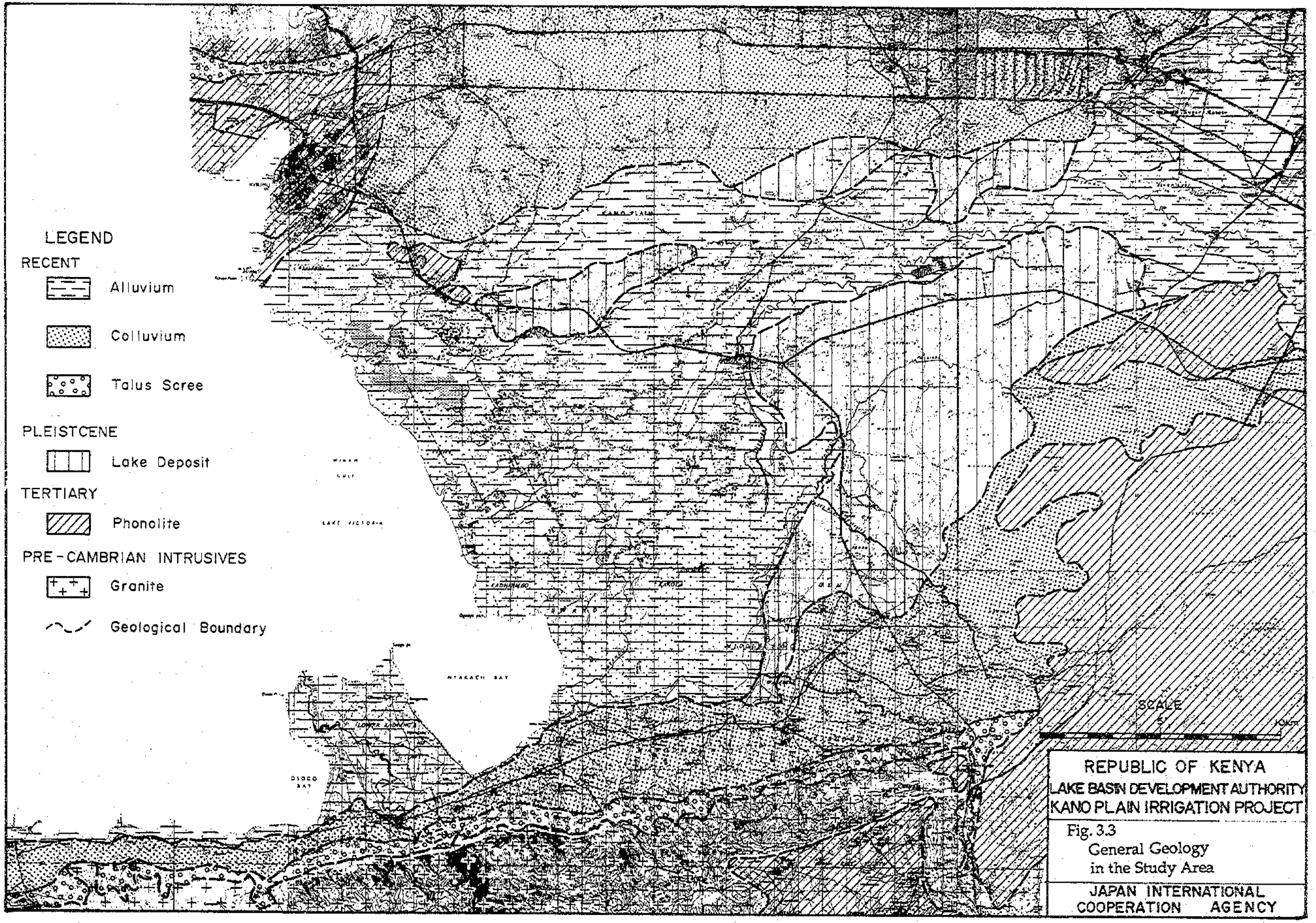


Fig. 3.2 Physiography of Sondu and Nyando River Basins


LEGEND
RECENT
Alluvium
Colluvium
Talus Scree
PLEISTCENE
Lake Deposit
TERTIARY
Phonolite
PRE-CAMBRIAN INTRUSIVES
Granite
Geological Boundary
WINAM GULF
LAKE VICTORIA
NYAKACH BAY
KANO PLAIN
SCALE
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. 3.3
General Geology
in the Study Area
JAPAN INTERNATIONAL
COOPERATION AGENCY


LEGEND
Symbol
Soil Unit
SA1
Gleysols
SA2
Histsols
AA
Fluvisols
PLA
Vertisols
YU
Planosols
LI
Lithosols
Pp
Cambisols
Ar
Arenosols
Lu
Luvisols
R
Regosols
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. 3.4
Soil Map
JAPAN INTERNATIONAL COOPERATION AGENCY
SCALE
LAKE VICTORIA
NYAKACH BAY
ODODO BAY

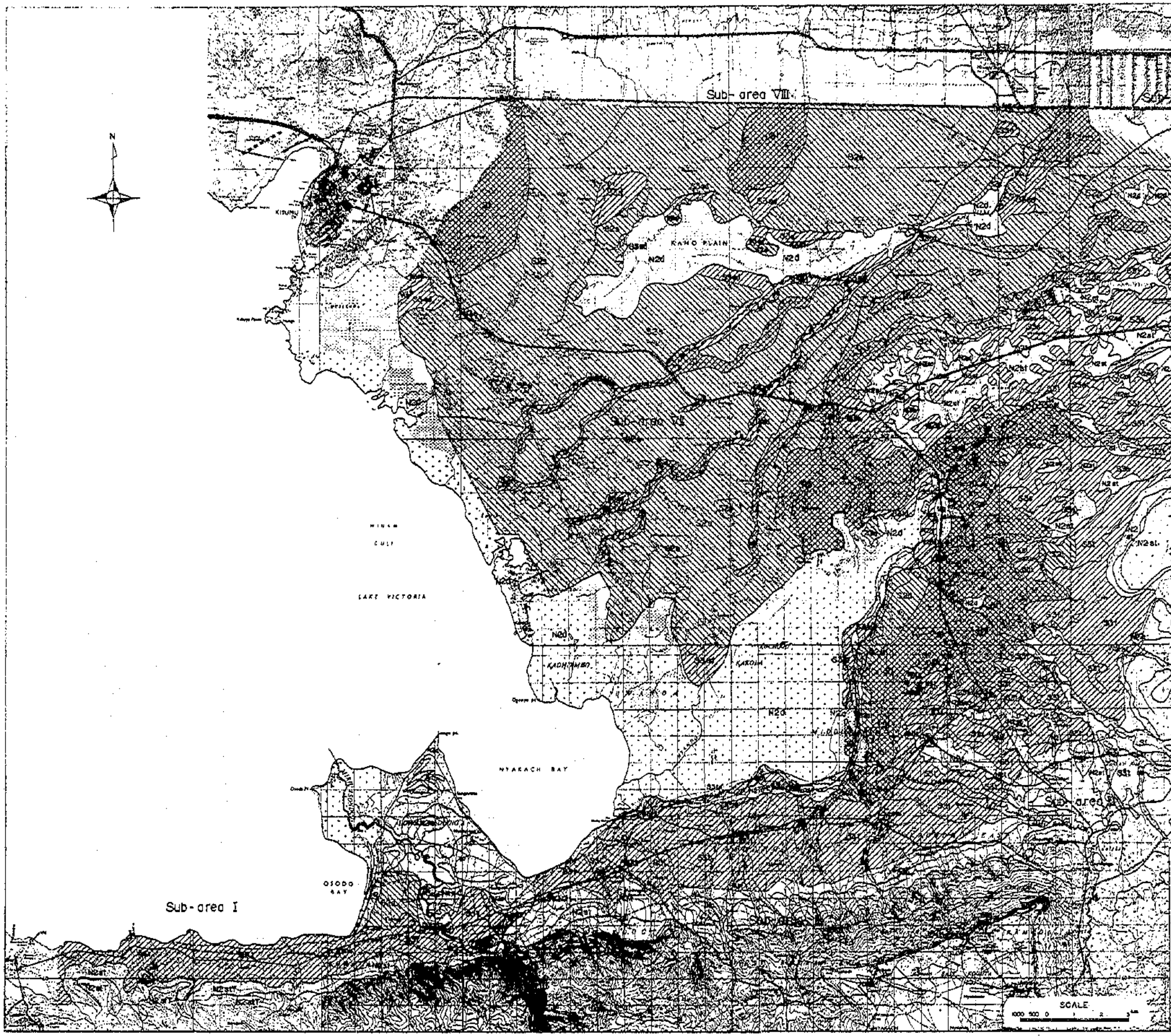


Fig. 3.5
Land Classification Map
(paddy plant)

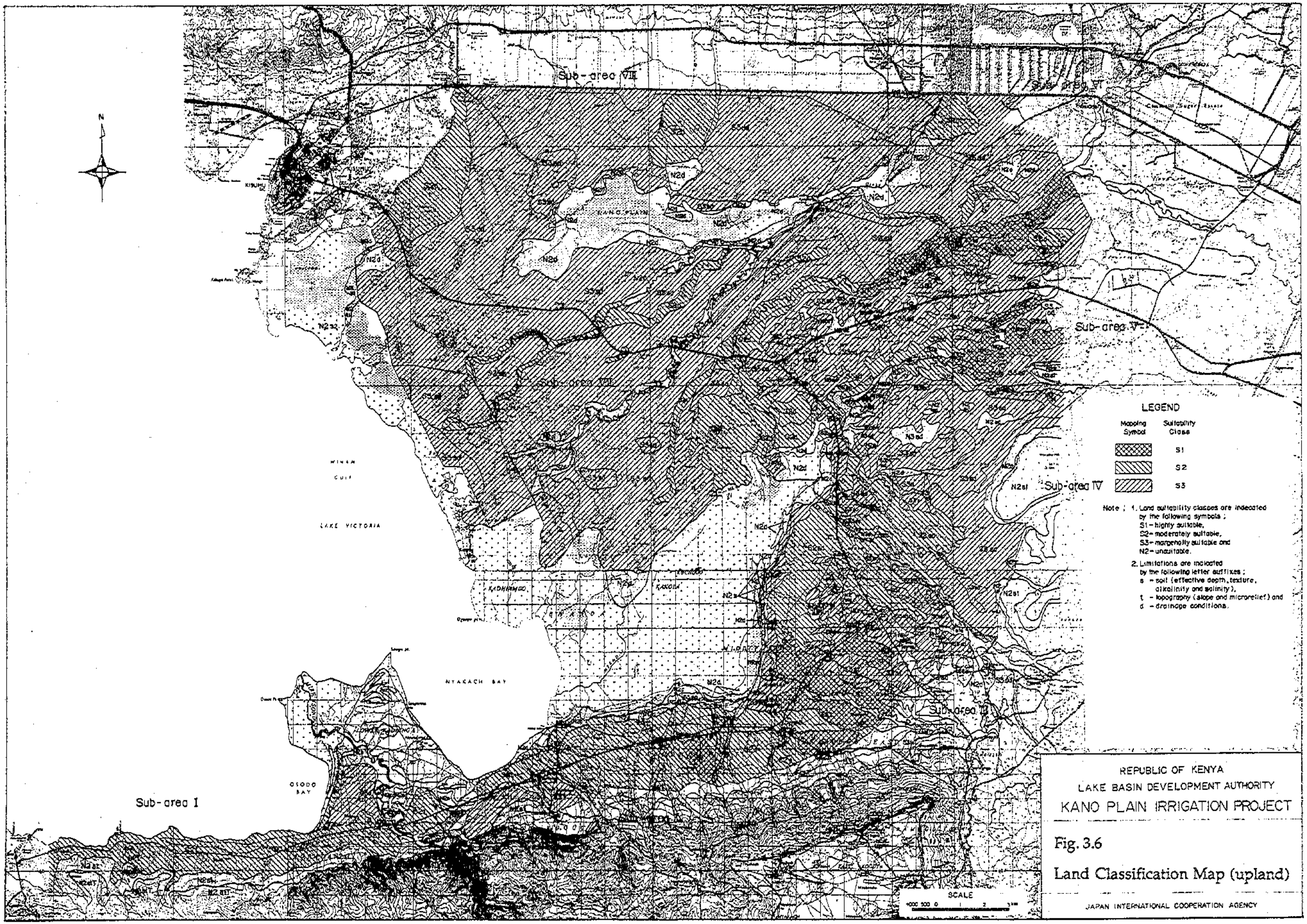
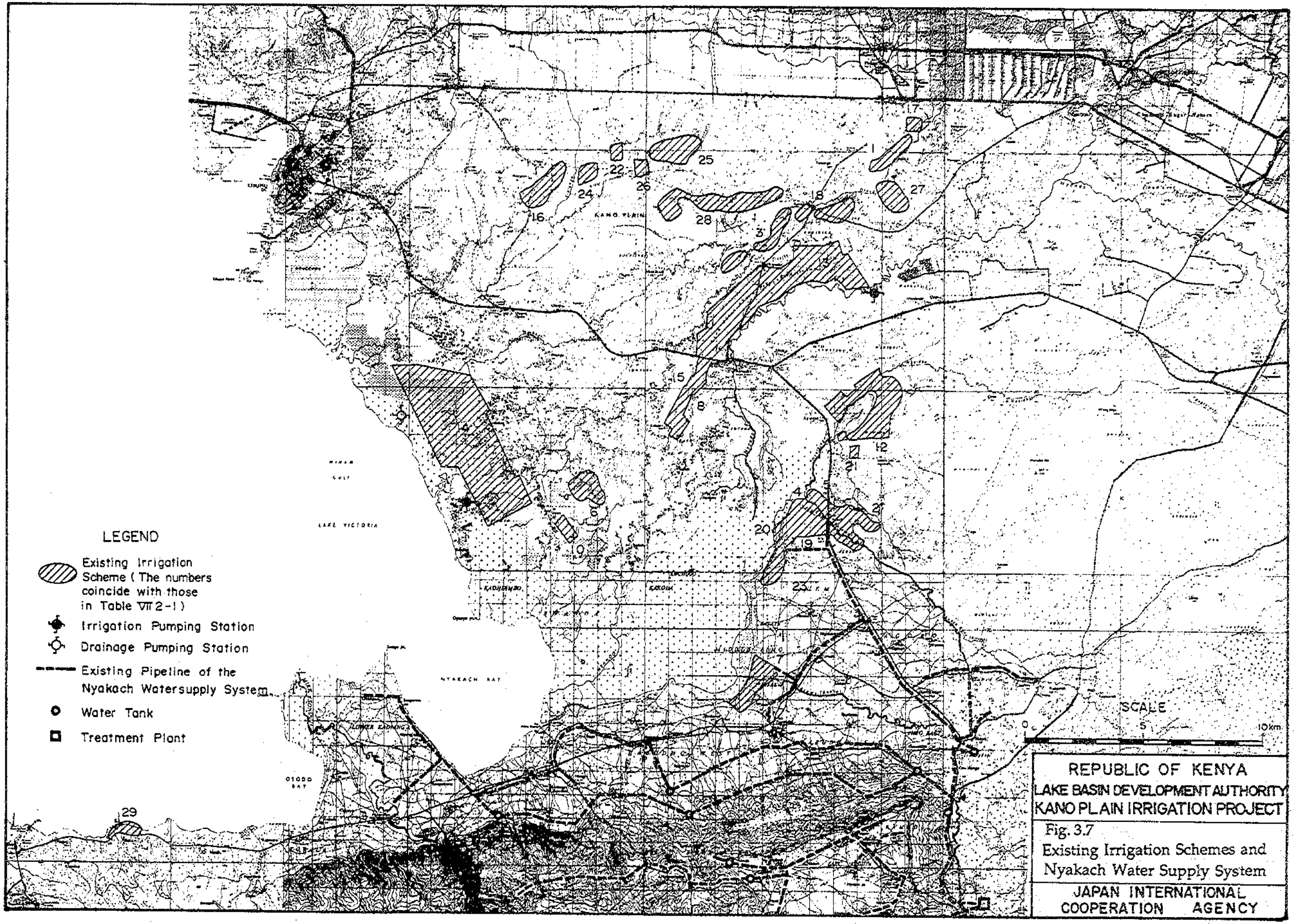


Fig. 3.6
Land Classification Map (upland)


LEGEND
Existing Irrigation Scheme (The numbers coincide with those in Table VII 2-1)
Irrigation Pumping Station
Drainage Pumping Station
Existing Pipeline of the Nyakach Watersupply System
Water Tank
Treatment Plant
KANO PLAIN
LAKE VICTORIA
NYAKACH BAY
SCALE
0
5
10km
REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT
Fig. 3.7
Existing Irrigation Schemes and
Nyakach Water Supply System
JAPAN INTERNATIONAL
COOPERATION AGENCY