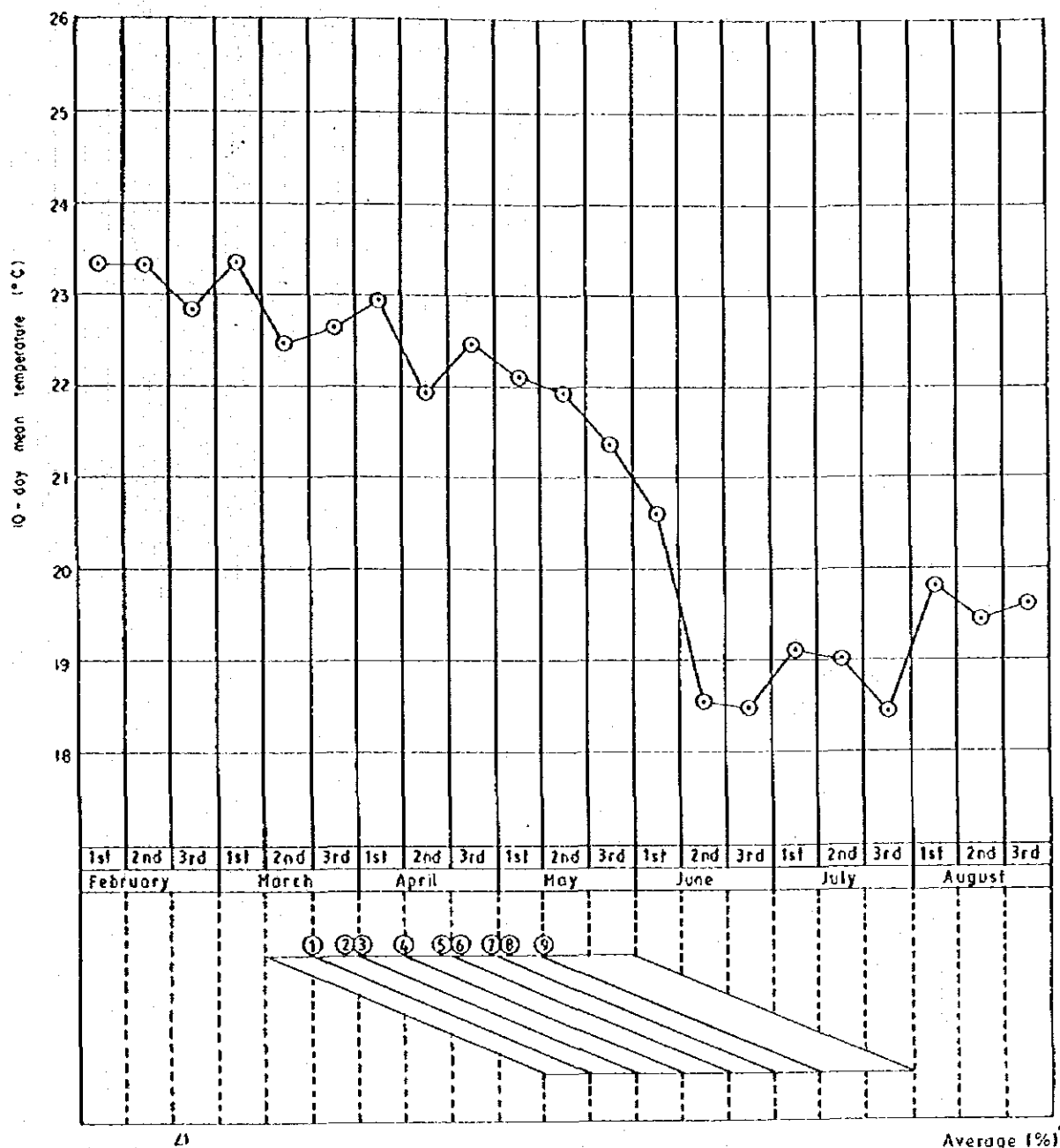


Yield Reduction Rate (%)																			Average (%)
① Tillering Stage		0	0	0	0	0	0												0
② Initial Panicle Formation Stage			0	0	0	0	0	0											0
③ Middle Panicle Formation Stage			0	0	0	0	0	1											0
④ Initial Booting Stage				10	7	9	10	13	17										11
⑤ Middle Booting Stage					0	0	0	0	6	17									4
⑥ Late Booting Stage					0	0	0	0	2	10									2
⑦ Heading / Flowering						4	5	10	12	20	21								12
⑧ Initial Ripening Stage						2	2	3	4	8	7								4
⑨ Middle Ripening Stage							0	0	0	0	0	0							0
Yield Reduction Rate per ha through cropping pattern																			29

(Note) Z1 : Yield reduction rate in each 10 days of cropping period

Z2 : Average yield reduction rate in each growing stage for 60 days of cropping period

Fig. VII-19 10 - DAY MEAN TEMPERATURE IN BASIC YEAR AND YIELD REDUCTION RATE ON LONG RAINS RICE UNDER PROPOSED CROPPING PATTERN

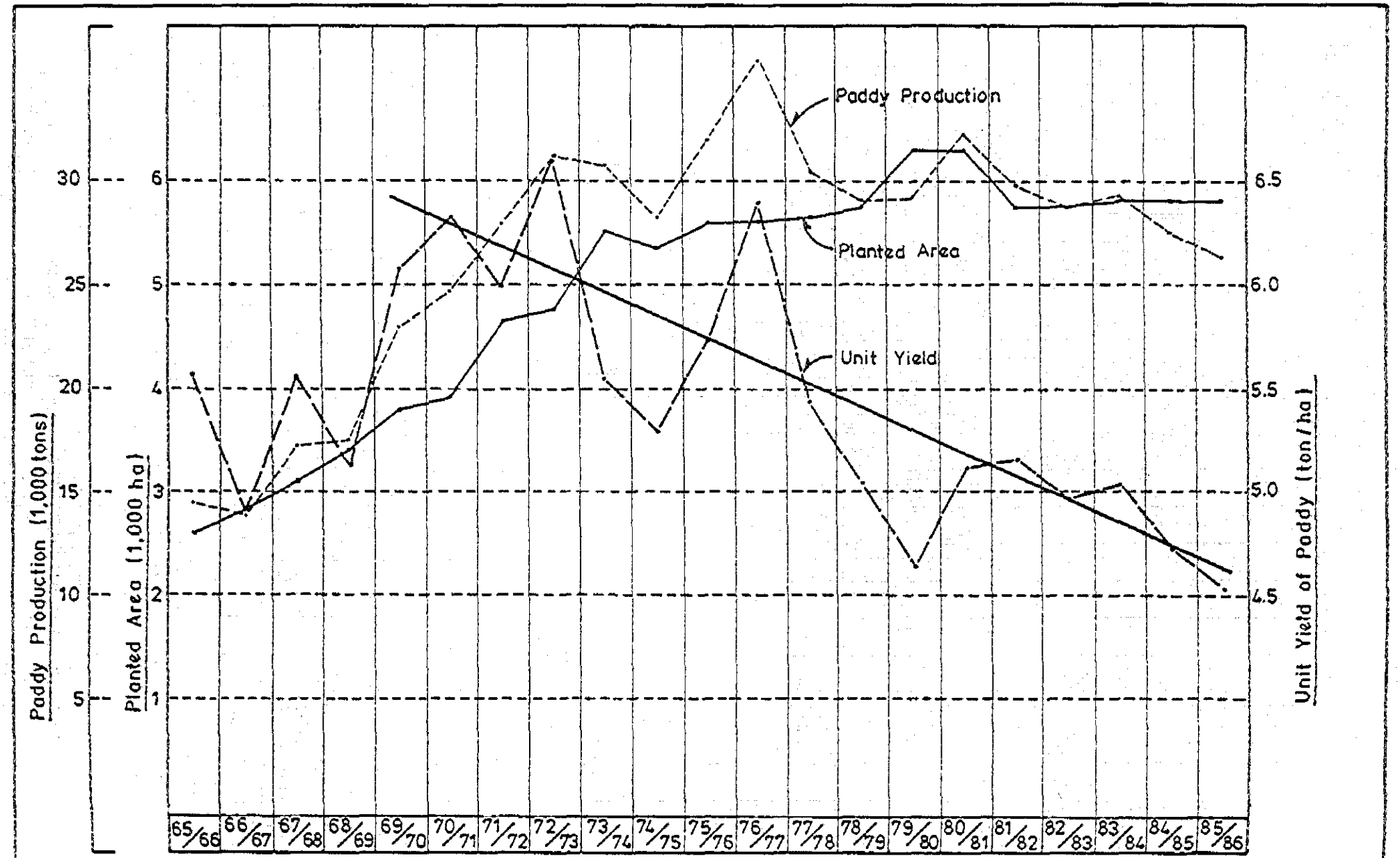
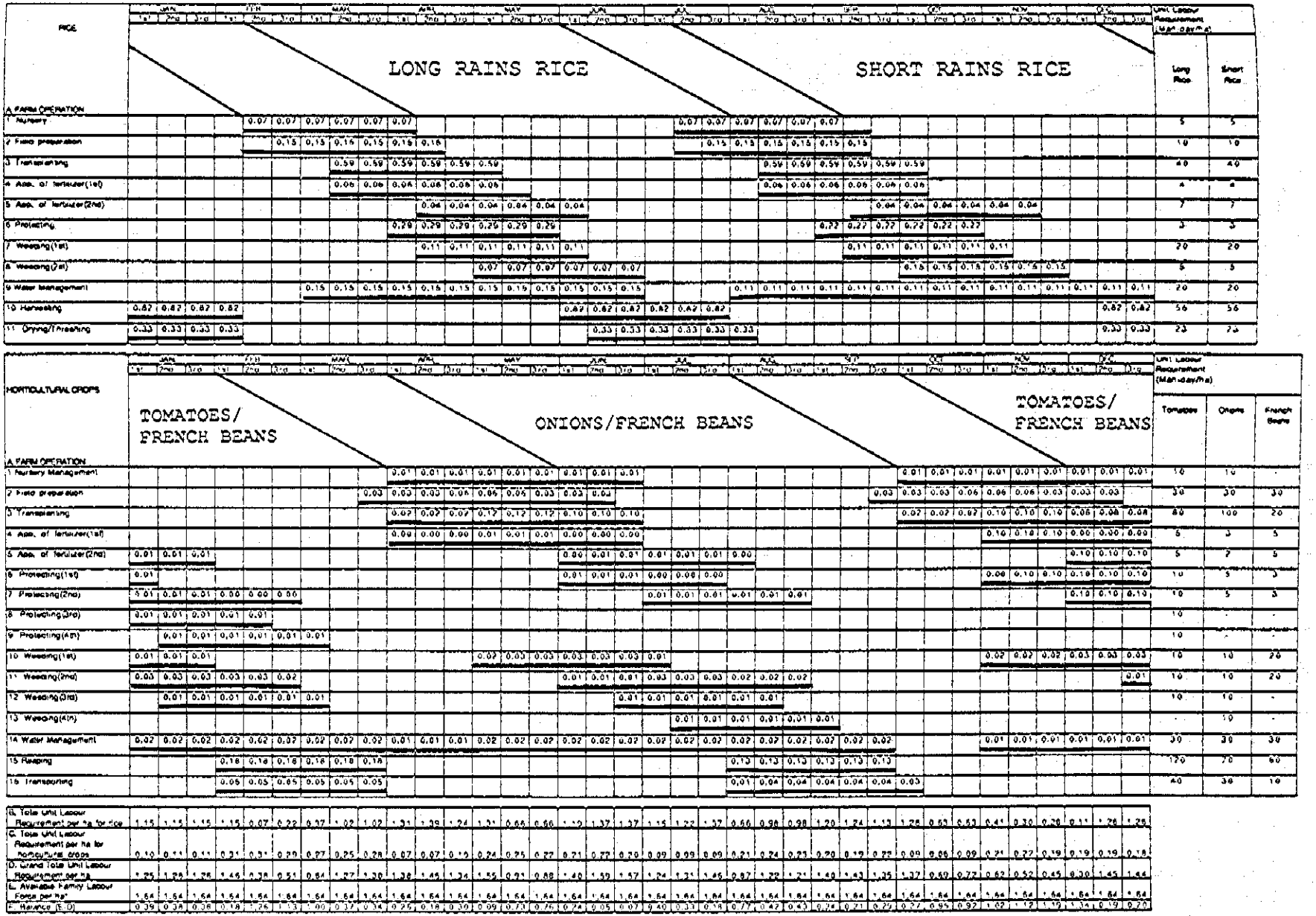


Fig. VII-20 DECLINE IN UNIT YIELD OF PADDY



Remarks:
Total available labour is 10,938 (See Table VII-22)
Total cultivated area is 6,660 ha.

Fig. VII-21 LABOUR BALANCE STUDY

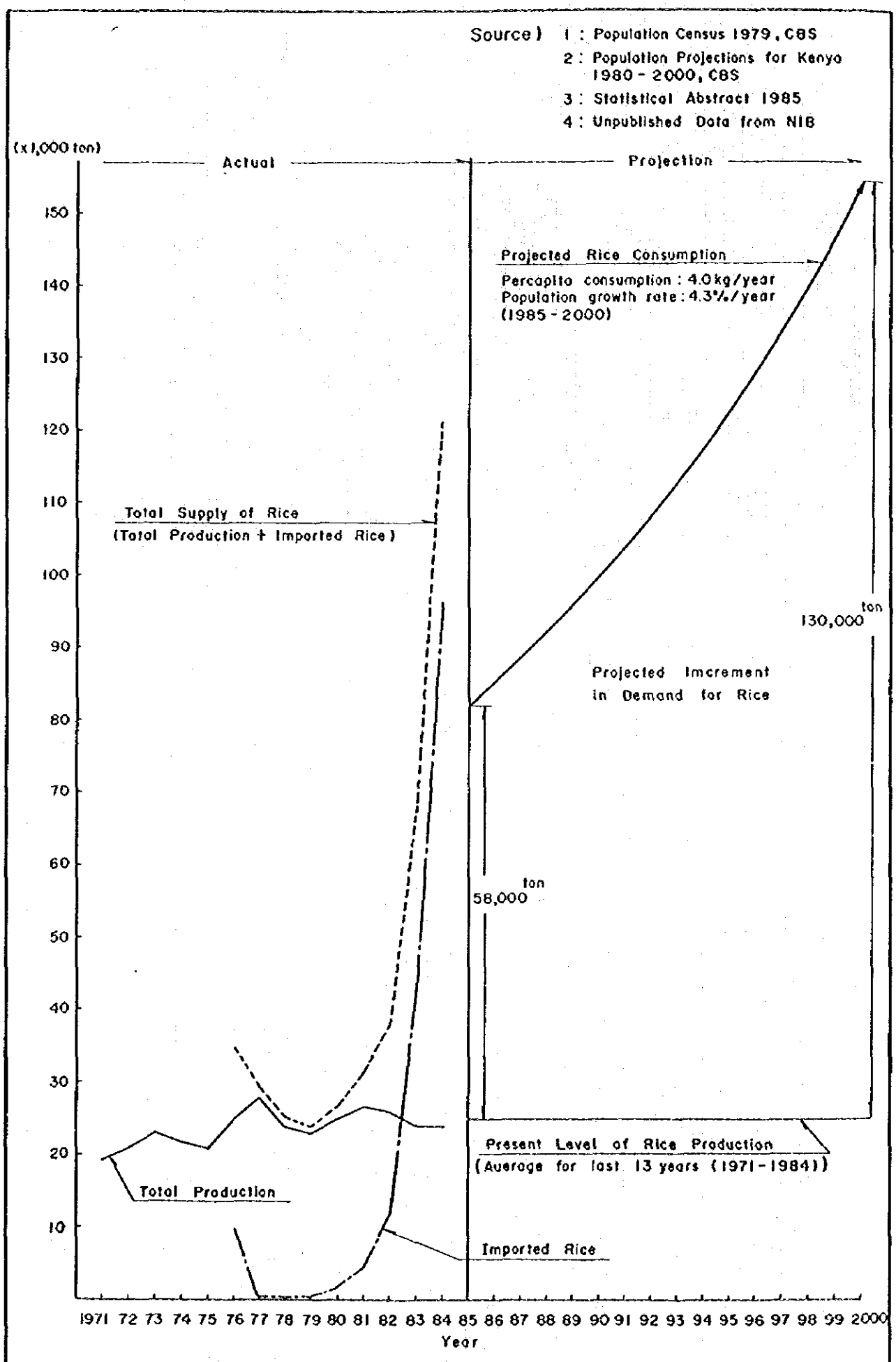
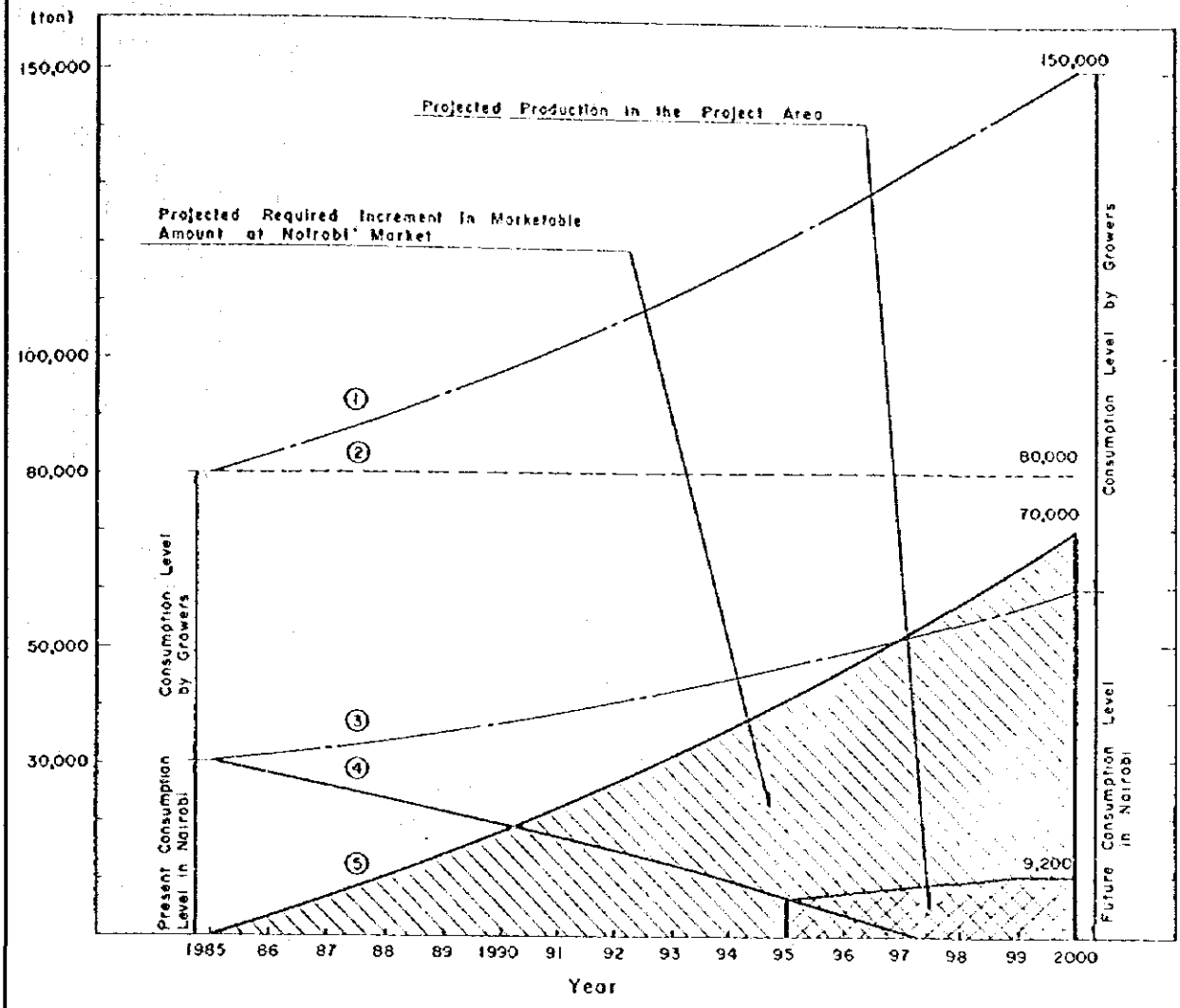


Fig. VII-22 DEMAND AND SUPPLY OF RICE



Note)

① Projected Demand in Kenya
per capita consumption : 3.9 kg/year ∠1, ∠3
population growth rate : 4.3 % /year ∠4

② Present Production Level in Kenya ∠3

③ Projected Demand in Nairobi
per capita consumption : 24.9 kg/year ∠2
population growth rate : 4.7 % /year ∠4

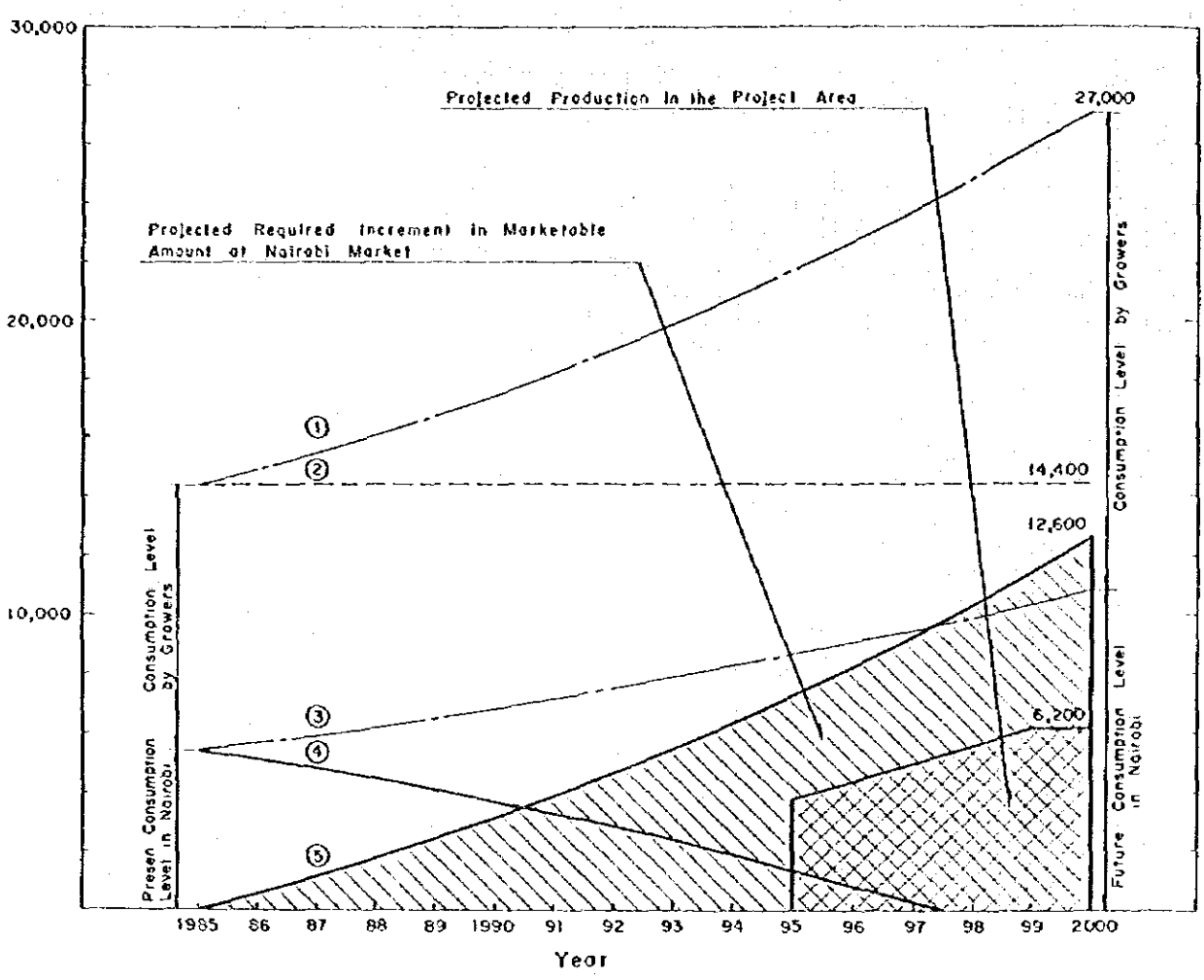
④ Projected Marketable Amount in Nairobi under Present Production Level
This amount is the balance between ② and projected consumption level by growers.

⑤ Projected Required Increment in Marketable Amount at Nairobi Market is the balance between ③ and ④.

Source)

∠1: Unpublished Data from MOA
∠2: Unpublished Data from HCDA
∠3: Production Yearbook 1985, FAO
∠4: Population Projections for Kenya 1980 - 2000, CBS

Fig.VII-23 DEMAND AND SUPPLY OF TOMATO



Note)

① Projected Demand in Kenya
per capita consumption : 0.7 kg / year ∠1, ∠3
population growth rate : 4.3 % / year ∠4

② Present Production Level in Kenya ∠3

③ Projected Demand in Nairobi
per capita consumption : 4.5 kg / year ∠2
population growth rate : 4.7 % / year ∠4

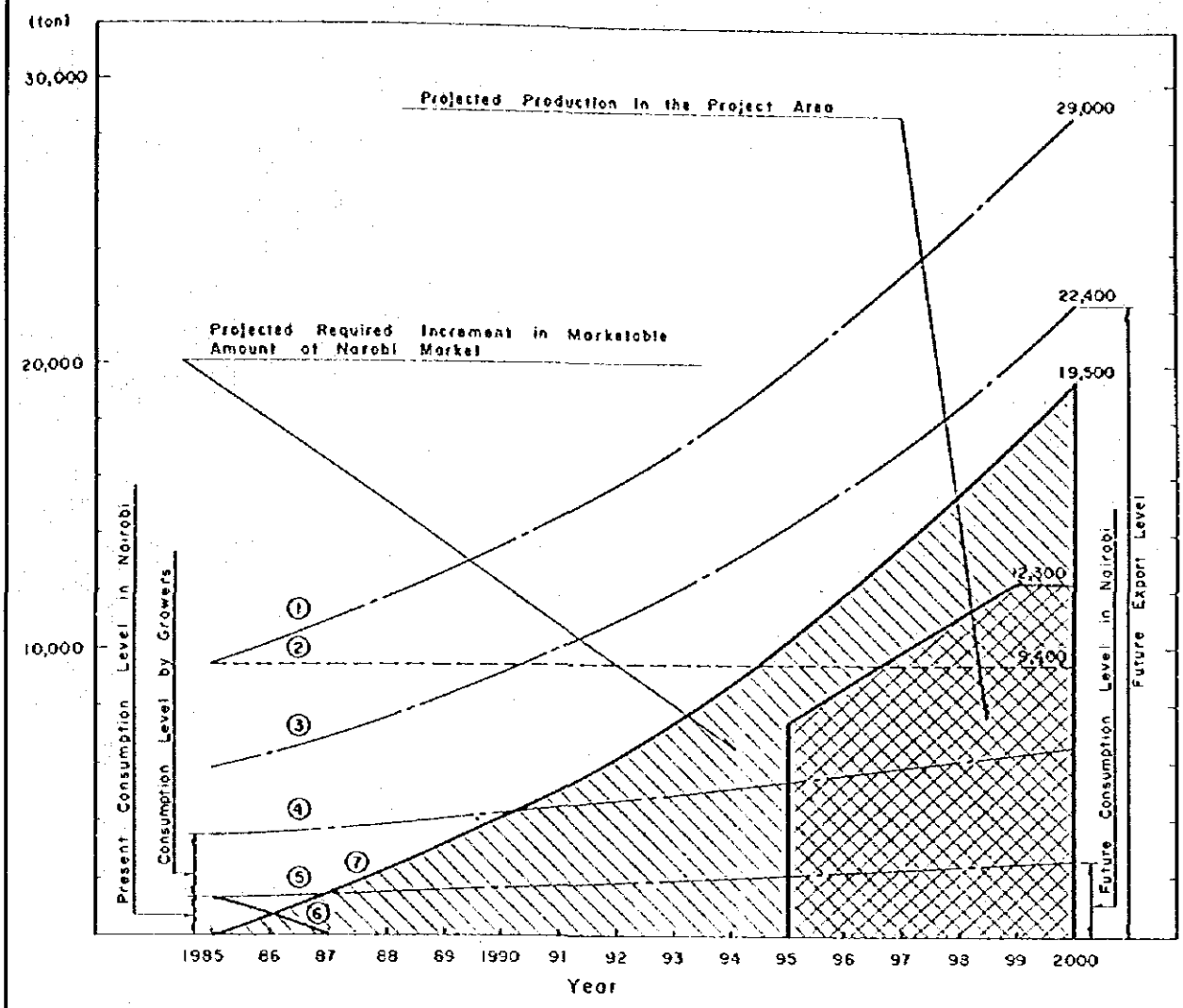
④ Projected Marketable Amount in Nairobi under Present Production Level
This amount is the balance between ② and projected consumption level by growers.

⑤ Projected Required Increment in Marketable Amount at Nairobi Market is the balance between ③ and ④.

Source)

∠1: Unpublished Data from MOA
∠2: Unpublished Data from HCDA
∠3: Production Yearbook 1985, FAO
∠4: Population Projections for Kenya 1980 - 2000, CBS

Fig.VII-24 DEMAND AND SUPPLY OF ONION



Note)

① Projected Total Demand including Export
② Present Production Level in Kenya ∠1
③ Projected Export Amount (Annual increase rate : 9.3%) ∠2
④ Projected Consumption in Kenya
per capita consumption : 0.17 kg / year ∠2
population growth rate : 4.3 % / year ∠3
⑤ *Projected Demand in Nairobi*
per capita consumption : 1.09 kg / year ∠2
population growth rate : 4.7 % / year ∠3
⑥ Projected Marketable Amount in Nairobi under Present Production Level
This amount is the balance between projected marketable amount in Kenya (②-③) and projected consumption level by growers (④-⑤).
⑦ Projected Required Increment in Marketable Amount at Nairobi Market is the balance between ⑤ and ⑥ .

Source)

∠1: Unpublished Data from MOA
∠2: Unpublished Data from HCDA
∠3: Population Projections for Kenya 1980 - 2000, CBS

Fig. VII-25 DEMAND AND SUPPLY OF FRENCH BEAN

ANNEX - VIII

WATER MANAGEMENT

ANNEX - VIII

WATER MANAGEMENT

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1. PRESENT WATER MANAGEMENT IN MIS

1.1 Regulation

The national irrigation Schemes, covering 12,600 ha, are comprised mostly of NIB Schemes (9,500 ha) and various small Schemes (3,100 ha). NIB was established in 1966 based on "THE IRRGATION ACT (Cap.347), June 1966". NIB Schemes are basically operated in accordance with "The Irrigation (National Irrigation Schemes) Regulations".

The official regulation governing the water management in the NIB Schemes is "The Irrigation Regulations 1977". No other regulations has been issued so far. All NIB Schemes, located over the country in different places under different conditions, are operated under this unified regulation. Even no internal regulations and/or guidelines are in operation other than "The Irrigation Regulations 1977".

1.2 Organization Set-up for Water Management

The MIS farmers are called as "Tenants" under the present regulations. The farmers are granted the licences from NIB to stay within the MIS Scheme area and cultivate the irrigated paddy of 4 acres (1.6 ha), provided that they have to follow the instructions from the NIB management. Individual farmer is not allowed to cultivate, by his own idea, the allocated paddy fields. Water management is therefore made by the MIS staff, not the farmers.

MIS has 320 staff in total, comprising 20 senior staff, 150 intermediate and 150 subordinates, out of which the staff for water management is limited to only 42 as of 1987 as shown in Fig. VIII-1.

In the MIS headquarters, the Department of Works is responsible for the allocation and distribution of water and maintenance of irrigation facilities.

The MIS is divided into five (5) sections, each of which is self-contained with its staff responsible for water management. Each section has an Irrigation Officer in charge assisted by a Head Field Assistant, 5-7 Field Assistants, a Head water guard, 7-8 Water guards and other intermediate and subordinates. The liaison with the tenant farmers is maintained via the head cultivator who represents the farmers.

The irrigation officer is a senior staff under the Production Department and is responsible for preparation of cropping schedule in his section. He asks the Scheme Manager to allocate the irrigation water based on his cropping schedule. The Scheme Manager informs his decision to the weir inspector through the Department of Works.

The weir inspector prepares, in accordance with the directive from the Scheme Manager, the irrigation schedule on the basis of his experiences and makes gate operations at the headworks by himself accordingly and gives the necessary instructions to the head water guard for operations of all the gates in each section.

The head water guard is responsible for the gate operations in his section. No one else can open the gates along the main feeder canal. The water guard is allocated his respective irrigation units in charge and responsible for application of irrigation water to the fields.

1.3 Present Condition of Irrigation Water Measurement

There are installed many measuring devices in whole area of the MIS Scheme. Generally speaking however those devices are not effectively utilized at present. For example, in Thiba part existing measurement devices are only 13 nos. which are now being used. The locations of the devices are shown in Fig. VIII-2.

Thiba irrigation system consists of a main canal and four branch canals. The intake discharge for branch canal-I is measured by the measurement device provided at beginning point of the canal. On the other hand, those for two other branch canal-II, -III are not utilized even though each one parshall flume is equipped to the respective canal. As for branch canal -IV, there is a measuring device. However, discharges of irrigation water and re-use water drained out from the paddy field in M9-M14, H18 and H19, are not distinguished each other because of only one measurement device. In addition, the discharge of re-use water flowing into irrigation canals at some points as shown also in Fig. VIII-2 can not be measured at all due to without devices.

1.4 Maintenance for Irrigation Facilities

MIS management is concentrated on the operation works and rice production, and the maintenance works for irrigation and drainage facilities are not at present taken care. The maintenance works for irrigation and drainage facilities are composed of repairing, desilting and removal of weeds. The removal of weed on feeder canals and levee of paddy field is carried out periodically by farmers. The desilting and removal of weeds on main and branch irrigation canals are conducted intermittently. However, the other maintenance works for irrigation canals are not a little performed. The drainage canals are not maintained at all.

The following table shows the total annual cost of MIS and the percentage of each operation and maintenance cost, such as staff salary, maintenance cost cost of buildings and facilities, fuel cost, maintenance

cost of plants, machinery, vehicles, tractors and other equipment to the total costs. The details are given in Table VIII-1.

(Unit: %)

Year	Total Expenditure (x103 KShs.)	Staff Cost	Maintenance of Building	Fuel	Plant and Machine	Maintenance 26 Vehicles	Tractor and Equipment	Total (1-6)	Others
		1	2	3	4	5	6	7	8
1976/77	10,939	35	5	8	3	3	4	58	42
1977/78	10,398	42	17	10	2	3	6	80	20
1978/79	10,413	45	8	9	4	3	8	77	23
1979/80	13,223	38	14	12	3	4	8	79	21
1980/81	16,997	36	10	13	4	5	8	76	24
1981/82	20,517	34	8	6	5	4	9	66	34
1982/83	15,111	35	6	18	4	3	8	74	26
1983/84	15,145	41	7	16	7	6	8	85	15
1984/85	19,884	34	4	18	3	5	23	87	13
1985/86	27,256	31	7	18	-	5	28	89	11
Average		37.1	8.6	12.8	3.9	4.1	11.0	77.1	22.9

The annual cost of MIS tends to be increased every two or three years and the percentages of each item to annual cost have not much variation except the item of tractor and equipment in 1984/85 and 1985/86. Judging from above table, MIS is straitened by the shortage of maintenance cost and compelled the poor maintenance works especially for irrigation and drainage facilities within the limited budget.

This tendency is shown in the condition of the maintenance equipment possessed by MIS. The inventory survey results of the existing maintenance equipment and vehicles are presented below:

Equipment	Purchase Year	Conditions
T3. Excavator	1968	Not in order
MF. Excavator	1979	Not in order
Mustang Excavator	1979	Not in order
Broyt Excavator	1971	In order
Bulldozer D6	1964	Not in order
MF. Roller	-	In order
Motor Grader	1980	In order
MF. Shovel	1979	In order
Concrete Mixer	1970	Not in order
Compressor	-	In order
Vehicles		
KVF 123	1978	In order
KVF 124	1978	Not in order
KVF 498	1978	Not in order
KRZ 480	1978	In order
KJT 945	1981	Not in order
Land rover	1979	In order

The possessed maintenance equipment and vehicles of 50% are out of order and it can be said the motive power for the maintenance is extremely low.

As for the communication system, one set of direct telephone is installed in MIS headquarters and five sets of the extension telephones in section offices. But extension telephones do not work at present.

1.5 Intention Survey on On-farm Water Management

To grasp the general intention of the tenant farmers and water guards, JICA team conducted a survey on 5 farmers as the water user and 5 water guards as the water supplier per reception center at random by means of questionnaire method.

By this survey result, various useful suggestions in formulating future plan on water management system are obtained. The major findings are summarized as below:

(1) Problems on on-farm water management

At present, it is difficult to solve the problems sometimes caused in the actual water management in units. The major problems are as follows:

- Unequal water supply due to the following:
  - ◊ Less communication among farmers of irrigation water supply to each farmer's field lots of its time and quantity.
  - ◊ Intentional unallowable water taking by some less conciliatory farmers.

- Less maintenance of on-farm facilities due to the following:
  - ◊ Less understanding by farmers of the maintenance works especially about scope of the works or objective facilities to be made by farmers.
  - ◊ Unsystematic maintenance works.

(2) Present countermeasures

In case such troubles occur, the following actions are taken at present:

- Discussions are made between the farmers concerned. In this case, the means of settling the trouble cannot be found sometimes.

- Farmers in difficulties complain of the trouble to water guard concerned. In this case also, the troubles are sometimes not settled despite of instructions made by the water guard.

The details of questions and answers are compiled in DATA BOOK.

As mentioned above, it is considered that the present problems about on-farm water management are caused due to lack of the effective on-farm water management rules or regulations.

1.6 Issue on Water Management

On the basis of the present conditions on water management, the following points should be considered for the improvement of water management of MIS.

(1) It is a major precondition for the introduction of double cropping of rice to keep the cropping programme severely and to make the condition that the irrigation schedule should not absolutely have an effect upon the cropping programme. Therefore, it is indispensable to establish the centralized water control system.

(2) In addition, in order to distribute the irrigation water fairly and adequately and produce the equal benefit to all farmers, the establishment of internal rules is necessary and the following major improvements on the water management should be performed.

a) The education and supervision of farmers to obey the cropping programme, open and close the field inlet and outlet not to over irrigate.

b) The installation and effective utilization of staff gauges provided at offtakes and supervision of check board in main feeder for the exact distribution of water to each unit.

c) The installation and effective use of discharge measurement facilities to control the water to be delivered from main canal to branch canals.

(3) The operation and maintenance equipment should be increased in both number and quality to have a proper scale of motive power.

(4) All irrigation personnels should be trained relating the new water control system.

2. PROPOSED WATER MANAGEMENT SYSTEM

2.1 Objectives

The irrigation project is generally planned on the basis of the field water requirement which is derived deducting the effective rainfall in the field from the crop water requirement assessed based on the cropping pattern.

After implementation of the project, however, actual water supply is made through irrigation facilities so as to meet the actual water requirement in the field and th effective rainfall is likely to be neglected. It means that irrigation water becomes short by the amount of irrigation water corresponding to th design effective rainfall, resulting in water shortage in downstream areas.

Rainfall in the field should therefore be monitored for its effective use and moreover timely information on rainfall be utilized for gate operations of intake and turnout structures. Water management system will have to be introduced for this purpose. In addition to the above, the proposed water management system will have the following objectives:

(1) To distribute the required irrigation water to each field properly and timely,

(2) To utilize the rainfall effectively and save the irrigation water (in drought years),

(3) To maintain the irrigation facilities properly and prevent the disaster on these,

(4) To save the operation and maintenance costs, and

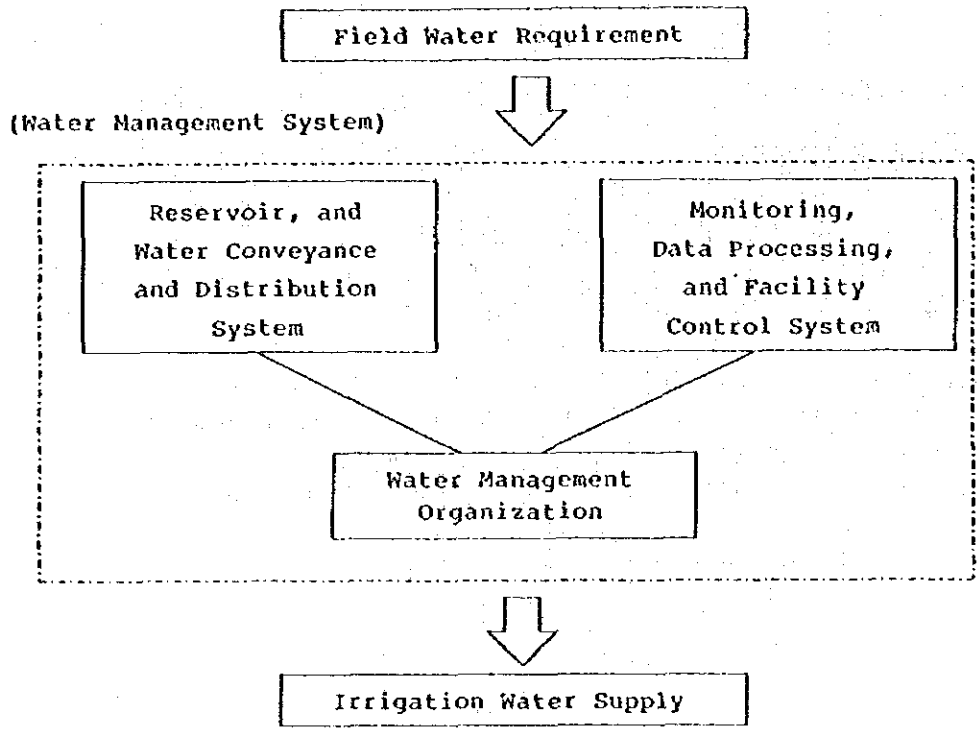
(5) To collect data on rainfall, river discharge, etc. for further improvement of water management.

2.2 Basic Concept of Water Management System

To achieve the above objectives, the water management system was planned on the following basic concept:

(1) Water management system

Prior to planning, the substance of the water management system was clarified as follows:



(2) Basic concept

The basic concept on planning of this water management system is to apply the practical and simple method as follows:

- The system is simply structured and easily known of any part by any body,
- The operation is easy and any high technique is not required,
- The maintenance and repair are possible to be executed easily and quickly,
- The system is equipped with a substitutional system, and
- Operation and maintenance cost is low.

Based on the above, the proposed water management system was formulated putting stress on introducing the telemeter system. It means that the facilities control would be made by manual operation at the sites.

2.3 Proposed Water Management

2.3.1 Water control plan

(1) Water supply program

(a) Field water requirement

The field water requirement at a turnout to a unit is initially computed as crop water requirement for the unit before considering expected effective rainfall.

After rainfall, new field water requirement would be computed including the effective rainfall.

(b) Interval of new water requirement

7-day is adopted as interval of new water requirement including the effective rainfall in last week. The new requirement would be applied on every Monday taking into account the weekly living cycles of people.

(2) Water control operation

In accordance with the weekly water supply program, the irrigation water would also be controlled weekly.

(a) Dam

The outlet gate of the dam would be adjusted on every Monday morning based on the computed required discharge from the reservoir.

On the other hand, the gate would be closed remaining only river maintenance flow and water right discharge when it rains in the field and the accumulated rainfall depth in the week reaches a certain amount.

Such "Limit rainfall" would be determined for each day in the week depending on remaining days till the weekend. For example, the amount would be calculated based on the effective rainfall which is equivalent to half of the field water requirement for remaining days till the weekend.

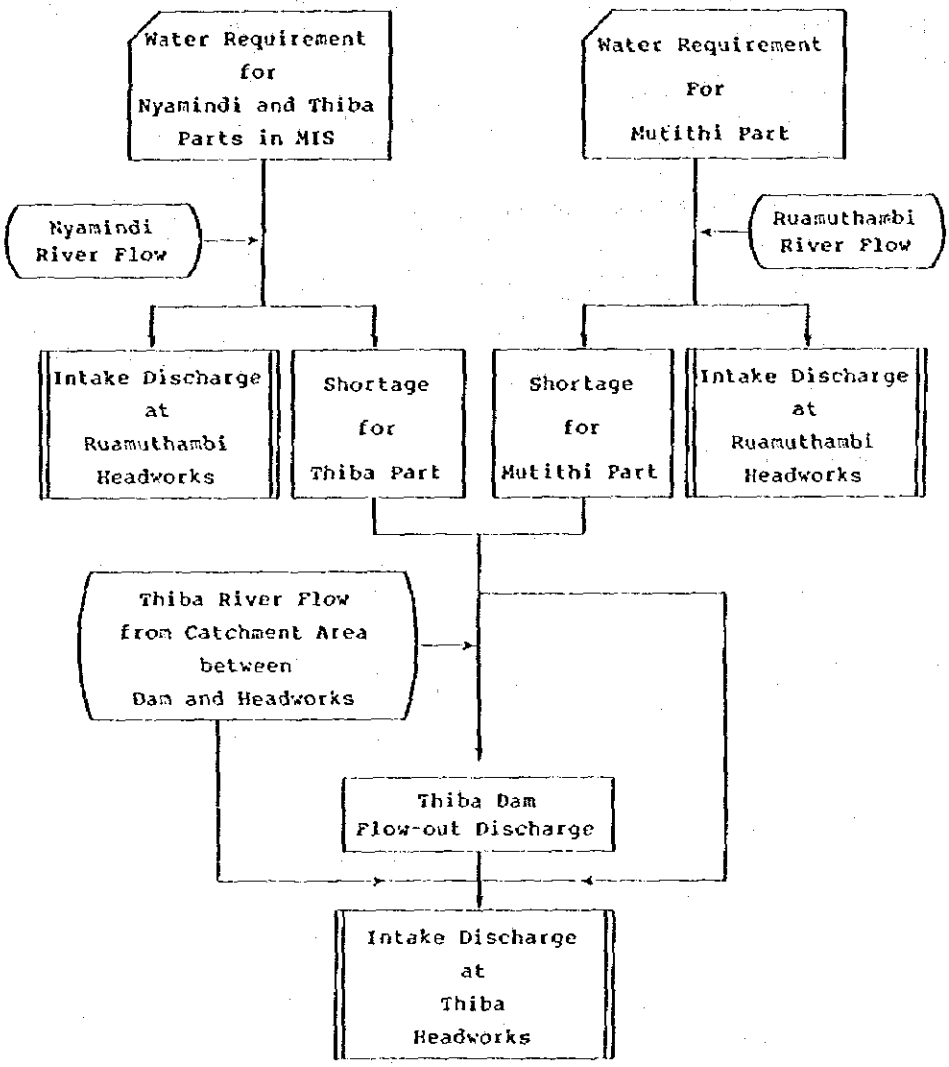
(b) Headworks

The intake gate at headworks would also be controlled on every Monday. The time lag between Thiba dam to Thiba headworks was roughly calculated to be about ten (10) hours, and it is enough

small comparing with the operation cycle of one week. Therefore, the time lag could be neglected.

The flow chart for intake discharge decision at the three (3) headworks is shown as below:

Flow Chart
For
Intake Discharge Decision at Headworks



(c) Major diversion facilities

The following are the major diversion facilities.

- Division works at the end of Nyamindi head race
- Division works at the end of Link canal-II
- Turnouts and checks at diversion points from main or branch canals to branch canals

The gates at the above diversion points would also be operated on every Monday neglecting time lag between headworks to the diversion points. The maximum time lag was roughly calculated to be 12 hours from Nyamindi headworks to E.P. of Thiba main canal.

When the outflow for irrigation from the dam is stopped after rainfall, the gate operation at the above diversion points would be made based on the discharge determined only for natural river flow.

(d) Offtakes to unit and offtakes in unit

Offtakes to supply water directly to units would also be operated based on same consideration as the major diversion facilities. Offtakes in units are also same as the above.

2.3.2 Irrigation facilities plan

Following the water control plan mentioned above, the irrigation facilities of the project was planned as follows:

(1) Dam

(a) Discharge control facilities

- Discharge control from the reservoir is made with jet flow gates equipped at the end of discharge conduit.
- Gate operation would be made at the gate side by dial control through oil pressure system.
- Discharge measurement be made with a supersonic flowmeter installed on the outside of the conduit and an automatic recorder is to be equipped.
- A gate operation house would be built.

(2) Water level recorder of reservoir

- Water level in the reservoir would be observed with an automatic water level recorder.

(3) Headworks (Nyamindi, Thiba, Ruamuthambi)

(a) Intake discharge control facilities

- Intake discharge control is made with slide gates.

- Gate operation would be made at the gate side manually by handle.

- Discharge measurement would be made with a cipolletti weir installed at just downstream of intake gates.

- An automatic water level recorder would be installed to measure the overflow depth at the weir.

(b) Water level recorder of river

- Water level of the river would be observed with an automatic water level recorder.

(c) Screen at intake gate

- Screen would be equipped in front of the intake gate to prevent the trash flowing into a canal.

(4) Division works (Nyamindi, Thiba)

- Discharge control be made with slide gates.

- Gate operation be made at gate side manually by handle.

- Measuring devices are combination of a cipolletti weir and an automatic water level recorder.

(5) Turnout (to branch canal)

- Discharge control and measurement

◊ Parent canal (Main or branch canal)
Combination of a check (slide gate), a cipolletti weir and an automatic water level recorder.

◊ Branch canal
Combination of a turnout (single orifice slide gate type), a cipolletti weir and an automatic water level recorder.

- All the gate operation be made at gate side manually by handle.

(6) Offtake (to unit)

- Discharge control and measurement would be made with double orifice type slide gates.

- Gate operation be manual.

(7) Offtake (Main feeder to feeder)

- Discharge control would be made by a combination of check gate in main feeder canal and offtake gate to feeder canal.

(8) Field inlet (Feeder to field lot)

- Discharge control be made by a combination of check plank in feeder canal and field inlet of field lot.

In addition to the above diversion facilities of (3) to (7), the spillway cum wasteway would be constructed at the middle part of long irrigation canals to prevent overflow from canal bank due to misoperation of irrigation facilities. For the same purpose, a check with overflow section at both sides of center gate would be put at each end of main and branch irrigation canals.

2.3.3 Monitoring, data processing and communication plan

To utilize the above irrigation facilities effectively according to the water control plan aforementioned, the monitoring, data processing and communication systems were planned as below.

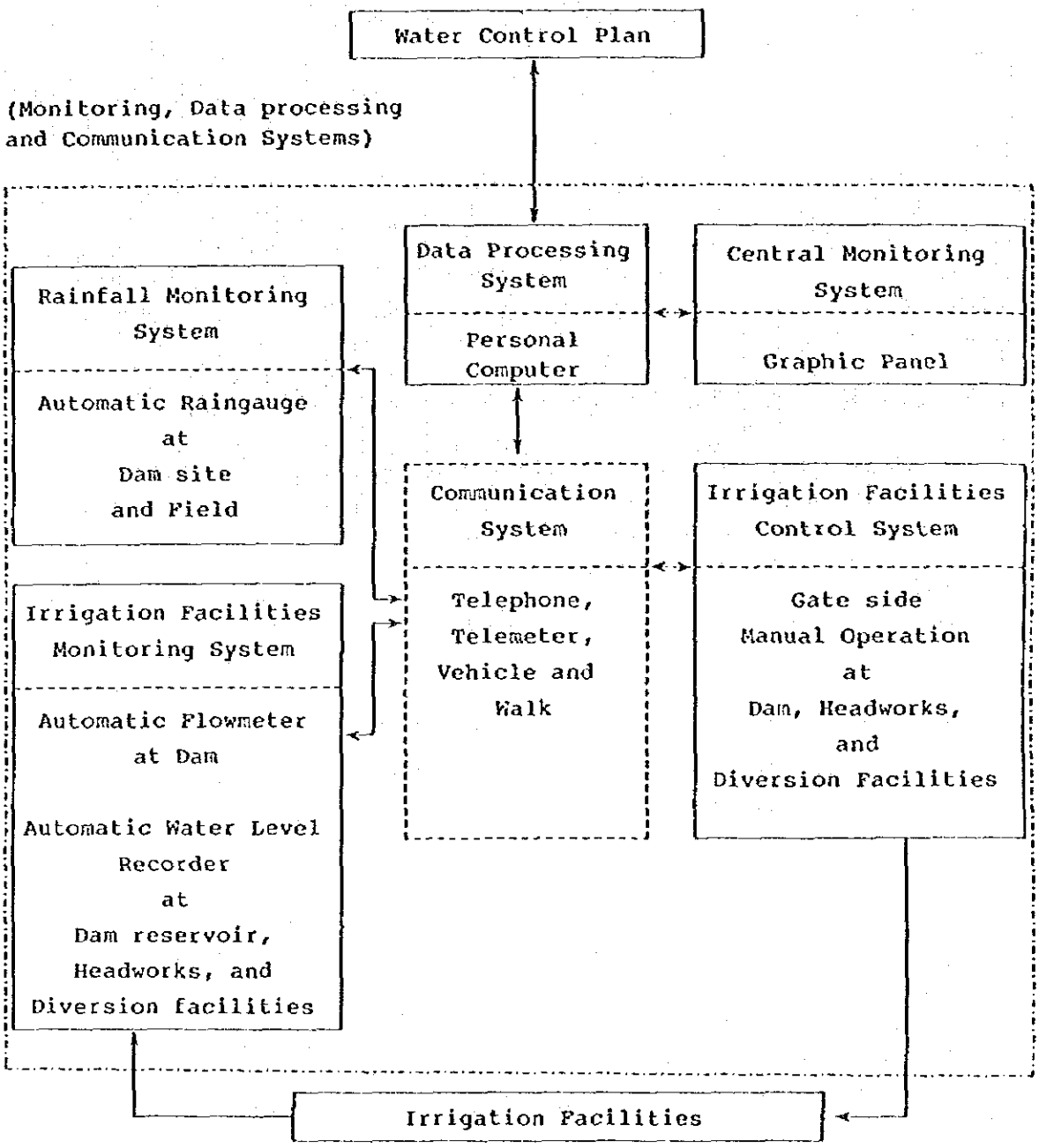
(1) Systems plan

The systems were planned based on the following considerations:

- Structure of the systems be simple.
- Facilities used in the systems also be simple.
  - ◊ Easy and reliable operation
  - ◊ Easy and quick maintenance and repair.
- Substitute system be considered.

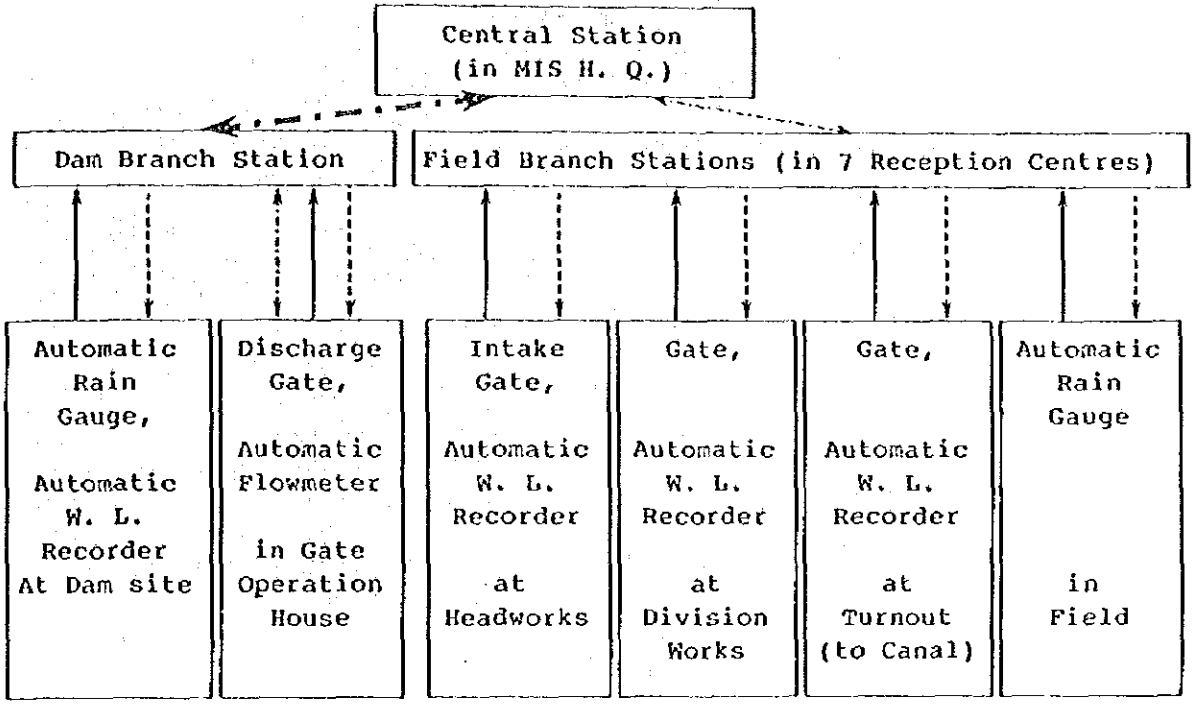
The framework of the systems is shown as below:

Framework of Monitoring, Data Processing and Communication Systems



(a) General structure of systems

To control the systems at a central station, the following structure was planned:



(Note) : Telephone (Public service line)

: Telephone (Private line)

: Telemeter

: Movement of staff by car or on foot

(b) Systems level

(i) Central station

- All the monitoring and facilities control would be made through telephone by central station staff.
- Data processing would be made with a personal computer.
- Data filing would be made by print out with a printer connected to the computer and by the magnetic floppy disc.

(ii) Branch station

- All the monitoring be made by telemeter system.
- All the facilities control be made by staff in charge moving to the site by car or on foot.
- No data processing be made.
- All the data recording be made with automatic recorders.

(iii) Facilities site

- All the facilities would be controlled manually by staff coming from Branch station.

(c) Software development for data processing

In software development for data processing, the following are to be considered:

- The software would have a clear structure and a logic so as to be easily modified and expanded coping with future change of cropping pattern, irrigation schedule and water management schedule.
- The software manual would be clearly compiled in detail to transfer the job smoothly to newly appointed staff when the old staff will change.
- For the above, the software development would be made by the method based on the software engineering. As an example of the method, "Improved Programing Technology (IPT)" developed by IBM is recommended.

The following are necessary software for the water management system.

- Crop water requirement
- Effective rainfall
- Field water requirement to unit
- Diversion water requirement at major diversion points
- Intake water requirement at headworks
- Reservoir water flowout requirement at dam
- Data record and filing

(d) Substitutional systems

The substitutional systems were planned against systems trouble and electric power suspension.

(i) Data processing system

- A portable computer by battery would be provided.
- Software would be of small scale by which required figures are roughly output.

(ii) Communication system

In case of telephone trouble, the staff in charge would move by car. It will take less than one hour to go to the dam branch station, the farthest, from the central station.

(iii) Monitoring system

- At flowmeter trouble of dam, the rating curve between reservoir water level and discharge would be applied.
- At automatic water level recorder trouble, the staff gauge would be used.
- At automatic rain gauge trouble, the ordinary rain gauge would be used.

(2) Systems facilities

According to the above systems plan, the following systems facilities were preliminary planned to be provided.

(a) Data processing facilities

(i) Personal computer 1 unit

- Central processing unit (CPU)
  - ◊ 16 bits
  - ◊ Read only memory (ROM) 256 K bites
  - ◊ Random access memory (RAM) 128 K bites
- Key board
- Cathode rays tube (CRT) display
- Printer
- Floppy disk drive (double)
- Console

(ii) Portable computer 1 unit

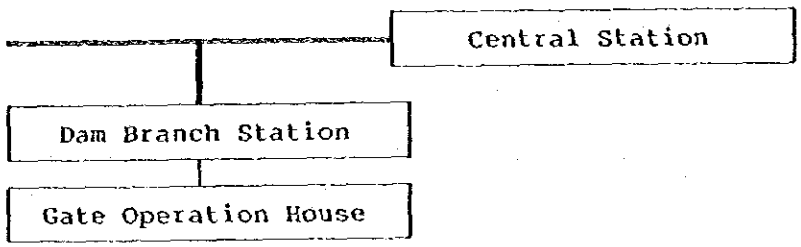
- Battery use type
- RAM 64 K bites
- Printer
- Mini floppy disc

These computers would be used not only for data processing on water management but also for administration works in the office.

(b) Communication system

The telephone system would be adopted as follows:

(i) Central station - Dam branch station

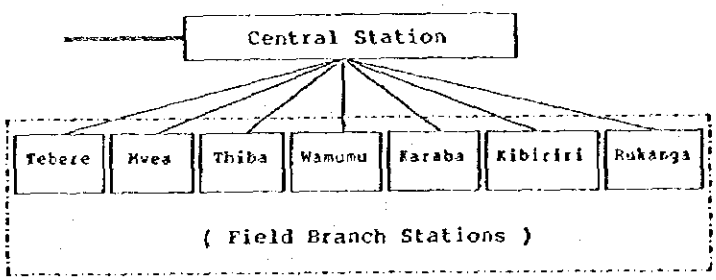


Public service line 1 circuit

(ii) Dam branch station - Gate operation house

Private line 1 circuit

(iii) Central station - Field branch stations



- Telephone swith board 1 unit
- Private line 2 circuits

Telephone switch board 1 unit

Private line 2 circuits

(c) Monitoring facilities

The telemeter system would be adopted as follows:

(i) Dam branch station

- Automatic rainfall recorder 1 unit
  (data from dam site)
- Automatic water level recorder 1 unit
  (data from dam reservoir)
- Automatic discharge recorder 1 unit
  (data from gate operation house)

(ii) Tebere branch station

- Automatic water level recorder 8 units
  (data from the following)
  - Nyamindi river at headworks
  - Nyamindi headrace at headworks
  - New Nyamindi main canal B.P. at division works
  - Link canal-I B.P. at division works
  - Nyamindi branch canal-I B.P.
  - Nyamindi branch canal-II B.P.
  - Nyamindi branch canal-II at turnout to branch canal-III
  - Nyamindi branch canal-III B.P.
- Automatic rainfall recorder 1 unit
  (data from Tebere section)

(iii) Mwea branch station

- Automatic water level recorder 6 units
  (data from the following)
  - Thiba river at headworks
  - Link canal-II B.P. at headworks
  - Link canal-II at turnout to Thiba branch canal-I
  - Thiba branch canal-I B.P.
  - Thiba main canal B.P. at division works
  - Link canal-III B.P. at division works
- Automatic rainfall recorder 1 unit
  (data from Mwea section)

(iv) Thiba branch station

- Automatic water level recorder 4 units
  (data from the following)
  - Thiba main canal at turnout to branch canal-II
  - Thiba branch canal-II B.P.
  - Thiba branch canal-III B.P.
  - Thiba branch canal-IV B.P.

- Automatic rainfall recorder 1 unit
  (data from Thiba section)

(v) Wamumu branch station

- Automatic rainfall recorder 1 unit
  (data from Wamumu section)

(vi) Karaba branch station

- Automatic rainfall recorder 1 unit
  (data from Karaba section)

(vii) Kibiriri branch station

- Automatic rainfall recorder 7 units
  (data from the following)
  - Mutithi main canal at turnouts to branch canals-I and -II
  - Mutithi branch canal-I B.P.
  - Mutithi branch canal-II B.P.
  - Mutithi branch canal-III B.P.
  - Mutithi branch canal-IV B.P.
  - Mutithi branch canal-IV at turnout to branch canal-V
  - Mutithi branch canal-V B.P.

- Automatic rainfall recorder 1 unit
  (data from Kibiriri section)

(viii) Rukanga branch station

- Automatic water level recorder 2 units
  (data from the following)
  - Ruamuthambi river at headworks
  - Ruamuthambi headrace B.P. at headworks
- Automatic rainfall recorder 1 unit
  (data from Rukanga section)

(d) Control monitoring facilities

A graphic panel would be installed to monitor the water control condition at the Central station.

- Graphic model of irrigation system is shown on the panel covering the following sites.
  - Dam
  - Headworks (3 places)
    Nyamindi, Thiba, Ruamuthambi
  - Division works (2 places)
    Nyamindi, Thiba
  - Major diversion points (8 places)

Nyamindi parts	2
Thiba parts	3
Mutithi parts	3

  - Rain gauge stations (9 places)

Dam site	1
Field	8

- Observed figures are to be input manually with a console type key board.
- Input figures be shown in the electric lighting display beside each facilities point on the graphic model.

2.3.4 Water management rules

In order to operate and maintain the water management facilities aftermentioned, the water management rules would be prepared as follows:

(1) Irrigation facilities operation rule

In accordance with the above-mentioned water control plan, the irrigaton facilities operation rule would be prepared, in which the following are to be clarified:

- Flow of decision and instruction on the facilities operation schedule
- Operation time of each facility
- Operation method of each facility
- Operation staff in charge
- Flow of report and explanation on the actual operation condition and result
- Operation method at the abnormal time

(2) Data systems facilities operation rule

Following the above-mentioned data systems plan, the data systems operation rule would be prepared, in which the following are to be clarified:

- Operation method of each facility
- Operation staff in charge
- Check method of careless mistakes such as misinput of data, etc.
- Operation method at the facilities trouble

(3) Facilities maintenance rule

To maintain the both irrigation facilities and data facilities, the facilities maintenance rule would be prepared, in which the following are to be clarified:

- Maintenance work item
- Maintenance schedule

  For each maintenance item, the time schedule would be prepared such as daily, weekly, monthly, annually and specially, etc.

- Maintenance method of each facility
- Maintenance staff in charge
- Criteria on repairing works
- Procedure at the repair required
- Section bearing the repairing cost

Those water management rules are closely related each other and to be harmoniously unified in accordance with the water management plan. The water management plan will be modified as various factors such as proper interval of water control operation, obtainable ratio of effective rainfall to actual rainfall, possible irrigation efficiency, systematic operation method of all the facilities and necessary water management staff numbers,

etc. will gradually become clear in the course of actual irrigation practice on the Project operation stage. In order to clear those factors, it is inevitably required that various records to be collected through the monitoring and data processing systems would be accumulated over a middle or long period. As mentioned above, the water management rules also would occasionally be modified to correspond to the water management plan changed.

2.3.5 Organization

To operate and maintain all the water management facilities smoothly and to execute the water management rules effectively, the adequate organization would be established as mentioned below:

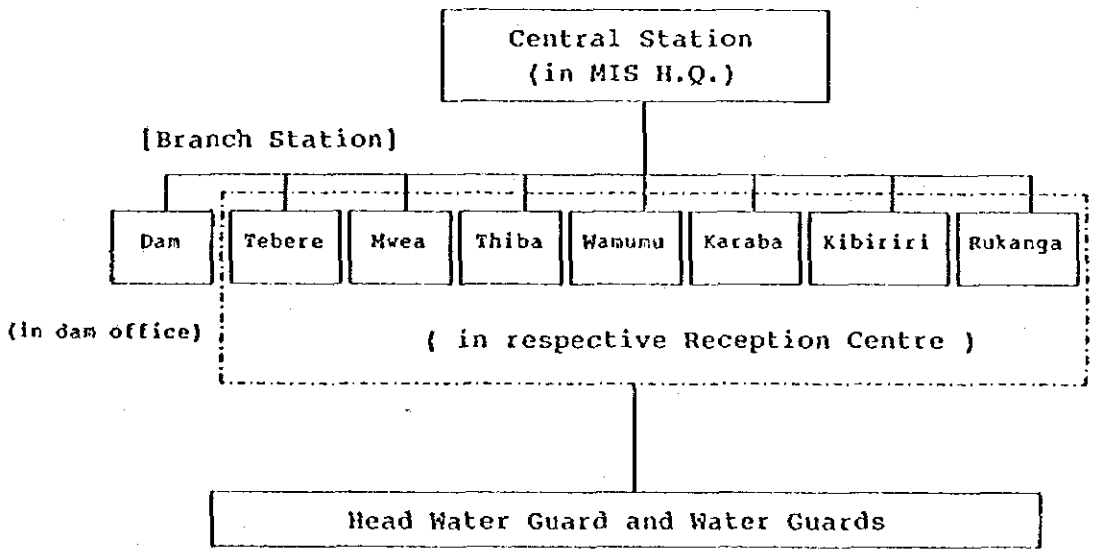
(1) Organization structure

(a) Basic considerations

- The new water management group would become an independent section under the proposed project O&M office.
- The present Weir Inspector would remove to the new water management section as a staff.
- The present Head Water Guard and Water Guard system would exist as it is, and work under the proposed field branch station.

(b) Organization structure of water management section

Water Management Section



(2) Project staff organization for water management

(a) Central station

	(persons)
Head of water management section	1
Deputy of water management section	1
Secretary	1
Monitoring staff	1
Data processing staff	2
Communication staff	1
Total	7

(b) Dam branch station

	(persons)
Head of dam sub-section	1
Reservoir control staff	1
Gate operator	1
Total	3

(c) Field branch station

Staff	Tebere	Mwea	Thiba	Wamumu	Karaba	Kibiriri	Rukanga	Total
Head of field sub-section	1	1	1	1	1	1	1	7
Headworks staff	1	1	-	-	-	-	1	3
Diversion points staff	1	1	1	-	-	1	-	4
Rain gauge staff	1	1	1	1	1	1	1	7
Total	4	4	3	2	2	3	3	21

(3) Farmers organization for water management

A water managing farmer would be elected among farmers group in a unit to manage and control the water supply in the unit under the guidance from the water guard. With this system, the water management in units would be executed on farmers own responsibility.

3. DAM RESERVOIR OPERATION

In this project plan, 1/5 drought year was set as a basic year. The reservoir operation would be executed basically according to the basic year with the required adjustment of operation schedule.

As an example, water balance calculations were done in 1/10 drought year and 1/10 flood year as shown in Table-VIII-2 and in Fig. VIII-3 to know the reservoir water fluctuation in case the required water is continuously taken till the water level decreasing to dead water level.

From the above, the following are to be considered:

(1) Drought year

The water supply control would be executed, periodically comparing reservoir water and expected water requirement till next rainy season, to minimize the damage of crops.

(2) Flood year

The water supply more than that determined by the original irrigation schedule would be possible after the peak period, in case the reservoir water is still enough for the expected water requirement till next rainy season, to make easier water management in the irrigation field.

REFERENCES

Ministry of Agriculture, Forestry and Fisheries, Japan, Technical Guide on Water Management Method (Dam, Headworks and Canal), 1982

Agricultural Land Development Public Corporation, Japan, Water Management Technology Study Committee Report, 1987

Japanese Society of Irrigation, Drainage and Reclamation Engineering (JSIDRE), Journal of JSIDRE Vol. 46 No. 9, 1978

Table VIII-1 Income and Expenditure Account of MIS(1976/77-1985/86)

Unit : KShs.1,000

		1976/77	1977/79	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
	INCOME:										
1.	Service charge						23,202	27,785	34,780	28,824	28,969
2.	Water	3,094	3,069	3,134	3,428	3,438	-	-	-	-	-
3.	Cultivation & hire charge	1,341	1,279	1,229	1,659	1,563	-	-	-	-	-
4.	Traders commission	1,704	1,469	1,378	1,382	1,520	-	-	-	-	-
5.	Transport	2,220	2,001	1,145	1,535	2,495	1,287	1,611	3,640	3,824	2,118
6.	Government grants	-	2,700	2,260	4,800	-	-	-	-	-	-
7.	Interest receivable	17	-	-	-	-	-	-	-	-	-
8.	Profit on sales of assets	32	-	27	26	-	23	4	-	-	-
9.	Sundry revenue/expenditure	161	223	(-235)	(-55)	(-556)	405	(-4,431)	3,819	5,867	(-1,515)
10.	Inter-scheme grants	2,170	(-343)	1,475	448	-	-	-	-	-	-
11.	Total Income	10,939	10,398	10,413	13,223	8,460	24,917	24,969	42,245	34,691	29,572
	EXPENDITURE:										
	Staff Cost	3,865	4,412	4,715	5,023	6,064	6,950	5,215	6,160	6,666	8,397
	Bursaries & Training	-	-	-	-	-	-	12	-	-	2
	Travelling	75	95	114	130	188	359	258	323	391	275
	Office expenditure insurance	256	247	320	441	773	779	491	501	1,085	854
	Public health	58	1	38	79	106	(-7)	58	199	60	90
	Building and facilities (Maintenance)	751	1,761	776	1,823	1,645	1,598	882	1,010	809	1,994
	Diesel, Petrol & oils	879	914	949	1,604	2,259	2,134	2,661	2,347	3,593	4,847
	Repairs & renewals, Plants & Machinery	296	253	362	489	694	1,040	576	1,078	661	-
	Motor vehicle	275	316	347	486	779	851	516	953	932	1,340
	Tractor & Equipment	463	616	783	1,018	1,413	1,779	1,132	1,193	4,465	7,843
	Interest on loans	3,474	1,044	428	667	1,507	2,553	1,203	142	121	-
	Bad and doubtful debts	-	-	28	-	-	-	400	-	-	-
	Auditors remuneration	17	37	27	37	37	(-19)	25	32	35	35
	Water rate remission	-	-	-	-	-	590	-	-	-	-
	Depreciation on fixed assets	519	702	989	1,426	1,532	1,910	1,596	1,207	1,066	1,579
	Total Expenditure	10,939	10,398	10,413	13,223	16,997	20,517	15,111	15,145	19,884	27,256
	Excess of Income/over	0	0	0	0	(-8,532)	4,400	(-9,858)	(-27,100)	14,807	2,316

Source: NIB ANNUAL REPORTS (1976/77 - 1983/84)

Table VIII-2 Thiba Dam Operation (1/6)

(1/5 Drought Year 1980)

Month	Day	(1) Discharge at Damsite without Dam (m^3/sec)	(2) Discharge at Damsite with Dam (m^3/sec)	(3)=(2)-(1)>0 Irri. Water Supplied from Dam (m^3/sec)	Reservoir Water Level (EL.m)
	1 - 10	1.89	1.89	0.00	1,380.0
Jan.	11 - 20	1.63	1.63	0.00	1,380.0
	21 - 31	1.78	1.78	0.00	1,380.0
	1 - 10	1.70	1.70	0.00	1,380.0
Feb.	11 - 20	1.26	1.26	0.00	1,380.0
	21 - 29	1.54	1.97	0.43	1,379.8
	1 - 10	2.26	1.87	0.00	1,380.0
Mar.	11 - 20	2.18	6.42	4.24	1,376.8
	21 - 31	2.08	7.18	5.10	1,371.3
	1 - 10	2.16	2.45	0.29	1,371.0
Apr.	11 - 20	2.27	1.00	0.00	1,372.1
	21 - 30	2.98	0.94	0.00	1,374.0
	1 - 10	2.97	0.48	0.00	1,376.0
May	11 - 20	5.74	1.40	0.00	1,380.0
	21 - 31	5.10	5.10	0.00	1,380.0
	1 - 10	3.94	3.94	0.00	1,380.0
Jun.	11 - 20	3.34	3.34	0.00	1,380.0
	21 - 30	2.87	2.87	0.00	1,380.0
	1 - 10	2.80	2.80	0.00	1,380.0
Jul.	11 - 20	2.48	2.48	0.00	1,380.0
	21 - 31	2.32	2.32	0.00	1,380.0
	1 - 10	2.94	2.94	0.00	1,380.0
Aug.	11 - 20	3.26	3.26	0.00	1,380.0
	21 - 31	3.20	3.20	0.00	1,380.0
	1 - 10	2.90	6.31	3.41	1,377.5
Sep.	11 - 20	2.58	7.29	4.71	1,373.0
	21 - 30	2.20	5.88	3.68	1,369.1
	1 - 10	1.83	1.83	0.00	1,369.1
Oct.	11 - 20	1.88	4.86	2.98	1,365.0
	21 - 31	2.70	0.48	0.00	1,368.0
	1 - 10	3.90	0.48	0.00	1,371.5
Nov.	11 - 20	5.40	0.48	0.00	1,375.8
	21 - 30	5.63	1.62	0.00	1,380.0
	1 - 10	3.87	3.87	0.00	1,380.0
Dec.	11 - 20	3.32	3.32	0.00	1,380.0
	21 - 31	3.38	3.38	0.00	1,380.0

Table VIII-2 Thiba Dam Operation (2/6)

(1/5 Drought Year 1980)

(Unit: MCM)

Month	Day	(1) Inflow to Reser-voir	(2) Released Water Requirement of Dam	(3) Outflow from Reser-voir	(4) Storage Water in Reservoir	(5)=(1)-(3)≥0 Increase of Storaged Water	(6)=(3)-(1)>0 Reservoir Water Use	(7) Excess Water from Spillway	(8) Shortage of Irri. Water
	1 - 10	1.63	0.00	1.63	18.00	0.00	0.00	1.22	0.00
Jan.	11 - 20	1.41	0.00	1.41	18.00	0.00	0.00	0.99	0.00
	21 - 31	1.69	0.00	1.69	18.00	0.00	0.00	1.24	0.00
	1 - 10	1.47	0.00	1.47	18.00	0.00	0.00	1.05	0.00
Feb.	11 - 20	1.09	0.00	1.09	18.00	0.00	0.00	0.67	0.00
	21 - 29	1.19	0.33	1.53	17.67	0.00	0.33	0.00	0.00
	1 - 10	1.95	0.00	1.62	18.00	0.33	0.00	1.21	0.00
Mar.	11 - 20	1.88	3.66	5.55	14.32	0.00	3.66	0.00	0.00
	21 - 31	1.98	4.84	6.82	9.50	0.00	4.84	0.00	0.00
	1 - 10	1.87	0.25	2.12	9.25	0.00	0.25	0.00	0.00
Apr.	11 - 20	1.96	0.00	0.86	10.35	1.10	0.00	0.00	0.00
	21 - 30	2.57	0.00	0.81	12.11	1.76	0.00	0.00	0.00
	1 - 10	2.57	0.00	0.41	14.27	2.15	0.00	0.00	0.00
May	11 - 20	4.96	0.00	1.22	18.00	3.74	0.00	0.79	0.00
	21 - 31	4.85	0.00	4.85	18.00	0.00	0.00	4.39	0.00
	1 - 10	3.40	0.00	3.40	18.00	0.00	0.00	2.99	0.00
Jun.	11 - 20	2.89	0.00	2.89	18.00	0.00	0.00	2.47	0.00
	21 - 30	2.48	0.00	2.48	18.00	0.00	0.00	2.06	0.00
	1 - 10	2.42	0.00	2.42	18.00	0.00	0.00	2.00	0.00
Jul.	11 - 20	2.14	0.00	2.14	18.00	0.00	0.00	1.73	0.00
	21 - 31	2.20	0.00	2.20	18.00	0.00	0.00	1.75	0.00
	1 - 10	2.54	0.00	2.54	18.00	0.00	0.00	2.13	0.00
Aug.	11 - 20	2.82	0.00	2.82	18.00	0.00	0.00	2.41	0.00
	21 - 31	3.04	0.00	3.04	18.00	0.00	0.00	2.58	0.00
	1 - 10	2.51	2.94	5.45	15.06	0.00	2.94	0.00	0.00
Sep.	11 - 20	2.23	4.07	6.30	10.99	0.00	4.07	0.00	0.00
	21 - 30	1.90	3.18	5.08	7.81	0.00	3.18	0.00	0.00
	1 - 10	1.58	0.00	1.58	7.81	0.00	0.00	0.00	0.00
Oct.	11 - 20	1.62	2.58	4.20	5.23(3.60)	0.00	2.58	0.00	0.00
	21 - 31	2.56	0.00	0.46	7.34	2.11	0.00	0.00	0.00
	1 - 10	3.37	0.00	0.41	10.30	2.96	0.00	0.00	0.00
Nov.	11 - 20	4.67	0.00	0.41	14.56	4.25	0.00	0.00	0.00
	21 - 30	4.86	0.00	1.40	18.00	3.45	0.00	0.98	0.00
	1 - 10	3.34	0.00	3.34	18.00	0.00	0.00	2.93	0.00
Dec.	11 - 20	2.87	0.00	2.87	18.00	0.00	0.00	2.45	0.00
	21 - 31	3.21	0.00	3.21	18.00	0.00	0.00	2.76	0.00
Total		91.72	21.85	91.72	-	21.85	21.85	40.80	0.00

Note: Parenthesis indicates the least storaged water in consideration of losses at reservoir and river.

Table VIII-2 Thiba Dam Operation (3/6)

(1/10 Drought Year 1984)

Month	Day	(1) Discharge at Damsite without Dam (m^3/sec)	(2) Discharge at Damsite with Dam (m^3/sec)	(3)=(2)-(1)>0 Irri. Water Supplied from Dam (m^3/sec)	Reservoir Water Level (EL.m)
	1 - 10	2.06	2.06	0.00	1,380.0
Jan.	11 - 20	1.76	1.76	0.00	1,380.0
	21 - 31	1.43	1.43	0.00	1,380.0
	1 - 10	1.47	1.47	0.00	1,380.0
Feb.	11 - 20	1.36	1.36	0.00	1,380.0
	21 - 29	1.50	2.36	0.86	1,379.7
	1 - 10	1.45	3.91	2.46	1,377.5
Mar.	11 - 20	0.87	7.56	6.69	1,371.3
	21 - 31	1.01	7.29	6.28	1,363.0
	1 - 10	1.85	1.85	0.00	1,363.0
Apr.	11 - 20	1.34	1.34	0.00	1,363.0
	21 - 30	3.97	0.48	0.00	1,367.5
	1 - 10	2.07	3.33	1.26	1,365.8
May	11 - 20	1.67	3.60	1.93	1,363.0
	21 - 31	1.26	1.26	0.00	1,363.0
	1 - 10	1.57	1.57	0.00	1,363.0
Jun.	11 - 20	1.28	0.86	0.00	1,363.5
	21 - 30	0.85	0.48	0.00	1,364.0
	1 - 10	0.94	0.48	0.00	1,364.5
Jul.	11 - 20	1.07	0.48	0.00	1,365.5
	21 - 31	1.22	1.22	0.00	1,365.5
	1 - 10	1.24	2.98	1.74	1,363.0
Aug.	11 - 20	1.31	1.31	0.00	1,363.0
	21 - 31	1.33	1.33	0.00	1,363.0
	1 - 10	1.23	1.23	0.00	1,363.0
Sep.	11 - 20	1.10	1.10	0.00	1,363.0
	21 - 30	1.13	1.13	0.00	1,363.0
	1 - 10	2.40	0.48	0.00	1,365.8
Oct.	11 - 20	1.78	1.78	0.00	1,365.8
	21 - 31	3.01	0.48	0.00	1,368.8
	1 - 10	3.03	0.48	0.00	1,371.3
Nov.	11 - 20	3.64	0.48	0.00	1,374.0
	21 - 30	4.48	0.48	0.00	1,377.1
	1 - 10	4.91	0.77	0.00	1,380.0
Dec.	11 - 20	4.72	4.72	0.00	1,380.0
	21 - 31	3.50	3.50	0.00	1,380.0

Table VIII-2 Thiba Dam Operation (4/6)

(1/10 Drought Year 1984)

(Unit: MCM)

Month	Day	(1) Inflow to Reser-voir	(2) Released Water Requirement of Dam	(3) Outflow from Reser-voir	(4) Storage Water in Reservoir	(5)=(1)-(3)≧0 Increase of Storaged Water	(6)=(3)-(1)>0 Reservoir Water Use	(7) Excess Water from Spillway	(8) Shortage of Irri. Water
	1 - 10	1.78	0.00	1.78	18.00	0.00	0.00	1.37	0.00
Jan.	11 - 20	1.52	0.00	1.52	18.00	0.00	0.00	1.11	0.00
	21 - 31	1.36	0.00	1.36	18.00	0.00	0.00	0.86	0.00
	1 - 10	1.27	0.00	1.27	18.00	0.00	0.00	0.86	0.00
Feb.	11 - 20	1.18	0.00	1.18	18.00	0.00	0.00	0.77	0.00
	21 - 29	1.17	0.67	1.84	17.33	0.00	0.67	0.00	0.00
	1 - 10	1.25	2.13	3.38	15.20	0.00	2.13	0.00	0.00
Mar.	11 - 20	0.75	5.78	6.53	9.42	0.00	5.78	0.00	0.00
	21 - 31	0.96	7.86	7.78	2.60	0.00	6.82	0.00	1.04
	1 - 10	1.60	3.66	1.60	2.60	0.00	0.00	0.00	3.66
Apr.	11 - 20	1.16	2.83	1.16	2.60	0.00	0.00	0.00	2.83
	21 - 30	3.43	0.00	0.41	5.62	3.02	0.00	0.00	0.00
	1 - 10	1.79	1.09	2.88	4.53	0.00	1.09	0.00	0.00
May	11 - 20	1.44	2.23	3.37	2.60	0.00	1.93	0.00	0.30
	21 - 31	1.20	2.53	1.20	2.60	0.00	0.00	0.00	2.53
	1 - 10	1.36	0.08	1.36	2.60	0.00	0.00	0.00	0.08
Jun.	11 - 20	1.11	0.00	0.74	2.97	0.37	0.00	0.00	0.00
	21 - 30	0.73	0.00	0.41	3.29	0.32	0.00	0.00	0.00
	1 - 10	0.81	0.00	0.41	3.69	0.40	0.00	0.00	0.00
Jul.	11 - 20	0.92	0.00	0.41	4.20	0.51	0.00	0.00	0.00
	21 - 31	1.16	0.00	1.16	4.20	0.00	0.00	0.00	0.00
	1 - 10	1.07	2.39	2.67	2.60	0.00	1.60	0.00	0.79
Aug.	11 - 20	1.13	3.77	1.13	2.60	0.00	0.00	0.00	3.77
	21 - 31	1.26	5.19	1.26	2.60	0.00	0.00	0.00	5.19
	1 - 10	1.06	5.89	1.06	2.60	0.00	0.00	0.00	5.89
Sep.	11 - 20	0.95	6.72	0.95	2.60	0.00	0.00	0.00	6.72
	21 - 30	0.98	5.07	0.98	2.60	0.00	0.00	0.00	5.07
	1 - 10	2.07	0.00	0.41	4.26	1.66	0.00	0.00	0.00
Oct.	11 - 20	1.54	0.00	1.54	4.26	0.00	0.00	0.00	0.00
	21 - 31	2.86	0.00	0.46	6.66	2.40	0.00	0.00	0.00
	1 - 10	2.62	0.00	0.41	8.87	2.21	0.00	0.00	0.00
Nov.	11 - 20	3.14	0.00	0.41	11.60	2.73	0.00	0.00	0.00
	21 - 30	3.87	0.00	0.41	15.06	3.46	0.00	0.00	0.00
	1 - 10	4.24	0.00	1.30	18.00	2.94	0.00	0.89	0.00
Dec.	11 - 20	4.08	0.00	4.08	18.00	0.00	0.00	3.67	0.00
	21 - 31	3.33	0.00	3.33	18.00	0.00	0.00	2.87	0.00
Total		62.15	57.89	62.15	-	20.02	20.02	12.40	37.87

Table VIII-2 Thiba Dam Operation (5/6)
(1/10 Drought Year 1982)

Month	Day	(1) Discharge at Damsite without Dam (m^3/sec)	(2) Discharge at Damsite with Dam (m^3/sec)	(3)=(2)-(1)>0 Irri. Water Supplied from Dam (m^3/sec)	Reservoir Water Level (EL.m)
	1 - 10	2.38	2.38	0.00	1,380.0
Jan.	11 - 20	2.55	2.55	0.00	1,380.0
	21 - 31	1.63	1.63	0.00	1,380.0
	1 - 10	1.57	1.57	0.00	1,380.0
Feb.	11 - 20	1.64	1.64	0.00	1,380.0
	21 - 29	1.11	2.11	1.00	1,379.5
	1 - 10	1.14	4.87	3.73	1,376.5
Mar.	11 - 20	1.32	7.16	5.84	1,370.8
	21 - 31	1.20	2.81	1.11	1,368.8
	1 - 10	2.38	0.48	0.00	1,370.6
Apr.	11 - 20	2.19	2.19	0.00	1,370.6
	21 - 30	4.90	0.48	0.00	1,374.5
	1 - 10	10.13	4.30	0.00	1,380.0
May	11 - 20	25.81	25.81	0.00	1,380.0
	21 - 31	54.04	54.04	0.00	1,380.0
	1 - 10	25.21	25.21	0.00	1,380.0
Jun.	11 - 20	8.95	8.95	0.00	1,380.0
	21 - 30	8.60	8.60	0.00	1,380.0
	1 - 10	5.47	5.47	0.00	1,380.0
Jul.	11 - 20	5.06	5.06	0.00	1,380.0
	21 - 31	6.68	6.68	0.00	1,380.0
	1 - 10	5.61	5.61	0.00	1,380.0
Aug.	11 - 20	4.83	4.83	0.00	1,380.0
	21 - 31	4.29	4.29	0.00	1,380.0
	1 - 10	3.35	3.35	0.00	1,380.0
Sep.	11 - 20	3.70	3.70	0.00	1,380.0
	21 - 30	4.12	4.12	0.00	1,380.0
	1 - 10	4.93	4.93	0.00	1,380.0
Oct.	11 - 20	11.89	11.89	0.00	1,380.0
	21 - 31	11.45	11.45	0.00	1,380.0
	1 - 10	11.80	11.80	0.00	1,380.0
Nov.	11 - 20	7.54	7.54	0.00	1,380.0
	21 - 30	6.74	6.74	0.00	1,380.0
	1 - 10	15.14	15.14	0.00	1,380.0
Dec.	11 - 20	6.01	6.01	0.00	1,380.0
	21 - 31	5.08	5.08	0.00	1,380.0

Table VIII-2 Thiba Dam Operation (6/6)

(1/10 Drought Year 1984)

(Unit: MCM)

Month	Day	(1) Inflow to Reser-voir	(2) Released Water Requirement of Dam	(3) Outflow from Reser-voir	(4) Storage Water in Reservoir	(5)=(1)-(3)≧0 Increase of Storaged Water	(6)=(3)-(1)>0 Reservoir Water Use	(7) Excess Water from Spillway	(8) Shortage of Irri. Water
	1 - 10	2.06	0.00	2.06	18.00	0.00	0.00	1.65	0.00
Jan.	11 - 20	2.20	0.00	2.20	18.00	0.00	0.00	1.79	0.00
	21 - 31	1.55	0.00	1.55	18.00	0.00	0.00	1.09	0.00
	1 - 10	1.36	0.00	1.36	18.00	0.00	0.00	0.95	0.00
Feb.	11 - 20	1.42	0.00	1.42	18.00	0.00	0.00	1.01	0.00
	21 - 29	0.77	0.69	1.46	17.31	0.00	0.69	0.00	0.00
	1 - 10	0.98	3.23	4.21	14.08	0.00	3.23	0.00	0.00
Mar.	11 - 20	1.14	5.05	6.19	9.03	0.00	5.05	0.00	0.00
	21 - 31	1.14	1.53	2.67	7.50	0.00	1.53	0.00	0.00
	1 - 10	2.06	0.00	0.41	9.15	1.65	0.00	0.00	0.00
Apr.	11 - 20	1.89	0.00	1.89	9.15	0.00	0.00	0.00	0.00
	21 - 30	4.23	0.00	0.41	12.97	3.82	0.00	0.00	0.00
	1 - 10	8.75	0.00	3.72	18.00	5.03	0.00	3.31	0.00
May	11 - 20	22.30	0.00	22.30	18.00	0.00	0.00	21.89	0.00
	21 - 31	51.36	0.00	51.36	18.00	0.00	0.00	50.95	0.00
	1 - 10	21.78	0.00	21.78	18.00	0.00	0.00	21.37	0.00
Jun.	11 - 20	7.73	0.00	7.73	18.00	0.00	0.00	7.32	0.00
	21 - 30	7.43	0.00	7.43	18.00	0.00	0.00	7.02	0.00
	1 - 10	4.73	0.00	4.73	18.00	0.00	0.00	4.32	0.00
Jul.	11 - 20	4.37	0.00	4.37	18.00	0.00	0.00	3.96	0.00
	21 - 31	6.35	0.00	6.35	18.00	0.00	0.00	5.89	0.00
	1 - 10	4.85	0.00	4.85	18.00	0.00	0.00	4.44	0.00
Aug.	11 - 20	4.17	0.00	4.17	18.00	0.00	0.00	3.76	0.00
	21 - 31	4.08	0.00	4.08	18.00	0.00	0.00	3.62	0.00
	1 - 10	2.89	0.00	2.89	18.00	0.00	0.00	2.48	0.00
Sep.	11 - 20	3.20	0.00	3.20	18.00	0.00	0.00	2.79	0.00
	21 - 30	3.56	0.00	3.56	18.00	0.00	0.00	3.15	0.00
	1 - 10	4.26	0.00	4.26	18.00	0.00	0.00	3.85	0.00
Oct.	11 - 20	10.27	0.00	10.27	18.00	0.00	0.00	9.86	0.00
	21 - 31	10.88	0.00	10.88	18.00	0.00	0.00	10.42	0.00
	1 - 10	10.20	0.00	10.20	18.00	0.00	0.00	9.79	0.00
Nov.	11 - 20	6.51	0.00	6.51	18.00	0.00	0.00	6.10	0.00
	21 - 30	5.82	0.00	5.82	18.00	0.00	0.00	5.41	0.00
	1 - 10	13.08	0.00	18.08	18.00	0.00	0.00	12.67	0.00
Dec.	11 - 20	5.19	0.00	5.19	18.00	0.00	0.00	4.78	0.00
	21 - 31	4.82	0.00	4.82	18.00	0.00	0.00	4.36	0.00
Total		249.38	10.50	249.38	-	10.50	10.50	220.00	0.00

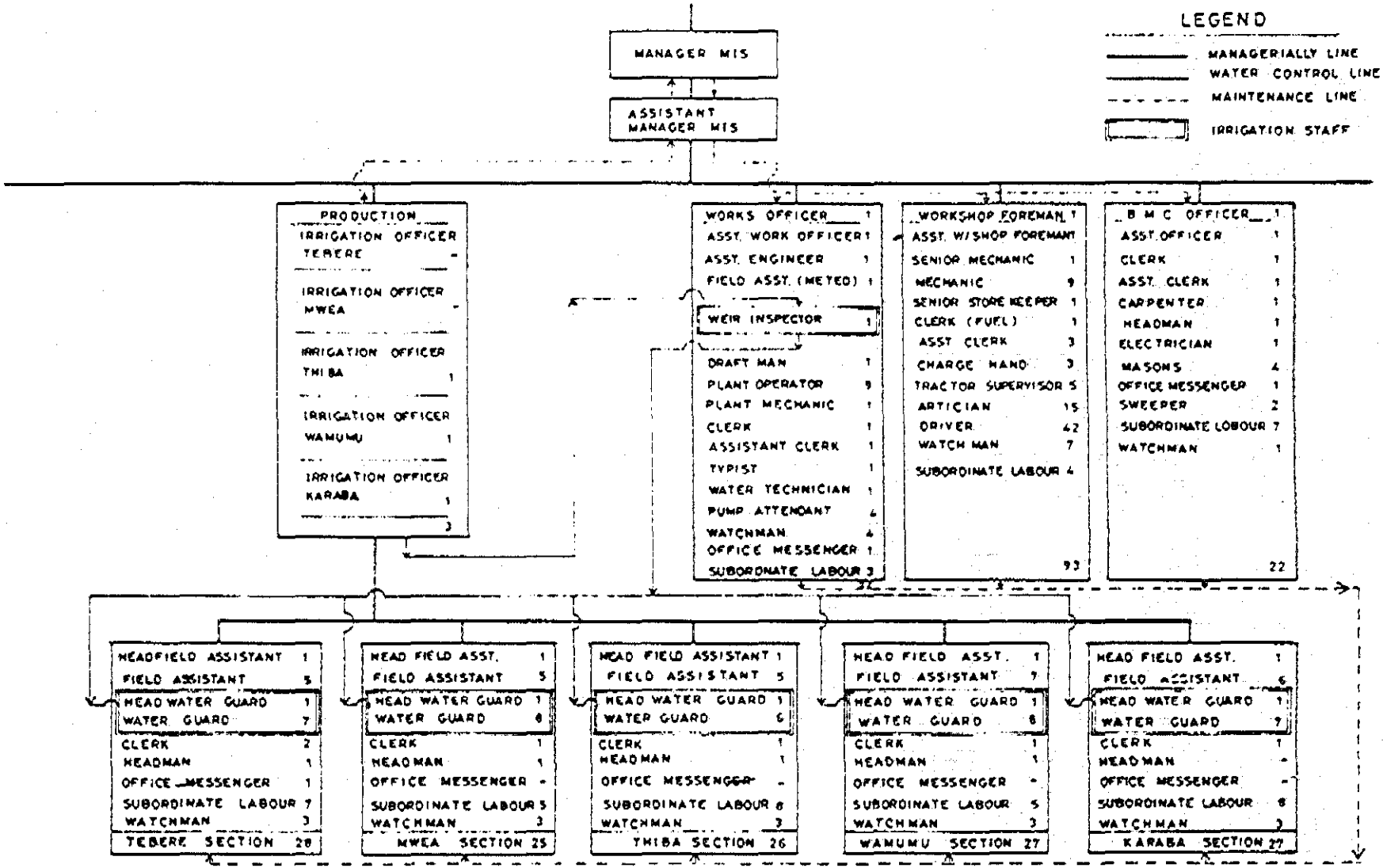


Fig. VIII-1 PRESENT ORGANIZATION OF O & M IN MWEA IRRIGATION SETTLEMENT SCHEME

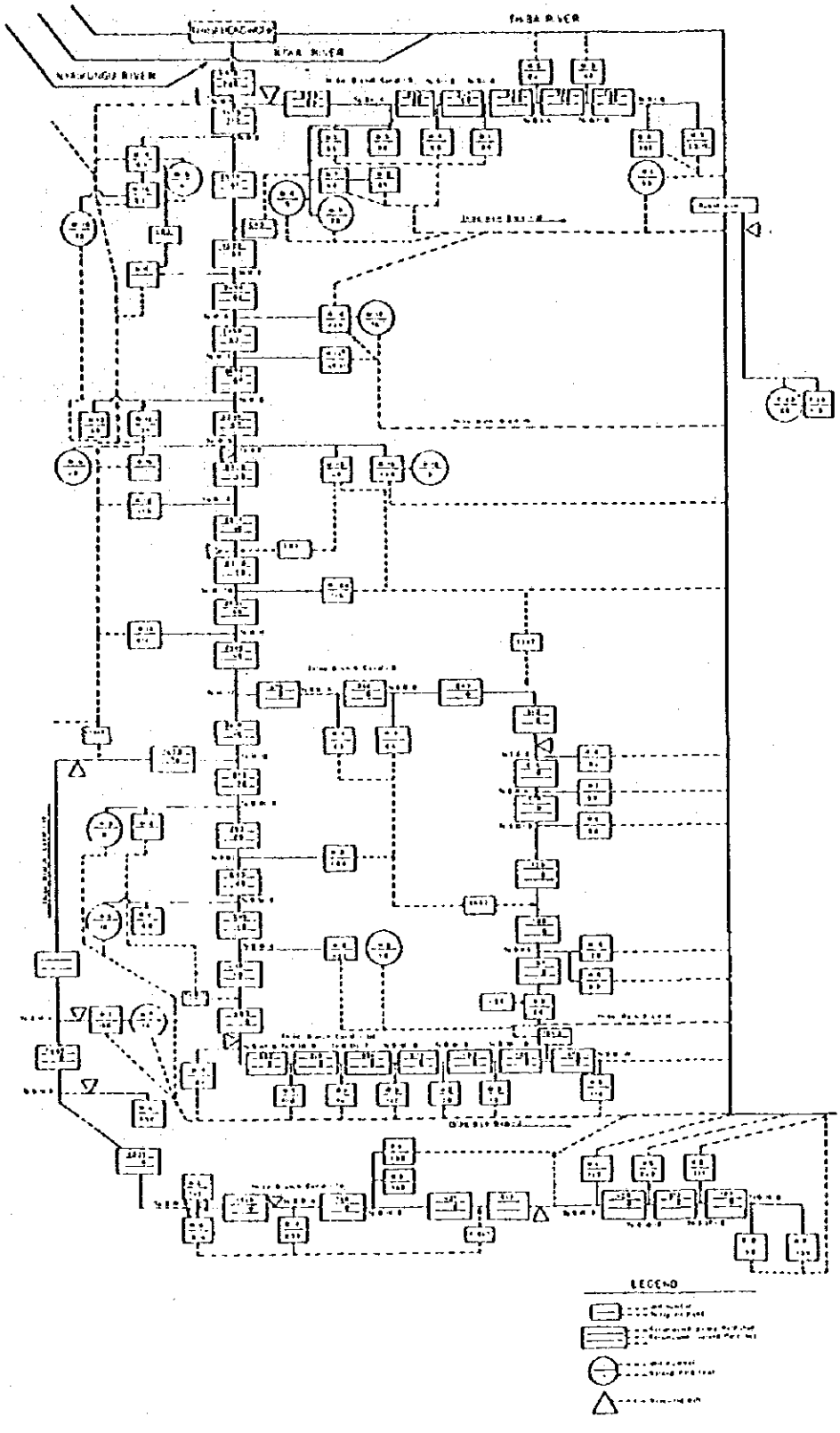


Fig. VIII-2 IRRIGATION DIAGRAM AND PRESENT MEASURING WEIR POINT IN THIBA PART

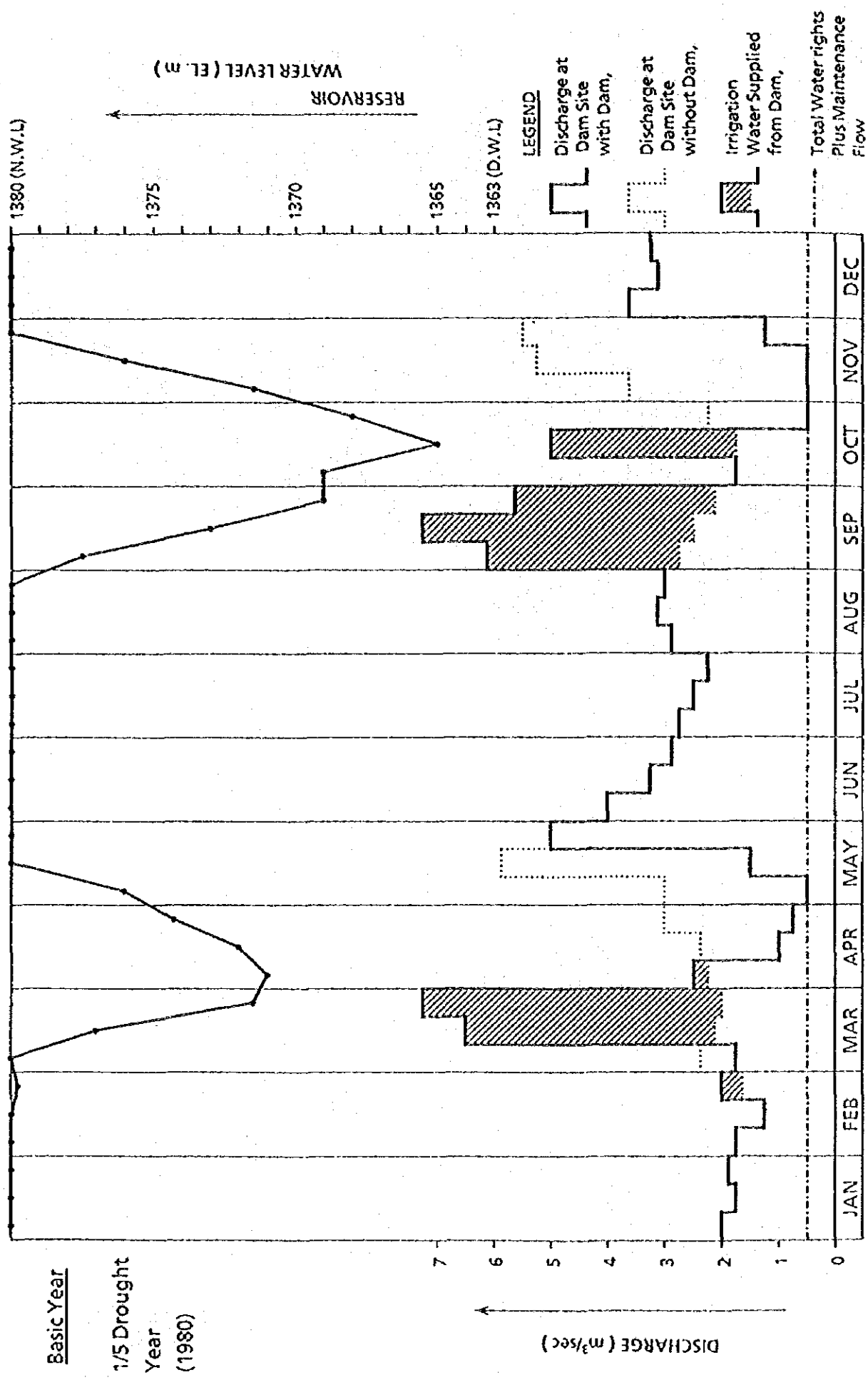


Fig. VII - 3 THIBA DAM OPERATION DIAGRAM (1/6)

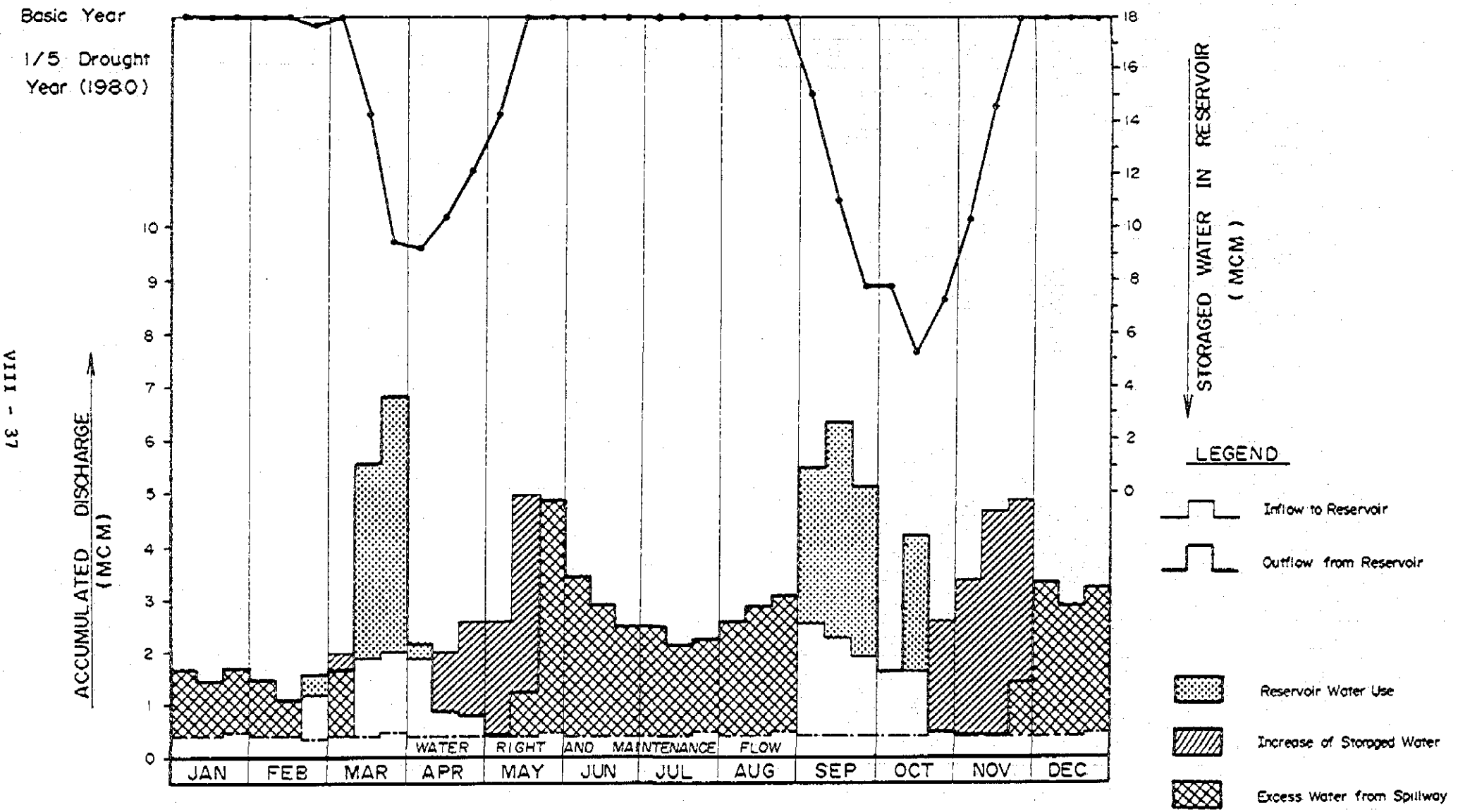


Fig. VIII-3 THIBA DAM OPERATION DIAGRAM (2/6)

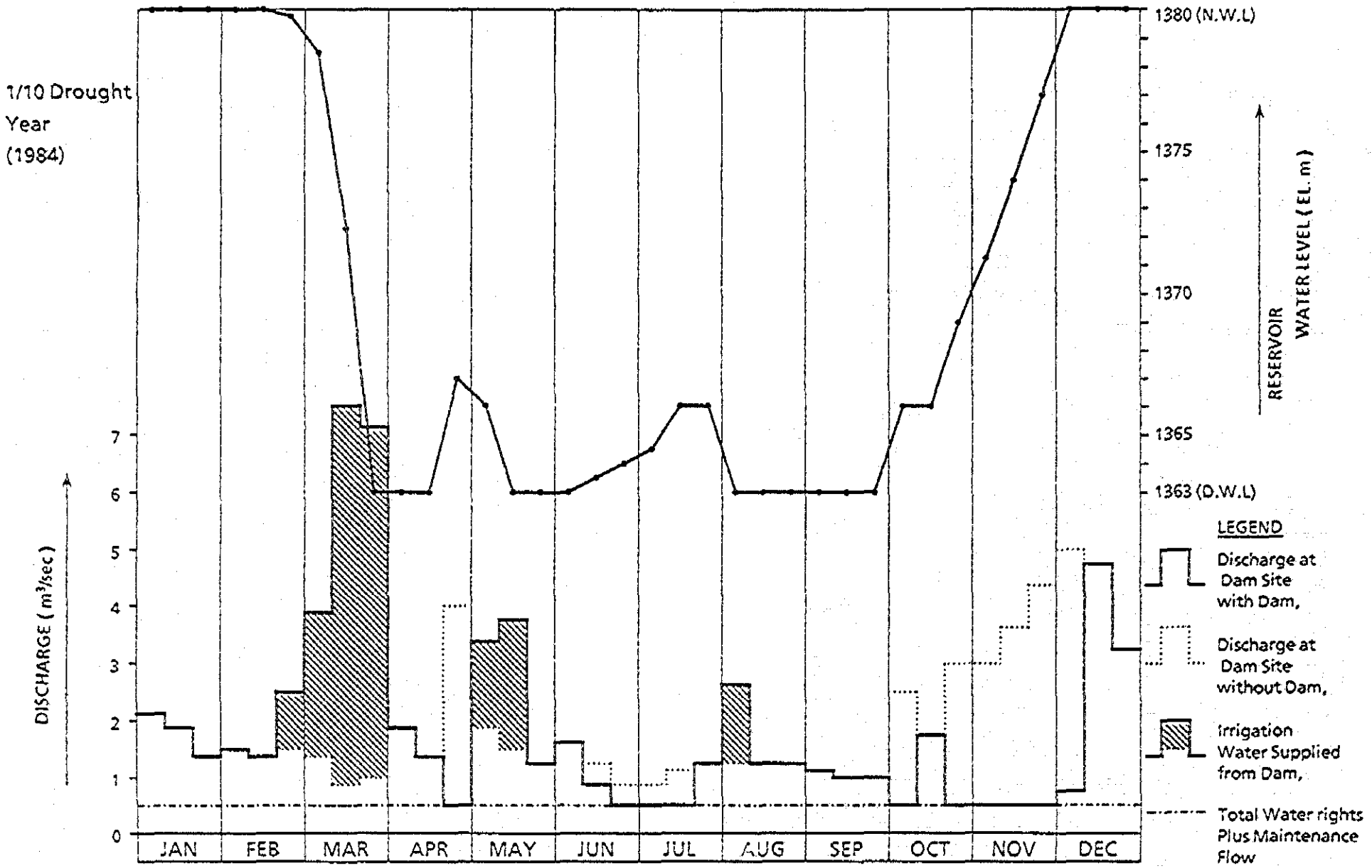


Fig. VIII - 3 THIBA DAM OPERATION DIAGRAM (3/6)

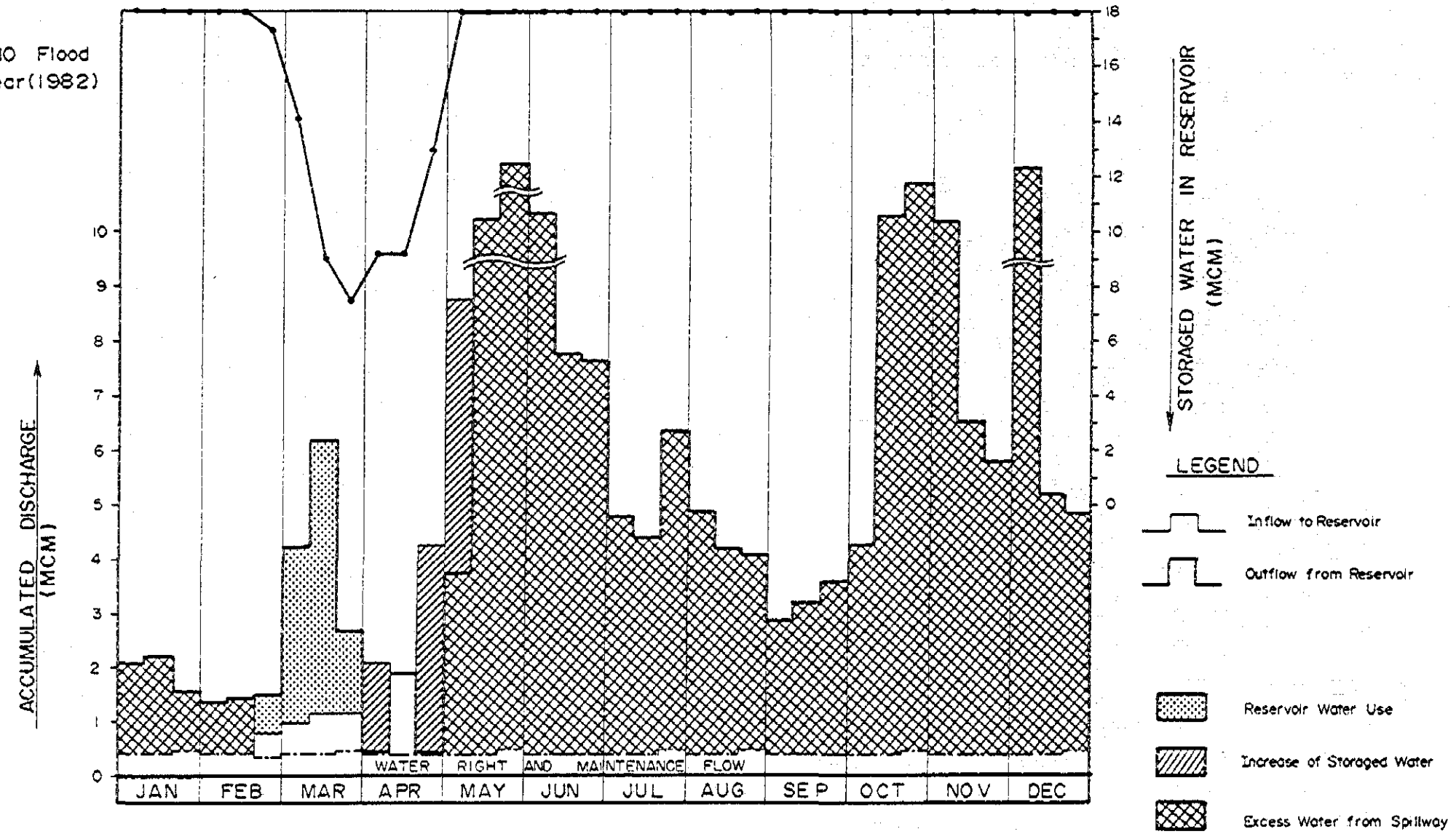


Fig. VIII - 3 THIBA DAM OPERATION DIAGRAM (6/6)

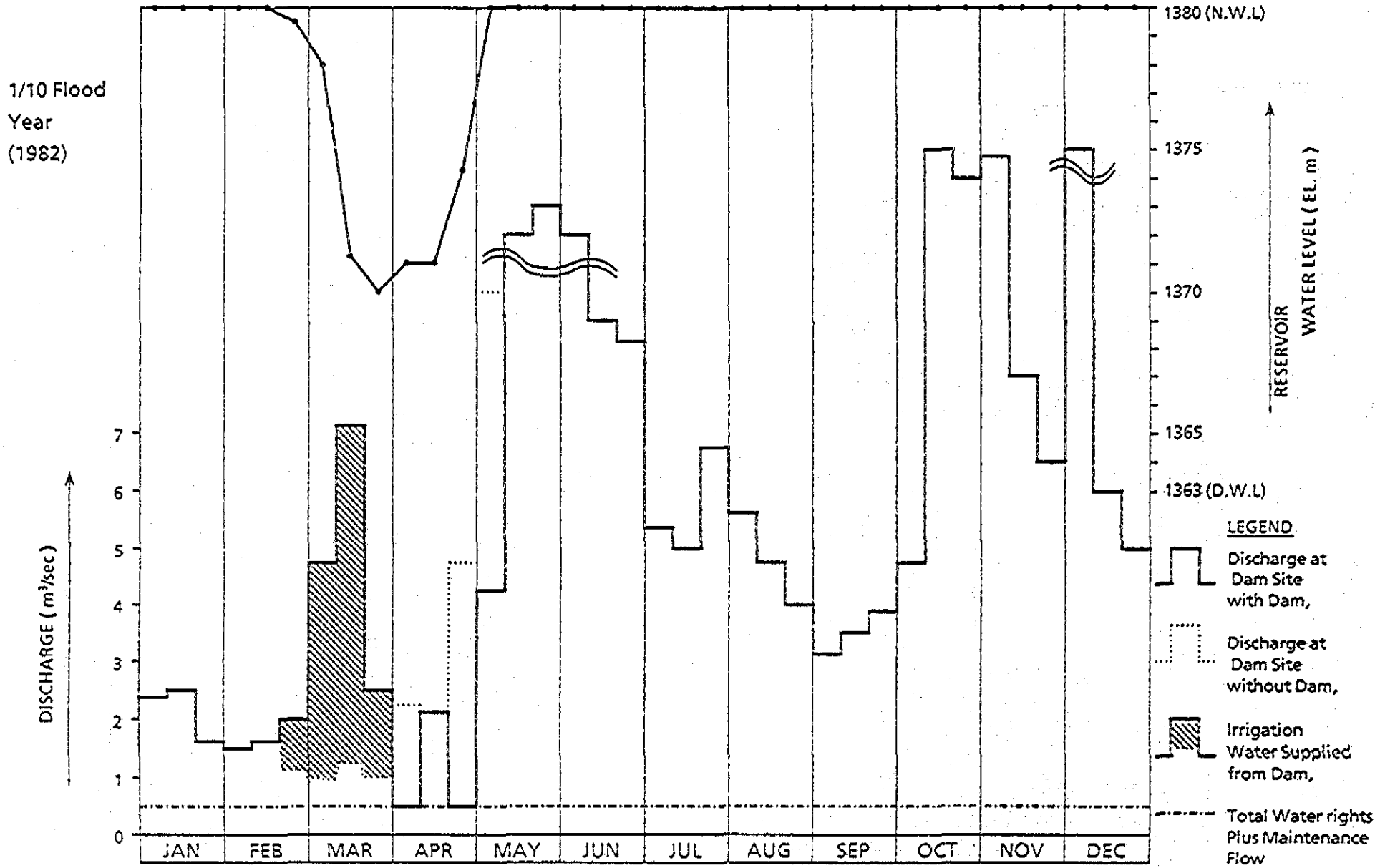


Fig. VIII - 3 THIBA DAM OPERATION DIAGRAM (5/6)

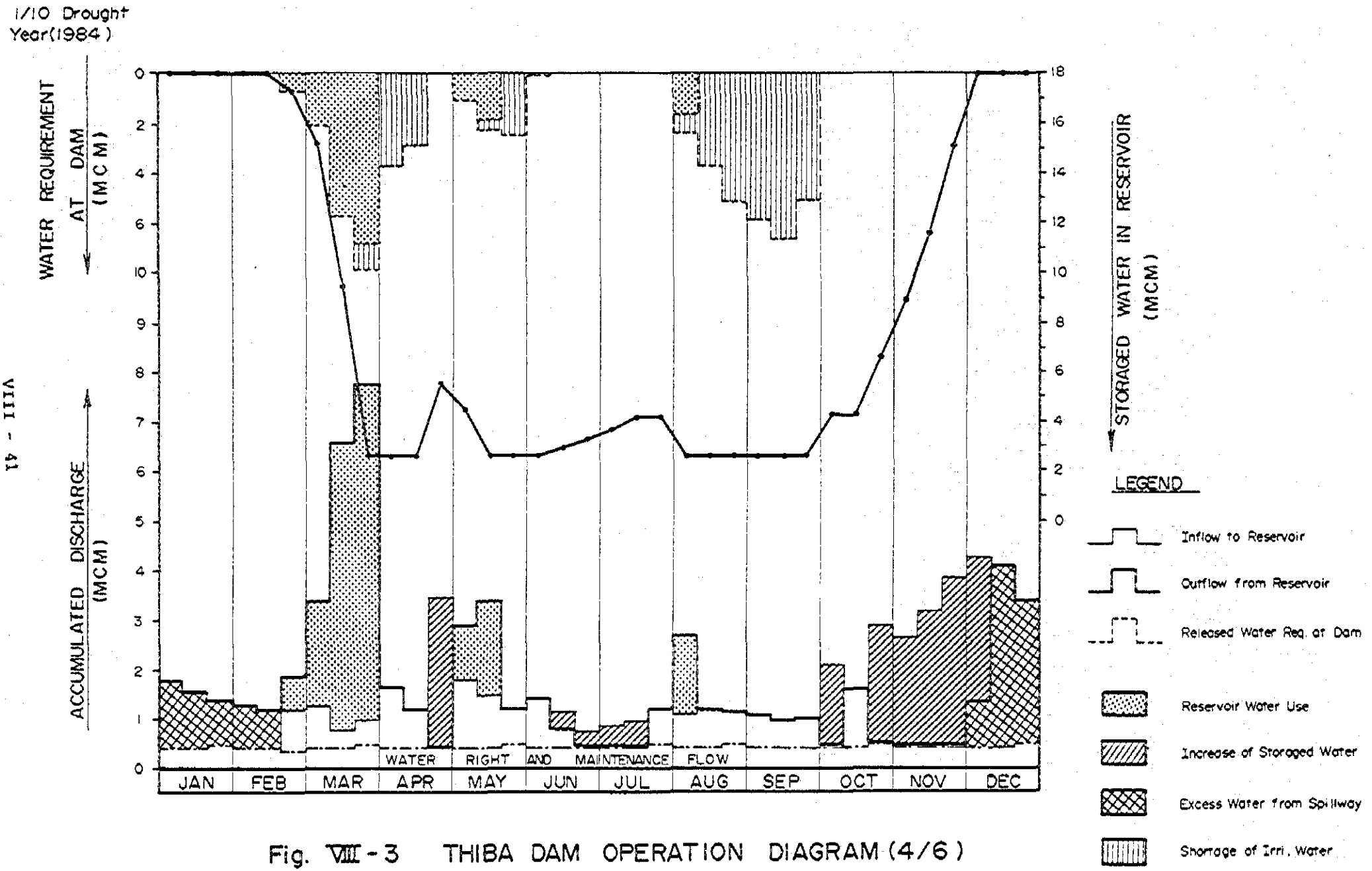


Fig. VIII-3 THIBA DAM OPERATION DIAGRAM (4/6)

ANNEX - IX

CONSTRUCTION PLAN AND COST ESTIMATE

ANNEX - IX

CONSTRUCTION PLAN AND COST ESTIMATE

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1. CONSTRUCTION PLAN

1.1 General Description

The construction works of the Mwea Irrigation Development Project comprise five (5) items as shown below:

a) Construction of dam
b) Construction/rehabilitation of headworks
c) Construction of link canals
d) Rehabilitation/improvement of MIS Scheme
e) Development of the Mutithi extension area

For implementation of the Project, a stagewise plan is conceived as described below:

The construction works are divided into Phase-I and Phase-II. Phase-I would be constructed for improvement of exist MIS Scheme, and comprise of four (4) items as shown below:

a) Construction of New Nyamindi Headworks
b) Rehabilitation of Ex. Thiba Headworks
c) Construction of Nyamindi Headrace, Nyamindi New Main Canal, Link Canal I and improvement of Link Canal II
d) Rehabilitation/improvement of MIS Scheme

Phase II would be constructed for development of the Mutithi extension area, and comprise of:

a) Construction of Thiba dam
b) Construction of Ruamuthambi Headworks
c) Construction of Link Canal III and Ruamuthambi Headrace
d) Construction of the Mutithi extension area

According to the result of the estimation for the implementation period, 3 years are enquired for Phase-I and 5 years are required for Phase-II.

1.2 Basic Assumption of Construction Planning

1.2.1 Workable days

The suspension of construction works for dam embankment in usually caused by heavy rainfall which effects on a moisture control of impervious materials.

Suspension of these earth works would be assumed as following criteria which is modified from Japanese criteria taking account of meteorological conditions in Kenya.

Daily Rainfall Intensity	Suspension of Work
0 to 10 mm	0 day
10 to 30 mm	1 day
30 to 50 mm	2 days
50 to 100 mm	3 days
more than 100	4 days

Monthly and annual mean suspension days are estimated on the basis of the above criteria and the daily rainfall records in Kianyaga station for recent 10 years, and the computed result is shown in Table IX-1.

The result of workable days shown that the impervious materials can be embanked almost every day in dry season, but in rainy season, 18-24 days are workable. And annual workable days are estimated at 319 days.

On the other hand, the general works such as concrete works, foundation treatment works is not subject to the rainfall so much as the embankment of the impervious materials. According to this, the workable days for the general works is assumed 28 days per month with consideration of extreme heavy rain, trouble of the equipment, etc. And at this point of view, the maximum workable days of impervious materials per month is fixed at 28 days.

Workable Days

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
General works	28	28	28	28	28	28	28	28	28	28	28	28	336
Impervious materials	28	27	27	18	23	28	28	28	28	24	24	28	311

1.2.2 Definition of earth material

The abbreviation of earth materials on the construction plan would be correlated with the geological definition as given in the table below:

Earth Materials of the Construction Plan	Abbrevi-ation	Geological Condition
Sand	S	Sand
Common Soil, Top Soil	C/S, T/S	Volcanic cohesive soil
Gravel & Weathered Rock	G, W/R	Decomposed aggromelates
Rock	R	Moderately weathered balalts

1.2.3 Conversion rate of earth materials

Earth volume should be counted according to their status. Earth materials naturally placed as they are, increase in volume after excavation and decrease after compaction. These changes in volume should be counted for the estimation of earth work capacity by construction equipment.

The conversion rate of earth volume is assumed as follows:

Earth Materials	Status of Material		
	In Place	Excavated	Compacted
S	1.00	1.20	0.95
C/S, T/S	1.00	1.25	0.90
G, W/R	1.00	1.20	1.00
R	1.00	1.60	1.30

1.2.4 Basic method of earth works

Earth works consist of excavating, loading, hauling, spreading and compacting. Since there are various methods for these earth works, due consideration must be made on the choice of the suitable method. Earth works of the big volumes would be depended on a heavy duty equipment.

Following equipments would be basically introduced on these earth works of the Project.

Earth Works	Earth Materials	Proposed Equipments
Excavation	Sand, Common Soil, Gravel	Bulldozer, Back-hoe Shovel
	Weathered Rock	Ripper Dozer, Back-hoe Shovel
	Rock	Blasting & Bulldozer
Loading	Any Kind of Excavated Materials	Crawler loader, Wheeled Loader, Back-hoe Shovel
Hauling	Any kind of Excavated Materials	Tipper Lorry
Spreading	Any Kind of Excavated Materials	Bulldozer
Compacting	Impervious Materials	Tamping Roller
	Coarse Materials	Vibration-Roller
	Common Soil (Standard works)	Compactor, Tamper

1.2.5 Filter materials and aggregates

Coarse aggretages and sands for five aggregates are able to be obtained around the project site and the daily product capacities of them are enough for irrigation facilities, however it is not enough for dam works.

Then the filter materials and aggregates for Thiba dam works should be produced insitu by aggregate production plant, but aggregates for irrigation facilities will be purchased from quarry sites.

1.3 Dam Construction

1.3.1 Earth moving plan

Materials for embankment are partly obtained from the excavation of dam foundation and structures but the greater part of the materials are to be obtained from borrow area and quarry site.

Impervious materials and transition material are obtained from borrow area about 1 km upstream from dam axes, and rock material is obtained from quarry site about 2 km upstream from dam axis. Filter material and aggregate material is also obtained from quarry site mentioned above.

Taking into account these available materials, conversion rate of earth, most economical construction method, etc., the earth moving plan for the dam is confirmed as shown in Table IX-2.

1.3.2 Construction procedure of the dam

After the preparatory works such as access roads, office yard, meter pools, etc., the river diversion tunnel works will be commenced at first. After the river would be diverted by coffer dam, the foundation excavation of dam will be carried out.

Foundation treatment works should be made from river bed in order to enable to earlier dam embankment works and remaining both sides treatment works might be gradually carried out prior to the dam embankment.

Spillway works will be executed in parallel with the dam embankment, because the useful excavated materials are planned to haul directly to the dam, and concrete works will be carried out partly after completion of the excavation.

After completion of dam embankment, the river diversion tunnel will be plugged and in parallel with the plug works, the outlet works will be carried out.

1.3.3 Construction method

(1) River diversion works

The river diversion works will be commenced by excavation of the diversion tunnel.

The tunnel excavation would be carried out by full face excavation method using blasting. Concrete lining would be executed by concrete pumping car using sliding steel form after completion of excavation. The aggregates for concrete should be produced insitu and concrete would be mixed by semi automatic mixing plant insitu.

(2) Foundation excavation

Stripping top soil and excavation of common soil and weathered rock (agglomerates) would be made by combination of bulldozer and crawler loader, while the strict part of weathered rock would be excavated by ripper.

(3) Foundation treatment

After excavation of the dam core trench, curtain grouting would be executed. After completion of grout hole drilling by hydraulic boring

machines, cement milk mixed by mortal mixer would be poured into the holes under the controlled pressure by grouting pump. For making sure the grouting condition, test hole would be drilled and grouting efficiency would be checked by observation of the lifted core. If non-effective condition is observed, supplemental grouting around there is required.

(4) Embankment

According to the earth moving plan estimated in Table IX-2, embankment materials to be transported from the proposed areas would be spread by bulldozer at the specified thickness and compacted by suitable compacting machines. The specified thickness of spreading, numbers of compaction runs and suitable compacting machines are proposed as follows:

Zone	Thickness of Spreading (cm)	Compaction Machine
Impervious Zone	20	Tamping Roller
Filter Zone	20	Vibratory Roller
Transition Zone	50	Vibratory Roller
Rock Zone	100	Vibratory Roller

Impervious materials would be strictly controlled by the D-value. Other materials would be supervised by the relation between minimum and maximum dry density. The water contents of compacted materials would be checked throughout the construction period and in case of a low water content ratio, some amount of water would be added to the materials by tank lorry so as to approximate the optimum water content.

(5) Construction of spillway

After completion of excavation works of spillway following to the earth moving schedule for dam embankment, concrete works would be commenced.

Concrete would be mixed by semi automatic batching plant and placed mainly by concrete pump and supplementary by manpower.

(6) Plug works and outlet works

After completion of dam embankment and spillway works, the plug works would be commenced. The plug works would be executed diverting by half section of tunnel in consideration with the normal discharge of the river. In parallel with the plug works, the outlet works would be carried out.

1.3.4 Major temporary works

The following temporary plants should be installed at damsite.

(a)	Semi automatic concrete mixing plant (0.75 m^3 mixer)	1 set
(b)	Aggregate production plant (80 t/H)	1 set
(c)	Electric power transforming station (500 kVA)	1 set
(d)	Muddy water treatment (reservoir)	1 nos.

1.4 Construction of Irrigation and Drainage Facilities

1.4.1 Headworks

The construction works of Headworks will be mainly executed during dry season in due consideration of magnitude of flood in the rivers.

After river diversion works, foundation excavation will be commenced and easily reached the rock bed. The concrete will be produced by several number of portable concrete mixers and placed by man power.

1.4.2 Link canals

Earth work of the link canals will be mainly made by heavy duty equipment such as back-hoe shovels and bulldozers.

And earth lining for preventing leakage, will be made by combination of back-hoe shovel and man power using vibratory plate compactor.

Concrete for proposed structures will be produced by portable mixers and placed by man power.

1.4.3 Irrigation facilities

Irrigation facilities comprise of irrigation canals, drainage canals, farm road and related structures.

Excavation for canalworks will be executed by back-hoe shovels and embankment will be made by man power using compactors. Roadworks will be made by bulldozers, motor graders and road rollers. Related structures will be constructed by man power using light equipments.

1.4.4 On-farm

Land reclamation works for newly proposed area will be executed by bulldozers and on-farm road works will be made by road construction equipments same as farm road, but other works such as canal works and related structures will be made mainly by man power using light equipments.

1.5 Implementation Schedule

The implementation schedule for the project is shown in Fig. IX-1.

The implementation schedule is divided into Phase-I and Phase-II as mentioned in IX-1.

The implementation period is estimated at 6 years in total, and partly 3 years for Phase-I and 3 years for Phase-I.

2. COST ESTIMATE

2.1 Basic Assumptions

The construction cost is estimated based on the following conditions:

(1) The unit prices are estimated based on the market prices in Kenya according to the Japanese standard on unit price estimation, and are checked using "Current construction cost" issued by the Ministry of Works and Housing in January, 1987.

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

US$1 = KShs.16.5 = ¥150

(3) The depreciation costs of machinery and equipment are considered in the estimate of the construction unit cost, based on the hiring rate in the "Current construction cost".

(4) Taxes on the construction materials, machinery and equipment to be imported from abroad are excluded in the cost estimate.

(5) The construction cost is divided into local and foreign currency portions. Local currency portion is estimated on the basis of current price in and around the project area. Foreign currency portion is estimated based on the CIF prices at Mombasa.

2.2 Financial Project Cost

The financial project cost comprises of the following items.

(1) Construction cost

Construction cost comprises direct construction cost, cost for preparatory and temporally works, contractor's field expenses and overhead expenses. The direct construction cost is estimated based on the proposed work quantity and the unit prices mentioned above.

(2) Initial farm investment

Initial farm investment comprises of the cost for agricultural machinery, O/M equipment and farm buildings. The cost for agricultural machinery and O/M equipment comprises of C.I.F. price in Mombasa and inland transportation cost.

(3) Administration cost

Administration cost is roughly estimated on the assumption that NIB would supervise the construction works directly. The cost is estimated at 3% of the total cost for the above two items. Administration cost is estimated applying this percentage (3%) to the total of above two (2) items.

(4) Engineering service

The cost for engineering service is roughly estimated the assumption that the consultants will be engaged in the detailed design and construction supervision. The estimate is fixed at 10% of the total cost for construction and cost for initial farm investment. Engineering service costs each development alternative are estimated, applying this percentage (10%) to the total of two (2) items mentioned above.

(5) Physical contingency

The physical contingency is fixed at 10% of the total for the above four (4) items.

(6) Price contingency

The price contingency is estimated by applying the inflation rate of 3 percent per annum for foreign currency portion and 7 percent per annum for local currency portion.

The price escalation is estimated on the disbursement schedule.

The total project cost is estimated at Kshs.1,227.1 million, comprising KShs.468.4 million (40% equivalence of the total project cost) of local currency portion and KShs.758.7. (60% equivalence of the total project cost) of foreign currency portion. The construction cost for infrastructural facilities would amount to KShs.637.2 million in total, corresponding to KShs.66,700 per ha.

The summary of the project cost is shown in Table IX-3.

2.3 Annual Disbursement Schedule

The annual disbursement schedule is worked out based on the construction implementation schedule. The details are stated in Table IX-13.

2.4 Annual Operation and Maintenance Costs

The annual operation and maintenance costs including the salaries of project administration and water control staffs, the materials and labour costs for repair and maintenance of O&M equipment, and running cost of project facilities. The annual operation and maintenance costs are estimated at KShs.53 million. (Tables IX-14, IX-15)

2.5 Replacement Cost

Some of the facilities, especially mechanical works have shorter useful life than the civil works and require replacement at a certain time within the project useful life. The Table IX-16 shows the useful life and replacement cost of the mechanical works.

Table IX-1 Suspension & Workable Days by Rainfall Intensity for Impervious Materials of Dam

Year	Jan.	Feb.	Mar.	Apr,	May	Jun.	Jul,	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1976	0	0	0	12	3	3	1	0	3	2	5	3	32
1977	4	0	1	13	7	1	0	-	1	-	9	3	39
1978	1	2	6	17	4	0	1	0	6	12	3	7	59
1979	4	0	4	8	9	1	2	3	0	6	6	4	47
1980	0	0	3	7	12	0	0	6	0	4	14	0	46
1981	0	0	10	14	13	1	1	3	1	6	6	4	59
1982	0	0	1	14	12	0	1	0	2	13	5	1	49
1983	0	0	0	17	5	4	0	1	0	6	2	6	41
1984	2	0	3	8	1	1	1	0	1	13	7	4	41
1985	0	4	9	9	9	0	0	0	0	4	6	0	41
Total	11	6	37	119	75	11	7	13	14	66	63	32	454
Mean Suspen-sion	1	1	4	12	8	1	1	1	1	7	6	3	46
Workable Day	30	27	27	18	23	29	30	30	29	24	24	28	319

Table IX-2 Earth Moving Plan of Thiba Dam

Excavation	Embankment		Coffer Dam	Dam Body				Backfill		Aggregate	Spoil Bank
				Impervious Zone	Filter Zone	Transition Zone	Rock Zone	River Division Works	Spillway		
			(24,000)	(320,000)	(80,000)	(280,000)	(520,000)	(1,000)	(52,000)	(32,400)	127,700
River Division Works	Soil	32,000		24,500 S (22,000)				1,100 S (1,000)			6,400
	Rock	48,000					37,400 (50,500)			5,800 (5,000)	4,800
Coffer Dam		26,700	26,700 (24,000)								60,000
Dam Foundation	Soil	120,000		60,000 S (54,000)							60,000
Spillway	Soil	82,000		16,000 (14,400)					57,800 S (52,000)		8,200
	Weathered Rock	33,000				29,700 (29,700)					3,300
	Rock	55,000					49,500 (66,800)				5,500
Borrow Area	Top Soil	25,500									25,500
	Soil	255,100		255,100 (229,600)							-
	Weathered Rock	250,300				250,300 (250,300)					-
Quarry Site	Top Soil	14,000									14,000
	Rock	415,600			80,000 (80,000)		298,300 (402,700)			37,300 (32,400)	-

Table IX-3 Summary of the Project Cost

(Unit: KShs.x10^6)

Description	Phase I			Phase II			Total		
	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
1. Construction Cost	70.5	87.9	158.4	156.4	322.4	478.8	226.9	410.3	637.2
Dam Works	-	-	-	96.9	235.0	331.9	96.9	235.0	331.9
Headworks	3.8	4.8	8.6	1.3	1.4	2.7	5.1	6.2	11.3
Link Canals	13.3	31.4	44.7	6.7	13.7	20.4	20.0	45.1	65.1
Irrigation Facilities	25.1	25.5	50.6	27.6	32.1	59.7	52.7	57.6	110.3
On-Farm	28.3	26.2	54.5	23.9	40.2	64.1	52.2	66.4	118.6
2. Initial Farm Investment	17.3	86.3	103.6	12.1	58.0	70.1	29.4	144.3	173.7
O & M Equipment	4.8	31.3	36.1	4.0	25.5	29.5	8.8	56.8	65.6
Agricultural Machinery	4.7	47.0	51.7	2.7	26.8	29.5	7.4	73.8	81.2
Farm Buildings	7.8	8.0	15.8	5.4	5.7	11.1	13.2	13.7	26.9
3. Administration Cost	7.9	-	7.9	16.5	-	16.5	24.4	-	24.4
4. Engineering Cost	10.5	15.7	26.2	22.0	32.9	54.9	32.5	48.6	81.1
5. Land Acquisition	0.3	-	0.3	1.6	-	1.6	1.9	-	1.9
Sub-total:	106.5	189.9	296.4	208.6	413.3	621.9	315.1	603.2	918.3
Physical Contingency	10.7	19.0	29.7	20.9	41.2	62.1	31.6	60.2	91.8
Total:	117.2	208.9	326.1	229.5	454.5	684.0	346.7	663.4	1,010.1
Price Contingency	26.8	18.8	45.6	94.9	76.5	171.4	121.7	95.3	217.0
Grand Total:	144.0	227.7	371.7	324.4	531.0	855.4	468.4	758.7	1,227.1

Table IX-4 Detailed Construction Cost (1/5)

- Thiba Dam -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Civil Works			
1-1	Preparatory Works	15,734	35,468	51,202
1-2	Direct Construction Cost			
	River Diversion Works	10,827	20,239	31,066
	Foundation Excavation Works	990	4,976	5,966
	Foundation Treatment Works	6,742	8,905	15,647
	Dam Embankment	5,478	20,218	25,696
	Stock Yard Works	252	1,833	2,085
	Borrow Area/Quarry Site Works	11,161	38,369	49,530
	Spoil Bank	42	183	225
	Spill Way	26,521	45,715	72,236
	Outlet Works	437	652	1,089
	Inspection Road	487	783	1,270
	Sub-total:	62,937	141,873	204,810
1-3	Contractors Expense	15,734	35,468	51,202
	Total:	94,405	212,809	307,214
2.	Metal Works/Monitoring Equipment			
	Metal Works	2,408	21,672	24,080
	Monitoring Instruments	50	550	600
	Total:	2,458	22,222	24,680
	Grand Total:	96,863	235,031	331,894

Table IX-4 Detailed Construction Cost (2/5)

- Headworks, Phase-I -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Civil Works			
1-1	Preparatory Works	490	446	936
1-2	Direct Construction Cost			
	New Nyamindi Headworks	1,959	1,899	3,858
	Ex. Thiba Headworks	493	331	824
	Sub-total:	2,452	2,230	4,682
1-3	Contractors Expenses	736	669	1,405
	Total:	3,678	3,345	7,023
2.	Metal Works			
	Nyamindi Headworks	120	1,080	1,200
	Ex. Thiba Headworks	42	378	420
	Total:	162	1,458	1,620
	Grand Total:	3,840	4,803	8,643

- Headworks, Phase-II -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Civil Works			
1-1	Preparatory Works	165	144	309
1-2	Direct Construction Cost			
	Ruamuthambi Headworks	827	718	1,545
1-3	Contractor's Expenses	248	216	464
	Total:	1,240	1,078	2,318
2.	Metal Works	38	334	372
	Grand Total:	1,278	1,412	2,690

Table IX-4 Detailed Construction Cost (3/5)

- Link Canals, Phase-I -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Civil Works			
1-1	Preparatory Works	1,441	3,340	4,781
1-2	Direct Construction Cost			
	Nyamindi Headrace	1,477	4,553	6,030
	Nyamindi Division Works	190	199	389
	Nyamindi New Main Canal	1,034	1,749	2,783
	Link Canal I	5,756	13,763	19,519
	Link Canal II	770	1,558	2,328
	Thiba Division Works	381	447	828
	Sub-total:	9,608	22,269	31,877
1-3	Contractor's Expenses	2,210	5,122	7,332
	Total:	13,259	30,731	43,990
2.	Metal Works			
	Nyamindi Division Works	27	239	266
	Link Canal I	3	23	26
	Thiba Division Works	42	374	416
	Total:	72	636	708
	Grand Total:	13,331	31,367	44,698

- Link Canals, Phase-II -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Preparatory Works	725	1,490	2,215
2.	Direct Construction Cost			
	Link Canal III	1,553	3,744	5,297
	Ruamuthambi Headrace	3,240	6,160	9,400
	Regulating Basin	39	32	71
	Sub-total:	4,832	9,936	14,768
3.	Contractor's Expenses	1,111	2,285	3,396
	Total:	6,668	13,711	20,379

Table IX-4 Detailed Construction Cost (4/5)

- Irrigation Facilities, MIS (Phase-I) -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Preparatory Works	2,726	2,775	5,501
2.	Direct Construction Cost			
	Irrigation Canals	11,187	8,453	19,640
	Drainage Canals	5,818	5,406	11,224
	Farm Road	1,167	4,642	5,809
	Sub-Total:	18,172	18,501	36,673
3.	Contractor's Expenses	4,180	4,255	8,435
	Total:	25,078	25,531	50,609

- Irrigation Facilities, Mutithi (Phase-II) -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Preparatory Works	2,997	3,487	6,484
2.	Direct Construction Cost			
	Irrigation Canals	7,091	4,235	11,326
	Drainage Canals	11,272	12,650	23,922
	Farm Road	1,619	6,361	7,980
	Sub-Total:	19,982	23,246	43,228
3.	Contractor's Expenses	4,596	5,347	9,943
	Total:	27,575	32,080	59,655

Table IX-4 Detailed Construction Cost (5/5)

- On-Farm, MIS (Phase-I) -

(Unit: KShs.x10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Preparatory Works	2,740	2,845	5,585
2.	Direct Construction Cost			
	Paddy Field	11,683	10,514	22,197
	Horticultural Crops Field	6,585	8,451	15,036
	Sub-total:	18,268	18,965	37,233
3.	Contractor's Expenses	7,307	4,362	11,669
	Total:	28,315	26,172	54,487

- On-Farm, Mutithi (Phase-II) -

(Unit: Kshs. x 10^3)

	Work Item	Local Currency	Foreign Currency	Total
1.	Preparatory Works	2,599	4,366	6,965
2.	Direct Construction Cost			
	Paddy Field	13,780	24,558	38,338
	Horticultural Crops Field	3,549	4,551	8,100
	Sub-total:	17,329	29,109	46,438
3.	Contractor's Expenses	3,986	6,695	10,681
	Total:	28,914	40,170	64,084

Table IX-5-1 Breakdown of Direct Construction Cost (1/6)

- Thiba dam, Civil works(1/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
1. River Diversion Works								
1-1 Inlet/Outlet Channels								
Excavation and Hauling, Soil	m^3	32,000	7.5	240	30.2	966	1,206	
- Ditto - Rock	"	21,000	24.8	521	99.9	2,098	2,619	
Backfill	"	1,000	3.6	4	6.8	7	11	
Reinforced Concrete	"	1,000	379.9	380	576.4	576	956	
Form Work	M^2	1,000	75.2	75	23.2	23	98	
Steel reinforcement	ton	60	3,578.5	215	7,284.5	437	652	
Miscellaneous works	L.S	1		144		411	555	10% above
Sub-total:				1,579		4,518	6,097	
1-2 Tunnel Works								
Excavation	m^3	27,000	173.4	4,682	364.2	9,833	14,515	
Concrete lining	m^3	6,000	295.5	1,773	433.7	2,602	4,375	
Form work	m^2	11,000	75.2	827	23.2	255	1,082	
Motar grouting	m^3	2,000	246.4	493	287.6	575	1,068	
Curtain grouting	m	720	340.5	245	449.7	324	569	
Consolidation grouting	m	960	340.5	327	449.7	432	759	
Miscellaneous works	L.S	1		835		1,402	2,237	10% above
Sub-total:				9,182		15,423	24,605	
1-3 Coffer Dam								
Excavation/Embankment	m^3	26,700	1.1	29	5.0	134	163	32B
Compaction	"	24,000	1.3	31	5.7	137	168	
Miscellaneous works	L.S	1		6		27	33	10% above
Sub-total:				66		298	364	
Total:				10,827		20,239	31,066	

Table IX-5-1 Breakdown of Direct Construction Cost (2/6)

- Thiba dam, Civil works(2/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
2. Foundation Excavation								
Excavation/Hauling,								
Soil	m^3	120,000	7.5	900	37.7	4,524	5,424	
Miscellaneous works	L.S	1		90		452	542	10%
Total:				990		4,976	5,966	
3. Foundation Treatment Works								
Curtain grouting	m	18,000	340.5	6,129	449.7	809.5	14,224	
Miscellaneous works	L.S	1		613		810	1,423	10%
Total:				6,742		8,905	15,647	
4. Dam Embankment								
Impervious zone	m^3	320,000	2.3	736	9.5	3,040	3,776	
Filter zone	"	80,000	39.9	3,192	125.1	10,008	13,200	
Transition zone	"	280,000	1.9	532	7.9	2,212	2,744	
Rock zone	"	520,000	1.0	520	6.0	3,120	3,640	
Miscellaneous works	L.S	1		498		1,838	2,336	10%
Total:				5,478		20,218	25,696	

Table IX-5-1 Breakdown of Direct Construction Cost (3/6)

- Thiba dam, Civil works (3/5)-

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
5. Stockyard								
Loading/Hauling, Impervious material	m^3	84,500	1.6	135	7.1	600	735	
- Ditto -, Backfill material	"	58,900	1.6	94	18.1	1,066	1,160	
Miscellaneous works	L.S	1		23		167	190	10%
Total:				252		1,833	2,085	
6. Borrow Area/Quarry Site								
Stripping top soil	m^3	39,500	1.1	43	6.1	241	284	
Excavation/hauling, Impervious material	"	255,100	6.6	1,684	25.9	6,607	8,291	
- Ditto -, Transition material	"	250,300	7.3	1,827	28.6	7,159	8,986	
- Ditto -, Rock material	"	298,300	22.1	6,592	70.0	20,874	27,466	
Miscellaneous work	L.S	1		1,015		3,488	4,503	10%
Total:				11,161		38,369	49,530	
7. Spoil Bank								
Spoil bank	m^3	42,600	0.9	38	3.9	166	204	
Miscellaneous works	L.S	1		4		17	21	10%
Total:				42		183	225	

Table IX-5-1 Breakdown of Direct Construction Cost (4/6)

- Thiba dam, Civil works (4/5)-

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
8. Spillway								
Excavation/hauling,								
Soil	m^3	82,000	7.5	615	30.2	2,476	3,091	
- Ditto -,								
Weathered rock	"	33,000	8.0	264	32.3	1,066	1,330	
- Ditto -,								
Rock	"	55,000	24.8	1,364	75.1	4,131	5,495	
Backfill	"	52,000	3.6	187	6.8	354	541	
Reinforced concrete	"	38,000	379.9	14,436	576.4	21,903	36,339	
Form work	m^2	24,000	75.2	1,805	23.2	557	2,362	
Steel reinforcement	ton	1,520	3,578.5	5,439	7,284.5	11,072	16,511	
Miscellaneous works	L.S	1		2,411		4,156	1,567	10%
Total:				26,521		45,715	72,236	
9. Outlet Works								
9-1 Inlet Structure								
Reinforced concrete	m^3	50	379.9	19	576.4	28	47	
Form work	m^2	100	75.2	8	23.2	2	10	
Steel reinforcement	ton	3	3,578.5	11	7,284.5	22	33	
Miscellaneous works	L.S	1		4		5	9	10%
Sub-total:				42		57	99	
9-2 Plug Works								
Plain concrete	m^3	580	295.5	171	433.7	252	423	
Form work	m^2	120	75.2	9	23.2	3	12	
Miscellaneous works	L.S	1		18		26	44	10%
Sub-total:				198		281	479	

Table IX-5-1 Breakdown of Direct Construction Cost (5/6)

- Thiba dam, Civil works (5/5)-

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
9-3 Outlet Structure								
Reinforced concrete	m^3	300	379.9	114	576.4	173	287	
Form work	m^2	150	75.2	11	23.2	3	14	
Steel reinforcement	ton	15	3,578.5	54	7,284.5	109	163	
Miscellaneous works	L.S	1		18		29	47	10%
Sub-total				197		314	511	
Total:				437		694	1,089	
10. Inspection Road								
Excavation	m^3	19,500	0.9	18	3.7	76	94	
Embankment	"	19,500	1.3	25	5.7	111	136	
Latelite pavement	m^2	26,000	2.6	68	10.5	273	341	
Bridge	nos	5	66,481.3	332	50,354.3	252	584	
Miscellaneous works	L.S	1		44		71	115	10%
Total:				487		783	1,270	
Grand Total:				62,937		141,873	204,810	

Table IX-5-1 Breakdown of Direct Construction Cost (6/6)

- Thiba dam, Metal works -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
Intake Screen	ton	3	7,000	21	63,000	189	210	
Penstock, ϕ2,000	"	36	7,000	252	63,000	2,268	2,520	
Jet Flow Gate, ϕ2,000	mm	2,000	350	700	3,150	6,300	7,000	
- Ditto -, ϕ400	"	400	350	140	3,150	1,260	1,400	
High Pressure Slide Gate, ϕ2,000	"	2,000	350	700	3,150	6,300	7,000	
" , ϕ400	"	400	350	140	3,150	1,260	1,400	
Flow Meter, ϕ2,000	Pcs.	1	60,000	60	540,000	540	600	
" , ϕ400	"	1	45,000	45	405,000	405	450	
Control Panel	L.S	1		350		3,150	3,500	
Total:				2,408		21,672	24,080	

Table IX-5-2 Breakdown of Direct Construction Cost (1/3)

- Headworks, Civil Work (1/2) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
1. New Nyamindi Headworks								
Excavation /Hauling, Soil	m^3	13,500	6.6	89	25.9	350	439	
- Ditto -, Rock	"	2,700	24.2	65	71.2	192	257	
Embankment	"	2,000	2.0	4	7.7	15	19	
Plain concrete	"	950	464.8	442	258.9	246	688	
Reinforced concrete	"	1,200	505.8	607	312.1	375	982	
Formwork	m^2	3,600	75.2	271	23.2	84	355	
Steel reinforcement	ton	60	3,578.5	215	7,284.5	437	652	
Wet masonry	m^2	400	171.3	69	55.0	22	91	
Riprap	m^3	150	124.0	19	35.1	5	24	
Miscellaneous works	L.S	1		178		173	351	10%
Total:				1,959		1,899	3,858	
2. Improvement of Ex. Thiba Headworks								
Plain concrete	m^3	280	464.8	130	258.9	72	202	
Reinforced concrete	"	290	505.8	147	312.1	91	238	
Formwork	m^2	580	75.2	44	23.2	13	57	
Steel reinforcement	ton	14	3,578.5	50	7,284.5	102	152	
Wet masonry	m^2	200	171.3	34	55.0	11	45	
Riprap	m^3	350	124.0	43	35.1	12	55	
Miscellaneous works	L.S	1		45		30	75	10%
Total:				493		331	824	

Table IX-5-2 Breakdown of Direct Construction Cost (2/3)

- Headworks, Civil Work (2/2) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
1. Ruamuthambi Headworks								
Excavation /Hauling, Soil	m^3	3,000	6.6	20	25.9	78	98	
- Ditto -, Rock	"	1,000	24.2	24	71.2	71	95	
Embankment	"	1,000	2.0	2	7.7	8	10	
Plain concrete	"	480	464.8	223	258.9	124	347	
Reinforced concrete	"	470	505.8	238	312.1	147	385	
Formwork	m^2	1,500	75.2	113	23.2	35	148	
Steel reinforcement	ton	24	3,578.5	86	7,284.5	175	261	
Wet masonry	m^2	200	171.3	34	55.0	11	45	
Riprap	m^3	100	124.0	12	35.1	4	16	
Miscellaneous works	L.S	1		75		65	140	10%
Total:				827		718	1,545	
Grand Total:				3,279		2,948	6,227	

Table IX-5-2 Breakdown of Direct Construction Cost (3/3)

- Headworks, Metal Work -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
1. New Nyamindi Headworks								
Slide gates	ton	23.0	5,000	115	45,000	1,035	1,150	
Intake screen	"	1.0	5,000	5	45,000	45	50	
Total:				120		1,080	1,200	
2. Ex. Thiba Headworks								
Slide gates	ton	7.8	5,000	39	45,000	351	390	
Intake screen	"	0.6	5,000	3	45,000	27	30	
Total:				42		378	420	
3. Ruamuthambi Headworks								
Slide gates	ton	7.1	5,000	36	45,000	320	356	
Intake screen	"	0.3	5,000	2	45,000	14	16	
Total:				38		334	372	
Grand Total:				200		1,792	1,992	

Table IX-5-3 Breakdown of Direct Construction Cost (1/6)

- Link Canal, Civil Works(1/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
1. Nyamindi Headrace								
Excavation	m^3	108,000	9.1	983	35.3	3,812	4,795	
Earth lining	"	6,800	8.1	55	11.5	78	133	
Wet masonry	m^2	510	171.3	87	55.0	28	115	
Measuring device	nos.	1	23,042.1	23	9,669.7	10	33	
Culvert, Type C	"	2	94,665.0	189	93,558.0	187	376	
Latelite pavement	m^2	2,800	2.1	6	8.4	24	30	
Miscellaneous works	L.S	1		134		414	548	10%
Total:				1,477		4,553	6,030	
2. Nyamindi Division Works								
Excavation	m^3	1,300	9.1	12	35.3	46	58	
Embankment	"	200	2.0	1	7.7	2	3	
Reinforced concrete	"	140	505.8	71	312.1	44	115	
Steel reinforcement	ton	10	3,578.5	36	7,284.5	73	109	
Form work	m^2	710	75.2	53	23.2	16	69	
Miscellaneous works	L.S	1		17		18	35	10%
Total:				190		199	389	

Table IX-5-3 Breakdown of Direct Construction Cost (2/6)

- Link Canal, Civil Works(2/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount (KShs.x10^3)	Unit Cost	Amount (KShs.x10^3)	(KShs.x10^3)	
3. Nyamindi New Main Canal								
Excavation	m^3	31,400	9.1	286	35.3	1,108	1,394	
Earth lining	"	1,900	8.1	15	11.5	22	37	
Plain concrete	"	200	464.8	93	258.9	52	145	
Form work	m^2	2,000	75.2	150	23.2	46	196	
Measuring device	nos.	1	23,042.1	23	9,669.7	10	33	
Culvert, Type D	"	4	38,172.0	153	33,676.8	135	288	
Drop	"	11	19,450.9	214	17,660.6	194	408	
Latelite pavement	m^2	2,700	2.1	6	84	23	29	
Miscellaneous works	L.S	1		94		159	253	10%
Total:				1,034		1,749	2,783	
4. Link Canal I								
Excavation	m^3	267,700	9.1	2,432	35.3	9,432	11,864	
Embankment	"	69,500	2.0	139	7.7	535	674	
Earth lining	"	58,400	8.1	473	11.5	672	1,145	
Murubara Syphon	m	170	4,533.1	771	4,412.5	750	1,521	
Measuring device	nos.	1	23,042.1	23	9,669.7	10	33	
Culvert, Type D	"	13	46,976.2	611	43,971.4	572	1,183	
Drop	"	1	32,054.9	32	28,782.6	29	61	
Reinforced concrete	m^3	20	505.8	10	312.1	6	16	
Steel reinforcement	ton	1	3,578.5	4	7,284.5	7	11	
Wet masonry	m^2	3,030	171.3	519	55.0	167	686	
Latelite pavement	m^2	30,200	2.1	63	8.4	254	317	
Asphalt pavement	"	100	122.9	12	72.9	7	19	
Cross drain, Type A	nos.	11	12,746.9	140	6,348.0	70	218	
Form work	m^2	53	75.2	4	23.2	1	5	
Miscellaneous works	L.S	1		523		1,251	1,774	10%
Total:				5,756		13,763	19,519	

Table IX-5-3 Breakdown of Direct Construction Cost (3/6)

- Link Canal, Civil Works(3/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
5. Link Canal II								
Excavation	m^3	26,000	9.1	237	35.3	918	1,155	
Embankment	"	10,000	2.0	20	7.7	77	97	
Earth lining	"	20,000	8.1	162	11.5	230	392	
Measuring device	nos.	1	23,042.1	23	9,669.7	10	33	
Drop	nos.	1	59,840.1	60	53,522.1	54	114	
Wet masonry	m^2	600	171.3	103	55.0	33	136	
Culvert, Type C	"	1	94,665.0	95	93,558.0	94	189	
Miscellaneous works	L.S	1		70		142	212	10%
Total:				770		1,558	2,320	
6. Thiba Division Works								
Excavation	m^3	4,300	9.1	39	35.3	152	191	
Embankment	"	850	2.0	2	7.7	7	9	
Reinforced concrete	"	250	505.8	126	312.1	78	204	
Steel reinforcement	ton	18	3,578.5	64	7,284.5	131	195	
Plain concrete	m^3	20	464.8	9	258.9	5	14	
Form work	m^2	1,030	75.2	77	23.2	24	101	
Wet masonry	m^2	170	171.3	29	55.0	9	38	
Miscellaneous works	L.S	1		35		41	76	10%
Total:				381		447	828	

Table IX-5-3 Breakdown of Direct Construction Cost (4/6)

- Link Canal, Civil Works(4/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
7. Link Canal III								
Excavation	m^3	76,000	9.1	692	35.3	2,683	3,375	
Embankment	"	5,400	2.0	11	7.7	42	53	
Earth lining	"	18,700	8.1	151	11.5	215	366	
Measuring device	nos.	1	23,042.1	23	9,669.7	10	33	
Culvert, Type D	"	5	65,029.7	325	60,783.5	304	629	
Wet masonry	m^2	1,100	171.3	188	55.0	61	249	
Latelite pavement	"	10,600	2.1	22	8.4	89	111	
Miscellaneous works	L.S	1		141		340	481	10%
Total:				1,553		3,744	5,297	
8. Ruamuthambi Headrace								
Excavation	m^3	115,000	9.1	1,047	35.3	4,060	5,107	
Embankment	"	27,000	2.0	54	7.2	194	248	
Earth lining	"	27,200	8.1	220	11.5	313	533	
Concrete lining	"	850	464.8	395	258.9	220	615	
Form work	m^2	8,800	75.2	662	23.2	204	866	
Measuring device	nos.	1	23,042.1	23	9,669.7	10	33	
Drop	"	15	19,946.0	299	17,840.7	267	566	
Cross drain	"	1	12,746.9	13	6,348.0	6	19	
Offtake	"	2	21,279.7	43	20,687.2	41	84	
Culvert, Type D	"	4	32,744.6	131	13,049.4	52	183	
Latelite pavement	m^2	27,700	2.1	58	8.4	233	291	
Miscellaneous works	L.S	1		295		560	855	10%
Total:				3,240		6,160	9,400	

Table IX-5-3 Breakdown of Direct Construction Cost (5/6)

- Link Canal, Civil Works(5/5) -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				($KShs.x10^3$)		($KShs.x10^3$)	($KShs.x10^3$)	
9. Regurating Basin								
Excavation	m^3	50	9.1	1	35.3	2	3	
Plain concrete	"	2	464.8	1	258.9	1	2	
Reinforced concrete	"	30	505.8	15	312.1	9	24	
Form work	m^2	140	75.2	11	23.2	3	14	
Steel reinforcement	ton	2	3,578.5	7	7,248.5	14	21	
Miscellaneous works	L.S	1		4		3	7	10%
Total:				39		32	71	
Grand Total:				14,440		32,205	46,645	

Table IX-5-3 Breakdown of Direct Construction Cost (6/6)

- Link Canal, Metal Works -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
1. Nyamindi Division Works								
Slide gates	ton	4.8	5,000	24	45,000	216	240	
Screen	"	0.5	5,000	3	45,000	23	26	
Total:				27		239	266	
2. Link Canal I								
Screen, Murubara siphon	ton	0.5	5,000	3	45,000	23	26	
Total:				3		23	26	
3. Thiba Division Works								
Slide gate	ton	7.5	5,000	38	45,000	338	376	
Screen	"	0.8	5,000	4	45,000	36	40	
Total:				42		374	416	
Grand Total:				72		636	708	

Table IX-5-4 Breakdown of Direct Construction Cost (1/4)

- Irrigation Facilities, MIS -

(Unit: Kshs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(Kshs.x10^3)		(Kshs.x10^3)	(Kshs.x10^3)	
1. Irrigation Canal								
1-1 Canal Works								
Excavation	m^3	113,000	2.3	260	9.5	1,074	1,334	
Embankment	"	93,900	6.5	610	5.2	488	1,098	
Reinforced concrete lining	"	4,900	505.8	2,478	312.1	1,529	4,007	
Plain concrete lining	"	1,100	464.8	511	258.9	285	796	
Steel reinforcement	ton	240	3,518.5	859	7,289.5	1,748	2,607	
Form work	m^2	20,400	75.2	1,534	23.2	473	2,007	
Demolishing	m^3	3,140	95.0	298	-	-	298	
Miscellaneous works	L.S	1		655		560	1,215	10%
Sub-total:				7,205		6,157	13,362	

Table IX-5-4 Breakdown of Direct Construction Cost (2/4)

- Irrigation Facilities, MIS -

(Unit: Kshs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($Kshs.x10^3$)	Unit Cost	Amount ($Kshs.x10^3$)	($Kshs.x10^3$)	
1-2 Related Structures								
Offtake , (RE)	nos.	20	21,279.7	426	20,687.2	414	840	
- Ditto - , (NE)	"	10	21,013.7	210	20,687.2	207	417	
Measuring device, (NE)	"	3	23,042.1	69	9,669.7	29	98	
Check, Type B , (RE)	"	4	21,962.8	88	18,470.7	74	162	
- Ditto - , (NE)	"	12	21,259.8	255	18,470.7	222	477	
- Ditto - , (DE)	"	2	703.0	2	-	-	2	
Horse shoe weir, (RE)	"	1	23,370.6	23	8,747.4	9	32	
Chute , (NE)	"	2	89,162.2	178	39,006.4	78	256	
Drop , (RE)	"	36	25,087.9	903	10,218.5	368	1,271	
- Ditto - , (NE)	"	40	23,757.9	950	10,218.5	409	1,359	
- Ditto - , (DE)	"	1	1,330.0	1	-	-	1	
Culvert, Type A, (RE)	"	7	7,957.5	56	3,711.4	26	82	
- Ditto, Type B, (RE)	"	5	17,459.6	87	7,982.6	40	127	
- Ditto, Type C, (RE)	"	1	72,974.6	73	99,708.4	100	173	
Spill way, Type B (RE)	"	1	29,909.1	30	17,429.8	17	47	
Step washing , (RE)	"	4	18,205.8	73	6,271.9	25	98	
- Ditto - , (NE)	"	11	17,806.8	196	6,271.9	69	265	
Miscellaneous works	L.S			362		209	571	10%
Sub-total:				3,982		2,296	6,278	
Total:				11,187		8,453	19,640	

Table IX-5-4 Breakdown of Direct Construction Cost (3/4)

- Irrigation Facilities, MIS -

(Unit: Kshs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount (Kshs.x10^3)	Unit Cost	Amount (Kshs.x10^3)	(Kshs.x10^3)	
2. Drainage Canal								
2-1 Canal Works								
Excavation	m^3	307,000	2.3	706	9.5	2,917	3,623	
Embankment	"	7,800	6.5	51	5.2	41	92	
Miscellaneous works	L.S	1		76		296	372	10%
Sub-total:				833		3,254	4,087	
2-2 Related Structures								
Drainage Drop , (RE)	nos.	1	43,978.3	44	17,696.3	18	62	
- Ditto - , (NE)	"	59	40,811.7	2,408	17,696.3	1,044	3,452	
Culvert, Type B, (RE)	"	3	17,237.1	52	7,982.6	24	76	
- Ditto -, Type C, (RE)	"	10	72,974.6	730	26,733.8	267	997	
- Ditto - , (NE)	"	7	69,649.6	488	26,733.8	187	675	
- Ditto -, Type D, (NE)	"	2	137,630.4	275	52,204.0	104	379	
Drainage Inlet, Type A, (NE)	"	2	39,282.5	79	19,666.9	39	118	
- Ditto -, Type B, (NE)	"	12	9,539.9	114	5,774.9	69	183	
Reuse structure, Type A, (RE)	"	6	33,978.6	204	18,036.7	108	312	
- Ditto -, Type B, (RE)	"	5	7,957.5	40	3,711.4	19	59	
- Ditto -, Type C, (RE)	"	2	15,608.3	31	10,137.2	20	51	
Drainage junction	"	3	4,615.0	14	5,205.0	16	30	
Check	"	2	26,746.4	53	20,561.0	41	94	
Miscellaneous works	L.S			453		196	649	10%
Sub-total:				4,985		2,152	7,137	
Total:				5,818		5,406	11,224	

Table IX-5-4 Breakdown of Direct Construction Cost (4/4)

- Irrigation Facilities, MIS -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
3. Farm Road								
Embankment	m^3	177,000	2.0	354	7.7	1,363	1,717	
Latelite pavement	m^2	272,100	2.6	707	10.5	2,857	3,564	
Miscellaneous works	L.S			106		422	528	
Total:				1,167		4,642	5,809	
Grand Total:				18,172		18,501	36,673	

Table IX-5-5 Breakdown of Direct Construction Cost (1/2)

- Irrigation Facillities, Mutithi -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
1. Irrigation Canal								
1-1 Canal Works								
Excavation	m^3	25,900	2.3	60	9.5	246	306	
Embankment	"	69,804	6.5	454	5.2	363	817	
Concrete lining	"	696	4,648	324	258.9	180	504	
Form work	m^2	7,560	75.2	569	23.2	175	744	
Miscellaneous works	L.S	1		141		96	237	10%
Sub-total:				1,548		1,060	2,608	
1-2 Related Structures								
Turnout, Type B, (NE)	nos.	5	10,568.1	303	40,621.6	203	506	
Offtake , (NE)	"	38	21,013.7	799	20,687.2	786	1,585	
Measuring device, (NE)	"	8	23,042.1	184	9,669.7	77	261	
Check, Type A, (NE)	"	11	25,663.4	282	20,561.0	226	508	
- Ditto -, Type B, (NE)	"	12	21,259.8	255	18,470.7	222	477	
Chute , (NE)	"	3	89,162.2	267	39,006.4	117	384	
Drop , (NE)	"	107	23,757.9	2,542	10,218.5	1,093	3,635	
Culvert, Type A, (NE)	"	3	7,957.5	24	3,711.4	11	35	
- Ditto, Type B, (NE)	"	5	16,937.1	85	7,982.6	40	125	
Cross drain, Type A_1, (NE)	"	4	7,957.5	32	3,711.4	15	47	
- Ditto -, Type A_2, (NE)	"	1	16,937.1	17	7,982.6	8	25	
Step , (Nz)	"	14	17,806.6	249	6,271.9	88	337	
Miscellaneous works	L.S	1		504		289	793	10%
Sub-total:				5,543		3,175	8,718	
Total:				7,091		4,235	11,326	

Table IX-5-5 Breakdown of Direct Construction Cost (2/2)

- Irrigation Facillities, Mutithi -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
2. Drainage Canal								
2-1 Canal Works								
Excavation	m^3	837,872	2.3	1,927	9.5	7,960	9,887	
Embankment	"	1,320	6.5	9	5.2	7	16	
Miscellaneous works	L.S	1		194		797	991	10%
Sub-total:				2,130		8,764	10,894	
2-2 Related Structure								
Drainage drop	nos.	116	40,811.7	4,734	17,696.3	2,052	6,786	
Culbert, Type B	"	11	16,937.1	186	7,982.6	88	274	
-Ditto-, Type C	"	23	69,649.6	1,602	26,733.6	615	2,217	
-Ditto-, Type D	"	9	137,630.4	1,239	52,204.0	470	1,709	
Drainage inlet, Type A	nos.	1	35,815.0	36	19,666.9	20	56	
-Ditto-, Type B	"	25	7,539.9	238	5,774.9	144	382	
Drainage junction	"	3	4,615.0	14	5,205.0	16	30	
Syphon, Type A	"	2	25,997.3	52	13,908.3	28	80	
-Ditto-, Type B	"	2	105,242.6	210	50,141.6	100	310	
Miscellaneous works	L.S	1		831		353	1,184	10%
Sub-total:				9,142		3,886	13,028	
3. Farm Road								
Embankment	m^3	200,000	2.0	400	7.7	1,540	1,940	
Latelite pavement	m^2	403,000	2.6	1,048	10.5	4,232	5,280	
Cross drain	nos.	3	7,957.5	24	3,711.4	11	35	
Miscellaneous works		1		147		578	725	10%
Total:				1,619		6,361	7,980	
Grand Total:				19,982		23,246	43,228	

Table IX-5-6 Breakdown of Direct Construction Cost (1/3)

- On-Farm, MIS -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount (KShs.x10^3)	Unit Cost	Amount (KShs.x10^3)	(KShs.x10^3)	
1. Improvement of Paddy Field								
1-1 Irrigation Facilities								
Feeder canal, Excavation	m^3	38,500	2.3	89	9.5	366	455	0.35BHS
-Ditto-, Embankment	"	38,500	6.5	250	5.2	200	450	M.P.
Drainage canal, Excavation	"	82,000	2.3	189	9.5	779	968	
-Ditto-, Embankment	"	23,200	6.5	151	5.2	121	272	
Farm road, Embankment	"	57,400	0.9	52	3.3	189	241	11B
-Ditto-, Latelite pavement	m^2	281,300	2.6	731	10.5	2,954	3,685	
Miscellaneous works	L.S	1		146		461	607	10%
Sub-total:				1,608		5,070	6,678	
1-2 Related Structures								
Offtake (NE)	nos.	30	1,933.6	58	1,180.3	35	93	
Culvert (RE)	"	60	2,917.8	175	1,377.2	83	258	
Check with Drop (RE)	"	1,950	1,794.2	3,499	577.4	1,126	4,625	
Farm Approach (NE)	"	3,660	1,195.3	4,375	727.9	2,664	7,039	
Drainage junction, Type A (NE)	"	1,760	597.9	1,052	591.3	1,041	2,093	
Miscellaneous works	L.S	1		915		495	1,411	10%
Sub-total:				10,075		5,444	15,519	
Total:				11,683		10,514	22,197	

Table IX-5-6 Breakdown of Direct Construction Cost (2/3)

- On-Farm, MIS -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount ($KShs.x10^3$)	Unit Cost	Amount ($KShs.x10^3$)	($KShs.x10^3$)	
2. Reclamation of Horticultural Crops Field								
2-1 Land Reclamation								
Excavation/Embankment	m^3	67,200	4.0	269	14.7	988	1,257	
Miscellaneous works	L.S	1		50		184	234	10%
Sub-total:				550		2,022	2,572	
2-2 Irrigation Facilities								
Feeder canal, Excavation	m^3	27,700	2.3	64	9.5	263	327	
-Ditto-, Embankment	"	51,500	6.5	335	5.2	268	603	
Drainage canal, Excavation	"	77,400	2.3	178	9.5	735	913	
-Ditto-, Embankment	"	16,700	6.5	109	5.2	87	196	
Farm road, Embankment	"	43,700	0.9	39	3.3	144	183	
-Ditto-, Latelite pavement	m^2	213,000	2.6	554	10.5	2,237	2,791	
Miscellaneous works	L.S	1		133		396	529	10%
Sub-total:				1,466		4,356	5,822	

Table IX-5-6 Breakdown of Direct Construction Cost (3/3)

- On-Farm, MIS -

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
2-3 Related Structures								
Offtake (NE)	nos.	130	1,726.4	224	1,180.3	153	377	
Culvert (RE)	"	130	2,765.8	360	1,377.2	179	539	
Check with drop (RE)	"	500	1,632.7	816	577.4	289	1,105	
Farm approach (NE)	"	500	1,195.3	598	727.9	364	962	
Drainage drop (NE)	"	1,340	1,513.9	2,029	577.4	774	2,803	
Drainage junction, Type A (NE)	"	130	597.9	78	591.3	77	155	
-Ditto-, Type B (NE)	"	70	697.6	49	689.9	48	97	
Miscellaneous works	L.S	1		415		189	604	10%
Sub-total:				4,569		2,073	6,642	
Total:				6,585		8,451	15,036	
Grand Total:				18,268		18,965	37,233	

Table IX-S-7 Breakdown of Direct Construction Cost (1/3)

- On-Farm, Mutithi -

(Unit: Kshs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				KShs.x10^3		KShs.x10^3	KShs.x10^3	
1. Paddy Field								
1-1 Land Reclamation								
Excavation/Embankment	m^3	618,000	4.0	2,472	147	9,085	11,557	
Levee	km	618	3,246.8	2,007	702.0	434	2,441	
Miscellaneous works	L.S	1		448		952	1,400	10%
Sub-total:				4,927		10,471	15,398	
1-2. Irrigation Facilities								
Feeder canal, Excavation	m^3	81,000	2.3	186	9.5	770	956	
-Ditto-, Embankment	"	81,000	6.5	527	5.2	421	948	
Drainage canal, Excavation	"	212,400	2.3	489	9.5	2,018	2,507	
-Ditto-, Embankment	"	48,900	6.5	318	5.2	254	572	
Farm road, Embankment	"	121,000	0.9	109	3.3	399	508	
-Ditto-, Latelite pavement	m^2	592,800	2.6	1,541	10.5	6,224	7,765	
Miscellaneous works	L.S	1		317		1,009	1,326	10%
Sub-total:				3,487		11,095	14,582	
1-3 Related Structures								
Offtake (NE)	nos.	140	1,724.6	241	1,180.3	165	406	
Culvert (NE)	"	270	2,765.8	747	1,377.2	372	1,119	
Check (NE)	"	860	1,632.7	1,404	577.4	497	1,901	
Farm approach (NE)	"	1,710	1,195.3	2,044	729.9	1,248	3,292	
Drainage junction, Type A (NE)	"	740	597.9	442	591.3	438	880	
Miscellaneous works	L.S	1		488		272	760	10%
Sub-total:				5,366		2,992	8,358	
Total:				13,780		24,558	38,338	

Table IX-5-7 Breakdown of Direct Construction Cost (2/3)

- On-Farm, Mutithi -

(Unit: Kshs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				KShs.x10^3		KShs.x10^3	KShs.x10^3	
2. Horticultural Crops Field								
2-1 Land Reclamation								
Excavation/Embankment	m^3	67,200	4.0	269	14.7	988	1,257	
Miscellaneous works	L.S	1		27		99	126	10%
Sub-total:				296		1,087	1,383	
2-2 Irrigation Facilities								
Feeder canal, Excavation	m^3	27,700	2.3	64	9.5	263	327	
-Ditto-, Embankment	"	27,700	6.5	180	5.2	144	324	
Drainage canal, Excavation	"	41,600	2.3	96	9.5	395	491	
-Ditto-, Embankment	"	9,000	6.5	59	5.2	47	106	
Farm road, Embankment	"	23,500	0.9	21	3.3	78	99	
-Ditto-, Latelite pavement	m^2	114,800	2.6	298	10.5	1,205	1,503	
Miscellaneous works	L.S	1		72		213	285	10%
Sub-total:				790		2,345	3,135	

Table IX-5-7 Breakdown of Direct Construction Cost (3/3)

- On-Farm, Mutithi -

(Unit: Kshs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				KShs.x10^3		KShs.x10^3	KShs.x10^3	
2-3 Related Structures								
Offtake (NE)	nos.	70	1,724.6	121	1,180.3	83	204	
Culvert (NE)	"	70	2,765.8	194	1,377.2	96	290	
Check with drop (NE)	"	270	1,632.7	441	577.4	156	597	
Farm approach (NE)	"	270	1,195.3	323	729.9	197	520	
Drainage drop (NE)	"	720	1,513.9	1,090	577.4	416	1,506	
Drainage junction, Type A (NE)	"	70	597.9	42	591.3	41	83	
-Ditto-, Type B (NE)	"	40	697.6	28	689.9	28	56	
Miscellaneous works	L.S	1		224		102	326	10%
Sub-total:				2,463		1,119	3,582	
Total:				3,549		4,551	8,100	
Grand Total:				17,329		29,109	46,438	

Table IX-6 Unit Cost of Labour

Description	Grade	Unit	Local Currency (KShs.)	Foreign Currency (KShs.)	Total
Foreman B	11	M.D.	110	-	110
Common Labour	2	M.D.	50	-	50
Skilled Labour	4	M.D.	55	-	55
Unskilled Labour	1	M.D.	45	-	45
Operator	9	M.D.	90	-	90
Driver A	9	M.D.	90	-	90
Driver B	8	M.D.	80	-	80
Carpenter	8	M.D.	80	-	80
Mason	8	M.D.	80	-	80
Plaster	8	M.D.	80	-	80
Pipe Filter	8	M.D.	80	-	80
Plumber	8	M.D.	80	-	80
Plant Operater	8	M.D.	80	-	80
Powder Operater	8	M.D.	80	-	80
Mechanic	9	M.D.	90	-	90
Electrician	9	M.D.	90	-	90
Welder	8	M.D.	80	-	80
Painter	8	M.D.	80	-	80
Reinforcement Worker	6	M.D.	65	-	65
Machine Attendant	4	M.D.	55	-	55
Tunnel Worker	8	M.D.	80	-	80

Table IX-7 Major Equipment Cost

Description	Spec.	Unit	Local Currency (KShs.)	Foreign Currency (KShs.)	Total (KShs.)
Bulldozer	11 ton	Day	440	1,760	2,200
" with ripper	21 ton	"	980	3,920	4,900
" "	32 ton	"	1,260	5,040	6,300
Wheeled Loader	1.0 m^3	"	380	1,520	1,900
Crowler Loader	2.2 m^3	"	940	3,760	4,700
"	0.8 m^3	"	460	1,840	2,300
"	3.2 m^3	"	1,080	4,320	5,400
Backhoe Shovel	0.35 m^3	"	380	1,520	1,900
"	0.7 m^3	"	500	2,000	2,500
"	1.2 m^3	"	780	3,120	3,900
Crowler Tractor	8 ton	"	320	1,280	1,600
Tamping Roller	6 ton	"	170	680	850
Vibratory Roller	9 ton	"	480	1,920	2,400
Macadom Roller	8-20 ton	"	480	1,920	2,400
Pneumatic Tyred Roller	8-20 ton	"	480	1,920	2,400
Vibratory Plate Compactor	90 kg	"	30	120	150
Tamper	60 kg	"	30	120	150
Motor Grador	125 H.P	"	780	3,120	3,900
Tipper Lorry	10 ton	"	350	1,400	1,750
Jack Hammer	20 kg	"	16	62	80
Leg Drill	40 kg	"	22	88	110
Crawler Drill	150 kg	"	720	2,880	3,600
Air Compressor	5 m^3/min	"	170	680	850
"	21 m^3/min	"	600	2,400	3,000
Vertiration Fun	400 m^3/min	"	86	344	430
Boring Rig	5.5 kW	"	68	272	340
Grouting Pump	7.5 kW	"	76	304	380
"	3.7 kW	"	50	200	250
Grouting Mixer	5.5 kW	"	30	120	150
"	2.2 kW	"	36	144	180
Concrete Mixer	0.2 m^3	"	30	120	150
Concrete Mixing Plant	0.75 m^3	"	700	2,800	3,500
Crushing Plant	50 t/h	"	2,540	10,160	12,700
Generator	5 kVA	"	30	120	150
Agitator Truck		"	250	1,000	1,250
Concrete Pumping Car		"	680	2,720	3,400

Table IX-8 Cost of Materials (1/2)

Description	Unit	Local Currency (KShs.)	Foreign Currency (KShs.)	Total (KShs.)
Gasoline	lit.	2.0	6.3	8.30
Light Oil	lit.	-	5.5	5.50
Electric Power Charge	kWh.	0.8	-	0.8
Portland Cement, Ordinary	kg	0.9	0.9	1.8
Air-bubble Agent	"	15.8	29.2	45.00
Water-reducing Agent	"	14.0	26.0	40.00
Asphalt Mixture	ton	720.0	480.0	1,200.00
Fine Aggregate, River Sand	"	100.0	-	100.00
Coarse Aggregate, Crushed	"	96.0	24.0	120.00
Crushed Stone	"	64.0	16.0	80.00
Stone Block	"	200.0	-	200.00
Steel Reinforcement	kg	3.0	7.0	10.00
Mild Steel Heavy Sections	"	5.4	12.6	18.00
Mild Steel Light Sections	"	4.5	10.5	15.00
Mild Steel Plates	"	5.4	12.6	18.00
Mild Steel Sheets	"	5.4	12.6	18.00
Bolts and Nuts	kg	12.0	28.0	40.00
Nails	"	3.0	7.0	10.00
Binding Wire	"	6.0	14.0	20.00
Gabion Box, #10x40x120x2,000	Pcs.	75.0	175.0	250.00
Concrete Pipes ϕ300 x 1,200	Pcs.	192.0	128.0	320.00
" ϕ375 x 1,200	"	258.0	172.0	430.00
" ϕ450 x 1,500	"	528.0	352.0	880.00
" ϕ525 x 1,500	"	636.0	424.0	1,060.00
" ϕ600 x 1,500	"	810.0	540.0	1,350.00
" ϕ675 x 1,500	"	990.0	660.0	1,650.00
" ϕ825 x 1,500	"	1,368.0	912.0	2,280.00
" ϕ975 x 1,500	"	1,716.0	1,144.0	2,860.00
Dynamite	kg	35.0	65.0	100.00
AN-FO Powder	kg	7.0	13.0	20.00
Detonator, Ordinary	Pcs.	7.0	13.0	20.00
Detonator, Delay	Pcs.	8.5	16.5	25.00

Table IX-8 Cost of Materials (2/2)

Description		Unit	Local Currency (KShs.)	Foreign Currency (KShs.)	Total (KShs.)
Cross Bit	36 mm	Pcs.	250.0	530.0	780.00
Cross Bit	65 mm	"	528.0	1,122.0	1,650.00
Rod, Tapered	22 R	"	272.0	578.0	850.00
Rod, Screwed	32 H	"	1,136.0	2,414.0	3,550.00
Shank Rod	32 H	"	768.0	1,632.0	2,400.00
Sleeve	32 H	"	346.0	734.0	1,080.00
Diamond Bit		ct.	352.0	748.0	1,100.00
Diamond Reamer		ct.	352.0	748.0	1,100.00
Core Tube, Double		Pcs.	608.0	1,292.0	1,900.00
Core Liftering		Pcs.	240.0	510.0	750.00
Boring Rod		Pcs.	480.0	1,020.0	1,500.00
Timber, Plank		m^3	4,500.0	-	4,500.00
Timber, Square		"	3,300.0	-	3,300.00
Timber, Log		"	2,800.00	-	2,800.00
Plywood		Panel	324.0	36.0	360.00
Form Oil		lit	16.5	40.0	56.50
Form Tie		Pcs.	3.5	6.5	10.00
Rib Washer		"	3.2	5.8	9.00
Cone		"	3.5	6.5	10.00
Separator		"	2.8	5.2	8.00
Pipe Support			50.6	94.4	145.00

Table IX-9 Procurement Cost of Major Equipment for Operation and Maintenance (1/3)

(Unit: KShs.x10^3)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
1. MIS								
1-1 Heavy Equipment/ Transportation Equipment								
Backhoe shovel, 0.3 m	nos.	3	133	399	1,307	3,921	4,320	
-Ditto-, 0.6 m^3	"	1	193	193	1,933	1,933	2,126	
Bulldozer, 11 t	"	1	132	132	1,342	1,342	1,474	
Wheeled loader, 1.0 m^3	"	1	73	73	777	777	850	
Motor grader, 3.7 m	"	2	147	294	1,483	2,966	3,260	
Road roller, 5 ton	"	1	68	68	712	712	780	
Vibrating plate, 3 PS	"	2	1	2	13	26	28	
Concrete mixer, 0.12 m^3	"	2	5	10	49	98	108	
Submersible pump, o50m/m	"	2	1	2	12	24	26	
Portable generator, 3kVA	"	1	5	5	48	48	53	
Long wheeled base lorry, 12 ton	"	2	83	166	827	1,654	1,820	
Fuel tunker, 8 ton	"	1	75	75	754	754	829	
Dump truck, 8 ton	"	2	64	128	641	1,282	1,410	
Dump truck, 3 ton	"	1	33	33	333	333	366	
Workshop service vehicle, 1.5 ton	"	1	23	23	230	230	253	
Cargo truck, 6 ton	"	5	40	200	404	2,020	2,220	
-Ditto-, but self loading, 5 ton	"	1	36	36	314	314	350	
-Ditto-, but with 3t crane, 6 ton	"	5	46	230	463	2,315	2,545	
Pick up truck, 1 ton	"	5	13	65	132	660	725	
Jeep, 4,000 cc	"	6	25	150	253	1,518	1,668	
Station wagon		5	15	75	150	750	825	
Motor cycle		15	2	30	17	255	285	
Spare parts and tools	L.S	1		119		1,196	1,315	5%
Sub-total:				2,508		25,128	27,636	

Table IX-9 Procurement Cost of Major Equipment for Operation and Maintenance (2/3)

(Unit: KShs.x10^3)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
1-2. Water Management Equipment								
Personal computer and attachment	L.S	1	33	33	326	326	359	
Control panel	nos.	1	94	94	942	942	1,036	
Meteorological equipment	L.S	1	361	361	3,613	3,613	3,974	
Telecommunication system, Base station	nos.	1	17	17	117	117	134	
-Ditto-, Field station	"	5	1	5	6	30	35	
-Ditto-, Distribution line	km	27	66	1,782	42	1,134	2,916	
Sub-total:				2,292		6,162	8,454	
Total:				4,800		31,290	36,090	
2. Mutithi Extension Area/Dam								
2-1 Heavy Equipment/ Transportation								
Backhoe shovel, 0.3 m^3	nos.	3	133	399	1,307	3,921	4,320	
-Ditto-, 0.6 m^3	"	2	193	386	1,933	3,866	4,252	
Bulldozer, 11 ton	"	2	132	264	1,342	2,684	2,948	
Wheeled loader, 1.0 m^3	"	1	73	73	777	777	850	
Motor grader, 3.7 m	"	2	147	294	1,483	2,966	3,260	
Road roller, 5 ton	"	2	68	136	712	1,424	1,560	
Vibration plate, 3 PS	ton	2	1	2	13	26	28	
Concrete mixer, 0.12 m^3	"	1	5	5	49	49	54	
Submersible pump, o50 mm	"	3	1	3	12	36	39	
Portable generator, 3kVA	"	2	5	10	48	96	106	
Dump truck, 8 ton	"	2	64	128	641	1,282	1,410	
-Ditto-, 3 ton	"	1	33	33	333	333	366	
Workshop service vihicle, 1.5 ton	"	1	23	23	230	230	253	

Table IX-9 Procurement Cost of Major Equipment for Operation and Maintenance (3/3)

(Unit: KShs.x10^3)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
Cargo truck, 6 ton	"	2	40	80	404	808	888	
-Ditto-, self loading, 5 ton	"	1	36	36	314	314	350	
-Ditto-, with 3t crane, 6 ton	"	2	46	92	463	926	1,018	
Pick up truck	"	2	13	26	132	264	290	
Jeep	"	2	25	50	253	506	556	
Station wagon	"	6	15	90	150	900	990	
Motor cycle	"	10	2	20	27	270	290	
Spare parts and tools	L.S	1	2	2	17	17	19	
Sub-total:				2,152		21,695	28,847	
2-2 Water Management Equipment								
Meteorological equipment	L.S	1	190	190	1,900	1,900	2,090	
Telecommunication system, Field station	nos.	2	1	2	6	12	24	
-Ditto-, Distribution line	km	21	66	1,386	42	882	2,268	
Sub-total:				1,578		2,794	4,372	
2-3 Dam Management Equipment								
Motor boat, 15 feet	nos.	1	53	53	353	353	406	
Boom	"	1	18	18	177	177	195	
Flood alarm system	L.S	1	164	164	319	319	483	
Survey instruments	"	1	12	12	118	118	130	
Miscellaneous facilities	"	1		12		48	60	5%
Sub-total:				259		1,015	1,274	
Total:				3,989		25,504	29,493	
Grand Total:				8,789		56,794	65,583	

Table IX-10 Procurement Cost of Agricultural Machinery

(Unit: KShs.x10^3)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
1. MIS								
4 wheel drive tractor (60 PS)	nos.	49	59	2,891	589	28,861	31,752	
Crawler tractor (60 PS)	"	10	77	770	765	7,650	8,420	
Rotavator	"	59	11	649	106	6,254	6,903	
Chizel plough	"	4	6	24	59	236	260	
Sprayer	"	19	7	133	71	1,349	1,482	
Trailer, 2t	"	32	8	256	82	2,624	2,880	
Total:				4,723		46,974	51,697	
2. Mutithi								
4 wheel drive tractor	nos.	31	59	1,829	589	18,259	20,088	
Crawler tractor	"	4	77	308	765	3,060	3,368	
Rotavator	"	35	11	385	106	3,710	4,095	
Chizel plough	"	2	6	12	59	118	130	
Sprayer	"	8	7	56	71	568	624	
Trailer	"	13	8	104	82	1,066	1,170	
Total:				2,694		26,781	29,475	
Grand Total				7,417		73,755	81,172	

Table IX-11 Detailed Construction Cost of Farm Building

(Unit: KShs.)

Work Item	Unit	Quantity	Local Currency		Foreign Currency		Total	Remarks
			Unit Cost	Amount	Unit Cost	Amount		
				(KShs.x10^3)		(KShs.x10^3)	(KShs.x10^3)	
1. MIS								
1-1 Reception Centre								
Drying floor	m^2	9,800	220	2,156	230	2,254	4,410	
Warehouse	"	5,500	220	1,210	230	1,265	2,475	
Collection/shipping space	"	4,000	220	880	230	920	1,800	
Office	"	1,000	220	220	230	230	450	
Sub-total:				4,466		4,669	9,135	
1-2 Machine Centre								
Garage	m^2	9,600	220	2,112	230	2,208	4,320	
Workshop	"	3,200	220	704	230	736	1,440	
Parking area	"	19,800	19.5	386	8.9	176	562	
Stores for spare parts	"	600	220	132	230	138	270	
Office	"	200	220	44	230	46	90	
Sub-total:				3,378		3,304	6,682	
Total:				7,844		7,973	15,817	
2. Mutithi								
Reception centre								
Drying floor	m^2	14,800	220	3,256	230	3,404	6,660	
Warehouse	"	2,400	220	528	230	552	1,080	
Collection/shipping space	"	2,200	220	484	230	506	990	
Storing space	"	4,400	220	968	230	1,012	1,980	
Office	"	900	220	198	230	207	405	
Total:				5,434		5,681	11,115	
Grand Total:				13,278		13,654	26,932	

Table IX-12 Cost for Land Acquisition

Description	Area (ha)	Unit Cost (KShs.)	Amount (KShs.x10^3)
1. Phase-I			
Link Canals			
Uncultivated Area	35	8,000	280
Total:			280
2. Phase-II			
Thiba Dam			
Cultivated Area	80	12,000	960
Uncultivated Area	60	8,000	480
Sub-total:			1,440
Link Canals			
Uncultivated Area	20	8,000	160
Total:			1,600
Grand Total:			1,880

Table IX-13 Annual Disbursement Schedule of the Project

(Unit: KShs.million)

Description	Fiscal Year 1988		1989		1990		1991		1992		1993		Total		
	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. Phase-I															
1 - 1 Construction Cost			24.4	41.3	2.1	4.3	44.0	42.3					70.5	87.9	158.4
Headworks			3.1	3.9	0.7	0.9							3.8	4.8	8.6
Link canals			11.9	28.0	1.4	3.4							13.3	31.4	44.7
Irrigation facilities			6.9	7.1			18.2	18.4					25.1	25.5	50.6
On-farm			2.5	2.3			25.8	23.9					28.3	26.2	54.5
1 - 2 Initial Farm Investment			7.1	37.2	7.0	17.2	3.2	31.9					17.3	86.3	103.6
O & M equipment			3.0	19.4	1.8	11.9							4.8	31.3	36.1
Agricultural machinery			1.5	15.1			3.2	31.9					4.7	47.0	51.7
Farm buildings			2.6	2.7	5.2	5.3							7.8	8.0	15.8
1 - 3 Administration Cost	1.9		2.0		2.0		2.0						7.9	0.0	7.9
1 - 4 Engineering Cost	5.3	7.9	2.1	3.1	0.5	0.8	2.6	3.9					10.5	15.7	26.2
1 - 5 Land Acquisition			0.3										0.3	0.0	0.3
Sub-total:	7.2	7.9	35.9	81.6	11.6	22.3	51.8	78.1					106.5	189.9	296.4
1 - 6 Physical Contingency	0.7	0.8	3.6	8.2	1.2	2.2	5.2	7.8					10.7	19.0	29.7
Sub-total:	7.9	8.7	39.5	89.8	12.8	24.5	57.0	85.9					117.2	208.9	326.1
1 - 7 Price Contingency	0.5	0.2	5.7	5.5	2.9	2.3	17.7	10.8					26.8	18.8	45.6
Total:	8.4	8.9	45.2	95.3	15.7	26.8	74.7	96.7					144.0	227.7	371.7
2. Phase-II															
2 - 1 Construction Cost							19.4	47.0	66.6	134.7	70.4	140.7	156.4	322.4	478.8
Dam works							19.4	47.0	38.7	94.0	38.8	94.0	96.9	235.0	331.9
Head works											1.3	1.4	1.3	1.4	2.7
Link canals									2.2	4.6	4.5	9.1	6.7	13.7	20.4
Irrigation facilities									13.8	16.0	13.8	16.1	27.6	32.1	59.7
On-farm									11.9	20.1	12.0	20.1	23.9	40.2	64.1
2 - 2 Initial Farm Investment											12.1	58.0	12.1	58.0	70.1
O & M equipment											4.0	25.5	4.0	25.5	29.5
Agricultural machinery											2.7	26.8	2.7	26.8	29.5
Farm-buildings											5.4	5.7	5.4	5.7	11.1
2 - 3 Administration Cost			2.8		2.8		2.9		4.0		4.0		16.5		16.5
2 - 4 Engineering Cost			6.3	9.4	6.4	9.4	3.1	4.7	3.1	4.7	3.1	4.7	22.0	32.9	54.9
2 - 5 Land Acquisition							1.6						1.6		1.6
Sub-total:			9.1	9.4	9.2	9.4	27.0	51.7	73.7	139.4	89.6	203.4	208.6	413.3	621.9
2 - 6 Physical Contingency			0.9	0.9	0.9	0.9	2.7	5.2	7.4	13.9	9.0	20.3	20.9	41.2	62.1
Sub-total:			10.0	10.3	10.1	10.3	29.7	56.9	81.1	153.3	98.6	223.7	229.5	454.5	684.0
2 - 7 Price Contingency			1.4	0.6	2.3	1.0	9.2	7.1	32.6	24.4	49.4	43.4	94.9	76.5	171.4
Total:			11.4	10.9	12.4	11.3	38.9	64.0	113.7	177.7	148.0	267.1	324.4	531.0	855.4
Grand Total:	8.4	8.9	56.6	106.2	28.1	38.1	113.6	160.7	113.7	177.7	148.0	267.1	468.4	758.7	1,227.1

Table IX-14 Annual Operation & Maintenance Cost

Item		Amount (KShs.x10^3)
1. Salaries & Wages		
1-1	Staff Salaries	13,700
1-2	Labour Wages (200 M/M @1600 KShs.)	320
2. Office Expenses		411
3. Operation & Maintenance Cost		
3-1	Depreciation of O & M Equipment	16,400
3-2	Dam	2,468
3-3	Irrigation	19,466
	Total:	52,765

Table IX-15 O & M Staff Salary

Item	Required Number	Annual Rate	Annual Amount (KShs.x10^3)
Managing staff	32	70	2,240
Technical & Administrative staff	174	40	6,960
Workers & Labours	225	20	4,500
Total:			13,700

Table IX-16 Replacement Cost

Item		Useful Life (year)	Replacement Cost (KShs.x10^3)
1. O & M Equipment		10	65,583
2. Project Facilities			27,223
(1)	Dam	25	24,433
(2)	Headworks	25	1,992
(3)	Irrigation facilities	25	708
(4)	On-Farm (stop log)	5	90

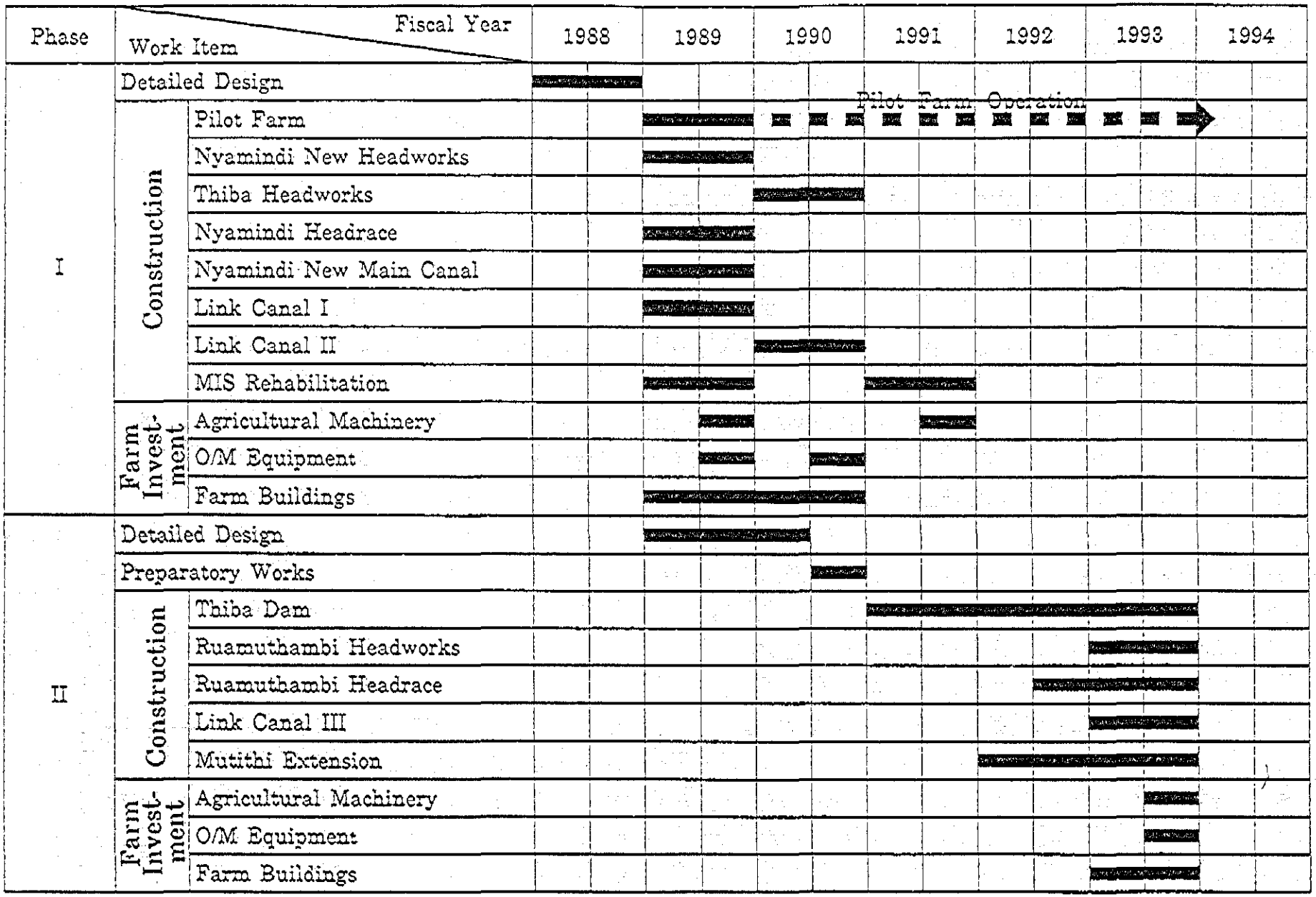

Fig. IX-1 IMPLEMENTATION SCHEDULE OF THE PROJECT

ANNEX - X

PROJECT EVALUATION

ANNEX - X

PROJECT EVALUATION

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1. GENERAL

The preliminary economic evaluations were carried out for six (6) alternative development options as a part of the Project optimization process discussed in Chapter IV. The height of the Thiba dam has been fixed at 35.0 m, corresponding to a reservoir capacity of 180 MCM, as the optimum size of the dam which also made optimum use of the available water resources.

The results from the initial evaluations which revealed a several economically feasible options, led to selection of the proposed development for an area of 9,560 ha, enabling a cropping intensity of 200%. The development area comprises 5,860 ha of the existing MIS Scheme area and 2,900 ha of the Mutithi extension area. In this Chapter, overall Project evaluation is discussed in detail for this selected one particular case.

The Project evaluation has been made through an assessment of Project feasibility in view of economic, financial and socio-economic aspects. The economic feasibility is evaluated by calculating the internal rate of return (IRR) and the net present value (NPV) at the discount rate of 10%. Sensitivity analyses have also been made in order to elucidate the economic viability of the Project against the changes in the benefits, build-up period, construction periods and the Project costs.

Financial evaluation has been carried out by analyzing the effect of the Project on a typical farm holding 1.6 ha of rice field and also by preparing the repayment schedule for the anticipated loan.

The socio-economic impacts from the implementation of the Project have also been briefly studied.

2. ECONOMIC EVALUATION

2.1 Basic Assumptions

The economic evaluation has been made on the following basic assumptions:

(1) The construction period will be six (6) years including the period of detailed design and preparatory works.

(2) The economic useful life of the Project will be 50 years after implementation.

(3) All prices are expressed in constant mid-1987 prices.

(4) The exchange rate of US$1.00 = KShs.16.5 = ¥150 as of mid-1987 is used throughout.

(5) Only irrigation benefits are counted in the economic evaluation, and any benefits to be derived from the fishery, hydropower generation, water release for downstream areas, etc., are not taken into account.

2.2 Evaluation of Economic Factors

For evaluation of economic prices and costs, the following criteria have been used:

2.2.1 Standard conversion factor (SCF)

In order to evaluate the Project costs and benefits with respect to world market prices, a SCF of 0.86 has been applied to the prices of non-traded goods and services. This figure is calculated on the basis of the export and import statistics for the years 1982-1986 given in the "Annual Trade Yearbook" published by the Custom & Excise Department of the Custom House.

2.2.2 Transfer payment

From the viewpoint of the international economy, the transfer payments such as contract tax, duty, subsidy and interest are considered as a domestic monetary movement without direct production. These transfer payments are, therefore, excluded from the Project costs as far as the economic analysis is concerned.