GOVERNMENT OF MALAYSIA

KINABATANGAN RIVER BASIN DEVELOPMENT PROJECT

MAIN REPORT

MARCH 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of Malaysia, the Government of Japan decided to conduct a pre-feasibility study on the Kinabatangan River Basin Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Malaysia a study team headed by Mr. Katsuhisa Abe of a joint venture of the CTI Engineering Co.,Ltd. and the Chuokaihatsu Corporation, from December 1980 to November 1981.

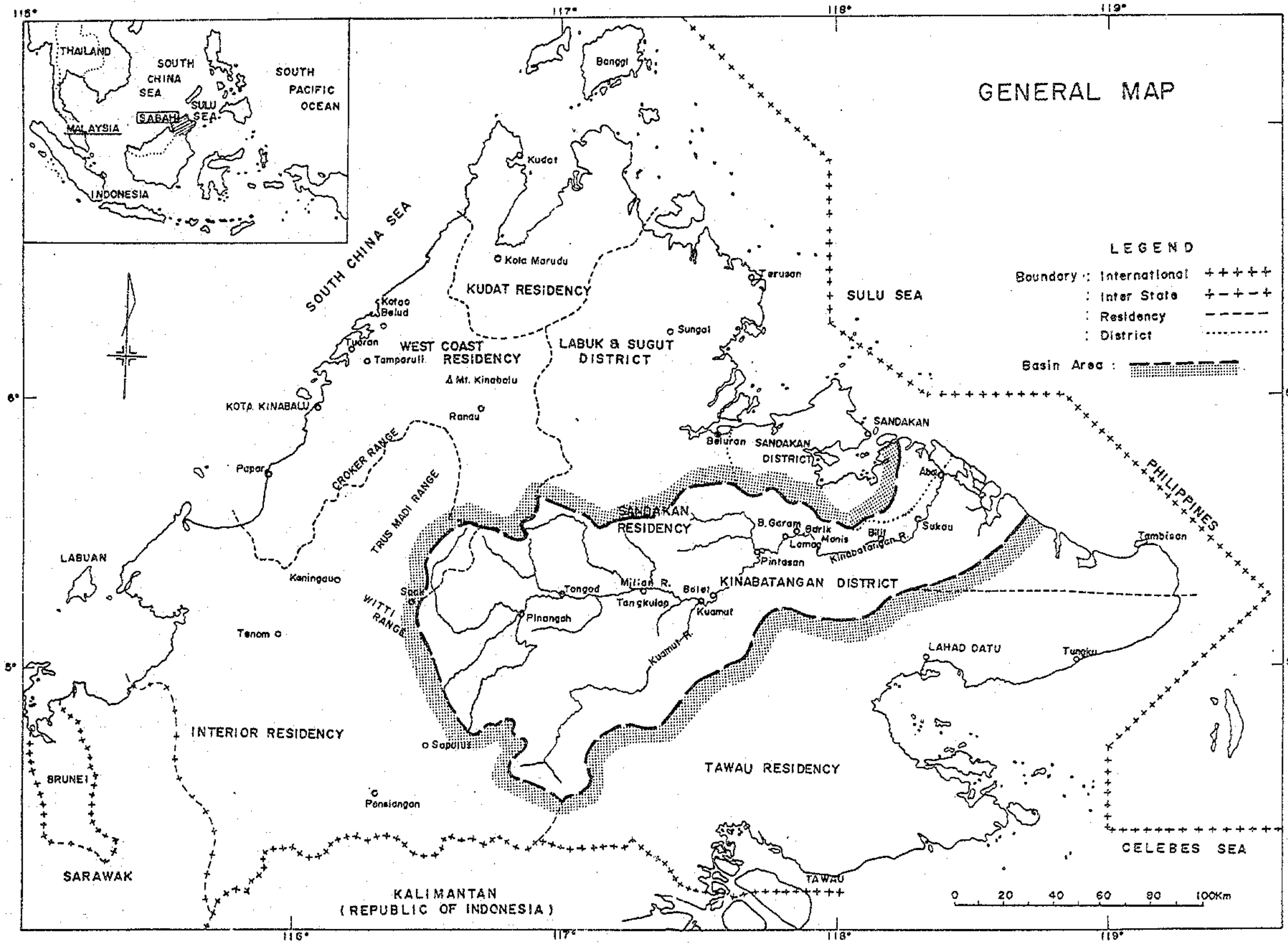
The team exchanged views with the Malaysian authorities concerned and conducted a field survey in the Kinabatangan river basin in the State of Sabah. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

March, 1982

Keisuke Arita
President
Japan International Cooperation Agency


GENERAL MAP
LEGEND
Boundary : International
: Inter State
: Residency
: District
Basin Area :
0 20 40 60 80 100Km
115°
116°
117°
118°
119°
6°
5°
THAILAND
SOUTH CHINA SEA
SOUTH PACIFIC OCEAN
SULU SEA
SABAH
MALAYSIA
INDONESIA
SOUTH CHINA SEA
SULU SEA
CELEBES SEA
PHILIPPINES
KALIMANTAN (REPUBLIC OF INDONESIA)
SARAWAK
BRUNEI
LABUAN
Banggi
Kudat
Kota Marudu
KUDAT RESIDENCY
LABUK & SUGUT DISTRICT
Sungai
Terusan
Kotaa Belud
Tuaran
Tamparuli
WEST COAST RESIDENCY
Mt. Kinabalu
Ranau
KOTA KINABALU
Papar
CROKER RANGE
TRUS MADI RANGE
WITTI RANGE
Keningau
Tenom
INTERIOR RESIDENCY
Sapulut
Pensiangan
SANDAKAN
Beluran
SANDAKAN DISTRICT
SANDAKAN RESIDENCY
Abai
Sukau
B. Garam
Batik
Lamag
Manis
Bilit
Kinabatangan R.
Pintasan
KINABATANGAN DISTRICT
Milian R.
Tongod
Tangkulap
Balat
Kuamut
Kuamut R.
Pinangah
Tambisan
LAHAD DATU
Tungku
TAWAU RESIDENCY
TAWAU

SUMMARY OF THE PROJECT

1. GENERAL

The vast natural resources scarcely tapped for countless centuries in the past in the Kinabatangan River Basin in the State of Sabah of the Federation of Malaysia began attracting serious attention of both the State Government and the Federal Government since the latter part of the 1970's.

While various development programmes are being laid out for the future, for orderly development of the flood prone area of the Basin, the proper control of the flooding water is indispensable. To attain this purpose, it is essential to construct dam in the upper or the middle reaches of the Kinabatangan River, as a result of which the benefitted area which is relieved from the flooding can be expected to develop for agricultural purpose and likewise hydro power generation can be developed to support the incremental demand in the East Division.

In connection to above, the dam whose construction is proposed at Balat, middle reaches of the Kinabatangan, will be designed as a multi-purpose dam to support the development plans in the project area which consist of flood control, agricultural development and hydro power generation.

The storage capacity to be developed has been allocated for the purpose of flood control and irrigation.

A hydro power generation which is generated by utilizing the water head to be created by the proposed dam, will support the power demand in the future.

2. OBJECTIVE AND SCOPE OF THE STUDY

Objective of the Study

The objective of the study which was agreed upon by and between the Government of Malaysia and the Government of Japan is to conduct a pre-feasibility study on the Kinabatangan River Basin Development Project, more specifically, the preparation of an outline development plan for flood prone area in the Kinabatangan River Basin.

Scope of the Study

- Study on potential water resources and agricultural viability in the Kinabatangan River Basin,

- Planning and comparative study on proposed dams and reservoirs,

- Planning and study on flood control schemes, and

- Planning and study on water resources development including hydro power and agricultural development.

3. PROJECT AREA

The Kinabatangan River with a catchment area of 16,800 km^2 drains the eastern part of Sabah State, which is demarcated within 4°30' - 5°45' North Latitude and 116°25' - 118°40' East Longitude.

The upper Kinabatangan River is named the Milian River while it is flowing down through the mountainous area and jointed by many tributaries before it meets the Kuamut River at Kampung Kuamut. The River flows down in the midst of the Basin absorbing the Lokan River and other tributaries drains into the Sulu Sea.

For a distance of 300 km from the mouth of the river, the riparian area is generally flat within the range of 15 m above mean sea level (M.S.L). Remarkable meandering in the middle and the lower reaches helped developing an extensive alluvial plain due to sedimentation. The gradient of the Kinabatangan River is extremely mild in the lower reaches being estimated around 1:15,000.

The Kinabatangan River Basin is the most sparsely populated of all in the State and has a population of approximately 29,000 in 1980, and annual growth rate of the population in the past decade, was approximately 7.6%.

The annual precipitation in the Kinabatangan River Basin is as high as 2,500-3,000 mm.

The biggest flood during these ten years occurred in February 1971, when the maximum daily mean discharge reached to 3,020 m^3/s at Tangkulap, and 5,250 m^3/s at Balat.

4. DAM AND RESERVOIR

The proposed Balat damsite is located in the middle reaches of the Kinabatangan River, 260 km upper reaches from the estuary. The dam is composed of a main dam and four sub dams, all of which are of earth fill type. The aggregate total volume of these dam bodies above, is estimated at 5,320,000 m^3.

The proposed Balat reservoir has an effective storage capacity of 4.785×10^9 m^3. A storage capacity of 4.665×10^9 m^3 will be allocated for flood control. This capacity is able to regulate 900 m^3/s out of the standard project flood of 5,400 m^3/s at the damsite. The remaining storage capacity of 0.12×10^9 m^3 will be utilized as water resources of the irrigation water supply.

The two different kinds of outlet facilities will be installed. One is to control flooding water and another to maintain Normal Water Level (N.W.L.). The flood control facility has a overflow portion of 5.0 m in width and 28.5 m in depth. The outlet facility to maintain N.W.L. consists of three outlet pipes (7 m in diameter, each). This facility is also to be utilized for power generation.

Two spillways having a free flow section, 300 m wide, will be constructed on the hilly land beside the dams. In case that the extraordinary flood discharge happens, the spillways will flow it safely.

A land of 520 km^2 shall be acquired and 850 houses shall be evacuated due to implementation of the project.

5. FLOOD CONTROL

The magnitude of flood control in the Kinabatangan River has been determined to be a 20-year return period. The flooding water of the river will be controlled by means of the proposed dam and reservoir. The reservoir storage capacity of 4.665×10^9 m^3 is required to regulate the standard project flood of 5,400 m^3/s at the proposed Balat damsite and 6,000 m^3/s at Barik Manis down to 900 m^3/s and 1,500 m^3/s at the above respective sites. The discharege of 1,500 m^3/s can be confined in the existing river channel without any river improvement works. After completion of the proposed Balat dam construction, the area of 107,000 ha will be relieved from flood damage of a 20-year return period or less, as a result of which the productivity of the project area will be remarkably enhanced.

6. AGRICULTURAL DEVELOPMENT

Out of the area of 107,000 ha which will be relieved from the flood damage by completion of the proposed dam and reservoir, the agricultural development area of 55,000 ha is delineated, 48,700 ha of which will be reclaimed through the proposed works of jungle clearing, root removing and leveling and eventually, the net cultivation area will be 44,000 ha excluding 4,700 ha for acquired land for facilities.

Full mechanized farming has been proposed for the paddy cultivation of double crop, one is off season paddy and the other main season paddy. The storage capacity of the proposed reservoir of 0.12×10^9 m^3 will be allocated for the water requirement of the off season paddy.

In successively implementing farming production, labour requirement for the agricultural development sector in full operation stage is estimated to be about 4,000 persons consisting of 190 of managing staff and specialist, 580 of skilled personnel and 3,230 of semi-skilled personnel.

7. HYDRO POWER

The hydro power station is constructed at the immediate downstream toe of the main dam on the left bank. The generation method is run-of-river type. The generation output is 31,500 KW in power capacity, and the annual energy output is 168 x 10^6 kWH. Power generation equipment consists of 3 units of tubular type turbines with the installed capacity of 10,500 kW each, and 3 units of 3-phase horizontal shaft type generator of 11,000 kVA each.

A transmission line from Balat power station to Sandakan will be constructed for a distance of about 100 km along the proposed access road of Balat dam and the existing main road between Sandakan and Kota Kinabalu. Generated power will be conveyed by a 132 kV three-phase, three wire transmission system.

8. CONSTRUCTION SCHEDULE

The total construction period required for the execution of the project works is 10 years. The construction work will be started in 1983 and terminated in 1992. Construciton schedule for each sector including the detailed design phase is given as below:

Sector		
Dam	:	July of 1983 - Dec. of 1992
Agricultural development	:	July of 1983 - Oct. of 1992
Hydro power	:	July of 1983 - Dec. of 1992

9. PROJECT COST

The total project cost is estimated at US$1,050 million, on the contract basis by using mid-1981 prices, of which US$622 million or 59% is foreign currency, and US$428 million or 41% is local currency. The project cost is classified by work item given as follows.

($x10^6$US$)

Work		Foreign currency	Local currency	Total
Dam & Reservoir	:	141.3	147.1	288.4
Agricultural development	:	422.3	270.9	693.2
Hydro power development	:	58.1	10.6	68.7
Total	:	621.7	428.6	1,050.3

10. PROJECT EVALUATION

Economic Cost

The total economic cost is estimated at US$705.3 million, which is composed of foreign currency portion of US$410.5 million and local currency portion of US$294.8 million equivalent. These costs are summarized below.

($x10^6$US$)

Work		Foreign currency	Local currency	Total
Dam & Reservoir	:	96.8	106.2	203.0
Agricultural development	:	279.6	182.4	462.0
Hydro power development	:	34.1	6.2	40.3
Total	:	410.5	294.8	705.3

Project Benefit

The total annual benefit of the project is estimated at US$ 81.03 million, which can be classified by sector as follows;

Purpose		Annual benefit ($x 10^6$US$)
Flood control	:	0.29
Agricultural development	:	77.04
Hydro power development	:	3.70
Total	:	81.03

Internal Rate of Return

Evaluation of the project was made by means of calculating Internal Rate of Return on the basis of the estimated benefit and economic cost. The Internal Rate of Return of the Kinabatangan River Basin Development Project is calculated at 7.1 %, assuming a project life of 50 years.

11. CONCLUSION

The Kinabatangan River Basin Development Project has been formulated for the purpose of development of the riparian areas of the Basin into agricultural land by flood control of the River, and of power generation to meet ever increasing demand in the east coast area.

It can not be recommended that the project will put into execution for the moment in due consideration of the economic viability and a vast initial investment, although it can be greatly expected to serve as a vital role to enhance the productivity of the entire Kinabatangan River Basin and also to promote the regional economy of the State of Sabah.

FEATURE OF THE PROJECT

1. Dam and Reservoir

Reservoir

Design flood water level (D.F.W.L.)	EL. 43.0 m
Surcharge water level (S.W.L.)	EL. 37.0 m
Normal water level (N.W.L.)	EL. 17.5 m
Low water level (L.W.L.)	EL. 16.5 m
Gross storage capacity	5,000,000,000 m^3
Effective storage capacity	4,785,000,000 m^3
Flood control capacity	4,665,000,000 m^3
Irrigation water capacity	120,000,000 m^3
Sediment capacity	215,000,000 m^3

Dam

Main Dam	
Height above foundation	46.0 m
Crest length	530.0 m
Crest width	10.0 m
Crest elevation	EL. 46.0 m
Dam volume	2,150,000 m^3
Sub Dam No. 1	
Height above foundation	16.0 m
Crest length	540.0 m
Crest width	10.0 m
Crest elevation	EL. 46.0 m
Dam volume	330,000 m^3
Sub Dam No. 2	
Height above foundation	42.0 m
Crest length	550.0 m
Crest width	10.0 m
Crest elevation	EL. 46.0 m
Dam volume	1,830,000 m^3
Sub Dam No. 3	
Height above foundation	10.0 m
Crest length	120.0 m
Crest width	10.0 m
Crest elevation	EL. 46.0 m
Dam volume	20,000 m^3
Sub Dam No. 4	
Height above foundation	26.0 m
Crest length	780.0 m
Crest width	10.0 m
Crest elevation	EL. 46.0 m
Dam volume	990,000 m^3

Spillway

No. 1 & No. 2	300 m wide x 2 units, free flow section

Outlet facilities

One for flood control	5.0 m wide x 28.5 m high, free flow section
One for maintaining N.W.L.	7.0 m in diameter x 40 m in length x 3 units steel pipe with gate

Access road	48 km

House evacuation and land acquisition

House evacuation	850 nos.
Land acquisition	520 km^2

2. Flood Control

Flood control scale	20-year return period

Standard project flood

Balat damsite	5,400 m^3/s
Barik Manis	6,000 m^3/s

Flood control measure	Balat dam and reservoir

Design flood

Balat damsite	900 m^3/s
Barik Manis	1,500 m^3/s

Area to be relieved from flood	107,000 ha

3. Agricultural Development

Area to be developed

Gross area	55,000 ha
Net cultivable area	44,000 ha

Cropping

Proposed crop	Paddy
Crop pattern	Double cropping
Expected yield	4.2 ton/ha in off season 3.8 ton/ha in main season

<u>Farming practice</u>	Mechanized large scale
Tractor	750 units
Combine	250 units
Rice mill	6 ton/hr x 11 places
Required number of labourer	4,000
<u>Irrigation system</u>	
Pumping station	Inclined mixed flow type: 23 nos.
Irrigation canal	
- Main canal	158 km, earth canal
- Secondary canal	461 km, earth canal
- Tertiary canal	2,244 km, earth canal
<u>Drainage system</u>	
Existing channel improvement	88 km
Lateral drain	231 km, earth canal
Sub lateral drain	1,122 km, earth canal
Related structures	645 nos.
<u>Farm road network</u>	
Farm road	635 km, gravel metaled:
On-farm road	935 km, non-metaled
<u>Related structures</u>	27 nos.
<u>Resettlement</u>	4,000 Household
<u>Land acquisition</u>	4,700 ha

4. Hydro Power

<u>Power Generation</u>	
Maximum out put	31,500 kW
Annual out put	168×10^6 kWH
<u>Power station</u>	
Maximum discharge	450 m^3/s
Power house	20 m wide x 48 m length x 35 m high Semi-underground type
<u>Generating equipment</u>	
Turbine	3 units x 10,500 kW, tubuler type
Generator	3 units x 11,000 kVA 3-phase horizontal shaft generator
<u>Transmission line</u>	100 km in total, 132 kV

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GLOSSARY

GENERAL ABBREVIATIONS

(1) Plan

FMP	First Malaysia Plan
SMP	Second Malaysia Plan
TMP	Third Malaysia Plan
NEP	New Economic Policy
OPP	Outline Perspective Plan

(2) Local Organization

DID	Drainage and Irrigation Department
DOA	Department of Agriculture
EPU	Economic Planning Unit
FELDA	Federal Land Development Authority
SAFODA	Sabah Forestry Development Authority
SEB	Sabah Electricity Board
SLDB	Sabah Land Development Board

(3) International or Foreign Organization

IBRD	International Bank for Reconstruction and Development
JICA	Japan International Cooperation Agency

(4) Others

CIF	Cost, Insurance and Freight
FOB	Free on Board
GDP	Gross Domestic Product
O/M	Operation & Maintenance
SRPS	Sabah Regional Planning Study
S.P.T.	Standard Penetration Test

ABBREVIATIONS OF MEASUREMENT

(1) Length

mm	millimeter
cm	centimeter
m	meter
km	kilometer
ft	foot

(2) Area

mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare

(3) Volume and Weight

m^3	cubic meter
m^3/s, m^3/sec	cubic meter per second
cuft	cubic feet
kg	kilogramme
kg/cm^2	kilogramme per square centimeter

(4) Money

M$	Malaysian ringgit
US$	US dollar
¥	Japanese Yen

(5) Electrical Measures

V	volt
KV	kilovolt
KW	kilowatt
MW	megawatt
KWH	kilowatt hour
MWH	megawatt hour
A.C.	alternating current
Hz	Hertz = cycles per second

(6) Others

EL.	elevation
HP	horsepower
°C	degrees centigrade
%	per cent

UNITS OF MEASUREMENT

(1) Length

1 cm = 0.394 inche
1 m = 3.28 feet
1 km = 0.621 mile

(2) Area

1 cm^2 = 0.155 square inch
1 m^2 = 10.76 square feet
1 ha = 2.47 acres
1 km^2 = 100 ha = 247.1 acres

(3) Volume

1 m^3 = 35.31 cubic feet
1 litre = 0.22 imperial gallon

(4) Weight

1 kg = 2,20 pound (lb)
1 kati = 0.75 pound (lb)
1 pikul = 100 katis = 0.06 ton

(5) Money

US$1 = M$2.3 = ¥230

CHAPTER I INTRODUCTION

1.1 PROJECT HISTORY

The vast natural resources scarcely tapped for countless centuries in the past in the Kinabatangan River Basin in the State of Sabah, Malaysia began attracting serious attention of both the State Government and the Federal Government since the latter part of the 1970's.

While various development programmes are being laid out for the future, a flood control and water resources development plan is the prerequisite for an orderly development of the Kinabatangan River Basin.

Under these circumstances, the Government of Malaysia proposed to the Government of Japan, in 1979, the implementation of a masterplan study for comprehensive water resources development in the East Coast of Sabah, including Kinabatangan River Basin. To this proposal, the Government of Japan duly agreed to comply with. Subsequently, however, the scope of the proposed masterplan study was included in the National Water Resources Study, under the mutual agreement between the two Governments, to cover the whole Malaysia, inclusive of Sabah. Eventually, Japanese Government dispatched a survey team for the National Water Resources Study through the Japan International Cooperation Agency (JICA) in 1980.

In the meanwhile, the Government of Malaysia, being eager to expedite the realization of the Kinabatangan River Basin Development, requested the Government of Japan for a dispatch of another survey team to conduct a pre-feasibility study of the said project.

1.2 OUTLINE OF THE STUDY

1.2.1 Objective of the Study

The objective of the study which was agreed upon by and between the Government of Malaysia and the Government of Japan is to conduct a pre-feasibility study on the Kinabatangan River Basin Development Project, more specifically, the preparation of an outline development plan for flood prone area in the Kinabatangan River Basin.

1.2.2 Scope of the Study

The scope of the study is as follows:

- Study on potential water resources and agricultural viability in the Kinabatangan River Basin,

- Planning and comparative study of proposed dams and reservoirs,

- Planning and study on flood control schemes, and

- Planning and study on water resources development including hydro power and agricultural development.

This study is conducted in two stages: the first stage lasted for three and a half months and the second stage for seven months. The first stage study covered the agricultural viability in the Kinabatangan River Baisn and comparative studies of the proposed dams and reservoirs. In the second stage, the project was formulated on the basis of the results of the topographic survey and geologic investigation which have been conducted by the authorities concerned of Government of Malaysia.

The results of the investigation and studies were presented in the report of the following two separate volumes:

(1) Main Report

(2) Supporting Report; Hydrology, Geology, Dam, Flood Control, Agriculture and Irrigation, Hydro Power, Socio-Economic Background and Project Economy.

CHAPTER II GENERAL BACKGROUND

2.1 SOCIO-ECONOMIC BACKGROUND

The New Economic Policy (NEP) of Malaysia aims at the poverty eradication and restructuring of the Malaysian society. For the attainment of the objective, Outline Perspective Plan (OPP) with a long-term (1971-90) development framework was set forth. The ultimate aim behind these two-pronged objectives is the creation of a united, secure, socially just, economically equitable and progressive society.

The first decade of the OPP (1971-80) was a period of rapid economic growth and structural change in Malaysia.

The Fourth Malaysia Plan (FMP), 1981-85, inaugurates the second decade of the OPP. It recites policy measures and programmes embodied in the Second and Third Malaysia Plans (SMP and TMP) to ensure that the socio-economic objectives of the NEP are achieved.

In Sabah, since the beginning of the Five-Year Malaysia Plan, concrete steps have been taking to diversify its economy. (Refer to Table 2-1)

The First Malaysia Plan (Sabah, 1966-70) was largely oriented toward solving the socio-economic problems of the State and principally aimed at economic growth (7.5% annual growth in Gross Domestic Product), reduction of social and economic inequalities, provision of more economic and social services and the development of human resources.

The entry of Malaysia into the period of Second Malaysia Plan (1971-75) marked a change in the emphasis of the objectives of the NEP toward poverty eradication and the restructuring of society. As a member of the national society, Sabah's development programmes reflect the national goals and objectives, but with modifications to better suit its specific kinds of problem and different state of development.

During the period of the SMP, the State of Sabah whose share of Gross Domestic Product (GDP) was only 7.2% of the national total in 1970, achieved during the same period a growth of GDP by 50.1% at an annual rate of 8.5%.

Under the TMP (1976-80), the Federation was expected to gain 50.7% increase of its GDP at an annual rate of 8.5%, while the planned increment of Sabah's GDP was expected at 43.8% at an annual rate of 7.5%, its share in the whole Malaysian GDP in 1980 would yet remain at 7.5%.

For the Fourth Malaysia Plan period, Sabah is planning to spend development expenditure of M$3,172.4 million. Of this, M$1,845.6 million (58.2 percent) is to come from the Federal Government, M$1,230.0 million (38.8 percent) from the State Government and M$96.7 million (3.0 percent) to be financed by State statutory bodies from their own funds.

The principal development strategies are directed at agricultural and rural development, achieving self-sufficiency in food production, industrial development ensuring adequate manpower supply and increasing labour productivity, increased Bumiputra participation in commerce and industry, and infrastructural development.

The economic growth in Sabah has been remarkable in recent years, but its economy is infested by a structural lopsidedness which has so far inhibited expansion of its share in the Malaysian economic prosperity. Firstly, it has been heavily dependent on a few products originating in the primary sector which have been mainly exported without local processing and, therefore, creating little added-value. Secondly, it inherits the dualistic economic structure as represented by the fact that while modernized manufacturing, commerce and estates are being developed, the traditional small holders remain to form a large proportion of the lower income groups.

A shift from heavy dependence on primary economic sectors will have to be attained, to a considerable extent, by means of developing processing industries of agricultural and forestry products. The State of Sabah has to drive at promotion of processing industries to get higher added-value. However, the development of agriculture by increasing productivity and by expanding new lands should not be set aside in order to support the agricultural processing industries and to meet increasing local demand for foodstuff.

2.2 PROJECT BACKGROUND

The annual precipitation in the Kinabatangan River Basin is as high as 2,500-3,000 mm. The gradient of the river course is approximately 1/15,000 from its estuary to Kuamut for a distance of 300 km. Extremely gentle river gradient and high precipitation combined, the riparian area of the River suffers every year from minor flooding and the lowlands in the Basin are habitually inundated during rainy season. Flood control scheme, therefore, is the prerequisite for smooth implementation of future development plan in the project area.

The vast land of the Basin, up to 99% of which is covered by the forests including scrub forest, swamp- and wetland-forest, has been least developed as will be known from the negligible percentage of its agricultural land that is merely 0.5% of the whole. On the other hand, Sabah had to import in 1978 about 63,000 tons of rice which represented some 54% of the total requirements. Since the Government is considering that rice consists of the strategic crop and is intending to achieve a high degree of food self-sufficiency in terms of an increased paddy production, the flood prone area is awaiting appropriate flood control and irrigation schemes to be undertaken in order to fulfill the Government's wishes for food self-sufficiency.

Sabah Electricity Board (SEB) has been successfully catering to the incremental demand for electricity both in the urban area and the rural area, to meet the felt needs amplified by an increasing number of consuming citizens in the former, and to help raising the standard of living of the rural population in line with the NEP in the latter. In anticipation of the further price hikes of fuel oil on which the SEB has been entirely dependent for power generation, serious efforts are being exhausted to find alternative energies, among which hydro power is given a top priority.

The State of Sabah, with a strong desire for realization of the basin development, thus has full justification for its persistent efforts to develop the Kinabatangan River Basin.

CHAPTER III PRESENT CONDITION OF THE PROJECT AREA

3.1 GEOGRAPHICAL CONDITION

3.1.1 Location and Topography

The Kinabatangan River Basin covers a greater part of Kinabatangan District, one of the three districts of Sandakan Residency, on the East Coast of Sabah State. Its location is shown in the General Map attached to this report.

The Kinabatangan River with a catchment area of 16,800 km^2 drains the eastern part of Sabah State, which is demarcated within 4°30' - 5°45' North Latitude and 116°25' 118°40' East Longitude. The main stream of the river has its source in the Witti and Trus Madi ranges, both of which are branching out from the Crocker Range the physical spine of the State. The length of the River is about 560 km.

3.1.2 Climate

Sabah is located in tropical climate zone. It is situated in the midst of the Southeast Asia monsoon area. The northeast monsoon begins in November and lasts until March, and the southwest monsoon prevails from May until August. Generally speaking, the southwest monsoon brings rainy season to the west coast and the northeast monsoon brings that to the east coast.

Rainfall

There are being maintained 28 rainfall stations in and around the Kinabatangan River Basin. According to the existing rainfall data, yearly rainfall is as much as 2,500 to 3,000 mm.

Temperature and Humidity

Temperature and humidity are observed at 4 stations. The highest daily mean temperature occurs in May. The difference in daily mean temperature is relatively small throughout a year, i.e. 27°C at Sandakan in the coastal side and 25°C at Kuamut in the mountain side. Daily mean of relative humidity is about 80% : it is almost the same throughout a year but is slightly higher at Kuamut on the mountain side than at Sandakan on the coastal side.

Sunshine and Evaporation

Sunshine hour has been observed at 2 stations and evaporation at 4 stations. The yearly sunshine hours total about 2,400 hours and insolation ratio is 27%. The yearly total evaporation ranges from 1,500 to 1,800 mm, and the maximum monthly evaporation reaches 150-170 mm in April to June.

3.1.3 Run-off, Sediment and Flood

Run-off

There are 4 water stage gauging stations in the project area; namely, Ulu Kuamut, Tangkulap, Balat and Barik Manis. Ulu Kuamut and Tangkulap stations were established in 1969, Balat in 1978 and Barik Manis in 1979. Water stage observation has been conducted at each station since their establishment. Discharge measurement has also been conducted at each of these stations, and the data except those obtained at Barik Manis which comes under tidal influences, have already been incorporated into the discharge rating curves by the Drainage and Irrigation Department (DID).

The daily mean discharge at Tangkulap is about 200 m^3/s during the ten years from 1970 to 1979 (refer to Fig. 3-1). The discharge at Balat is estimated at 350 m^3/s when the figure at Tangkulap is multiplied by the ratio of catchment area.

Sediment

The river water running down the Kinabatangan River looks brownish, apparently containing much mud and fine sand, and its sediment load consists mostly of wash and suspended loads. The yearly amount of sediment load at Tangkulap, as estimated from the sediment load observation data by DID, would be approximately 0.86×10^6 m^3/year, and the specific sediment load, 140 m^3/km^2/year.

Flood

The big floods recently occurred in 1963, 1968, 1971 and 1981. During each flood, inundation lasted for about one month, which makes the project area unutilizable. Although accurate hydrological data are not sufficiently available, the 1963 flood is deemed to be the biggest. The biggest flood during these ten years occurred in February 1971, when the maximum daily mean discharge reached 3,020 m^3/s at Tangkulap, and 5,250 m^3/s at Balat.

3.1.4 Tidal Stage

Tidal stage of the Sulu Sea is being recorded at the Sandakan Port gauging station. The tidal stage fluctuates with an amplitude of 40 cm at low water springs and 150 cm at high water springs.

3.1.5 Geology

Sedimentary rocks with less distribution of igneous rocks and crystaline basement rocks spread all over the Sabah State. They are covered by surface deposits.

Sedimentary rocks consist of sandstone, siltstone, mudstone, shale, conglomerate, chert, limestone and tuff, ranging in geologic age from Cretaceous, Mesozoic to Pliocene in Tertiary, Cenozoic. Igneous rocks and crystalline basement rocks are sporadically distributed and consist of granite, diorite, gabbro, andesite, basalt, ultra-mafic rocks and some kinds of metamorphic rocks, ranging in geologic age from Triassic and/or older to Quaternary. Surface deposits consist of gravel, sand, silt, clay and peat in Alluvium and Diluvium of the Quaternary, being distributed along the river as well as in and around delta and internal basin. Most of the rocks in the Kinabatangan River Basin belong to geologic age of Neogene in the Tertiary and are younger than those distributed in the other area. They consist mainly of sandstone, shale, mud-stone, their alternating beds and less limestone, conglomerate, chert, aplite, igneous rock, and crystalline basement rocks. These rocks are more or less affected by many faults and folds.

3.1.6 Soils and Land Capability

According to the reports/1, the Kinabatangan River Basin holds very extensive agricultural soils, which have been classified into five groups from their agricultural suitability. Group 1 soils which have no limitation for agricultural development does not occur in the Kinabatangan River Basin. Group 2 soils with high potential for agriculture and Group 3 soils with moderate potential have a wide distribution in the Basin. The other two classifications, Group 4 and Group 5 soils, are not suitable for agriculture, the former being intended for mining and the latter having no practical use.

About half area of the land in the middle and lower reaches of the Kinabatangan River Basin is covered by the soils which belong to Group 2 and Group 3. (Refer to Fig. 3-2).

/1 "Land Resources Study, the Soil of Sabah, Vol. 2, Sandakan and Kinabatangan Districts", and "Land Capability Classification of Sabah, Vol. 2, the Sandakan Residency Maps"

3.1.7 River

River Basin

The upper Kinabatangan River is named the Milian River while it is flowing down through the mountainous area being joined by many tributaries before it meets the Kuamut River at Kampung Kuamut; the catchment areas of the Milian and the Kuamut are 6,825 km^2 and 3,140 km^2, respectively. The River flows down in the midst of the Basin absorbing the Lokan River and the other tributaries before draining into the Sulu Sea. Numerous tributaries are contributing to make the Kinabatangan River a mighty river which may be likened to a trunk of a giant tree with countless branches (refer to Fig. 3-3).

For a distance of 300 km from the mouth of the river, the riparian area is generally flat within the range of 15 m above mean sea level (M.S.L). Remarkable meandering in the middle and the lower reaches helped developing an extensive alluvial plain due to sedimentation. At the estuary is extending a vast deltaic zone through which several channels branching off from the River are running down towards the sea. The gradient of the Kinabatangan River is extremely mild in the lower reaches being estimated around 1:15,000.

River Channel

The actual river length measured along the meandering course indicates an incremented rate of about 1.5 times that of the straight reaches.

The cross-section presents mostly single cross-section of a natural eroded valley with its banks rising about 10 m above the river bed. Sectional river gradient appears to be about 1/10,000 in the stretch from Balat to Bukit Garam/Barik Manis, 1/15,000 from Bukit Garam to Sukau, and 1/20,000 from Sukau to the estuary, and the river width ranges from 150 m to 200 m as illustrated in Fig. 3-4.

The minimum and average values of the channel flow capacity along the river course are estimated at 1,500 m^3/s and 1,800 m^3/s, respectively. The distribution of flow capacity is given in Fig. 3-5.

3.1.8 Flood Damages

Floods occur almost every year in the Kinabatangan River Basin. Once in several years, a large-scale flood causes loss of life with considerable damages to the houses, crops and fowls. Therefore, they give great damage and much inconvenience to inhabitants of the Basin.

Although the actual conditions of the flood damage can not be exactly known due to a lack of record, it is said that the flood in 1963 was the biggest in the past few decades and lasted more than one month.

According to the comparably well-recorded data during the recent ten odd years, flood damage in January 1968 was the biggest, i.e. 8,000 people affected, 193 houses washed away and 700 houses damaged. (Refer to Table 3-1).

The inundation area of the 20-year flood with discharge of 6,000 m^3/s at Balik Manis is estimated at 107,000 ha, as illustrated in Fig. 3-6.

3.2 AGRICULTURAL CONDITION

3.2.1 Present Land Use

The area of Kinabatangan District is 4,537,075 acres. (1,814,830 ha) in total. Out of which, more than 99% is occupied by forest, swamp and others, and remaining 0.52% only is cultivated as the farming land. In the cultivated area of 23,624 acres (9,450 ha), about 73% is planted by tree crops such as rubber, oil palm, coconuts and cacao, and about 14% is covered by hill paddy in the shifting cultivation as shown in Table 3-2.

The project area is mostly covered by secondary forest which is growing on the alluvial and peat soils. Only about one percent or less of the land is being utilized as the cultivation area at the present.

With regard to the agricultural production in the project area, little can be said except rattan cultivation and paddy pilot farm in a small scale.

3.2.2 Agricultural Setting

Agricultural activities in the District have so far been extremely restrained, mainly due to a lack of infrastructure and labour resources. Agricultural activities undertaken in the District may be broadly categorized into;

1) Estate farming
2) Primitive shifting cultivation
3) Small holding subsistance-cum-marketing farming known as 'mixed horticultural', and
4) Government-sponsored minor schemes for improvement of the above 2) and 3).

In terms of the sizes of the land and technology put under respective use, estate farming and shifting cultivation represent the characteristic features of the agriculture in the Kinabatangan River Basin.

3.2.3 Present Cropping

According to the estimated cropped area of the District in 1979, the main crops are oil palm, coconuts, rubber, cacao and paddy. These crops, except paddy, are usually planted in medium or large scale estate farms and harvested through the year.

Annual crops such as maize, cassava, vegetables, groundnuts, sweet potatoes etc. are planted in small scale at shifting cultivation area and harvested through the year for the purposes of self consumption or for local market.

Hill paddy is sown directly in the small scale shifting cultivation field or upland field between August and October to be harvested during January and March, while wet paddy at Bukit Garam Pilot Farm is sown in the nursery in June and transplanted in July. It would be harvested in November to avoid flooding during January or February. (Refer to Fig. 3-7).

3.2.4 Agricultural Production

Crop yields in the District are estimated to be somewhat lower, say about 10 or 20%, than the State averages. This would be attributable to the smallness in scale of farming, combined with primitive technology as far as annual crops and fruits trees. Immaturity of tree crops such as oil palm and cacao also helps lower the yield.

3.2.5 Related Sector of Agriculture

Livestock

Livestock farming is centerring around Sandakan where marketing facilities are available. In the Kinabatangan District, there is no commercial livestock farming.

Fishing

There are about 260 fishponds covering about 110 acres (44 ha) and more than 20,500 fish fry were distributed in the Residency including the Kinabatangan District in 1979. The species of the fry are Lampan Jawa, Common Carp, Big Head, Silver Carp, Grass Carp and Tilapia.

Forestry

As in 1978, 23% of the total forest reserve area and more than one-fourth of the commercial forest in the State of Sabah were in Lamag Forest District in the Kinabatangan River Basin.

The production of timber in the area has been continuously declining since 1973, and it is feared that a serious limitation of the forest resources may come to be felt in the near future. Most of the timber is for export.

3.3 SOCIO-ECONOMIC SETTING

3.3.1 Administrative Divisions

The administrative division is set up as Kampung (village), District, Residency and State in the order of magnitude. Fig. 3-8 shows the boundaries of each Division except the Kampungs, which are omitted due to a lack of clear demarcation. According to this administrative division, the extent of the Kinabatangan District almost coincides with the area of the Kinabatangan River Basin.

By division of forest district, the river basin is almost entirely covered by the Lamag Forest District, the remaining small portion belonging to the Sandakan Forest District (South).

In addition to the division of the area mentioned above, the Sabah Electricity Board has divided the State into the East and the West Divisions, in which the Kinabatangan River Basin belongs to the East.

3.3.2 Demography

Kinabatangan District had a population of approximately 29,000 in 1980, and annual growth rate of the population in the past decade, 1970 to 1980, was approximately 7.6%. This rate of increase was indeed a high one as compared with the natural increase rate in the State of Sabah and Sandakan Residency which showed estimated figures of 5.3% and 5.5%, respectively, in the same decade.

The Kinabatangan River Basin is the most sparsely populated of all in the State, the population density being only 1.6 persons/km^2. These people live in numerous Kampungs scattered in the Basin. Family size in the Kinabatangan River Basin is 5.4 persons in 1980 which shows a remarkable increase from 4.5 persons in 1970.

The labour force is also absolutely small. It was more or less 9,800 in 1980. Most of the people living in the Kinabatangan River Basin support their living by forestry and crop farming, and, among those, some of the people are engaged in inland fishery as side job.

The Kinabatangan River Basin is vast but has a small population which is composed of diverse communities. Of these the Indigenous, especially Orang Sungai is the largest group consisting 79% in 1970. The Indonesians are the second largest group, and the Chinese, though the second largest group in the whole Sabah, occupied only 3% in the Kinabatangan River Basin, in 1970.

3.3.3 Water Utilization

It is generally understood that the river water is utilized for irrigation water and municipal water. In the riparian area along the Kinabatangan River, though there are being maintained small scale rainfed paddy fields, no irrigation facility is present except at the pilot farmland at Bukit Garam.

Likewise, there is no municipal water supply system in the Kinabatangan River Basin. Inhabitants along the river course depend on the river water for general household use, and rainfall water is also collected for the same purpose.

3.3.4 Electric Power

In the State of Sabah, generation, distribution and control of electric power is all under the management of the Sabah Electricity Board (SEB) established in 1957.

As of 1978, there were 12 power stations (5 major and 7 minor) in urban areas, and 29 small stations in rural areas. At every station the power is generated by diesel plant.

At the end of 1978, about 30% of the total inhabitants of the State of Sabah benefitted from the power supply, and the total units sold per year in the entire State of Sabah amounted to some 250 x 10^3 MWh. Out of the above total, about 27% was intended for industry, about 33% for domestic consumption, and the balance for commercial and public purposes and others.

Since inter-station transmission grids are not yet established, all power stations are serving the respective neighbouring areas only. However, among cities in the West Division with more population, shorter transmission lines such as 22 kV line between Kota Kinabalu and Tuaran and 11 kV and 6.6 kV line between Kota Kinabalu and Papar are already in service. And 33 kV transmision line is installed along the Labuk road at sandakan in East Division. Also, the 132 kV and 66 kV transmission line from the Tenom Pangi power station to Kota Kinabalu (now under construction) will begin service in 1983. The domestic current is either in 240 V single phase or 415 kV three-phase, 50Hz, AC.

Location of the power stations and routes of the major transmission and the daily load curve in the major cities of the East Coast Division are shown in Figs. 3-9 and 3-10, respectively.

3.3.5 Transportation and Telecommunication

Transportation service in the Kinabatangan River Basin is provided by means of road and river channel. The road network consists of some logging roads and two main roads which connect Sandakan to Lahad Datu in one direction and Sandakan to Lukit Garam in another direction, though they are not paved yet.

River channels play the vital role for transporting the passengers, commodities and the timber which is the principal product in the Kinabatangan River Basin.

National carrier, Malaysian Airline Systems, operates daily services between Kota Kinabalu and Sandakan which is as far as 90 km from Bukit Garam.

Ocean-going boats also reach Sandakan Port which handles a large quantity of export timber as the center of the State's timber industry.

Sandakan and Bukit Garam are connected by telecommunication services under the operation and maintenance of the Department of Telecoms.

3.4 ON-GOING DEVELOPMENT PLANS

Under TMP, the State of Sabah planned land development of 203,346 acres (81,340 ha) which consisted of 126,465 acres (50,586 ha) and 76,881 acres (30,752 ha) of public and private sectors, respectively.

In the project area, about 40% has been allocated for the Government development schemes and another 20% has been alienated to the private or joint venture estates. The remaining 40% of land is not allocated for development, however, the alienation of remaining lands for private venture is increasing rapidly.

Among these allocated and alienated areas, no schemes except Rattan Development Project by Sabah Forestry Development Authority (SAFODA) and Paddy Pilot Farm by Paddy Board are being implemented in the flood prone area due to habitual flooding.

Also, a township development named Kota Kinabatangan and Sandakan-Lahad Datu Road Project including the Batu Puteh Bridge are the two on-going development projects of note in and around the project area.

CHAPTER IV PROJECT FORMULATION

4.1 GENERAL

For orderly development of the project area, a proper control of the flooding water is indispensable. To attain this purpose, it is essential to construct dam in the upper or the middle reaches of the Kinabatangan River, as a result of which the benefitted area which is relieved from flooding can be expected to develop for agricultural purpose and likewise hydro power generation can be developed to support the incremental demand in the east division.

In this connection, the dam whose construction is proposed at Balat, middle reaches of the Kinabatangan River, will be designed as a multi-purpose dam to support the development plans in the project area which consist of flood control, agricultural development and hydro power generation.

The storage capacity to be developed will be allocated for the purpose of flood control and irrigation.

Flood control plan by means of the reservoir will be formulated in order to mitigate the flood damage, and to enhance the productivity of the flood prone area.

Agricultural development plan for the area will be formulated basically to increase the agricultural production, especially in line with the policy of self-sufficiency for food crops, through utilization of water resources developed by the proposed reservoir.

A hydro power generation plan by utilizing the water head to be created by the proposed dam will be formulated considering the incremental demand of the power in the future.

4.2 OUTLINE OF DEVELOPMENT SCHEME

4.2.1 Role of the Flood Prone Area of the Kinabatangan River Basin

In line with the context of the NEP, the development policy objectives under the FMP are mostly directed to the agricultural sector as it is now the dominant sector and will continue to be a mainstay in the State's economy for the decade.

For agricultural development, two approaches are being proposed. One is an intensive approach called in situ development designed to improve infrastructure in the existing rural areas to enable farmers increase their productivity without moving into unfamiliar area for resettlement. Another is the resettlement scheme which aims at opening up of new land to achieve higher income with better crops on scale of economy and an equitable distribution of the land resources to the rural poor.

Judging from the present distribution of the population, pattern of land ownership and stage of infrastructural development in the State, the latter approach is believed to be best applicable to the Divisions of Sandakan and Tawau where there still is abundant open land suitable not only for paddy but also for other promising crops. Particularly, the flood prone area of the Kinabatangan River Basin is considered to be the only and best area left untouched for paddy production in the State, where there is huge potential to make up for current production deficit of rice and to produce marketable surplus to outside country in the future along the line of the State export crop diversification programme.

4.2.2 Development Constraint of the Flood Prone Area

The project area has such major problems as the flooding from the Kinabatangan River and the shortage of labour force which hamper development of the area, as follows:

1) The Kinabatangan River inflicts the areas with regular flood damage which has resulted in deterring development not withstanding an availability of vast flat areas.

2) The populatiuon density remains only 1.6 persons/km^2 which is extremely low while the State's average is 15 persons/km^2, though the population has grown at 7.6% per annum in the past decade during which the State average was 5.3%.

4.2.3 Basic Considerations for Development

Now that the biggest asset of the State i.e., the forest resources tend to dwindle away rapidly, it is proper for the State to pay special attention to the Kinabatangan River Basin, especially to the flood prone areas, in view of positively utilizing the resources endowed there for a sustained growth of the State's economy.

Thus the basic issues to be considered are:

1) To develop flood free arable land to its maximum extent at the minimum cost through flood control measure.

2) To give the highest priority to rice crop production to cope with the national and State policy of food self-sufficiency.

3) To introduce mechanized farming in parallel with modern estate management system to cover perpetual shortage of labour and, simultaneously, to achieve the highest labour productivity to win over an international competition.

4) To develop hydro power primarily for supplying to the east coast area and to reduce absolute dependence on fuel oil for power generation.

5) To induce agro-based industries to earn higher added value.

4.3 DAM AND RESERVOIR

4.3.1 Required Function of the Proposed Reservoir

As for the planning of dam and reservoir, the items for primary consideration will be as follows:

1) Flood Control

The magnitude of flood control in the Kinabatangan River Basin is proposed to be a 20-year return period, in due consideration of flood control scale of the rivers in Malaysia. The project area will be free from the damage of the flood not bigger than a 20-year return period.

2) Water Requirement

Water to be developed by the proposed dam will be utilized for irrigation purpose during dry season.

Water requirement in the irrigable area will be estimated on the basis of flow regime which is equivalent to the 5-year return period. The storage capacity will have an allocation for the irrigation purpose.

3) Hydro Power

The storage capacity will have no specific allocation for the purpose of hydro power generation, as run-of-river type is adopted for power generation.

4.3.2 Damsite Selection

Thirteen possible damsites located in the Kinabatangan River Basin have been selected through the study of the topographic maps, scale 1 : 50,000, and aerial photographs. The location and features of the selected damsites are shown in Fig. 4-1 and Table 4-1 respectively.

From among the thirteen possible damsites, three damsites i.e., Balat, Deramakot and Milian-Kuamut have been chosen on the basis of the following criteria and by considering the storage capacity required in the benefitted area.

- High economicality: Ratio of effective storage capacity per dam body volume is higher.

- High flood control efficiency: The catchment area governed by the dam-reservoir is larger.

The detailed comparative study was conducted among the three damsites on the economical viewpoint as shown in Table 4-2.

Finally, Balat has been selected as the optimum damsite of the project.

Topographical, geological and social conditions of the proposed Balat dam are as follows:

- Topographical conditions

  Balat is situated in about 260 km upstream from the estuary just near Kpg. Balat.

  On the left side of the Kinabatangan River at the damsite is a hill with a relatively steep slope. Conversely, a very gentle slope can be observed on the right side. Four small valleys are found on the right side also.

  The longitudinal section of the dam suggests that as soon as its crest exceeds EL. 60 m or so, an abrupt increase in dam body volume will be required.

- Geological conditions

  Bedrocks such as sandstone and mudstone are found at both sides of the river, all of which were formed in the geological age of Oligocene to Miocene in the Tertiary. And Alluvium in the Quarternary, which is composed of very thick sediments, covers these bedrocks along the present river and other valleys. The stratigraphic cross section of the Alluvium reveals, in descending order, layers of silt, clay, sand and gravel.

  From the viewpoint of geology, construction of a very high dam does not seem feasible.

- Social aspect

  Though data so far available are not sufficient enough to allow proper evaluation, in the case a reservoir stage exceeds high water level of around EL. 50 m, the number of submergible houses will be increasing, which is tremendous impact on the welfare of the inhabitants now living in the submerged area. Distribution of the submergible Kampungs is shown in Fig. 4-2.

4.3.3 Proposed Scale of Balat Dam and Reservoir

The proposed scale of the dam and reservoir is determined after comparison of the dam and other alternatives to fulfill the purpose of the project.

As described in the followings, the required storage capacities of the respective sectores have been determined. All of which will be discussed later in the each sector.

Gross storage capacity	:	5.0×10^9 m^3
Flood control capacity	:	4.665×10^9 m^3
Irrigation capacity	:	0.120×10^9 m^3
Effective storage capacity	:	4.785×10^9 m^3
Sediment capacity /1	:	0.215×10^9 m^3
Submerged area /2	:	520 km^2

Water stages of the reservoir which correspond to the storage capacities above are as follows:

Design flood water level (D.F.W.L.)	:	EL. 43.00 m
Surcharge water level (S.W.L.)	:	EL. 37.00 m
Normal water level (N.W.L.)	:	EL. 17.50 m
Low water level (L.W.L.)	:	EL. 16.50 m

Allocation of storage capacity is shown in Fig. 4-4.

The above scale of Balat dam meets the topographical, geological and social conditions mentioned elsewhere in the foregoing.

/1 : The sediment storage capacity will be estimated on the basis of specific sediment, 200 $m^3/km^2/year$. This figure with ample safety margin in design criteria has been arrived at from both the recorded data on sediment load in this river and the projected value of the Padas River Reservoir on the west coast area of East Malaysia.

/2 : Refer to Fig. 4-3.

4.4 FLOOD CONTROL

4.4.1 Flood Control Scale

Flood discharge on a 20-year return period was employed for the formulation of the flood control plan in due consideration of the flood control scales to other rivers in Malaysia.

4.4.2 Standard Project Flood

The standard project flood discharge has been determined on the basis of hydrological analysis in the Kinabatangan River Basin, and also in reference to the specific discharge of a 20-year return period which has been taken up in other river basins of East Malaysia. Eventually, the standard project flood discharges determined for the respective sites of Balat dam, Barik Manis and Estuary are as follows:

Balat Damsite: 5,400 m^3/s (Catchment area 10,730 km^2)
Barik Manis : 6,000 m^3/s (Catchment area 12,960 km^2)
Estuary : 6,000 m^3/s (Catchment area 16,800 km^2)

The distribution of standard project flood discharge is shown in Fig. 4-5. The flood hydrograph during the flood of February 1971 was applied for the standard project flood as illustrated in Fig. 4-6.

4.4.3 Flood Control Measures

The flood control measures for mitigating flood damages include;

1) dam
2) floodway
3) river channel improvement including ring-levee
4) retarding basin

These measures may be adopted either independently or jointly. After careful study as discribed below, it has been justified that flood control by means of dam construction is most appropriate.

<u>Study Result of Flood Control Measure</u>

In the case of the Kinabatangan River, it is topographically extremely difficult to find out an area suitable for a retarding basin to control a 20-year return period flood and also a floodway works has been found less advantageous than dam construction or river improvement works from the construction cost point of view.

Thus the river improvement and dam construction were nominated as the appropriate flood control measures.

Further study on the optimum share for the flood control between dam construction and river improvement was continued.

As for the relationship between the total construction cost of dam and river improvement and the discharge at Barik Manis it has been arrived at that the Kinabatangan River channel should control a discharge of 1,500 m^3/s, in view of striking the most economically balanced combination of dam construction and river improvement work in the total cost (refer to Fig. 4-7). Eventually, the discharge of 1,500 m^3/s coincides the present flow capacity of the Kinabatangan River. This proves that the flood control by dam construction only is most economical.

4.4.4 Design Flood and Flood Control Storage Capacity

The design flood at the respective sites of Balat dam, Barik Manis and Esturary are as follows.

Balat damsite	:	900 m^3/s
Barik Manis	:	1,500 m^3/s
Estuary	:	1,500 m^3/s

To regulate the standard project flood of 5,400 m^3/s at Balat damsite to 900 m^3/s, the storage capacity of 4.665 x 10^9 m^3 will be required in the proposed reservoir.

Figs. 4-5 and 4-6 also show the design flood discharge distribution and hydrograph.

4.4.5 Benefit

The flood control benefit is defined as the flood damage reduction due to implementation of the project, whose calculation is based on the flood discharge under the with and without the project conditions.

Flood damages consist of the direct damage, indirect damage and intangible damage. In this study, only the direct damages to buildings and the indirect damages are assessed and evaluated. Furthermore, flood control benefit is estimated with the cases of existing properties in the project area.

The annual flood control benefit is estimated at US$290 thousand and its breakdown is shown in Table 4-3.

4.5 AGRICULTURAL DEVELOPMENT

4.5.1 Proposed Agricultural Development Area

Potential area appropriate for agricultural development in the entire Kinabatangan River Basin has been estimated at approximately 1,200,000 acres (486,000 ha) which is almost 30% of the entire area of the Basin. (Refer to Fig. 4-8.)

After construction of the dam, total area of 107,000 ha will be released from the flood in the downstream of the proposed dam. The area will be consisted by alluvial soils of 55,000 ha, peat soils of 45,500 ha and river bank portion with alluvial soils of 6,500 ha.

As for the peat soil area of 45,500 ha, it is better to exclude it from the development area on the ground that the peat soils are generally acidic and sometimes very acidic and the yields of crops are usually poor.

Therefore, the agricultural development area has been decided at 55,000 ha. Excluding unsuitable area such as small hilly terraces, the scattering swamp and also the sites for major irrigation and drainage system and on-farm facilities, the net cultivation area of 44,000 ha is selected. (Refer to Fig. 4-9.)

4.5.2 Selection of Crops

There are several factors as described below which need to be taken into consideration when suitable crops are to be selected for intensive cultivation as the key products for agricultural development. (Refer to Table 4-4.)

1)	Flood condition	A flood of 20-year return period
2)	Soils and Land capability	Fertility and slopes
3)	Weather conditions	Rainfall distribution and others
4)	Productivity	Production cost and net returns
5)	Labour requirements	Labour shortage and easy mechanized operations
6)	Marketability of products	Domestic and international

Annual crops are to be selected on the grounds that 1) the area may be affected by floods of 20-year probability even after the completion of the proposed dam, which might annihilate such tree crops as oil palm and cacao, and 2) the Kinabatangan River Basin has extensive terrace land outside the project area, which is more suitable for tree crops.

Among annual crops, paddy is the optimum choice for the alluvial soil because 1) it is one of a few crops which large scale mechanization for irrigated farming would be possible owing to its vast plain and 2) rice has comparatively high and stable market value. As for the weather conditions such as temperature and rainfall, most of the above-mentioned crops are not affected in the case of crop selection. Temperature and rainfall is enough for growing every kind of crops throughout a year.

4.5.3 Farming Form

As for the paddy cultivation in the area of 44,000 ha, the total number of required farming families would be over 22,000 if the area is to be developed by small-holders on the basis of 5 acres to a family. Allowing 5 persons per family, the number of persons who could be settled on this paddy scheme would be over 110,000.

The major handicaps likely to be faced in the development of the Kinabatangan plains is the lack of population.

Large scale farming with minimum labour forces will obtain higher productivity compared to small scale individual farming owing to scale merit of production. (Refer to Table 4-5.) Furthermore, the topographical condition of the project area is very favourable for a large scale mechanized paddy production.

Therefore, large scale commercial paddy-planting utilizing machinery and a minimum of man-power is proposed under the project.

In order to ascertain the responsibilities for the management of the project, it is proposed that an efficient autonomous organization with commercial base production activities is established for operation and maintenance of irrigation and drainage, paddy cultivation, rice processing, and the sales of agricultural products. The proposed organization is as shown in Fig. 4-10.

The agricultural development area will be divided into 11 tracts for the convenience of project management and farming activities based on the capacity of rice mill plant.

In each tract branch office, branch workshop and other facilities will be installed. One of these tracts will be selected as a central tract with head office and other centralized facilities.

The Experiment Pilot Farm will be undertaken the technical support duty including not only farming experiment but also training of the technical personnel under the project.

4.5.4 Farming and Processing

1) Cropping Pattern and selection of varieties

The following cropping pattern has been selected from the physiological characteristics of paddy, meteorological conditions and irrigation water consumption.

From April to May and June, rainfall will increase gradually. This produces convenient conditions of soil for sowing the first crop (off season). The harvesting of it should be done by September otherwise rainfall will increase from October to December.

October to December is in turn a very suitable season for sowing of the second crop(main season). The harvesting of the second crop should be undertaken after March in order to avoid the comparatively heavy rainfall in January and February.

Thus, the first paddy, crop will take place during the season of mid April/May to mid August/September (about 120 days). The second crop would be grown during the period October/mid November to March/mid April (about 150 days). The proposed cropping pattern will be shown in Fig. 4-11.

At present, two varieties of IR-42 (135-150 days) and MR-7 (115-130 days) are recommendable. These varieties are highly resistant to blast, "Penyakit merah" and bacterial leaf blight. The yeild would be around 4 tons per hectare and milling recovery ratio would be 68%.

Therefore, MR-7 would be planted for the first and IR-42 for the second crop.

2) Proposed Farming Practices

Full mechanized farming is proposed throughout the paddy rice cultivation. As for the farming operation unit, an area of 400 ha will be cultivated by one farming operation group. The operation unit will consist of 6 tractors and 2 combine harvesters as the prime moved machinery and 25 machine operators and farm labours.

The direct sowing by drill seeders in saturated condition of farmland is proposed and after germination the paddy field will be irrigated until the mild ripening stage of rice.

Land preparation would be carried out by using 70 HP class tractors. Plant protection practices would be adopted with sprayers and dusters. Harvesting will be mechanized by utilization of combine harvesters.

3) Expected Yield

The target yield of rice in the full operation stage in each tract will be estimated at 4.2 tons/ha by the first cropping (off season) and 3.8 tons/ha by the second cropping (main season) with the implementation of the project. The paddy production in the initial stage will increase year after year through improved field conditions and farming techniques. The following table shows the anticipated yields during the built-up period of 5 years.

	Year				
	1st	2nd	3rd	4th	5th
First cropping (off season)	2.6	3.0	3.4	3.8	4.2
Second cropping(main season)	2.4	2.8	3.2	3.5	3.8
Total (ton/ha)	5.0	5.8	6.6	7.3	8.0

4) Processing

The paddy produced under the project will be milled by modern rice mills at the project site in order to improve the milling recovery ratio and to minimize the transportation cost from the project area to Sandakan. The rice mill with milling capacity of 6 tons/hr will be installed in each tract which covers the area of around 4,000 ha. Thus, the rice mills will be constructed at 11 places in the whole project area. (Refer to Fig. 4-12).

4.5.5 Land Development Plan

1) Land Reclamation

Out of 55,000 ha suitable for agricultural development, 48,700 ha which consists of 4,700 ha for acquired land for facilities and 44,000 ha for net irrigable area (divided into 23 blocks) is to be reclaimed in the flood prone area through the proposed works of jungle clearing, root removing and levellig. (Refer to Fig. 4-12).

2) Irrigation System

i) Diversion water requirement

The diversion requirement has been estimated based on the rainfall pattern and the evaporation value. The rainfall pattern adopted is that in 1978 recorded at Kuamut rainfall station (equivalent to the 5-year probability) and the evaporation value is what has been identified by the pan evaporation method.

Required reservoir capacity allocated for irrigation: 0.12×10^9 m^3

Design maximum diversion water requirement:
1.772 litres/s/ha
= 78 m^3/s/44,000 ha

Fig. 4-13 shows calculation result of the required reservoir capacity.

ii) Diversion method

After studying three different diversion methods, i.e., gravity irrigation directly from dam, gravity irrigation from head work, and pumped irrigation from the river, the last method that is the pumped irrigation has been finally adopted. According to the preliminary comparative study, pumped irrigation system has more than 4 times advantage on the direct gravity irrigation systems from dam and head works in its annual cost i.e., sum of depreciation and O/M cost. The proposed flow diagram for the maximum diversion requirement is illustrated in Fig. 4-14.

3) Drainage System

i) Design drainage discharge

Drainage facilities have been designed based on the 144.8 mm of the maximum daily rainfall that was recorded on 6 February, 1971 at Kuamut Rainfall Station; its probability has a 5-year recurrence.

Design drainage discharge has been estimated taking the extent of catchment area, required drainage time and run-off coefficient into account as follows:

External area	:	5.0 litre/s/ha
Existing canal in the paddy field	:	5.45 litre/s/ha
Lateral drain	:	8.4 litre/s/ha
Sub lateral drain	:	10.9 litre/s/ha

ii) Drainage method

Since design high water level of the river after regulation by the proposed reservoir is lower than the elevation of proposed paddy field, the gravity can be adoptable to drain the excess water from paddy field to the river.

4.5.6 Labour Requirement

Labour requirement for the project in full operation stage is estimated to be about 4,000 persons.

The project personnel could be classified into 3 categories: 190 of staff and specialist, 580 of skilled personnel and 3,230 of semi-skilled personnel.

Among these categories, the staff and specialist group will need to be the highly experienced personnel in the field of office management, marketing, company management, and technology concerning rice production and processing. They will be recruited from the whole area of the country because of the high qualification personnels required.

The skilled personnel group will be required enough experiences in office works and/or workshop such as accountant, clerk, mechanics, etc. They could be recruited from Sandakan and/or Kota Kinabalu.

The semi-skilled labour group could be recruited in the Basin itself after some training for farm machinery operation, irrigation farming, processing plant operation, etc.

4.5.7 Benefit

At the full operation stage, 239,360 tons of milled rice and 31,680 tons of rice bran will be produced by the project.

On the basis of the unit prices of rice and rice bran, M$1,242/ton and M$417/ton respectively, the gross production value is estimated at M$310 millions. The net production value of the project is estimated to be M$177 millions by deducting the production cost of M$125 millions (M$2,854/ha) and damages cost of M$8 millions due to the flooding over a 20-year return period from the gross production value.

The first stage production will be obtained in the 6th year from the commencement of project construction, and 15th year of its will be reached to full production stage of paddy through stepwise land development. The unit prices of rice and the annual benefits of this period will be shown in Tables 4-6 and 4-7.

4.6 HYDRO POWER DEVELOPMENT

4.6.1 Future Demand and Supply Area

To cope with growing power demand, SEB has been trying to enhance the existing diesel power station and is also planning to build hydro power and natural gas power station etc.

The future power demand in the whole Sabah State, and in such major cities as Sandakan, Tawau, Lahad Datu in the East Division are shown in Table 4-8.

Among these major cities, Sandakan has been selected as the supply area based on the following reasons:

- The nearest city to the proposed Balat power station.
- Generated energy of 31.5 x 10^3 kW at the power station for the future demand at Sandakan of 68.3 x 10^3 kW in 1990.

4.6.2 Power Generation

Selection of Generating Type

The following three generating types may be taken up for the Balat power station:

1) Run-of-river type
2) Regulation pondage type
3) Reservoir type

Out of these three types, the run-of-river types has been adopted because of economic advantage over the other two. (Refer to Fig. 4-15)

Power Generation

To identify the optimum scale of Balat power station, the discharge duration data in 1975, which corresponds to the average of the years (1970-1979), was adopted. Power generations cost by use of the run-of-river type facilities was calculated for four alternative cases of each installed capacity of power generator.

The optimum generating capacity which has ultimately been selected as the most economical alternative is follows: (Refer to Table 4-9)

Maximum discharge	:	450 m^3/s
Effective head	:	8.4 m
Maximum generated output	:	31,500 kW
Annual generated energy	:	168 x 10^6 kWh

4.6.3 Transmission Line

A transmission line from Balat power station to Sandakan will be constructed for a distance of about 100 km along the proposed access road of Balat dam and the existing main road as shown in Fig. 4-16. Generated power will be conveyed by a 132 kv three-phase, three wire transmission system.

4.6.4 Benefit

The value of Balat hydro power station is evaluated based on the cost of the lowest-priced alternative thermal plant.

In this study, a gas fired steam station with the capacity of 350,000 kW (/1) will be adopted for the alternative. The capacity value and energy value of the alternative plant have been estimated at US$68/kW and US$0.019/kWH, respectively. Annual benefit is estimated at US$ 3.7 million, which consists of capacity benefit of US$ 0.7 million and energy benefit of US$ 3.0 million.

/1 : "MASTER PLAN FOR POWER SYSTEM DEVELOPMENT - INTERIM REPORT, June 1980, SAMA Consortium"

CHAPTER V PRELIMINARY DESIGN

5.1 GENERAL

Based on the optimum size of the related facilities which have been studied in Chapter IV, preliminary design has been done. The preliminary design discussed in this chapter includes the Balat dam and the related facilities, agricultural facilities, irrigation and drainage facilities and hydro power station with transmission line.

5.2 DAM AND RESERVOIR

5.2.1 Dam

The Balat dam comprises the main dam and four sub dams. The main dam which is located on the Kinabatangan River will be built to shut down the river water and the sub dams which are situated on the right side of the main dam to close saddles for storing the reservoir water.

The followings are the principal features of each dam which is decided on the basis of the study results mentioned below and 5.5.2 Spillway.

	Main dam	Sub dam			
		No. 1	No. 2	No. 3	No. 4
Height (m)	46	16	42	10	26
Length (m)	530	540	550	120	780
Dam volume (m^3)	2,150,000	330,000	1,830,000	20,000	990,000

The aggregate total volume of these dams will be 5,320,000 m^3.

General plan, profile and cross-section of the dam and appurtenant structures are illustrated in Figs. 5-1, 5-2 and 5-3.

Dam Type

As for dam type, an earthfill dam with a rip-rap slope was selected for the following reasons:

1) Bedrocks around the damsite consist of sandstone bed and mudstone bed. Alluvium in Quarternary which is composed of very thick sediment, covers these bed rocks. Mudstone and Alluvium sediment cannot withstand a concrete dam.

2) Construction materials for an earthfill dam are available around the damsite, but it is difficult to obtain rock materials around this area.

Freeboard

The freeboard of 3.0 m provided above the design flood water level of 43.0 m is adopted for safety of dam body in due consideration of reservoir water level raising caused by waving in reservoir, upstream side slope of dam.

Dam Foundation

Alluvial deposit of more than 36 m deep is present at the location of the foundation of Balat dam. To cope with this condition, various methods of the dam foundation were studied and an impermeable blanket method was adopted as economically most advantageous and easier in construction execution.

5.2.2 Spillway

The design flood discharge of 15,500 m^3/s which corresponds to probable maximum flood at Balat damsite is adopted for spillway design. A free overflow type of spillway was adopted to discharge the flood from the viewpoint of avoiding the man-made flood and easier maintenance of the facilities.

Taking the topographic configuration of the damsite in consideration, two spillways are required; one to be located on the right side of the main dam, and the other between No. 1 and No. 2 sub dams. The overflow portion of the respective spillway is 300 m wide and 6 m water depth as shown in Fig. 5-2.

5.2.3 Outlet Facilities

The two outlet facilities are to be constructed, the one is to control the flooding water and the other to maintain Normal Water Level (N.W.L.).

Both are located in parallel on the left side of the main dam. The flood control facility is designed for controlling a 20-year probable flood of 5,400 m^3/s down to 900 m^3/s, and has a overflow portion of 5.0 m in width and 28.5 m in depth. The outlet facility to maintain N.W.L. is designed for a discharge of 450 m^3/s and consists of three outlet pipes (7 m in diameter), each has an emergency gate and main gate. This facility is also to be utilized for power generation. (Refer to Fig. 5-4)

5.2.4 Diversion Works

The diversion works are required for construction of main dam and No. 2 sub dam and no diversion works for construction of other three sub dams which are located in higher elevated area.

The diversion works consist of temporary diversion tunnel and coffer dam. Two different discharges for diversion work design are adopted because of different construction period between of main dam and of No.2 sub dam.

A discharge of 20-year probable of 5,400 m^3/s is adopted for diversion work design of the main dam and is diverted by a coffer dam having a crest elevation of 22 m, and by two temporary diversion tunnels of 8 m in diameter and 950 m in extension which are located in parallel below the left abutment of the main dam.

A discharge of 5-year probable of 3,500 m^3/s is adopted for diversion work design of No.2 sub dam and will be diverted by a coffer dam having a crest elevation of EL.27 m, the diversion tunnels mentioned above and outlet facility of the main dam.

5.2.5 Access Road

The access road for transportation of construction materials and equipment is to link the damsite to the main road running between Sandakan and Kota Kinabalu. The length of the access road is about 48 km. The access road may require two bridges.

5.3 AGRICULTURAL DEVELOPMENT

5.3.1 Irrigation and Drainage Facilities

The required facilities are shown in Table 5-1 and typical layout of field structures are illustrated in Fig. 5-5.

- Irrigation system

  Irrigation water is supplied by 23 pumping stations. Each station is installed with 3-4 numbers of inclined mixed flow pump of 500-900 mm diameter. All irrigation canal has been designed as unlined earth canal and its canal density is 64 m/ha. Other related structures such as secondary and tertiary canals, diversion and so on are provided in accordance with the DID Manual.

- Drainage system

  All drainage canal is planned as unlined earth canal and its density is 33 m/ha. The sluices with flap gate are provided at the ends of the main or lateral drains.

- Road network

  The gravel metaled farm roads and non-metaled on-farm roads are planned with the density of 14 m/ha and 20 m/ha, respectively, to enable the effective mechanized farming practice.

5.3.2 Farming Facilities

Each farming tract will require some facilities for paddy production, the main facilities being office buildings, workshops, warehouses, tractor shades, rice mills, pilot farm, etc.

These facilities will have to be constructed at compratively higher altitude in each tract in order to avoid the flood.

<u>Project Office</u>

The head office will be constructed as a centre of the project management, and it will be installed with main office spaces, meeting rooms, waiting rooms etc. The capacity of the office is estimated for about 550 personnel.

The branch office with including waiting room will be constructed in each tract.

The capacity of each branch office will be for about 280 personnel. The required spaces of head office and each branch office are as follows.

Head office	:	1,500 m^2	1 place
Branch office	:	600 m^2	10 places

Warehouse

The warehouse for storing farm inputs and others will be constructed in each tract in conjunction with project office. The installed capacity of the warehouse will be about 1,500 tons of fertilizers; 250 tons of chemicals and other farming materials such as spare parts of machinery and lubricating oil.

Warehouse	:	2,500 m^2	11 places

Workshop

The workshop will be constructed in each tract for repair and maintenance of farm machinery and irrigation pumps.

The workshop facilities will include machinery tools for repair and maintenance such as lathe, welding units, grinding machine, drilling machine, air compressor, hydraulic press etc.

Central workshop	:	2,000 m^2	1 place
Branch workshop	:	1,000 m^2	10 places

Tractor Shed

The tractor shed for farm machinery will be constructed in each tract. About 60 tractors, 2 combines and about 150 units of attachments will be accomodated in the shed.

Tractor shade	:	2,000 m^2	11 places

Rice Mill

As for the post harvest of paddy, the rice mill will be constructed in each tract.

Rice mill building	:	3,400 m^2	11 places
Storage	:	1,000 m^2	11 places
Power house	:	680 m^2	11 places
Milling capacity	:	6 ton/hr	11 places

Others

Among other facilities required, shipping wharfs are indispensable for transportation purposes.

Shipping wharf	:	50 m^2	11 places

5.3.3 Farm Machinery

As for the farm machinery of paddy cultivation, four wheel tractors and big combine harvesters will be introduced as the prime moved machinery.

Total number of main machinery and its attachment including some standby units are as follows:

Wheel tractor	:	600 units
Crawler tractor	:	150 units
Combine harvester	:	250 units
Disk plough	:	250 units
Rotavator	:	350 units
Drill seeder	:	150 units
Power duster	:	250 units
Dump truck	:	250 units

5.4 HYDRO POWER

5.4.1 Power House

The power house is to be constructed on the left side of the river downstream of the outlet facility of the proposed Balat dam. Three generators will be accommodated in the power house which is built with reinforced concrete, 20 m in length, 48 m in width, 20 m above and 15 m below the ground level.

The power house and water way are illustrated in Fig. 5-6.

5.4.2 Generating Equipment

Each one of the proposed hydraulic turbines which has been designed under conditions of 150 m^3/s of discharge each at 8.4 m design head, will be of bulb type, tubular turbine.

The selection of the turbines has been made by considering the under-mentioned items.

Normal water level	:	EL.17.5 m
Low water level	:	EL.16.5 m
Normal tail water level	:	EL. 8.0 m
Effective head	:	8.4 m
Head loss	:	1.1 m

Three generators to be provided for the power station will be of horizontal shaft, and rated at 11,000 kVA, 3 phase 50 Hz. each.

5.4.3 Transmission Line

The steel tower for the 132 kV transmission line will be installed at every 250 m, for a distance of about 100 km between Balat power station and Sandakan. The conductor selected is 160 mm^2 Aluminum Cable Steel Reinforced (ACSR) considering corona discharge.

CHAPTER VI CONSTRUCTION SCHEDULE AND COST

6.1 GENERAL

In this Chapter, construction schedule and cost as to dam, agricultural facilities and hydro power, will be described.

In working out these construction plans, careful consideration of and evaluation with such items as the local availability of construction machinery and material, their prices, the facilities and capability for repairing of the machinery and equipment to be mobilized for construction works, the conveniences of their transport to the job sites, and other necessary items relevant to construction work has been made.

Lumbers, bricks, stones, fuels and oils which are necessary as the construction materials in general are almost entirely obtainable locally, but the structual steel, iron/steelpipes, water gates, valves and other materials which need to be of high precision and good quality will have to be imported. Cement is partly imported and partly purchased locally.

Construction schedules proposed in this report are those which have been worked out essentially from the technical viewpoints and, therefore, it is necessary to review them from the standpoint of actual implementation and to make some amendment or alternation.

6.2 DAM

6.2.1 Construction Schedule

Construction schedule of the main work of Balat dam will follow the stages as mentioned below;

- Diversion Work	: Oct. 1985	- Mar. 1987
- Coffer Dam	: Apr. 1987	- Sep. 1988
- Outlet Facilities	: Jan. 1987	- June 1990
- Main Dam	: Oct. 1988	- Dec. 1990
- Sub Dam	: Jan. 1990	- Jun. 1992
- Spillway	: Jan. 1988	- Jun. 1992

An entire construction period covering all stages above will be for 10 years and is shown in Fig. 6-1.

While the excavation work will be continuously done all through the year, embankment and concrete works will be done except rainy days (above 20 mm daily rainfall) and holidays.

6.2.2 Cost Estimate

Construction Cost

Total construction cost of Balat dam comprises main civil works, land acquisition, engineering cost plus 10% physical contingencies.

The total cost will be US$201 million, out of which US$97 million is in foreign currency and US$104 million in local currency.

The construction cost by kind of works is shown in Table 6-1.

Operation, Maintenance and Replacement Cost

The dam operation and maintenance cost will comprise the personnel cost, operational machinery and equipment, vehicles, boats, administrative cost and miscellaneous. As an annual operation and maintenance cost for the whole period of the project life, US$0.15 million is estimated. Replacement cost of the gates after 35 years from the initial dam operation is US$7.4 million.

6.3 AGRICULTURAL DEVELOPMENT

6.3.1 Construction Schedule

As for the construction schedule of the net cultivation area of 44,000 ha, a rapid development schedule was adopted from the economic view point and the paddy could be planted as early as technically possible following protection from flood damage through dam construction.

During the dam construction period, paddy cultivation in the off-season will be possible without any flood control measure because the habitual flood will occur only in main seasons.

Therefore, single cropping in the off season will be implemented till 1993 year when the Balat dam construction is completed, and after completion of the dam, double cropping will be implemented as projected.

To fully develop the net cultivation area at time of the completion of Balat dam, an entire construction period for agricultural development excluding the detailed design phase will be at least 8 years. The construction schedule covering all the stages is shown in Fig. 6-1.

The net development area will be divided into 7 portions for stepwise development. Each portion will be developed within three years including jungle clearig, land levelling, construction of pumping stations, office and rice mill buildings etc. in order.

6.3.2 Cost Estimate

Construction Cost

Total construction cost comprises agricultral development, resettlement, land acquisition, engineering cost plus 10% physical contingencies.

The total cost will be US$460 million, out of which US$280 million is in foreign currency and US$180 million in local currency.

The construction cost by kind of works is shown in Table 6-2.

Production Cost

Production cost including operation and maintenance comprises necessary input for the cultivation, labour force fuel, spare parts, etc.

As an annual production cost for the whole period of the project life, US$54.6 million is estimated.

Replacement Cost

The equipment and machinery to be replaced consist of pumps, gates, rice mills, farm machinery, equipments for operation and maintenance.

Total replacement cost for entire period of project life is estimated at US$685.1 million.

6.4 HYDRO POWER

6.4.1 Construction Schedule

The commencement of commercial operation of power generation is scheduled simultaneously with the completion of the dam construction.

Construction schedule of power station is formed taking time required for the following matters into consideration.

- Manufacture of power generating equipment
- Transportation of the equipment to the project site.
- Installation of the equipment
- Construction of outlet facility of main dam.

The total time required for the above is estimated at 3 years. The commencement of the construction of transmission lines will be in time with the completion of installation of the power generating equipment at the proposed site.

The construction schedule is shown in Fig. 6-1.

6.4.2 Cost Estimate

Construction Cost

The construction cost for the hydro power generation comprises station house, civil works, generating equipment, transmission line, engineering cost plus 10% physical contingencies.

The total cost of US$40.3 million consists of US$34.1 million in foreign currency and US$6.2 million in local currency.

The breakdown of the construction cost is shown in Table 6-3.

Operation, Maintenance and Replacement Cost

The operation and maintenance cost will comprise the personnel cost, operation of machinery and equipment, vehicles, administrative cost and miscellaneous. The annual operation and maintenance cost is estimated at US$0.80 million for the whole period of the project life. Replacement cost of the generating equipment after 35 years from the initial operation is US$19.6 million.

6.5 RESETTLEMENT, LAND ACQUISITION AND HOUSE EVACUATION

Resettlement

The resettlement scheme will be required for the following background;

1) The area where 850 houses are located will be submerged by dam construction. Consequently the inhabitants in the area must be resettled.

2) 4,000 labour forces which consists of 770 skilled and 3,230 semi-skilled labourers will be needed for the management and operation of agricultural project proposed in this project. And all of them will be settled.

In this study, 770 skilled labourers are assumed to be settled from Kota Kinabalu, while 3,230 semi-skilled labourers will be raised from amongst the settlers from submergible area of Balat dam and the inhabitants of other areas in the Kinabatangan River Basin.

The required facilities for resettlement consist of i) settler's housing including quarters for management and administration staff, ii) school, hospital, mosque, and shops, iii) transportation, and iv) electric power supply facility.

The resettlement cost is estimated at US$16.4 million.

Land Acquisition

The land of 520 km^2 in the submergible area must be acquired for implementation of the project.

Moreover, acquisition of land meant for roads and irrigation facilities provided in the agricultural development area is necessary. The area to be acquired amount to 8% of the total agricultural development area.

The cost required for land acquisition is estimated at US$ 32.2 million in total.

House Evacuation

In the submergible area, the number of houses to be evacuated is estimated at 850. The house evacuation cost is estimated at US$1.1 million.

CHAPTER VII PROJECT EVALUATION

7.1 GENERAL

This chapter deals with the economic evaluation of the project. The project would substantially reduce flood damage by construction of the dam and increase the agricultural production through the conversion of the present flood prone area to agricultural use. Hydro power sector which will support the demand in Sandakan city would be taken into consideration in the project.

The economic viability of this project will be evaluated as a package of development plans for flood control, agriculture and hydro power generation, by means of calculating Internal Rate of Return.

The assessment of economic viability of the project will be made on the basis of the terms of the implementing schedule mentioned elsewhere in the foregoing.

Sensitivity analysis is also made with regard to any change in the implementing schedule and the expected quantity of rice produced.

Malaysian Ringgit and Yen are converted to US Dollar at the exchange rates of M$ 2.30 to US$ 1.00 and ¥230 to US$ 1.00. The project life for the economic evaluation is fixed at 50 years.

7.2 PROJECT COST

The total project cost is estimated at US$1,050 million, on the basis of 1981 prices, of which US$622 million is in foreign currency, and US$428 million is in local currency. The quantity of works is estimated on the basis of the preliminary design which has been prepared during the study period. Unit prices and the costs of equipment required for the project implementation are in line with the recent bid prices for similar works. These and duties are included in these prices and costs. Physical contingencies of 10% have been applied to all the works and equipment costs. Price contingencies are also taken into account at an annual escalation rate of 7% for foreign currency and for local currency.

The project cost is classified by work item given as follows.

($\times 10^6$ US$)

Work	Foreign portion	Local portion	Total
Dam & Reservior	141.3	147.1	288.4
Agricultural development	422.3	270.9	693.2
Hydro power development	58.1	10.6	68.7
Total	621.7	428.6	1,050.3

Table 7-1 shows the annual disbursement of the project cost.

7.3 ECONOMIC EVALUATION

7.3.1 Project Benefit

The project benefit may be classified into primary and secondary benefit. The actual figure has been presented only for the primary benefit.

1) Primary Benefit

The benefit of this project will accrue from flood control sector, agricultural development sector and also power generation sector.

Annual benefit derived from each sector which has been calculated in the monetary terms are summarized in below.

($x10^6$US$)

Sector		Annual benefit
Flood control	:	0.29
Agricultural development	:	77.04
Hydro power development	:	3.70
Total	:	81.03

The flood control benefit will begin to accrue in 1993 that is, after completion of Balat dam due to its regulation effectiveness.

As agricultural development will be expanded stepwise during a period of 10 years, the agriculture benefit can be expected to accrue from the area after completion of all the related works. However, the annual average benefit will not be brought about immediately thence forward. The built-up period of agriculture benefit is assumed to be five years after completion of the related works, during which time the benefit will increase linerly.

Benefit from power generation is to accrue in 1993 when all the works required for power generation are completed.

The benefit of each sector is assumed to accrue in annual terms throughout the project life.

2) Secondary Benefit

Some benefits expected from the project are to be identified as the secondary benefits.

They include such benefits as promotion of recreation/tourism, provision of infrastructure, and development of fishing culture by using the reservoir, and some portion of the cut-down trees in the course of land clearance may also be utilized as the timber logs for local use.

In addition, the project will contribute much to saving of foreign currency.

Though the State of Sabah has imported about 63,000 tons of rice in 1978, the project area is expected to bring about surplus production of rice within a short time. After completion of the project, rice production will increase by 239 x 10^3 tons, which will contribute in saving foreign currency in Malaysia through reduction of rice import. If all this production is consumed in whole Malaysia, the foreign currency can be saved by US$129 million per annum in full-operation stage of the rice production.

7.3.2 Economic Cost

Estimation of costs required for materials equipment and engineering services, which are to be procured by international competitive bidding, is based on the international price levels. The local cost is estimated on the basis of the prevailing prices for similar works which are now going on in and around the project area.

The construciton cost includes that for construction of dam and its appurtenant facilities, agricultural development, and hydro power generation. The total economic construction cost is estimated at US$705.3 million, which is composed of foreign currency portion of US$410.5 million and local currency portion of US$294.8 million equivalent. These costs are summarized below.

($x10^6$ US$)

Work	Foreign portion	Local portion	Total
Dam & reservoir	96.8	106.2	203.0
Agricultural development	279.6	182.4	462.0
Hydro power development	34.1	6.2	40.3
Total	410.5	294.8	705.3

Table 7-2 shows the annual disbursement of the economic construciton cost.

Cost Allocaiton

To identify the equitable cost for each purpose, the economic cost for dam construction has been allocated according to the share ratio of capacity for flood control and agricultural development. The result of cost allocation is as follows:

($x10^6$ US$)

Sector	Foreign portion	Local portion	Total
Flood control	94.4	103.5	197.9
Agricultural development	2.4	2.7	5.1
Total	96.8	106.2	203.0

The cost for power generation is excluded from the cost for dam construction, since any reservoir capacity will not be allocated for hydro power generation.

Cost Estimate by Purpose

Based on the above allocation of the dam construction cost, the total project economic cost can be further classified by each purpose as follows:

($x10^6$ US$)

Sector	Foreign portion	Local portion	Total
Flood control	94.4	103.5	197.9
Agricultural development	282.0	185.1	467.1
Hydro power development	34.1	6.2	40.3
Total	410.5	294.8	705.3

Operation and Maintenance Cost

To assure the benefits throughout the project life, the related facilities should be successfully operated and safely maintained. The annual cost for operation and maintenance is estimated at US$55.55 million, which is composed of;

Work	Annual cost ($x10^6$ US$)
Dam & Reservoir	0.15
Agricultural development	54.60
Hydro power development	0.80
Total	55.55

6

Replacement Cost

Facilities related to the project are to be replaced periodically to attain their original purposes during the project life; the facilities to be replaced and their costs are summarized as below:

	Total cost ($x10^6$ US$)
Dam	7.4
Agricultural development	685.1
Hydro power development	19.6

7.3.3 Internal Rate of Return

Evaluation of the project was made by means of calculating Internal Rate of Return on the basis of the estimated benefit and economic cost including operation and maintenance cost and replacement cost. The Internal Rate of Return is calculated at 7.1% assuming a project life of 50 years.

7.3.4 Sensitivity Analysis

Sensitivity analysis has also been made on the assumptions of 1) reduction of the expected rice production, 2) extention of construction period and 3) increase of construction cost.

The results are summarized below.

		IRR (%)
1)	Reduction of rice production (-10%)	5.5
2)	Construction period (10 years extention)	6.4
3)	Increase of construction cost (+10%)	5.6

7.4 SOCIO-ECONOMIC IMPACTS

In addition to the benefits stipulated in the economic evaluation, favourable socio-economic impacts are anticipated from the implementation of the project.

Improvement of local transportation will result from the construction of the access road to damsite and of farm road. The expanded road system will not only promote the economic activity in the region but also contribute to inter-regional transportation and communications.

The enhanced economic activity through the increases of agricultural production, and the improved living condition by the completion of the flood control measures, will also substantially facilitate socio-economic stability in the region.

Furthermore, agro-based industrial activities will come to flourish with the increase of agricultural production, mechanized farming and provision of infrastructural facilities.

However, implementation of the project requires acquisition of a considerable land for the area of dam and reservoir and over 850 families will have to be moved out elsewhere even through they may be fully compensated for their lands and quarters. The community life of the people living in the adjacent area will also be seriously affected.

Therefore, restoration of the local communities and resettlement of the displaced people needs to be implemented very carefully for the successful implementation of the project.

The river channel will also be expected to play a part of the transportation system for the passengers, commodities and the timber logs, while the role for the timber transport may reduce in parellel with the dwindling of the timber product. However, as the river navigaiton will be interrupted by dam construction, the access road will take over some portion of the role of the river channel.

CHAPTER VIII CONCLUSION

The Kinabatangan River Basin Development Project has been formulated for the purpose of development of the riparian areas of the basin into agricultural land by flood control of the River and of power generation to meet ever increasing demand in the east coast area.

It is identified that the project is technically feasible but not so high in its economic viability with a 7.1% of Internal Rate of Return. Besides, a vast initial investment for jungle clearance, establishment of infrastructure, immigration of workers as well as flood control will be required to orderly develop the area which is now covered with unexploited forest having a small population. It cannot be recommended, therefore, that the project will be put into execution for the moment, although it can be greatly expected to serve as a vital role to enhance the productivity of the entire Kinabatangan River Basin and also to promote the regional economy of the State of Sabah.

T A B L E

Table 2-1 GROSS DOMESTIC PRODUCT

	1970-GDP (M$ Million)		1970-80 Av. Annual Growth (%)		1980-GDP (M$ Million)		1980-85 Av. Annual Growth (%)		1985-GDP (M$ Million)		1985-90 Av.Annual Growth (%)		1990-GDP (M$ Million)	
	M	S	M	S	M	S	M	S	M	S	M	S	M	S
Agriculture, forestry and fishery	3,852 (30.5)	460 (54.2)	4.2	6.5	5,809 (22.9)	861 (44.3)	3.0	2.2	6.720 (18.3)	962 (34.8)	4.0	4.6	8,193 (14.9)	1,203 (29.3)
Mining and Quarrying	834 (6.6)	3 (0.3)	3.8	56.5	1,214 (4.8)	264 (13.6)	5.8	8.6	1,607 (4.4)	400 (14.5)	3.0	5.3	1,863 (3.4)	517 (12.6)
Manufacturing	1,858 (14.7)	21 (2.5)	11.2	7.9	5,374 (21.2)	45 (2.3)	11.0	16.6	9,040 (24.6)	97 (3.5)	10.8	13.4	15,121 (27.6)	182 (4.4)
Construction	541 (4.3)	36 (4.2)	8.2	11.1	1,186 (4.7)	103 (5.3)	9.0	11.9	1,824 (5.0)	181 (6.5)	10.0	12.0	2,938 (5.4)	320 (7.8)
Electricity, Gas and Water	238 (1.9)	10 (1.2)	9.5	9.1	592 (2.3)	24 (1.2)	10.0	10.2	953 (2.6)	39 (1.4)	9.5	10.4	1,500 (2.7)	64 (1.6)
Transport, Storage and Communications	632 (5.0)	44 (9.3)	10.4	9.3	1,696 (6.7)	107 (5.5)	8.0	9.7	2,492 (6.8)	170 (6.1)	9.0	10.7	3,834 (7.0)	283 (6.9)
Wholesale, Hotels and Restaurans	1,717 (13.6)	105 (12.4)	6.7	6.1	3,295 (13.0)	189 (9.7)	8.0	12.2	4,841 (13.2)	336 (12.1)	8.5	11.0	7,279 (13.3)	568 (13.8)
Insurance and Ownership of Dwellings	1,126 (8.9)	66 (7.8)	6.7	7.3	2,155 (8.5)	134 (6.9)	7.4	8.9	3,079 (8.4)	205 (7.4)	8.5	10.1	4,629 (8.4)	332 (8.1)
Public Administration and Defence	1,466 (11.6)	89 (10.5)	8.8	7.7	3,398 (13.4)	187 (9.6)	9.0	11.8	5,228 (14.2)	327 (11.8)	9.0	11.0	8,044 (14.7)	553 (13.5)
Other Services	354 (2.9)	14 (1.7)	6.4	7.9	657 (2.5)	30 (1.6)	7.6	10.6	948 (2.6)	50 (1.8)	9.0	11.2	1,459 (2.7)	85 (2.1)
TOTAL GDP	12,618 (100.0)	848 (100.0)	7.2	8.7	25,376 (100.0)	1,944 (100.0)	7.7	7.3	36,732 (100.0)	2,767 (100.0)	8.4	8.2	54,860 (100.0)	4,107 (100.0)
(GDP per capita)	1,172.2	1,302.9			1,836	1,847			2,337.8	2,216.9			3,128.5	2,807.6

Source: Forth Malaysia Plan, 1981-85

Note: M: Malaysia, S: Sabah and ( ) : %

Table 3-1 FLOOD DAMAGE

Item	Year						
	1968	1971	1974	1976	1977	1980	1981
Farmland:ha (acre)	*	*	*	*	58 (144)	11 (28)	227 (567)
Affected people:nos	8,000	5,000	*	*	2,500	*	*
Dead or lost: nos	*	*	*	13	*	*	1
House : nos							
-Washed away	193	*	3	*	20	1	>130
-Broken	700	*	*	*	>400	6	
-Inundated		*	*	*		123	300
Fowl: nos	*	*	*	*	1,090	*	*

Note : This is compiled based on the recods collected from Drainage & Irrigation Dept., District Office, and Relief Committee.

* No data available

Table 3-2 PRESENT LAND USE

Unit : Acre

Group	1970	1979
Rubber	1,993	1,383
Oil Palm	4,197	12,457
Coconut	2,627	2,251
Cocoa	0	1,074
Paddy (Wet)	26	110
Paddy (Hill)	-	3,200
Maize	-	473
Ground Nuts	-	59
Sweet Potato	-	200
Mixed Horticulture	2,810	-
Agricultural Land	11,661*	23,624

\- Not available

* Except shifting cultivation area

Source: The Present Land Use of the Sandakan Residency,1970
Crop Acreage Sabah 1979

Table 4-1 FEATURES OF POSSIBLE DAMSITES

Damsite	/1 Catchment Area (km^2)	/2 Dead Storage ($x10^6$ m^3)	/3 Effective Storage ($x10^6$ m^3)	/4 Dam Height (m)	/5 Dam Body Volume ($x10^6$ m^3)	Effective Storage per Dam Body Volume (m^3/m^3)	/6 Flood Control Potentiality (km^2/km^2)
1. Milian (1)	950	19	300*	97	9	33	0.089
2. Milian (2)	1,640	33	600*	42	8	75	0.153
3. Melikop	290	6	100*	20	3	33	0.027
4. Pinangah	1,200	24	1,200	35	1	1,200	0.112
5. Tongod	660	13	70*	32	1	70	0.062
6. Imbak	390	8	100*	51	2	50	0.036
7. Karamuak	450	9	200*	24	2	100	0.042
8. Kuamut (1)	980	20	200*	81	7	29	0.091
9. Kuamut (2)	2,770	55	2,770	95	22	126	0.258
10. Kuamut	3,100	62	3,100	76	24	129	0.289
11. Milian	6,650	133	6,650	45	11	605	0.620
12. Deramakot	10,360	207	10,360	46	10	1,036	0.966
11. Balat	10,730	215	10,730	43	8	1,341	1.000

Note : /1 For the sizes of the respective basins, numbered 1 to 13 inclusive, see Fig. 4-1
/2 Equivalent to 100-year volume at unit silt deposit of 200 m^3/km^2/year.
/3 Effective storage is estimated by the unit volume of $1x10^6$ m^3/km^2/year which is the annual available rainfall.
* Effective storage modified by the topographic configuration of the respective damsites.
/4 Height of dam crest above the presumed existing riverbed.
/5 Dam body volume is computed on the basis of a fill dam with fase slope of 1 : 3.0 on both up- and down-stream of the dam body.
/6 The ratio of catchment areas between Balat dam and the other dams.

Table 4-2 COMPARISON OF THREE DANSITES

Unit : million US$

Damsite	Milian-Kuamut	Deramakot	Balat
Cost (C)	1,380.0	820.1	707.4
Benefit (B)	60.7	59.4	58.1
(B) / (C)	0.04	0.07	0.08

Table 4-3 ANNUAL EXPECTED FLOOD DAMAGE REDUCTION

(1) Annual Expected Direct Flood Damage Reduction

1	2	3		4		5	6 (4 x 5)	
Return Period	Discharge (m^3/s)	Flood Damage (10^3US$)		Average Damage (10^3US$)		Expected Value	Expected Damage (10^3US$)	
		Without Dam	With Dam	Without Dam	With Dam		Without Dam	With Dam
1/1.2	1,500	0	0					
				265	0	0.633	168	0
1/5	3,890	531	0					
				531	0	0.100	53	0
1/10	4,840	531	0					
				531	0	0.050	27	0
1/20	6,000	531	0					
				531	265	0.017	9	5
1/30	6,450	531	531					
						Total	257	5

(2) Annual Flood Control Benefit

(unit: 10^3US$)

		Expected Damage	
		Without the project	With the Project
Building & Interior Effects	Direct	257	5
	Indirect	39	1
Total		296	6
Damage Reduction (Benefit)		296 - 6 = 290	

Note : The indirect damage to buildings and inteiror effects is fixed at 15% of the direct damage.

Table 4-4 COMPARISON FOR CROP SELECTION

Crops	Soils	Yield	Mechanized Harvesting	Marketability	Productivity
Paddy	Alluvial	+++	+ +	+++	+++
Soya bean	Peat & Alluvial	+	+	+	±
Groundnuts	Peat & Alluvial	±	–	±	+
Mangobeans	Peat & Alluvial	+	±	±	±
Tapioca	Peat & Alluvial	+++	–	+ +	+++
Maize	Peat & Alluvial	+ +	+ +	+ +	±
Ginger	Peat & Alluvial	+	–	+ +	+
Red chilly	Peat & Alluvial	+	–	+ +	+++
Pineapple	Peat & Alluvial	+++	–	–	+ +

+++ Very suitble, Very good

\+ + Suitable, good

\+ Moderate

± Limited

– Not suitable, difficult

Table 4-5 FARMING SCALE AND BENEFIT

Case	I	II	III
1. Farming Form	Small Scale	Medium Scale	Large Scale
2. Operation Unit	15 ha/group	35 ha/group	400 ha/group
3. Manpower	1.2 ha/man (0.87 man/ha)	4.5 ha/man (0.23 man/ha)	16 ha/man (0.06 man/ha)
4. Planting Method	Transplanting	Drill sowing	Drill sowing
5. Main Machinery	Power tiller x 3 Binder x 3 Thresher x 3	Tractor (25HP) x 2 Small combine x 2	Tractor (75HP) x 5 Clawler x 1 Big combine x 2
6. Machinery Invest-ment (M$/ha)	2,210	2,380	2,638
7. Yield			
Paddy (ton/ha)	8.0	8.0	8.0
Rice (x 65%)	5.2	5.2	5.2
Bran (x 9%)	0.72	0.72	0.72
8. Production Value			
Rice M$1,242/ton	6,458	6,458	6,458
Bran M$417/ton	300	300	300
Total	6,758	6,758	6,758
9. Production Cost (M$/ha)	4,156	3,822	2,854
Labour cost	2,150	1,610	300
OM - machinery*	457	663	1,005
Farm inputs etc.	1,549	1,549	1,549
10. Net Benefit (M$/ha)	2,602	2,936	3,904

* Excluding depreciation cost of farm machinery

Table 4-6 ECONOMIC PRICE OF RICE

Item	Unit	Rice
Projected 1990 World Market Price /1	US$/ton	575
Quality Adjustment /2	%	90
Projected Price	US$/ton	518
Shipping & Handling	US$/ton	+ 33
FOB/CIF Price, Sandakan	US$/ton	551
Equivalent in M$ (x2.3)	M$/ton	1,267
Domestic Transport/Handling	M$/ton	- 25
Farm Gate Economic Price	M$/ton	1,242

/1 Mid-Year Updating of Commodity Price Forecast, IBRD, June 1981.

/2 The produced rice in the project has a little high percentage of brokens, its price is assumed to be 10% lower than Bangkok FOB price of Thailand 5% broken rice.

Table 4-7 NET PRODUCTION VALUE UNTIL FULL PROCUCTION STAGE

Unit : 1,000M$

Construction Year /1		Gross Production Value	Total Production Cost	Net Production Value
1987	6th	4,587	2,854	1,733
1988	7th	21,346	12,843	8,503
1989	8th	40,576	22,832	17,744
1990	9th	62,276	33,821	29,455
1991	10th	86,445	42,810	43,635
1992	11th	112,378	52,799	59,579
1993	12th	265,421	125,576	139,845
1994	13th	283,945	125,576	168,369
1995	14th	297,529	125,576	171,953
1996	15th	306,174	125,576	180,598
1997	16th	310,496	125,576	184,980

/1 See Fig. 6-1

Table 4-8 FUTURE POWER DEMAND

Unit: MW

Year	Sabah	Sandakan	Tawau	Lahad Datu	Semporna
1981	93.7	20.3	11.4	3.0	0.7
1982	112.0	23.5	13.7	3.5	0.9
1983	113.0	27.3	16.4	4.1	1.1
1984	157.0	31.4	19.5	4.7	1.3
1985	185.0	36.1	23.2	5.4	1.6
1986	210.9	41.2	27.4	6.1	1.9
1987	238.3	46.9	32.4	6.9	2.3
1988	266.9	53.5	38.2	7.9	2.7
1989	296.3	60.5	44.7	8.9	3.2
1990	328.9	68.3	52.3	10.2	3.7
1991	361.7	No figure available			
1992	397.9				
1993	437.7				
1994	477.2				
1995	520.1				
1996	566.9				
1997	617.9				
1998	667.3				
1999	720.7				
2000	778.4				

Source : Sabah Electricity Board (SEB)

Table 4-9 COMPARISON OF UNIT CONSTRUCTION COST PER KWH

Maximum Discharge (m^3/s)	400	450	500	550
Effective Head (m)	8.40	8.40	8.40	8.40
Maximum Output (kw)	28,000	31,500	35,000	38,500
Annual Energy Output (10^6 kwh)	159	168	175	182
Unit Construction Cost per kwh (US$)	0.142	0.141	0.154	0.179

Table 5-1 MAIN COMPONENT OF IRRIGATION PROJECT

1.	Pumping Stations (Inclined Mixed Flow Type)		23 places
	Dia. 500mm x3 units - Dia. 900mm x4 units	(130-590 HP)	
2.	Irrigation Canal		
	Convey Canal (Steel Pipe Line Dia. 1200mm- Dia. 1,800mm)		10 km
	Main Canal	(50-160 cusec.)	158 km
	Secondary Canal	(32 cusec.)	461 km
	Tertiary Canal	(1.2 cusec.)	2,244 km
	(Total 2,830 km)		
	Related Structures		
	Check Gate	(50-160 cusec.)	70 nos.
	Offtake	(32 cusec.)	161 nos.
	Turn out (Type I & II)	(1.2 cusec.)	2,200 nos.
	End check	(1.2 cusec.)	2,200 nos.
	Division Box		28,600 nos.
	Main Syphon	(50-160 cusec.)	12 nos.
	Secondary Syphon	(32 cusec.)	13 nos.
	Secondary Crossing Structures	(32 cusec.)	550 nos.
	Tertiary Crossing Structures	(1.2 cusec.)	13,200 nos.
3.	Drainage Canal		
	Existing Channel Improvement		88 km
	Lateral Drain	(210 cusec.)	231 km
	Sub Lateral Drain	(20 cusec.)	1,122 km
	(Total 1,455 km)		
	Related Structure		
	End Sluice	(210 cusec.)	95 nos.
	Drainage Conduit	(210 cusec.)	550 nos.
4.	Road & Bridge		
	Farm Road (gravel metaled)		635 km
	On-farm Road		935 km
	Bridge		27 nos.
5.	Land Acquisition		4,700 ha

Table 6-1 CONSTRUCTION COST OF BALAT DAM

Unit: 10^3 US$

	Work Item	Foreign Currency	Local Currency	Total
1.	Main Work			
	Access Road	2,900	3,400	6,300
	Diversion	10,000	6,900	16,900
	Dam Body	11,000	12,000	23,000
	Spillway	24,200	21,200	45,400
	Outlet	21,900	11,700	33,600
	Preparatory Work	7,000	5,500	12,500
	Sub Total	77,000	60,700	137,700
2.	Land Acquisition and House Evacuation	-	30,800	30,800
3.	Engineering Service	11,000	2,800	13,800
4.	Physical Contingency	8,800	9,400	18,200
	Total	96,800	103,700	200,500

Table 6-2 AGRICULTURAL DEVELOPMENT COST

Unit: 10^3 US$

Work Item	Foreign Currency	Local Currency	Total
1. Main Work			
Jungle Clearing & Levelling	38,000	33,600	71,600
Irrigation, Drainage, Farm Road, Related Structres	63,400	75,500	138,900
Preparatory Work	10,100	10,900	21,000
Sub Total	111,500	120,000	231,500
2. Agricultural Production Facilities			
Buildings & Equipment for Office, Workshop and Pilot Farm	14,400	2,500	16,900
Rice Mill & Farm Machinery	99,300	15,300	114,600
Sub Total	113,700	17,800	131,500
3. Resettlement Scheme	-	16,400	16,400
4. Land Acquisition	-	2,500	2,500
5. Engineering Service	29,000	7,300	36,300
6. Physical Contingency	25,400	16,400	41,800
Total	279,600	180,400	460,000

Table 6-3 HYDRO POWER DEVELOPMENT COST

Unit: 10^3 US$

	Work Item	Foreign Currency	Local Currency	Total
1.	Main Work			
	Civil Works	800	700	1,500
	Power House	1,900	900	2,800
	Generating Equipment	18,200	1,400	19,600
	Transmission Line	4,900	1,500	6,400
	Preparatory Work	2,600	400	3,000
	Sub Total	28,400	4,900	33,300
2.	Engineering Service	2,600	700	3,300
3.	Physical Contingency	3,100	600	3,700
	Total	34,100	6,200	40,300

Table 7-1 ANNUAL DISBURSEMENT OF THE PROJECT COST

Unit : $x10^6$ US$

WORK ITEM	GRAND TOTAL	TOTAL F.C.	TOTAL L.C.	1982 (1st)		1983 (2nd)		1984 (3rd)		1985 (4th)		1986 (5th)	
				F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
Dam	288.35	141.28	147.07	---	---	0.62	0.18	1.34	0.40	7.14	16.91	15.97	24.86
Agricultural Development	693.17	422.32	270.85	---	---	3.19	0.83	5.12	1.46	6.41	4.48	26.79	21.18
Hydro Power Development	68.65	58.08	10.57	---	---	0.37	0.09	0.37	0.10	---	---	---	---
Total	1050.17	621.68	428.49			4.18	1.10	6.83	1.96	13.55	21.29	42.76	46.04

(CONTINUED)

WORK ITEM	1987 (6th)		1988 (7th)		1989 (8th)		1990 (9th)		1991 (10th)		1992 (11th)	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
Dam	15.72	23.99	20.20	14.10	24.18	17.96	24.99	21.61	17.04	15.50	14.08	11.56
Agricultural Development	45.07	35.02	62.15	39.61	66.50	42.53	71.15	45.30	76.13	48.47	59.81	31.97
Hydro Power Development	---	---	---	---	---	---	19.00	3.00	18.70	3.57	20.04	3.81
Total	60.79	59.01	82.35	53.71	90.68	60.49	115.14	69.91	111.47	67.59	93.93	47.34

Note : F.C. : Foreign Currency
L.C. : Local Currency

Table 7-2 ANNUAL DISBURSEMENT OF THE ECONOMIC COST

Unit : x10^6 US$

WORK ITEM	GRAND TOTAL	TOTAL F.C.	TOTAL L.C.	1982 (1st)		1983 (2nd)		1984 (3rd)		1985 (4th)		1986 (5th)	
				F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
Dam	203.00	96.80	106.20	---	---	0.62	0.18	1.25	0.37	6.24	15.07	13.04	20.59
Agricultural Development	462.00	279.60	182.40	---	---	3.19	0.83	4.79	1.36	5.60	4.31	21.87	17.69
Hydro Power Development	40.30	34.10	6.20	---	---	0.37	0.09	0.35	0.09	---	---	---	---
Total	705.30	410.50	294.80			4.18	1.10	6.39	1,82	11.84	19.38	34.91	38.28

(CONTINUED)

WORK ITEM	1987 (6th)		1988 (7th)		1989 (8th)		1990 (9th)		1991 (10th)		1992 (11th)	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
Dam	12.00	18.60	14.40	10.35	16.11	12.27	15.56	13.46	9.92	9.02	7.66	6.21
Agricultural Development	34.38	27.12	44.31	28.64	44.31	28.64	44.31	28.21	44.31	28.21	32.53	17.39
Hydro Power Development	---	---	---	---	---	---	11.83	1.87	10.65	2.08	10.90	2.07
Total	46.38	45.72	58.71	38.99	60.42	40.91	71.7	43.54	64.88	39.31	51.09	25.75

Note : F.C. ; Foreign Currency
L.C. ; Local Currency