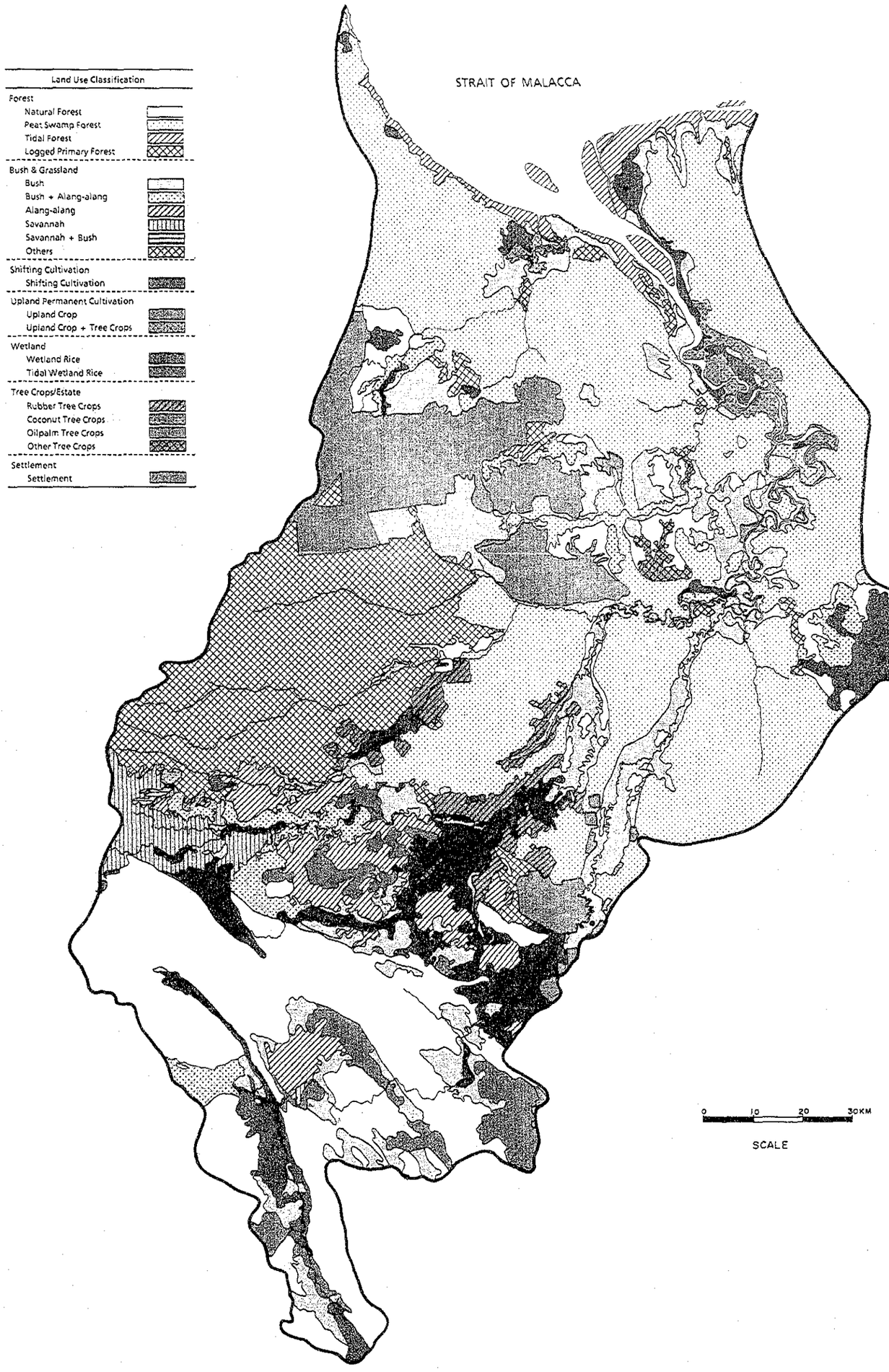


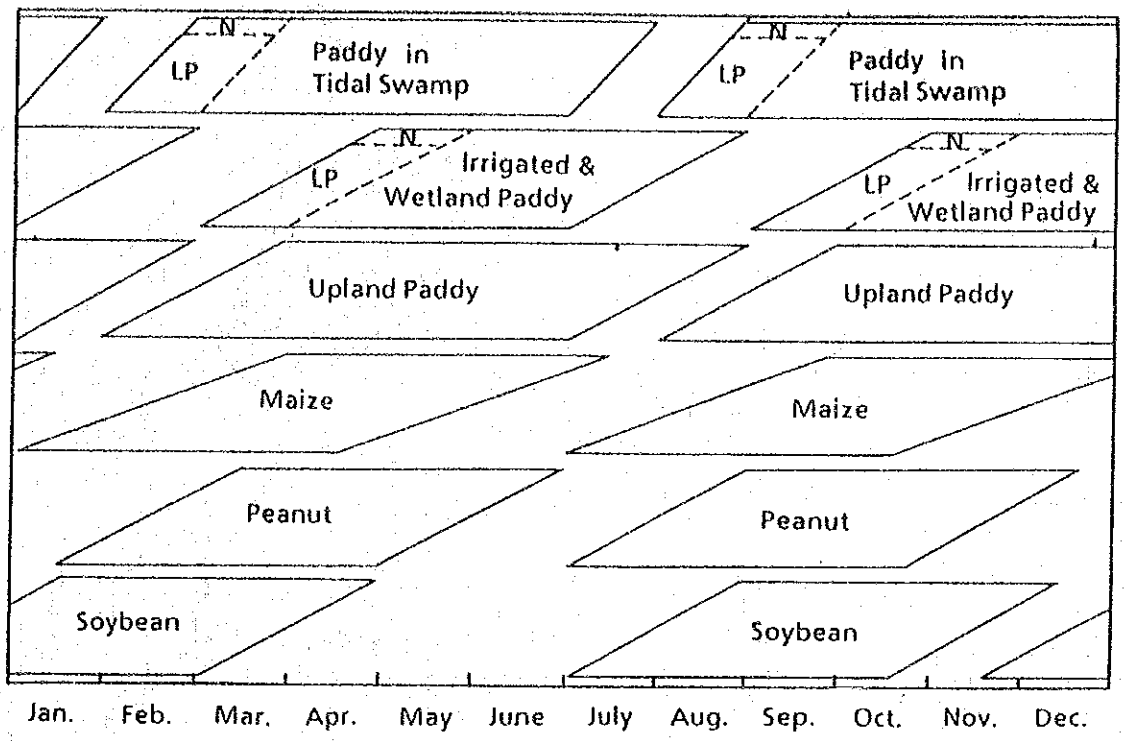
Fig. 3.3.1 Present Land Use Map

REPUBLIC OF INDONESIA MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON LOWER ROKAN KIRI IRRIGATION PROJECT

PRESENT LAND USE MAP
(OBJECTIVE AREA)

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO (JICA)

DWG NO 5



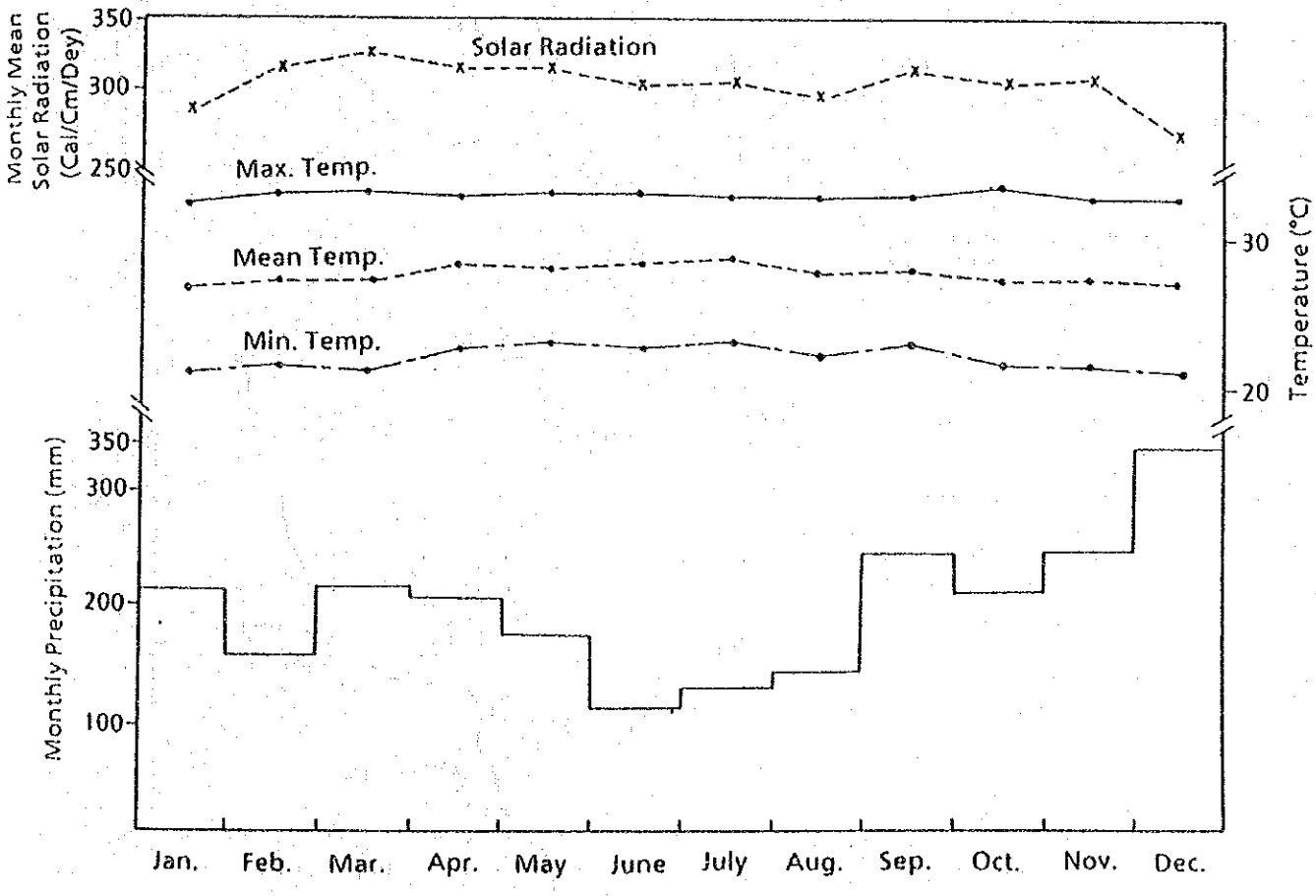


Fig. 3.3.2 Present Cropping Pattern

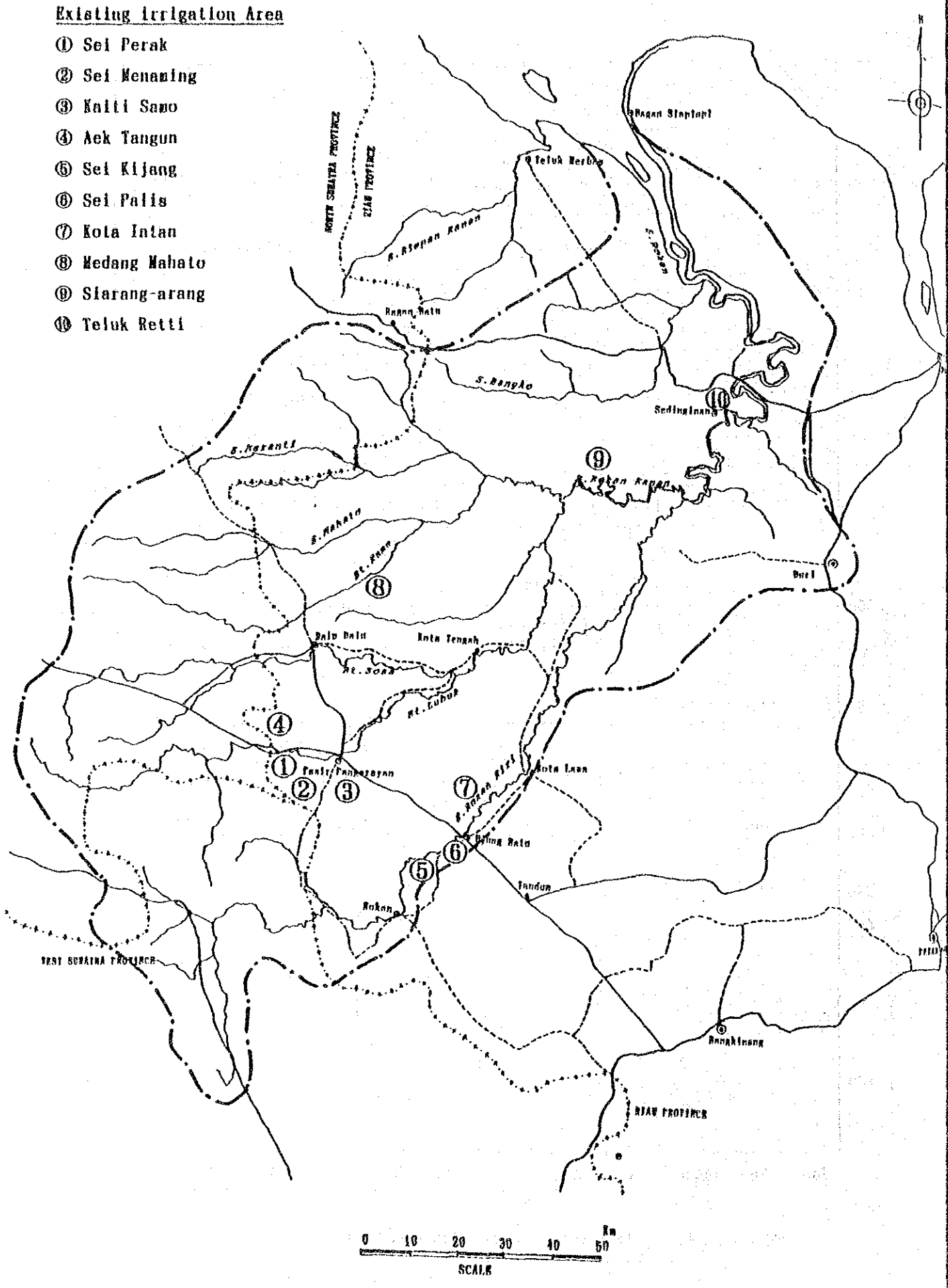
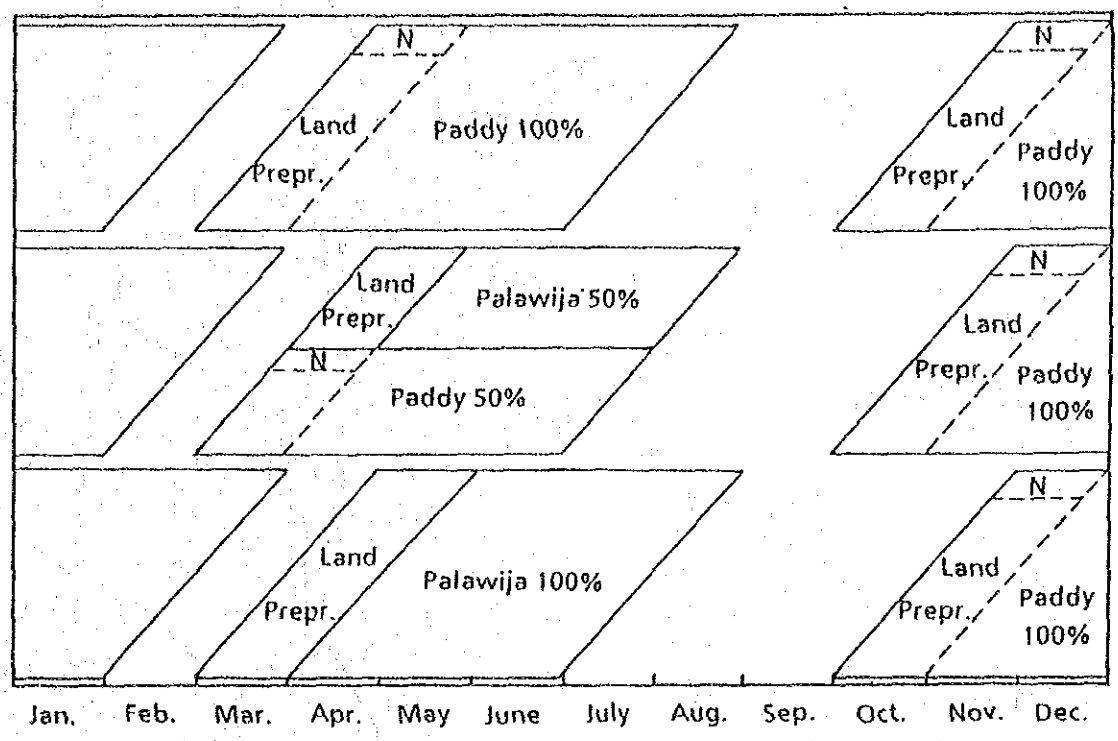


Fig. 3.3.3 Location of Existing Irrigation Schemes



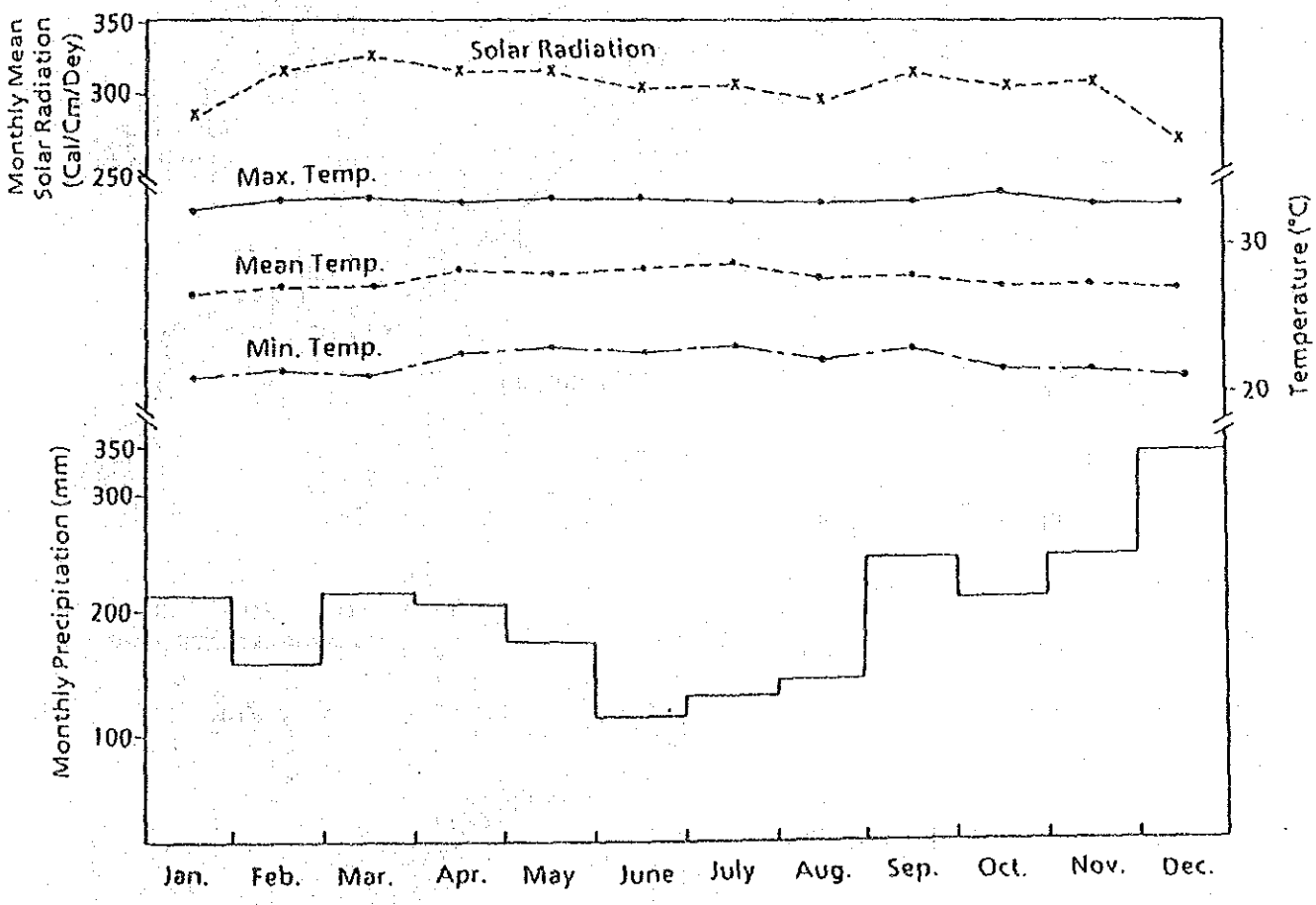


Fig. 4.1.1 Planning Cropping Pattern

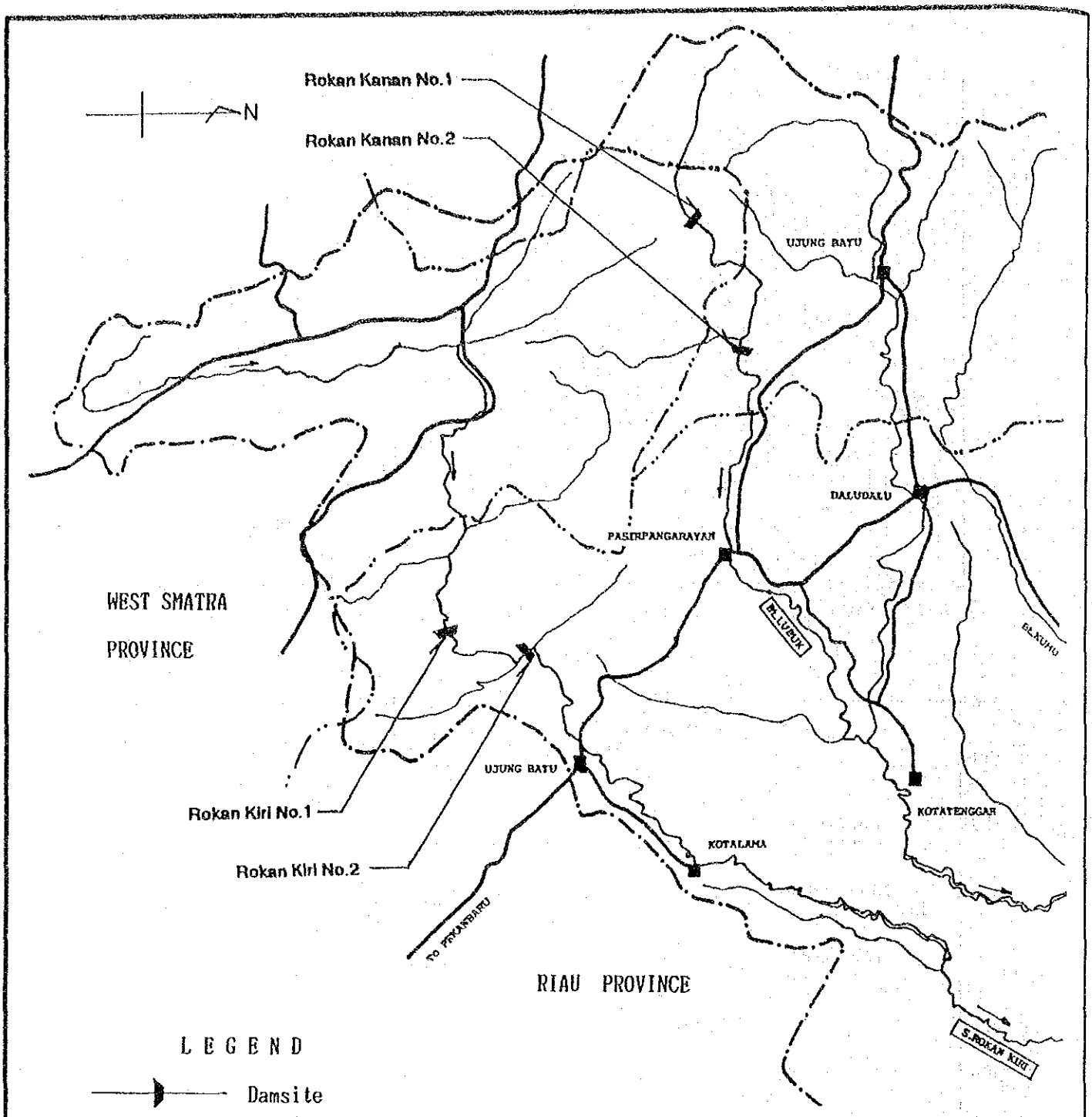


Fig. 4.4.1(1) Location of Planned Hydrological Generation Plants

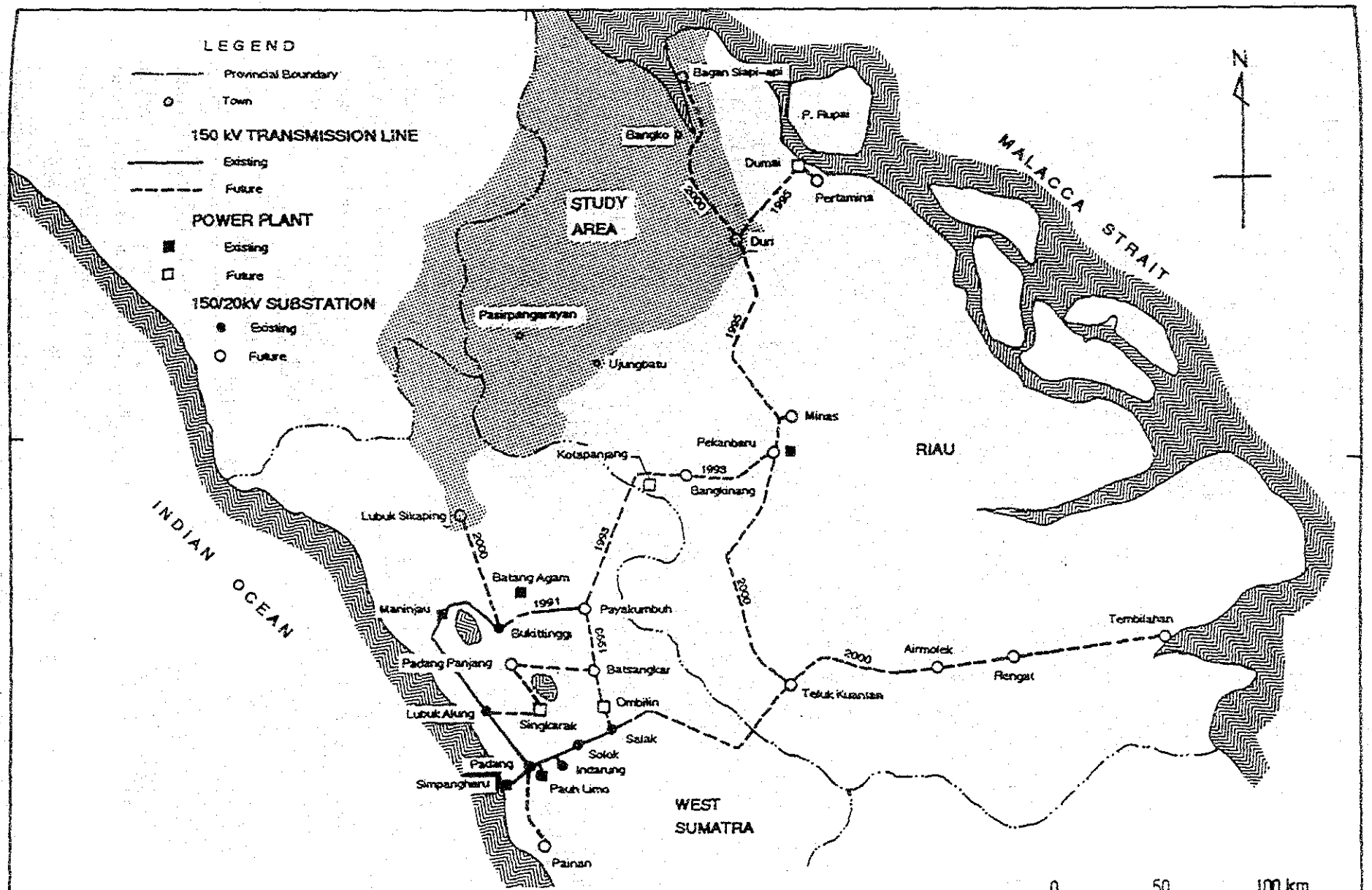
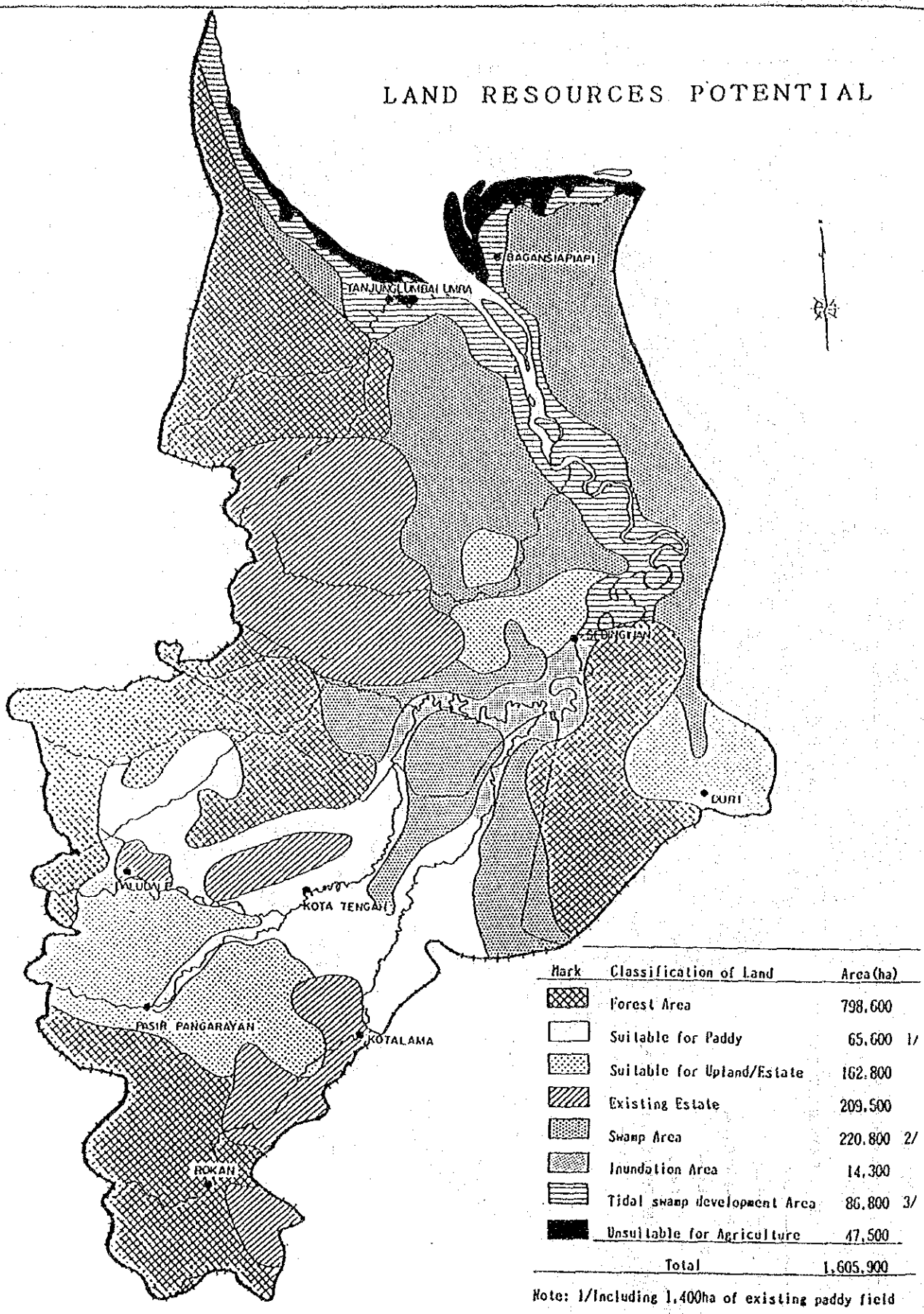


Fig. 4.4.1(2) Plan of Transmission Line Proposed by PLN in Riau and West Sumatra Provinces



Mark	Classification of Land	Area (ha)	
	Forest Area	798,600	
	Suitable for Paddy	65,600	1/
	Suitable for Upland/Estate	162,800	
	Existing Estate	209,500	
	Swamp Area	220,800	2/
	Inundation Area	14,300	
	Tidal swamp development Area	86,800	3/
	Unsuitable for Agriculture	47,500	
	Total	1,605,900	

Note: 1/Including 1,400ha of existing paddy field
2/Including 39,900ha of land with potential for Agricultural development
3/Including existing Tidal swamp development area of 39,800ha

Fig. 5.3.1 Development Potential Map

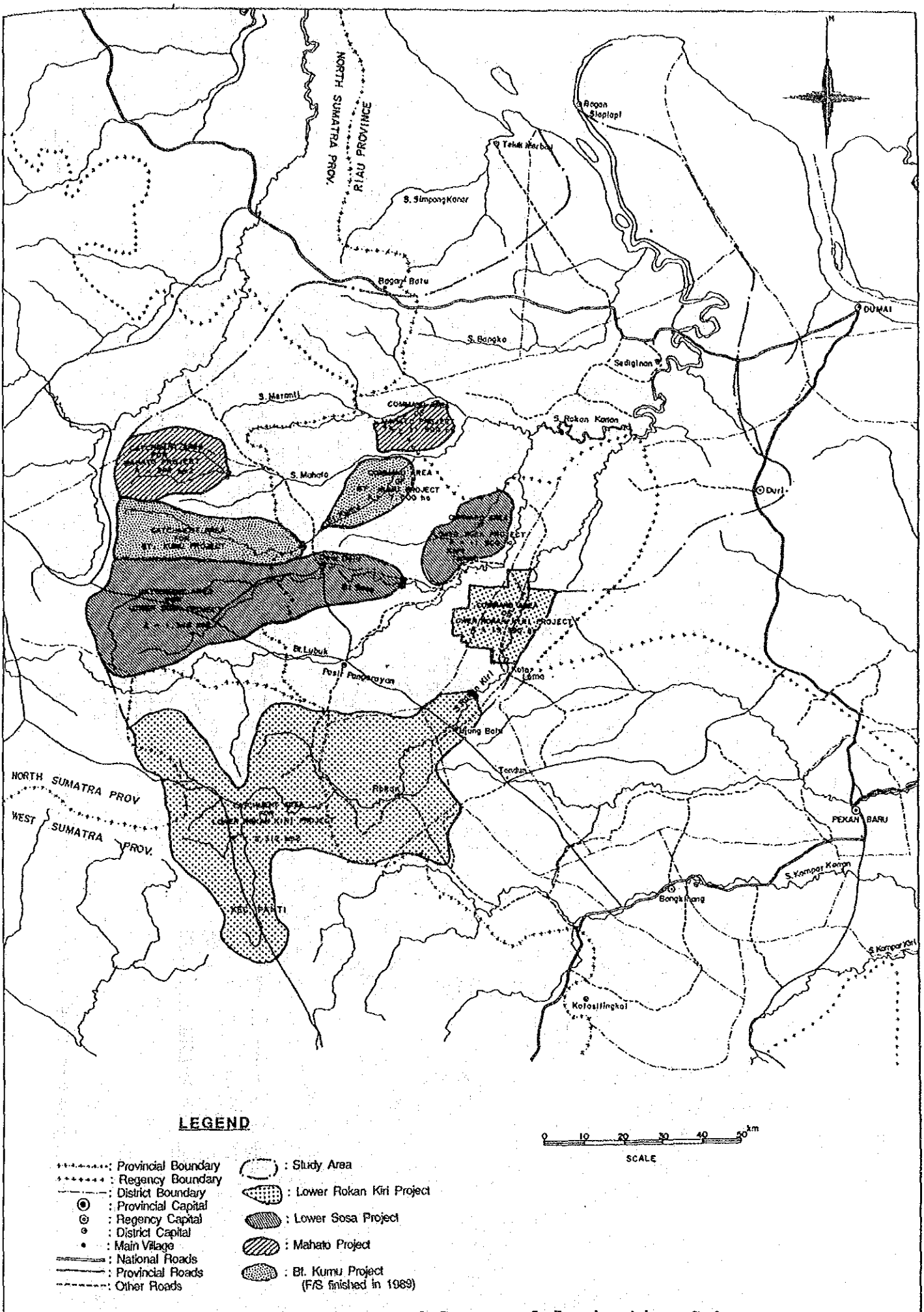
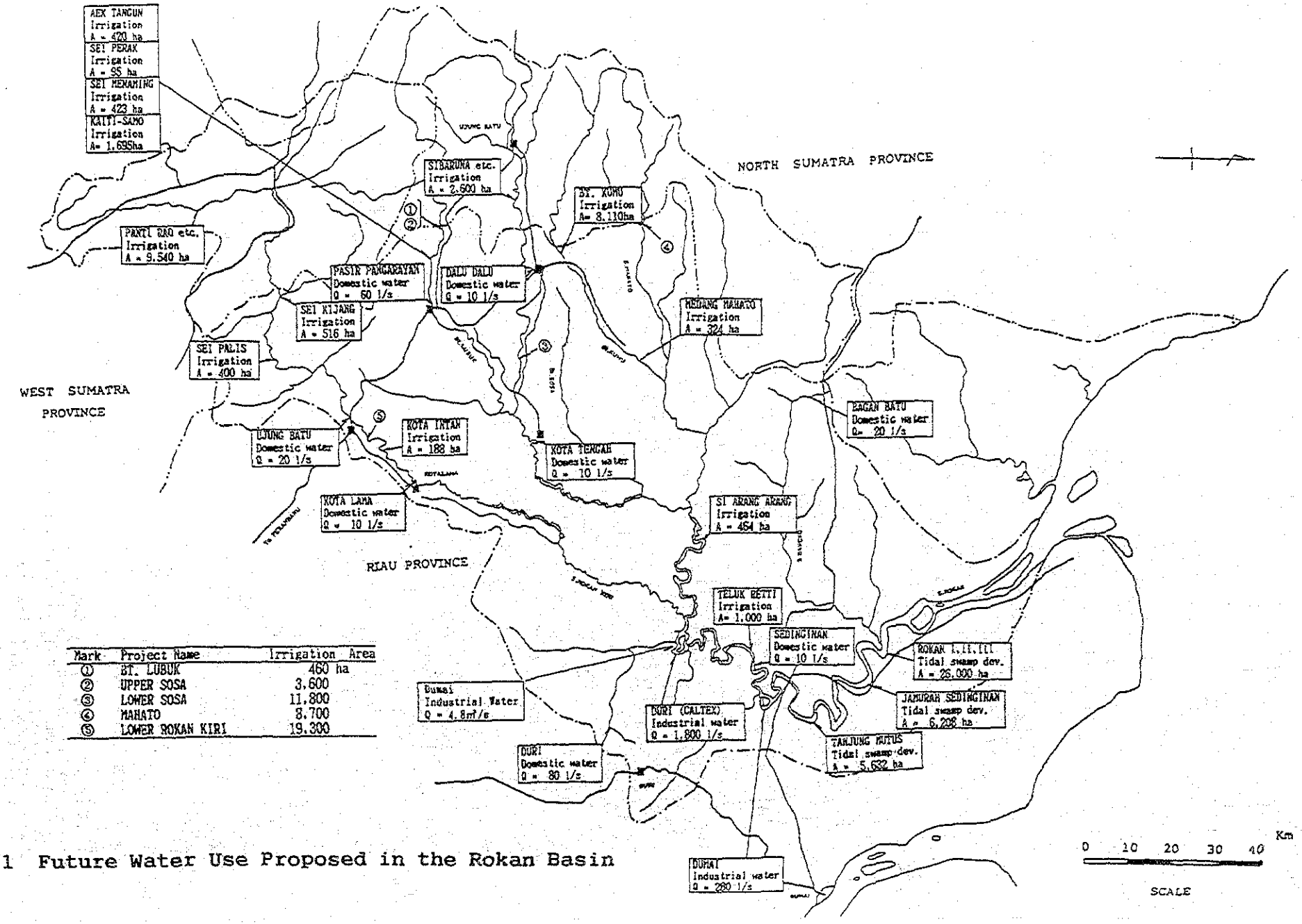


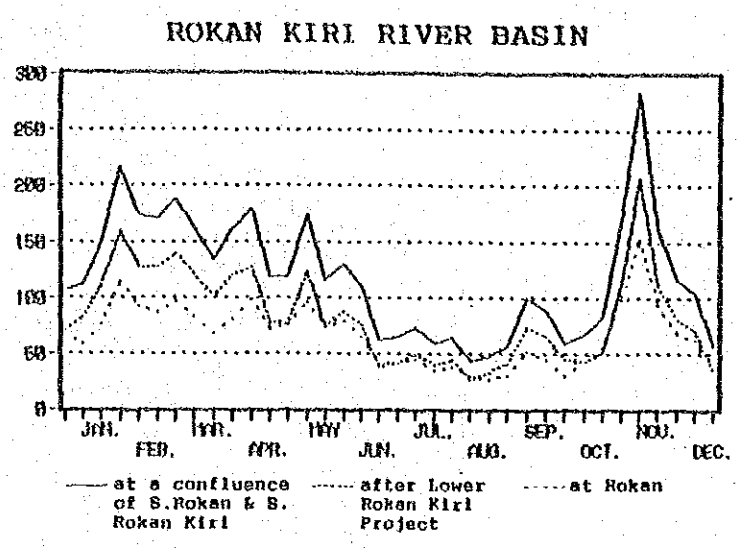
Fig. 6.1.1 Location of Proposed Irrigation Schemes

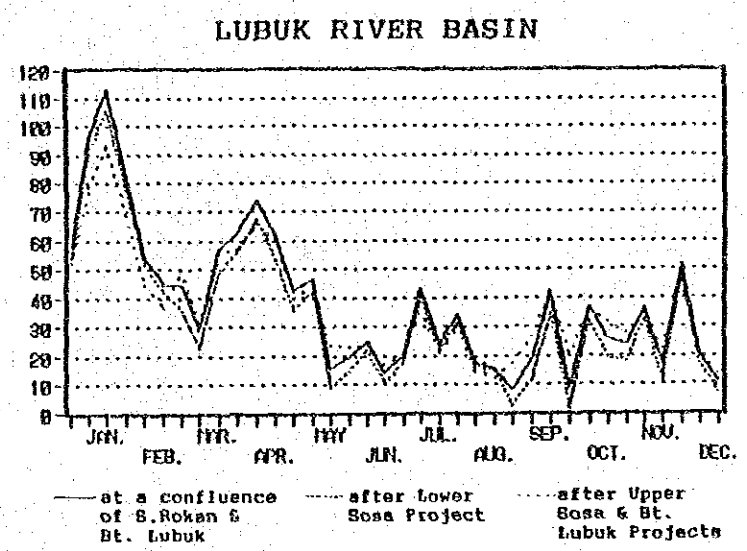


Mark	Project Name	Irrigation Area
①	ST. LUBUK	460 ha
②	UPPER SOSA	3,600
③	LOWER SOSA	11,800
④	MAHATO	8,700
⑤	LOWER ROKAN KIRI	19,300

Fig. 6.2.1 Future Water Use Proposed in the Rokan Basin

RIVER DISCHARGE IN WATER BALANCE CALCULATION
(BASE YEAR 1984, Unit in m3/s)





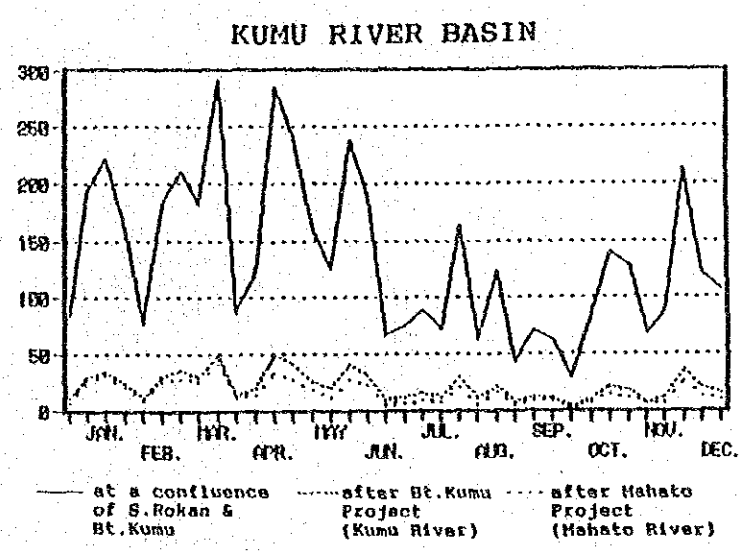


Fig. 6.2.2 River Discharge in Water Balance Calculation (Base Year 1984)

Photo. 1 Color Composite Image by Remote Sensing (1989/90)

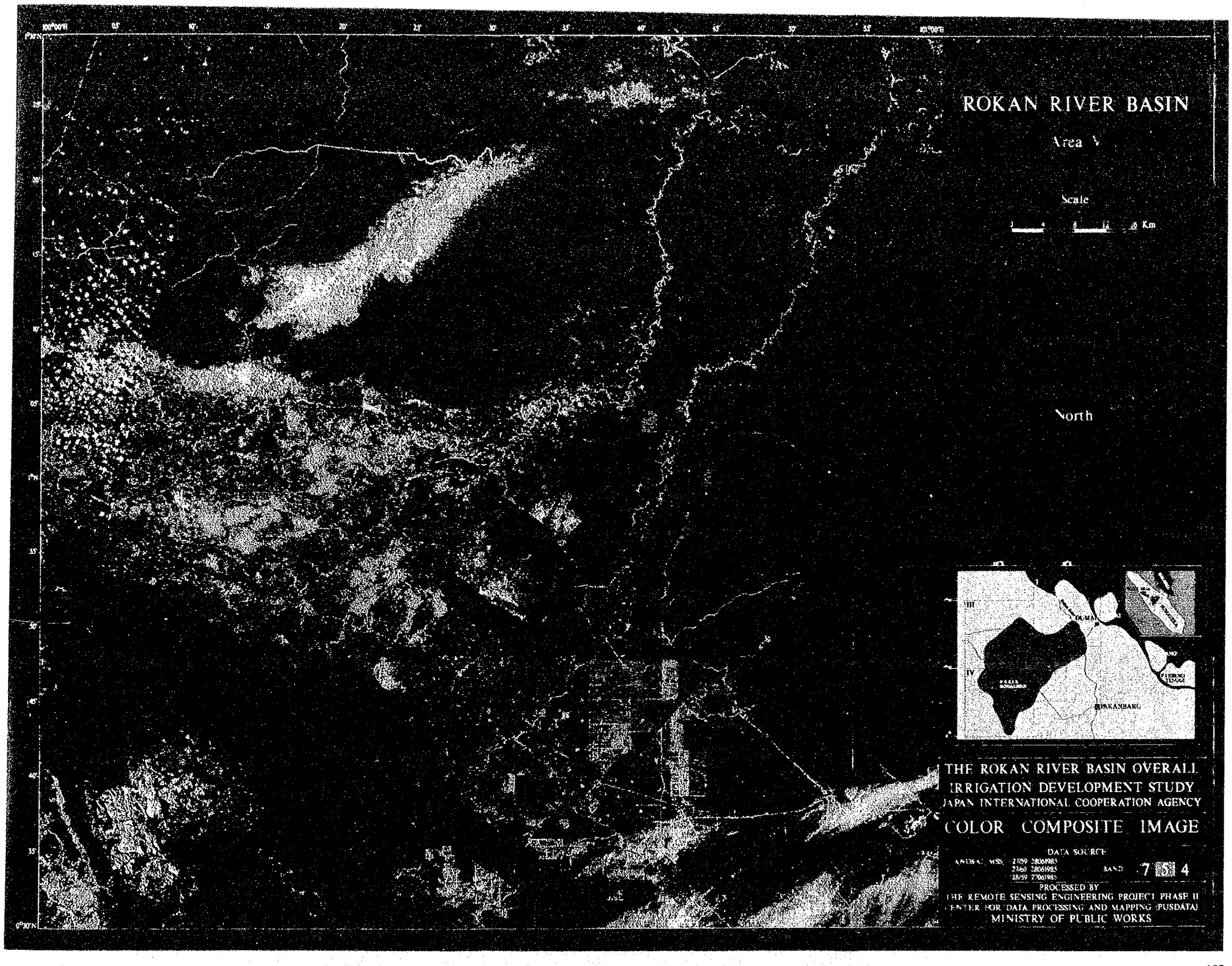


Photo. 2 Color Composite Image by Remote Sensing (1985)

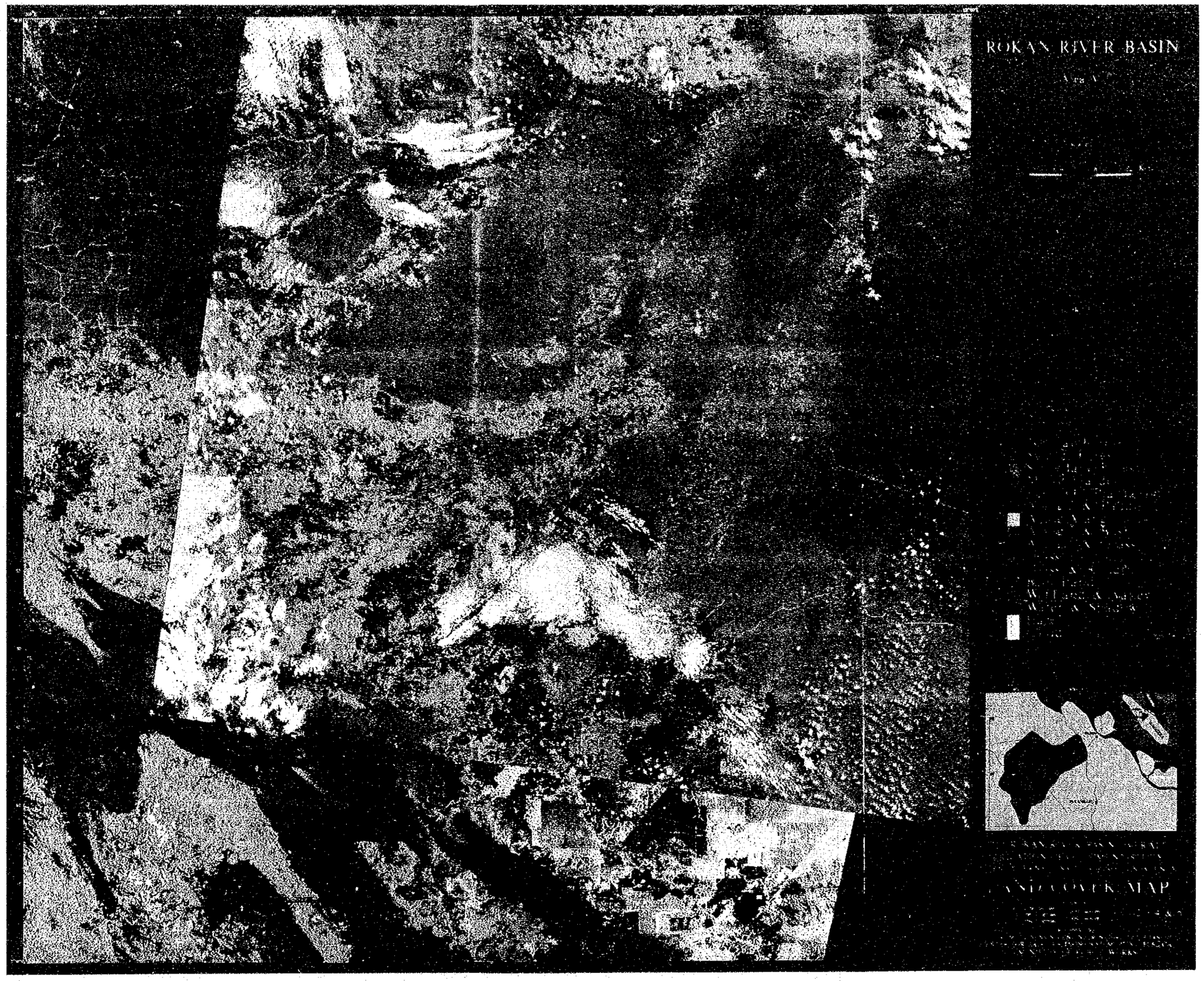


Photo. 3 Land Cover Map by Remote Sensing(1989/90)

ANNEXES

ANNEX A

SOCIOECONOMY

ANNEX A SOCIOECONOMY

TABLE OF CONTENTS

LIST OF TABLES

ANNEX A SOCIOECONOMY

1. NATIONAL ECONOMIC BACKGROUND

1.1 Land and Population

Indonesia is an archipelago consisting of about 13,700 islands of varied size and character. It has a land of about 1.9 million sq km and a population of 179.2 million in 1990. The population is unevenly distributed among five major islands (Java, Sumatra, Sulawesi, Kalimantan and Irian Jaya) and some 900 minor ones. Java, covering 6.7 per cent of the total land area, is the most populated island. Almost 60 per cent of the total population lives in Java, whereas only 1.9 per cent of Indonesians live in Irian Jaya and Maluku. Land area and population distribution in Indonesia is presented in Table 1.1.

1.2 Administrative Divisions

Indonesia is administratively divided into 27 Provinces, including the special territories of Jakarta, Yogyakarta and Aceh. The Provinces are subdivided into 55 municipalities (Kotamadyas) and 241 districts (Kabupatens). The Provinces as well as Kotamadyas and Kabupatens are autonomous. They have an elected assembly with power to make local laws, have their own budget, levy local taxes and charges, and have their own Planning Boards; the Provincial Planning Board (BAPPEDA I), and the Kotamadya/Kabuapaten Planning Board (BAPPEDA II), respectively. Kabupatens are further subdivided into approximately 3,600 subdistricts (Kecamatans) and about 67,000 villages (Kelurahan/Desa).

1.3 Population and Employment

Indonesia is the fifth most populous nation in the world with a population of 179.2 million in 1990 and an annual growth rate of approximately 2.0 per cent between 1980 and 1990. Population of Indonesia by province during 1980-1990 is presented in Table 1.2. The population is unevenly distributed among the five major islands and some 900 minor ones. The average density for the country is 92 persons per sq km. A successfully implemented family planning program has gradually diminished the rate of growth of Indonesia's population, particularly on the densely populated islands.

Indonesia is facing substantial increases in labor supply. Thus, in the period 1980 - 1985 labor force grew at an annual rate of about 4 per cent compared with 3 per cent during the period 1971-1980.

Recent growth rate of labor force, however, has tapered off reflecting fewer births and children per mother plus improved educational levels attained in 1960s and 1970s. Thus, during the Repelita V (1989/90-1993/94) period, the labor force is projected to grow at an annual average rate of 2.9 per cent, with an estimated increase of 11.9 million persons in the labor force. Indonesia will still have to tackle the problem of absorbing additional entrants amounting to 2.4 million annually to the labor force. Projected growth in the labor force by province is shown in Table 1.3.

1.4 National Economy

The Indonesian economy is exhibiting accelerating growth with continued financial stability. The resource constraints are gradually being eased through the growth of non-oil/gas exports, the improved resource mobilization through the budget, and the higher than expected oil prices.

Real GDP during 1983 and 1988, which corresponds roughly to the period of PELITA IV, grew at an annual average of 5.1% over this period as presented in Table 1.4. The rate is slightly higher than the rate of 5.0% per annum which was set out as the target in PELITA IV. The agriculture sector's share in GDP declined gradually during that period with an overall growth rate of 3.5%. Nevertheless, agriculture is far from stagnant. It is simply overshadowed by industries which are growing very fast. Food crop production exceeded population growth by about one percentage point annually, and estate crops grew at a more respectable 8.9%. Small holders estate crops production grew at an average growth rate of 4.3% per annum.

Th mining and quarrying sector declined both relatively and absolutely, owing to a fall in the real value of oil and gas output. Other sectors showing below-average growth performance included construction and services. Among sectors registering above-average growth, manufacturing outperformed others. Non-oil/gas manufacturing registered an annual average of 12.4% which was outperformed by the higher growth rates of petroleum refining (22.4%) and liquid natural gas (14%). Growth in the very small utilities sector (electricity, gas and water) is put at almost 12% annually in real terms, while banking and financial institutions recorded almost 9% growth.

The overall growth rate in 1989, the commencing year of PELITA V, is estimated to be 7.4% which is higher than anticipated. Higher estimated GDP growth in 1989 is supported by increased exports of non-oil/gas, increased prices of oil, and increase in government revenue.

1.5 Economic Development Plans

Economic development in Indonesia is being pursued in the context of successive five-year development plans. The focus of the current development plan, Repelita V (1989/90-1993/94), is to create a financially sound and consolidated economy,that is, an economy where fluctuations of world oil prices could be cushioned through strengthening of non-oil/gas industries and the external debt problem could be brought into manageable proportions and where, within a conservative financial policy framework, a dynamic industrial sector is supported by a strong agriculture sector.

Repelita V envisages an overall growth target of 5 per cent per annum. While mining sector is projected to grow at a lower rate of 0.4%, agriculture sector is expected to grow at a slightly higher raste (3.6%) than in the 1980s. Althou the highest growth rate is expected for the industry sector, the projected rate is somewhat lower than REPELITA IV. The rapid growth in this sector is unlikely to be repeated in early 1990s. Higher growth rates are expected in construction, trade and trasnport sectors. The projected growth rates of GDP for PELITA IV and V are presented in Table 1.5.

2. REGIONAL ECONOMIC BACKGROUND

2.1 Location and Population

Riau province is located in the eastern part of central Sumatra island, consisting of about 3,200 small and large islands. It has a land area of 94,561 sq km or 2.7% of the total Indonesia, with a total population of 3.28 million in 1990. Population density in 1990 was 35 persons per sq km. The population of Riau province increased from 2.16 million in 1980 to 3.28 million in 1990 at an anuual average of 4.25%, which was more than twice the national population growth, as presented in Table 2.1. This high growth rate is mainly due to rapid migration flow to the province icluding general as well as spontaneous transmigrants. Although definite data are not available, the number of spontaneous transmigrants is estimated to amount to more than 300,000 which is equivalent to the total number of general transmigrants settled in the Riau province during 1980 and 1990.

The province has five districts (Kabupaten; Indragiri Hulu, Indragiri Hilir, Kepulauan Riau, Bengkalis and Kampar) and two municipalities (Kotamadya; Pekanbaru and Batam). Pekanbaru is the capital of the province. Bengkalis occupies the largest part of the province (32.4%), followed by Kampar (29.5%).
In terms of population density, Pekanbaru, the capital of the province, is the most densely populated (892 persons per sq km), followed by Batam (175 persons per sq km) and Kepulauan Riau (61 persons per sq km). Bangkalis and Kampar are not so densely populated due to larger land areas.

2.2 Economic Base

As indicated in Table 2.2, mining sector, especially oil and gas, is playing a dominant role in Riau province, accounting for more than 70% of the total Gross Regional Domestic Product (GRDP) in 1988. Trade and commerce sector accounted for 7.5%, followed by manufacturing (6.7%) and agriculture (5.5%). In terms of GRDP excluding petroleum, the agriculture sector had the largest share at 26.2% in 1988.

GRDP of the Riau province at current prices in 1988 amounted to Rp 9,225.4 billion including petroleum which corresponded to 6.6% of the GDP in Indonesia. In 1988, per capita GRDP in Riau amounted to Rp 620,382 or US$359 including petroleum. Per capita GRDP is reduced to Rp 427,610 or US$247 excluding petroleum.

GRDP including petroleum at 1983 constant price increased at an annual average of 9.6% during 1985 and 1988, while GRDP excluding petrolum grew at 7.2% during the same period.

Agriculture sector plays a leading role in Riau in terms of working population. Results of 1985 Intercensal Population Survey indicated that 497,465 persons or 59.7% of the total labor force

in Riau were engaged in the agriculture sector, as presented in Table 2.3. Services sector ranked the second, accounting for 15.5%, followed by trade and commerce (11.1%) and manufacturing (4.3%). The mining sector employed only 1.6% of the total labor force in 1988.

2.3 Transmigration Program

Indonesia has a long history in conducting its transmigration program. Throughout the 20th century, transmigration has been regarded as a means of reducing overcrowding in Java and providing land and employment to the poor. More recently, in 1980s, transmigration has also been seen as a means of increasing national food production and reducing Indonesia's dependence on imports, stimulating development in remote and under populated provinces and exploiting underutilized natural resources.

Transmigration conducted under government support is called general transmigration (transmigrasi umum). Other form of transmigration is called spontaneous transmigration (trasmigrasi swakarsa), conducted at the expenses of transmigrants themselves. The extent of spontaneous movement is not known, but according to the 1971 census, of the one million Java-born residents in Lampung province, only 250,000 were moved with government support. According to the report issued by the World Bank, i.e. "Transmigration Program in Perspective, 1988", the Indonesian transmigration program sponsored the movement of over two million people from densely populated areas to the less populated islands between 1980 and 1986, and a further two million people are believed to have moved spontaneously.

Transmigration program in Riau has also been conducted in accordance with the basic policy of the national development plans, as a means of manpower development and balanced distribution of the population, aiming at promoting regional development. Transmigrants in Riau during 1961-1988 totaled to approximately 65,000 families (280,000 persons) as presented in Table 2.4. The curent PELITA V in Riau has the target of receiving 53,953 families in total or 10,791 families p.a.

3. SOCIOECONOMIC SITUATIONS IN THE STUDY AREA

3.1 Administrative Divisions

The Riau province administratively consists of five districts (Kabupaten) and two municipalities (Kotamadya). Among these, the Study Area in Riau (hereinafter referred to as the "Objective Area") is included within the boundaries of the districts (Kabupaten) of Kampar and Bengkalis. The Kabupaten is administratively divided into Kecamatan, and Kecamatan is further subdivided into Kelurahan/Desa (villages). As presented in Table 3.1, Kabupaten Kampar consists of 15 Kecamatans, of which 6 Kecamantans are included in the Objective Area. Kabupaten Bengkalis consists of 14 Kecamatans, of which 4 Kecamatans are within the Objective Area. The above 10 Kecamatans are subdivided into 118 Kelurahan/Desas.

As shown in Table 3.1, the 6 Kecamatans in Kampar account for 25% of the total area and 34% of the population of the Kabupaten. Likewise the 4 Kecamatans in Bengkalis account for 52% of the area and 40% of the population, respectively.

3.2 Population

Population of the Objective Area increased from 223,763 in 1980 to 426,899 in 1990 at an annual average of 7.0% (see Table 3.2) which outpaced the provincial average of 4.25% p.a. This high growth rate is considered to be caused as a result of migration flow due to general as well as spontaneous transmigration. It is roughly estimated that increased population of 203,136 between 1980 and 1990 consist of about 49,000 by natural increase, 80,0000 by general transmigration and the remaining 74,136 by spontaneous transmigration.

Among the 10 Kecamatan in the Objective Area, the highest annual growth rate is recorded in Tandun at 13.59%, followed by Tambusai at 11.75%, Kubu at 10.31% and Kunto Darusalam at 10.98% (see Table 3.2).

3.3 Transmigration Program

Transmigration in the Study Area can be categorized into: i) foodcrops oriented general transmigration, and ii) plantation-oriented swakarsa (spontaneous) transmigration. The former is oriented to produce food crops as its major income source with some tree crops as its secondary income source. This form of transmigration was necessary for the attainment of food self-sufficiency, especially rice, in Indonesia. Since Indonesia reached the level of self-sufficiency in rice production in 1985, the transmigration program has started to place its emphasis also on increse of tree crops production under nucleus estate system, although food crops production has still been the national top

priority policy in agriculture sector. In such a situation coupled with the government budget constraints, the number of general transmigrants has had tendency to decline during the course of implementation of PELITA IV.

The plantation oriented transmigrants are oriented to produce tree crops as its main income source. Most of swakarsa transmigrants have been settled under nucleus estate projects called Pir-Trans and Pir-Sus. Although swakarsa transmigrants under such projects are entitled to an allocation of land and credit in the case of those settling in nucleus estate projects, they are on average far less costly than fully sponsored transmigrants, who are entitled to housing, rice allocations and other benefits, as well as to transport costs. In the Objective Area, swakarsa transmigrants, moving at their own expenses, has been increased after 1986 in relation to the rapid expansion of nucleus estate projects.

The number of transmigrants in the Objective Area totals about 80,000 persons, of which about 57,600 (72 %) moved during 1979 - 1981 and the remaining during 1981 - 1989 as presented in Tables 3.3 and 3.4.

4. SOCIOECONOMIC PROJECTIONS

4.1 Population

Population of Riau province increased at an annual average of 4.25% between 1980 and 1990 as presented in Table 2.1 of ANNEX A. Within the province, Batam showed the highest growth rate of 10.7%, followed by Kabupaten Kampar at 6.2%, Pekanbaru at 5.31%, Indragiri Hulu at 4.9%, Bengkalis at 4.8%, etc. Population of the Study Area in Riau (Objective Area) increased at an annual average of 7.0% during 1980 and 1990 as explained in the preceeding section.

Taking into account the population growth rates in the past, population projections in Riau province as well as in the Objective Area up to the year 2020 have been prepared. In the population projections, it is assumed that population growth rate will gradually be reduced due to the reasons that overall fertility rate would be reduced by implementation of family planning and the number of transmigrants would be dwindled owing to difficulty in securing suitable agricultural land in the future.

The assumed population growth rates and projected population for Riau province and the Objective Area are summarized below.

Projected Population Growth Rate

	Riau Province	Objective Area
1991 - 2000	4.0 %	6.5 %
2001 - 2010	3.5 %	5.5 %
2011 - 2020	3.0 %	4.5 %

Projected Population, 1990-2020

	Riau Province	Objective Area
Population in 1990	3,281,046	426,899
Population in 2000	4,856,750	801,348
Population in 2010	6,850,926	1,368,818
Population in 2020	9,207,072	2,125,732

Note: Population in 1990 is based on the 1990 Population Census data.

4.2 Supply and Demand Forecast for Major Food Crops

4.2.1 Production Projections in Riau Province

Paddy production is projected to increase at an annual rate of 5% between 1990 and 2000, and at an annual rate of 3.5% between 2001 and 2020 based on the past performance of rice production in the province. Implementation of new irrigation projects would be required to achieve the target.

Maize production is projected to increase at an annual rate of 7% between 1990 and 2000, and at an annual rate of 5% between 2001 and 2020 based on the past performance of maize production in the province.

Soybeans production is projected to increase at an annual rate of 4% between 1990 and 2000, and at an annual rate of 3.5% between 2001 and 2020 based on the past performance of soybeans in the province.

Groundnut production is projected to increase at an annual rate of 7% between 1990 and 2000, and at an annual rate of 5% between 2001 and 2020. Implementation of some new irrigation projects would be required to achieve the target.

The projected production for major food crops is presented in Table 4.1.

4.2.2 Demand Projections in Riau Province

Demand projections depend largely on the increase in population as well as increase in per capita consumption. In demand forecast of this report, however, increase in per capita consumption is not taken into account due to lack of reliable data on this subject. Instead, per capita consumption in the national food

balance in 1987 has been extensively referenced as a proxy to future consumption volume of food crops in the province. Per capita consumption has been assumed as follows: rice 141 kg, maize 18 kg, soybeans 5 kg, and groundnut 3.5 kg. The projected demand for major food crops is presented in Table 4.1.

4.2.3 Supply and Demand Forecast for Food Crops in Riau

Based on the production and demand projections as stated above, supply and demand forecast for some major food crops in Riau has been prepared as presented in Table 4.1. As indicated by the table, Riau province will not be self-sufficient in major food crops. It should be noted however that the production increase in the future can be attained by increasing the productivity of farmland through improvement of irrigation infrastructures as well as the introduction of new agricultural technology and farming practices. Without any investment in the irrigation as well as agricultural development projects, the province would suffer from heavy shortage of major food crops in the future.

4.2.4 Supply and Demand Forecast for Food Crops in the Objective Area

Supply and demand forecast for major food crops in the Objective Area has also been prepared in the same manner as in the case of Riau province. The results of the forecast is presented in Table 4.2. Although the Objective Area is self-sufficient in groundnut production, it will not be self-sufficient in rice and soybeans in the future due to its high population growth rate. It will be necessary therefore to expedite improvement of irrigation infrastructures and introduction of new farming technology in the Objective Area.

Table 1.1 Land and Population Distribution of Indonesia (1990)

Region	Area		Population (1990)		Population Density
	km2	%	millions	%	(persons/km2)
Sumatra	481,780	24.7	36.4	20.3	76
Java 1/	130,398	6.7	107.5	60.0	824
Nusa Tenggara	87,693	4.5	10.2	5.7	116
Kalimantan	549,032	28.2	9.1	5.1	17
Sulawesi	194,441	10.0	12.5	7.0	64
Irian Jaya 2/	505,388	25.9	3.5	2.0	7
Total	1,948,732	100.0	179.2	100.0	92

Source: (1) Statistik Indonesia 1989
(2) 1990 Population Census

Note: 1/ including Madura Island
2/ including Maluku Islands

Table 1.2 Population of Indonesia by Province (1983-1993)

Province	1980 Census	1990 Census	Annual Growth Rate (%)
D.I. Aceh	2,610,528	3,415,393	2.72
North Sumatra	8,350,950	10,252,311	2.07
West Sumatra	3,406,132	3,998,677	1.62
Riau	2,163,896	3,281,046	4.25
Jambi	1,444,476	2,014,054	3.38
South Sumatra	4,627,719	6,275,945	3.09
Bengkulu	767,988	1,178,951	4.38
Lampung	4,624,238	6,004,109	2.65
Sumatra	27,995,927	36,420,486	2.67
DKI Jakarta	6,480,654	8,222,515	2.41
West Java	27,449,840	35,378,483	2.57
Central Java	25,367,344	28,516,786	1.18
D.I. Yogyakarta	2,750,128	2,912,611	0.58
East Java	29,169,004	32,487,568	1.08
Java	91,216,970	107,517,963	1.66
Bali	2,469,724	2,777,356	1.18
West Nusa Tenggara	2,723,678	3,368,699	2.15
East Nusa Tenggara	2,736,988	3,267,919	1.79
Timor Timur	555,350.00	747,557.00	3.02
Nusa Tenggara	8,485,740	10,161,531	1.82
West Kalimantan	2,484,891	3,235,366	2.67
Central Kalimantan	954,176	1,395,861	3.88
South Kalimantan	2,063,227	2,596,647	2.33
East Kalimantan	1,214,602	1,875,032	4.44
Kalimantan	6,716,896	9,102,906	3.09
North Sulawesi	2,114,822	2,477,946	1.60
Central Sulawesi	1,284,528	1,703,330	2.86
South Sulawesi	6,059,564	6,980,589	1.43
Southeast Sulawesi	941,634	1,349,298	3.66
Sulawesi	10,400,548	12,511,163	1.86
Maluku	1,408,451	1,851,087	2.77
Irian Jaya	1,107,291	1,629,087	3.94
Irian Jaya	2,515,742	3,480,174	3.30
Total	147,331,823	179,194,223	1.98

Source: 1990 Population Census

Table 1.3 Projected Growth in the Labor Force by Province (1983 - 1993)

Province	Labor Force ('000)		Annual Growth Rate (%)
	1988	1993	
D.I. Aceh	1,335	1,604	3.74
North Sumatra	4,081	4,807	3.33
West Sumatra	1,457	1,634	2.32
Riau	1,040	1,285	4.32
Jambi	782	997	4.98
South Sumatra	2,364	2,921	4.32
Bengkulu	496	661	5.91
Lampung	2,860	3,916	6.49
DKI Jakarta	3,051	3,818	4.59
West Java	12,540	14,395	2.80
Central Java	13,341	14,654	1.90
D.I. Yogyakarta	1,682	1,885	2.31
East Java	14,978	16,147	1.51
Bali	1,496	1,739	3.06
West Nusa Tenggara	1,385	1,650	3.56
East Nusa Tenggara	1,605	1,904	3.48
Timor Timur	289	347	3.73
West Kalimantan	1,410	1,736	4.25
Central Kalimantan	551	716	5.38
South Kalimantan	1,156	1,390	3.76
East Kalimantan	713	952	5.95
North Sulawesi	1,011	1,245	4.25
Central Sulawesi	717	935	5.45
South Sulawesi	2,339	2,716	3.03
Southeast Sulawesi	520	668	5.14
Maluku	642	811	4.78
Irian Jaya	654	826	4.78
Total	74,495	86,359	3.00

Source: REPELITA V document

Note: D.I. = Daerah Istimewa (Special District)
DKI = Daerah Khusus Istimewa (Super-Special District)

Table 1.4 GDP Growth Rate in Indonesia (1983-1988)
(at constant 1983 price)

Industry	1983		1988		Annual Growth Rate (%)
	Billion Rp	%	Billion Rp	%	
Agriculture	17,692.2	22.8	21,007.6	21.1	3.5
Food crops	11,057.4	14.2	12,796.9	12.8	3.0
Non-food crops	2,294.9	3.0	2,832.9	2.8	4.3
Estate crops	375.3	0.5	576.8	0.6	8.9
Livestock	1,754.3	2.3	2,211.7	2.2	4.7
Forestry	994.2	1.3	1,013.0	1.0	0.4
Fisheries	1,220.1	1.6	1,576.4	1.6	5.2
Mining & Quarrying	16,107.4	20.7	15,934.0	16.0	-0.2
Oil and gas	15,103.0	19.4	14,691.2	14.7	-0.5
Other	1,004.4	1.3	1,242.8	1.2	4.3
Manufacturing	9,896.4	12.7	18,339.9	18.4	13.1
Non-oil/gas	7,666.3	9.9	13,758.2	13.8	12.4
Oil refinery	358.9	0.5	980.4	1.0	22.3
Natural gas	1,871.2	2.4	3,601.3	3.6	14.0
Utilities 1/	313.9	0.4	547.5	0.5	11.7
Construction	4,597.2	5.9	5,119.1	5.1	2.2
Trade, hotels, etc.	11,540.7	14.9	15,662.3	15.7	6.3
Wholesale, retail	9,932.5	12.8	12,998.5	13.0	5.5
Hotel, restaurant	1,608.2	2.1	2,663.8	2.7	10.6
Transport/commun.	4,098.1	5.3	5,225.2	5.2	5.0
Transport	3,693.7	4.8	4,637.5	4.7	4.6
Communications	404.4	0.5	587.7	0.6	7.8
Banking	2,358.6	3.0	3,597.2	3.6	8.8
Dwelling ownership	2,355.5	3.0	2,762.2	2.8	3.2
Public services	5,711.5	7.4	7,932.1	8.0	6.8
Services	3,000.8	3.9	3,569.8	3.6	3.5
GDP Total	77,676.3	100.0	99,696.9	100.0	5.1

Source: Statistik Indonesia 1989

Note: 1/ Utilities include electricity, gas and water

Table 1.5 Projected Growth of GDP by Sector in Repelita IV and V

Sector	Average Annual Growth Rate	
	Projected REPELITA IV	Projected REPELITA V
Agriculture	3.0	3.6
Mining	2.5	0.4
Industry 1/	9.5	8.5
Construction	5.0	6.0
Commerce	5.2	6.0
Transport	5.0	6.4
Other 2/	5.0	6.1
GDP 3/	5.0	5.0

Source: Bulletin of Indonesian Studies, August 1989

Note: 1/ Industry includes manufacturing and utilities
2/ Other includes financial, public and other services
3/ GDP = Gross Domestic Product

Table 2.1 Population of Riau Province, 1980-1990

Kabupaten/ Katamadya	Population in 1980	Population in 1990	Annual Growth Rate (%)
Indragiri Hulu	227,885	367,470	4.89
Indragiri Hilir	398,214	477,958	1.83
Kepulauan Riau	384,049	458,463	1.79
Kampar	311,036	567,790	6.20
Bengkalis	566,377	903,919	4.79
Pekanbaru	237,672	398,621	5.31
Batam	38,663	106,825	10.70
Total	2,163,896	3,281,046	4.25

Source: Kantor Statistik Provinsi Riau

Note: Total population does not include such temporary residents as homeless, sailers, etc.

Table 2.2 GRDP of Riau Province

	1985	1986	1987	1988
Gross Regional Domestic Product (GRDP) in Billion (Bn) Rp				
GRDP at Current Market Prices				
Including Petroleum (Bn Rp)	7,433.1	7,538.9	9,392.9	9,225.4
Excluding Petroleum (Bn Rp)	1,266.2	1,399.0	1,628.0	1,923.5
GRDP at 1983 Constant Prices				
Including Petroleum (Bn Rp)	6,500.6	7,336.3	8,197.6	8,551.8
Excluding Petroleum (Bn Rp)	1,071.5	1,125.9	1,212.6	1,319.4
Growth Rate (%)				
Including Petroleum (Bn Rp)	-4.2	12.8	11.7	4.3
Excluding Petroleum (Bn Rp)	4.6	5.1	7.7	8.8
Per Capita GRDP				
Including Petroleum (Rp)	453,114	484,257	546,787	620,382
Excluding Petroleum (Rp)	383,672	389,902	407,587	427,610
GRDP Share by Sector at CMP (Including Petroleum)				
Agriculture (%)	4.7	5.0	4.7	5.5
Mining (%)	79.1	75.3	77.1	73.2
Manufacturing (%)	4.7	6.6	5.9	6.7
Trade & Commerce (%)	6.0	7.0	6.6	7.5
Others (%)	5.5	6.1	5.7	7.1
GRDP Share by Sector at CMP (Excluding Petroleum)				
Agriculture (%)	27.7	26.8	26.9	26.2
Mining (%)	6.2	6.0	6.3	6.1
Manufacturing (%)	7.7	7.7	8.2	8.5
Trade & Commerce (%)	26.6	26.4	25.1	24.9
Others (%)	31.8	33.1	33.5	34.3

Source: Pendapatan Regional Provinsi Riau 1983-1989, Kantor Statistik Provinsi Riau

Note: 1/ Bn = Billion
2/ CMP = Current Market Prices

Table 2.3 Labor Force by Sector in Riau, 1985-1988

	1985	1986	1987	1988
Total Labor Force 1/				
Employed	832,889	861,457	891,005	921,567
Agriculture Sector	497,465	512,289	527,556	543,277
Mining	13,714	13,999	14,290	14,588
Manufacturing	35,412	35,940	36,475	37,019
Construction	29,454	32,888	36,723	41,005
Trade	92,744	96,509	100,428	104,505
Services	129,288	131,977	134,722	137,525
Others	34,812	37,854	40,811	43,649
Unemployed	24,987	n.a.	n.a.	n.a.
Unemployment Rate (%)	3.0	n.a.	n.a.	n.a.

Source: (1) Data Profil Ketenaga Kerjaan Daerah, Departemen Tenaga Kerja, Riau
(2) Kantor Statistik Provinsi Riau

Note: 1/ Labor Force data are based on the 1985 intercensal survey Labor force data in 1986, 1987 and 1988 are estimated from the figures in 1985.

Table 2.4 Implementation of Transmigration Program in Riau Province, 1961-1988

Period	Target H.H.	Actual H.H.	Actual Persons
1961/1962	100	100	489
1969/1970	300	298	1,325
1971/1972	150	150	735
1973/1974	150	150	732
PELITA-I Sub-total	600	598	2,792
1974/1975	200	200	821
1977/1978	500	500	2,304
1978/1979	2,400	2,400	10,261
PELITA-II Sub-total	3,100	3,100	13,386
1979/1980	9,021	8,821	37,791
1980/1981	10,396	9,049	44,427
1981/1982	9,068	7,233	31,936
1982/1983	9,284	8,270	35,066
1983/1984	4,650	3,742	17,055
PELITA-III Sub-total	42,419	37,115	166,275
1984/1985	15,955	8,819	35,638
1985/1986	9,545	117	457
1986/1987	4,784	4,161	17,624
1987/1988	5,300	4,644	19,822
1988/1989	9,121	6,228	26,460
PELITA-IV Sub-total	44,705	23,969	100,001
Total	90,924	64,882	282,943

Source: (1) Riau Dalam Angka 1988/1989
(2) REPELITA V document, Riau

Note: H.H. = Household (family)
PELITA-I: First Five-year Development
PELITA-II: Second Five-year Development
PELITA-III: Third Five-year Development
PELITA-IV: Fourth Five-year Development

Table 3.1 Administrative Divisions in the Objective Area

Kabupaten	Kecamatan	Area (km2)	Village No.	Population (1990)	Population Density
Kampar	(Objective Area)				
	Tambusai	1,629.09	21	30,660	19
	Kepenuhan	918.82	9	14,627	16
	Kunto Darussalam	1,179.47	10	17,943	15
	Rambah	1,029.60	26	72,711	71
	Rokan IV Koto	1,114.31	11	20,094	18
	Tandun	203.31	2	7,334	36
	Sub-total	6,074.60	79	163,369	27
	(Other Area)	21,733.72	182	404,421	19
	Kampar Total	27,808.32	261	567,790	20
Bengkalis	(Objective Area)				
	Bangko	2,528.35	36	97,491	39
	Kubu	3,023.59	25	97,090	32
	Tanahputih	3,329.65	19	43,326	13
	Mandau	1,397.09	38	25,623	18
	Sub-total	10,278.68	118	263,530	26
	(Other Area)	20,368.15	233	640,389	31
	Bengkalis Total	30,646.83	351	903,919	29
Objective Area Total:		16,353.28	197	426,899	26

Source: Kantor Statistik Propinsi Riau

Table 3.2 Population Trend and Density in the Objective Area

Kecamatan	Area (km2)	Population 1980	Population 1990	Growth Rate(%)	Density (1990)
Bengkalis Total	30,646.83	566,377	903,919	4.8	29
(Objective Area)					
Bangko	2,528.35	70,643	97,491	3.27	39
Kubu	3,023.59	36,392	97,090	10.31	32
Tanahputih	3,329.65	24,055	43,326	6.06	13
Mandau 1/	1,397.09	12,992	25,623	7.03	2
Sub-total	10,278.68	144,082	263,530	7.44	26
Kampar Total	27,908.32	311036	567790	6.2	20
(Objective Area)					
Tambusai	1,629.09	10,097	30,660	11.75	19
Kepenuhan	918.82	6,974	14,627	7.69	16
Kunto Darussalam.	1,179.47	6,869	17,943	10.08	15
Rambah	1,029.60	42,866	72,711	5.43	71
Rokan IV Koto	1,114.31	10,824	20,094	6.38	18
Tandun 2/	203.31	2,051	7,334	13.59	36
Sub-total	6,074.60	79,681	163,369	8.17	27
Objective Area	16,353.29	223,763	426,899	7.00	26

Source: Kantor Statistik Propinsi Riau

Note: 1/ Mandau within the Objective Area corresponds to 20% of the total area and population
2/ Tandun within the Objective Area corresponds to 20% of the total area and population

Table 3.3 Implementation of Transmigration Program in the Objective Area, 1979-1981

Projects	Kabupaten/ Kecamatan	Year of Migration	Target H.H.	Present H.H.	Present Persons
Pasir Panggarayan I/A	Kampar/ Rambah	1979/80	2,000	2,076	9,372
Pasir Panggarayan II SKP.B.	Kampar/ Rambah				
-UPT. I.		1980/1981	624	637	2,917
-UPT. II.		1980/1981	460	452	2,226
Pasir Panggarayan II SKP.C.	Kampar/ Rambah				
-UPT. I.		1980/1981	623	617	2,801
-UPT. II.		1980/1981	501	501	2,328
-UPT. III.		1980/1981	550	543	2,745
-UPT. IV.		1980/1981	492	457	2,077
-UPT. V.		1981/1982	450	438	2,003
Pasir Panggarayan II SKP.D.	Kampar/ Rambah				
-UPT. I.		1981/1982	624	610	3,127
-UPT. II.		1981/1982	504	618	2,752
-UPT. III.		1981/1982	400	374	1,723
-UPT. IV.		1981/1982	300	299	1,548
-UPT. V.		1981/1982	450	446	2,081
Pasir Panggarayan E	Kampar/ Tambusai				
-UPT. I.		1981/1982	616	593	3,173
-UPT. II.		1981/1982	400	245	1,008
-UPT. III.		1981/1982	400	384	1,812
-UPT. IV.		1981/1982	400	377	1,963
-UPT. V.		1981/1982	400	400	2,144
Tandun Pirsus -UPT. I.	Kampar/ Tandun	1982/1983	500	500	2,648
Rokan I.	Bengkalis/ Bangko				
-UPT. I.		1980/1981	704	442	1,866
-UPT. II.		1980/1981	418	101	447
Rokan II.	Bengkalis/ Bangko				
-UPT. I.		1980/1981	545	479	2,212
-UPT. II.		1980/1981	523	536	2,388
-UPT. III.		1980/1981	312	57	283
Total			13,196	12,182	57,644

Source: Kanwil Departemen Transmigrasi Provinsi Riau

Table 3.4 Implementation of Transmigration Program in the Objective Area, 1981-1989

Project	Kabupaten/ Kecamatan	Year of Migration	H.H. at Migration	Present H.H.	Presnt Persons
Pasir Panggarayan XIId/F	Kampar/ Rambah				
-UPT. I.		1981/1982	600	580	2,620
-UPT. II.		1981/1982	473	473	2,021
-UPT. III.		81/82,82/83	512	449	2,147
-UPT. IV.		81/82,82/83	256	244	1,185
Sub-total			1,841	1,746	7,973
Kota Tengah XIIIb/A	Kampar/ Kepenuhan				
-UPT. I.		1982/1983	400	400	1,668
-UPT. II.		1982/1983	440	440	1,878
-UPT. III.		1982/1983	460	458	2,106
-UPT. IV.		1982/1983	400	400	1,782
Sub-total			1,700	1,698	7,434
Kota Tengah XIIIb/B,F,G	Kampar/ Kepenuhan				
-UPT. V.		1987/1988	401	398	1,887
-UPT. VI.		1988/1989	345	345	1,581
-UPT. VII.		1988/1989	185	190	811
Sub-total			931	933	4,279
Kota Lama XIIIa/A	Kampar/ Kunto				
-UPT. I.	Darussalam	1988/1989	190	190	811
Total			4,662	4,567	20,497

Source: Kanwil Departemen Transmigrasi, Propinsi Riau

Table 4.1 Supply and Demand Forecast for Major Food Crops in Riau

Unit: ton

	Production	Feed, Waste & Seed	Total Supply	Population	Total Demand	Surplus (Deficit)
Rice						
1990	409,087	36,493	253,364	3,281,046	462,627	(209,263)
2000	605,549	52,399	553,150	4,856,750	684,802	(131,652)
2010	854,186	72,468	781,718	6,850,926	965,981	(184,262)
2020	1,204,914	100,459	1,104,456	9,207,072	1,298,197	(193,741)
Maize						
1990	25,994	3,179	22,815	3,281,046	59,059	(36,244)
2000	51,133	6,014	45,119	4,856,750	87,422	(42,303)
2010	83,291	9,637	73,653	6,850,926	123,317	(49,663)
2020	135,672	15,504	120,168	9,207,072	165,727	(45,559)
Soybeans						
1990	5,358	670	4,688	3,281,046	16,405	(11,717)
2000	7,931	841	7,091	4,856,750	24,284	(17,193)
2010	11,188	1,050	10,138	6,850,926	34,255	(24,117)
2020	15,782	1,284	14,497	9,207,072	46,035	(31,538)
Groundnuts						
1990	4,529	509	4,020	3,281,046	11,484	(7,464)
2000	8,910	844	8,065	4,856,750	16,999	(8,933)
2010	15,806	1,353	14,453	6,850,926	23,978	(9,525)
2020	25,747	2,081	23,666	9,207,072	32,225	(8,559)

Source: Estimate of the Study Team

Note: Annual production is assumed to increase at the following rates.
1) Rice at 5% between 1990-2000 and 3.5% between 2001-2020
2) Maize at 7% between 1990-2000 and 5% between 2001-2020
3) Soybeans at 4% between 1990-2000 and 3.5% between 2001-2020
4) Groundnut at 7% between 1990-2000 and 5% between 2001-2020

Table 4.2 Supply and Demand Forecast for Major Food Crops in the Objective Area, 1990-2020

Unit: ton

	Production 1/	Feed, Waste & Seed	Total Supply	Population	Total Demand	Surplus (Deficit)
Rice						
1990	90,544	7,851	56,231	426,899	60,193	(3,962)
2000	147,486	12,317	135,169	801,348	112,990	22,179
2010	218,315	17,868	200,448	1,368,818	193,003	7,444
2020	323,160	26,003	297,157	2,125,732	299,728	(2,571)
Maize						
1990	9,789	1,155	8,635	522,058	9,397	(762)
2000	19,257	2,213	17,044	801,348	14,424	2,620
2010	31,368	3,566	27,802	1,368,818	24,639	3,163
2020	51,095	5,762	45,334	2,125,732	38,263	7,070
Soybeans						
1990	3,191	320	2,871	522,058	2,610	261
2000	4,723	413	4,310	801,348	4,007	303
2010	6,662	528	6,134	1,368,818	6,844	(710)
2020	9,398	686	8,712	2,125,732	10,629	(1,916)
Groundnuts						
1990	3,308	275	3,034	522,058	1,827	1,207
2000	6,508	480	6,029	801,348	2,805	3,224
2010	10,601	747	9,854	1,368,818	4,791	5,063
2020	17,268	1,170	16,098	2,125,732	7,440	8,658

Source: Estimate of the Study Team

Note:
1/ Annual production is assumed to increase as follows;
1) Rice at 5% between 1990-2000 and 3.5% between 2001-2020
2) Maize at 7% between 1990-2000 and 5% between 2001-2020
3) Soybeans at 4% between 1990-2000 and 3.5% between 2001-2020
4) Groundnut at 7% between 1990-2000 and 5% between 2001-2020

ANNEX B

HYDROLOGY

ANNEX B HYDROLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX B HYDROLOGY

1. INTRODUCTION

The total area of the Rokan River Basin is 18,405 Km² and located over three provinces i.e. Riau, North Sumatra and West Sumatra provinces. The area in Riau, North Sumatra and west Sumatra provinces area 12,365 Km², 3,690 Km² and 2,350 Km² respectively. The basin is divided into five(5) sub-basins, S.Rokan Kiri, Bt.Lubuk, Bt.Kumu, S.Bangko and S.Rokan, as shown in Fig.1.1.

In this study, a river system of the said sub-basins are further divided into 30 tertio-basins as shown below;

Block No.	Sub-basins	Catchment Area(Km²)	Number of Tertio-basins
1	S.Rokan Kiri	4,312	6
2	Bt.Lubuk	4,610	9
3	Bt.Kumu	3,913	8
4	S.Bangko	1,565	2
5	S.Rokan	4,005	5
	Total	18,405 Km²	30

The configuration of the Rokan River system is shown in Fig.1.2.

1.1 Data Available

A number of meteo-hydrological stations was installed and observed by the provincial PU and provincial agriculture office in the Study Area. The provincial PU has recorded meteorological data such as air temperature, evaporation, relative humidity, rainfall and so on since 1970 and hydrological data such as river water level and river flow discharges since 1977. Some of hydrological data were analyzed by LITBANG AIR, Bandung but the analyzed data are not updated. Therefore, the raw data obtained in the provincial PU are used for the study. A few of water quality and suspended load analysis for the Study Area were carried out by LITBANG AIR, Bandung occasionally.

Fig.1.3 shows the location of the existing meteorological stations operated by the provincial PU in the study area.

1.2 Data Collection

all of the data kept by the hydrological section in the provincial PU were obtained. The number of the observation stations in the Study area is as follows;

Item	Number	Remarks
Meteorological station	4	1 of 4 was newly installed in 1990
Rainfall station	14	5 of 14 were newly installed in 1990
Water level gauging station	9	1 of 9 was newly installed in 1990

The observation duration of each station is shown in Fig.1.4.

2. CLIMATE

2.1 Climate Feature

The climate in the Study Area is characterized by tropical monsoon climate. Annual rainfall is more than 2,000 mm whole the area, and is more than 3,500 mm in mountain area. Judging from a rainfall pattern and river discharge, dry season occur between June to October, while wet season between November to May.

(1) Rainfall

Annual rainfall ranges from about 2,000 mm to 3,500 mm and monthly rainfall changes widely depending on years. Isohyetal map in the Study Area is shown in Fig.1.5. The maximum rainfall of 199 mm was recorded at Rao MT. in October 15, 1989.

(2) Temperature

Annual mean temperature observed at four(4) stations varies from 25.3°C to 28.0°C. The maximum annual mean temperature recorded as 32.7°C at Pasir Pangarayan and the minimum one as 29.7°C at Kota Lama.

(3) Relative humidity

Annual mean relative humidity is rather high ranging from 84.9% to 91.4%.

(4) Evaporation

Annual mean evaporation measured by pan-A varies between 1,350 mm to 1,710 mm and daily mean evaporation shows within the limit of 3 mm/day to 4 mm/day.

(5) Wind speed

Daily mean wind velocity varies from 11.8 Km/day to 35.1 Km/day and annual mean wind velocity ranges from 16.6 Km/day to 32.5 Km/day depending on the locations.

(6) Sunshine ratio

Annual mean sunshine ratio is 37.6% to 46.1% and the maximum monthly mean sunshine ratio of 57.4% was observed at Kota Lama and the minimum one of 31.0% at Pasir Pangarayan.

(7) Solar Radiation

The annual mean solar radiation is 193 70 308 cal/cm²/day and monthly one varies from 164 to 321 cal/cm²/day.

The foregoing climate feature is shown in Fig.2.1 and Fig.2.2.

3. RUNOFF ANALYSIS

Runoff analysis is carried out in order to estimate the available river runoff to formulate water resources development plan in the Study Area. Since the period of water level recorders is insufficient to estimate the probable low flow in the Study Area, the long-term runoff is estimated by applying the Tank Model using long-term rainfall records.

3.1 Data

The runoff records of 8 AWLR stations are available in the Study Area. However, number of runoff observation is too short to establish the rating curves in 2 stations out of 8 stations.

The rainfall has been recorded for more than 10 years at 4 rainfall stations, while the other 5 rainfall stations have records for less than 10 years.

3.2 River Discharge

The provincial P.U has been carried out river flow discharge measurement at AWLR stations from time to time since 1977. Those data show that river discharges and river water level have good correlation. Thus, the rating curves for all AWLR stations were estimated by applying the quadratic equation as shown below:

$$Q = a \cdot (H+b)^2$$

where, Q : discharge(m^3/sec)
H : water level(m)
a,b : constants

Constants of a and b are determined by the least square method and the results are shown below:

AWLR station	Name of river	Catchment area(Km²)	Constants a	b
Lubuk Bendahara	S.Rokan Kiri	3,094	30.434	0.338
Ujung Gurap	Bt. Lubuk	1,308	14.657	0.689
Suka Damai*	Bt. Kumu	1,882	7.513	0.887
Pasar Tangun	Bt. Lubuk	808	35.576	-1.900
			(for 1979	to 1984)
			41.450	-0.052
			(for 1985	to 1990)
Dalu Dalu	Bt. Sosa	1,154	11.717	0.768
Kota Bangun	Bt. Kumu	520	5.466	0.375
Tanjung Medan	Bt. Kumu	3,795	6.582	0.541
Pematang Ibul*	S. Bangko	942	1.708	1.099

Remarks: * Available data are not enough.

Fig.3.1 presents the rating curves at the forementioned AWLR stations.

3.3 Methodology

The Tank Model simulation is applied to convert rainfall data to runoff discharge. The procedure is:

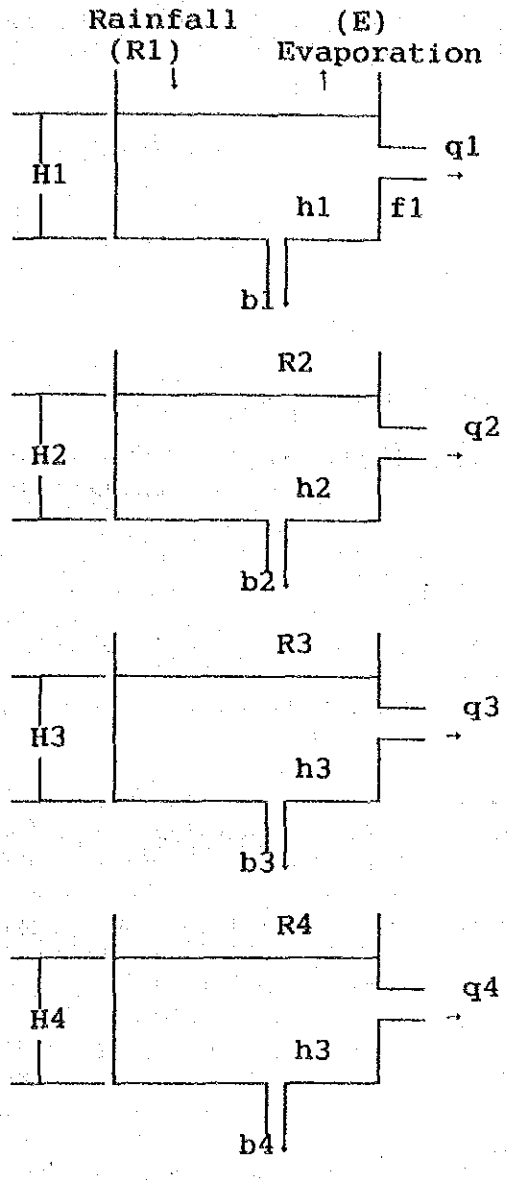
1) to determine the Model coefficients at the selected AWLR station by trial and error, and
2) to simulate long-term monthly runoff in each basin by applying long-term monthly rainfall

As shown in Fig.1.1, the Rokan River Basin is divided into five(5) sub-basins. The Model are constructed at AWLR stations selected from sub-basins if they have sufficient period of both runoff and rainfall data to determine the Model coefficients.

As a result, the Models for S. Rokan Kiri, Bt. Lubuk and Bt. Kumu are constructed.

3.4 Tank Model

The Tank Model assumes that a sub-system is analogous to vertical stacks of horizontal soil layers, usually having four layers (tanks) as shown below:



Top tank represents the ground surface and the outflow from the top tank gives the surface runoff. The second tank outflow shows intermediate runoff. The third and fourth tanks show the ground water layer and give baseflow discharge.

Runoff of Q is calculated by the following formula:

$$Q = \Sigma qi = \Sigma\{(Ri+Hi-hi)xfi - (Ri+Hi)xbi - Ei\}$$

where, Q : total runoff
qi : outflow from a tank
Ri : rainfall or inflow from upper tank
Hi : water depth in a tank
hi : height of orifice

fi : coefficient of outflow(qi) calculation
bi : coefficient of infiltration(Ri) calculation
Ei : evaporation

The parameters of each tank are determined by trial and error method.

3.5 Simulation

3.5.1 Construction of Tank Model

As mentioned in Section 3.3, three Tank Models are constructed in order to simulate long-term runoffs in three sub-basins.

The applied AWLR stations and rainfall stations are selected taking into account the following:

1) long observation period with less missing,
2) enough drainage area,
3) located on the upstream of diversion points and
4) reliable records.

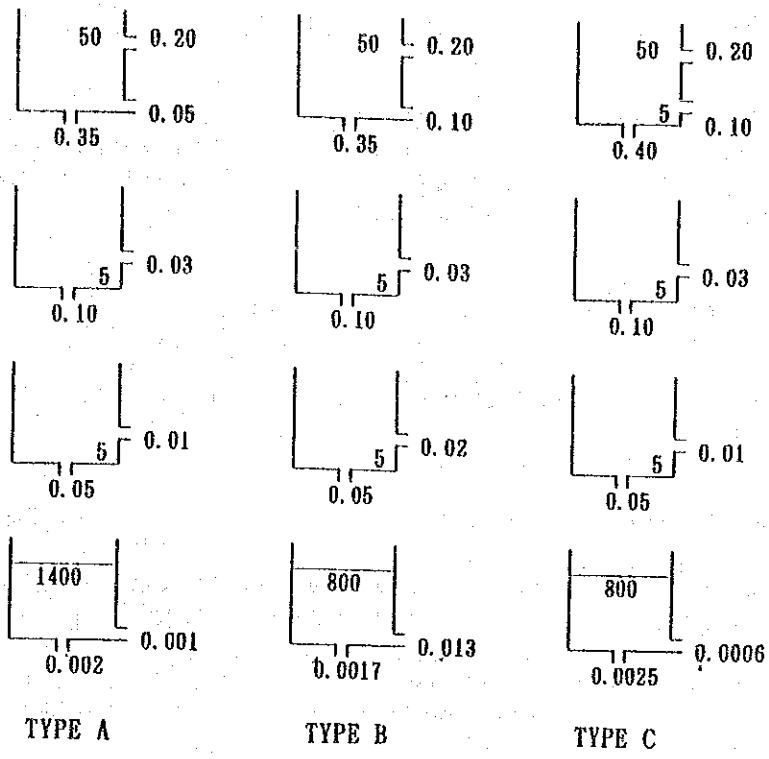
No. of Tank Model	Sub-basin	AWLR station	Rainfall station
Type A	S.Rokan Kiri	Lubuk Bendahara	Rao MT
Type B	Bt. Lubuk	Ujung Gurap	Pasir Pangarayan
Type C	Bt. Kumu	Suka Damai	Dalu Dalu

The pan evaporation record at Pasir Pangarayan is adopted for evaporation value form ground surface as follows:

Adopted daily evaporation (Unit mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
3.0	3.6	3.5	3.6	3.7	3.6	3.4	3.4	3.5	3.4	3.9	3.4

Trial and error calculation are carried out to minimize the average error of low flows (dry season's runoff) for 1985 to 1987 (three years). After some calculations, the parameters of each Model are determined as follows:



The comparison of the calculation results and actual recorded values are presented in Fig.3.2 to Fig.3.4.

3.5.2 Simulation of basin runoff

To estimate low monthly flows occurring once in five years, probable rainfall is calculated. As a result, rainfall in 1984 is decided as base year for the low monthly flows estimation.

The estimated monthly flows at the confluent points in 1984 are as follows:

(Unit m^3/sec)

Sub-basin Catchment	S.Rokan Kiri 4,312 Km^2	Bt.Lubuk 4,610 Km^2	Bt.kumu 3,913 Km^2
Jan.	141.4	295.4	176.1
Feb.	208.6	196.5	147.4
Mar.	176.6	181.6	234.7
Apr.	180.1	242.2	172.1
May	174.8	145.7	186.4
Jun.	131.2	87.9	174.0
Jul.	86.1	103.1	83.7
Aug.	66.4	74.2	119.7
Sep.	90.6	116.8	60.2
Oct.	93.0	119.6	94.0
Nov.	248.8	113.4	107.1
Dec.	119.3	106.2	155.8

4. WATER BALANCE

Water demand and supply balance projection is carried out to find areas which will be in short supply of water and those which will be in surplus with water in the future. Results of water balance study are presented in this chapter.

4.1 Water Demand Projection

Water demands are projected for population, industry and irrigation for each sub-basin.

4.1.1 Domestic Water Demand

Water demand for domestic water for each sub-basin in 2020 is estimated based on the following conditions:

1) The objective population for domestic water is 100 % of the projected population in both urban and rural areas in 2020.

2) Water demand for domestic water per capita is estimated to be 60 lit/capita/day and 30 lit/capita/day for urban area and rural area respectively.

3) Intake water discharge includes 15% of conveyance loss and 5% of non-domestic water use.

Based on the forementioned conditions, domestic water demands for the Objective Area in Kecamatan level are estimated as shown in the following Table. The total demand in the Objective Area will account for 137,000 m^3/day.

Projection of Domestic Water Demand in 2020

Kabupaten	Population projection			Total Demand	Water Source
	Urban (person)	Rural (person)	Total (person)	(m^3/day)	
(Kabupaten Kampar)					
Tambusai	69,000	84,000	153,000	8,200	Bt.Sosa
Kepenuhan	22,000	51,000	73,000	3,500	Bt.Lubuk
K.Darussalam	49,000	40,000	89,000	5,100	S.Rokan
Rambah	290,000	72,000	362,000	24,200	Bt.Lubuk
Rokan IV Koto	45,000	55,000	100,000	5,400	Rokan Ki
Tandun	35,000	2,000	37,000	2,700	Rokan Ki
Sub total	510,000	304,000	814,000	49,100	
(Kabupaten Bengalis)					
Bangko	412,000	73,000	485,000	33,300	S.Rokan
Kubu	435,000	48,000	483,000	34,000	S.Kubu
Tanahputih	97,000	119,000	216,000	11,600	S.Rokan
Mandau	115,000	13,000	128,000	9,000	Rokan Ki
Sub total	1,059,000	253,000	1,326,000	87,900	
Total	1,569,000	557,000	2,126,000	137,000	

Remarks: 1)Population projection is made based on 1990 population sensus and following estimated population increase ratio:
1991 - 2000 : 6.5 %
2001 - 2010 : 5.5 %
2011 - 2020 : 4.5 %
2)Population projection in an urban area is population who is expected to live in an urban area with population of more than 10,000 in 2020.

4.1.2 Industrial Water Demand

Dumai located in the vicinity of the Objective Area is a large manufacturing city and has a plan to construct industrial factories for rubber, wooden products, plastic products, foods, etc. by receiving supply of raw materials from the Objective Area. According to the plan, the factories will take industrial water of 2,000 m^3/day from the Rokan river.

Now, PERTAMINA, state operated oil company, is using industrial water of 50 lit/sec from the Rokan river and the oil company CALTEX, in Duri is taking 220 lit/sec from Rangau river, a tributary of the Rokan river. These industrial water are planned to increase to 280 lit/sec and 1,800 lit/sec respectively.

4.1.3 Irrigation Water Demand

Water demand for irrigation in 2020 are estimated based on the results of irrigation study in Annex F. The development areas for both the proposed and existing areas are identified as follows:

(Unit ha)

Sub-basin	Name of Project	Irrigable area (ha)	Remarks
S.Rokan Kiri	Panti Rao	9,540	On going
	Sei Kijang	516	Existing
	Sei Palis	400	Existing
	Lower Rokan Kiri	19,300	Proposed
	Kota Intan	188	Existing
Bt.Lubuk	Bt.Lubuk	460	Proposed
	Upper Sosa	3,600	Proposed
	Aek Tangun	420	Existing
	Sei Perak	95	Existing
	Sei Menaming	423	Existing
	Kaiti Samo	1,695	Existing
	Sibaruna etc.	2,600	Existing
	Lower Sosa	11,800	Proposed
Bt.Kumu	Bt.Kumu	8,110	Proposed
	Medan Mahato	324	Existing
	Mahato	8,700	Proposed
S.Rokan	Si Arang Arang	464	On going
	Teluk Retti	1,000	On going

Water requirements of the base year 1984 adopted for each sub-basin are as follows:

Irrigation water Requirement (Unit lit/s/ha)

Month	Type 1	Type 2	Type 3
Jan. 1-10	0.62	0.65	1.26
11-20	0	0.28	0.28
21-31	0.13	0	0
Feb. 1-10	0.15	0.16	0.52
11-20	0	0.15	0.51
21-29	0	0	0.04
Mar. 1-10	1.79	0	0.23
11-20	1.09	1.09	0.14
21-31	1.28	1.28	0
Apr. 1-10	0.81	1.09	0
11-20	0.73	0.72	1.00
21-30	1.29	1.15	1.43
May 1-10	1.12	1.62	1.77
11-20	0.50	0.65	1.01
21-31	1.49	1.23	1.74
Jun. 1-10	1.05	1.17	1.54
11-20	0.50	1.03	1.01
21-30	0.75	0.64	1.09
Jul. 1-10	0.50	0.53	1.05
11-20	0.10	0.50	0.91
21-31	0.21	0.17	0.56
Aug. 1-10	0.18	0.18	0.57
11-20	0	0.34	0.87
21-31	0	0	0.26
Sep. 1-10	1.48	0	0.14
11-20	1.65	1.65	0.18
21-30	1.19	1.19	0
Oct. 1-10	1.76	2.06	0
11-20	0.81	0.81	1.11
21-31	1.45	1.32	1.62
Nov. 1-10	1.22	1.73	1.89
11-20	0.40	0.54	0.90
21-30	1.28	0.99	1.51
Dec. 1-10	0.40	0.67	0.98
11-20	0.50	1.03	1.09
21-31	0.75	0.65	1.16

4.2 Water Balance

Water balance is computed from an upstream to a downstream of sub-basin by following a river configuration as shown Fig.1.2 with the following formula:

$$Qout = Qin + Qrun - Qd$$

where, Qout : outflow to a downstream
Qin : inflow from an upstream

Qrun : runoff within the tertio-system
Qd : water demand in the tertio-system

As Qrun, annual runoff values which may occur once in 5 years (80% dependability), that is, runoff in the base year 1984, are used. as discussed in 5.3.2. The computed are shown in Table 4.1 to Table 4.4.

As a results, no water deficit occurs in each sub-basin in the base year 1984.

5. FLOOD FLOW ANALYSIS

5.1 Methodology

The following methods are named to estimate flood discharge.

1) Rational Methods
   - Melchior (Catchment area > 100 Km^2)
   - Rational formula
   - Haspers
2) Unit Hydrograph
3) Storage Function Model

Along the above methods, the flood discharge obtained by the Rational Formula shows a tendency to the maximum. Thus, the Rational Formula is adopted for this flood runoff analysis. For the other methods will be applied for the further study, i.e. the feasibility study.

5.2 Probable Rainfall

There exists sixteen(16) rainfall stations in the Rokan River Basin, whereas, the daily rainfall data for more than 8 years area available at 8 stations.

The maximum daily rainfall at 8 stations mentioned above are shown in Table 5.1. Iwai's method and Gumbel method are used to obtain the probable rainfall. The calculation results are shown in Table 5.2 and Table 5.3.

For the calculation of flood discharge at the proposed weir sites, the following probable rainfall are adopted.

PROPOSED WEIR SITE AND ADOPTED PROBABLE RAINFALL
FOR FLOOD RUN-OFF ANALYSIS (Unit mm)

Project name	Lower Rokan Kiri	Lubuk & Upper Sosa	Lower Sosa	Mahato
River	S.Rokan Kiri	Bt.Lubuk	Bt.Sosa	S.Mahato
Weir site	Kota Lama	Muara Katogan	Kepayan	No name
Catchment area(Km^2)	3,312	816	1,348	348
Adopted ARR station	Lubuk Bendahara	Pasir Pangara-yan	Dalu DAlu	Dalu Dalu
Probable Year				
1,000	400.3	227.6	270.5	270.5
500	347.7	213.9	253.3	253.3
200	287.4	195.7	230.7	230.7
100	248.0	182.0	213.4	213.4
50	213.5	168.2	196.2	196.2
20	174.7	149.8	173.1	173.1
10	149.9	135.5	155.3	155.3
5	128.5	120.7	136.8	136.8
2	104.3	98.3	108.7	108.7
Applied method	Imai's	Gumbel	Gumbel	Gumbel

5.3 Flood Discharge

The peak flood discharge is calculated by the use of the following rational formula;

$$q = 0.2778 \times f \times rt$$
$$Q = q \times A$$

where, Q : the peak flood discharge (m^3/s)
q : specific peak flood discharge ($m^3/s/Km^2$)
A : catchment area (Km^2)
f : run-off coefficient (=0.6)
rt: mean rainfall intensity within arrival time of flood (mm/hr)

The mean rainfall intensity within the arrival time of flood is obtained by the following equation;

$$rt = (r24/24) \times (24/T)^n$$