REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS

DIRECTORATE GENERAL
OF
WATER RESOURCES DEVELOPMENT

ROKAN RIVER BASIN
OVERALL IRRIGATION DEVELOPMENT PLAN STUDY

VOLUME III

FEASIBILITY STUDY ON THE LOWER
ROKAN KIRI IRRIGATION DEVELOPMENT PROJECT

OCTOBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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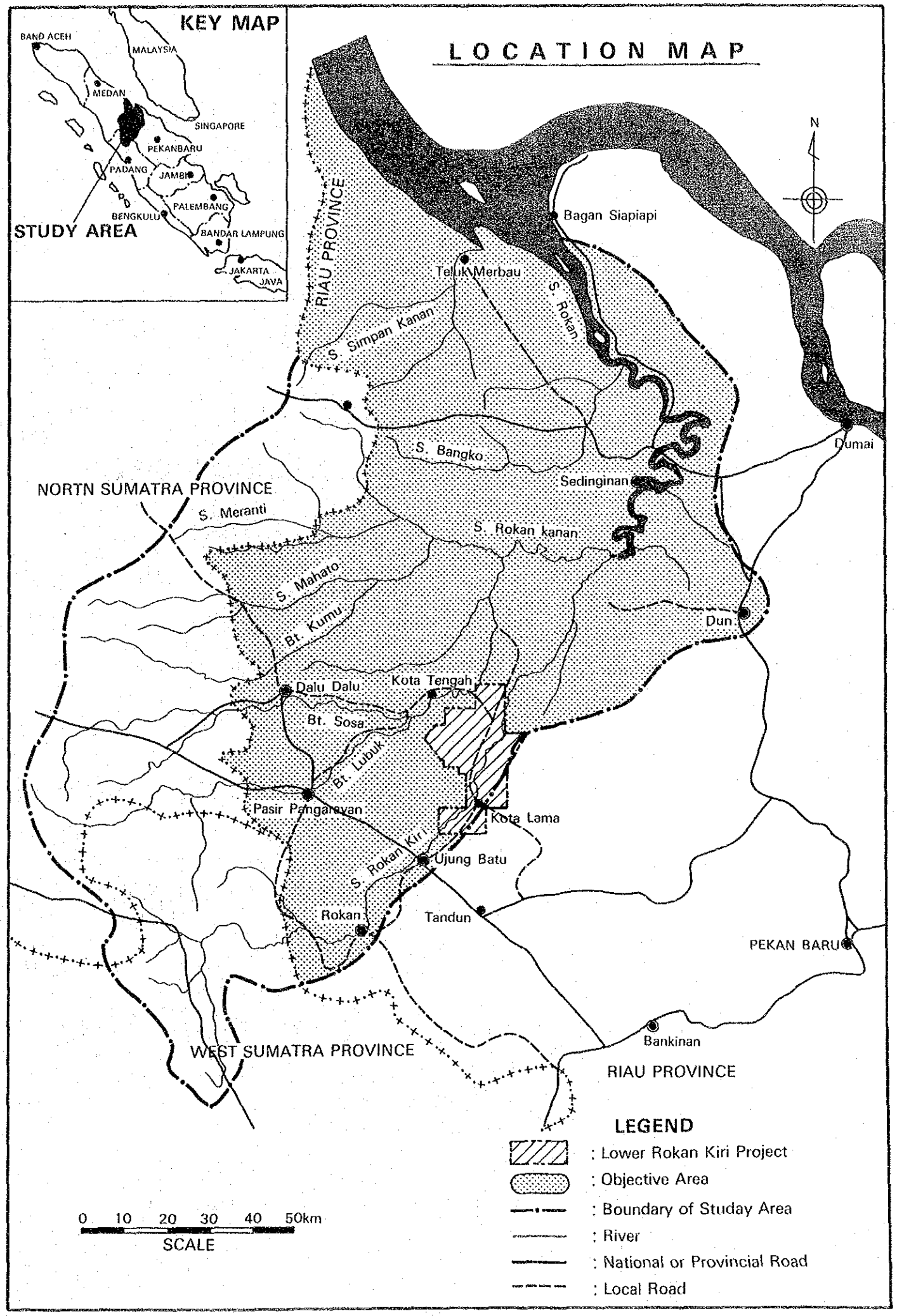
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SINGAPORE
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BANDAR LAMPUNG
JAKARTA
JAVA
STUDY AREA
LOCATION MAP
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Bagan Siapiapi
Teluk Merbau
S. Rokan
S. Simpan Kanan
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S. Mahato
Bt. Kumu
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Dalu Dalu
Kota Tengah
Bt. Sosa
Bt. Lubuk
Pasir Pangaraian
Kota Lama
S. Rokan Kiri
Ujung Batu
Rokan
Tandun
PEKAN BARU
Bankinan
WEST SUMATRA PROVINCE
RIAU PROVINCE
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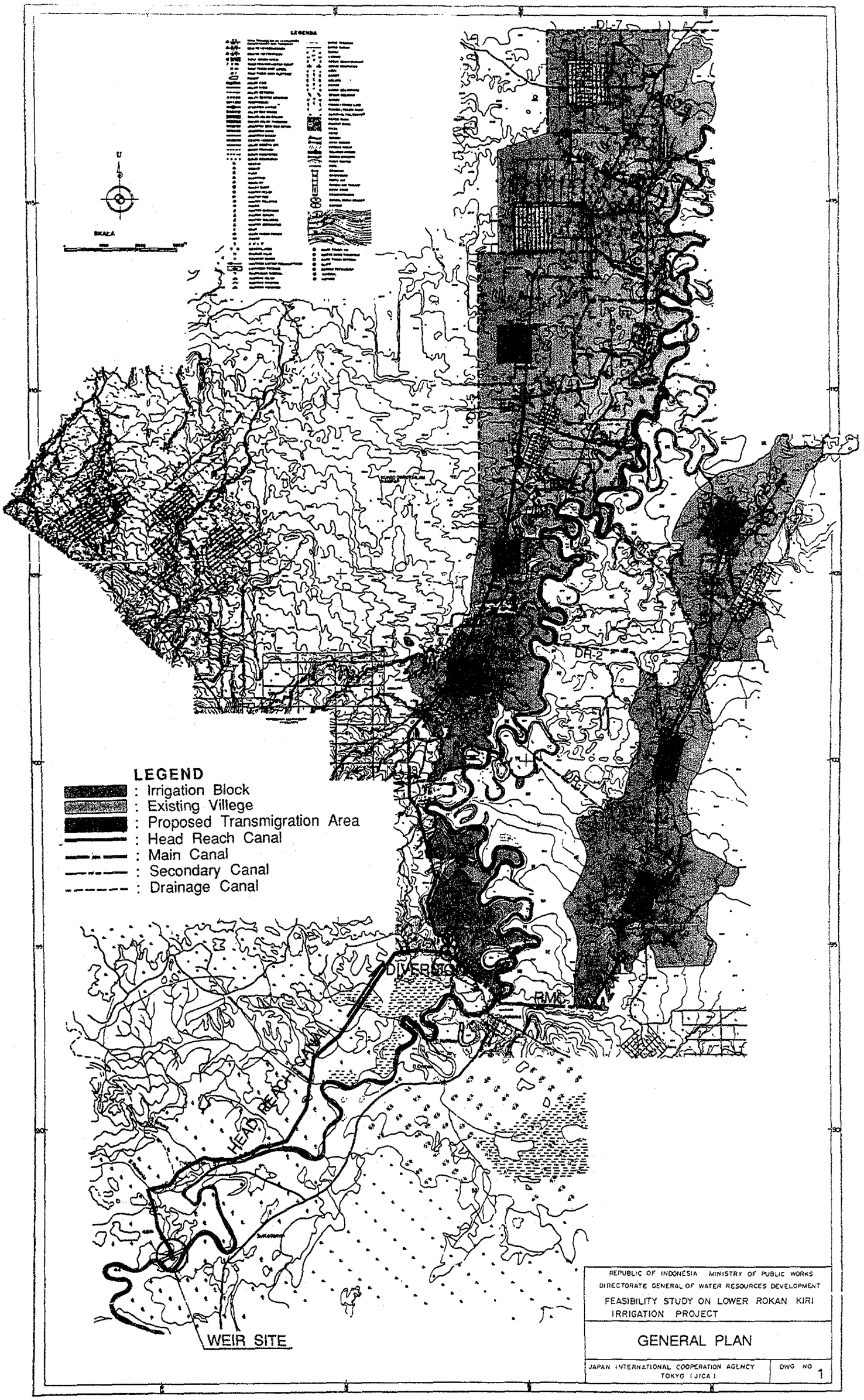
LEGEND
SKALA
DL-7
DR-2
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DIVERSION
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HEAD REACH CANAL
WEIR SITE
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: Main Canal
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FEASIBILITY STUDY ON LOWER ROKAN KIRI IRRIGATION PROJECT
GENERAL PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO (JICA)
DWG NO 1

ROKAN RIVER BASIN
OVERALL IRRIGATION DEVELOPMENT PLAN STUDY

FINAL REPORT

VOLUME III

FEASIBILITY STUDY
ON
THE LOWER ROKAN KIRI IRRIGATION PROJECT

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1. Introduction

The Final Report was made in accordance with the scope of work for the Rokan River Basin Overall Irrigation Development Plan Study in Indonesia agreed upon between the Directorate General of Water Resources Development, Ministry of Public Works (DGWRD) and the Japan International Cooperation Agency (JICA) on October 1990.

The Final Report consists of the following four(4) Volumes:

Volume I	MAIN REPORT
Volume II	OVERALL IRRIGATION DEVELOPMENT PLAN STUDY IN ROKAN RIVER BASIN
Volume III	FEASIBILITY STUDY ON THE LOWER ROKAN KIRI IRRIGATION DEVELOPMENT PROJECT
Volume IV	DRAWINGS

This is the Volume III report and presents the result of the feasibility study on the Lower Rokan Kiri Irrigation Development Project, which was carried out during the period of January to August 1992(Phase II study). The Lower Rokan Kiri irrigation project is the highest priority project selected in the Rokan River Overall Irrigation Development Plan Study in the Riau Province covering the survey area about 22,100 Km^2, that was conducted during the period of January to August, 1991(Phase I study) and discussed in the Volume II of the Final Report.

On 20th January 1992, after discussing the result of the said overall development plan study, it was agreed upon between DGWRD and JICA that the feasibility study of the Lower Rokan Kiri irrigation project be carried out.

This Volume III Report involves the following:

Main contents with Tables and Figures
Annex A : Meteorology and Hydrology
Annex B : Geology and Soil Mechanics
Annex C : Soil and Land Use
Annex D : Farm Practices
Annex E : Irrigation and Drainage
Annex F : Cost Estimate
Annex G : Environmental Impact Assessment

2. Project Area

2.1 Location

The Project Area is surrounded by the administrative boundary of the Kepunuhan and Kunto Darussalan sub-districts. The village included are 11 villages of Kunto Darussalam sub-district (Kota Lama, Kota Intan, Muara Dilam, Pagaran Tapah, Teluk Sono, SKP A, SKP F, SKP G, Kota Baru, Kota Raya and Muara Jaya) and one transmigration village (SKP B) of Kepenuhan sub-district. The extent of the Project Area is 942 Km². Within this Project Area, the Survey Area is also delineated on the basis of the area of the water intake facility, canal routes and topographic survey. The Project Area is 426 Km² as shown in Fig.2.1.

The existing Kota Intan project which is located on the left bank of the river and close to the project is included in the new project formulation. The water source is the Rokan Kiri river.

2.2 Physical Situation

2.2.1 Topography

The Project Area is situated at either bank of the Rokan Kiri river. The left bank area is a comparatively flat area hemmed in by the Bt. Lubuk and the Rokan Kiri, extending from the skirts of the hills stretched from Tandun to Dalu Dalu, to the lower reaches of both rivers. The elevation of the area ranges from 40 m to 20 m. The right bank area is located the downstream end of the hilly area that is stretching along the right bank of the Rokan Kiri river from Kota Lama.

2.2.2 Climate

The catchment area for the Lower Rokan Kiri Project is 3,267 Km² at the proposed weir site. While, the benefitted area is about 30,000 ha in gross. The meteorological conditions in the Project area are as follows;

(1) Rainfall

The annual mean rainfall in the catchment area ranges from 3,654 mm at Rao MT of the West Sumatra Province to 2,390 mm at Lubuk

Bendahara, while in the benefitted area it is 2,300 mm approximately.

(2) Evaporation

The monthly mean evaporation in the benefitted area(Kota Lama) ranges 3.0 mm/day to 3.9 mm/day and the annual mean one is 3.5 mm/day.

(3) Wind velocity

The monthly mean wind velocity in the benefitted area is 11.8 Km/day to 20.1 Km/day and the annual mean one is 16.6 Km/day.

(4) Air temperature

The monthly mean air temperature in the benefitted varies 24.5° C to 26.1° C and the maximum and minimum ones are 28.9° C to 30.5° C and 20.4° C to 21.8° C respectively.

(5) Relative humidity

The monthly mean relative humidity in the benefitted area ranges from 82.3% to 92.6% and the annual mean one is 91.4%.

(6) Sunshine Ratio

The monthly mean sunshine ratio in the benefitted area ia 31.0% in January to 43.4% in july, while the annual mean one is 37.6%.

(7) Solar radiation

The monthly mean solar radiation in the benefitted area ranges from 229 cal/cm²/day in December to 285 cal/cm²/day, while the annual mean one is 264 cal/cm²/day.

2.2.3 Hydrology

(1) Rokan Kiri river

The Rokan Kiri river originates from Barisan Range and runs to the north-east direction until the confluence of the Rokan river. The Project Area spreads both sides of the downstream of the Rokan Kiri river. The total river length from the mountain peak to the junction is about 205 Km with total area of the river basin of about 4,412 Km². Whereas the catchment area of the

proposed weir site is estimated at 3,267 Km^2.

(2) River discharge at the proposed weir site

The river discharge at the proposed weir site is estimated by applying the correlation between river discharges at Lubuk Bendahara and at Kota Lama among other methods such as Tank model, Moch Model because of the accuracy. The comparative study using other methods is discussed in Annex A.

Annual river run-off at the proposed weir site from 1978 to 1991 are estimated as follows:

Year	Annual Run-off(10^6 m^3)
1978	4.89
1979	4.22
1980	3.67
1981	3.59
1982	4.85
1983	3.74
1984	5.22
1985	4.76
1986	4.89
1987	5.65
1988	5.38
1989	4.30
1990	3.97
1991	5.67
Average	4.60

On the other hand, ten-day 80% dependable discharges at the proposed weir site are estimated as follows:

	80% dependable discharge (m^3/s)		
Month	1 -10	11-20	21-30(31)
Jan.	140.0	108.0	106.7
Feb.	99.6	85.2	94.2
Mar.	109.7	97.0	103.2
Apr.	122.0	111.8	107.4
May	131.7	106.0	86.0
Jun.	81.4	65.7	60.9
Jul.	58.5	57.1	54.4
Aug.	50.7	49.5	49.3
Sep.	57.3	61.7	69.2
Oct.	67.4	72.6	90.2
Nov.	113.6	90.9	108.9
Dec.	165.6	151.8	128.4

(3) Flood at the proposed weir site

The flood discharge with return period of 1/100 for designing of permanent weir and with 1/10 for designing of temporary works at the proposed weir site are decided to be 2,200 m^3/s and 1,400 m^3/s respectively.

(4) Water quality

In order to assess the water quality of river water and drinking water, sampling water were taken from the Rokan Kiri river, Madino river, swamp and four wells in the project area. Chemical and bio-chemical properties of the samples were analyzed to check suitability for drinking and irrigation purposes. The items of the analysis are those necessary for assessment of water quality in accordance with the Indonesian criteria(RAMPIRAN PERATURAN PEMERINTAH REPUBLIK INDONESIA NOMOR 20 TAHUN 1990 TANGGAL 5 Juni 1990).

The results of analysis and standard figures of criteria for assessment are shown in Annex A. The results offer that all the water in the project area are suitable for irrigation purposes as well as bathing and washing for local people, however, it is not suitable for drinking purpose without any treatment such as boiling.

2.2.4 Soil

Based on the physiographic conditions and the results of laboratory analysis, the major soils in the survey area are classified into Tropodults, Dystropepts, Tropaquepts and Tropofluvents according to the U.S. Soil Taxonomy.

Soils on undulating hills in the southern fringes of the survey area are mainly classified into Tropodults (Acrisols). These soils have been derived from quaternary deposits through weathering and leaching. They are more or less well drained and have been utilized for shifting cultivation. In these days, however, considerable area have been brought under large scale plantation of oil palm.

Soils on the terraces can be classified either Dystropepts/Humitropepts (Cambisols) or Tropaquepts (Gleisols). Dystropepts/Humitropepts are found on the terrace of both banks and the escarpment slopes. Texture of this soil varies from

sandy loam to clay and the drainage conditions are moderately well to somewhat poor. Aquic Dystropepts are distributed at low relief with rather high groundwater table of about 50-100 cm. Tropaquepts, on the other hand, extend their area only on the terrace of left bank of the river. These soils are strongly affected by high groundwater table which is generally at or near the surface. The soil is characterized by a deep black humic layer at the surface. In most cases, white sandy sediments underlie below 50-90 cm from the ground surface.

The presence of Tropohemists (Histosols) in the survey area was suggested by the careful interpretation of landsat image. This was practically confirmed by the soil survey done by P.T. ISUDA. Furthermore, according to the information obtained through inhabitants of transmigration area, the presence of Tropohemists in some depressions was also confirmed. It was, however, difficult to demarcate the exact distribution area of these soils. These soils are scatteredly distributed within the area of Tropaquepts.

Dominant soil types of alluvial plain in both sides of the river are Tropofluvents (Fluvisols). These soils have been derived from recent alluvial deposits. The effective soil depth is deep to very deep. In some cases, the soils have been influenced by high water table and periodic stagnant water by seasonal flood. The frequency of flood reported by the villagers was approximately once per 5 years.

The soil distribution map is shown in Fig.2.2. The acreage and the proportional extent of each soil mapping unit are shown in Table 2.1.

2.2.5 Land Suitability

To assess land development potentials of the survey area, the land suitability classification was carried out. The lands were assessed mainly based on the principles of the FAO system and the criteria proposed by the Soil Research Institute, Bogor (TOR No. 59b/1982) with some modification.

Each land unit was evaluated in terms of its suitability for paddy, upland crops and perennial crops (Fig.2.3 to 2.5).

(1) Land Suitability for Paddy

Undulating hills and escarpment slopes are currently not suitable for paddy due mainly to rather steep topography and the moderately well to well drainage condition.

Terrace soils are marginally suitable for paddy due to a high degree of the micro-relief.

Alluvial soils are moderately suitable for paddy cultivation. The degree of micro-relief, the somewhat poor drainage condition and the frequency of flood hazard are moderate limitations.

(2) Land Suitability for Upland Crops

Undulating hills and escarpment slopes are marginally suitable for the cultivation of upland crops. The low fertility status of the soils is one of the limitations. The lands are susceptible to erosion due to their gently sloping to undulating topography.

Terrace soils are also marginally suitable for upland crops. The low fertility status of the soils is the main limitation. The poor to very poor drainage conditions are the other limitation for the Gleisols.

Alluvial soils are moderately suitable for the cultivation of the upland crops. The low soil fertility, the erodibility, the somewhat poor drainage condition and the frequency of flood hazard are moderate limitations.

(3) Land Suitability for Perennial Crops

Undulating hills and escarpment slopes are marginally suitable for the cultivation of perennial crops due mainly to the low soil fertility and erodibility.

Terrace soils are also marginally suitable for perennial crops. The low fertility status of the soils is the main limitation. The poor to very poor drainage conditions are the other limitation for the Gleisols.

Alluvial soils are moderately suitable for the cultivation of the perennial crops. The low soil fertility, the erodibility and the somewhat poor drainage condition are moderate limitations.

2.2.6 Geology and Soil Mechanics

(1) Regional Geology

Sumatra is an island with 1,650 Km length extending from north west to southeast, and belongs to the India-Australian plate. It is located on a part of the Great Sunda Land Plate which covers most of the Southeast area.

Ocean crust of the Indian Ocean which is belonging to the Indian-Australian plate is being subducted along the Sunda trench at the western margin of the Sunda Land plate. Sumatra and its offshore islands make form parallel and close to the Sunda trench. Magma generation is deeply and closely associating with subduction along the Sunda trench and has given rise to the Cenozoic Sumatra volcanic arc. This dominates Sumatra geology and forms the north west extension of Sunda volcanic arc. The oblique approach and subduction of the incoming ocean crust have been producing enormous stress. This stress has been released periodically by dextral fault movement parallel to the plate margin which resulted in the major Sumatra Fault System. The subduction seems to have been taking place intermittently since the late permian.

East of Sumatra is back-arc basin behind volcanic arc where thick sequence of Tertiary sediments accumulated and swampy coastal plain and peneplain are widely spreading at present.

Riau Province is located in the middle-east of Sumatra bordering North Sumatra Province on the north, West Sumatra Province on the west and South Sumatra Province on the south. The province is facing to the Malacca Strait on the north-east and borders on the Barisan Range in the rear. A hilly area parallel with the Barisan Range, so called as Minas Hills, is located at near Duri, through the west of Roakn Kiri River and forms anticline structure of Duri and Kampar.

The geology of the Rokan Kiri River Basin which originates from the Barisan Range consists of mainly tertiary sedimentary rock. The main rocks are mudstone, sandstone, limestone and conglomerate. The surface of the terrace consists of tuffaceous pyroclastic sediments of quaternary pleistocene. The lower reach and swampy areas of the Rokan River consist of alluvial sediments and lower layer is soft sand while surface is back swamp peat.

The regional geology including the project area and its surrounding areas is shown in Fig.2.6.

(2) Geological Features in the Proposed Project Area

i) General

The mountain area where is in the Barisan Range consists of volcanic rock such as hornblende granite and granite formed in the later Paleozoic period or the first Mesozoic period. The hilly area consist of mudstone and sandstone of the Neogene period as a foundation and the terrace consists of tuffaceous clay as a top layer and tuffaceous clay which contains reddish spots in milk-white weathered quartz andesite as a second layer.

There exists weathered Siliceous Limestone of the secondary sediments on the area which located at about 15 Km downstream from Kota Lama in the left side of the Rokan Kiri river and the Quartz changed from Dolomite transformed white-sand layer mixed with gravel surrounds the area above and forms the foundation of back swamp. The area extends from 0° 56' to 1° 01' north latitude and from 103° 59' to 103° 41' east longitude.

According to the field reconnaissance and dutch cone penetration tests, the soil of the area along the both sides of the Rokan Kiri river from the proposed weir site to Kota Lama is covered with Quaternary Pleistocene Tuff clay with 3 to 5 m thick as a top layer and with clay with gravel of the first Pleistocene period in the lower layer. Within 300m from the both sides of the Rokan Kiri river, river sediment gravel is accumulated below the Tuff clay. Sandstone is partly exposed near Kp.Kota Intan and runs to the North and soft sand forms terrace near SP-1. The flat area including the existing plantation area consists of weathered sandstone sediments.

The surface soil of SP-1 and SP-2 areas on the left side of the Rokan Kiri river is clay with 1.0 m thick. The lower layer is composed of sandstone as a foundation.

On the left side of the Rokan Kiri river, reddish clay is distributed within about 15 Km from Kota Lama to the north and weathered limestone and white sand are distributed from the 15 Km point to SPK-F and SPK-G in long and narrow. Swamp peat is distributed in and around SPK-B with 1.0 m to 1.5 m thick.

On the right side of the river, the area is divided into two, i.e. terrace and swamp. Reddish clay of tuff layer is distributed in and around SPK-A and the remaining is covered with thin peat layer of about 0.6 m to 0.8 m thick and sand layer is distribute

below peat.

Fig.2.7 presents surface geological map in the project area.

ii) Proposed weir site

The proposed weir site is located at ancient river bed where the river is meandering now, about 2 Km upstream from Kota Intan. The site is flat and approximate ground elevation is 46 m, while the existing river bed is about EL.42 m. The river gradient is about 1/2,100 at this point. The site is blessed with construction materials such as sand and gravel in the river.

Geologically, the site consists of mudstone of Tertiary Miocene as a foundation and river sediment gravel of Quaternary Pleistocene with thickness of 4.5 m on the above. The surface soil is silty sand of Quaternary Pleistocene with 2 m thick on the axis of the proposed weir.

Ground water is found 1.15 m to 1.50 m below the surface and is the same level with the river water surface. Judging from this, the river sediment gravel layer mentioned above is connected with the existing river bed gravel layer.

Preliminary evaluation for the strength of foundation can be given in accordance with the dutch cone penetration tests. The cohesion of the silty sand of the surface layer is estimated at C=5.0 t/m^2. This value derives bearing capacity of the foundation can be expected as 7.5 t/m^2.

The second layer of river sediment gravel for the structural foundation is stable foundation showing N-value of 11 to 50. The diameters of the gravel are 2 mm to 40 mm including much andesite with the maximum size of about 100 mm. According to the field permeability tests, permeability coefficient of this layer is Kf=10^{-3} to 10^{-4} cm/sec, i.e. pervious layer.

N-values of mudstone for the base foundation shows more than 50. The layer is more than 10 m thick and impervious. Compressive strength of this mudstone may indicate between quf=20 and 30 kgf/cm^2 and it is classified as Soft Rock.

Fig.2.8 shows Geological column section at the proposed weir site.

iii) Canal foundation

The head reach, from intake of diversion weir to Kota Lama, will be excavated canal on Tuff Clay. This offers no problems against bearing capacity and permeability.

A canal along SP-1 to Sp-3 will be excavated and/or embankment canal. The soil along this canal has no problems as a foundation while this is weak against erosion. Therefore, it is necessary to be lined.

A canal on white sand up to SKP-B through SKP-F and SKP-G has also no problem as foundation, while lining is required. Embankment material can be obtained from hilly area with reddish clay near Kota Lama.

Since the bearing capacity of swamp area is qa=2 to 3 t/m^2, foundation settlement by embankment is expected. The thickness, however, is 0.8 m to 1.5 m so, embankment works can be carried out by applying replacement method or compulsory consolidation method.

A canal on the right bank of the Rokan Kiri river will be constructed on swamp mainly. Since the thickness is 0.6 m to 0.8 m, however, this matter offers no problem to embankment work. The reddish clay found near SKP-A can be used as embankment material.

2.3 Socioeconomic Situation

2.3.1 Administrative Division

The Project Area administratively consists of twelve (12) villages, of which eleven (11) villages belong to Kunto Darusalam sub-district (kecamatan) and only one village (SKP-B) belongs to Kepenuhan sub-district in Kampar District. Kecamatan centre of Kunto Darusalam subdistrict is located at Kota Lama village, and that of Kepenuhan subdistrict is located at Kota Tengah village. Kota Tengah village is sutuated out of the Project Area.

The villages in the Project Area can be classified into the following three categories (refer to Table 2.2).

(a) Old villages: The villages falling under this category are Pagaran Tapah, Kota Lama, Kota Intan, Teluk Sono and Muara Dilam. All these villages belong to Kunto Darusalam sub-district.

(b) New villages: Villages falling under this category are Kota Baru, Kota Raya and Muara Jaya. These villages were transferred in 1991 from the Ministry of Transmigration to the Provincial Government to belong to Kunto Darusalam sub-district. At the time of 1990 Population Census, these villages were classified as transmigration villages belonging to Kepenuhan sub-district.

(c) Transmigration villages which are still administered by the Transmigration office. Villages falling under this category are SKP-A, SKP-B, SKP-F and SKP-G. Of these villages, SKP-B is supposed to belong to Kepenuhan sub-district. All other villages belong to Kunto Darusalam sub-district. Socioeconomic conditions of Transmigration villages including population, origin, market, social infrastructure, household effects, etc. are tabulated in Table 2.3.

2.3.2 Population and Labour Force

The total population of the Project Area is estimated at 22,567 in 1990, of which population in the old villages accounts for 12,040 or 53.4% of the total population and that of new and

transmigration villages accounts for 10,527 or 46.6% of the total population (refer to Table 2.2). About 80% of transmigrants came from West, Central and East Jawa, and the remaining include local transmigrants from Kampar District.

The working age population, i.e. population of 10 years old and over, is estimated at 16,251 or 72 % of the total population as shown in Table 2.4. Assuming that about 90 % of the working age population are economically active, the labour force in the Proejct Area is estimated at 14,625 persons.

Main economic activity is agriculture in the Project Area. In old villages, the major activities are small trading, shifting cultivation, rubber plantation and fish catch. On the other hand, in new and transmigration villages, the major activities are farming of food crops and casual labour employment in a large scale plantation.

2.3.3 Land Tenure

Land ownership in the Project Area may be classified into national land, private land, and customary (adat) land. Most of forest land are classified as the national land, accounting for about 64.5% of the total land area. The land title certificates are to be given to the transmigrants who have stayed in their land for more than five (5) years. Their land can be classified as private land. In the case of the residents in old villages, the land ownership is secured under the customary (adat) law.

In the Project Area, the land owners (owner non-tillers and owner tillers combined) accounted for 80.2% of the total households in 1991. The rest included non-owner tillers or tenancy cultivators (2.1%), landless farm labours (0.7%) and others (16.9%) (refer to Table 2.5).

2.3.4 Social Infrastructure

1) Road

The provincial road from Rantau Berangin(15 Km west of Bankinang) to Sibubuhan in North Sumatra via Ujung Batu where located about 20 Km from Kotal Lama is an asphalt road and nearest main road to the project area. From Ujung Batu, regional road which is partly asphalt paved runs to Kota Lama, the entrance of the

irrigable area. Two(2) transmigration roads extend to both the left and right sides of the Rokan Kiri river in the irribale area. The existing villages including transmigrants in the area exist along these transmigration roads.

2) Domestic water

No public water supply system is found in the area, whereas design of water supply facilities for Kota Lama has been completed. The local people takes water from shallow wells in the area.

3) Electricity

The PLN generating facility with 3 nos. of 300 KW was installed at Ujung Batu in 1984. The local electric supply is found in Kota Lama, while, private generators are found in a few houses in the irrigable area.

2.3.5 Income

Based on the data from the Farm Economy Survey in 1992, the average household income (before deducting living expenses) of the typical farm household in the Project Area is estimated at Rp 1,013,957 (US$504) which correspond to per capita income of Rp 229,402 (US$114). Out of the total income, approximately 55% are derived from farm activities and the remaining 45% from such off-farm activities as small trading, working in the palm oil plantation and working in other sectors (e.g. construction labours). (Refer to Table 2.6)

As shown in Tables 2.7 to 2.9, the old villages have the highest average household income of Rp 1,292,750 (US$643), followed by new villages with Rp 953,899 (US$474) and transmigration villages with Rp 953,260 (US$474).

Household income analysis shows that the residents in the Project Area, mostly farmers, tend to seek off-farm employment on estates (oil palm plantation) in and around the Project Area due to low returns from farm activities. The low returns from farm activities are due mainly to low productivity of agricultural products which are grown on un-irrigated dryland.

2.4 Land Use and Agricultural Situation

2.4.1 Present Land Use

The present land use/vegetation map of the survey area is shown in Fig.2.9. Table 2.10 shows the acreage and the proportional extent of each category in the survey area.

Primary forests are the thick tropical rain forests with fully developed stratification. The first layer is composed of large trees about 30-35 m in height with discontinued canopy surface. While, thickly populated trees about 20 m in height with continued canopy surface constitute the second and/or third layer. Under these tree layers, usually, bush and floor layers are existing. These forests occupies more than 40% of the survey area.

Secondary forests, on the other hand, have been established after certain human activities and the average tree height is about 10-20 m. These forests are composed of pioneer species and are densely populated with very flat canopy layer. They are clearly distinguished from primary forests and are mainly distributed around the river course of Rokan Kiri. A part of these forests is being utilized for the small scale plantation of rubber plants. These areas are mainly distributed around original villages such as Kota Lama and Kota Intan.

Bush/grass lands are distributed near the river course, around the road systems and the periphery of transmigration areas. A part of this area is also categorized as the small scale plantation area of young rubber trees. These areas are mainly distributed around the original villages and also around the new villages such as Kota Baru, Kota Raya and Muara Jaya.

Alang-alang lands can intensively be found at the periphery of the developed area for transmigration activities. These lands can be considered to have been formed through abandonment of the field once cleared for transmigration activities and also for shifting cultivation.

Farm lands are mainly utilized for the cultivation of upland crops. These fields are found in both the river course and transmigration areas. The main upland crop is dry land rice and the other crops such as maize, peanut and soybean are also cultivated. Wet land rice have been cultivated within a very

limited area mainly at Kota Intan, SKP-A and Kota Raya

Plantation areas are distributed in the southern fringes of the survey area mostly on the undulating hills. Oil palms are mainly cultivated under large scale commercial plantation.

Residential areas are the transmigration areas and the original villages such as Kota Lama, Kota Intan and Muara Dilam. Within the residential area, about 800 ha are utilized for gardens around the houses. Of those, the area about 275 ha is utilized for the cultivation of vegetable crops such as sweet potato, cassava, green beans and others. The remaining areas are mainly utilized for the cultivation of tree crops such as coconut, coffee and clove.

2.4.2 Irrigation and Drainage

The rain-fed paddy is being cultivated within a very limited areas mainly at SKP-A in the right side of the river. No irrigation system is found in the irrigable area at present.

The irrigable area is comparatively flat. In addition to this condition, cross section of the small rivers which are flowing to the Rokan Kiri river through the irrigable area are not enough to evacuate the flood water.

In the transmigration settlement areas, people suffers from perennial inundation due to poor drainage. It may be caused by insufficient of capacity of the drainage canals. These canals have been aligned in sudden change of flow direction and in insufficient canal slope. Drainage in the transmigration areas is not affected by the water level of the Rokan Kiri river during rainy season.

2.4.3 Crop Production

The major crops in the Project Area are both wet and upland rice, maize, cassava, sweet potato, peanut, green beans, soybean, vegetables, and chili. Production statistics according to the Agricultural Extension Office of Kunto Darussalam and Kepenuhan Sub-districts are summarized as below;

Summary of Agricultural Production in the Project Area

	Area(Ha)	Yield(t/Ha)	Prod'tn(t)
1990 Apr.-Sep., Wet Season Cropping			
Wet land rice	27.0	2.3	62.8
Upland rice	1,238.8	1.1	1,408.9
Maize	47.8	1.9	91.1
Cassava	45.4	16.7	711.4
Sweet potato	155.4	1.7	258.2
Peanut	40.5	0.8	30.8
Mung bean	27.2	0.6	17.1
Soybean	115.4	0.7	77.7
Vegetables	47.4	0.7	35.3
Chili	32.9	1.1	36.5
Total	1,777.8		
1990/1991 Oct.-Mar., Dry Season Cropping			
Wet land rice	44.0	2.3	102.1
Upland rice	67.5	0.8	55.6
Maize	78.0	2.0	154.5
Cassava	77.0	15.4	1,182.0
Sweet potato	10.0	7.9	79.0
Peanut	27.0	0.8	20.6
Mung bean	19.0	0.7	13.2
Soybean	246.5	0.9	218.2
Vegetables	72.0	0.8	56.6
Chili	20.5	1.5	30.3
Total	661.5		

Source : Program Penyuluhan Pertanian 1991/1992, BPP, Kota Lama and Agricultural Statistics of Kec. Kepunuhan 1991

The yield of all crops in the Project Area is lower than that of the Objective Area, namely wet land rice yield is 2.3 t/ha in the Project Area and 3.6 t/ha in the Objective Area and soybean's yield is 0.7-0.9 t/ha in the Project Area and 1.25 t/ha in the Objective Area. These low yields are probably caused by low technology level, unstable natural factors and low availability of farm inputs.

Farm Economy Survey was conducted in order to grasp the accurate figures of agricultural production in the Project Area. Since this survey has been conducted through detailed interview survey of 150 samples, it seems reasonable to conclude that these figures represent the present agricultural condition in the Project Area. The present crop yields are 3.1 t/ha for irrigated rice, 0.8 t/ha for wet land rice, 0.9 t/ha for upland rice, 0.7 t/ha for soybean, 0.6 t/ha for peanut, 0.9 t/ha for maize, 9.0

t/ha for cassava, 0.4 t/ha for chili, and 0.4 t/ha for mung bean.

On the basis of the crop yields above, the present agricultural production in the Project Area is estimated as shown in Table 2.11. In this table rubber which is widely planted and for which the planted area is rapidly increasing has been included. In addition some crops which are assumed to be cultivated mainly in home yards are excluded from the table.

The cropping intensity under these conditions is estimated at 125 %, provided that the present farming land is 1,905 ha in total including rubber planted area.

2.4.4 Cropping Patterns and Farming Practices

According to Farm Economy Survey the present cropping pattern, and farm inputs and labour requirement are shown in Fig. 2.10 and Table 2.12, respectively.

Wet land rice

Cultivation of wet land rice area is very limited due to the low level of land reclamation and the productivity of the same is as low as 0.8 t/ha. In Kota Intan rice cultivation shows high productivity, namely 3.1 t/ha in the rainy season because of semi-technical irrigation system.

Cropping seasons are twice during the year. One is wet season cropping, namely starting land preparation in July, transplanting in August/September and harvesting in December/January. The other is dry season cropping, namely starting land preparation in January/February, transplanting in February/March and harvesting in June/July. High Yielding Variety(HYV) is commonly utilized and local varieties rarely cultivated. Land preparation is mostly done by hand and farm mechanization has not yet began. However, draft animal ploughing is being extended by the effort of the livestock office and IFAD. Farm inputs are still at a minimal level. Labour source is usually family labour. At the peak time of labour demand, labour is supplied by communal work, called Gotong Royong.

Dry land rice

Upland paddy is widely planted. Planted area is 1,239 ha in the wet season (July to December/January) and 68 ha in the dry season

(February/March to June/July) 1990/1991. Draft animal ploughing is often used for land preparation in the three new villages of Kota Baru, Kota Raya and Muara Jaya, and manual ploughing in other areas. Direct seeding method is used with HYV. Cultivation of local varieties is rarely seen.

Palawija crops (secondary crops)

The most important palawija crop is soybean, especially in SKP F and SKP G under UPSUS Programme (the government's technical support programme of fertilizer and leguminous bacteria). The planted area of soybean is more than that of both wet land and upland rice in dry season cropping. Yield is 0.7 t/ha which is relatively low. Fertilizer is usually used and inoculation with rhizobium is practiced for nitrogen fixation.

Other crops are sweet potato, maize, vegetables, cassava, peanut, chili and mung bean in descending order of size of planted area as of the cropping season of October/March, 1990. The yields of these crops are generally low.

Plantation crops

Cultivation of small scale plantation crops, of which the major ones are rubber, coconut, coffee and clove, is gradually increasing. The most important plantation crop is rubber and the harvested area and yield are 275 ha and 0.8 ton of unsmoked latex respectively (refer to Table 2.13). In the new villages the planted area of rubber is increasing, namely by 160 ha in 1991.

2.4.5 Prices of Farm Inputs and Outputs

Farm gate prices of farm inputs and outputs as of March 1992 in the Project Area were estimated on the basis of data obtained from Provincial Agriculture Service Office (Dinas Pertanian Tanaman Pangan), Provincial Logistics Depot (DOLOG) and P.T. Pertani. Survey results of the Farm Economy Survey were also taken into consideration.

Future farm gate prices of farm inputs and outputs in the year 2000 were also estimated on the basis of the commodity price projections prepared by the World Bank. Some of the commodity prices which were not contained in the commodity price projections were assumed to be the same price level with the present market prices.

The estimated prices of farm inputs and outputs at the present and future market prices are presented in Table 2.14.

2.4.6 Processing and Storage Facilities

There are 4 rice milling units and 9 Engelberg milling units in Kunto Darusalam and Kepenuhan sub-districts (refer to Table 2.7 of ANNEX-E in Volume II). It is roughly estimated from these figures that the combined capacity of rice milling units in the Project Area is approximately 1,800 tons per year.

Agricultural production in the Project Area is considered to be at subsistence level without any significant surplus for marketing. Therefore it is concluded that there is little demand for storage facilities of agricultural products. Any surplus of agricultural products in the Project Area are usually stored in farmers' houses.

2.4.7 Profitability of Crops

Crop budgets of major food crops grown in the Project Area have been prepared on the basis of the results of the Farm Economy Survey and field interviews with farmers made by the Study Team as shown in Table 2.15(1) and 2.15(2).

Main crop grown in the Project Area is upland paddy, accounting for about 61 % of the total area harvested. In spite of the farmers' efforts to increase the production, productivity of upland paddy remains at low level (901 kg per ha). Productivity of other food crops are in general low compared to that of other regions. The low productivity results in low profitability of crops as shown in the above tables.

Irrigated agriculture is conducted at Kota Intan village on a small scale, producing 3.1 tons of paddy per ha with gross margin of Rp 892,200. Paddy production under irrigated field is more than 3.5 times that of lowland paddy, resulting in gross margin of more than 4.7 times that of lowland paddy.

Other important food crops grown in the Project Area include palawija crops such as soybean, maize, and groundnut. Soybean is the most important palawija crops, accounting for about 17 % of the total area harvested of food crops in 1990. Among these crops, groundnut has shown the highest profitability with gross margin of Rp 340,100.

From the viewpoint of crop profitability, increase in the production of paddy is considered to be the most important factor for improving the standard of living of the farmers in the Project Area. In addition, increase in the production of palawija crops such as groundnut, soybean, and maize is also necessary.

2.4.8 Farm Budget

The farm budget of a typical farm in the Project Area has been prepared on the basis of data obtained from the Farm Economy Survey and field interviews made by the Study Team (refer to Table 2.16).

Based on the farm budget as shown in Table 2.16, farm economy in the Project Area is summarized as follows.

(a) Income source consists of about 58 % of farm income (crop and non-crop income) and about 42 % of off-farm income such as small trading, working in the estates (e.g. oil palm plantation) and working in other sectors.

(b) Out of farm income, crop income accounts for 52% and the remaining 48% include non-crop income from smallholder plantation (rubber and coconut), livestock and fishery. Although 2.0 ha of land are given to each transmigrant family, all the land are not available for their farm activities. The low availability of agricultural land is due mainly to delay of land reclamation in the second arable land (Lahan Usaha II).

(c) Although the bulk of crop income is derived from paddy, the production is still at its subsistence level due to

low productivity. The production of palawija crops is also at its subsistence level.

(d) Off-farm income source consists of small trading, working in the oil palm plantation and working in other sectors, accounting for about 43 % of the gross income. More than 50 % of off-farm income are derived from off-farm works in the nearby oil palm plantations.

2.4.9 Farmer Attitudes Regarding to Irrigation Development

The farmer attitudes regarding to the proposed irrigation development is positive and encouraging. 88 % of the farmers expressed their willingness to join the irrigation scheme. The remaining 12 % of farm households do not think that irrigation is urgently needed, or otherwise, they do not understand the benefit generated by irrigation.
94 % of farmers are willing to pay the irrigation fee of Rp 1,000 to 50,000 per hectare per year. The mean and median of this amount which farmers are willing to pay is Rp 8,685 and Rp 6,500, respectively.

The farmers are ready to provide land for the irrigation facilities, unless such land is very productive with tree crops, or such land that needs to be provided is very large in size. In these cases appropriate compensation is essential by "land for land" or "cash for land" basis.

When the irrigation system is ready, farmers are willing to intensify their farming together with introduction of modern farming technology and more farm inputs. For the transmigrants this intensified farming system itself well accords with their original aspirations and purpose for transmigration to this area.

2.5 Agroeconomic Situation

2.5.1 Agroeconomic Features

(1) Farm Population

Out of 5,111 households in the Project Area, the farm households account for 3,968 or 77.6% of the total households. With average family size of 4.42 persons per household, total farm population is estimated at 17,221 (refer to Table 2.2). The working age population (10 years old and over) of these farm households is estimated at 12,399 or 72% of the total farm population. Assuming that about 90 % of the working age population are economically active, the labour force at each farm household is estimated at 2.8 on the average.

(2) Farm Size

Land holding size in new villages and transmigration villages is almost the same, i.e. 2.0 ha per household which consist of 0.25 ha of home yard, 1.0 ha of first arable land (Lahan Usaha I) and 0.75 ha of second arable land (Lahan Usaha II). However, these land are not fully utilized for farm activities as most of second arable land are located in the forest area, where land reclamation has not been completed yet.

Based on the results of the Farm Economy Survey, average size of operational land (farm size) is estimated at 0.88 ha with average cropping intensity of 125 %.

2.5.2 Agricultural Supporting Services

(1) Extension Services

Out of twelve (12) villages in the Project Area, ten (10) villages are presently receiving agricultural extension services provided by BPP Kota Lama. Although BPP Kota Lama is staffed with eleven (11) PPLs, no PPL is available for Teluk Sono village. SKP-B belong to the working area of BPP Kota Tengah. However, it is reported that the visit of a PPL to SKP-B has been irregular which is partly due to its remoteness from BPP office. It is recommended, therefore, that SKP-B should be served under the working area of BPP Kota Lama in the future.

(2) Cooperatives

Out of twelve (12) villages in the Project Area, nine (9) villages have a KUD (agricultural cooperative) in each village. These KUDs members total 1,950 or 61.4% of the total farmer groups members. KUDs in the new villages have the highest participation ratio of 82.7%, followed by the transmigration villages with participation ratio of 68.9%. Original villages have the lowest participation ratio with only 21.7% (refer to Table 2.17).

Although KUDs are expected to become a strong economic base for farmers in rural areas, activities of KUDs have generally been unsatisfactory. As clearly stated in the Farm Economy Survey report, KUDs in the sample villages were not active in conducting its activities such as purchase of farm outputs, sale of farm inputs and provision of farm credit. The reasons for unsatisfactory performance of the KUDs are due partly to lack of experience in management and partly to small amount of transaction because of low agricultural production level.

(3) Agricultural Credit

For the needs of farmers who are members of KUD, working capital for farming activities is provided by BRI through KUD under the Farming Credit System (Kredit Usaha Tani). As there is no BRI office in the Project Area, the farmers in need of farming credit have to contact BRI Unit Desa office at Ujung Batu, located approximately 24km south of Kota Lama village. However, no lending to the farmers in the Project Area has been recorded at this office in 1991.

(4) Farm Input Supply

The need for farm input supply such as certified seed, fertilizers and pesticides is not readily available in the Project Area. KUDs are not active in supplying farm input and there is no private shop in the villages in selling those inputs. The farmers have to obtain farm inputs, especially fertilizers, through private shops in Ujung Batu, approximately 24 km south of Kota Lama village.

In the case of transmigration villages, assistance of providing farm input to transmigrant farmers is available for three (3) years after their settlements under the sponsored transmigration program.

2.5.3 Farmers' Organizations

Basic unit of farmers' organizations is called the farmer group (kelompok tani), each consisting of approximately 30 farmers. There are 113 farmer groups in the Project Area with a total members of 3,174. Farmer groups in the Project Area are generally not well developed. Out of 99 farmer groups within the working areas of BPP Kota Lama, 26 groups (26%) are classified as the beginning level (pemula) farmer groups. These "pemula" level groups are located in Kota Intan, Kota Baru and Muara Jaya villages. There are no advanced (Lanjut), semi-prime (Madya) nor prime (Utama) level farmer groups in the Project Area.

In the area where irrigation facilities are available, farmer groups are usually to be converted into water users associations (WUAs) to ensure sustained operation and maintenance of the completed on-farm irrigation facilities. It has been the policy of the Government that O&M of the tertiary and on-farm facilities is the responsibility of the farmers through the WUAs.

There is only one WUA at Kota Intan in the Project Area. The WUA at Kota Intan has 82 members with about 64 ha of irrigable area. Out of the 64 ha, however, it is reported that only about 10ha are presently functional for irrigation.

2.5.4 Land Reclamation

The organizational and financial responsibility for tertiary systems and on-farm land irrigation development was always completely with the farmers. In order to assist farmers in regard to land development, the Government initiated a Land Development (Pencetakan Sawah) Program in 1979/80 which was intended to assist farmers in developing land with irrigation potential and bringing such land as quickly and efficiently as possible under irrigation command. The implementation of the Program was assigned to the Directorate of Agriculture Area Development (DAAD) of the Directorate General of Food Crops (DGFCA) of the Ministry of Agriculture.

In the Project Area, land development of about 35 ha has been carried out in Kota Intan under the Food Crops Intensification Project supervised by the field implementation unit (UPP) of the Land Development Section of the Provincial Agriculture Service. Under this project, land clearing and levelling have been conducted by the field implementation unit and construction of

tertiary systems and on-farm land irrigation development has been carried out by the farmers. The cost for land development ranged from Rp 400,000 to 500,000 per ha.

2.6 Environment

As discussed in the Chapter 2.4.1, about 42 % of the gross area is occupied by natural forest. On the other hand, the Indonesian Government has been fixed the classification of forest, namely conservation forest, protected forest, limited production forest, fixed production forest and conversion forest taking into account the regional conditions. The gross area is situated in the conversion forest in which any development project is restricted for land use.

The local people in the area sometime shifts their residents to look for a suitable land for cultivation due to lack of irrigation system. In order to avoid disorderly individual development, systematic irrigation system is expected in the area to conserve the natural resources.

3. The Project

3.1 Approach to the Project

3.1.1 Objectives of the Project

The Lower Rokan Kiri irrigation project was formulated under the framework of the Rokan River Basin Overall Irrigation Development Plan Study which is presented in Volume II "Overall Irrigation Development Study for Rokan River Basin".

Based on the basic direction of irrigation development study, the objectives of the Lower Rokan Kiri irrigation project are set up as follows;

(i) To stabilize livelihood of the transmigrants who have already settled and local people in the area by supplying irrigation water as well as by draining excess water.

(ii) To contribute to the regional need to increase rice production with the aim of achieving self-sufficiency rice in Riau Province.

(iii) To support the Government's settlement program by providing irrigation and drainage facilities for transmigrants and local farmers to be settled.

The transmigration program has played an important role in sparsely populated area in outer island for agricultural development and contributed in the regional development.

The local farmers of 1,216 families composed of three(3) villages (Muara Dilam, Teluk Sono and Kota Lama) and transmigrants of 1,120 families composed of four(4) unit(SKP-A, SKP-B, SKP-F and SKP-G) have settled in the gross area.

The project should aim to maximize the potential agricultural benefits through efficient use of the available land and water resources and to establish the rice production base according to the Governor's instruction. For increasing rice production, the following items should be increased;

(i) The unit yields of paddy
(ii) The annual cropping intensity of paddy
(iii) The area of paddy fields as much as possible

For this purpose, the following should be implemented as soon as possible;

a. Construction of systematic irrigation facilities
b. Improvement of drainage conditions by introducing drainage facilities
c. Development of paddy field and farmland in the area
d. Coordination to the new transmigration plan in the area to be newly developed
e. Introduction of operation and maintenance facilities to the area
f. Arrangement of agricultural support services and organization
g. Construction of related social infrastructure

3.1.2 Factors for Delineation of the Project Area to be Developed

In the delineation of the development area, the following factors are taken into consideration.

1) Location and intake water level of weir
2) Possible intake discharge and water requirement
3) Land suitability classification
4) Number of household of farmers, allocated area and land use plan

Based on the results of surveys in the field and study and analysis concerning the various fields, the estimates of the gross area of the project are made based on the following conditions;

1) Location of headwork

In planning new irrigation development areas, gravity irrigation system without a reservoir is regarded as the given condition. To decide approximate location of water source facilities, the following considerations are given to the first factor:

- To select approximate locations of water source facilities presupposing elevation and location of the highest part of potential irrigation areas, and

- To regard a confluence of rivers as an important location where economical runoff can be collected.

2) Intake water level

The intake water level was estimated by presupposing the location and elevation of the highest part of the potential irrigation area, and by considering the extent of inundation after completion of the headwork.

As for the inundation area, rise of water level will be accommodated in the present river reservation cross section in the case when appropriate intake water level is employed.

3) Drainage

The irrigable area is comparatively flat. In addition to this condition, cross sections of the small rivers which are flowing through the irrigable area are not enough to evacuate the flood water.

In the transmigration settlement areas, people suffers from perennial inundation due to poor drainage. According to survey, the cross sections of the drainage canals are insufficient to release water. These canals have been aligned in sudden change of flow direction and in insufficient canal slope. Drainage in the transmigration areas is not affected by the water level of the Rokan Kiri river during rainy season.

4) Irrigable area

The irrigable area is delineated on the detailed topographical maps of scale 1:5,000 by reference to the physical boundaries such as roads, small rivers, local depressions, ridge terrains, and extent of river reservation zone and soil and land suitability survey.

5) Water source

The discharge of the Rokan Kiri river is abundant. Thus, a year-round reliable supply of irrigation water can be expected.

The maximum command area by the use of the Rokan Kiri river to meet the irrigation demand of the proposed cropping patterns including paddy and palawija is estimated at 40,000 ha through water balance study.

3.1.3 Approach to a Development Plan

1) Basic Concept of Development Plan

The project area to be developed is rich in land and water resources. About 90% of the area is estimated to be suitable for paddy farming and water availability for irrigation is about 40,000 ha. Therefore, the area has high potential for the irrigation development. The existing households including transmigrants are 2,336 families now.

Taking the present condition mentioned above, the following three(3) alternative development plans are considered as a basic concept.

Plan-1 : Irrigation and drainage facilities are to be provided for the existing transmigrants and local farmers.

Plan-2 : Irrigation and drainage facilities are to be provided for the existing transmigration and local farmer plus new transmigrants settled along the upstream of left and right main canals in the Plan-1 above.

Plan-3 : The area is to be fully developed as much as land and water available.

The development area of the study for each plan is formulated as follow;

Plan	Location	Gross Area (ha)	Net Irrigable Area (ha)
Plan-1	Left side	4,512	3,445
	Right side	1,068	915
	Total	5,580	4,360
Plan-2	Left side	8,062	5,485
	Right side	4,138	2,815
	Total	12,200	8,300
Plan-3	Left side	15,400	10,225
	Right side	9,800	6,915
	Total	25,200	17,140

The general plan for each plan is presented in Fig.3.1. to Fig.3.3.

Among three(3) plans, the following characteristics can be pointed out;

a) The location of intake weir for each Plan is the same because the irrigable areas for 3 Plans are located on the same gentle slope area and the proposed weir site is fixed from the topographical view point.

b) In case of Plan-1, the slope of canal profile becomes steeper than these for Plan-2 and Plan-3 because of less canal discharge. Therefore, intake water level for Plan-1 is not so different form that for Plan-2 & 3.

c) The intake water levels for Plan-2 and Plan-3 are the same.

d) The type of weir is gated weir for all Plans. The height of gate is 3.5 m for Plan-1 and 4.3 m for Plan-2 & 3 respectively. By employing the gated weir, no influence of back water is considered during flood.

e) 1/5 non-exceed probable river discharge on the Rokan Kiri river at the proposed weir site is 49.3 m^3/s in minimum, so the irrigation water for three plans with 200%/year can be sufficiently supplied.

f) The number of new settlers under Plan-3, which is the largest among three plans, is about 7,300 families in total, while that of Plan-2 is about 2,250 families. The existing farmers is 2,336 families consisting of 1,216 for transmigrants and 1,120 for local people.

g) From the economical aspect, the priority is given as follows;

Plan-3 > Plan-2 > Plan-1>

From the study above, Plan-2 is finally employed for the project planning because of the following reasons;

1) Although Plan-3 is the top priority from economical view point, huge amount of new transmigrants of about 7,300 families shall be settled. This can be said unrealistic figure.

2) Since the location and scale of intake weir as well as slope of the head reach canal are the same for Plan-2 and Plan-3,

development area can be easily extended from Plan-2 to Plan-3 according the progress of transmigration program.

3) In Plan-2, EIRR is expected to be more than 11 %.

Therefore, the project size under the study is given as follows;

- Irrigable area	: 8,300 ha
- Upland area	: (2,371 ha) included in the irrigable area
- Existing household	: 2,336 KK
- New settlers	: 2,254 KK
- Intake weir	: about 5 Km upstream from Kp. Kotaintan
- Weir height (gate)	: 4.3 m
- Length of weir	: 24m x 4nos + 5m x 2nos = 106m
- Flood discharge(1/100)	: 2,200 m^3/s

COMPARISON OF STRUCTURAL PLAN

Item	Plan-1	Plan-2	Plan-3
Gross area	5,580 ha	12,200 ha	25,200 ha
Net irrigable area	4,360 ha	8,300 ha	17,140 ha
Upland	(1,246 ha)	(2,371 ha)	(4,897 ha)
Existing transmigrants	1,120 KK	1,120 KK	1,216 KK
Local people	1,216 KK	1,216 KK	1,120 KK
New settlers	-	2,254 KK	7,305 KK
Distributed land			
Homeyard	0.25 ha	0.25 ha	0.25 ha
Paddy field	1.75 ha	1.75 ha	1.75 ha
Upland field	(0.50 ha)	(0.50 ha)	(0.50 ha)
Water source	Rokan Kiri river	Rokan Kiri river	Rokan Kiri river
Intake facility	Gated weir	Gated weir	Gated weir
Catchment area	3,267 Km2	3,267 Km2	3,267 Km2
Location of weir	Approximate 5 Km upstream from Kp. Kotaintan		
Elevation of river bed	EL.41.7 m	EL.41.7 m	EL.41.7 m
Height of weir(gate)	3.5 m	4.3 m	4.3 m
Elevation of crest	EL.45.2 m	EL.46.0 m	EL.46.0 m
Length of flood gate	24mx4nos=96 m	24mx4nos=96 m	24mx4nos=96 m
Length of sand flush gate	5mx2nos=10 m	5mx2nos=10 m	5mx2nos=10 m
Max. water requirement			
For first paddy	1.16 l/s/ha	1.16 l/s/ha	1.16 l/s/ha
For seconf paddy	1.58 l/s/ha	1.58 l/s/ha	1.58 l/s/ha
PLanning intake discharge	4.92 m3/s	9.35 m3/s	19.34 m3/s
Intake water level	EL.45.1 m	EL.45.9 m	EL.45.9 m
Flood discharge (1/100)	2,200 m3/s	2,200 m3/s	2,200 m3/s
Head reach canal	13.0 Km	13.0 Km	13.0 Km
Main canal, left	16.1 Km	16.1 Km	16.1 Km
" , right	16.7 Km	19.1 Km	19.1 Km
Cecondary canal, left	19.4 Km	24.3 km	67.1 Km
" , right	2.2 Km	5.2 Km	38.0 Km
Tertiary system, left	3,445 ha	5,485 ha	10,225 ha
" , right	915 ha	2,815 ha	6,915 ha
Drainage canal, left	23.3 Km	38.3 Km	58.6 Km
" , right	10.0 Km	17.9 Km	17.9 Km
Access road	2.5 Km	2.5 Km	25.0 Km

COMPARISON OF APPROXIMATE PROJECT COST

Unit : Million Rp.

Item	Plan-1	Plan-2	Plan-3
1. Preparatory work	2,996	2,351	6,424
2. Main civil works	51,456	65,303	104,098
2.1 Access road	590	590	5,900
2.2 Head works	17,416	19,351	19,351
2.3 Head reach canal	6,653	8,316	12,474
2.4 Main irrig. system(Left)	11,442	12,220	23,196
2.5 Main irrig. system(Right)	4,727	5,745	10,151
2.6 Dranage system	5,363	9,059	12,329
2.7 Tertiary system	5,265	10,022	20,697
3. O & M Facilities	1,249	1,633	2,677
4. Land acquisition cost	852	888	1,350
5. Administrative cost	1,250	1,698	2,679
6. Engineering services	4,777	5,224	6,536
Sub-total	62,580	77,079	123,764
7. Contingency	3,129	4,049	6,188
Total	65,709	81,146	129,952
Farm size (paddy+upland)	4,360 ha	8,300 ha	17,140 ha
Index of project cost	0.81	1.00	1.60
Project cost per ha. by farm size (Mill. Rp./ha)	15.07	9.78	7.58
Approximate EIRR	7.8 %	12.0 %	15.3 %

3.2 Agricultural Development Plan

3.2.1 Proposed Land Use

According to the information on soil condition, present land use condition and other physical and social factors, the following points have been taken into consideration for the formulation of a rationalized land use plan.

- The land near the edge of the terraces and on the escarpment slopes (Soil Mapping Unit 2) should be protected from soil erosion by conserving the existing vegetation cover.

- Priority should be given to the alluvial plains (Soil Mapping Unit 5) as a potential area for the agricultural development due to its rather high suitability to the crop production.

- According to the result of the present land use, the primary forests occupy more than 40% of the survey area. Although these primary forests belong to the conversion forest which could be utilized for agriculture, they play very important roles in the environment. Furthermore, these forests provide the inhabitants with a considerable amount of fuel wood for their cooking and other purposes. The effective conservation of these forest resources should therefore be considered very carefully.

- The area of Bush/Grass Lands and Alang-alang Lands should selectively be converted to a potential area for agricultural development due to their easy accessibility.

Accordingly, the gross area to be developed as a first stage was designated as shown in Fig. 3.4. The future land use plan of the gross area has been proposed by taking the existing settlements and new transmigration program into account. The land allocation has been designed according to the following basis;

- Net irrigation area per 1 H/H : 1.75 ha
- Residential area including home yard per 1 H/H : 0.25 ha
- Public area per 1 H/H : 0.25 ha
- Right of Way : 5 % of the total of above 3 items

Table 3.1 shows the proposed land allocation in the gross area.

The land of 2,643 ha was allocated for the total of 1,120 H/H in the existing transmigration area. The land was also allocated for the people in Teluk Sono and Muara Dilam based on the same principle. For the people form Kota Lama and Kota Intan, however, the village areas (residential area and public area) were excluded. The new transmigration programme should consequently be planned for the total of 2,254 H/H to be allocated in the area of 5,320 ha which is about 44 % of the gross area.

Table 3.2 shows the comparison between the present land use and the proposed land use. The net irrigable area is 8,300 ha in total which will mainly be availed for paddy and upland crop cultivation. The area which is currently not suitable for the crop cultivation will be protected against soil erosion by maintaining the present vegetation cover. The village areas for the new villages will be developed according to the new transmigration programme. The existing village areas will also be developed by expanding the home yard and public spaces as per above mentioned principle.

3.2.2 Proposed Crops

Following the policy and strategy of agricultural development in the Project Area, It seems reasonable and appropriate to select rice as a main crop and soybean and peanut as palawija crops in both the wet and dry season under irrigation condition. This crop selection well accords with the SUPRA INSUS which is the national super intensification programme in irrigated area. Soybean and peanut are also advantageous from the viewpoint of soil fertility, profitability, marketability, and nutrition. Soybean and peanut, however, may be affected by injury through continuous cropping. In order to avoid this injury, the rotation of irrigated paddy and upland crops is essential and useful.

From the viewpoint of profitability, vegetables of solanaceae and cucurbitaceae families are promising but it may not be possible to produce these in large scale due to available labour force and market limitation.

3.2.3 Proposed Cropping Pattern

In SUPRA INSUS a cropping intensity of more than 200 % is proposed as the technical package. However, the present

mechanization level is still initial and population pressure is low, thus the practical cropping intensity seems to be 200 %.

The propposed cropping pattern shown in Fig.3.5 has been proposed as the most appropriate pattern on the basis of the study of the present cropping pattern, the recommendation by the Dinas Pertanian Riau, the cropping pattern of similar projects, irrigation water availability, various aspects of agronomic factors and profitability. Wet season rice cropping starts with sowing in October/November and is harvested in February/March. Rice cultivation in the dry season is from March/April to July/September. As for palawija, wet season cropping starts with land preparation in November/December and is harvested in February/March. Cultivation of dry season palawija is from April/March to July/August.

It is expected that cropping intensity will be raised through farmers effort's to maximize their profitability under the proposed irrigation condition. It is estimated that each farmer will cultivate rice in 70 % of the area of his farm, namely 1.25 ha out of 1.75 ha, and palawija crops on the rest of his farm in both dry and wet seasons. The cropping intensity of this proposed cropping pattern is 200 %.

3.2.4 Proposed Farming Practices and Farm Inputs

Proposed farming practices should be suitable to each area's specific condition, following the recommendation by SUPRA INSUS.

The proposed farming practices are explained as follows (refer to Table 3.3 and the Annex D for detailed information):

(1) Paddy

(i) Variety

High yielding varieties (HYVs) should be essentially adopted and appropriate resistant varieties should be chosen taking pest occurrence into consideration. Present recommended varieties are PB46, PB56, Kelera, Bahbutong etc. On the other hand, commonly planted rice varieties are PB42 and Sentani.

It is important to consider pest resistance, farmers' preference, productivity, etc, in order to determine

the recommendation of rice varieties.

(ii) Seed

Recommended seed amount is 30 kg/ha. Selection by specific gravity of 1.13 should be practiced. Seed disinfection before pregermination should be done and sowing to nursery should be done at the appropriate time.

(iii) Land Preparation

Plowing at least twice with 15 - 20 cm depth and puddling one time ten days before transplanting should be practiced. It is recommended to do these works by oxen.

(iv) Transplanting

Transplanting is done by hand. High density planting of more than 200,000 hills per ha can be materialized with the spacing of 30 cm x 15 cm. Number of plants per hill should be two to three with depth of two to three centimeter.

(v) Fertilizer

Fertilizer application should be planned on the basis of soil type. The standard plan is summarized as follows:

Type	Total amount(kg/ha)	Basal (ratio)	1st top* (ratio)	2nd top** (ratio)
Urea	200	1/3	1/3	1/3
TSP	100	1/1		
Kcl	50	1/3	1/3	1/3

* : 20 days after transplanting
**: Panicle formation stage

Manure use is recommended as much as possible.

(vi) Weeding

Weeding should be manually done at least three times

in one cropping. It is recommended to introduce the rotary weeder.

(vii) Pest Control

As well as herbicide, agrochemical use should be minimized as little as possible with respect to financial and environmental impact. This can be made possible by the introduction of an integrated pest control system. Rat and wild boar should be controlled by regional coordinated work.

(viii) Harvesting and Post-Harvest

It is recommendable to use sickle for harvesting but not Ani-ani. The post-harvest processing of rainy season rice is troublesome and thus the threshing and drying should be completed within a short period. It is, therefore, desired to introduce at least the pedal thresher. As for drying, it is essential to construct communal paved drying yards.

(ix) Water Control and Others

Appropriate water control and management through irrigation facilities is essential to achieve effective results. There are several critical periods when appropriate water control is required. Thus, water control and management should be carefully done at these stages.

(2) Palawija Crops

It is important to cultivate palawija crops from aspects of pedology, integrated pest management, profitability, marketability, diversification of labour requirement and so on.

Recommended palawija crops are soybean and peanut. The detailed farming practice should follow the recommendation of the BPP Kota Lama. Two important points for soybean and peanut cultivation are (a) Inoculation of leguminous bacteris, and (b) Lime application.

The standard farming descriptions recommended by the Agricultural Department of Riau Province are as follows:

	Soybean	Peanut
Variety	Wilis, Dempo, Kerinci	Gajah, Macan Banteng
Planting period	100 days	90 days
Yield	1.8 t/Ha	1.6 t/Ha
Plant density	500,000 plants 20cm x 20cm 2 plants/hill	160,000 plants 25cm x 25cm 1 plant/hill
Inoculation	necessary	necessary

3.2.5 Anticipated Crop Yields and Production

As a result of the studies on the present productivity and other crop production anticipation, the crop yields under the condition of with and without Project are anticipated as follows:

Anticipated Crop Yields

crop	anticipated yield(t/ha)	
	with Project	without Project
Wet season paddy		
irrigated	5.0	3.5
rainfed		0.9
upland		1.0
Dry season paddy		
irrigated	5.5	
rainfed		0.9
upland		1.0
Soybean	1.6	0.7
Peanut	1.8	0.6

The crop yields will reach the anticipated level five years after the completion of project construction accompanied by upgrading of farming technology. The crop production increase is assumed to be linear over five years.

The anticipated crop production under present, without Project, and with Project conditions are shown in Table 3.4 in detail and summarized as below:

Anticipated Crop Production (unit: metric ton)

	Present	without Project	with Project
Paddy	522	581	62,223
Palawija	301	301	7,596

3.2.6 Processing and Storage

Present rice milling capacity is estimated at about 1,800 tons per year. It is expected, however, that total paddy production in the Project Area will amount to approximately 62,200 tons after the implementation of the Project. In this regard, rice milling capacity should be increased in keeping pace with the increased paddy production in the Project Area.

Presently there is not any significant demand for storage facilities of agricultural products in the Project Area due to very low production level in the agriculture sector, particularly in food crops sub-sector. After the implementation of the proposed Project, however, storage facilities for marketable surplus of paddy will be necessary.

In order to meet the requirement for increased rice milling capacity and storage facilities in the future, measures should be taken to promote and strengthen the marketing ability of KUDs. First step will be to strengthen education and training activities for the farmers to improve knowledge and skill in KUD management. The second step will be to provide soft loan for the construction of KUD offices with retail shops. The third step will be provision of processing and storage facilities for the prospective KUDs in the Project Area.

3.2.7 Marketing of Agricultural Products

As explained in detail in Annex A of Volume II, supply and demand forecast for major food crops in Riau indicates that the province will continue to suffer from shortage of main food crops including rice, soybean, maize and groundnut without implementing any irrigation projects. Therefore, any surplus of rice and palawija crops produced in the project area could be marketed within Riau province without any difficulty.

3.2.8 Transmigration Plan

Both transmigration villages and old villages are benefitted by the proposed Project. However, land resource and water resource for agricultural development are abundant and thus new transmigration may be able to be benefitted. This new transmigration is secured with better social and agricultural infrastructure, while previous transmigrations suffered from poor infrastructure.

(1) Land Allocation

Land allocation is defined by the transmigration law for general transmigration programme. The defined land allocation, which was off course applied to the existing transmigration villages, is as follows:

House and garden area	0.25 ha
Lahan Usaha I	1.00 ha
(cleared by the government before transmigration)	
Lahan Usaha II	0.75 ha
(developed by transmigrant with self-effort)	

In addition 0.25 ha per household is allocated for public facilities, such as road, school, cemetery, government offices, etc.

As for the original farmers of the old villages, the same size of farming land with transmigrant for land reallocation, namely 1.75 ha seems to be principally appropriate, considering equity of transmigrant and original local farmers, and compensation for land which local farmers have been using and provide for the Project facilities.

(2) Number of Required Transmigration Household

The household numbers of the required new transmigration programmes are estimated as follows:

New Village 1:	400	H.H
New Village 2:	380	H.H
New Village 3:	450	H.H
New Village 4:	345	H.H
New Village 5:	235	H.H
New Village 6:	360	H.H

New Village 7:	84	H.H
Total	2,254	H.H

The locations of these transmigration areas are shown in the proposed land use plan of Fig. 3.2.1.1. The total area occupied by the new transmigration villages is 5,320 ha which is 43.6 % of the Gross Area.

Reserve area for future generation of the present transmigrants, which the transmigration office requested to the Study Team, can be provided from the currently unused and existing forest area in/around the Project Area.

(3) Transmigration Schedule

It is assumed that the implementation of the transmigration plan takes four years. On the other hand, it is supposed that the Project takes two years for detailed design and five years for construction works. Therefore, after the start of detail design for the Project, the transmigration plan starts and during the third year of the Project construction, the transmigration plan will be completed.

Ministry of transmigration is responsible to all planning and implementation of transmigration activities. In addition, the promotion work for Lahan Usaha II should be conducted by Ministries of Transmigration, Agriculture, and Cooperative, while Transmigration Office is responsible for the existing transmigrants through various subsidies, such as food, clothes, farm inputs, farm tools and equipment, till transmigrants are comfortably settled.

3.2.9 Crop and Farm Budgets

Crop and farm budgets of a typical farmer with land holding of 2.0 ha have been prepared under future with and without the project conditions. As a results, it is estimated that the net household income of a typical model farmer will be increased to Rp.5,219,500 under "with the Project" condition which is approximately 900 % higher than that under "without the Project" condition.(Refer to Table 3.5(1) and 3.5(2).

3.2.10 Requirement of Labour and Draft Animal

On the basis of Farm Economy Survey the present labour inputs have been estimated by crop. On the basis of this analysis the labour requirements with Project and without Project in the future have been estimated as follows:

Anticipated labour requirement (man-day)

Crop	with Project	without Project	present
Irrigated	137	131	127
Rainfed		150	147
Upland		139	135
Soybean	120	91	91
Peanut	124	129	129

This labour requirement and presently available labour force per farm household have been utilized to finalize the proposed cropping season together with water availability, since labour force is an essential factor and also a major potential constraint for agricultural production. Upon conclusion of labour requirement analysis, it has become clear that necessary labour force for the proposed cropping pattern and farming practices can be supplied within the present labour availability.

As for draft animal power, cows are used for land preparation in the New Villages and the average quantity of cow per household is 0.7 in Kota Baru, 0.6 in Kota Raya, 1.4 in Muara Jaya and 0.9 in three villages. This extension of cows has been promoted by the IFAD programme which started in 1983. In the transmigration villages this programme is under processing and will soon start. Thus, in the year 2000, most farm household will own cows for land preparation and it is expected that there will be no shortage for draft animal power supply.

3.2.11 Farm Mechanization

One of the most important objectives of the Project is to increase farmers' income. The possible strategies to achieve this objective are to raise and stabilize crop productivity through good farm management and good production infrastructure, and to enlarge farm size by enlargement of planting area, efficient labour use, and farm mechanization.

The farm mechanization in the Project Area so far is non-existent, except for ox ploughing.

Farm mechanization includes not only land preparation but also transplanting, harvesting, and post-harvesting. Unless mechanization of all farming activities is established, the enlargement of farm size can not be expected. Land preparation and threshing are relatively easy to mechanize, but transplanting and harvesting have not yet been mechanized. Thus the enlargement of farming size is not easy under the present condition.

3.2.12 Land Clearing

Department of Public Works (DPU) is in principle responsible for the implementation of irrigation development projects. However, in practice irrigation development projects generally consist of three parts, namely (1) construction of major facilities and secondary canals, (2) on-farm facility development such as tertiary canal, quaternary canal, farm ditch, farm road and land reclamation, and (3) operation and maintenance of the irrigation system. The responsibility of DPU is limited only to (1) above. On-farm facility development and land clearing are often delayed due to inappropriate coordination of funding, technology, man power, etc.

In the Project Area there are two different types of villages/areas. One is transmigration area where one hectare of each transmigrant's farm has been systematically cleared before transmigration and thus the land reclamation of this area requires less labour and cost. Each transmigrant has in addition 0.75 ha which has to be cleared by transmigrant's self-effort. This area requires more labour, cost and time for land reclamation.

The other is original villages/areas where local people are traditionally practicing farming. Therefore, this area might not be flat or cleared and thus needs much more labour, cost and period for land clearing and reclamation. Considering this situation, necessary arrangements and coordination for land clearing and reclamation should be made in the ministries concerned, namely DPU, Ministry of Agriculture, and Transmigration.

3.2.13 Agricultural Supporting Services

(1) Extension Services

Present facilities and personnel for agricultural extension services in the Project Area are not sufficient to ensure the present crop development program and future implementation of irrigated agriculture. Provision of additional staff and equipment (e.g. motorcycles) would be necessary. Education and training program for extension workers with regard to irrigated agriculture is dispensable.

(2) Agricultural Credit

Although institutional credit services are presently available at BRI office at Ujung Batu, the number of reliable and profitable KUDs as primary channels for agricultural credit is limited in the Project Area. In order to improve such situations, KUDs should be strengthened under the government guidance and assistance. Provision of education and training on cooperative management, credit system, marketing, etc. by the Department of Cooperative should be more extensively promoted.

(3) Input Suuply

There is very little demand for farm input in the Project Area as agricultural production is generally conducted in traditional manner. As a result, farm input supply system is not adequately provided. It is expected, however, that the needs for farm input such as certified seeds, fertilizers and agrochemicals will be increased sharply with the implementation of the proposed Project. In order to meet the growing demand for farm input, strengthening of KUDs will be indispensable. The government guidance and assistance on this subject will be highly required.

3.2.14 Pilot Demonstration Farm

The conditions for agricultural activities widely vary by area. In Riau Province there is no agricultural research station and thus the information and experience under similar agricultural climate and condition, especially for irrigated agriculture, are limited. In order to exploit the benefit generated by the proposed irrigation development project, it is essential to study and develop appropriate farming practices and to demonstrate and extend these methods and technology. The experimental farm,

therefore, should have the following functions:

(1) Selection of appropriate crops and varieties,
(2) Development of appropriate farming technology concerned with fertilizer application, water control, nursery management technique, labour saving technique (ex.: direct seeding, etc.) and so on,
(3) On-farm and post-harvest mechanization,
(4) Study on integrated pest management and pest forecasting,
(5) Seed multiplication, and
(6) Demonstration of appropriate farming practices to extension staff as well as farmers.

It is recommended that the proposed experimental farm be administered by the Indonesian government agency concerned. This experimental farm requires approximately 10 ha of farm land.

3.3 Irrigation and Drainage Plan

3.3.1 Water Source

Irrigation water is required for the irrigable area all the year round and is supplied through the weir on the Rokan Kiri river whose location was decided during the study.

According to the low water discharge analysis, mean annual discharge and average annual discharge at the proposed weir site are estimated at 146.7 m^3/s and 4.60×10^9 m^3 respectively. The total irrigation water to be supplied throughout a year is estimated at 0.12×10^9 m^3. Thus, 2.6 % of annual discharge is utilized for irrigation.

3.3.2 Runoff Analysis

(1) Low water discharge analysis

The runoff analysis was carried out by the Tank Model method, Moch Model method and actual observed river discharge at the upstream of the proposed weir site(Lubuk Bendahara). As a result, runoff obtained by the observed river discharges are employed.

Ten-day mean discharge and ten-day discharge in 1/5 years non-exceedance are estimated as follows;

Month	Mean discharge			80% dependable discharge		
	1 -10	11-20	21-31	1 -10	11-20	21-31
Jan.	209.0	201.1	167.5	140.0	108.0	106.7
Feb.	180.8	148.4	138.2	99.6	85.2	94.2
Mar.	176.0	168.4	156.3	109.7	97.0	103.2
Apr.	196.6	198.8	170.6	122.0	111.8	107.4
May	187.8	163.7	128.7	131.7	106.0	86.0
Jun.	131.4	93.5	70.3	81.4	65.7	60.9
Jul.	71.7	72.4	73.5	58.5	57.1	54.4
Aug.	72.4	80.6	68.3	50.7	49.5	49.3
Sep.	94.1	113.9	113.9	57.3	61.7	69.2
Oct.	105.3	128.5	139.7	67.4	72.6	90.2
Nov.	221.4	157.9	199.4	113.6	90.9	108.9
Dec.	236.1	248.1	200.9	165.6	151.8	128.4

(2) Flood runoff analysis

Six methods, that is, Rational formula, Melchior' method, Haspers method, Unit hydrograph, Peak Over Threshold(TOP) method and provability analysis for past records are used for the comparative study on the flood runoff discharge at the proposed weir site. The results are as follow;

Return Period	Peak flood runoff (m^3/s)					
	Rational	Melchior	Haspers	Unit H.	POT	Past R.
1,000	3,365	2,412	1,192	3,100	3,270	2,522
100	2,156	1,553	836	1,996	1,903	1,901
50	1,895	1,354	739	1,740	1,659	1,714
20	1,568	1,126	616	1,448	1,444	1,463
10	1,372	978	527	1,258	1,269	1,270
5	1,176	848	437	1,090	1,123	1,068

As a result, the flood discharge with return period of 1/100 for designing of permanent structures and with 1/10 for designing of temporary structures are decided as follows;

$$Q_{100} = 2,200\ m^3/s \quad \text{and} \quad Q_{10} = 1,400\ m^3/s$$

3.3.3 Irrigation Water Requirement

To estimate the irrigation water requirement, the consumptive water use of crops is calculated by the modified Penman method and the crop coefficients due to the guideline of DGWRD using the climatological data at Pasir Pangarayan for the past 11 years. The effective rainfall is assumed to be 70 % of the monthly rainfall in the 1/5 year probability and percolation is assumed to be 3.0 mm/day. The irrigation requirement at field level for land preparation puddling is estimated by the method of Van Goor and Zijlstra and the irrigation efficiency is taken as 55 %. As a results, the maximum ten-day irrigation water requirement are estimated at 1.16 l/s/ha for the first paddy and 1.58 l/s/ha for the second paddy.

3.3.4 Irrigation Plan

(1) Water source

The irrigation water for the Project is taken from the weir on the Rokan Kiri river.

(2) Distribution method of irrigation water

Golongan system and plot to plot irrigation will be adopted for the irrigable area.

For the both 1st and 2nd paddy, the whole area of 8,300 ha will be divided into three(3) Golongan blocks. The area of one Golongan block will become about 2,800 ha. The land to be developed slopes gently in north direction with an average fall of less than 5 %, with no major discontinuities of slope. Therefore, land slopes of the irrigable area with an average fall of less than 5 % is adopted considering paddy cultivation.

(3) Cropping period and irrigation area

The 1st paddy cultivation is proposed to start two and half months after the harvest of the 2nd paddy and the period to release water from canal for maintenance is also proposed one month after completion of irrigation period of the 1st paddy cultivation.

The following cases were studied staggering 10 days based on the prevailing cropping practices in and around the area.

Case	Paddy		Palawija		Max. water requirement l/s/ha
	1st crop	2nd crop	1st crop	2nd crop	
Case-1	Feb.11	Sep. 1	Mar. 1	Sep.21	1.65
Case-2	Feb.21	Sep.11	Mar.11	Oct. 1	1.60
Case-3	Mar. 1	Sep.21	Mar.21	Oct.11	1.60
Case-4	Mar.11	Oct.11	Apr. 1	Oct.21	1.58
Case-5	Mar.21	Oct.11	Apr.11	Nov. 1	1.66

In order to minimize the canal capacity, the smallest water requirement is employed. Thus, Case-4 is adopted as cropping pattern.

(4) Ten-day intake discharge

Ten-day intake discharge for paddy and palawija cultivation of 8,300 ha in total are shown in the following table. The ten-day

river discharge occurring once in five years non-exceedance and surplus river discharge after taking irrigation water are also shown in the same table.

Month	Period	River Dis. in 1/5	Intake Discharge	Surplus Discharge
		(m^3/s)	(m^3/s)	(m^3/s)
Jan.	1-10	140.0	3.02	136.98
	11-20	108.0	5.99	102.01
	21-31	106.7	6.40	100.30
Feb.	1-10	99.6	1.19	98.41
	11-20	85.2	3.72	81.48
	21-29	94.2	3.26	90.94
Mar.	1-10	109.7	0.00	109.70
	11-20	97.0	6.17	90.83
	21-31	103.3	6.70	96.60
Apr.	1-10	122.0	0.00	122.00
	11-20	111.8	0.59	111.21
	21-30	107.4	3.56	103.84
May	1-10	131.7	2.49	129.21
	11-20	106.0	7.53	98.47
	21-31	86.0	5.93	80.07
Jun.	1-10	81.4	4.16	77.24
	11-20	65.7	6.62	59.08
	21-30	60.9	7.68	53.22
Jul.	1-10	58.5	4.51	53.99
	11-20	57.1	2.94	54.16
	21-31	54.4	2.67	51.73
Aug.	1-10	50.7	2.95	47.75
	11-20	49.5	0.00	49.50
	21-31	49.3	0.00	49.30
Sep.	1-10	57.3	0.00	57.30
	11-20	61.7	0.00	61.70
	21-30	69.2	0.00	69.20
Oct.	1-10	67.4	5.04	62.36
	11-20	72.6	4.03	68.57
	21-31	90.2	6.11	84.09
Nov.	1-10	113.6	1.54	112.06
	11-20	90.9	8.54	82.36
	21-30	108.9	5.04	103.86
Dec.	1-10	165.6	9.35	156.25
	11-20	151.8	1.01	150.79
	21-31	128.4	1.90	126.50

3.3.5 Drainage Plan

(1) Drainage system

Provision of a suitable drainage facility is one of the most

important factor to improve agricultural productivity in the low-lying land of the project.

The Rokan Kiri river which stretches in the center of the project area becomes main natural drainage channel, while smaller streams connecting to the Rokan Kiri river function as the secondary drainage. Since the natural streams do not function well due to lack of their capacity, however, widening of such small streams and construction of artificial drainage canals are necessary.

(2) Design discharge

Design discharge analysis will be divided into two methods, namely drainage requirement for rice fields(Q1) and non-rice fields(Q2).

The design drainage discharge combines those of rice fields and non-rice fields. The total drainage discharge Qd will be ;

$$Q_d = 1.15 \times (Q_1 + Q_2)$$

3.3.6 Alternative Study on Intake Facility

The main point of the development plan for this project is to irrigate the area throughout a year, introducing double crops. A year-round reliable supply of irrigation water can be expected because of abundant discharge of the Rokan Kiri river. However, the construction cost would be comparative high in view of the topographical conditions and the existing features of the area. Generally, the construction cost of the intake facility occupies the large portion of the total cost.

(1) Case Study

The following alternative water source facilities for irrigation are studied from the technical and economical points of view:

1) Case - 1 : Free intake without a weir
2) Case - 2 : Headworks
3) Case - 3 : Pumping station

The Case -2 is classified into two types, by weir type, that is, a movable weir equipped with steel gates (Case -2.1), and a rubber dam (Case -2.2).

(2) Free Intake without Diversion Weir (Case - 1)

Location of Free Intake

In the case of free intake, the inlet should be installed where the flow channel(gut) of the river is approaching to the river bank. In addition to the condition of the gut, the river should be stable and deep enough to take water.

The free intake is practically not possible to control taking required discharges and to obtain head for diversion at normal flow. Moreover, it is difficult to control the inflow of suspended sediment.

Therefore, the outside of a meander bend in the river is the most preferable from the viewpoint of preventing inflow of sand. It is important to make sure that the water level would not be lower than design intake level in the future. The location of free intake site is selected about 8 km upstream from Sukadamai.

Basic Statistics of Facility

1)	River width	:	77.0 m
2)	River bed elevation	:	46.4 m
3)	River bed slope	:	1/2,100
4)	Catchment area	:	3,240 km^2
5)	Design flood discharge(1/100)	:	2,180 m^3/sec
6)	Elevation of design intake bed	:	48.5 m
7)	Design intake water level	:	49.9 m
8)	Head reach canal	:	24.0 km

(3) Headworks (Case - 2)

Location of headworks

Alternative locations of headworks were proposed at the meander bends upstream from Sukadamai because construction in a curved coupure may be considered with the advantage of easy construction in the dry.

Site 1. The weir site is proposed at the meander bend located about 2 km upstream from Sukadamai.

Site 2. The weir site is proposed at the meander bend located about 3 km upstream from Sukadamai, that is, 1 km upstream from the site 1.

Topographic characteristics around Site 1.and Site 2. are distinguished as follows:

a) Downstream from Site 1.to Kota Intan, high riverbank is located near the river on the left bank. However, on the right bank, higher part of land is distant from the river.
b) The higher part of land is approaching to the Rokan Kiri river from the both banks between Site 1. and Site 2.
c) Upstream from Site 2., the both higher parts of land become distant from the river.

At the weir site, it is preferable that higher parts of both river banks are approaching to the river, because they can be used for dikes. From the view point of accessibility to the weir site during construction, they can be used for approaching roads.

Based on the above reasons, the Site 1.and Site 2. were proposed for the weir location.

The results of the comparative study on the above two plans are as follows:

a) The riverbed slope is about 1/2,100 upstream from Site 1. Therefore, much rise of water level can not be expected if the weir location is shifted 1 km upstream from Site 1. to Site 2. Namely, moving the weir location upstream will result in only about 50 cm higher than required intake water level assuming the same weir height.
b) According to the field survey, the river channel just upstream from Site 2. has shifted right bank side recently. The river condition at the Site 2 is unstable.

Therefore, the Site 1 was selected for the weir site from the above reasons.

Backwater due to construction of the weir was studied at the each water level. Consequently, 46 m of water level was adopted for the intake water level.

(3-1) Movable Weir equipped with Steel Gates (Case - 2.1)

Basic Statistics of Facility

In order to prevent the extension of inundation area in the upstream area, the movable type of weir is preferable in this project considering the characteristics of topography.

Approximate basic statistics of movable weir are as follows;

1)	River width	:	100.0 m
2)	River bed elevation	:	41.7 m
3)	River bed slope	:	1/2,100
4)	Catchment area	:	3,267 km²
5)	Design flood discharge(1/100)	:	2,200 m³/sec
6)	Flood water level	:	48.7 m (HWL)
7)	Design intake water level	:	45.9 m (NWL)
8)	Weir Width	:	118.0 m
9)	Crest Elevation	:	46.0 m
10)	Flood Sluice	:	Roller gate (24 m × 4 gates)
11)	Scouring Sluice	:	Roller gate (5 m × 2 gates)
12)	Intake	:	Sluice type gate (2 m × 2 gates)
13)	Headreach canal	:	13.0 km

(3-2) Rubber Dam (Case - 2.2)

Basic Statistic of Facility

In this case, the location and basic statistics are the same as the Case -2.1, except the type of flood sluice.

The rubber dam functions as flood sluice in this case, while scouring sluice is equipped with steel gates. Because it is difficult for water level to be regulated by the rubber dam. The scouring sluice has function to remove sediment in front of intake as well as to regulate the water level in the river.

(4) Pumping Station (Case - 3)

Location of Pumping Station

The location of the pumping station is selected about 1.0 km upstream from Kotalama because the site is the nearest from

the first diversion .

Irrigation water is pumped up from the Rokan Kiri river to the first diversion through pipe line, and flows down from there to the irrigable area by gravity.

Basic Statistics of Facility

Approximate basic statistics of the pumping station are shown as follows:

1)	Design discharge	:	9.35 m^3/sec (561 m^3/min)
2)	Kind of pump	:	Vertical mixed flow pump
3)	Total pump head	:	12 m
4)	Diameter & no. of pumps	:	ϕ1,200 mm x 3 nos
5)	Horse power of engine	:	830 ps x 3 nos
6)	Pipe line	:	ϕ2,600 mm, l=1.1 km

(5) Economic Comparison

Rough estimates of the construction costs in each case are shown as follows:

Comparison of Construction Cost

Unit : Rp. x 10^6

Case - 1	Case - 2		Case - 3
	Case - 2.1	Case -2.2	
Free Intake	Movable Weir	Rubber Dam	Pumping Station
20,448	27,667	29,518	29,245

The above construction costs include not only intake facilities but also conveyance facilities to the first diversion.

(6) Conclusion

The characteristics of each case can be pointed out as follows:

1) Case - 1 In this case, intake water level can not be controlled. Accordingly, it is difficult to take a stable amount of irrigation water