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No.

GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

STATE REPORT

VOL. 10

SARAWAK

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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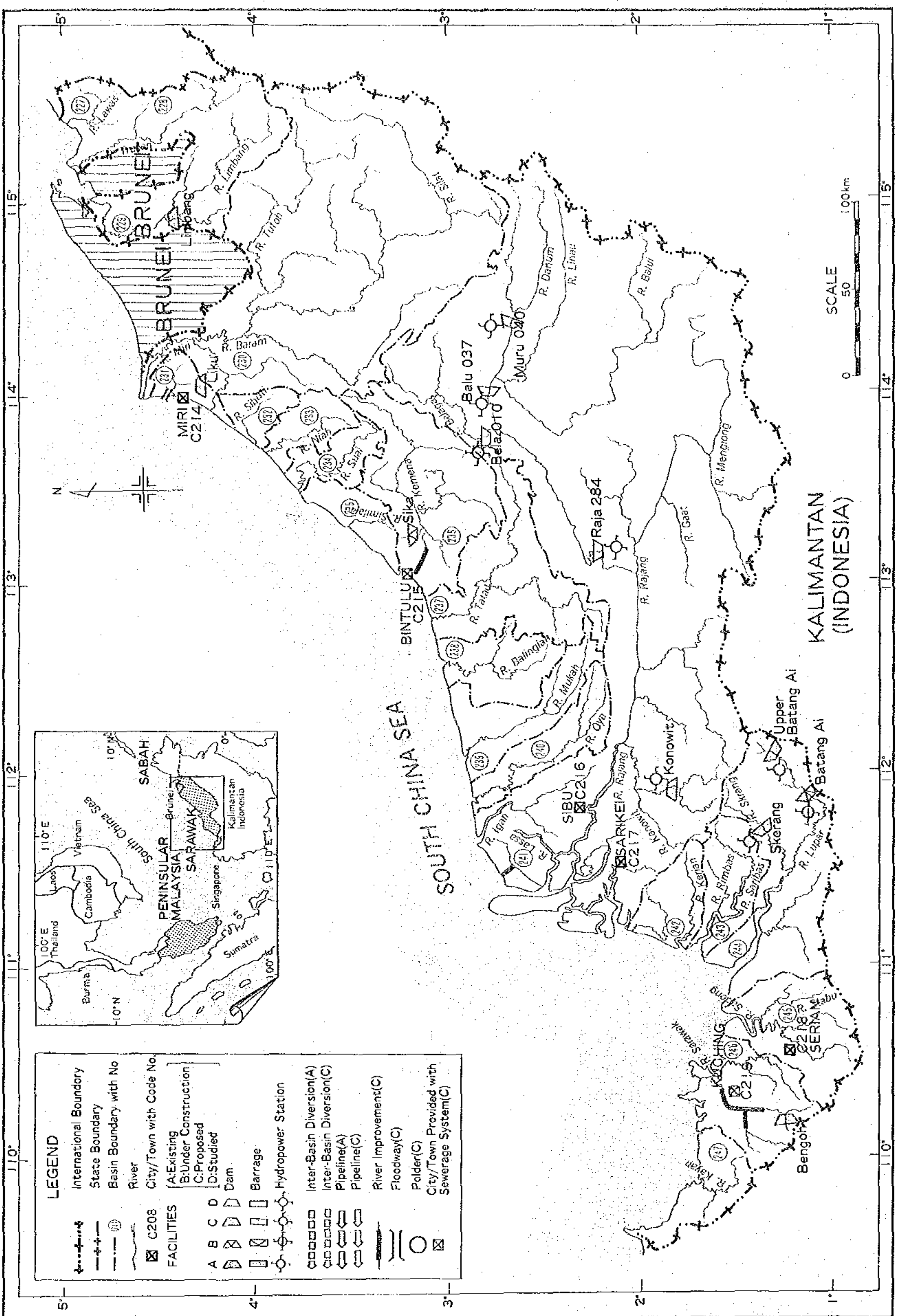

Recommended Plan
for the State of Sarawak

GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

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ABBREVIATIONS

(1) Plan

FMP	:	First Malaysia Plan
SMP	:	Second Malaysia Plan
TMP	:	Third Malaysia Plan
4MP	:	Fourth Malaysia Plan
5MP	:	Fifth Malaysia Plan
6MP	:	Sixth Malaysia Plan
7MP	:	Seventh Malaysia Plan
NEP	:	New Economic Policy
OPP	:	Outline Perspective Plan
RESP	:	Rural Environmental Sanitation Program

(2) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance
MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries

MRRDB	:	Malaysia Rubber Research and Development Board
NDPC	:	National Development Planning Committee
NEB (LLN)	:	National Electricity Board
PORIM	:	Palm Oil Research Institute of Malaysia
PWD (JKR)	:	Public Works Department
RDA	:	Regional Development Authority
RISDA	:	Rubber Industry Small-holders Development Authority
RRIM	:	Rubber Research Institute of Malaysia
SEB	:	Sabah Electricity Board
SEBC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
SESCO	:	Sarawak Electricity Supply Croporation
UDA	:	Urban Development Authority

(3) International or Foreign Organization

ADAA	:	Australian Development Assistance Agency
ADB	:	Asian Development Bank
ASCE	:	American Society of Civil Engineers
FAO	:	Food and Agriculture Organization of the United Nations
IBRD	:	International Bank for Reconstruction and Development
ILO	:	International Labour Organization
IMF	:	International Monetary Fund
IRRI	:	International Rice Research Institute
JICA	:	Japan International Cooperation Agency
JSCE	:	Japan Society of Civil Engineers
MOC	:	Ministry of Construction, Japan
OECD	:	Organization for Economic Cooperation and Development
OECF	:	Overseas Economic Cooperation Fund, Japan
UK	:	United Kingdom
UNDP	:	United Nations Development Program
UNSF	:	United Nations Special Fund
US or USA	:	United States of America
US/AID	:	United States Agency for International Development
USBR	:	United States Bureau of Reclamation
WHO	:	World Health Organization
WMO	:	World Meteorological Organization

(4) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
CIF	:	Cost, Insurance and Freight
COD	:	Chemical Oxygen Demand
D&I	:	Domestic and Industrial
dia	:	Diameter
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation above mean sea level
Eq.	:	Equation
Fig.	:	Figure
FOB	:	Free on Board
FSL	:	Full Supply Level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
HWL	:	Reservoir High Water Level
LWL	:	Reservoir Low Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SITC	:	Standard International Trade Classification
SS	:	Suspended Solid
V	:	Volume
W	:	Width

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot
yd = yard

Area

cm^2 = sq.cm = square centimeter
m^2 = sq.m = square meter
ha = hectare
km^2 = sq.km = square kilometer

Volume

cm^3 = cu.cm = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cu.m = cubic meter
gal.= gallon

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton
lb = pound

Time

s = second
min = minute
h = hour
d = day
y = yard

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

Derived Measures

m^3/s = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = Kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere
BTU = British thermal unit
psi = pound per square inch

Money

M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch 1 m = 3.28 ft = 1.094 yd 1 km = 0.621 mile	1 inch = 2.54 cm 1 ft = 30.48 cm 1 yd = 91.44 cm 1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in 1 m^2 = 10.76 sq.ft 1 ha = 2.471 acres 1 km^2 = 0.386 sq.mile	1 sq.ft = 0.0929 m^2 1 sq.yd = 0.835 m^2 1 acre = 0.4047 ha 1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in 1 lit = 0.220 gal.(imp.) 1 kl = 6.29 barrels 1 m^3 = 35.3 cu.ft 10^6 m^3 = 811 acre-ft	1 cu.ft = 28.32 lit 1 cu.yd = 0.765 m^3 1 gal.(imp.) = 4.55 lit 1 gal.(US) = 3.79 lit 1 acre-ft = 1233.5 m^2
Weight	1 g = 0.0353 ounce 1 kg = 2.20 lb 1 ton = 0.984 long ton = 1.102 short ton	1 ounce = 28.35 g 1 lb = 0.4536 kg 1 long ton = 1.016 ton 1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F − 32) · 5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec 1 kg/cm^2 = 14.2 psi 1 ton/ha = 891 lb/acre 10^6 m^3 = 810.7 acre-ft 1 m^3/s = 19.0 mgd	1 cusec = 0.0283 m^3/s 1 psi = 0.703 kg/cm^2 1 lb/acre = 1.12 kg/ha 1 acre-ft = 1,233.5 m^3 1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang 1 kg = 1.65 kati 1 ton = 16.5 pikul	1 gantang = 4.55 lit 1 kati = 0.606 kg 1 pikul = 60.6 kg

Exchange Rate
(As average between July and December 1980)

$1 = M$2.22
¥100 = M$1.03

1. INTRODUCTION

Malaysia's rapid development has begun to strain her water resources. Increasingly water stress has occurred in places where previously water was found abundant for use. The responsibility for water resources development and management in Malaysia has traditionally been fragmented among various departments and agencies in accordance with their respective functions and activities related to water. In the absence of a comprehensive system to coordinate the multifarious activities in water resources development and management, these activities tend to take place in isolation. This may lead to competition in water use and even duplication of activities and functions. An integrated approach to water resources development and management is therefore necessary to ensure future efficient use of water and other resources, and a study in this regard has become necessary.

The National Water Resources Study, Malaysia, has been carried out by the Study Team of the Japan International Cooperation Agency (JICA) in collaboration with officials of the Government of Malaysia for 3 years since October, 1979 in order to establish a basic framework for the orderly planning and implementation of water resources development programs and projects and for rational water resources management consistent with the overall national socio-economic development objective.

The Final Report submitted now comprises Volume 1 Master Action Plan and Volume 2 Water Resources Development and Use Plan, being supported by the State Reports and Sectoral Studies.

The Master Action Plan contains recommendations on actions to be taken by the Federal and State Governments to ensure efficient and effective execution of water resources development and management in the future, including the national water policy, implementation program, financial system, water administration, institutional framework, legal provisions and further study.

The Water Resources Development and Use Plan is a translation of the national water policy into a long-term national master plan for water resources development, reflecting the needs based on socio-economic goals and also the availability of water and other resources as well as the extent and distribution of water stress.

Each volume of the State Reports is a version of the Water Resources Development and Use Plan compiled for a State or a group of States, including more information regarding the specific State or States. The State Report Volume 10 herein presented describes the matters for the State of Sarawak.

The Water Resources Development and Use Plan was prepared to show general direction of water resources development in Malaysia, identifying future problems and needs and availability of water and other resources, based on analysis and interpretation of readily available data and information. Individual projects indicated are, therefore, only notional and no intention has been made to define any of their details.

2. BACKGROUND

2.1 The Land

Sarawak occupies the northwestern part of Borneo Island. The State of Sarawak is situated between 0° 50′ and 5° 05′ north in latitude and 109° 30′ and 115° 40′ east in longitude. It encompasses Brunei's territory in the northeastern part and borders on the frontier of Sabah in the east and that of Indonesia's Kalimantan in the east to southwest. Sarawak skirts the South China Sea coast in the northwest. The total area of Sarawak is 124,450 sq.km.

Sarawak has two geological regions; the Northwest Borneo Geosyncline and West Sarawak on the craton. The former region covers central Sarawak and affords a good foundation for dam construction.

Alluvial and coastal plains mostly extend over its northwestern part and are intersected by numerous rivers flowing from hilly and mountainous hinterlands in the southeast. The highest peak is Mt. Murud of El.2,438 m.

Alluvial soils occur in coastal plains, riverine, flood plains, low riverine terrace, and intermediate and high terraces with a total coverage of 26,500 sq.km. In particular, these alluvial soils on coastal plains are composed of peat and subject to poor drainage or periodic brackish water flooding. Sedentary soils cover mountains to undulating plains totalling an area of 97,900 sq.km.

Climate of Sarawak is generally characterized by the northeast monsoon from November to January and the southwest monsoon from May to July. Air temperature and relative humidity are usually high with little variation. The average annual rainfall is 3,836 mm. Rainfall in mountanous part is plentiful and amounts to more than 4,000 mm, while that in some parts of coastal areas is less than 3,000 mm. Meteorological data at Kuching and Miri are summarized in Table 1.

Aquifers are recognized mainly in sandy of Quaternary sediments and fissures or cracks of Neogen sandstones with alternating shales. The estimated safe yield is 8.6 million cu.m, out of which 7.3 million cu.m are concentrated into the Baram and Rajang river basins. Rock aquifers are located in the limestone of crystalline and Karst type as well as Neogen sandstone and those excellent to good yields can be prospected in the Sarawak river basin.

2.2 The Rivers

The number of river systems in Sarawak is nearly 50. The average surface run-off estimated is 2,431 mm/y or 306.7 billion cu.m/y. The low flow is high except for the central part of the coastal regions of Sarawak while the flood discharge is high in this central part as well as the southernmost coastal regions.

The seriously eroded areas by the bank erosion due to meandering action and tidal bore phenomena are Marudi along the Baram river, Simunjan along the Sadong river and riverains along the Lupar and Samarahan rivers.

As there is only one gauge site measuring suspended load in Sarawak, the average yield of sedimentation was not able to be estimated.

Rivers in the whole Sarawak meander in their lower reaches. The estuaries of rivers and in the northern Sarawak are affected by drifting sand of the South China Sea. Estuary clogging disturbs local navigation in the Miri river.

Most rivers are affected by problems of sea water intrusion. The longest tidal reach of 200 km from the estuary is observed in the Rajang river. The river water use for domestic and irrigation purposes often encounters with difficulties in the saline reaches.

Flood occurs from December to January in most areas of Sarawak. The Baram and Rajang rivers further inundate riverains after the northeast monsoon season.

The river characteristics in terms of river morphology, estuary, sediment and sea water intrusion in Sarawak is shown in Tables 2 through 4.

The present BOD concentration in the river of Sarawak is reported to be mostly less than 3 mg/lit except for a high value of 26 mg/lit observed in the Samarahan river.

Opening-up of residential areas and construction of roads are major causes of high concentration of suspended solid (SS) in some rivers. The aggradation and degradation occur in the river channel resulting in that some kinds of fishes become extinct. High SS values of more than 1,000 mg/lit have been observed at times in the Lupar and Samarahan rivers by the effect of effluent from the town and pig farm, respectively.

2.3 Watershed

Natural vegetation occupies 95,100 sq.km or 76% of the total land consisting of hill forest of 74,200 sq.km, swamp forest of 20,100 sq.km and grassland of 800 sq.km. The varieties range from the mangroves on coastal fringes to the mixed dipterocarp forests in lowlying and hilly areas and the mountain forests of the highlands.

The total forest area decreased from 100,300 sq.km or 81% of the whole State in the early 1970's to 94,300 sq.km or 76% in 1979, as the result not only forest exploitation but also shifting cultivation and illegal felling undertaken in virgin forest areas.

Through the soil erosion potential evaluation in the Study, it was preliminarily estimated that the sediment load is high at present due to the surface soil loss occurred in the catchment areas of the Lawas, Limbang, Miri, Sibuti, Niah, Oya, Rajang, Kerian, Saribas, Lupar, Sadong and Sarawak rivers.

2.4 Present Socio-economic Condition

The administrative division in the State of Sarawak is composed of seven divisions or 25 districts as illustrated in Fig.1. Towns having population of more than 10,000 are Kuching, Sibu and Miri.

Sarawak had the population of 1.3 million in 1980 and the average annual growth rate was 3.0% between 1970 and 1980. The population density rose from 8 persons/sq.km to 11 persons/sq.km in 1980.

Gross regional product (GRP) grew from M$882 million in 1971 to M$1,726 million in 1980 in factor cost at 1970 constant price with the average annual growth rate of 7.7%. Manufacturing sector shared M$78 million or 8.8% of GRP in 1971 and M$170 million or 9.8% in 1980. Per capita GRP in 1980 was M$1,313 in factor cost at 1970 constant price with the average annual growth rate of 4.6% between 1971 and 1980.

Major land use patterns in 1979 were forest land of 94,300 sq.km, grassland of 800 sq.km, annual and perennial crop land of 4,700 sq.km, shifting cultivation land of 18,500 sq.km and miscellaneous land of 6,100 sq.km. The present land use in Sarawak is presented in Fig.2.

Rubber, oil palm, coconut and pepper are planted for earning of foreign currency by export. The total planted area during the past 10 years since 1971 increased from 192,900 to 199,900 ha for rubber and rose from 2,700 to 22,300 ha for oil palm. The planted area of pepper was 23,700 ha in 1976 and that of coconut was 54,800 ha in 1980. The exported products of these crops in 1979 were 38,600 tons in rubber, 18,800 tons in palm oil, 4,200 tons in palm kernel, 5,200 tons in coconut oil, 25,500 tons in black pepper and 10,600 tons in white pepper.

There existed 141,100 ha of paddy cultivation area in 1979/80 consisting of wet paddy field of 66,900 ha and hill paddy field of 74,200 ha. Irrigated paddy field shared only 6,600 ha in which double cropping area of 1,600 ha and control drainage scheme area of 4,500 ha were included.

Domestic production of rice in 1975/76 was 90,600 tons, being composed of wet paddy rice of 60,800 tons and hill paddy rice of 29,800 tons, which covered 63% of the total rice consumed in the State. In 1979/80, the total rice consumption was 183,200 tons out of which 85,500 tons were covered with domestic wet paddy rice, 28,500 tons were supplemented by domestic hill paddy rice and the rest were imported. The present self-sufficiency rate is 62%.

3. PRESENT CONDITION OF WATER RESOURCES DEVELOPMENT AND USE

3.1 Domestic and Industrial Water Supply

Public water supply in Sarawak is administered by PWD, Kuching and Sibu Water Boards, except that the Bau District Council provides untreated water from the Bau lake to its town people, which was 2,400 in 1980.

PWD supplies piped and treated water to major towns in urban area, excluding Kuching and Sibu, and to minor towns and villages in rural area. The water supply system for an urban area also commands some suburban rural areas nearby. The water pipelines are connected to individual taps but, in some minor towns, stand pipes are equipped for the common use of nearby households. Most of the water sources are rivers, but impounded rainfall storages constitute substantial water sources in such waterworks as Serian, Limbang, Lundu, Santubong, Triboh, Simunjan and Lawas. In the delta of the Rajang river, Jerijeh waterworks have 12 boreholes, the existing sole groundwater source in Sarawak, with the yield of 1,350 cu.m/d in total and the pipeline extended to Belawai and Rajang areas.

The Water Boards are State's statutory bodies of independent profit system. The Kuching Water Board supplies water to the whole area of Kuching Municipal Council and its environs as well. The Sibu Water Board supplies water to the whole area of Sibu Municipal Council and its environs. The Water Boards provide fully treated piped water. The Sibu Water Board depends on river water, while the Kuching Water Board has two reservoirs in addition to a river water source.

As shown in Table 5, the forty two waterworks of PWD and Water Boards delivered 105,000 cu.m/d of water to 475,000 people in 1980, corresponding to 194 lpcd of water consumption. The share of supply by the two Water Boards was 63%.

In the interior and isolated rural areas, untreated water supply system has been developed by the State Government by either withdrawing water from small river to individual house connections or digging shallow wells equipped with hand pumps with materials and technical advices from MOH, under the Rural Environmental Sanitation Program (RESP). It was estimated that 295,000 people were served water by the untreated water supply system in 1980. The water users are suggested to boil water before drinking.

Consequently, 770,000 people or 59% out of the total State population of 1.31 million were served water through PWD, Water Boards and RESP in 1980.

Peculiar to Sarawak, especially in the First, Second and Sixth Divsions, is drought prone area, which is mainly located on the coastal plain. Rain tubs or small streams only are the means to collect drinking water in these areas, because rivers are deeply intruded by sea water. In 1981 when the drought was hardest during the last 10 years, the total population of 102,600 living in 227 villages was suffered from an extreme water shortage. PWD transported potable water to these areas by water tankers, barges, launches and trucks, and even by helicopter. The similar drought occurred in 1972 and 1979 as well. Not a few people were suffered from epidemics such as cholera and dysentery in these areas during the drought years. To cope with the situation, PWD Sarawak has been making efforts extensively to construct the public water supply system in the drought prone areas. By the end of 4MP period, more than 42,000 people are planned to be benefitted by PWD water supply in these areas.

3.2 Irrigation

DID Sarawak maintains 28 irrigation schemes with a total area of 6,000 ha, comprising 17 control drainage schemes of 4,400 ha, 10 pumping irrigation schemes of 1,600 ha and a gravity irrigation scheme of 100 ha. The irrigated double cropped area is 1,600 ha. There remain rainfed wet paddy field of 64,800 ha in total. Fig.4 shows areal distribution of wet paddy field in the State. The notable schemes are the Tanjong Bizat Control Drainage Scheme and Paya Selanyan Irrigation Scheme, Stage II.

Most of control drainage schemes exist along the rivers in the flood plain or near the coast, which store rain water as needed on the fields and in the drains by a system of bunds, drains, controls and gates, and drain out excess water during low tide. Sea water intrusion is prevented by the bunds and gates closed during high tide.

The Tanjong Bijat Control Drainage Scheme is the largest control drainage scheme in Sarawak. It is located in lowlying area along the Lupar river, benefiting 1,214 ha. There exist irrigation canals of 8 km, drainage canals of 25 km, perimeter bunds of 19 km and drainage facilities, but no access road.

The Paya Selanyan Irrigation Scheme, Stage II, covers 324 ha and is the largest pumping irrigation scheme in the State. It depends on the water of the Sibuti river and withdraws it through a pumping station with three pumps of 142 lit/s in a total capacity. The present canal density is 34 m/ha.

3.3 Flood Mitigation

The flood area, affected population and estimated damage by the recorded maximum flood under the condition of 1980 are listed up in Table 6. The flooded areas by the recorded maximum floods are illustrated in Fig.5.

The flooded area estimated is 11,000 sq.km with affected population of 134,000 and damage value of M$23.1 million at 1980 price level.

There are neither flood control nor flood mitigation facilities in Sarawak except those related with agricultural project. Perimeter bunds were constructed around lowlying farm lands to protect crops and farm villages from floods.

Flood warning facilities of siren system have been installed at Siniawan along the Sarawak river since 1976. The first flood warning level is set up 0.6 m or 2 feet below the ground level. Around 500 people enjoy the benefit of this flood warning system.

3.4 Power Generation

SESCO power supply system of 148 MW in total installed capacity consists of entirely isolated systems depending on diesel and gas turbine power. Major power stations are located in Kuching (77.7 MW), Sibu (31.6 MW), Miri (14.5 MW), Bintulu (11.4 MW) and Sarikei (2.6 MW). Gas turbine units installed are 1 x 3.8 MW in Miri and 2 x 1.9 MW in Bintulu.

The total power demand in SESCO power supply system was 73.6 MW in 1980. According to a preliminary projection by SESCO, the future power demand will be 274 MW in 1990 and 600 MW in 2000, but 500 MW will be added if energy-intensive industries such as iron ore direct reduction plant, electric arc steel plant and aluminum smelter are established in Bintulu.

The Batang Ai hydropower station of 92 MW including a 2-circuit 275 kV transmission line between the power station and Kuching is going to be completed in 1984. In addition to this project, SESCO includes the construction of some gas turbine plant and diesel power plant in its short-term expansion plan which can meet the power demand in major towns up to 1990, if the energy-intensive industries are not established.

The Upper Rajang River Hydroelectric Development is being studied by SESCO for a long-term power balance not only in the State of Sarawak but in the whole Malaysia.

3.5 Inland Fishery

Riverine fishing, freshwater pond culture and brackish water pond culture are predominant fishery activities in the State. The instream freshwater ponds are 229,000 in number and 1,761 ha in surface area. About three-quarters are located in the First and Second Divisions.

3.6 Inland Navigation

Inland navigation plays very important role in transportation networks of Sarawak. Major predominant rivers are the Lawas, Limbang, Baram, Miri, Kemena, Mukah, Igan, Paloh, Rajang, Saribas, Lupar, Sadong and Sarawak rivers. The river ports of Kuching along the Sarawak river and Tanjung Mani along the Rajang river have been used as the major ports in the State for import and export. In 1978, 39,000 tons of cargo were loaded and 0.40 million tons were unloaded at the Kuching port. Timber exports recorded in 1980 through the Tanjung Mani deep anchorage point was about 1.7 million tons as logs and sawn timber.

At present, there are 161 jetties along 55 rivers serving for various purposes including loading and unloading of daily necessities, agricultural goods, fish, construction materials and others and daily communication of villagers.

3.7 Sewerage System

In Sarawak, no town is equipped with sewerage system at present.

3.8 Water Purification System in Private Sector

The Federal DOE started to monitor the river water quality since April, 1981 in Sarawak, with the frequency ranging from twice a year to once a month in seven river basin control regions.

There are three rubber factories one of which, being located near Kuching, is equipped with recycle-type treatment plant of effluent. The rest discharges effluent of 55,000 cu.m/y to nearby watercourses. The water quality at factories' outlets ranges from 99 to 156 mg/lit in BOD concentration and from 110 to 287 mg/lit in SS concentration.

Presently, four oil palm mills with a total milling capacity of 70.5 tons/hr as fresh fruit bunch (FFB) are under operation and another two mills are under construction. Raw or treated effluent is discharged into watercourses. The effluent discharge ranges between 370 and 100,000 tons/y. The water quality varies from 100 to 500 mg/lit in BOD concentration and is around 200 mg/lit in SS concentration.

3.9 Watershed Management

The Forest Department of Sarawak manages 31,700 sq.km corresponding to 34% of the total forest areas in the State. The exploitable forest area is 86,100 sq.km including 3,900 sq.km of gazetted forests under the control of the Department. According to the State Government's policy, approximately 9,000 sq.km of it will be developed by 2000.

Besides forest exploitation, a hill paddy growth in shifting cultivation areas has caused sheet and gully erosion problems on steeply dissected land. The present area recognized as shifting cultivation area totalled around 30,000 sq.km and shared nearly 25% of the whole State. The hill paddy grown area is nearly 700 sq.km every year.

The above-mentioned activities as well as execution of land development schemes are other sources of man-made sedimentation. To reduce the adverse effects by migration of shifting cultivators, several regional development schemes are under planning stage.

3.10 Dams

The Kuching Water Board operates two rain and impounding reservoirs for domestic and industrial water supply to its service area. As shown in Table 7, three dams for hydropower and one reservoir for domestic and industrial water supply are in feasibility stage and under construction.

4. FUTURE WATER DEMAND AND ASSOCIATED PROBLEMS

4.1 Projected Socio-economic Condition

The socio-economic framework was projected based on the planned values of 4MP and the Outline Perspective Plan (OPP) as well as the latest figures of 1980 Population Census as the preliminary field count. For projection, assumption was made that the 4MP/OPP target be achieved by 1990 and thereafter the growth rate be 7.5% between 1990 and 2000. Outcome for the State of Sarawak is described hereunder.

The population in Sarawak was estimated to grow at the average annual growth rate of 3.2% for the next two decades from 1981. Projected population is 1.81 million in 1990 and 2.48 million in 2000. The distribution of projected population by urban and rural area is as shown in Table 8.

GRP in factor cost at 1970 constant price was projected to be M$2,630 million in 1985, M$4,027 million in 1990 and M$10,401 million in 2000 with the average annual growth rate of 9.4% from 1980 to 2000.

Projected gross value of output in manufacturing sector will rise from M$498 million in 1980 to M$839 million in 1985, M$1,575 million in 1990 and M$7,602 million in 2000 at factor cost in 1970 as shown in Table 9.

The future rice consumption in the State was estimated to be 217,200 tons in 1990 and 298,000 tons in 2000. To raise the average rice self-sufficiency rate in Malaysia up to 85% in 1990 and in 2000 as well, implementation of the following irrigation development plans is indispensable: (1) provision of irrigation system for the existing rainfed paddy field of 33,600 ha and the newly reclaimed paddy field of 11,700 ha and (2) provision of control drainage system for the existing rainfed paddy field of 19,900 ha. The total rice production anticipated under the above plans will be 124,900 tons in 1990 and 227,200 tons in 2000.

Oil palm planting area was projected to increase to 59,400 ha in 1990 and 71,800 ha in 2000. The prospected processing volume of oil palm in the State will be 670,000 ton as fresh fruit bunch in 1990 and 1.12 million ton in 2000.

Rubber planting area was projected to be kept in the present hectarage of 200,000 ha in 1990 and 2000. The total processing amount was projected to be 30,000 ton as dry rubber content in 1990 and 40,000 ton in 2000.

4.2 Basin Division

For the purpose of the Study, Sarawak was divided into 21 Basins each being a river basin or a group of river basins as shown in Fig.6. Each Basin is further divided into effective area and ineffective area. The former is the upper part of the Basin in which part of the water uses was assumed to return into lower stretches of river. The latter is the remainder of the Basin, in which water used and surface flow originating therefrom were assumed to run totally into the sea. The boundary of the two areas is normally located below the lowest intake site, herein called the balance point, in the major river in the Basin. The total catchment area, effective area, the location of balance point from the estuary and assumed river maintenance flow (see Section 5.2) are as shown in Table 10.

4.3 Domestic and Industrial Water Demand

Domestic and industrial water demand was projected based on the projected population and gross value of output in manufacturing sector for 1990 and 2000.

For the domestic water supply, it was assumed that the entire population in urban area will be fully served by piped water supply. While in rural area, 60% of the total population in 1990 and 90% of the total population in 2000 were assumed to be served by piped water supply. Assumption was made that 50% of the total industrial water demand will be served by piped water supply. Table 11 shows the assumed per capita daily use of domestic water and service factor. The unit net manufacturing water use per gross value of manufacturing output by commodity group was assumed as shown in Table 12.

The total water demand will attain 124 million cu.m/y in 1990 and 273 million cu.m/y in 2000 as shown in Table 13. Major demand centers are Bintulu with the largest industrial water demand, Kuching having the largest domestic water demand, Sibu and Miri. In 2000, four Basins including the above cities/towns will need 151.0 million cu.m/y or 78% of the State's domestic water use and 73.0 million cu.m/y or 91% of the total industrial water demand.

All the urban water demand was assumed to be supplied by surface water both in 1990 and 2000. For rural water supply, the share of groundwater use was assumed based on the estimated safe yield for each district.

The location of demand centers of domestic and industrial water is shown in Fig.6.

4.4 Irrigation Water Demand

The irrigated land development was projected taking into account information obtained from DID and the assumed rate of self-sufficiency in domestic rice production in the State. As shown in Table 14, the projected irrigation area will increase from 1,680 ha in 1980 to 17,200 ha in 1990 and 47,000 ha in 2000. Other than these irrigated area, wet paddy field facilitated with control drainage system will expand from 4,350 ha in 1980 to 13,500 ha in 1990 and 22,700 ha in 2000 in coastal alluvial plains. As priority is given for developing potential area of irrigated double cropping, double cropping ratio will be 87% in 1990 and 78% in 2000.

The irrigation water demand was calculated for 1990 and 2000 as shown in Table 15. Irrigation efficiency applied is 55% for both major and minor irrigation projects. The annual irrigation water demand will be 196 million cu.m in 1990 and 482 million cu.m in 2000, respectively.

4.5 Fish Pond Water Demand

The future hectarage of freshwater fish pond in Sarawak was projected to be 197 ha by 2000. The total water demand projected for freshwater fish culture is 6.3 million cu.m in 2000.

4.6 River Utilization Ratio and Water Deficit

The relative burden of water use on a river is indicated by the river utilization ratio, which is the ratio of water demand to natural run-off. All natural flow cannot meet water demand, because it mostly runs to the sea as flood flow. It was estimated that natural flow would often fail to meet all water demand if the river utilization ratio is not less than 10% under the hydrological condition in Malaysia. The area with river utilization ratio of not less than 10% is, therefore, herein called the water stress area. Table 16 shows the estimated long-average natural run-off, projected water demand and river utilization ratio in 21 Basins for 1990 and 2000.

The river utilization ratio was calculated for each basin for 1990 and 2000 as shown in Table 16. The river utilization ratio in Sarawak is projected to be less than 10% in most of all basins in 2000 except the Miri river basin.

In order to determine the total requirement for storage supply and water diversion, the water deficit at the balance point was calculated for each Basin, assuming the hydrological condition in the recorded period.

Natural runoff in each basin was estimated on 5-day basis, based on daily hydrological records prepared by DID. The recorded period was 19 years from 1961 to 1979 for the Peninsular Malaysia and ranged from 10 to 15 years for Sabah and Sarawak.

Groundwater potential is still to be clarified. Groundwater development will be essential especially for the villages with difficulty of access of clean surface water. Groundwater use is assumed for some rural domestic water supplies based on the estimated safe yield in each district.

A part of water taken from a river returns to the river. It is herein called the return flow. The return flow from irrigated paddy was assumed to be 20% of irrigation water demand within the effective area. The return flow from domestic and industrial water use within the effective area was estimated depending on the purpose of water use; 5% to 90% of demand.

The water withdrawal is herein defined as the net reduction in river flow which is required to meet the water demand and it was calculated by the water demand deducted by the return flow and the groundwater use.

Certain discharge is necessary to sustain normal water use and environmental condition in the river. It is herein called the river maintenance flow as will be explained in more detail in Section 5.2. The rate of river maintenance flow was assumed as shown in Table 10.

All the water demand can be met and all the water use can be sustained if river flow is more than the sum of water withdrawal and river maintenance flow, and if otherwise river flow is in deficit. The water deficit was calculated as the water withdrawal plus river maintenance flow less the natural run-off in each 5-day period during the recorded period.

The estimated water deficit varies depending on the assumed hydroloical condition. Among the hydrological conditions in the recorded period of N years, that resulting the largest annual volume of water deficit is herein regarded as the driest condition and called 1/N drought, that resulting the second largest annual volume of water deficit is called 2/N drought, and so on. The estimated water deficit by Basin under 1/N to 5/N drought is as shown in Table 17.

The water deficit as shown in Table 17 was calculated under without-dam condition. If the estimated supply capacity of the existing and under construction dams listed up in Table 7 is taken into account, the above-mentioned water deficit will be reduced in Basins where dam is located. It is noted that the water deficit in each Basin was calculated only at the balance point and it indicates an overall balance in the Basin. There may be the cases that river flow is in deficit in some section upstream of the balance point if major demand is located upstream.

4.7 Water Quality

To estimate BOD concentration in the river, BOD load flowing into a river was calculated based on the water use by pollution source. Major pollution sources are the domestic and industrial water users comprising eight urban areas, 7 palm oil mills, 3 rubber factories, pig farms in the rural areas. However, waste water from Miri and Bintulu was assumed to be directly discharged to sea.

It was assumed that BOD concentration in the effluent remains at the present level except that the land disposal system is progressively applied in the palm oil mills and rubber factories as shown in Table 18. BOD concentration along the main streams of rivers was calculated for the condition that the rate of run-off at just downstream of each outlet of effluent was equal to the assumed rate of river maintenance flow at that point, and the residual purification ratio varies in the range of 0.7 to 0.9 according to the characteristics of the rivers.

Discharge ratio, run-off ratio and BOD concentration assumed by type of pollution source for 1990 and 2000 are as shown in Table 19. A portion of water is consumed by being incorported in products, by evaporation and by leakage in the process it is used and treated. The ratio of water after consumption to that before consumption is called the discharge ratio. A portion of water is again lost during the travel that water is released by the consumer and it enters into a river. The ratio of water reaching the river to that discharged by the consumer is the run-off ratio.

The projected maximum BOD concentration in Sarawak will not be more than 5 mg/lit except in the Suai river in 1990 and 2000. This projection states that most rivers are little polluted presently and will be still clean in 1990 and 2000.

4.8 Watershed Problems

Annual rate of soil erosion ranges from about 30 tons/sq.km in natural forest to over 6,000 tons/sq.km in cleared land shifting cultivation land. Soil erosion reduces productivity in soil and also causes sedimentation in rivers. Erosion potential was studied in relation with soil erodability, slope and land use.

Present annual erosion rate is estimated to be 1,500 tons/sq.km. High erosion rate in Sarawak is mainly due to shifting cultivation, wherein disturbed and cleared forest including shifting cultivation land accounts for 24% of land.

It is estimated that reforestration for all disturbed forest in Sarawak can reduce erosion rate to 60 tons/sq.km. Reforestration in the disturbed forest can reduce erosion in a long run.

Based on these considerations, the following conclusions are preliminarily drawn:

(1) Forest clearing should be limited within the lan of 2 degrees in slope.

(2) After clearing forest, such land use as appropriately protecting soils against erosion should be undertaken.

(3) As a long-term program for preservation of productive forest and soil conservation, reforestation should be undertaken in the disturbed forest.

It has been believed that forest clearing results in reduction of low river flow and increase of flood discharge. Experimental records in this respect in other countries are inadequate to draw conclusions applicable to Malaysia. There are also some experimental data in Malaysia but they are still insufficient for quantification. This aspect has not been analysed, but this does not mean that the importance of forest conservation in water resources conservation can be neglected.

5. STRATEGIES FOR WATER RESOURCES DEVELOPMENT AND USE

5.1 Problem Areas

Water resources use can be classified into instream uses, consumptive uses and energy potential use. Instream uses include navigation, fish catch and recreation. Consumptive uses are domestic and industrial water supply and irrigation. Energy potential use is hydropower generation. Water resources are liable to be deteriorated by man-made actions. Rivers are polluted by sewage and industrial effluent. Mining, logging, urban area development and road construction increases sedimentation in the rivers. Water resources have adverse characteristics such as drought and flood. Drought may constrain ordinary water uses. Rivers inundate vast lands and causes damages even loss of life.

Engineering measures are envisaged, corresponding to the characteristics of water resources and their use. Maintenance of low flow is required for sustaining not only instream water use but consumptive water use and environmental quality. Domestic and industrial water supply system and irrigation system and fishponds are provided to give consumptive water users access to water, also adjusting water quality to the use. When consumptive water use increases, competition may take place among the instream water users and consumptive water users, especially in the dry spell. Dams and basin transfer facilities are source development measures to augment low flow in the river so that all water uses can be sustained. Hydropower station is a measure to develop hydroelectric potential. Pollution abatement is to adjust water quality to water uses and requirement from the viewpoint of environmental quality.

The strategies for the water resources development and use are set for the following categories:

(1) maintenance of low flow necessary for sustaining various water uses and environmental quality;

(2) development of water supply and irrigation systems;

(3) source development for balancing water demand and supply;

(4) hydropower development;

(5) conservation of water quality; and

(6) flood mitigation.

5.2 Maintenance of Low Flow

Water has been utilized as need arises without causing any hazard yet to other water use in most rivers in Malaysia. The reduction of river flow due to intensified water use will, however, hurt various water users. The adverse effect of a small reduction of river flow may not be hazardous, but hazard becomes significant and irretrievable if small reductions accumulate.

It is proposed to establish the concept of river maintenance flow. The river maintenance flow is the minimum discharge which is required to maintain water depth, flow velocity, water quality, channel stability, aquatic eco-system and scenery to the extent necessary for navigation, fish catch, operation and maintenance of intakes, maintenance of river facilities, sea water repulsion, prevention of estuary clogging, conservation of groundwater, preservation of riparian land and people's amenity.

The river maintenance flow is the indicator of the allowable limit of water withdrawal from the river and is to be considered in allocating and developing water resources. Water withdrawal should not be increased, if it is expected to impair the river maintenance flow frequently. Source development such as construction of dam and inter basin water diversion system will be conducted, if it is necessary to augment low flow in the river to allow expected increase in water withdrawal, while sustaining the river maintenance flow. An estuary barrage will be constructed, if it contributes to the reduction of the required rate of river maintenance flow through preventing sea water intrusion and through maintaining water level for the intakes located in the estuary area.

The river maintenance flow should be sustained to the extent possible, but its temporary reduction can be allowed to a certain extent. The river flow which corresponds to the subsistence level of water uses is herein called the essential river maintenance flow. The river maintenance flow may not be reduced to the essential river maintenance flow even if an extreme drought takes place. When the essential river maintenance flow is needed to be sustained under any drought, water withdrawal from the river should be reduced.

The river maintenance flow should be determined individually for each river, based on the conditions particular to the river. The river maintenance flow may require a costly development, if its rate is set considerably high. It should be determined based on the minimum requirement in each river. On the other hand, the river maintenance flow should not be so low as the recorded minimum flow, which is too small to sustain the existing water uses and environmental quality. It is preliminarily assumed that the rate of river maintenance flow is equal to the daily natural discharge of 97% in probability of exceedence as shown in Table 10 and that of essential river maintenance flow is equal to the daily natural discharge of 99% in probability of exceedence, referring to examples in several countries.

5.3 Development of Water Supply and Irrigation Systems

Water supply system and irrigation system have been developed, in order to transmit water from sources and to distribute it to the consuming ends.

Domestic and industrial water supply is conducted along with the objectives of national economic development, regional development and social well-being improvement. The service factor of urban water supply system is already high, and the development of rural water supply system has been forcefully promoted in the recent years. Taking into account the Government policy prevailing, it is assumed that the public water supply system will be developed to supply domestic water to all people by 2000 and to supply 50% of industrial water, except that 10% of rural people in Sabah and Sarawak will still not be publicly supplied, because of remoteness and non-availability of suitable water source.

Irrigation development on paddy, including the tertiary development is carried out along with the objectives of national economic development, improvement of food self-sufficiency and increase in farmers' real income. It is assumed that the irrigation facilities will be provided in accordance with the projected land development schedule.

5.4 Source Development

Balancing water demand and supply is the requisite for water resources development and use. The water demand projection was made assuming that concerned agencies would take appropriate measures for water saving such as recyclic use of water and increase in efficiency of facilities and utilization of sea water. Where frequent water deficit are foreseen even with these water saving measures, the development of source facilities such as water storage and/or interbasin diversion are proposed.

The strict adherence to the river maintenance flow will result in the construction of costly facilities even in the rivers in which water use is small compared with natural flow. Analysis showed that all the water demand could be met for more than 85% of time in the rivers of less than 10% in river utilization, if a temporary reduction in the river maintenance flow to a minor extent is permitted. With these considerations, it is proposed that the source development should be implemented only in the rivers in which the river utilization ratio will be more than 10%.

5.5 Water Pollution Abatement

Water pollution abatement is considered from the viewpoint of environmental quality and maintenance of water uses. River water can be treated ordinarily for domestic and industrial use, if its quality is on an adequate level from the viewpoint of environmental quality.

The concept of water quality standard in the river should be established as the indicator showing the target of water pollution abatement, which is performed by reducing pollution load discharged into the river.

The biochemical oxygen demand (BOD) is the oxygen used to meet the metabolic needs of aerobic micro-organisms in water rich in organic matter. Self-purification mechanism of river is greatly reduced and the aquatic ecosystem is also affected if BOD concentration in the rivers is more than 5 mg/lit. Odour occurs if the BOD concentration is over 10 mg/lit. Pre-treatment is necessary if BOD concentration in raw water is more than 2 mg/lit for domestic water supply and 5 mg/lit for industrial water supply. River water quality standards in terms of BOD concentration in several countries are illustrated in Fig.7. The target for water pollution abatement is set in terms of BOD concentration in the river, because BOD concentration is the most common and important parameter of man-made pollution of inland water.

The measures for organic pollution abatement in the river are the improvement of purification system of effluent from the palm oil mills and rubber factories as well as public sewerage development.

5.6 Hydropower Development

Power demand in Malaysia is growing at a high rate, while the existing power supply system largely depends on thermal power. Nation's energy policy directs the development of hydroelectric potential and the saving in fuel resources.

Hydroelectric potential in Sarawak has been estimated to be more than 20,000 MW. The Upper Rajang Hydroelectric Development is being studied in order to develop hydropower of 4,550 MW in the upper Rajang river in Sarawak. Power generated will be transmitted not only to Sabah and Sarawak but to Peninsular Malaysia by constructing submarine transmission line of 700 km. The total construction cost of the development has been estimated to be M$11 billion including the interconnection system. Further development including power supply to ASEAN countries has also been envisaged.

Due to uncertainties in the inter-connection systems for power transmission to Peninsular Malaysia and Sabah and also in the establishment of energy intensive industries in the State of Sarawak, this vast potential is, however, assumed to be made available only after the year 2000. The strategy of hydropower development is thus set to contribute to bridge power demand and supply balance up to 2000.

According to a recent projection by NEB, the maximum power demand in Peninsular Malaysia in 2000 will be 9,140 MW, while the installed capacity of existing and under construction hydropower totals only 1,206 MW at present. It is recommended that all known potential of economical hydropower of 1,026 MW in Peninsular Malaysia should be developed by 2000 for the maximum contribution in balancing power demand and supply.

There is a large power potential in Sabah and Sarawak, in addition to that in the Rajang river. The maximum power demand in 2000 has been projected to be a little over 1,000 MW each. Although power demand is generally fragmented into small isolated demand centers, hydropower development should be envisaged for such major demand centers as Kota Kinabalu in which the maximum power demand will be 460 MW in 2000 and Kuching in which the maximum power demand will grow to 295 MW by 2000. Such hydropower development should be capable of supplying to Tawau, Sandakan and Labuan if some or all of them are interconnected with Kota Kinabalu. It is recommended to develop hydropower in Sabah and Sarawak to such an extent that the incremental power demand in major demand centers can be met up to 2000.

5.7 Flood Mitigation

Flood mitigation contributes to the national economic development and social well-being by reducing flood damage and protecting people's life. The measures for flood mitigation should be provided in consonance with the socio-economic development.

The structural measures for the flood mitigation are channel improvement, bypass floodway, polder, flood control dam and their combinations as described below:

(1) Channel improvement: Channel improvement will increase the discharge capacity of river by reshaping the river channel and constructing levees including protection work against erosion and sedimentation in the river.

(2) Bypass floodway: Bypass floodway is a short-cut canal for flood where there are certain constraints for channel improvement. The discharge capacity of the floodway is usually determined to allow releasing the excess water of the original channel.

(3) Polder (Ring Bund): Polder is a ring bund to protect an area of high damage potential. It includes the construction of drainage canal and drainage pump for the protected area.

(4) Flood control dam: A flood control dam will retain flood temporarily. A single purpose flood control dam can hardly be justified, unless the flood damage is tremendous. The inclusion of flood control purpose into the dams proposed for other purposes is studied. The flood control space in the dam is determined to reduce the design flood discharge to 1/4, as a rule.

Non-structural measures are proposed for such river stretch as where structural measures are not applicable or where supplemental measures are required. They are the restriction of development and resettlement plan as described below:

(1) Restriction of development: The restriction of development is the control of damageable values in the flood vulnerable areas by restricting new development.

(2) Resettlement plan: The resettlement plan is also the restriction of development but it includes the resettlement of people.

In addition to the above-mentioned measures, flood forecasting and warning system is proposed for some river basins having more than 5,000 inhabitants liable to flood hazard as shown in Table 20.

5.8 Inland Fishery

Development of inland fishery contributes to the national economic development and social well-being by providing fish protein source and for eradicating poverty through providing employment opportunity in rural areas.

Inland fisheries activities comprise fishing and culturing in various waters such as rivers, lakes and reservoirs, tin mining pools, paddy fields, constructed ponds and mangrove areas. Along with the Government's policy for fish culture development presented in 4MP, the areal development was estimated in this Study. The beneficial and adverse effects of inland fishery development are shown in those of recommended plan for water demand and supply balance.

6. ALTERNATIVE STUDIES

6.1 Scope of Alternative Studies

In Chapter 5, the rate of river maintenance flow was provisionally assumed and the targets for domestic and industrial water supply, irrigation, water demand and supply balance and hydropower development were set. Herein presented are such alternative studies as those for water demand and supply balance plan by varying risks in supply, hydropower development plan by power supply system development plan, pollution abatement plan by target water quality standard, and flood mitigation plan for varying target of protection. Hydropower development alternatives are presented only for Sabah. For Peninsular Malaysia, it was assumed that all the known power potential should be fully developed by 2000 following the preliminary development schedule prepared by NEB. For Sarawak, as mentioned in 5.6, the hydropower potential was assumend to be so developed as to bridge demand and supply up to 2000.

The criteria for alternative setting and for comparison of the public expenditure and beneficial and adverse effects of alternatives are described hereunder, wherein, costs and effects were all estimated based on the criteria described in Chapter 7.

6.2 Water Demand and Supply Balance Alternatives

Both the instream water use and the consumptive water use can be sustained if river flow is more than the river maintenance flow. If otherwise, river flow should be augmented by developing source facilities such as dam for regulation of river flow or diversion facilities to transfer water from a river to another. A source development plan was proposed for each water stress Basin of which river utilization ratio in the projected year would be not less than 10% and the existing source facilities could not meet the estimated water deficit.

The water stress basin was found only in the Miri Basin in Sarawak, which was therefore further sub-divided into a number of sub-basins. It was found that the river ulilization ratio in the Miri Sub-basin only will be more than 10% in 2000 as shown in Table 21.

Natural flow varies not only seasonally but from year to year to a large extent. Any measures cannot meet all water demand under an extremely dry condition. In planning source facilities, water supply capacity is usually determined allowing a certain risk. If the risk is set considerably small, the source facilities are costly and if otherwise, adverse effects such as reduction in production and people's dissatisfaction may take place. The water demand and supply balance alternatives were proposed assuming different levels of risk.

Alternative sizes of the proposed source facilities were determined based on the following criteria:

Alternative B1: The supply capacity of source facilities is determined against the driest condition ever recorded; 1/N drought where N denotes the length of hydrological records in years.

Alternative B2: The supply capacity of source facilities is determined against the second driest condition ever recorded; 2/N drought.

Alternative B3: The supply capacity of source facilities is determined against the fourth driest condition (4/N drought) for Peninsular Malaysia and the third driest condition (3/N drought) for Sabah and Sarawak, ever recorded. This was proposed based on the difference in the length of hydrological records. (These conditions approximately correspond to 5-year drought according to Hazen's plotting method.)

A dam is constructed to retain water in the flood period and release it to augment river flow for the use in the dry period. Once a dam is constructed, inflow into the dam can be retained at any time, so far the storage capacity is available. It is required for a dam to release water at a rate which, together with the natural flow from the downstream catchment area, is sufficient to supply water demand while sustaining the river maintenance flow. In other words, the supply capacity of a dam is determined to supply all the water deficit. By doing so, the dam can develop water to meet the future water demand not affecting adversely on the existing water users.

The proposed dams were those either identified on 1/63,360 or 1/50,000 maps or proposed in previous studies. The water supply capacity of each dam was estimated based on hydrological record and on assumed storage capacity. The total water supply capacity of the proposed dams in a basin was determined to meet the total water deficit in the basin, allowing an operational loss which was assumed to be 10 to 20% of the water deficit.

If the total water supply capacity of all the proposed dams in a basin is not enough, diversion of water from other basin was proposed and, if necessary, the construction of a dam in the latter basin was further proposed.

The estimated public development expenditure and manpower requirement showed a large differences among the alternatives, indicating that a high guarantee of supply would be costly and requires a large manpower. A high guarantee of supply would bring a low value of internal rate of return, because benefit is little sensitive to the risk of supply. Alternative B1 can guarantee safe supply all the time even under the driest condition ever recorded but some interruption in safe supply have to be involved in the other alternatives. Considerations were made also of adverse effects such as removal of people from the proposed reservoir areas and change in fish fauna, and beneficial effects such as fish culture and recreation in a lake created.

It is recommended that Alternative B1 should be selected for the Basins where domestic and industrial water demand is predominant in accordance with the common understanding in Malaysia that domestic and industrial water supply should be sustained even under the serious drought.

Irrigation facilities have been designed against a drought of 5-year in return period in Malaysia, this criterion corresponds to the criteria in Japan, Korea, Indonesia and other countries in Southeast Asia. Under the condition that irrigation demand is already high, grading-up of the above-mentioned criterion will immediately require a large investment for source development. With these considerations, it is recommended to select Alternative B3 for the Basins where water is predominantly used for irrigation.

The alternative plans for water demand and supply balance are shown in Tables 22 for Alternatives B1, B2 and B3.

6.3 Hydropower Development Alternatives

The projected power demand and SESCO expansion schedule are illustrated for major power demand cent rs in Fig.8. The projected power demand in 2000 is less than 100 MW in each demand center except for Kuching. It is appropriate to install thermal power of around 10 MW, probably diesel, in unit capacity as an additional expansion plan to 2000 in these demand centers. On the other hand, in Kuching, hydropower development or thermal plant of larger unit capacity should be considered for the period after 1990, in which power demand will be 150 to 300 MW. It was estimated that 190 MW of additional capacity including reserved capacity is necessary to meet the growing demand in Kuching up to 2000, after the Batang Ai power station.

A map study resulted some potential hydropower projects near the Batang Ai project. They are the Upper Batang Ai, Batang Sekrang and Kanowit (identified as KONO 110 in SESCO, Master Plan) projects as shown in Fig.9. Their outline is as shown in Table 23.

If the energy-intensive industries are established in Bintulu, the power demand there will be more than 500 MW. In this case, the Raja 284 of 770 MW, proposed in the Upper Rajang Hydroelectric Development, should be constructed, and the interconnection of Kuching, Sarikei, Sibu and Bintulu should be considered.

6.4 Water Pollution Abatement Alternatives

Two alternative plans for water pollution abatement were proposed setting target BOD concentration in the river as mentioned below.

Alternative P1: 5 mg/lit in BOD concentration in 1990 onwards

Alternative P2: 10 mg/lit in BOD concentration in 1990 onwards

If the reduction of BOD concentration in a stretch of a river is found necessary to attain the target, the improvement of purification method in all palm oil mills and rubber factories in the river was, first of all proposed. The Basin where the improvement was proposed for both the alternatives for 1990 and 2000 were the Suai Basin.

If there still remains a river stretch of higher BOD concentration than the proposed limit, the construction of a sewerage system in the urban area upstream of the river stretch was proposed: it is not the case in the State of Sarawak and therefore, the two alternatives are identical.

No treatment measures were assumed for the sewage from the towns of less than 50,000 in population and rural areas and for the effluent from animal husbandry. With these conditions, it was estimated that some river stretches in the west coast of Peninsular Malaysia would show higher BOD concentration than the target value.

The ordinary treatment method for the domestic water supply is the sedimentation, filtration and chlorination, if BOD concentration in raw water is not more than 2 mg/lit. The ordinary treatment method for the industrial water supply is the sedimentation, if BOD concentration in raw water is not more than 5 mg/lit. Pre-treatment facilities are needed to varying extent for raw water with BOD concentration above these limits. For BOD concentration in raw water more than the above-mentioned limit but not more than 20 mg/lit, pre-treatment is carried out by the rapid sand-filter bed and activated carbon absorption (secondary treatment). For BOD concentration between 20 and 200 mg/lit, an aerated lagoon process such as aerated lagoon or maturing pond (primary treatment) is further needed. The cost for pre-treatment facilities was taken into account for the economic comparison of the alternatives.

The public development expenditure and manpower requirement were estimated in this Study to hardly vary between the two alternatives. The results of economic benefit cost analysis also showed little difference between the alternatives; although the economic cost is larger than the economic benefit, the water pollution abatement should be conducted from the viewpoint of environmental and social well-being impacts. Meanwhile, the problem is that the public development expenditure and manpower requirement would be largely concentrated in the earlier part of development, i.e., in 4MP and 5MP periods. In order to avoid this concentration, it is necessary to slow-down the rate of development up to 1990. With these considerations, it is recommended that the pollution in the river should be gradually abated by setting the target BOD concentration at 5 mg/lit for 2000.

6.5 Flood Mitigation Alternatives

Three alternatives are proposed for the flood mitigation:

Alternative F1: Structural measures are provided by 2000 for the entire river system to protect 90% of people within the flood prone area.

Alternative F2: Structural and non-structural measures are provided by 2000 for densely populated areas to protect 50% of people within the flood prone area.

Alternative F3: Structural and non-structural measures are provided by 2000 so far as such measures are economically viable.

The return period of design flood is assumed to be 20-year for the river stretch where the estimated annual flood damage is less than M$20,000/km and the population is 500 persons/km, and 50-year for the other river stretches, but 100-year if loss of life has been recorded.

The problem rivers were divided into stretches of 30 to 60 km in length. The measures explained in Section 5.7 were compared and the most economical measures was selected for each river stretch. The resulted alternative plans for the State are as outlined in Table 24.

Alternative F1 appeared to require a prohibitively large expenditure for the whole Malaysia. Alternative F3 should be implemented if considered from the viewpoint of national economic development, but it will increase the disparity between developed and underdeveloped areas. Taking into account the fact that social well-being objective has been emphasized through discussions between Malaysian Government officials and the Study Team, it is recommended that Alternative F2 should be taken up for the period up to 2000.

The flood mitigation alternatives including Alternatives F1, F2 and F3 are illustrated in Figs.10 through 12.

7. RECOMMENDED PLAN

A Water Resources Development and Use Plan is recommended, based on the comparison of alternatives. Its outline is illustrated in Cover Map.

7.1 Public Water Supply and Irrigation Development Plan

Public water supply system including PWD and Water Boards systems and RESP system is recommended to be provided to meet all urban domestic water demand, 90% of rural domestic water demand and 50% of industrial water demand by 2000, in accordance with the plan as shown in Tables 25 through 27.

Irrigation water supply system will be constructed in accordance with the schedule assumed in Table 14.

7.2 Source Development

The recommended water source development plan for balancing water demand and supply is summarized in Table 28. The water source development plan in the problem area is mentioned hereunder. Fig.13 illustrates the recommended water demand and supply program for the State.

Miri has a population of 55,000. PWD water supply system has a treatment capacity of 9,100 cu.m/d (3.3 million cu.m/y), conveying water from the Liku river by a pipeline of 10 km in length. Sarawak Shell Berhad has its own water supply system of 7,000 cu.m/d (2.6 million cu.m/y) to provide water to its oil refinery and residential quarters. PWD delivered 3.1 million cu.m of water in 1980, but the supply was not enough for the served population of 37,000. PWD purchased 700,000 cu.m of treated water from Sarawak Shell Berhad in the same year.

Population in Miri is projected to be 94,000 for 1990 and 177,000 for 2000. Corresponding domestic and industrial water demand is estimated to be 13 million cu.m in 1990 and 51 million cu.m in 2000.

The Liku river has a catchment area of only 150 sq.km at the PWD intake and the water demand in 2000 is expected to reach 21% of the natural flow. Augmentation of river flow is necessary for supporting future water demand.

The recommended source development plan is the construction of the Liku dam in the Liku river for the domestic and industrial water supply in Miri.

7.3 Water Pollution Abatement Plan

The recommended plan for the water pollution abatement in the river is the improvement of purification method in the palm oil mills in the Suai river basin.

It is proposed to provide a secondary pre-treatment plant for the Miri water supply system, because it was projected that BOD concentration at the intake will be 4 mg/lit in the future.

Although it is ineffective for the water pollution abatement in the river, sewerage development in Bintulu and Kuching is assumed from the viewpoint of public health.

The recommended plan for water pollution abatement including the assumed sewerage development is shown in Tables 29 through 31.

7.4 Flood Mitigation Plan

The recommended plan for flood mitigation is mentioned hereunder and is summarized in Table 32.

7.4.1 Limbang flood mitigation dam project

The Limbang valley project has beeen proposed for agricultural development of 20,000 ha including 8,600 ha of paddy irrigation in the lower Limbang valley. The major constraint of the development is flood problem. The Limbang flood mitigation dam is proposed at just upstream of the Limbang valley project area. The storage capacity of 450 million cu.m can reduce flood discharge to a non-damage flow in the downstream river channel, and also power generation will be made possible. Since the project is for irrigation purpose, the project cost is included in the irrigation sector of this study.

7.4.2 Miri river flood mitigation project

The Miri river inundated 674 sq.km in January, 1963. Miri town located near the estuary of the Miri river is an industrial town of 55,000 in population at present. The flood damage must be large if the same flood occurs under the present condition. The recommended flood mitigation plan is the construction of a bypass flood-way of 5 km in length at just upstream of Luton, which is located 2 km to the north of Miri.

7.4.3 Construction of ring bund at Niah

The construction of ring bund including bank protection work is recommended for Niah of 900 in population.

7.4.4 Kemena river channel improvement plan

The river channel improvement is recommended for a 30 km stretch in length of the Kemena river to protect 17,000 people in the flood prone area in Bintulu.

7.4.5 Matu river channel improvement plan

The Matu river flooded 226 sq.km in 1963 affecting 7,000 people. The recommended plan is the river channel improvement of 21 km.

7.4.6 Sarawak river flood mitigation plan

The recommended plan includes the Bengoh flood mitigation dam in the Sarawak river and channel improvement of 142 km in the Sarawak and Samarahan rivers to protect 62,000 people in the flood prone area. The dam can be developed as a multipurpose project with water supply scheme. The superiority on technical and economic points of view is preliminarily given to the Bengoh dam over the Giam dam, however, the latter shall be examined in the feasibility stage.

7.4.7 Flood forecasting and warning system

The flood forecasting and warning systems are proposed for 9 basins for Sarawak by the year 2000. Of these, the system in Baram (Basin 230) and Sarawak (Basin 246) are recommended to be installed by 5MP period.

7.5 Hydropower Development Plan

The hydropower development plan is proposed assuming that the energy-intensive industry will not be established yet and, accordingly, hydropower should be developed in order to meet the power demand in Kuching. Another assumption is that the recommended plan is for bridging the power demand and supply balance before the Upper Rajang Hydroelectric Development comes to operation. Therefore, the two plans should not be mutually exclusive.

The recommended hydropower development plan is as shown in Table 33. It is noted that the size and cost of the projects are very preliminary and need further study.

7.6 Inland Navigation Development Plan

Considering the significance of the inland navigation development for the economic development and the enhancement of social well-being, it is recommended that, in the short-run, the 4MP, which envisages to implement 95 projects at the cost of about M$38 million proposed by the State PWD, should fully be implemented.

7.7 Cost Estimate

The construction costs of the proposed facilities were estimated at the constant price in December, 1980.

The construction costs consist of direct construction cost (contract amount), engineering and administration, land acquisition and physical contingency. The direct construction cost was estimated based on the actual costs and previous estimate for similar projects in Malaysia. Major unit costs assumed are listed in Tables 34 and 35. The physical contingency was assumed to be 30%. The construction cost is disbursed in five years antecedent to the year of commission of the proposed facilities. The construction cost of the untreated rural water supply, however, was assumed to be disbursed in one year exceptionally.

The construction costs were estimated for all the proposed facilities to be commissioned in 1985 onward, including storage and diversion facilities, domestic and industrial water supply system, irrigation system, flood mitigation facilities and public sewerage system, but the sunk cost was not estimated.

The purification facilities for the palm oil mills and rubber processing factories were assumed to be privately financed.

According to the present practice, it was assumed that the construction cost of sewerage system borne by private sector is the house connections in the existing town area, and branch sewers and house connections in the new town areas. In estimating the sewerage treatment capacity in the new town area, it was assumed that the population within the existing town area will remain unchanged and the treatment capacity is allocated in proportion to the population.

The development expenditure and recurrent expenditure in public sector for the recommended plan was estimated as shown in Tables 36 and 37.

7.8 Beneficial and Adverse Effects

The beneficial and adverse effects of the recommended plans were evaluated from the viewpoints of national economic development, environmental quality and social well-being. The beneficial and adverse effects of the recommended plans comprising each aspect of national economic development, environmental quality and social well-being are presented in Tables 38 and 39 for water demand and supply balance, in Table 40 for water pollution abatement, in Table 41 for flood mitigation and in Table 42 for hydropower development.

7.8.1 National economic development

The beneficial and adverse effects of the recommended plans for the national economic development account are calculated as the annual equivalent of economic benefits and costs, assuming a discount rate of 8% for an evaluation period of 50 years between 1981 and 2030.

The prices of internationally traded goods and services were estimated based on the World Bank projection up to 1990, or the international market price in December, 1980. The prices of locally traded goods and services were the normalized price in December, 1980. The transfer payments such as tax and local contractors' profit are deducted from all prices. The ratio of transfer payment to the financial cost was assumed to be 20% of financial cost referring to the ratio of tax revenue to GDP at purchasers' price in 1980 in 4MP.

The domestic and industrial water supply benefit was estimated based on the least-costly alternative facilities cost criteria. The cost of the above-mentioned alternative facilities including dams and the proposed intake, conveyance, treatment and distribution systems is regarded as the benefit of domestic and industrial water supply without drought damage.

There should be established a rule for the emergency operation against the drought in which both the rate of water withdrawal and rate of river maintenance flow should be sustained as much as possible and the river flow should be kept not below the essential river maintenance flow. Herein a simplified rule was assumed: water withdrawal for use continues until the river flow after the water withdrawal lowers to the essential river maintenance flow and thereafter the water withdrawal is reduced so that river flow no longer lowers. Consequently, the reduction in supply for domestic and industrial water and irrigation water is calculated through the period in which run-off record is available, allowing low flow after the water withdrawal to be equal to the essential river maintenance flow. The reduction in benefit is calculated assuming that it is proportional to the reduction in the supply.

The economic farmgate price of paddy during the evaluation period was estimated to be M$640/ton based on the projected price of 5% broken rice, FOB Bangkok. Estimated paddy yield, gross value, production cost and net value are estimated for 1990 and 2000 as shown in Table 43. The hectarage of newly reclaimed land and upgraded lands from rainfed paddy to irrigated or control drainaged paddies, single crop to double crop and minor scheme to major scheme were estimated for the future. Then the irrigation benefit is obtained as the incremental net production value.

The sewerage benefit is the willingness-to-pay by served people and saving in the cost of purification of industrial waste. It was herein assumed to be 0.6% of real income of served people and to be the same percentage of gross value of manufacturing production of served industries.

Pre-treatment facilities are necessary if BOD concentration in raw water is more than 2 mg/lit for domestic water supply and 5 mg/lit for industrial water supply. Its costs can be saved, if the proposed water pollution abatement measures reduce BOD concentration in the river below this limit. This saving in cost is counted as a part of water pollution abatement benefit.

Under the flood mitigation benefit, average value of reduction in annual damage by the proposed measures only is counted, while land enhancement benefit is counted in the irrigation benefit. It is assumed that the damageable value in the flood prone area will increase at a rate of gross regional product of the state.

The fish culture benefit was estimated to be M$2,200/ha for the fish pond and M$1.7 million/reservoir for the cage culture in the created reservoir.

Benefit of the created lake recreation is estimated by willingness-to-pay of the visitors to the lake. The willingness-to-pay is measured in terms of the travelling, or fuel cost of the vehicles to the recreation area. The said cost is assumed to be M$0.1/km.

The economic cost is calculated as the annual equivalent of the construction cost and OMR cost. It is noted that the private sector cost of industrial water supply facilities, purification facilities in palm oil mills and rubber factories and sewerage facilities are included in the economic cost of water pollution abatement measures.

The economic internal rate of return (EIRR) is calculated as the discount rate with which the present worth of benefit equals to that of cost.

7.8.2 Environmental quality

The beneficial and adverse effects of the recommended plans from the viewpoint of environmental quality are descriptively displayed.

The river maintenance flow is the requisite for the conservation of river environment and adequate water use. The effect on the river maintenance flow is evaluated as the number of days when the river maintenance flow can be sustained in the driest year ever recorded.

The water surface of created reservoir provides favorable scenery, place of recreation and enhancement of wildlife. The beneficial effect of created lake is counted by the water surface area.

The reduction in length of river stretches in which BOD concentration will be more than 5mg/lit regarded as the beneficial effect of water pollution abatement.

The channel improvement stabilizes the river channel and provides favorable condition for navigation and other instream water use. The length of improved river stretches is counted as a parameter showing the beneficial effect on environmental quality.

If a dam is constructed, some species of fish would probably disappear in certain length of river stretch immediately downstream of the dam showing an adverse effect on ecological system, though such adverse effect can be compensated by possible cage culture in the created reservoir.

7.8.3 Social well-being

The income increase, health improvement, life saving, and reduced risk in water supply are counted as the beneficial effect from the viewpoint of social well-being. The adverse effect is the inevitable removal of people for the purpose of construction of proposed facilities.

8. PLAN UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

8.1 Assumed GDP Growth Rate

The recommended plan mentioned in the foregoing Chapter 7 is based on an assumption that the growth rate of GDP is 7.7% in the period from 1980 to 1985, 8.4% from 1985 to 1990, and 7.5% from 1990 to 2000, in accordance with 4MP and OPP.

For reference, a plan under a lower economic growth was prepared, assuming that Malaysia's economy might be affected by a long-lasting world-wide economic depression. The growth rate of GDP assumed was 7% in the period from 1980 to 1985, 6% from 1985 to 1990, and 5% from 1990 to 2000.

8.2 Parameters Predominantly Related to GDP Per Capita

The parameters dominated by GDP per capita are the urbanization ratio, share of manufacturing sector in GDP, gross value of industrial output, power consumption per capita, domestic water consumption per capita and value of flood damage, so far related with the water resources development and use. These parameters under the condition of lower economic growth were estimated assuming a functional relationship with GDP per capita.

8.3 Assumed Targets

The service factor and per capita daily use (PCDU) in domestic water supply and rate of irrigation development may be affected by the economic growth and by the socio-economic policy as well. It is herein assumed that, in case of the lower economic development, the target service factor and PCDU in domestic water supply for 2000 is delayed by five years but the rate of irrigation development does not change even under the lower economic development. The estimated service factor and PCDU under the condition of lower economic growth are shown in Table 44. The domestic and industrial water demand estimated under the condition of lower economic growth is shown in Table 45.

8.4 Development Plan

The development plan under the condition of lower economic growth is tabulated in Tables 46 through 53.

8.5 Public Expenditure

The public development and recurrent expenditures are estimated for the case of lower economic growth as shown in Tables 54 and 55.

8.6 Beneficial and Adverse Effects

The beneficial and adverse effects of the water resources development and use plan for the case of lower economic growth are summarized in Tables 56 to 59.

9. NEEDS FOR GROUNDWATER EXPLORATION

9.1 Present Conditions of Groundwater Use

The use of groundwater for potable water supply is at its initial stage in Sarawak. Jerijeh waterworks situated at the delta of the Rajang river as stated in Section 3.1, is the sole groundwater source of PWD water supply system. At Kuala Lawas in the Fifth Division and at Kabong in the Second Division, groundwater exploration is under way. Both Kuala Lawas and Kabong are located near at the river mouths of the Lawas river and the Kabong river respectively. At Nonok in the First Division, the Geological Survey Department (GSD) is carrying out a preliminary monitoring of groundwater level and water quality. According to the data provided by MOH, 319 shallow wells have been constructed by the end of 1980 under the RESP for the total population of 43,700 in the interior rural areas in Sarawak.

9.2 Drought Prone Area in Coastal Plain

As pointed out in Section 3.1, the low land areas extending along the coastal plains of the South China Sea have been suffered from an extreme water shortage in drought periods. Among others, the coastal low lands of the Kuching, Simunjan, Simanggang, Saribas, Kalaka, Sarikei, Binatang and Matu/Daro Districts have been severely affected by drought. Under normal rainfall, the people in these areas obtain water through either nearby small streams or individual rain tubs. But, when a dry spell comes, small streams are dried up. The dry spell varies by year and by area ranging from one month to two months continuosly during the months of June, July and August. As an emergent measures, the PWD transports water to these areas by water tankers, barges, launches and trucks when accessible by road. The total population in the drought prone area is estimated to be 103,000.

9.3 Domestic Water Supply Program for the Drought Prone Area

The plan includes five rain harvesting projects are new under design stage. According to the plan, storage tanks store rainfall during the rainy season and deliver it in the drought period. The rain harvesting project may provide water for subsistence of people in the drought period, but for increased supply, conceivable measures are the extension of water supply pipeline from the existing system, construction of new supply system depending on nearby stream, construction of rain storage reservoir and groundwater exploitation. The former two measures are mostly included in 4MP, and the latter two should, therefore, be considered for the future planning. The rain storage reservoir requires a high investment for construction and sanitary care in operation. Groundwater exploitation is the most feasible measure for domestic water supply in the drought prone area.

9.4 Proposed Groundwater Exploration

A preliminary assessment of groundwater by the Study indicated that good alluvial aquifers could be found in the Quarternary Sediment in the coastal plains of the Rajang river and some other rivers, and excellent aquifers were probably located in limestone occurring in Limbang, Baram, Serian, Kuching and Bau districts. Each aquifer seems to be limited in area and too little data are available to determine the boundary of intruded sea water. This assessment is only indicative, based on a small scale hydrogeological map and limited data of wells. It is noted that the condition in the Quarternary Sediment below 30 m in depth is unknown being limited by the capacity of drilling equipment in GSD.

It is recommended that a groundwater exploration should be carried out in the First, Second and Sixth Divisions where there are many drought prone areas, in order to delineate exploitable aquifers, to estimate water yield, to clarify the location and characteristic of the boundary of sea water intrusion and to estimate the effects of artificial recharge.

The proposed groundwater exploration will include the following works:

(1) To collect and review all available data on meteorology, hydrology and hydrogeology.

(2) To collect and study all existing tube well data, and make additional field survey as required.

(3) To measure for one year at least the monthly electric conductivity and water table in the selected dug-wells in the First, Second and Sixth Divisions concentrating at coastal low land.

(4) To make electric resistivity prospecting in potential groundwater development areas. This is made from ground surface for zoning of subsurface geology in terms of electric resistivity of earth.

(5) Subsurface exploration, including drilling, logging, pumping test and chemical analysis of water quality of test tube wells in the potential development areas. The number and the depth of the tube wells may be subject to the results of electric resistivity prospecting in item (4). In the test tube wells, electric resistivity logging, self-potential or spontaneous polarization logging, electric conductivity logging and pumping test shall be performed.

(6) Results of the above works will be presented in hydrogeological map, geological profile, drill logs, water quality table, contour map of saline water intrusion inferred from electric resistivity prospecting and confirmed by drillings.

(7) To install automatic water level recorders for the test wells after the pumping tests are completed.

(8) To determine locations and design of production tube wells and dug-wells.

(9) The above test wells will be enrolled in geological survey department's groundwater monitoring system and will be monitored periodically.

TABLES

Table 1 METEOROLOGICAL DATA IN SARAWAK

Station	Month	Air Temperature (°C) Max.	Min.	Mean	Relative Humidity (%)	Daily Sunshine (hrs.)	Pan Evaporation (mm)	Rainfall (mm)
Kuching								
	Jan.	29.7	22.6	25.4	87.5	3.6	108	677
	Feb.	30.2	22.7	25.7	86.5	4.0	105	600
	Mar.	31.2	23.1	26.2	85.1	4.5	126	356
	Apr.	32.2	23.2	26.5	85.2	5.4	126	276
	May	32.8	23.3	26.9	83.6	6.4	140	252
	June	32.5	23.0	26.7	83.0	6.2	129	215
	July	32.4	22.9	26.7	81.9	6.2	135	194
	Aug.	32.3	22.8	26.4	82.8	5.5	136	237
	Sep.	32.2	22.8	26.3	83.5	5.0	125	254
	Oct.	32.0	22.8	26.1	85.2	4.8	129	345
	Nov.	31.5	22.7	25.8	86.4	4.7	115	346
	Dec.	30.7	22.8	25.7	87.4	4.1	112	465
	Annual	31.6	22.9	26.2	84.8	5.0	1,486	4,217
Miri								
	Jan.	29.7	22.7	25.8	87.2	5.4	122	342
	Feb.	30.0	22.7	25.9	86.6	6.0	125	157
	Mar.	30.7	23.1	26.5	85.4	6.4	145	156
	Apr.	31.2	23.4	27.0	85.6	7.1	152	179
	May	31.6	23.6	27.3	84.9	7.1	153	175
	June	31.3	23.3	27.0	83.9	6.5	145	225
	July	31.1	23.0	26.8	84.0	6.8	152	202
	Aug.	31.1	23.0	26.7	83.7	6.4	154	210
	Sep.	30.9	23.0	26.7	84.9	6.2	148	233
	Oct.	30.5	23.2	26.6	86.0	5.8	146	303
	Nov.	30.3	23.0	26.3	86.6	5.9	130	342
	Dec.	30.2	23.0	26.2	87.5	5.8	125	332
	Annual	30.7	23.1	26.6	85.5	6.3	1,697	2,856

Remarks; Temperature, humidity and sunshine data are the average for 13 years (1968 - 1980).
Pan evaporation data are the average for 14 years (1967 - 1980).
Rainfall data are the average for 20 years (1960 - 1980).

Table 2 RIVER CHARACTERISTICS IN SARAWAK (1/3)

Basin No.	Item	Description
229	Limbang river	
	(A) River Morphology	Heavy meandering exists in the lower reach. Narrow Cross-section of Sg. Limbang (in the middle reaches) results to a higher flood depth during flooding in the settlement adjacent to the river.
	(B) Sea Water	Tidal reach is between Kg. Telahak and Kg. Epai 40 km from the estuary.
230	Baram river	
	(A) River Morphology	Heavy meandering exists in the lower reach. Marudi town is reported to be in danger because of bank erosion. Banks are eroded by floods. Tidal fluctuation and inland navigation boats.
	(B) Estuary	Estuary cloggings are reported.
	(C) Sediment	Sediment yield seems large from aerial view.
	(D) Sea Water Intrusion	Salt water reaches Kpg. Maro 156 km from Estuary.
231	Miri river	
	(A) River Morphology	No heavy meanders. Stable bank being formed by hard ground. The estuary moved to south-west may deteriorate the flood problem.
	(B) Estuary	Huge sand dune is developed at the estuary, on which oil refinary quarters locate. River dredging is reported to excise every year.
	(C) Sea Water Intrusion	Salt water reaches Long Palai 22.5 km from Estuary.

Table 3 RIVER CHARACTERISTICS IN SARAWAK (2/3)

Basin No.	Item	Description
232	Sibuti river	
	(A) River Morphology	No heavy meanderings exist. Gentle river gradient due to estuary movement caused by sea current may deteriorate flood situation for Bekenu town.
	(B) Estuary	River mouth seems to be moving to south-west by sea current.
	(C) Sediment	Sediment yield seems large judging from aerial survey.
	(D) Sea Water Intrusion	Salt water reaches Bekenu 21.5 km from Estuary.
241	Rajang river	
	(A) River Morphology	Heavy meanderings exist in the lower reach. Banks are eroded by flood, tidal fluctuation and inland navigation boats. Rivers trifurcated at downstream of Sibu play as floodways.
	(B) Estuary	No problem exists.
	(C) Sediment	Sand and gravels are extracted for construction purposes. No silting-up problems reported so far.
	(D) Sea Water Intrusion	Salt water reaches until R. Patah 238 km from Estuary.
245	Sadong river	
	(A) River Morphology	Heavy meanderings exist in the lower and middle reaches.
	(B) Estuary	No problem exists.
	(C) Sea Water Intrusion	Salt water reaches until confluence of Sg. Sebengkong 75 km from estuary.
	(D) Other Items	Simunjau town was resettled because of bank erosion. Two flood control dams were proposed to mitigate floods at upstream of Btg. Kayan and Sg. Kedup.

Table 4 RIVER CHARACTERISTICS IN SARAWAK (3/3)

Basin No.		Item	Description
246	Sarawak river		
	(A)	River Morphology	Meanderings exist in the middle reach but of local and minor scale. Narrow Cross section of Sg. Sarawak near Batu Kitang results in higher flood depths.
	(B)	Estuary	No problem exists.
	(C)	Sea Water Intrusion	Salt water reaches until Ngiru 69.5 km from Estuary.

Table 5 PWD WATER SUPPLY IN SARAWAK IN 1980

Water Works	Type of Supply /1	Design Capacity (m^3/d)	Water Delivered from Works (m^3/d)	Daily Water Consumption (m^3/d)	Served Population	Daily Per Capita Consumption (lpcd)
Serian	I.G.C.	1,183	1,042	1,015	1,015	298
Miri	R.P.T.C.F.	9,100	8,504	9,291 /3	9,291 /3	251
Bintulu	R.P.T.C.F.	4,550	3,322	2,530	10,000	253
Marudi	R.P.T.C.F.	1,310	1,183	924	4,800	192
Limbang	R.P.I.G.T.F.	1,424	1,808	1,627	13,000	125
Sarikei	R.P.T.F.	4,550	2,366	2,343	18,000	130
	PWD Total	22,117	18,225	17,730	86,201	206
Kuching Water Board	R.P.I.T.F.	54,330	50,780	41,820	190,370	220
Sibu Water Board	R.P.T.F.	27,300	19,500	16,170	93,000	174
	W.B. Total	81,630	70,280	57,990	283,370	205
Urban Total		103,747	88,505	75,720	369,571	205
Tapah/Beratok	R.P.T.	2,184	1,465)	1,452	6,507	137
Siburan	R.P.C.	946	410)		5,281	156
Triboh	I.G.C.	273	99	25	562	44
Simunjan	I.G.T.	983	760	528	3,865	137
Sematan	R.P.T.	655	146	137	878	155
Tabakang	R.P.T.	655	396	350	1,369	256
Siniawan	R.P.T.	655	68	55	355	154
Sri Aman	R.P.T.F.	4,550	4,095	3,003	14,500	207
Melugu	R.P.T.F.	655	319	305	2,141	142
Skrang	R.T.P.	655	105	100	1,315	76
Betong	R.P.T.F.	983	605	546	4,418	124
Saratok	R.P.T.	1,092	755	719	7,015	102
Engkilili	R.P.T.	655	396	355	2,024	175
Lubok Antu	R.P.T.	655	123	114	883	129
Roban	R.P.T.	655	178	164	1,660	99
Mukah	R.P.T.F.	3,413	1,092	978	12,000	82
Kanowit	R.P.T.F.	546	410	373	3,000	124
Sibintek	R.P.T.	655	237	216	1,500	158
Dalat	R.P.T.	1,092	259	246	3,200	77
Balingian	R.P.T.	983	64	55	530	102
Long Lama	R.P.T.C.	655	387	255	900	283
Bario	R.G.	n.a.	n.a.	n.a.	n.a.	n.a.
Bekenu /2	R.P.T.C.	1,310	369	191	950	201
Bukit Peninjau	R.P.T.C.	n.a.	n.a.	n.a.	n.a.	n.a.
Lawas	R.P.I.G.T.F.	983	737	623	5,000	125
Panduruan	R.P.T.	228	n.a.	77	980	79
Bintang	R.P.T.F.	983	692	687	8,000	86
Meradong	R.P.T.F.	655	228	37	270	154
Julau	R.P.T.F.	655	473	441	1,850	239
Belawai/Jerijeh	U.P.T.F.	328	n.a.	n.a.	742	n.a.
Lundu	I.G.C.	n.a.	1,060	819	5,561	147
Santubong	I.G.C.	n.a.	n.a.	223	816	273
Kapit	R.P.T.F.	1,310	746	737	4,650	159
Song	R.P.T.	655	309	300	2,650	113
Institutions		5,242	n.a.	2,071	n.a.	n.a.
Rural Total		35,944	16,983	16,182	105,372	154
Total		139,691	105,488	91,902	474,943	194

Remarks: /1: Type of Supply: R - River; I - Impounded; U - Underground water; P - Pumped; G - Gravity; C - Chlorinated; T - Fully Treated; F - Fluoridated

/2: Also supplies to Bukit Peninjau LDS

/3: Shell water supply of 2,000 m^3/d included.

Source: PWD Headquarters, Kuching, Sarawak

Table 6 FLOODED AREA BY RECORDED MAXIMUM FLOOD IN SARAWAK

Basin No.	River Basin	Year	Flooded Area (km^2)	Population 1980 (10^3)	Estimated Damage at 1980 Condition (M$$10^3$)
227	Lawas	1963	34	0	15
228	Trusan	1963	187	1	267
229	Limbang	1963	262	3	1,362
230	Baram	1963	4,491	8	1,915
231	Miri	1963	674	21	1,871
232	Sibuti	1963	214	2	616
233	Niah	1963	480	5	699
234	Suai	1963	211	0	50
235	Similajau	1963	17	0	1
236	Kemena	1963	884	18	1,942
237	Tatau	1963	698	5	155
238	Balingian	1963	108	0	89
239	Mukah	1963	180	2	520
240	Oya	1963	397	1	619
241	Rajang	1963	1,434	24	5,695
245	Sadong	1963	96	1	96
246	Sarawak	1963	449	41	6,984
247	Kayang	1963	181	2	167
	Total		10,997	134	23,063

Table 7 LIST OF EXISTING AND PLANNED DAMS IN SARAWAK

Name	River	Purpose & Year of Commission	Organi-zation	Catchment Area (km^2)	Active Storage (10^6 m^3)	Net Supply Capacity (m^3/d)
Existing						
Two dams under Matang scheme	Sarawak	WS	Kuching Water Board			9,120
Under Construction						
Batang Ai dam	Lupar	HY:92MW/ 1985	SESCO	1,200	750	
Siku reservoir	Kemana	WS/1983	PWD	–	1:2	94 m^3/s guaranteed, 38.6 m^3/s at first stage
Under Planning						
Raja 284 (Pelagus) dam	Rajang	HY:770MW/ 1990	SESCO	20,919	1,200	
Balu 037 dam	Rajang	HY:2,580MW/ 1994	SESCO	14,764	16,200	

Remarks; WS: Domestic and industrial water supply
HY: Hydropower

Table 8 HISTORICAL AND PROJECTED POPULATION OF DISTRICT BY CITY/TOWN AND RURAL AREA IN SARAWAK

Unit: 10^3

District		City/Rural	Historical 1980	Projected 1985	Projected 1990	Projected 2000	Average Annual Growth(%) 1980-2000
224. Lawas		Rural	20	22	24	26	1.3
225. Limbang	212.	Limbang	8	11	15	28	6.5
		Rural	18	20	22	24	1.4
		Total	26	31	37	52	3.5
226. Baram	213.	Marudi	7	8	11	20	5.4
		Rural	47	56	65	72	2.2
		Total	54	64	76	92	2.7
227. Miri	214.	Miri	55	70	94	177	6.0
		Rural	46	65	86	105	4.2
		Total	101	125	180	282	5.3
228. Bintulu	215.	Bintulu	17	26	34	51	5.6
		Rural	42	47	52	57	1.5
		Total	59	73	86	108	3.1
229. Mukah		Rural	36	41	46	49	1.6
230. Oya/Dalat		Rural	23	26	28	31	1.5
231. Sibu	216.	Sibu	88	117	164	331	6.8
		Rural	49	49	49	48	-0.1
		Total	137	166	213	379	5.2
232. Kanowit		Rural	29	32	35	37	1.2
233. Belaga		Rural	12	14	16	17	1.8
234. Kapit		Rural	39	46	53	59	2.1
235. Song		Rural	17	20	23	26	2.1
236. Matu/Daro		Rural	17	19	20	22	1.3
237. Binatang		Rural	30	33	36	38	1.2
238. Sarikei	217.	Sarikei	13	19	28	62	8.1
		Rural	31	32	33	34	0.5
		Total	44	51	61	96	4.0
239. Julau		Rural	28	31	34	36	1.3
240. Kalaka		Rural	36	39	43	45	1.1
241. Saribas		Rural	42	46	49	52	1.1
242. Lubok Antu		Rural	21	23	25	26	1.1
243. Simanggang		Rural	63	68	72	75	0.9
244. Simunjan		Rural	38	42	46	49	1.3
245. Serian	218.	Serian	4	6	8	17	7.5
		Rural	64	72	79	86	1.5
		Total	68	78	87	103	2.1
246. Kuching	219.	Kuching	175	218	281	497	5.4
		Rural	143	158	173	215	2.3
		Total	318	376	454	712	4.2
247. Bau		Rural	33	35	37	38	0.7
248. Lundu		Rural	23	26	29	32	1.7
		Urban Total	367	475	635	1183	6.0
		Rural Total	947	1062	1175	1299	1.6
		State Total	1314	1537	1810	2482	3.2

Table 9 HISTORICAL AND PROJECTED GROSS VALUE OF MANUFACTURING OUTPUT BY COMMODITY GROUP IN SARAWAK

Item	Year 1980	1985	1990	2000
Food	131	147	164	840
Textile	3	3	3	16
Wood	232	260	291	1,492
Paper	0	0	0	1
Publishing	14	15	17	87
Chemical	51	339	1,015	4,731
Rubber	8	9	10	51
Non-metal	12	13	15	76
Basic metal	1	1	2	8
Machinery	43	48	54	278
Others	3	4	4	22
Total	498	839	1,575	7,602

Remarks; In factor cost at 1970 prices

Table 10 BASIN AREA AND ASSUMED RIVER MAINTENANCE FLOW IN SARAWAK

Basin No.	Basin	Total Catchment Area (km^2)	Effective Catchment Area (km^2)	Balance Point (km)	River Maintenance Flow (m^3/s)
227	Lawas	1,080	977	5	7.8
228	Trusan	2,768	2,598	15	14.3
229	Limbang	3,920	3,865	6	71.1
230	Baram	22,325	21,822	63	388.0
231	Miri	788	263	20	1.8
232	Sibuti	935	790	15	4.5
233	Niah	1,345	1,117	12	6.1
234	Buai	1,440	1,242	31	8.5
235	Similajau	1,268	935	3	7.9
236	Kemena	6,000	5,745	21	62.0
237	Tatau	5,150	4,790	19	51.7
238	Balingian	2,518	1,548	46	16.3
239	Mukah	2,625	1,486	40	16.0
240	Oya	2,005	1,277	25	10.8
241	Rajang	51,053	46,035	15	1,409.0
242	Kerian	1,675	849	26	9.3
243	Saribas	1,900	799	39	8.4
244	Lupar	6,813	5,209	36	56.3
245	Sadong	3,645	2,935	81	33.2
246	Sarawak	3,358	2,152	35	36.4
247	Kayan	1,838	1,549	11	32.1
	Total	124,449	107,983		

Remarks; The location of balance point is the river km measured upstream from the estuary.

Table 11 ESTIMATED AND PROJECTED SERVICE FACTOR AND PER CAPITA DAILY USE OF DOMESTIC WATER IN SARAWAK

Item	Service Factor (%)				Per Capita Daily Use (lpcd)			
	Estimated	Projected			Estimated	Projected		
	1980	1985	1990	2000	1980	1985	1990	2000
1. Urban Area								
212 Limbang	100	100	100	100	98	144	190	220
214 Miri	68	75	85	100	158	174	190	230
215 Bintulu	59	70	80	100	163	177	190	220
216 Sibu	100	100	100	100	153	177	200	230
217 Sarikei	100	100	100	100	92	141	190	220
218 Serian	83	85	90	100	153	157	160	220
219 Kuching	100	100	100	100	197	199	200	230
223 Marudi	74	80	85	100	121	156	190	220
2. Rural Area								
PWD Area	12	18	21	24	75	100	125	175
MOH Area	32	37	43	54	40	45	55	70
3. Non-pipe-served Area	-	-	-	-	40	40	40	40

Table 12 NET UNIT MANUFACTURING WATER USE PER GROSS VALUE OF MANUFACTURING OUTPUT BY COMMODITY GROUP

Unit: $m^3/d/M\$10^6/y$

	Commodity Group	Assumed/1 1975	Estimated/2 1980	Projected 1985/2	Projected 1990 & 2000
1.	Food	77.0	75.0	73.0	71.0
2.	Textile	79.0	77.0	75.0	73.0
3.	Wood Product	12.0	12.3	12.7	13.0
4.	Paper Product	581.0	560.7	540.3	520.0
5.	Publishing	10.0	10.0	10.0	10.0
6.	Chemicals	140.0	136.7	133.3	130.0
7.	Rubber Manufacturing	126.0	105.7	85.3	65.0
8.	Non-metal	88.0	86.7	69.3	68.0
9.	Basic Metal	53.0	51.7	50.3	49.0
10.	Machinery	16.0	17.3	18.7	20.0
11.	Miscellaneous	48.0	48.3	48.7	49.0

Remarks; /1: Assumed from data in Japan in 1970
/2: Obtained by interpolation

Note; The values indicated are net manufacturing water use (excluding the water used cyclically) per $M\$10^6$ of the gross value of manufacturing output at 1970 price.

Table 13 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN SARAWAK

Unit: 10^6 m^3/y

Basin No.	City/Rural	Estimated 1980 D&I	Projected 1985 D	1985 I	1985 Total	1990 D	1990 I	1990 Total	2000 D	2000 I	2000 Total
227	Rural	0.4	0.5	0.0	0.5	0.5	0.0	0.5	0.8	0.0	0.8
228	Rural	0.3	0.3	0.0	0.3	0.5	0.0	0.5	0.8	0.0	0.8
229	212 Limbang	0.7	1.3	0.0	1.3	1.8	0.0	1.8	3.6	0.1	3.7
	Rural	0.3	0.3	0.0	0.3	0.5	0.0	0.5	0.7	0.1	0.8
	Basin Total	1.0	1.6	0.0	1.6	2.3	0.0	2.3	4.3	0.2	4.5
230	213 Marudi	0.6	0.7	0.7	1.4	0.9	0.7	1.6	2.1	3.7	5.8
	Rural	0.8	1.4	0.0	1.4	1.9	0.0	1.9	3.4	0.0	3.4
	Basin Total	1.4	2.1	0.7	2.8	2.8	0.7	3.5	5.5	3.7	9.2
231	214 Miri	4.4	5.0	5.4	10.4	7.6	5.9	13.5	19.6	31.8	51.4
	Rural	0.3	0.5	0.5	0.5	0.6	0.0	0.6	0.7	0.0	0.7
	Basin Total	4.7	5.5	5.4	10.9	8.2	5.9	14.1	20.3	31.8	52.1
232	Rural	0.3	0.3	0.1	0.4	0.5	0.1	0.6	0.8	0.1	0.9
233	Rural	0.4	0.4	0.2	0.6	0.6	0.2	0.8	1.3	0.2	1.5
234	Rural	0.3	0.5	0.0	0.5	0.8	0.1	0.9	1.4	0.1	1.5
235	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.4	0.0	0.4
236	215 Bintulu	1.6	1.8	8.2	10.0	2.6	13.5	16.1	5.4	20.5	25.9
	Rural	0.5	0.6	0.0	0.6	0.8	0.0	0.8	1.3	0.0	1.3
	Basin Total	2.1	2.4	8.2	10.6	3.4	13.5	16.9	6.7	20.5	27.2
237	Rural	0.4	0.5	0.0	0.5	0.6	0.0	0.6	1.0	0.1	1.1
238	Rural	0.4	0.5	0.0	0.5	0.6	0.0	0.6	1.0	0.0	1.0
239	Rural	0.7	1.1	0.1	1.2	1.5	0.1	1.6	2.4	0.2	2.6
240	Rural	0.5	0.6	0.0	0.6	0.8	0.0	0.8	1.4	0.0	1.4
241	216 Sibu	8.0	10.3	1.1	11.4	16.1	1.1	17.2	37.0	5.7	42.7
	217 Sarikei	0.9	1.9	0.4	2.3	2.9	0.4	3.3	8.0	2.1	9.1
	Rural	5.6	7.3	0.1	7.4	8.5	0.1	8.6	12.5	0.3	12.8
	Basin Total	14.5	19.5	1.6	21.1	27.5	1.6	29.1	56.5	8.1	64.6
242	Rural	1.1	1.1	0.1	1.2	1.5	0.1	1.6	2.6	0.4	3.0
243	Rural	1.0	1.1	0.1	1.2	1.4	0.1	1.5	2.3	0.5	2.8
244	Rural	3.4	3.7	0.3	4.0	4.2	0.4	4.6	5.7	1.3	7.0
245	218 Serian	0.4	0.4	0.0	0.4	0.5	0.1	0.6	1.8	0.4	2.2
	Rural	2.3	2.8	0.0	2.8	3.6	0.0	3.6	6.0	0.1	6.1
	Basin Total	2.7	3.2	0.0	3.2	4.1	0.1	4.2	7.8	0.5	8.3
246	219 Kuching	20.5	22.6	2.2	24.8	28.9	2.4	31.3	57.4	12.4	69.8
	Rural	2.5	4.4	0.1	4.5	6.0	0.1	6.1	10.1	0.2	10.3
	Basin Total	23.0	27.0	2.3	29.3	34.9	2.5	37.4	67.5	12.6	80.1
247	Rural	0.8	1.0	0.0	1.0	1.3	0.0	1.3	1.9	0.0	1.9
Total		59.1	73.2	19.1	92.2	98.3	25.4	123.7	192.4	80.3	272.7

Remarks; Water demand: Total source demand
D: Domestic water demand
I: Industrial water demand

Table 14 ESTIMATED AREA OF IRRIGATED PADDY FIELD IN SARAWAK

Unit: ha

Basin No.	Basin Name	Scheme	1980 Positive Main	1980 Positive Off	1980 C/D	1990 Positive Main	1990 Positive Off	1990 C/D	2000 Positive Main	2000 Positive Off	2000 C/D
227	Lawas	Minor	-	-	-	408	408	-	408	408	-
228	Trusan	Minor	-	-	-	540	540	-	1429	1429	189
229	Limbang	Major/1	-	-	-	3100	3100	-	8600	8600	-
		Minor	219	219	-	323	323	-	323	323	-
230	Basam	Minor	162	162	-	1414	1414	-	3883	3883	-
231	Miri	Minor	-	-	128	108	108	128	108	108	128
232	Sibuti	Minor	546	546	202	546	546	394	546	546	778
233	Niah	Minor	-	-	-	-	-	-	-	-	-
234	Buai	Minor	-	-	-	-	-	-	-	-	-
235	Similajau	Minor	-	-	-	-	-	-	-	-	-
236	Kemena	Minor	-	-	109	962	962	109	2666	2666	328
237	Tatau	Minor	-	-	-	182	182	-	182	182	-
238	Balingian	Minor	-	-	-	-	-	-	257	257	-
239	Mukah	Minor	-	-	-	418	418	-	418	418	728
240	Oya	Minor	-	-	-	266	266	-	532	532	304
241	Rajang	Major/2	-	-	-	-	-	-	4000	2000	-
		Minor	150	150	1379	970	970	5189	1641	1641	6150
242	Kerian	Minor	-	-	231	-	-	2069	-	-	3032
243	Saribas	Minor	-	-	304	126	126	817	126	126	2096
244	Lupar	Major/3	-	-	-	-	-	-	4000	2000	-
		Minor	349	349	1441	1321	1221	2738	3240	3140	3911
245	Sadong	Major/4	-	-	-	1800	1000	-	4000	2000	-
		Minor	60	20	297	518	518	297	1432	1432	297
246	Sarawak	Major/5	-	-	-	3000	1600	1500	6000	1600	4500
		Minor	-	-	259	707	707	259	2123	2123	259
247	Kayan	Minor	194	194	-	491	491	-	1086	1086	-
	Total		1680	1640	4350	17200	14900	13500	47000	36500	22700

Remarks; Positive : Positive irrigation scheme (Gravity or Pumping)

C/D : Control drainage scheme

/1 : Limbang Valley Project

/2 : Binatang Barat Project

/3 : Batang Lupor Project

/4 : Sadong Krang Project

/5 : Samarahan River Basin Development Project

Table 15 ESTIMATED IRRIGATION WATER DEMAND FOR PADDY IN SARAWAK

Unit: $10^6 m^3/y$

Basin No.	Basin	Scheme	1980	1990	2000
227	Lawas	Minor	-	5	5
228	Trusan	Minor	-	6	17
229	Limbang	Major	-	27	74
		Minor	1	4	4
230	Baram	Minor	2	28	78
231	Miri	Minor	-	2	2
232	Sibuti	Minor	5	11	11
233-235	Niah	-	-	-	-
236	Kemena	Minor	-	14	38
237	Tatau	Minor	-	3	3
238	Balingian	Minor	-	-	4
239	Mukah	Minor	-	6	6
240	Oya	Minor	-	4	7
241	Rajang	Major	-	-	30
		Minor	1	13	22
242	Kerian	-	-	-	-
243	Sarabas	Minor	-	2	2
244	Lupar	Major	-	-	36
		Minor	3	20	49
245	Sadong	Major	-	10	21
		Minor	0	6	16
246	Sarawak	Major	-	21	21
		Minor	-	8	24
247	Kayan	Minor	2	6	12
	Total		14	196	482

Table 16 RIVER UTILIZATION RATIO BY BASIN IN SARAWAK FOR 1990 AND 2000

Unit: 10^6 m^3/y

Basin No.	Basin	Surface** Runoff (1)	1990 Demand* D&I	1990 Demand* Irr.	1990 Demand* Total (2)	1990 Ratio (2)/(1) (%)	2000 Demand* D&I	2000 Demand* Irr.	2000 Demand* Total (2)	2000 Ratio (2)/(1) (%)
227	Lawas	2,422	0.5	5	5.5	0.2	0.8	5	5.8	0.2
228	Trusan	4,424	0.5	6	6.5	0.1	0.8	17	17.8	0.4
229	Limbang (C212 Limbang)	10,432	2.3	31	33.3	0.3	4.5	78	82.5	0.8
230	Baram (C213 Marudi)	56,893	3.5	28	31.5	0.1	9.2	78	97.2	0.2
231	Miri	432	14.1	2	16.1	3.7	52.1	2	54.1	12.5
	C214 Miri	247	13.5	0	13.5	5.5	51.5	0	51.5	20.9
232	Sibuti	1,106	0.6	11	11.6	1.0	0.9	11	11.9	1.1
233	Niah	1,489	0.8	0	0.8	0.1	1.5	0	1.5	0.1
234	Buai	2,064	0.9	0	0.9	0***	1.5	0	1.5	0
235	Similajau	1,934	0.3	0	0.3	0	0.4	0	0.4	0
236	Kemena	15,160	16.9	14	30.9	0.2	27.2	38	65.2	0.4
	C215 Bintulu	304	16.1	0	16.1	5.3	25.9	0	25.9	8.5
237	Tatau	12,610	0.6	3	3.6	0	1.1	3	4.1	0
238	Balingian	3,941	0.6	0	0.6	0	1.0	4	5.0	0.1
239	Mukah	3,915	1.6	6	7.6	0.2	2.6	6	8.6	0.2
240	Oya	2,630	0.8	4	4.8	0.2	1.4	7	8.4	0.3
241	Rajang (C216 Sibu)	114,699	29.1	13	42.1	0	64.6	52	116.6	0.1
	C217 Sarikei	209	3.3	0	3.3	1.6	9.0	0	9.0	4.3
242	Kerian	1,924	1.6	0	1.6	0.1	3.0	0	3.0	0.2
243	Saribas	1,739	1.5	2	3.5	0.2	2.8	2	4.8	0.3
244	Lupar	11,674	4.6	20	24.6	0.2	7.0	85	92.0	0.8
245	Sadong	6,882	4.2	16	24.2	0.4	8.3	37	45.3	0.7
	C217 Serian	2,052	0.5	0	0.5	0	2.2	0	2.2	0.1
246	Sarawak	5,875	37.4	29	66.4	1.1	80.1	45	125.1	2.1
	C219 Kuching	2,006	31.3	0	31.3	1.6	69.8	0	69.8	3.5
	Major irrigation	964	0	21	21.0	2.3	0	21.0		2.3
247	Kayang	5,164	1.3	6	7.3	0.1	1.9	12	13.9	0.3

Remarks; *: Source demand.
**: Surface runoff in effective area.
***: The ratio of less than 0.1% was assumed to be zero.

Table 17 ANNUAL DEFICIT BY BASIN IN SARAWAK FOR 1990 AND 2000

Unit: 10^6 m^3/y

Basin No.	Name of Sub-basin	Drought Level 1/N Deficit	Year	2/N Deficit	Year	3/N Deficit	Year	4/N Deficit	Year	5/N Deficit	Year
1990											
231	Miri	3.3	1976	2.4	1977	1.9	1973	0.8	1974	0.4	1972
2000											
231	Miri	13.2	1976	9.8	1977	8.2	1973	7.5	1974	4.9	1975

Table 18 ASSUMED DEVELOPMENT OF LAND DISPOSAL IN PALM OIL MILLS AND RUBBER FACTORIES IN SARAWAK

Unit: %

	1980	1990	2000
Palm oil mills	25	50	75
Rubber factories	0	10	20

Table 19 DISCHARGE RATIO, RUNOFF RATIO, INFILTRATION RATIO AND BOD CONCENTRATION OF EFFLUENT ASSUMED UNDER PRESENT PURIFICATION LEVEL IN SARAWAK

Pollution Source	Year	Discharge Ratio	BOD Concentration (mg/lit)	Runoff Ratio	Infiltration Ratio
Domestic					
Urban sewerage	1999 & 2000	0.9	30	1.0	0.2
Urban non-sewerage	1990	0.9	160	0.6	0
	2000	0.9	140	0.6	0
Rural	1990 & 2000	0.8	200	0.1	0
Manufacture					
Urban sewerage	1990 & 2000	1.0	30	1.0	0.2
Urban non-sewerage }	1990	1.0	200	0.6	0
Rural }	2000	1.0	200	0.1	0
Palm Oil Mill					
With P.S./1	1990	0.55	50	0.6	0
	2000	0.3	50	0.6	0
Without P.S.	1990	0.55	22,000	0.6	0
	2000	0.3	22,000	0.6	0
Land disposal	1990	0.1	50	0.6	0
	2000	0.1	50	0.6	0
Rubber Factories					
With P.S.	1990	0.9	50	0.6	0
	2000	0.8	50	0.6	0
Without P.S.	1990	0.9	2,320	0.6	0
	2000	0.8	2,320	0.6	0
Land disposal	1990	0.1	50	0.6	0
	2000	0.1	50	0.6	0
Animal Husbandry	1990 & 2000	1.0	200/2	0.1	0

Remarks; /1: Purification System
/2: g/d/head

Table 20 PROPOSED FLOOD FORECASTING AND WARNING SYSTEM IN SARAWAK

Basin No.	River Basin	People Rel'ved by F/F (10^3)	Construction Cost (M$$10^6$)	Construction Period
229	Limbang	2.6	3.6	7MP
230	Baram	6.0	9.8	5MP
231	Miri	14.0	2.3	6MP
233	Niah	5.0	2.6	7MP
236	Kemena	11.1	4.1	6MP
237	Tatau	2.7	3.8	7MP
241	Rajang	16.6	19.9	6MP
245	Sadong	5.0	2.7	4MP
246	Sarawak	22.9	3.4	5MP
Total		85.9	52.2	

Table 21 RIVER UTILIZATION RATIO IN MIRI SUB-DIVISION

Unit: 10^6 m^3

Basin No.	Sub-basin	C.A. (km^2)	Run-off	1990 Demand D&I	1990 Demand Irri.	1990 Utilization Ratio (%)	2000 Demand D&I	2000 Demand Irri.	2000 Utilization Ratio (%)
231	Miri	150	247	14	-	6	52	-	21

Remarks; C.A.: Catchment
Irri: Irrigation
D&I : Domestic and industrial water

Table 22 PRINCIPAL FEATURE OF PROPOSED SOURCE FACILITIES BY ALTERNATIVE IN MIRI SUB-BASIN

Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construction Cost (M$$10^6$)	Construction Period
231	Liku dam	WS	33				
	-Alternative B1			5	20	14.9	1985-1989
	-Alternative B2			4	15	12.9	1985-1989
	-Alternative B3			3	13	11.9	1985-1989

Table 23 OUTLINE OF FLOOD MITIGATION PROGRAM BY ALTERNATIVE IN SARAWAK

Basin No.	Basin	Improved River Length (km)	Dam (nos)	Bypass Flood-way (km)	Polder (nos)	Protected Popula-tion (10^3)	Protected Area (km^2)	Const. Cost (M$$10^6$)
Alternative F1								
230	Baram	41	-	-	-	11.0	402	607.3
231	Miri	-	-	5	-	27.9	542	10.7
232	Sibuti	27	-	-	-	4.3	190	57.4
233	Niah	33	-	-	1	8.4	291	90.8
236	Kemena	103	-	-	-	31.1	884	493.7
237	Tatau	63	-	-	-	4.1	364	316.7
241	Rajang	221	-	-	-	103.9	1,236	2,620.7
246	Sarawak	142	1	-	-	68.8	425	328.1
247	Kayang	9	-	-	1	0.7	45	16.8
	Total	639	1	5	2	260.2	4,379	4,542.2
Alternative F2								
231	Miri	-	-	5	-	27.9	542	10.7
233	Niah	-	-	-	1	0.9	3	0.8
236	Kemena	30	-	-	-	16.6	178	156.1
241	Rajang	21	-	-	-	9.3	266	23.1
246	Sarawak	142	1	-	-	62.1	425	328.1
	Total	193	1	5	1	116.8	1,414	518.8
Alternative F3								
230	Baram	-	-	-	1	2.8	24	3.5
231	Miri	-	-	5	-	27.9	542	10.7
233	Niah	-	-	-	1	0.9	3	0.7
247	Kayang	-	-	-	1	0.7	16	6.2
	Total	-	-	5	3	32.3	585	21.1

Remarks; Protected population: in 2000

Table 24 ALTERNATIVE HYDROPOWER DEVELOPMENT PLAN IN SARAWAK

Name	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Installed Capacity (MW)	Construction Cost (M$$10^6$)	Construction Cost (M$/MW)
Upper Batang Ai	360	340	48	460	9.6
Batang Sekrang	440	451	46	310	6.7
Konowit	1,250	1,175	110	510	4.5

Table 25 RECOMMENDED WATER SUPPLY DEVELOPMENT PLAN FOR CITIES/TOWNS IN SARAWAK

Basin No.	Code No.	Town	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
229	212	Limbang	3.9	100	17.0	5.4	100	20.5	11.2	100	35.1
230	213	Marudi	3.0	80	6.4	3.6	85	9.3	11.8	100	20.3
231	214	Miri	11.8	75	52.5	21.4	85	79.6	97.6	100	177.4
236	215	Bintulu	26.8	70	18.2	44.9	80	27.4	64.2	100	51.2
241	216	Sibu	32.5	100	122.0	50.0	100	169.3	119.9	100	336.1
241	217	Sarikei	6.3	100	24.0	9.3	100	32.8	24.1	100	67.3
245	218	Serian	1.2	85	5.1	1.5	90	7.2	6.0	100	17.0
246	219	Kuching	71.4	100	236.0	90.7	100	302.3	191.7	100	520.8
Total			156.9	95	481.2	226.8	97	648.4	526.5	100	1225.2

Remarks; TC: Treatment capacity required in the corresponding year in 10^3 m^3/d

SF: Service factor in %

SP: Served population in 10^3

Table 26 RECOMMENDED TREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SARAWAK

Basin No.	Name	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
227	Lawas	0.9	55	5.6	1.2	65	6.0	2.1	90	1.8
228	Trusan	0.3	55	2.3	0.6	65	3.0	1.2	90	4.5
229	Limbang	0.3	55	2.1	0.6	65	2.8	0.9	90	4.1
230	Baram	1.2	55	8.8	2.4	65	12.2	5.4	90	18.8
231	Miri	0.6	55	1.7	0.9	65	2.7	1.2	90	4.1
232	Sibuti	0.6	55	1.8	0.9	65	2.9	1.5	90	4.9
233	Niah	0.9	55	2.6	1.2	65	4.1	2.7	90	6.9
234	Suai	0.3	55	2.8	1.2	65	4.4	2.4	90	7.4
235	Similajau	0.3	55	1.0	0.3	65	1.4	0.6	90	2.3
236	Kemena	0.6	55	3.4	0.9	65	4.5	2.1	90	6.8
237	Tatau	0.3	55	2.9	0.6	65	3.8	2.1	90	5.8
238	Balingian	0.3	55	3.0	0.6	65	3.9	1.5	90	5.8
239	Mukah	2.7	55	14.6	3.9	65	17.6	6.9	90	6.1
240	Oya	0.6	55	3.9	0.9	65	4.9	2.1	90	7.5
241	Rajang	7.8	55	31.2	10.2	65	40.1	16.6	90	58.9
242	Kerian	2.4	55	11.8	3.3	65	15.3	6.9	90	22.2
243	Saribas	1.2	55	6.8	2.1	65	8.6	4.5	90	12.6
244	Lupar	8.4	55	28.2	9.9	65	35.6	16.6	90	51.3
245	Sadong	2.7	55	16.9	4.2	65	22.0	9.6	90	32.9
246	Sarawak	4.2	55	26.6	7.2	65	33.2	16.0	90	55.8
247	Kayang	2.4	55	9.1	3.0	65	12.0	4.8	90	18.3
Total		39.0	55	187.1	56.1	65	241.0	107.7	90	338.8

Remarks; TC: Treatment capacity in the corresponding year in 10^3 m^3/d
SF: Service factor in %
SP: Served population in 10^3

Table 27 RECOMMENDED UNTREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SARAWAK

Basin No.	Basin	1985 SD	1985 SF	1985 SP	1990 SD	1990 SF	1990 SP	2000 SD	2000 SF	2000 SP
227	Lawas	0.1	55	-	0.1	65	-	0.2	90	-
228	Trusan	0.1	55	6.4	0.2	65	8.2	0.4	90	12.3
229	Limbang	0.1	55	5.6	0.2	65	7.6	0.4	90	11.2
230	Baram	0.4	55	23.8	0.8	65	32.9	1.7	90	50.8
231	Miri	0.1	55	4.0	0.2	65	6.2	0.4	90	10.5
232	Sibuti	0.1	55	5.0	0.2	65	7.7	0.4	90	13.1
233	Niah	0.2	55	7.0	0.3	65	11.0	0.6	90	18.7
234	Suai	0.2	55	7.6	0.3	65	11.8	0.7	90	20.1
235	Similajau	0.1	55	2.7	0.1	65	3.9	0.2	90	6.1
236	Kemena	0.2	55	9.3	0.3	65	12.1	0.6	90	18.3
237	Tatau	0.2	55	7.9	0.3	65	10.4	0.4	90	15.7
238	Balingian	0.2	55	8.1	0.3	65	10.7	0.4	90	15.8
239	Mukah	0.2	55	-	0.3	65	-	0.4	90	-
240	Oya	0.2	55	10.4	0.3	65	13.3	0.7	90	20.4
241	Rajang	2.3	55	115.1	3.5	65	147.7	6.6	90	217.4
242	Kerian	0.3	55	9.7	0.4	65	12.6	1.0	90	18.3
243	Saribas	0.4	55	18.5	0.6	65	23.3	1.1	90	34.2
244	Lupar	0.8	55	21.8	1.2	65	27.4	2.2	90	39.6
245	Sadong	1.0	55	45.7	1.5	65	59.3	2.9	90	88.9
246	Sarawak	1.6	55	71.9	2.5	65	89.7	5.0	90	150.9
247	Kayang	0.2	55	5.2	0.4	65	6.9	0.7	90	10.6
Total		9.0	55	385.7	14.0	65	502.7	27.0	90	772.9

Remarks; SD: Source demand (piped) in the corresponding year in 10^6 m^3/y

SF: Service factor in %

SP: Served population in 10^3

Table 28 RECOMMENDED WATER SOURCE DEVELOPMENT PLAN IN SARAWAK

River system	Miri
Name of facilities	Liku dam
Catchment area	33 km^2
Active storage capacity	5×10^6 m^3
Net supply capacity	20×10^6 m^3/y
Purpose	Water supply to Miri
Investment	M$14.9 x 10^6
Construction period	1985 - 1989

Table 29 RECOMMENDED PLAN FOR IMPROVEMENT OF PURIFICATION SYSTEM IN PALM OIL MILLS AND RUBBER FACTORIES IN TREATMENT CAPACITY IN SARAWAK

Unit: m^3/d

Basin		1981 - 1990			1991 - 2000		
No.	Name	Palm Oil	Rubber	Total	Palm Oil	Rubber	Total
234	Suai	440	0	440	40	0	40
Total		440	0	440	40	0	40

Table 30 ASSUMED PUBLIC SEWERAGE DEVELOPMENT NOT AFFECTING RIVER WATER QUALITY IN SARAWAK

Basin	City/Town		1990			2000		
No.	No.	Name	Treatment Capacity ($10^3m^3/y$)	Service Factor (%)	Served Population (103)	Treatment Capacity ($10^3m3/y$)	Service Factor (%)	Served Population (10^3)
236	C215	Bintulu	120	75	26	577	80	41
246	C219	Kuching	39	55	155	128	80	398
Total			159	-	181	705	-	439

Table 31 POLLUTION LOAD IN 2000 BY BASIN UNDER WITH-AND-WITHOUT IMPLEMENTATION OF RECOMMENDED PLAN IN SARAWAK

Basin		Without Project					With Project				
		BOD Load into River (ton/d)				Max. BOD in River	BOD Load into River (ton/d)				Max. BOD in River
No.	Name	PR	UI	RA	Total	(mg/lit)	PR	UI	RA	Total	(mg/lit)
227	Lawas	0	0	0	0	0	0	0	0	0	0
228	Trusan	0	0	0	0	0	0	0	0	0	0
229	Limbang	0	1	0	1	0	0	1	0	1	0
230	Baran	0	1	0	1	0	0	1	0	1	0
231	Miri	0	0	1	1	4	0	0	1	1	4
232	Sibuti	0	0	0	0	0	0	0	0	0	0
233	Niah	0	0	0	0	0	0	0	0	0	0
234	Suai	2	0	0	2	0	0	0	0	0	0
235	Similajau	0	0	0	0	0	0	0	0	0	0
236	Kemena	0	0	0	0	0	0	0	0	0	0
237	Tatau	1	0	0	1	0	1	0	0	1	0
238	Balingian	0	0	0	0	0	0	0	0	0	0
239	Mukah	0	0	0	0	0	0	0	0	0	0
240	Oya	0	0	0	0	0	0	0	0	0	0
241	Rajang	3	9	1	13	0	3	9	1	13	0
242	Kerian	0	0	0	0	0	0	0	0	0	0
243	Sarabas	0	0	0	0	0	0	0	0	0	0
244	Lupar	2	0	0	2	1	2	0	0	2	1
245	Sadong	2	0	3	5	1	2	0	3	5	1
246	Sarawak	0	10	1	11	1	0	10	1	11	1
247	Kayan	1	0	0	1	0	1	0	0	1	0
	Total	11	21	6	38	–	9	21	6	36	–

Remarks; PR: Palm oil mill and rubber factory effluent
UI: Urban sewer and industrial effluent
RA: Rural sewer and animal husbandry

Table 32 RECOMMENDED FLOOD MITIGATION PROGRAM IN SARAWAK

Basin No.	Basin	R.I. (km)	F.W. (km)	Dam (nos)	Polder (nos)	P.P. (10^3)	F.A. (km^2)	C.C. (M$$10^6$)
By 1990								
229	Limbang	-	-	1	-	5	262	-
231	Miri	-	5	-	-	28	542	11
Total		-	5	1	-	33	804	11
By 2000								
229	Limbang	-	-	1	-	5	262	-
231	Miri	-	5	-	-	28	542	11
233	Niah	-	-	-	1	1	3	1
236	Kemena	30	-	-	-	17	178	156
241	Rajang	21	-	-	-	9	266	23
246	Sarawak	142	-	1	-	62	425	328
Total		193	5	2	1	122	1,676	519

Remarks; R.I.: River improvement
F.W.: Floodway
Pold.: Polder
N.S.: Non-structural measure
P.P.: Population protected (the year 2000)
F.A.: Flood area relieved
C.C.: Construction cost

Cost of Limbang project be borne by irrigation sector.

Table 33 RECOMMENDED HYDROPOWER DEVELOPMENT PLAN IN SARAWAK

Name	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Installed Capacity (MW)	Construction Cost (M$$10^6$)	Construction Period
Konowit	1,250	1,180	110	510	1991-1995
Batang Sekrang	440	450	46	310	1991-1995
Upper Batang Ai	360	340	48	460	1993-1997

Table 34 ASSUMED UNIT CONSTRUCTION COST (1/2)

1. Compensation on Land (M$$10^6/km^2$)

Irrigated paddy	2.5	Urban area class S	100
Rainfed paddy	1.5	Urban area class A	10
Tree crop field class A	1.5	Urban area class B	5
Tree crop field class B	1.0	Village area class A	5
Tree crop field class C	0.5	Village area class B	1
Forest class A	0.5		
Forest class B	0.1		

S: very good access, A: good access
B: poor access, C: very poor access

2. Resettlement (M$$10^3$/household)

Urban	30	Rural	10

3. Civilwork

Dam	M$50-70 per m^3 of embankment volume
Canal	M$60-100 m per m^3/s of discharge capacity
Tunnel	M$180-200/m per m^3/s of discharge capacity
Pipeline	M$1,090-2,180/m per m^3/s of discharge capacity
Barrage/Weir	M$1,450/m per m^3/s 100-y maximum capacity
Pumping station	M$8,500-15,700 m^3/s of discharge capacity

4. River Facilities

Channel improvement (M$$10^6$/km)		Floodway (M$$10^6$/km)	
200 m^3/s	0.2 - 0.4	200 m^3/s	0.2 - 0.6
500 m^3/s	0.3 - 0.7	500 m^3/s	0.4 - 1.0
1,000 m^3/s	0.4 - 0.9	1,000 m^3/s	0.6 - 1.3
10,000 m^3/s	1.3 - 3.2	2,000 m^3/s	0.8 - 2.0

Polder

Protection bund	M$170-770 x 10^3/km
Drainage system	M$590 x 10^3/km
Drainage pump	M$170-420 x 10^3 per m^3/s

Remarks; Unit construction costs include the engineering and administration cost, but the physical contingency is not included.

Table 35 ASSUMED UNIT CONSTRUCTION COST (2/2)

5. D&I Water Supply System

Pipeline	M$470/m per m^3/s of discharge capacity
Treatment plant	M$780 per m^3/d of capacity
Distribution system	M$1,430 per m^3/d of capacity

6. Sewerage System — M$173 x 10^6 per 100 x 10^3 m^3/d

7. D&I Pre-treatment System

Aerated lagoon	M$42 x 10^6 per 100 x 10^3 m^3/d
Rapid sandfilter bed	M$123 x 10^6 per 100 x 10^3 m^3/d

8. Power Facilities

Generating equipment

Rated head more than 140 m	M$300-480 per kW
Rated head 20 - 80 m	M$600-970 per kW
Rated less than 30 m	M$1,450-1,690 per kW

Transmission line — M$180-210 x 10^3 per km

9. Irrigation Facilities

From rainfed paddy to irrigated paddy	M$11,370 per ha
From new reclaimed land to irrigated paddy	M$12,300 per ha
From irrigated single cropped paddy to double	M$6,150 per ha
Tertiary development and rehabilitation	M$5,470 per ha
From rainfed to control drainage scheme	M$3,000

Remarks; Unit construction costs include the engineering and administration cost, but the physical contingency is not included.

Table 36 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE OF RECOMMENDED PLAN IN SARAWAK

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	2	13	0	0	15
Irrigation	39	280	245	243	807
Inland Fishery	0	0	28	28	56
Public Water Supply	143	365	445	187	1,140
Public Water Supply; Pre-treatment facilities	4	6	6	2	18
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	76	186	224	89	575
Flood Mitigation	3	24	196	349	572
Hydropower	51	459	586	184	1,280
Total	318	1,333	1,730	1,082	4,463

Remarks; (1): At 1980 constant price
(2): The amount shown for 4MP is the additional budget, assuming that the original budget can provide the capacity necessary up to 1985.

Table 37 ESTIMATED ANNUAL RECURRENT EXPENDITURE OF RECOMMENDED PLAN IN SARAWAK

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	0	0	0	0	0
Irrigation	0	3	24	42	69
Inland Fishery	0	0	1	4	5
Public Water Supply	0	27	68	106	201
Public Water Supply; Pre-treatment facilities	0	1	1	2	4
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	0	29	70	108	207
Flood Mitigation	0	1	9	38	48
Hydropower	0	3	13	27	43
Total	0	64	186	327	577

Remarks; (1): At 1980 constant price
(2): Recurrent expenditure on the capacity, which is to be constructed by the original budget for 4MP, is not included.

Table 38 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER DEMAND AND SUPPLY BALANCE IN SARAWAK

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Irrigation	(M10^6)	47
D&I water supply	(M10^6)	62
Fish culture	(M10^6)	2
Reservoir recreation	(M10^6)	1
Total	(M10^6)	112
1.2 Economic Cost		
Irrigation	(M10^6)	29
D&I water supply	(M10^6)	61
Fish culture	(M10^6)	2
Dams, barrages & diversion facilities	(M10^6)	1
Total	(M10^6)	93
1.3 EIRR	(%)	11
2. Environmental Quality		
2.1 Beneficial Effect		
Safe maintenance flow period (2000)		See Table
Surface area of lake created	(km^2)	3
2.2 Adverse Effect		
Possible reduction in kind of fish immediately downstream of dams and barrages	(nos. of site)	1
3. Social Well-being		
3.1 Beneficial Effect		
Number of farm households benefited by proposed irrigation in 2000	(10^3)	60
Number of people served by proposed public water supply in 2000	(10^3)	2,337
Safe supply period (2000)		See Table
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^2)	10

Remarks; All effects by proposed hydropower project are not shown except irrigation, D&I water supply and lake recreation benefit.

Table 39 SAFE SUPPLY PERIOD AND SAFE RIVER MAINTENANCE FLOW PERIOD IN 2000 WITH RECOMMENDED PLAN IMPLEMENTED IN SARAWAK

Unit: days

Basin No.	Basin Name	Safe Supply Period: Plan Implemented	Safe Supply Period: Natural Flow	Safe Maintenance Flow Period: Plan Implemented	Safe Maintenance Flow Period: Natural Flow
231	Miri	365	298	365	278

Remarks; Natural Flow: Natural flow only is depended upon, with neither existing nor proposed facilities.

Table 40 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER POLLUTION ABATEMENT IN SARAWAK

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	($M\$10^6$)	8
Saving in pre-treatment for D&I water supply	($M\$10^6$)	1
Total	($M\$10^6$)	9
1.2 Economic Cost		
Sewerage	($M\$10^6$)	27
Private purification facilities	($M\$10^6$)	0
Pre-treatment for D&I water supply	($M\$10^6$)	1
Total	($M\$10^6$)	28
2. Environmental Quality		
2.1 Beneficial Effects		
Length of river stretch where BOD concentration is not more than 10 mg/lit in 2000 compared with without project condition (Study length = 1,810 km)	(km)	1,810/1,800 /1
Length of river stretch where BOD concentration is not more than 5 mg/lit in 2000 compared with without project condition (Study length = 1,810 km)	(km)	1,810/1,800 /1
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	438
3.2 Adverse Effect		-

Remarks; /1: (Length of river stretch with Project)/ (Length of river stretch without Project)

Table 41 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR FLOOD MITIGATION IN SARAWAK

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Damage reduction	(M$$10^6$)	7.7
1.2 Economic Cost		
Flood mitigation work	(M$$10^6$)	12.0
1.3 EIRR	(%)	5.7
2. Environmental Quality		
2.1 Beneficial Effect		
Length of improved stretch	(km)	198
2.2 Adverse Effect		-
3. Social Well-being		
3.1 Beneficial Effect		
Number of protected people by proposed facilities in 2000	(10^3)	122
Population served by proposed flood warning system in 2000	(10^3)	86
Area relieved from flood hazards	(10^3 ha)	168
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	4

Table 42 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR HYDROPOWER DEVELOPMENT IN SARAWAK

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Power generation	(M$$10^6$)	57
1.2 Economic Cost		
Dam & power facilities	(M$$10^6$)	30
1.3 EIRR	(%)	14
2. Environmental Quality		
2.1 Beneficial Effect		
Surface area of lake created	(km^2)	94
2.2 Adverse Effect		
Possible reduction in kind of fish in immediately downstream of dam	(nos. of site)	3
3. Social Well-being		
3.1 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	3

Remarks; Economic benefit other than power generation benefit is not shown here, but included in the water demand and supply account.

Table 43 SUMMARY OF FUTURE ECONOMIC NET VALUE OF WET PADDY BY TYPE OF SCHEME IN SARAWAK

	Yield (tion/ha)	Unit Price (M$/ton)	Gross Value (M$/ha)	Production Cost (M$/ha)	Net Value (M$/ha)
(1) Major Irrigation Scheme					
- Binatang Barat					
Double cropping	8.0	640	5,120	1,646	3,474
Single cropping	3.6	640	2,304	810	1,494
- Batang Lupor, Sadong Krang and Samarahang					
Double cropping	7.6	640	4,864	1,629	3,235
Single cropping	3.4	640	2,176	801	1,375
- Limbang					
Double cropping	7.2	640	4,608	1,606	3,002
Single cropping	3.2	640	2,048	749	1,299
(2) Minor Irrigation Scheme					
Double cropping	7.1	640	4,544	1,584	2,960
Single cropping	3.2	640	2,048	780	1,268
(3) Control Drainage Scheme					
Single cropping	2.7	640	1,728	712	1,016
(4) Rainfed Scheme					
Single cropping	1.7	640	1,088	515	573

Table 44 ESTIMATED AND PROJECTED SERVICE FACTOR AND PER CAPITA DAILY USE OF DOMESTIC WATER IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

	Service Factor (%)				Per Capita Daily Use (lpcd)			
	Estimated	Projected			Estimated	Projected		
Item	1980	1985	1990	2000	1980	1985	1990	2000
1. Urban Area								
212 Limbang	100	100	100	100	98	142	185	210
214 Miri	68	75	80	95	158	172	185	220
215 Bintulu	59	65	75	90	163	174	185	210
216 Sibu	100	100	100	100	153	174	195	220
217 Sarikei	100	100	100	100	92	139	185	210
218 Serian	83	85	90	95	153	153	160	210
219 Kuching	100	100	100	100	197	197	200	220
223 Marudi	74	80	85	95	121	153	185	210
2. Rural Area								
PWD Area	12	17	18	24	75	95	115	155
MOH Area	32	38	42	56	40	45	55	65
3. Non-pipe-served Area	-	-	-	-	40	40	40	40

Table 45 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: 10^6 m^3/y

Basin No.	City No.	City Name	Estimated 1980 D&I	Projected 1985 D	1985 I	1985 Total	1990 D	1990 I	1990 Total	2000 D	2000 I	2000 Total
227		Rural	0.4	0.5	0.0	0.5	0.6	0.0	0.6	0.6	0.0	0.6
228		Rural	0.3	0.3	0.0	0.3	0.5	0.0	0.5	0.8	0.0	0.8
229	212	Limbang	0.7	1.3	0.0	1.3	1.6	0.0	1.6	2.9	0.0	2.9
		Rural	0.3	0.3	0.0	0.3	0.4	0.0	0.4	0.7	0.1	0.8
	Sub-total		1.0	1.6	0.0	1.6	2.0	0.0	2.0	3.6	0.1	3.7
230	213	Marudi	0.6	0.7	0.6	1.3	0.8	0.6	1.4	1.6	1.2	2.8
		Rural	0.8	1.4	0.0	1.4	1.8	0.0	1.8	3.5	0.0	3.5
	Sub-total		1.4	2.1	0.6	2.7	2.6	0.6	3.2	5.1	1.2	6.3
231	214	Miri	4.4	5.0	5.2	10.2	6.6	5.4	12.0	14.9	10.8	25.7
		Rural	0.3	0.4	0.0	0.4	0.5	0.0	0.5	0.9	0.0	0.9
	Sub-total		4.7	5.4	5.2	10.6	7.1	5.4	12.5	15.8	10.8	26.6
232		Rural	0.3	0.3	0.1	0.4	0.5	0.1	0.6	1.0	0.1	1.1
233		Rural	0.4	0.4	0.2	0.6	0.7	0.2	0.9	1.4	0.2	1.6
234		Rural	0.3	0.5	0.0	0.5	0.7	0.1	0.8	1.6	0.1	1.7
235		Rural	0.1	0.2	0.0	0.2	0.3	0.0	0.3	0.4	0.0	0.4
236	215	Bintulu	1.6	1.6	8.0	9.6	2.4	9.2	11.6	4.0	14.5	18.5
		Rural	0.5	0.6	0.0	0.6	0.7	0.0	0.7	1.2	0.0	1.2
	Sub-total		2.1	2.2	8.0	10.2	3.1	9.2	12.3	5.2	14.5	19.7
237		Rural	0.4	0.5	0.0	0.5	0.6	0.0	0.6	1.0	0.1	1.1
238		Rural	0.4	0.5	0.0	0.5	0.6	0.0	0.6	1.0	0.0	1.0
239		Rural	0.7	1.0	0.1	1.1	1.3	0.1	1.4	2.5	0.2	2.7
240		Rural	0.5	0.6	0.0	0.6	0.8	0.0	0.8	1.3	0.0	1.3
241	216	Sibu	8.0	10.3	1.0	11.3	15.2	1.0	16.2	30.7	2.0	32.7
	217	Sarikei	0.9	1.8	0.4	2.2	2.6	0.4	3.0	5.6	0.8	6.4
		Rural	5.6	7.0	0.1	7.1	8.1	0.1	8.2	11.5	0.3	11.8
	Sub-total		14.5	19.1	1.5	20.6	25.9	1.5	27.4	47.8	3.1	50.9
242		Rural	1.1	1.1	0.1	1.2	1.4	0.1	1.5	2.3	0.1	2.4
243		Rural	1.0	1.1	0.1	1.2	1.3	0.1	1.4	2.1	0.2	2.3
244		Rural	3.4	3.8	0.3	4.1	4.1	0.4	4.5	5.1	0.6	5.7
245	218	Serian	0.4	0.4	0.0	0.4	0.4	0.0	0.4	1.3	0.2	1.5
		Rural	2.3	2.8	0.0	2.8	3.3	0.0	3.3	5.6	0.1	5.7
	Sub-total		2.7	3.2	0.0	3.2	3.7	0.0	3.7	6.9	0.3	7.2
246	219	Kuching	20.5	22.0	2.2	24.2	26.9	2.2	29.1	46.4	4.2	50.6
		Rural	2.5	4.3	0.1	4.4	5.6	0.1	5.7	10.2	0.2	10.4
	Sub-total		23.0	26.3	2.3	28.6	32.5	2.3	34.8	56.6	4.4	61.0
247		Rural	0.8	1.0	0.0	1.0	1.2	0.0	1.2	1.8	0.0	1.8
Total			59.5	71.7	18.5	90.2	91.5	20.1	111.6	163.9	36.0	199.9

Table 46 RECOMMENDED WATER SUPPLY DEVELOPMENT PLAN FOR CITIES/TOWNS IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Code No.	Town	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
229	212	Limbang	3.9	100	16.6	4.8	100	19.8	8.7	100	31.3
230	213	Marudi	3.0	80	6.5	3.3	85	8.8	6.6	95	16.0
231	214	Miri	11.5	75	51.7	17.8	80	71.0	51.5	95	139.7
236	215	Bintulu	25.3	65	16.5	31.6	75	24.4	50.6	90	38.3
241	216	Sibu	32.5	100	123.2	47.3	100	164.0	95.5	100	290.5
241	217	Sarikei	6.0	100	23.4	8.4	100	31.3	18.1	100	56.6
245	218	Serian	1.2	85	4.7	1.2	90	6.8	4.2	95	13.4
246	219	Kuching	69.6	100	233.3	84.4	100	288.3	146.2	100	440.9
Total			153.0	94	475.9	198.8	96	615.0	381.4	99	1026.7

Remarks; TC: Treatment capacity required in the corresponding year in 10^3 m^3/d

SF: Service factor in %

SP: Served population in 10^3

Table 47 RECOMMENDED TREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Name	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
227	Lawas	0.9	55	0.9	1.2	60	1.1	1.5	80	1.7
228	Trusan	0.3	55	2.5	0.6	60	2.9	0.9	80	4.4
229	Limbang	0.3	55	2.1	0.3	60	2.6	0.9	80	4.1
230	Baram	1.2	55	8.8	2.1	60	11.4	4.8	80	20.6
231	Miri	0.6	55	1.7	0.9	60	2.6	1.2	80	5.6
232	Sibuti	0.6	55	1.8	0.9	60	2.7	1.5	80	6.0
233	Niah	0.9	55	2.6	1.2	60	3.9	2.7	80	8.5
234	Suai	0.3	55	2.8	0.9	60	4.2	2.7	80	9.1
235	Similajau	0.3	55	1.0	0.3	60	1.4	0.6	80	2.5
236	Kemena	0.6	55	3.5	0.6	60	4.2	1.5	80	6.8
237	Tatau	0.3	55	3.0	0.6	60	3.6	1.5	80	5.8
238	Balingian	0.3	55	3.0	0.6	60	3.6	1.2	80	5.9
239	Mukah	2.4	55	3.1	3.3	60	3.8	6.9	80	6.2
240	Oya	0.6	55	3.9	0.9	60	4.7	2.1	80	7.6
241	Rajang	7.5	55	30.9	8.4	60	36.8	14.8	80	55.7
242	Kerian	2.4	55	12.0	3.0	60	14.1	5.7	80	21.4
243	Saribas	1.2	55	6.8	1.5	60	8.1	3.3	80	12.3
244	Lupar	8.4	55	28.3	9.9	60	33.2	13.0	80	48.8
245	Sadong	2.7	55	16.9	3.6	60	20.4	8.4	80	32.8
246	Sarawak	4.2	55	26.8	6.3	60	34.0	15.1	80	59.7
247	Kayang	2.4	55	9.2	2.7	60	11.0	4.5	80	18.8
Total		38.4	55	171.6	49.8	60	210.3	94.8	80	344.3

Remarks; TC: Treatment capacity in the corresponding year in $10^3\ m^3/d$
SF: Service factor in %
SP: Served population in 10^3

Table 48 RECOMMENDED UNTREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Name	1985 SD	1985 SF	1985 SP	1990 SD	1990 SF	1990 SP	2000 SD	2000 SF	2000 SP
227	Lawas	0.1	55	2.6	0.1	60	3.1	0.1	80	4.5
228	Trusan	0.1	55	6.6	0.2	60	7.9	0.4	80	11.8
229	Limbang	0.1	55	5.6	0.2	60	7.0	0.3	80	11.1
230	Baram	0.4	55	23.8	0.7	60	30.8	1.7	80	55.6
231	Miri	0.1	55	4.0	0.2	60	5.9	0.4	80	13.0
232	Sibuti	0.1	55	5.0	0.2	60	7.4	0.4	80	16.2
233	Niah	0.2	55	7.0	0.3	60	10.5	0.7	80	23.0
234	Suai	0.2	55	7.6	0.3	60	11.3	0.7	80	24.7
235	Similajau	0.2	55	2.8	0.1	60	3.7	0.2	80	6.8
236	Kemena	0.1	55	9.4	0.3	60	11.4	0.6	80	18.3
237	Tatau	0.2	55	8.1	0.2	60	9.8	0.4	80	15.7
238	Balingian	0.2	55	8.1	0.2	60	9.9	0.4	80	16.0
239	Mukah	0.2	55	8.4	0.2	60	10.3	0.4	80	16.7
240	Oya	0.2	55	10.4	0.3	60	12.7	0.6	80	20.4
241	Rajang	2.3	55	114.3	3.1	60	136.0	5.8	80	205.9
242	Kerian	0.3	55	10.0	0.4	60	11.7	0.9	80	17.8
243	Saribas	0.4	55	18.5	0.4	60	21.9	1.0	80	33.3
244	Lupar	0.8	55	21.8	1.0	60	25.6	1.9	80	37.6
245	Sadong	1.0	55	45.7	1.3	60	55.3	2.7	80	88.6
246	Sarawak	1.5	55	72.3	2.2	60	91.9	4.9	80	161.3
247	Kayang	0.2	55	5.3	0.3	60	6.4	0.7	80	10.8
Total		8.9	55	397.3	12.2	60	490.5	25.2	80	809.1

Remarks; SD: Source demand (piped) in the corresponding year in 10^6 m^3/y.

SF: Service factor in %.

SP: Served population in 10^3.

Table 49 RECOMMENDED SOURCE DEVELOPMENT PLAN IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

River system	Miri
Name of facilities	Liku dam
Catchment area	33 km^2
Active storage capacity	1.2×10^6 m^3
Net supply capacity	7.6×10^6 m^3/y
Purpose	Water supply to Miri
Investment	M$10.0 x 10^6
Construction period	1985 - 1989

Table 50 RECOMMENDED PLAN FOR IMPROVEMENT OF PURIFICATION SYSTEM IN PALM OIL MILLS AND RUBBER FACTORIES IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: m^3/d

Basin		1981 - 1990			1991 - 2000		
No.	Name	Palm Oil	Rubber	Total	Palm Oil	Rubber	Total
234	Suai	440	0	440	40	0	40
Total		440	0	440	40	0	40

Table 51 ASSUMED PUBLIC SEWERAGE DEVELOPMENT NOT AFFECTING RIVER WATER QUALITY IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin	City/Town		1990			2000		
No.	No.	Name	Treatment Capacity ($10^3m^3/d$)	Service Factor (%)	Served Population (10^3)	Treatment Capacity ($10^3m^3/d$)	Service Factor (%)	Served Population (10^3)
236	C215	Bintulu	85	75	25	238	75	32
246	C219	Kuching	26	40	106	75	65	268
Total			111	-	131	313	-	300

Table 52 RECOMMENDED FLOOD MITIGATION PROGRAM IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Basin	R.I. (km)	F.W. (km)	Dam (nos)	Polder (nos)	P.P. (10^3)	F.A. (km^2)	C.C. ($M\$10^6$)
By 1990								
229	Limbang	–	–	1	–	5	262	–
231	Miri	–	5	–	–	37	542	11
Total		–	5	1	–	42	804	11
By 2000								
229	Limbang	–	–	1	–	5	262	–
231	Miri	–	5	–	–	37	542	11
233	Niah	–	–	–	1	1	1	1
236	Kemena	30	–	–	–	15	178	156
241	Rajang	21	–	–	–	17	266	23
246	Sarawak	142	–	1	–	76	425	328
Total		193	5	2	1	151	1,674	519

Remarks; R.I.: River improvement
F.W.: Floodway
Pold.: Polder
P.P.: Population protected (the year 2000)
F.A.: Flood area relieved
C.C.: Cosntruction cost

Cost of Limbang project be borne by irrigation sector.

Table 53 RECOMMENDED HYDROPOWER DEVELOPMENT PLAN IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item	Unit	Description
Number of Basin		244
Name of the Project		Batang Sekrang
Catchment Area	(km^2)	440
Active Storage Capacity	(10^6 m^3)	420
Surface Area	(km^2)	15
Installed Capacity	(MW)	46
Annual Energy Output	(GWh)	210
Purpose		Hydropower
Construction Cost	(M$$10^6$) /1	310
Date of Commission		1996

Remarks; /1: Financial cost at 1980 constant price

Table 54 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE OF RECOMMENDED PLAN IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	1	9	0	0	10
Irrigation	39	280	245	243	807
Inland Fishery	0	0	28	28	56
Public Water Supply	102	259	321	137	819
Public Water Supply; Pre-treatment facilities	4	4	4	2	14
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	51	84	83	33	251
Flood Mitigation	3	24	196	349	572
Hydropower	0	186	124	0	310
Total	200	846	1,001	792	2,839

Remarks; (1): At 1980 constant price
(2): The amount shown for 4MP is the additional budget, assuming that the original budget can provide the capacity necessary up to 1985.

Table 55 ESTIMATED ANNUAL RECURRENT EXPENDITURE OF RECOMMENDED PLAN IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	0	0	0	0	0
Irrigation	0	3	24	42	69
Inland Fishery	0	0	1	4	5
Public Water Supply	0	20	49	76	145
Public Water Supply; Pre-treatment facilities	0	1	1	1	3
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	0	17	34	47	98
Flood Mitigation	0	1	9	38	48
Hydropower	0	0	5	8	13
Total	0	42	123	216	381

Remarks; (1): At 1980 constant price
(2): Recurrent expenditure on the capacity, which is to be constructed by the original budget for 4MP, is not included.

Table 56 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER DEMAND AND SUPPLY BALANCE IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Irrigation	(M$$10^6$)	47
D&I water supply	(M$$10^6$)	39
Fish culture	(M$$10^6$)	2
Reservoir recreation	(M$$10^6$)	1
Total	(M$$10^6$)	92
1.2 Economic Cost		
Irrigation	(M$$10^6$)	29
D&I water supply	(M$$10^6$)	39
Fish culture	(M$$10^6$)	2
Dams, barrages & diversion facilities	(M$$10^6$)	1
Total	(M$$10^6$)	71
1.3 EIRR	(%)	12
2. Environmental Quality		
2.1 Beneficial Effect		
Safe maintenance flow period (2000)		See Table
Surface area of lake created	(km^2)	2
2.2 Adverse Effect		
Possible reduction in kind of fish immediately downstream of dams and barrages	(nos. of site)	1
3. Social Well-being		
3.1 Beneficial Effect		
Number of farm households benefited by proposed irrigation in 2000	(10^3)	60
Number of people served by proposed public water supply in 2000	(10^3)	2,180
Safe supply period (2000)		See Table
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^2)	10

Remarks; All effects by proposed hydropower project are not shown except irrigation, D&I water supply and lake recreation benefit.

Table 57 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER POLLUTION ABATEMENT IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	($M\$10^6$)	4
Saving in pre-treatment for D&I water supply	($M\$10^6$)	1
Total	($M\$10^6$)	5
1.2 Economic Cost		
Sewerage	($M\$10^6$)	13
Private purification facilities	($M\$10^6$)	0
Pre-treatment for D&I water supply	($M\$10^6$)	1
Total	($M\$10^6$)	14
2. Environmental Quality		
2.1 Beneficial Effects		
Length of river stretch where BOD concentration is not more than 10 mg/lit in 2000 compared with without project condition (Study length = 1,810 km)	(km)	1,810/1,800 /1
Length of river stretch where BOD concentration is not more than 5 mg/lit in 2000 compared with without project condition (Study length = 1,810 km)	(km)	1,810/1,800 /1
2.2 Adverse Effect		
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	300
3.2 Adverse Effect		-

Remarks; /1: (Length of river stretch with Project)/ (Length of river stretch without Project)

Table 58 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR FLOOD MITIGATION IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item			Amount
1.	National Economic Development		
1.1	Economic Benefit		
	Damage reduction	($M\$10^6$)	5.9
1.2	Economic Cost		
	Flood mitigation work	($M\$10^6$)	12.0
1.3	EIRR	(%)	3.6
2.	Environmental Quality		
2.1	Beneficial Effect		
	Length of improved stretch	(km)	198
2.2	Adverse Effect		-
3.	Social Well-Being		
3.1	Beneficial Effect		
	Number of protected people by proposed facilities in 2000	(10^3)	151
	Population served by proposed flood warning system in 2000	(10^3)	94
	Area relieved from flood hazards	(km^2)	1,676
3.2	Adverse Effect		
	Number of people to be removed for construction of facilities	(10^3)	5

Table 59 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR HYDROPOWER DEVELOPMENT IN SARAWAK UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Power generation	(M$\$10^6$)	10
1.2 Economic Cost		
Dam & power facilities	(M$\$10^6$)	6
1.3 EIRR	(%)	12
2. Environmental Quality		
2.1 Beneficial Effect		
Surface area of lake created	(km^2)	15
2.2 Adverse Effect		
Possible reduction in kind of fish in immediately downstream of dam	(nos. of site)	1
3. Social Well-being		
3.1 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	0.1

Remarks; Economic benefit other than power generation benefit is not shown here, but included in the water demand and supply account.