at 50 years, considering the durable life of facilities to be installed and other similar projects in Indonesia;

(4) Project benefit is estimated on the projected development stage in 2019 in accordance with the final completion year; and

(5) Currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90 as of July 1994.

Water Resources Development Plan

The water demand forecast for the ten categories in 2019 is presented in Section 5.6. In this section, four out of the ten categories, namely (1) domestic water, (2) industrial water, (3) tourism and (4) urban area flushing water are called public water, and the benefits of public water and irrigation water have been estimated. The benefit of hydropower use has been estimated separately and the remaining four categories were not included in the estimation of benefit because these categories are not expected to bring any monetary benefit.

Basic conditions for economic evaluation of the Water Resources Development Plan are the same as those of the Flood Control Plan above except item (2).

Hydropower Development Plan

The economic evaluation on the Hydropower Development Plan is conducted for Kampar Kiri No. 1 Dam, Kampar Kiri No. 2 Dam and Kuantan Dam which are proposed as multipurpose dams.

Basic conditions for economic evaluation of the Hydropower Development Plan are the same as those of the Water Resources Development Plan mentioned above.

5.14.2 Economic Benefit

Flood Control Plan

Flood control benefit is defined as the reduction of inundation damage attributed to the proposed works. The reduction is obtained as the difference between the estimated inundation damage under the with- and the without-the-project situations.

Inundation damage consists of direct and indirect damages. Direct damages concern the following items:

(1) Agricultural and aquacultural products;

(2) Residential, industrial and business houses and buildings; and

(3) Public facilities.

The value of direct damage is calculated as follows:

[Direct Damage in the Area (Rp.)] = [Area Size (ha)]

× [Damageable Value (Rp./ha)] × [Damage Rate]

The direct damages of item (2) above include indoor movables or household effects with the following ratios:

Residence	0.600
Industrial Building	2.000
Business Building	2.364
Public Building	0.769

The direct damage to item (3) is estimated in proportion to the damage of (2). The applied proportions are as follows:

Roads and Bridges	28.2%
Farmland	5.6%
Railways	13.2%
Telecommunications	3.1%
Electric Power Facilities	2.4%

Indirect damage means damage caused by business suspension due to floods, and is estimated as 6% of the direct damage of (2). Damage is calculated for five cases of floods, 2-, 5-, 10-, 25- and 50-year return periods of with- and without-the-project situations. The estimated benefit of the Flood Control Plan is summarized in the table below.

Flood Control Project	Average Annual Benefit (Rp. 10^6)
(1) Kampar Kanan River Improvement Project	
- Bangkinang Area River Improvement Works	38,342
- Lower Kampar Kanan River Improvement Works	51,846
(2) Kampar and Kampar Kiri River Improvement Project	
- Kampar Kiri River Improvement Works	7,250
- Kampar Kiri No. 1 Dam	3,259
- Kampar Kiri No. 2 Dam	480
- Kampar River Improvement Works	35,298
(3) Indragiri River Development Project / Kuantan-Indragiri River Improvement Project	
- Lubukjambi-Peranap Area River Improvement Works	69,763
- Peranap-Japura Area River Improvement Works	58,833
- Rengat Area Flood Protection Works	36,536
(4) Upper Indragiri River Improvement Project	
- Payakumbuh Area River Improvement Works	43,556
- Solok Area River Improvement Works	34,453
- Sijunjung/Muara Area River Improvement Works	12,420

Water Resources Development Plan

The benefit of the Water Resources Development Plan consists of the following:

(1) Public Water

The benefit of public water is estimated as the economic price of raw water at intake points. The unit price of raw water is assumed at Rp. 46.3 /m^3. However, the unit price of raw water for urban area flushing is 60% of Rp. 46.3/m^3.

Kuok Intake Weir will start to supply public water at 4.78 m^3/s in 2004 and gradually increases as the demand increases until 10.90 m^3/s in 2019, and generate the average annual benefit of Rp. 5,075×10^6 at 4.78 m^3/s and Rp. 12,230×10^6 at 10.90 m^3/s.

(2) Irrigation Water

The benefit by irrigation water is generated on (1) existing; (2) existing, rainfed; (3) existing, undeveloped; and (4) incremental paddy fields. Unit economic value of benefit is estimated at Rp. 1,020,300 /ha. This value is the net value of rice derived from deducing market price of production cost from farmer's gate price. In this study, it is assumed that unit economic value of benefit is different from the additional harvesting ratio by kind of paddy field. Then the unit economic values of benefit and annual benefit of Rantauberangin Irrigation Area are estimated as follows:

Kind of Paddy Field	Unit Benefit (Rp. 1,000/ha)	Initial Phase (Start from 2005)		Final Phase (Start from 2010)	
		ha	Average Annual Benefit (Rp. 10^6)	ha	Average Annual Benefit (Rp. 10^6)
Existing	306.1 (30%)	3,659	1,120.0	0	0
Existing (Rainfed)	612.2 (60%)	928	568.1	0	0
Existing (Undeveloped)	1,020.3 (100%)	4,922	5,021.9	0	0
Incremental	1,020.3 (100%)	4,706	4,801.5	6,088	6,211.6
Total		14,215	11,511.5	6,088	6,211.6

The total annual benefit of Rantauberangin Irrigation Area is estimated at Rp. $17{,}723\times10^6$.

The unit economic values of benefit and annual benefit of Lubukjambi Irrigation Area are estimated as follows:

Kind of Paddy Field	Unit Benefit (Rp. 1,000/ha)	Initial Phase (Start from 2005)		Final Phase (Start from 2015)	
		ha	Average Annual Benefit (Rp. 10^6)	ha	Average Annual Benefit (Rp. 10^6)
Existing	306.1 (30%)	1,670	511.2	1,515	463.7
Existing (Rainfed)	612.2 (60%)	376	230.2	65	39.8
Existing (Undeveloped)	1,020.3 (100%)	2,096	2,138.5	650	663.2
Incremental	1,020.3 (100%)	5,234	5,340.3	18,543	18,919.4
Total		9,376	8,220.2	20,773	20,086.1

The total annual benefit of Lubukjambi Irrigation Area is estimated at Rp. $28{,}306\times10^6$.

Hydropower Development Plan

The benefit of the Hydropower Development Plan is the cost of alternative facilities. The alternative facilities are assumed as a hypothetical thermal power plant with the same capacity as the hydropower plant.

The cost of a diesel power plant is estimated as the sum of kWh value and kW value. The unit kWh and kW values have been assumed as follows based on actual past records of thermal power plants in Sumatra Island and through the discussion with PLN officials.

kWh value	US$0.0178/kWh	Rp. 38.715
kW value	US$318.14/kW (> 50,000 kW)	Rp. 691,955
	US$391.66/kW (< 50,000 kW)	Rp. 851,861

The estimated benefit of hydropower is summarized below.

Project	Starting Year	Energy Value		Power Value		Annual Benefit (Rp. 10^6)
		Energy Output (GWh)	kWh Value (Rp. 10^6)	Installed Capacity (MW)	kW Value (Rp. 10^6)	
Kampar Kiri No. 1 Dam	2010	398.5	15,428	121.2	83,865	99,293
Kampar Kiri No. 2 Dam	2016	128.3	4,967	38.2	32,541	37,508
Kuantan Dam	2005	583.4	22,586	94.4	65,321	87,907
	2015	657.0	25,436	103.6	71,687	97,123

5.14.3 Economic Cost

Basic Conditions

Economic costs which have been converted from financial costs were used for the economic evaluation. The conversion of financial costs to economic costs was made with the following assumptions:

(1) Transfer items such as value added tax (10%) of market price of construction cost and contractor's profits (10%) of market price of construction materials procured locally are exempted.

(2) Standard conversion factor (SCF) to be applied for local commodities and services is assumed to be 96.8% of the local prices, based on export and import statistics in recent years.

(3) Economic wage of unskilled laborers employed for construction works of the project is assumed to be 75% of the actual market wage, taking account of the employment opportunity of laborers in Indonesia.

(4) Economic cost of land compensation is assumed to be 90% of the actual payment, taking account of the opportunity cost of land.

(5) Price contingency is excluded from the financial cost, while physical contingency is included in the economic cost.

Economic Cost

Based on the basic conditions mentioned above, economic costs of the Overall Development Projects are estimated as follows:

Project	Economic Cost (Rp. 10^6)
(1) Kampar Kanan Water Supply Project	234,606
(2) Kampar Kanan River Improvement Project	719,397
(3) Kampar and Kampar Kiri River Improvement Project	1,501,603
(4) Indragiri River Development Project	2,073,459
(5) Upper Indragiri River Improvement Project	553,387

5.14.4 Economic Evaluation on Overall Development Plan

Projects to be Evaluated

The proposed projects to be evaluated in the Overall Development Plan are as follows:

(1) Kampar Kanan Water Supply Project
(2) Kampar Kanan River Improvement Project
(3) Kampar and Kampar Kiri River Development Project
(4) Indragiri River Development Project
(5) Upper Indragiri River Improvement Project

Method of Economic Evaluation

The economic evaluation is made by means of Economic Internal Rate of Return (EIRR), Benefit-Cost Ratio (B/C) and Net Present Value (NPV), with comparison between cash flow of annual economic project cost and benefit that may accrue in the project life.

Cash Flow of Annual Cost and Benefit

To calculate the indicators of EIRR, B/C and NPV of the projects, the annual cost-benefit flow, together with operation, maintenance and replacement cost (OMR cost), is estimated based on the disbursement schedule (refer to Tables 5.14.1 to 5.14.6).

Economic Viability

The estimated EIRR, B/C and NPV are summarized below.

Project	EIRR (%)	B/C	NPV (Rp. 10^6)
(1) Kampar Kanan Water Supply Project	9.82	0.98	- 2,300
(2) Kampar Kanan River Improvement Project	10.30	1.03	7,592
(3) Kampar and Kampar Kiri River Development Project	12.46	1.23	71,146
(4) Indragiri River Development Project	13.19	1.33	222,775
(5) Upper Indragiri River Improvement Project	10.55	1.07	15,851
(6) All Overall Development Projects	11.90	1.20	315,451

Judging from the results of calculation for indicators, Indragiri River Development Project has the highest economic viability. Its indicators show 13.19% of EIRR, 1.33 of B/C and Rp. 222,775×10^6 of NPV (refer to Tables 5.14.1 to 5.14.5).

As for the economic evaluation of all projects integrated, the results show 11.90% of EIRR, 1.20 of B/C and Rp. 315,451 of NPV. The EIRR is more than 10% (refer to Table 5.14.6).

5.15 Environmental Study

5.15.1 Components of Environmental Study

The implementation of projects may cause certain environmental impacts. In accordance with Government Regulation PP No. 51, 1993, therefore, the Environmental Impact Assessment (AMDAL) shall be conducted before project implementation. AMDAL shall include the Environmental Impact Analysis (ANDAL), the Environmental Management Plan (RKL) and the Environmental Monitoring Plan (RPL).

5.15.2 Objectives of AMDAL Study

The objectives of the AMDAL study are as follows:

<u>ANDAL Study</u>

The general objectives of the ANDAL study are as follows:

- To identify the major activities of the project which may potentially cause serious impacts against the environment;
- To identify the components of life environment which may be subjected to the impacts;
- To estimate the extent, intensity, quality of impacts, and its significance based on agreed criteria; and
- To use the results for deciding project implementation;
- To integrate the balance between each plan of project activity and environments; and
- To formulate the Environmental Management Plan (RKL) and the Environmental Monitoring Plan (RPL) with due consideration on the results of the ANDAL study.

<u>RKL</u>

The objectives of RKL are as follows:

- To conserve the environment of the project area by effective and efficient ways;
- To find out ways to solve negative impacts as well as to optimize positive impacts; and
- To decide on relevant agencies to be responsible for the management of environment impacts as identified in ANDAL.

RPL

The objectives of RPL are as follows:

- To evaluate and control the efforts of environmental management;
- To make the development effective and efficient;
- To complete the development plan; and
- To determine the relevant agencies responsible for the monitoring of environment, the location and time of monitoring.

5.15.3 Procedure of AMDAL

The procedure for carrying out AMDAL was revised in October 1993 in accordance with Government Regulation PP No. 51, 1993. The original and revised procedures of AMDAL are as compared in Fig. 5.15.1, and the detailed revised procedure is in Fig. 5.15.2. Since the revised guideline for AMDAL study has not been issued during period of the present study, the original guideline was used as suggested by the Environmental Impact Assessment Committee (KOMPUS).

The main points of revision are as follows:

- The Terms of Reference (TOR) for ANDAL shall be submitted to and approved by KOMPUS before the commencement of ANDAL study..
- Instead of the Initial Environmental Information (PIL) in the original procedure, a preliminary study for ANDAL, which is informal, is to be carried out to roughly understand the present situation of the whole objective area. The preliminary study for ANDAL shall be conducted in the master plan study stage, and the ANDAL in the feasibility study stage.

- The Environmental Management Plan (RKL) and the Environmental Monitoring Plan (RPL) shall be prepared together with the ANDAL study. The report on RKL and RPL shall be included in the report on ANDAL.

5.15.4 Present Environmental Condition

The present environmental condition of the study area is as described below.

Forest

(1) Upper Reaches

In the upper reaches around the provincial boundary, dense forest still remain. Other hill forests are exploited for logging and cultivation. Merksi Pine tree, indigenous to North Sumatra Province, is mainly planted on hilly and mountainous areas. Along the road from Payakumbuh to Bukittinggi, well irrigated paddy fields extend. The landscape of intensive paddy fields and pine plantations is clearly different from the landscape of the lower reaches in Riau Province.

Woody ferns, 3 to 8 m in height, often appear on high altitudes, an indication of vegetation at higher elevations. Another outstanding species is seen at the foothills in the limestone area, Cemara Sumatra. Casuarina sumatrana is dominant in this area because of its so tolerance to ultrabasic soil.

(2) Middle Reaches

In the middle reaches between Pekanbaru - Taluk Kuantan and Pekanbaru - Rengat, the forest area has decreased drastically and degraded due to commercial logging, estate rubber and oil palm plantations, and rubber plantations of small holders.

In the logged-over forest near Logas along the Kampar Kiri River, large Meranti trees have been logged actively. Meranti tree is one of the Dipterocarpaceae family which has been considered as commercially and ecologically important species. Middle-size poles and small saplings of

Meranti trees are still in the forest concession, suggesting that these lowland forests belong to a type of typical dipterocarp forest.

(3) Lower Reaches

In the lower reaches of the river basins, peat swamp forest is dominant and spread largely because of difficulty of access has made modern exploitation slow. The trees of Rengas, Ramin and Meranti rawa, which are economically and ecologically valuable species are seen in the forest. Besides the forest, major peat swamp land is exploited and converted to coconut plantations and paddy fields. Fallow paddy fields also spread over and secondary growth such as ferns and shrubs are dominant.

Patches of Sago palm are sparsely distributed over the swamp. In the mouth of the Kampar River, diversified vegetation is seen, such as Nippa palm, Avicennia and Rhizophora, according to salinity and muddy conditions. Both Avicennia spp. and Rhizophora spp. are the important tree species of mangrove forests. Logging and agricultural cultivation extends to this forest also.

(4) Protected Forest

In the Kampar and Indragiri river basins, conservation and protection forests have been established at the following areas.

Particulars	Area (ha)
Conservation Forest	
(1) Kerumutan	120,000
(2) Bukit Rimbang baling	136,000
(3) Bukit Bungkuk	20,000
Protection Forest	
(1) Bukit Sentajo	42,000
(2) Bukit Ulak-I	15,000
(3) Bukit Ulat-II	18,000
(4) Bukit Balung	19,500
Wildlife Reservation Forest	
(1) Tasik Nambus	80,000

Endangered and Protected Plant Species

There are two endangered and protected plant species, Rafflesia and Amorphophallus. No sign of both species has been reported in the study area.

Wildlife

Among wildlife, some valuable and protected animals in the study area have been reported, as follows:

- Asian Elephant : 1,100 heads
- Sumatran Tiger : 400 heads
- Sumatran Rhinoceros : very few
- Sun Bear : not specified
- Orangutan : not specified
- White-handed Gibon : not specified
- Agile Gibon : not specified

Valuable Aquatic Fauna

The following fishes have been reported as valuable aquatic fauna in the study area:

- Tapah
- Patin
- Freshwater Shrimp
- Freshwater Shark
- Leptobarbus Fish

5.15.5 Proposed Structures of Preliminary Study for ANDAL

The following are proposed as the major structures for the Overall Development Plan:

(1) Kampar River Basin

- Kampar Kiri No. 1 Dam
- Kampar Kiri No. 2 Dam
- Kuok Intake Weir and Rantauberangin Irrigation Canal

- River Improvement Works for Kampar River System

(2) Indragiri River Basin

- Kuantan Dam
- Lubukjambi Intake Weir and Irrigation Canal
- River Improvement Works for Indragiri River System

5.15.6 Preliminary Study for ANDAL

Objectives of Preliminary Study

The preliminary study for ANDAL is an informal study to be done before the ANDAL study with the following objectives:

(1) To study the present environmental conditions of the location;
(2) To provide information for the selection of appropriate projects from the overall plan;
(3) To determine environmental components to be studied in the ANDAL study; and
(4) To prepare the Terms of Reference for ANDAL.

Natural Environmental Condition

(1) Water Quality

The water quality of Kampar Kanan, Kampar Kiri, Kuantan and Indragiri rivers have been classified as category B, which means that the water is suitable for drinking after boiling.

(2) Terrestrial Flora

From the field observation and data collection, 33 species of flora were found in the Kampar river basin and 51 species in the Indragiri river basin. The protected species are as follows:

- Kulim
- Tembusu

- Meranti Putih
- Keruing
- Kantong Semar

(3) Terrestrial Fauna

The number of species and protected ones are summarized below. Total number of species found were 41 species, and 20 of them are protected species.

Terrestrial Fauna	Kampar River Basin	Indragiri River Basin
Mammal	17 species	21 species
Birds	14 species	19 species
Reptile	7 species	7 species
Amphibia	3 species	3 species

(4) Aquatic Flora

There are 16 species of aquatic plants found in the study area.

(5) Aquatic Fauna

(a) Fish

Nine orders of fish were found near the proposed structure in the Kampar river system. It has been reported that there are seven rare fishes in this river system.

Around the Kuantan damsite in the Indragiri river system, six orders of fish were found.

(b) Aquatic Mammals and Reptiles

Aquatic mammals and reptiles found in the study area are Crocodiles, Monitor Lizards, Water Snakes, Otters, and Freshwater Turtles. Crocodile is not found anymore in the Sinamar and Sukam rivers. In the Kuantan River, crocodile is so rarely found, but local people still believe their existence.

Socioeconomic Conditions

Population and economic structure in the study area are described in CHAPTER 3 and land use in CHAPTER 2.

(1) Mining

No active mining works were found in and around the proposed facilities. Inactive gold mining and coal mining were found near the sites of Kampar Kiri No. 2 Dam and Kuantan Dam, respectively.

(2) River Water Use

Inhabitants of towns and villages along the Kampar and Indragiri rivers use river water for domestic use, agriculture (including fishpond), waterborne transportation and industry. Along the Kampar River, 45% of households use river water for the above purposes and 49% along the Indragiri River.

(3) Infrastructure and Public Facilities

(a) Roads

National and provincial roads in the study area are kept in good condition, while local roads are in poor condition.

(b) Public Schools

There are 431 units and 743 units of public schools near the proposed facilities in Kampar and Indragiri river basins, respectively. These public schools consist of elementary, junior high and high schools.

(c) Health Care Facilities

There are 35 units and 130 units of hospitals and clinics around the proposed facilities in the Kampar and Indragiri river basins, respectively.

(4) Historical Assets and Cultural Properties

As representative historical assets, there is an old mosque called Jamik Mosque at Air Tiris, six old cemeteries (graveyards) and two units of traditional buildings. As cultural properties, Seni Rebana (playing a traditional tambourine to accompany a song) and Balimau (bathing in water soaked with aromatic substances such as flowers and leaves, done by Moslems some days before the month of fasting) are known. These historical assets and cultural properties are not affected by the implementation of the project.

Study Results

The project will bring negative as well as positive impacts to the environment. From the study on the present environmental conditions of the study area, it is concluded that the socioeconomic component should be studied with special concern. Other components such as physical and chemical components may be less significant compared to the socioeconomic component in terms of impact on the natural environment.

CHAPTER 6 SELECTION OF PRIORITY PROJECTS

6.1 Criteria for Selection

Priority projects to be studied further in the Feasibility Study were selected from the Overall Development Plan under the following criteria.

(1) Economic Viability

To realize earlier benefit, projects with high economic viability shall be selected.

(2) Urgent Requirement

Projects which are urgently required for flood damage protection or water supply shall be selected.

(3) Less Social and Environmental Impacts

Projects with less social and environmental impacts shall be selected.

6.2 Identification of Priority Projects

Based on the criteria for selection mentioned in the preceding section, the following have been identified as priority projects.

6.2.1 Kampar River Basin

The following were identified as the two priority projects in the Kampar river basin:

(1) Kampar Kanan Water Supply Project

(a) Economic Viability

The results of preliminary economic evaluation show that the Kampar Kanan Water Supply Project has a high EIRR of about 10.1% and B/C of 1.0 which are considered to have enough economic viability for a priority project.

(b) Urgent Requirement

The shortage of municipal water supply for Pekanbaru City is very critical with the recent rapid growth of population and further aggravation of the shortage is forecasted in consideration of the nationwide trend of population concentration in city areas. Irrigation water is also urgently required for the Rantauberangin area to realize self-sufficiency of rice in Riau Province.

(c) Less Social and Environmental Impacts

Construction of Kuok Intake Weir and Rantauberangin Irrigation Canal will not cause any serious social and environmental impacts.

(2) Bangkinang Area River Improvement Works

(a) Economic Viability

The results of preliminary economic evaluation show the EIRR of about 10.2% and B/C of 1.0 which seem to have enough economic viability for a priority project.

(b) Urgent Requirement

The town of Bangkinang has the largest population and paddy fields along the Kampar River, and was hit by floods in 1978, 1991 and 1995 with big flood damage. This area is expected to have more damage in the future without any flood protection measures.

(c) Social and Environmental Impacts

The construction of river improvement works for this area will not bring about any serious environmental impacts, but it will cause house evacuation of about 400 units.

6.2.2 Indragiri River Basin

The following were identified as the two priority projects in the Indragiri river basin:

(1) Kuantan River Multipurpose Development Project

(a) Economic Viability

The results of preliminary economic evaluation show the EIRR of about 15.3% and B/C of 1.7 which seem to have enough economic viability for a priority project.

(b) Urgent Requirement

The areas downstream from the proposed Kuantan Dam along the Kuantan and Indragiri rivers are hit by floods almost every year and the floods in 1986 and 1988 brought wide inundation. Construction of the Kuantan Dam which has multiple purposes with the function of flood control up to almost a 5-year return period is urgently necessary.

The Kuantan Dam has another function of hydropower generation. According to the power forecast by PLN on the balance between future electricity supply and demand, the demand will exceed the supply capacity in Region III. Earlier construction of the dam will help supplement the shortage of electricity supply capacity in the region.

(c) Social and Environmental Impacts

The construction of the dam and reservoir will give strong impacts to the region. Therefore, the impacts shall have to be carefully assessed.

(2) Rengat Area Flood Protection Works

(a) Economic Viability

The results of preliminary economic evaluation show the EIRR of about 11.0% and B/C of 1.1 which seem to have enough economic viability for a priority project.

(b) Urgent Requirement

The town of Rengat is the biggest along the Indragiri River and suffer from inundation almost every year, especially the big floods in 1986 and 1988 which brought serious flood damage. Since there is more than 6,000 km^2 of residual catchment area downstream from the proposed Kuantan Dam, the flood control function of the dam will not reach the Rengat area. Therefore, other flood protection measures for the Rengat area are urgently necessary.

(c) Social and Environmental Impacts

No serious social and environmental impacts are expected with the construction of ring dikes around Rengat Town which are proposed as a flood protection measure.

6.3 Order and Cost for Priority Projects

The order of priority of the selected priority projects is decided by the Indonesian Government in accordance with the request of the provincial government.

The order and financial costs of the priority projects are shown in the following table.

Order	Priority Projects	Financial Cost (Rp. 10^6)
(1)	Kampar Kanan Water Supply Project (Initial Phase)	195,816
(2)	Kuantan River Multipurpose Development Project (Initial Phase)	740,325
(3)	Rengat Area Flood Protection Works	40,295
(4)	Bangkinang Area River Improvement Works (Initial Phase)	247,312
	Total	1,223,748
	(in ¥10^6) (¥1.00 = Rp. 21.90)	55,879
	(in US$$10^6$) (US$1.00 = Rp. 2,175)	563

Note: Financial costs include Physical Contingency and Value Added Tax. Price Contingency is excluded.

CHAPTER 7 FEASIBILITY STUDY

7.1 General

7.1.1 Objective Priority Projects

Objective priority projects for feasibility study as identified in CHAPTER 6 are as follows:

(1) Kampar Kanan Water Supply Project

(2) Bangkinang Area River Improvement Works

(3) Kuantan River Multipurpose Development Project

(4) Rengat Area Flood Protection Works

7.1.2 Basic Conditions

Target Year for Planning

The target year for planning is set at 2019, same as the Overall Development Plan. This target year is used to determine water demand in the future.

Target Completion Year

The target year for completion of priority projects is set at 2004. The year 2004 is the last year of the Seventh Five-Year Development Plan (REPELITA VII). The implementation period of nine years (1996-2004) is deemed appropriate by the feasibility study.

Cost Estimate

Cost estimate has been conducted on the same conditions as the Overall Development Plan, i.e., the cost is as of July, 1994 and currency conversion rates are assumed at US$1.00 = Rp. 2,175 and ¥1.00 = Rp. 21.90.

7.2 Kampar Kanan Water Supply Project

7.2.1 Present Condition

The project area is situated on both banks of the Kampar Kanan River from Rantauberangin Bridge in the upstream end to Danaubingkuang Bridge in the downstream end and in Pekanbaru City. From the viewpoint of water resources development, water deficit for irrigation and urban water in Pekanbaru City has been identified as hindrance to the development of this area.

7.2.2 Planning Criteria

Planning criteria have been employed for the formulation of the Kampar Kanan Water Supply Project, as follows:

<u>Purpose and Major Components of the Project</u>

The purposes of the project is as follows:

(1) To supply irrigation water to priority areas of Rantauberangin Irrigation Development Project.

(2) To develop water resources and ensure the required urban water demand (domestic, industry, tourism, urban area flushing uses) of Pekanbaru City.

The proposed structures consist of the Kuok Intake Weir, main irrigation canals and on-farm development structures of Rantauberangin Irrigation Project.

<u>Objective Area</u>

In accordance with the results of selection of priority projects for the Overall Development Plan, the objective area for irrigation development in priority projects is the area on the right and left banks from Kuok Intake Weir to Danaubingkuang Bridge, as tabulated below. The objective area for urban water supply is Pekanbaru City.

Unit: ha

Rantauberangin Irrigation Development Area	Left Bank Area	Right Bank Area
Existing Irrigation Area	5,171	4,338
Presently Irrigated	1,837	1,822
Presently Rainfed	553	375
Presently Undeveloped	2,781	2,141
Net Additional Area	4,429	277
Total	9,600	4,615

Design Scale

The design scale for the determination of irrigation water requirement is set at 5-year return period. The target year for the determination of future water demand for urban water of Pekanbaru City is set at the year 2019.

7.2.3 Study and Analysis

Water Demand

(1) Irrigation Water Requirement

(a) Optimum Cropping Pattern

Firstly, eight cases of alternative cropping patterns have been prepared by staggering the starting date of land preparation in 15 days from January 1 to April 16. Total diversion water requirements for each cropping pattern have accordingly been calculated. The optimum cropping pattern has been finally selected as the one which minimizes the total diversion water requirement, as follows:

Crop	Starting Date of Land Preparation
1st Crop	April 1
2nd Crop	October 16

(b) Design Water Requirement

(i) Peak Water Requirement

The peak water requirements in the optimum cropping pattern for left bank and right bank areas of the Rantauberangin Irrigation Development System have been calculated as follows:

Unit: m^3/s

Area	Peak Water Requirement
Left Bank	11.31
Right Bank	4.80
Total	16.11

(ii) Semimonthly Diversion Water Requirement

The semimonthly diversion water requirement in the optimum cropping pattern is calculated by combining water requirements for the net additional area with the additional supply for the existing irrigation schemes, as shown in Table 7.2.1.

According to the results of the water balance study, all the existing irrigation schemes in Rantauberangin Irrigation Development Project will have irrigation water deficit.

(2) Urban Water of Pekanbaru City

The water demand of Pekanbaru City as estimated in the Overall Development Plan has been applied for the feasibility study. Water demand is as follows:

Unit: m^3/s

Purpose	Peak Water Requirement
Domestic	3.80
Industry	0.78
Tourism	0.01
Urban Area Flushing	6.31
Total	10.90

(3) Total Water Demand

Based on the above, the peak water demand in the Feasibility Study was determined, as follows:

Unit: m^3/s

Purpose	Peak Water Demand
Left Bank Irrigation	11.31
Right Bank Irrigation	4.80
Pekanbaru City	10.90
Total	27.01

Storage Capacity of Kuok Intake Weir

The required capacity of Kuok Intake Weir to regulate hydropower generation release to constant release is calculated at $1.2 \times 10^6 m^3$ on the basis of the water requirement for the priority projects at Kuok Intake Weir. This is estimated for power generation duration of 12-hour of the Kotapanjang Power Station. On the other hand, the same capacity for the Overall Development Plan has been estimated at $1.6 \times 10^6 m^3$ from the peak diversion water requirement of 25.49 m^3/s and water demand in Pekanbaru City of 10.90 m^3/s.

The weir crest elevation proposed in the Overall Development Plan should be maintained in the initial phase since elevations which are determined by the alignment of the main irrigation canals could not be changed. Accordingly, the storage capacity of $1.6 \times 10^6 m^3$ required for the Overall Development Plan has been applied in order to avoid reconstruction of intake and distribution facilities.

Diversion of Water for Pekanbaru City

In the present study, the water demand of Pekanbaru City was estimated for the water balance study. This value has been considered for the estimation of necessary storage capacity of the Kuok Intake Weir. However, optimum intake and transmission facilities were not studied and they should be selected through an independent study for this purpose.

These would include the option of taking water at Kuok Intake Weir and transmitting water partly using the irrigation canal, or taking water by pumping up in the downstream area for the shortest transmission length.

Accordingly, the volume of water to be supplied to Pekanbaru City has not been considered in the left bank irrigation canal, but it has been considered for the determination of the required regulation capacity at Kuok Intake Weir.

7.2.4 Preliminary Design

Preliminary design has been conducted for Kuok Intake Weir and main irrigation canals of the Rantaubcrangin Irrigation Development plan.

Kuok Intake Weir

Preliminary design has been conducted as presented below. The location of the weir and the structural design drawing are presented in Fig 7.2.1 and 7.2.2, respectively.

(1) Basic Design Conditions

Basic conditions for preliminary design of the weir are as presented together with the major structural features in item (4).

(2) Selection of Weir Type

Weirs can be broadly classified into two types, movable and fixed. A fixed type weir is an obstacle to smooth flow of floods. On the other hand, a movable type weir is able to pass floods without obstruction by means of gate operation.

Kuok Intake Weir is located on the main stream of the Kampar Kanan River which has a large catchment area of approximately 3,400 km^2 and control of discharge will be required. Taking these conditions into consideration, a movable type weir has been adopted. Types of gate generally applied for movable weirs are the roller gate, the radial gate, the tilting gate and the rubber gate.

Of these types, a radial gate is not applicable because gate pins should be above the high water level and this cannot be realized in Kuok Intake Weir. Hence, the roller gate, the tilting gate and the rubber gate have been compared for the selection of optimum type. As a result of the comparative study as tabulated in Table 7.2.2, the rubber gate type has been selected from the technical and economical viewpoints.

The Kuok Intake Weir is designed to cope with a 50-year return period flood and the intake discharges of the overall plan considering its durability. The proposed intake weir with rubber gates is shown in Fig. 7.2.2.

(3) Design of Structures

(a) Flood Discharge Gate

The flood discharge rubber gates shall have a function to smoothly release floodwater and to store regulated water at normal time. The spillway section consists of five spans; each with a 30 m long and 3.7 m high rubber gate.

(b) Flush Gate

Flush gates with roller gates are provided at both sides to flush out accumulated sediment in front of inlets. The bottom elevation of flush gates are set at 1.0 m below the weir sill.

(c) Apron and Riprap

Concrete aprons, concrete blocks and gabion mattress riprap are placed at both downstream and upstream sides of the spillway to prevent scouring of the riverbed.

(d) Inlet

Inlets require a structure to easily control intake discharge and as prevention measures against foreign materials flowing into the canal. For these purposes, control gates, screen, inlet apron, etc., are installed.

(e) Foundation

According to the results of drilling investigation conducted in this study, a residual soil layer is designated as a bed of shallower foundation of the proposed structures. Sheet piles are provided to the bottom of the residual soil layer for seepage prevention.

(4) Major Structural Features

Major structural features and design conditions are set as follows:

Particulars	Value
Afterbay Reservoir	
Normal Water Level	EL 40.0 m
Low Water Level	EL 38.0 m
Required Storage Capacity	$1.6 \times 10^6 m^3$
Intake Discharge (for Overall Plan)	
Left Bank	$20.69 m^3/s$ *
Right Bank	$4.80 m^3/s$
Design Flood	
Design Scale (Return Period)	50 year
Design Flood Discharge	$4,000 m^3/s$
High Water Level	EL 45.24 m
Dike Crest Elevation	EL 46.44 m
Riverbed Elevation	EL 36.30 m
Structural Dimensions of Weir	
Gate Type	Rubber Gate
Sill Elevation	EL 36.3 m
Crest Elevation	EL 40.0 m
Length×Height×Unit	30.0 m × 3.7 m × 5 units
Structural Dimensions of Flushing Gate	
Gate Type	Steel Roller Gate
Sill Elevation	EL 35.3 m
Crest Elevation	EL 40.0 m
Length×Height×Unit	5.0 m × 4.7 m × 2 units

* Design discharge for the whole irrigation area on the left bank; does not include diversion water to Pekanbaru City.

Main Irrigation Canal

Main irrigation canals proposed in the Initial Phase are shown in Fig. 7.2.3 and Table 7.2.3, designed in the same manner as the Overall Development Plan. Major features are as given in the following table.

Particulars	Unit	Irrigation Canal	
		Left Bank	Right Bank
Canal Length	km	44.00	40.00
Design Discharge*	m^3/s	11.31	4.80
Gradient		1/3,000	1/3,000
Max. Velccity	m/s	1.02	0.79
Lining		10-cm thick concrete lining side slopes with stone wet masonry footing and compacted earth on bottom.	

Note: The design discharge of 11.31 m^3/s of the left bank canal is for the initial phase.

7.2.5 Construction Plan

(1) Kuok Intake Weir Construction Works

The weir site is located at around 14 km from Bangkinang and 1.2 km downstream from Rantauberangin Bridge. The national highway connecting Pekanbaru and Payakumbuh through Bangkinang passes on the right bank of the river. Layout plan of temporary construction facilities has been prepared, as shown in Fig. 7.2.4.

Shortcut sections on the riverbank will be utilized as the main source of construction materials for the weir. Land for site offices, plant yard, abutments of the weir, access roads and spoil bank are to be acquired or rented. Land acquisition and house evacuation are not required because of the small size of the pondage area and weir height.

The construction plan is accordingly prepared in due consideration of the physical and socioeconomic conditions in the area. The construction schedule is shown in Fig. 7.2.5.

(2) Rantauberangin Irrigation System Construction Works

The irrigation area stretches from the intake weir to the Danaubingkuang Bridge on both banks of the Kampar Kanan River. On the right bank, village roads from the national highway can be utilized as access road. A provincial bridge crossing the Kampar Kanan River near Bangkinang is the major access to the left bank.

Riverbed materials in the Kampar Kanan River along project sites is available as fine and coarse aggregates. Excavated material from the riverbank can also be utilized both as aggregate and embankment material.

Right-of-way for headreaches and main canals is to be acquired and families to be affected have to be compensated and evacuated prior to construction. Lands to be acquired and houses to be evacuated are 220 ha and 430 houses, respectively.

The construction schedule is shown in Fig. 7.2.6.

7.2.6 Cost Estimate

Project cost has been estimated based on the basic conditions, as discussed in Subsection 7.1.2. Tables 7.2.4 and 7.2.5 show the financial cost and disbursement schedule, respectively, as summarized in the following table.

Unit: Rp. 10^6

Item	Value
Construction Base Cost	137,067
Compensation Cost	4,620
Administration and Engineering Cost	20,790
Price Contingency	76,752
Physical Contingency	22,783
Sub-Total	262,012
Value Added Tax	26,201
Total	288,213

7.2.7 Project Evaluation

Economic Benefit

(1) Irrigation Water

Unit economic value of benefit is estimated at Rp. 1,020,300/ha as net value of rice derived from deducing market price of production cost from farmer's gate price. Unit value of benefit for the existing irrigation area and benefit value have been calculated, as follows:

Category	Unit Benefit (Rp. 1,000/ha)	Area (ha)	Benefit (Rp. 10^6)
Existing (Irrigated)	306.1 (30%)	3,659	1,120.0
Existing (Rainfed)	612.2 (60%)	928	568.1
Existing (Undeveloped)	1,020.3 (100%)	4,922	5,021.9
Net Additional Area	1,020.3 (100%)	4,706	4,801.5
Total		14,215	11,511.5

(2) Urban Water

Basic conditions are the same as the Overall Development Plan. Kuok Intake Weir will start to supply water of 4.78 m^3/s in 2004 and gradually increases as the demand increases until 10.90 m^3 in 2019. Annual benefit has been calculated at Rp. $5{,}067 \times 10^6$ for 4.78 m^3/s and Rp. $12{,}234 \times 10^6$ for 10.90 m^3/s.

Economic Cost

The economic project cost is estimated at Rp. $162{,}695 \times 10^6$ based on the basic conditions discussed in Subsection 7.1.2.

Economic Evaluation

The project has been evaluated from the economic viewpoint in terms of Economic Internal Rate of Return (EIRR), Benefit-Cost Ratio (B/C) and Net Present Value (NPV). The opportunity cost of capital is assumed at 10% and applied to a discount rate for the calculation of B/C and NPV.

(1) Annual Cost-Benefit Flow

Annual cost-benefit flow is shown in Table 7.2.6. The benefit is assumed to accrue at the same level until the end of project life. The estimated operation, maintenance and replacement (OMR) cost is needed annually after project completion to keep duly the designed function.

(2) Economic Evaluation

The EIRR as well as B/C and NPV for the project is calculated on the annual cost-benefit flow. The economic viability is as follows:

EIRR	10.14%
B/C	1.02
NPV	Rp. $1,524 \times 10^6$

(3) Sensitivity Analysis

Sensitivity analysis is carried out for the project on several cases of changes in the benefit or cost, as summarized below.

CASE	EIRR (%)	B/C	NPV (Rp. 10^6)
Benefit, 5% down	9.91	0.99	- 920
Benefit, 10% down	9.45	0.94	- 5,561
Cost, 5% up	9.93	0.99	- 734
Cost, 10% up	9.54	0.95	- 5,189

Project Justification

The EIRR of the project shows 10.14%, and in any case of sensitivity analysis on case changes in the benefit or cost, it is more than 9.4% as presented above. The Kampar Kanan Water Supply Project is therefore evaluated to be economically viable.

Furthermore, consideration is given to the exclusion of intangible benefits generated by the project such as preservation or improvement of environment that may be lost without the project in this calculation. If these intangible benefits are quantified, the EIRR can be a higher figure and viability of the project will increase.

7.3 Bangkinang Area River Improvement Works

7.3.1 Present Condition

The project area is situated on both banks of the Kampar Kanan River. The area suffer from habitual flooding of the river. The cause of flooding is the poor flow capacity of the present river channel.

Located in the area is Bangkinang, the capital of Kab. Kampar and Airtiris, the capital of Kec. Kampar. The flood inundation area is generally of agricultural lands. Some parts of the proposed irrigation development area of Kampar Kanan Water Supply Project is in the objective area and flood protection works are deemed necessary.

7.3.2 Planning Criteria

Purpose and Major Component of the Project

The purpose of the Bangkinang Area River Improvement Works is to mitigate flood damages along the Kampar Kanan River in Bangkinang Area by the implementation of river improvement. Major work items are embankment of dikes, excavation of shortcut channels and construction of related structures.

Objective River Stretch

The objective river stretch is the Kampar Kanan River from Rantauberangin Bridge (just upstream of Kuok Intake Weir) down to Danaubingkuang Bridge with a total length of approximately 49 km. This stretch corresponds to the irrigation development area for the priority project of Kampar Kanan Water Supply Project.

Design Scale

Design scale for the feasibility study stage is set at 5-year return period considering that the area consists mainly of agricultural lands. Consideration should be given, however, to upgrading the structures in the future in accordance with the Overall Development Plan of 50-year return period scale. Accordingly, structures difficult for upgrading in the future, e.g., bridges and sluice gates, are to be designed for 50-year return period scale.

Standard Flood Discharge

Standard flood discharges by design scale have been determined through hydrological analysis, as follows:

5-year Return Period	2,800 m^3/s
50-year Return Period	4,000 m^3/s

7.3.3 Study and Analysis

Optimization studies have been conducted for the alignment, longitudinal profile and cross section of the proposed river improvement, as discussed below.

(1) Optimization of Alignment and Longitudinal Profile

The plan and profile have been determined basically following the Overall Development Plan. The 1/50,000 topographical maps and the river survey results prepared during the Overall Development Plan stage have been used. The proposed plan and longitudinal profile are presented in Figs. 7.3.1 and 7.3.2.

(2) Optimization of Cross Sections

In the Overall Development Plan stage, optimization study has been conducted and the optimum plan has been determined as follows:

- Assure flow capacity mainly by embankment.
- Channel of moderate width will be created.
- Excavation is considered only for the extremely narrowed sections.

The width of the channel has been determined at 300 m comparing 200 m to 400 m.

The basic policy of the Overall Development Plan has been maintained, namely, flow capacity is assured mainly by embankment. On the basis of the cross sections determined in the Overall Development Plan stage, more detailed optimization has been conducted. Construction costs were compared against the width of the five cases of 200, 250, 300, 350 and 400 m. The width has been finally determined at 300 m, same as the Overall Development Plan.

Design crest elevation has been determined based on a 5-year return period flood. Future raising of the dike will be made on the land side. Proposed cross sections are presented in Fig. 7.3.3.

(3) Inundation Analysis

Flood inundation analysis has been conducted to obtain inundation depth and duration for the calculation of flood protection benefit, as follows:

- The whole inundation area is divided into 930 m by 930 m mesh blocks which are equivalent to half minute of longitude and latitude.
- The average ground height of each mesh is obtained using the topographic map with a scale of 1/50,000.
- The overflow discharge is given by the discharge volume as in the case of the Overall Development Plan.
- Two cases, 2- and 5-year return periods, are calculated considering the design scale of the flood control project.

7.3.4 Preliminary Design

The preliminary design of structures is as described below.

(1) Dike

Dikes to be constructed in the Initial Phase are designed in the same manner as the Overall Development Plan. Fig. 7.3.4 shows the typical section of the dike. In the final plan, dikes will be raised on an average of 1.3 m. Soils from the excavation of channel banks and shortcuts will be used for embankment of dikes.

(a) Freeboard

In accordance with the Design Criteria of DPU, a freeboard of 1.2 m is adopted referring to the design discharge of 2,800 m^3/s (5-year return period). Additional 0.3 m of freeboard is provided along critical reaches of dike where the height exceeds 3.5 m.

(b) Crown Width

Dike crown width of 5.0 m is applied in accordance with the Design Criteria.

(c) Side Slope

Side slope of 1 : 2.0 (V : H) or 1 : 3.0 is adopted.

(d) Filter

No filter is provided in the Initial Phase in consideration of design discharge, dike height, and reconstruction of filter in the Final Phase.

(e) Maintenance Road

Maintenance road, 3.0 m wide metaled by 0.15 m thick gravel, is provided on top of the dikes.

(f) Slope Protection Works

Wet masonry revetment type slope protection works proposed in the Initial Phase are designed in the same manner as the Overall Development Plan.

(2) Related Structures

(a) Groin

A group of concrete pile permeable type groins provided at extreme meandering portions are designed in the same manner as the Overall Development Plan (refer to Fig. 7.3.1).

(b) Sluice

Location of the sluices required are determined based on the 1/50,000 scale topographic maps. Sluice types are proposed depending on drainage area. Outlets are provided where channels by shortcut remain.

Sluices of the Initial Phase shall be designed and constructed in accordance with the section of dike proposed in the Final Phase, considering the concrete structure lifetime of 50 years.

(c) Bridge

There are two existing bridges crossing the Kampar Kanan River in the Bangkinang Area, Bangkinang Bridge and Danaubingkuang Bridge. Structural type is upper steel truss for superstructure and mass-concrete type pier for substructure. The bridges shall be designed and reconstructed in accordance with the river width (300 m) and the design high water level proposed for a design discharge of 4,000 m^3/s for the Final Phase.

7.3.5 Construction Plan

The objective stretch is from Kuok Intake Weir down to Danaubingkuang Bridge on the Kampar Kanan River. On the right bank, village roads from the national highway can be utilized as access roads. A provincial bridge crossing the Kampar Kanan River near Bangkinang is the major access to the left bank area.

Soil material for the embankment is to be taken from the foot of the low undulating hills along the river.

Right-of-way for dikes and related structures is to be acquired and families to be affected have to be compensated and evacuated prior to construction. Lands to be acquired and houses to be evacuated are 197 ha and 300 houses, respectively.

The construction schedule is shown in Fig. 7.3.5.

7.3.6 Cost Estimate

Project cost has been estimated based on the basic conditions as discussed in Subsection 7.1.2. Tables 7.3.1 and 7.3.2 show the financial cost and disbursement schedule, respectively, as summarized in the following table.

Unit: Rp. 10^6

Item	Value
Construction Base Cost	176,070
Compensation Cost	2,591
Administration and Engineering Cost	26,540
Price Contingency	116,133
Physical Contingency	30,586
Sub-Total	351,920
Value Added Tax	35,192
Total	387,112

7.3.7 Project Evaluation

Economic Benefit

Flood control benefit is defined as the reduction of inundation damage attributed to the proposed works. The reduction is obtained as the difference between the estimated inundation damage under the with- and the without-the-project situations.

(1) Inundation Damage

Inundation damage consists of direct and indirect damage. Direct damage in the area (Rp.) can be obtained by multiplying area size (ha) by the damageable value (Rp./ha) and damage rate. Damageable value is calculated for each asset classification, namely, agriculture related asset, house and building related asset, and public facilities.

Indirect damage caused by business suspension due to the flood is estimated using the rate (6%) to the damage to general assets (houses/building and their indoor movables).

(2) Damage Rate by Inundation Depth

Damage rates for each item vulnerable to flood damage are determined in accordance with the inundation depth, the field survey and other reports. Inundation depth is calculated by the mesh unit for floods of 2-, and 5-year return periods.

(3) Calculated Flood Damage

Direct flood damage as well as the indirect one is calculated for each mesh in the two cases of flooding conditions mentioned above.

(4) Annual Average Benefit

Flood control benefit is defined as the expected amount of average annual reduction of damages by the proposed works. The annual average benefit is calculated by summing up probable damages that are obtained by multiplying probable damage of a certain probability by the probability of occurrence.

The annual average benefit of river improvement of Bangkinang area is accordingly estimated at Rp. $22{,}712\times10^6$.

Economic Cost

The economic project cost is estimated at Rp. $204{,}867\times10^6$ based on the basic conditions discussed in Subsection 7.1.2.

Economic Evaluation

The project has been evaluated from the economic viewpoint in terms of Economic Internal Rate of Return (EIRR), Benefit-Cost Ratio (B/C) and Net Present Value (NPV). The opportunity cost of capital is assumed at 10% and applied to a discount rate for the calculation of B/C and NPV.

(1) Annual Cost-Benefit Flow

Annual cost-benefit flow is shown in Table 7.3.3. The benefit is assumed to accrue at the same level until the end of project life. The estimated operation, maintenance and replacement (OMR) cost is needed annually after project completion to keep duly the designed function.

(2) Economic Evaluation

The EIRR as well as B/C and NPV for the project is calculated on the annual cost-benefit flow. The economic viability is as follows:

Item	Value
EIRR	10.19%
B/C	1.02
NPV	Rp. $2{,}216 \times 10^6$

(3) Sensitivity Analysis

Sensitivity analysis is carried out for the project on several cases of changes in the benefit or cost as summarized below.

CASE	EIRR (%)	B/C	NPV (Rp. 10^6)
Benefit, 5% down	9.73	0.97	- 3,120
Benefit, 10% down	9.25	0.92	- 8,456
Cost, 5% up	9.75	0.99	- 3,009
Cost, 10% up	9.34	0.93	- 8,234

Project Justification

The EIRR of the Bangkinang Area River Improvement Works shows 10.19%, and in any case of sensitivity analysis on case changes in the benefit or cost, it is more than 9.2% as presented above. The Works are therefore evaluated to be economically viable.

Furthermore, consideration is given to the exclusion of intangible benefits generated by the project such as saving of invaluable human lives that may possibly be lost by flooding, protection from possible injuries, and prevention of disease occurrence. If these intangible benefits are quantified, the EIRR can be a higher figure and viability of the project will increase.

7.4 Kuantan River Multipurpose Development Project

7.4.1 Present Condition

The project area is located in the middle stretches of the Kuantan-Indragiri river system. The Kuantan River flows out from mountainous areas at Lubukkambacang (441 km point from the river mouth). The areas in the downstream stretch from this point suffer from habitual flooding from the Kuantan-Indragiri River and this fact has been a constraint to the development of the area.

From the viewpoint of water resources development, deficit of water in the Lubukjambi Irrigation System is the major constraint in this area. Besides, potential hydropower generation at the conceived dam is identified in this area.

7.4.2 Planning Criteria

Purpose and Major Component of the Project

The purposes of the project are as follows:

(1) Flood Control

To protect areas for irrigation development from flooding.

(2) Irrigation Water Supply

To supply irrigation water to priority areas of Lubukjambi Irrigation Development Project.

(3) Hydropower Generation

To execute hydropower generation at the proposed Kuantan Dam.

The proposed structures consist of the Kuantan Dam, the Lubukjambi Intake Weir, a main irrigation canal and on-farm development structures of Lubukjambi Irrigation Development Project.

Objective Area

The objective area for flood control is the area to be developed in the Irrigation Development Plan as discussed hereafter.

In accordance with the results of the selection of the priority projects of the Overall Development Plan, the objective area for irrigation development in priority projects is defined as the area on the left bank from Lubukjambi Intake Weir to Kampung Baru, as tabulated below.

Unit: ha

Lubukjambi Irrigation Development Area	Left Bank Area	Right Bank Area
Existing Irrigation Area	4,142	-
Presently irrigated	1,670	-
Presently rainfed	376	-
Presently undeveloped	2,096	-
Net Additional Area	5,234	-
Total	9,376	-

Design Scale

The design scale for flood control for the feasibility study stage is set at 5-year return period considering that the area consists mainly of agricultural lands. The design scale for the determination of irrigation water requirement is set at 5-year return period.

Standard Flood discharge

Standard flood discharge of the Kuantan River at Kuantan Dam is determined through hydrological analysis, as follows:

- 5-year Return Period : 3,900 m^3/s

7.4.3 Study and Analysis

Water Demand

(1) Irrigation Water Requirement

(a) Optimum Cropping Pattern

Firstly, eight cases of alternative cropping patterns have been prepared by staggering the starting date of land preparation in 15 days from January 1 to April 16. Total diversion water requirements for each cropping pattern have accordingly been calculated. The optimum cropping pattern has been finally selected as the one which minimizes the total diversion water requirement as follows:

Crop	Starting Date of Land Preparation
1st Crop	March 16
2nd Crop	October 1

(b) Design Water Requirement

(i) Peak Water Requirement

The peak water requirements in the optimum cropping pattern for left bank area of the Lubukjambi Irrigation Development System have been calculated, as follows:

Unit: m^3/s

Area	Peak Water Requirement
Left Bank	7.85

(ii) Semimonthly Diversion Water Requirement

The semimonthly diversion water requirement in the optimum cropping pattern has been calculated by combining water requirements for the net additional area with the additional supply for the existing irrigation schemes, as shown in Table 7.4.1.

According to the results of the water balance study, existing irrigation schemes in the area for the feasibility study of Lubukjambi Irrigation Development Project will not have irrigation water deficit throughout the year.

(2) River Maintenance Flow (Constant Release)

The specific discharge of river maintenance flow is taken at 0.9 $m^3/s/100\ km^2$. The river maintenance flow at the proposed Kuantan Dam is calculate at 57.39 m^3/s from the catchment are of 6,377 km^2 (except Singkarak Lake basin of 1,076 km^2).

(3) River Maintenance Flow (Supplementation of Deficit in Downstream Area)

The river maintenance flow of 57.39 m^3/s at Kuantan damsite as calculated above will be constantly released. This value can be considered as the responsible release at the damsite.

The other river maintenance flow is to supplement deficit which might occur in the residual catchment of the Kuantan-Indragiri River. With this release, a specific discharge of 0.9 $m^3/s/100\ km^2$ is realized at the river mouth. A peak release of 24.64 m^3/s for this purpose has been calculated.

(4) Total Water Demand

Based on the above, the peak water demand in the Feasibility Study was determined as follows:

Unit: m^3/s

Purpose	Peak Water Demand
Left Bank Irrigation	7.85
River Maintenance Flow (Constant Release)	57.39
River Maintenance Flow (Supplementation of Deficit in Downstream Area)	24.64
Total	89.88

Storage Capacity of Kuantan Dam for Irrigation and River Maintenance

The objective irrigation area for the priority project has been decreased from 30,149 ha for the Overall Plan to 9,376 ha. By this decrease, the required storage volume for irrigation use has been calculated at $4.0 \times 10^6 m^3$ by the reservoir operation. Accordingly, the necessary storage capacity for irrigation and river maintenance has been determined as follows:

Unit: $10^6 m^3$

Purpose	Allocated Capacity
Irrigation	4
River Maintenance	213

Storage capacity for flood control and hydropower generation has been determined considering the optimum combination as discussed later.

Storage Capacity of Lubukjambi Intake Weir

The required capacity of Kuok Intake Weir to regulate hydropower generation release to constant release is calculated at $0.45\times10^6 m^3$ on the basis of the water requirement for the priority projects at Lubukjambi Intake Weir. This is estimated for power generation duration of 8-hour of the Kuantan Power Station. On the other hand, the same capacity for the Overall Development Plan has been estimated at $2.2\times10^6 m^3$ from the peak diversion water requirement of 36.93 m^3/s.

The weir crest elevation proposed in the Overall Development Plan should be maintained in the initial phase since elevations which are determined by the alignment of the main irrigation canals could not be changed. Accordingly, the storage capacity of $2.2\times10^6 m^3$ required for the Overall Development Plan has been applied to avoid reconstruction of intake and distribution facilities.

Optimization of Kuantan Reservoir Allocation for Initial Phase

Kuantan Dam is to be constructed in the initial phase of the Indragiri River Development Project at the scale determined in the Overall Development Plan. Presented in this chapter is the operation of Kuantan Reservoir for the period until the downstream river improvement is completed.

(1) Basic Conditions

Basic conditions for the optimization study are set for each component as follows:

(a) Flood Control

In the initial phase, the irrigation development area is the objective flood control area. The design scale is set at 5-year return period.

In the case when a 5-year return period project flood occurs and flood control operation as determined for the Overall Development Plan is conducted (constant rate discharging method with a control starting discharge of 500 m^3/s and a constant rate of 0.440), the peak discharge of 3,900 m^3/s is reduced to 2,000 m^3/s. The discharge of 2,000 m^3/s exceeds the flow capacity of the present channel of the Kuantan River along the irrigation development area, so that countermeasures are needed.

(b) Irrigation Development

In the initial phase, the left bank upstream area of the Lubukjambi Irrigation System is to be developed. The reservoir capacity for water supply to this area is $4.0\times10^6 m^3$ only as mentioned before and the remaining capacity of $113\times10^6 m^3$ to that of the Overall Development Plan ($117\times10^6 m^3$) is allocated for other purposes.

(c) Hydropower Generation

In the initial phase, hydropower generation is considered to be subsidiary to flood control and irrigation development.

(2) Study on Alternative Cases

The following two alternative cases have been studied and the optimum plan was selected.

(a) Case 1

A part of the storage capacity for hydropower generation at Kuantan Dam is used for flood control during rainy seasons. The peak of a 5-year return period flood is reduced to the discharge of 1,000 m^3/s that will not cause damage to the objective flood control area, and no river improvement works are implemented. Hydropower generation benefit will be reduced from those of the Overall Development Plan.

Capacity allocation of Kuantan Dam in the initial phase has been determined as tabulated below.

Unit: $10^6 m^3$

Capacity	Allocation	
	Dry Season (April-September)	Rainy Season (October-March)
Flood Control	400	793
Hydropower Generation	528	135
Irrigation	4	4
River Maintenance	213	213
Dead Storage	425	425
Gross Storage	1,570	1,570

(b) Case 2

The allocation of storage capacity is the same as the Overall Development Plan and river improvement works are implemented in the Kuantan River. The design discharge is 2,000 m^3/s, the maximum release when a 5-year return period project flood occurs, and flood control operation as determined for the Overall Development Plan is conducted. In this case, hydropower generation benefit of the Overall Development Plan will be maintained.

Accordingly, in Case 1, hydropower generation benefit decreases and in Case 2, additional cost for river improvement works is required. The present value of cost and benefit reduction has been compared, as shown in the table below, and Case 1 was selected as the optimum plan. Capacity allocation for Kuantan Dam in the initial phase is as presented in Fig. 7.4.1.

Unit: Rp. 10^9

Case No. and Explanation	Value
Case 1: (Reduction of Hydropower Generation Benefit)	91.2
Case 2: (River Improvement Cost)	342.0

7.4.4 Preliminary Design

Preliminary designing has been conducted for the Kuantan Dam, Lubukjambi Intake Weir and Main Irrigation Canal for the Initial Phase of the Lubukjambi Irrigation Development Plan.

Kuantan Dam

Preliminary designing has been conducted as presented below. The location of the dam and the structural design drawing are presented in Fig. 7.4.2 and 7.4.3, respectively.

(1) Principal Features and Design Conditions

(a) Principal Features

The principal features of the Kuantan Dam as determined in the Overall Development Plan are given in the table below.

Particulars	Unit	Value
Surcharge Water Level (SWL)	EL m	120.0
Normal Water Level (NWL)	EL m	115.2
Low Water Level (LWL)	EL m	102.0
Effective Storage for Water Supply	10^6 m^3	745
Installed Capacity	MW	114
Maximum Turbine Discharge	m^3/sec	270

(b) Design Flood Discharge

Design flood discharges have been determined in the Overall Development Plan as follows:

Particulars	Design Flood Discharge and Return Period
Diversion Scheme	1,510 m^3/sec (2-year)
Dam and Spillway	10,050 m^3/sec (1,000-year)
Spillway Energy Dissipater	7,360 m^3/sec (100-year)
River Outlet	100 m^3/sec

(c) Design Values

Various design values for the dam are as follows:

Particulars	Unit	Value
Seismic Coefficient		0.12
Period of Seismic Wave	sec	1.0
Wind Velocity	m/sec	30
Fetch	m	2,100
Unit Weight of Mass Concrete	ton/m^3	2.30
Unit Weight of Silted Deposit in the Air	ton/m^3	1.80
Porosity (n) of Silted Deposit		0.40
Allowable Bearing Capacity of Rock Foundation	kg/cm^2	40
Shearing Strength of Bedrock	kg/cm^2	15
Internal Friction for Bedrock	degree	35

(2) Design of Main Dam

(a) Dam Axis

Taking the geological and topographic conditions into consideration, three alternatives of dam axis; namely, upstream axis, middle axis and downstream axis, are set as given in Fig. 7.4.4, based on the topographic maps with a scale of 1/5,000.

The three alternatives were compared mainly according to cost and geological conditions. The cost of the three alternatives were estimated, as follows:

Unit: Rp. 10^6

Item of Work	Axis		
	Upstream	Middle	Downstream
Access Road	8,400	8,000	7,500
Diversion Tunnel	24,900	27,400	29,100
Cofferdam	6,500	6,300	7,200
Main Dam and Spillway	91,600	96,700	96,900
Powerhouse and Tailrace	25,800	24,800	26,400
Total (Ratio)	157,200 (100.0%)	163,200 (103.8%)	167,100 (106.3%)

Considering geological conditions and cost, the middle dam axis is finally selected in view of the following reasons:

- Geological condition of the upstream axis is considered to be the worst among the three because of the existence of a shale zone in the riverbed and left abutment. A shale zone does not appear at the middle and downstream axes and a concrete gravity dam can be constructed at such locations.

- Since both the upstream and downstream axes have steep slopes for abutments, excavation of slope for the construction of powerhouse will reach nearly 100 m in height assuming an average slope cut of 1 : 1.0, and it is difficult or costly to maintain stability at such a high slope. The slope cut at the middle axis will be around 30 m in the maximum height.
- The cost of the middle axis is the second lowest among the three, but the difference with the lowest cost is small at 6 billion Rp. (3.8% of the lowest cost).
- At the middle axis, there is a gently sloped terrain in the downstream side of the axis on the right abutment. It will be convenient to accommodate construction facilities at this area and also to keep work space.

(b) Dam Type

The topography and geology at the proposed damsite will allow the construction of either a concrete gravity dam or a rockfill type dam. However, a rockfill dam plan is abandoned from the viewpoint of safety because the proposed Kuantan Dam is situated on the mainstream of the Indragiri River and has a large catchment area of 6,377 km^2 (excluding Singkarak Lake basin) and a large design flood discharge of 10,050 m^3/sec.

(c) Dam Crest Elevation

The proposed reservoir has SWL at EL 120.00 m and NWL at EL 115.20 m. The flood water level (FWL) was estimated at EL 121.08 m by flood routing, assuming the retarding effect of reservoir for the 1,000-year probable flood.

The dam crest elevation should be designed to be safe against flood discharge, water waves by wind or earthquake and other allowances. It has been determined at EL 123.0 m.

(d) Typical Structure

The proposed typical structure of the dam has been determined, as shown in Fig. 7.4.3. The principal dimensions are as follows:

Particulars	Value
Crest Elevation	EL 123.00 m
Crest Width	5.0 m
Upstream Slope	
Below EL 100 m	1 : 0.25
Above EL 100 m	vertical
Downstream Slope	1 : 0.85

These dimensions were determined by conventional 2-dimensional stability analysis based on the following conditions:

- SF (safety factor) shall not be less than 4.0.
- Eccentricity shall be less than 12.4 m.
- Base reaction shall be less than 400 ton/m^2.

(e) Foundation Treatment

In the geological assessment, no serious defect was found at the proposed damsite. However, considering the type and height of the dam, careful attention should be paid to the foundation treatment. In this design, the following grouting works are planned.

Particulars	Contents of Works
Consolidation Grout (dam foundation)	4 m grid of 5 m deep
Curtain Grout	1 m interval in 1 row of 20 m to 50 m deep

(3) Design of River Diversion

(a) Design Conditions

Diversion tunnels and cofferdams are provided to divert river flow during the period of construction of the main dam, as shown in Fig. 7.4.3. The diversion tunnels are arranged on the right abutment side considering the topographic and geological conditions at the damsite.

Two lanes of diversion tunnels are provided to cope with the rather large design flood and river closure sequence. A 2-year probable flood with a peak discharge of 1,510 m^3/sec is adopted as the design flood discharge for the diversion scheme of a concrete gravity dam without the effect of flood retarding in the river channel.

(b) River Diversion Scheme

Since the upstream cofferdam is set apart from the main dam in case of a concrete gravity dam, the optimum diversion scheme is selected to minimize the total construction cost of the upstream cofferdam and the diversion tunnels.

The comparison study was made assuming several combination of the different diameters of diversion tunnel and different height of the cofferdam. Type of the cofferdam is concrete gravity. Freeboard is taken at 1.0 m to the water level for the design discharge. Three cases of the diameter of the diversion tunnel, namely, 8.3, 8.8 and 9.3 m are compared.

The combination of a diversion tunnel of 8.8 m diameter and a 26.9 m high cofferdam (crest elevation at EL 79.00 m) is selected as the least cost combination. The flow velocity of the diversion tunnel at the design discharge is 12.4 m/sec.

(4) Design of Spillway

(a) Design Conditions

The spillway is designed to be an over-flow type with gates in the central part of the main dam as shown in Fig. 7.4.3. A stilling basin type energy dissipater is adopted from the viewpoint of reliable energy dissipation because the powerhouse locates beside the spillway.

The spillway is designed to discharge a 1,000-year probable flood with a peak discharge of 10,050 m^3/sec, taking the retarding effect of the reservoir into account. However, the energy dissipater is designed for a 100-year probable flood with a peak discharge of 7,360 m^3/sec.

(b) Optimization of Spillway Width

The width of spillway overflow crest is related with the dam crest elevation. A smaller width for spillway requires a higher dam crest elevation. A comparative study was therefore made to determine the least cost combination. The crest elevation of the spillway is set at EL 106.5 m for the flood control purpose which has to discharge 500 m^3/sec at water level EL 109.5 m.

As a result of the study, the width of the spillway is determined at 60 m. Fig. 7.4.5 shows the result of flood routing for the width of 60 m. The maximum outflow from the spillway comes to 6,970 m^3/sec against the inflow peak of 10,050 m^3/sec and the reservoir water level (FWL) reaches EL 121.08 m.

(c) Stilling Basin

The dimension of the stilling basin designed to cope with a 100-year probable flood is 69 m wide × 115 m long × 26 m deep. The apron is set at EL 53.00 m and the elevation of top of sidewall is EL 79.00 m.

(5) Waterway

(a) Design Conditions

The waterway for power generation is arranged on the right side of the dam body to secure suitable location for powerhouse as shown in Fig. 7.4.3. The waterway is composed of an intake, a penstock line and a tailrace. The design discharge is 270 m^3/sec.

(b) Intake

The intake is divided into three to cope with the penstock line. Fan-shaped weir is provided in the inlet portion to prevent sediment and air entrance. The elevation of inlet center is EL 95.0 m. Intake gate of roller gate type is installed in front of each intake. The dimension of the gate is 5 m wide × 5 m high × 3 units. Trashrack with fixed screen is also installed in front of each intake to prevent entrainment of flowing logs into the penstock lines. The dimension of trashrack is 23 m high × 7 m wide × 3 units.

(c) Penstock Line

The penstock consists of 3 lines of steel pipes connecting the intake and turbine. The diameter of penstock is determined to be 4.2 m, assuming economic flow velocity of 5 m/sec against turbine discharge of 270 m^3/sec. The penstock is set at EL 95.0 m at inlet and EL 50.0 m at outlet for turbine. The length of penstock line is 105 m.

(6) Power Station

The power station is located immediately downstream from the main dam on the right bank, taking the topographic conditions into account as shown in Fig. 7.4.3. The power station consists of a powerhouse, a tailrace and an outdoor switchyard. The powerhouse will accommodate three units of generating equipment.

(a) Turbine and Generator

A vertical shaft Kaplan type turbine is selected applying one unit output of 38 MW and a net head of 50.7 m. The generator is designed to have a capacity of 38 MW of output and 45 MVA of capacity, assuming the power factor of 0.85. The centerline of the turbine is set at EL 50.0 m.

(b) Powerhouse and Tailrace

An open-type powerhouse is adopted taking the topographic conditions into account. The powerhouse has a dimension of 20 m wide × 60 m long to accommodate three units of turbines and generators. The ground floor is set at EL 79.0 m. The tail water level is EL 59.0 m for the maximum turbine discharge of 270 m^3/s.

(c) Outdoor Switchyard

The outdoor switchyard will accommodate the main switchgear equipment and is situated between the main dam and the powerhouse at ground elevation of EL 79 m.

(7) River Outlet

A square conduit type of river outlet is provided in the main dam body, under the rightmost spillway pier. The dimension of the river outlet is 2.3 m wide × 2.3 m high. It is set at EL 80.0 m to discharge 100 m^3/s against LWL of EL 102.0 m. The river outlet is equipped with a high pressure type slide gate.

(8) Transmission Line and Substation

A substation is planned in the town of Telukkuantan according to the PLN's plan. The Kuantan Power Station is therefore planned to be connected to the Telukkuantan Substation by a transmission line.

The transmission line has a capacity of 150 kV. The distance from the power station to Telukkuantan Substation is about 30 km.

(a) Major Structural Features

The major structural features of the project are as follows:

Reservoir	
Gross Storage Capacity	$1,570\times10^6 m^3$
Effective Storage Capacity	$1,145\times10^6 m^3$
Flood Water Level (FWL)	EL. 121.08 m
Surcharge Water Level (SWL)	EL. 120.00 m
Normal Water Level (NWL)	EL. 115.20 m
Low Water Level (LWL)	EL. 102.00 m
Sediment Level	EL. 99.50 m
Effective Depth	18.0 m
Surface Area at SWL	91.5 km^2
Catchment Area	6,377 km^2 (excl. Singkarak Lake basin)
Annual Average Inflow	210.1 m^3/s

Dam	
Type	Concrete Gravity
Dam Crest Elevation	EL 123.00 m
Height	73.0 m
Freeboard	1.9 m
Crest Length × Crest Width	294.0 m × 5.0 m
Non-overflow Crest Elevation	EL 123.00 m
Overflow Crest Elevation	EL 106.50 m
Overflow	
Depth	14.6 m
Length	69 m (15 m × 4 gates + 3 m × 3 piers)
Volume of Dam	339,100 m^3
Base Width	74.55 m
Slope	
Upstream Face	Vertical (above EL 100 m) 1 : 0.25 (below EL 100 m)
Downstream Face	1 : 0.85

Spillway	
Type	Gated type
Discharge Capacity	6,970 m^3/s
Gate Type and Dimension	Roller Gate; 14.5 m (H) × 15.0 m (W) × 4-unit

Diversion Works	
Diversion Tunnel	
Number	2 lanes
Length	460 m (No. 1) and 510 m (No. 2)
Inner Diameter	8.8 m
Total Design Capacity	1,510 m^3/s

Intake	
Type	Submerged on Upstream Face
Elevation of Intake	95.0 m
Gate Type and Dimension	Roller Gate; 5.0 m (H) × 5.0 m (W) × 3-unit
Screen	23 m (H) × 7 m (W) × 3-unit

Penstock	
Type	Partly embedded, encased in dam body
Dimension	4.2 m (Dia.) × 105 m (L) × 3-line

Power Station	
Type	On Ground
Dimension	58 m (L) × 29 m (W) ×53 m (H)

Tailrace	
Type	Open Channel
Length	52 m
Gradient	1 : 2.0
Section	Trapezoidal
Gate Type	Roller Gate; 6.0 m (H) × 6.0 m (W) × 1-unit

River Outlet	
Type	Conduit
Dimension	2.3 m (H) × 2.3 m (W) × 1-unit
Gate Type	Slide Gate; 2.3 m (H) × 2.3 m (W) × 1-unit

Capacity of Power Plant	
Maximum Output	114,000 kW (38,000 kW× 3-unit)
Maximum Turbine Discharge	270 m^3/s
Effective Head	50.7 m
Annual Ave. Generated Energy	657 GWh

Turbine	
Type	Vertical Shaft, Kaplan
Installed Capacity	40.0 MW × 3-unit
Effective Head	50.7 m
No. of Revolutions	214 rpm

Generator	
Type	3-Phase AC, Synchronous
Capacity	46,000 kVA × 3-unit
Voltage / Frequency	11 kV / 50 Hz

Main Transformer	
Type	3-Phase ONAF Outdoor Type
Capacity	46,000 kVA × 3-unit
Voltage	11/150 kV

Transmission Line from Kuantan P/S to Telukkuantan S/S (Planned)	
Length	30 km
Phase	3-Phase System
Voltage	150 kV
No. of Circuits	Double

Substation	
Location	Telukkuantan
Type	3-Phase, Outdoor, Single Bus
Voltage	150/20 kV

Switchyard	
Location	Right Bank of Damsite
Type	3-Phase, Outdoor
No. of Bays	5 Bays (3 for G/E and 2 for T/L)
Voltage	150/11 kV

Lubukjambi Intake Weir

Preliminary design has been conducted as presented below. The location map of the weir and the structural design drawing are presented in Fig. 7.4.6 and 7.4.7, respectively.

(1) Basic Design Conditions

Basic conditions for preliminary design of the weir are as presented together with the major structural features in item (5) below.

(2) Location of Intake Weir

Lubukjambi Intake Weir is proposed at the meander bend near the foot of the mountains, 11.5 km downstream from the proposed Kuantan Dam (refer to Fig. 7.4.6). This location was determined in consideration of the following conditions:

- The required regulation volume of the reservoir is $2.2 \times 10^6 m^3$.
- It is difficult to construct a weir in the existing channel because the water depth of the channel in rainy seasons is high at about 10 m.

- From the viewpoint of easy construction, the meander bend which is proposed to be shortcut is desirable.

(3) Selection of Weir Type

The weir is located on the main stream of the Kuantan River at a point with a catchment area of approximately 7,450 km^2. A movable type weir is adopted considering safe passage of floods. Two types of movable weir are applicable for the Lubukjambi Intake Weir, namely, roller gate type and radial gate type.

Rubber gate and tilting gate types were excluded from the comparative study because the required gate height is too high for these types. As a result of the comparative study tabulated in Table 7.4.2, the roller gate type is selected from the technical and economical viewpoints.

(4) Design of Structures

(a) Flood Discharge Gate

The flood discharge roller gates shall have function to smoothly release floodwater and to store re-regulated water at normal time. The spillway section consists of four spans; each with a 29.4 m long and 4.7 m high roller gate.

(b) Flush Gate

Flush gates with roller gates have been provided at both sides to flush out sediment accumulated in front of inlets. The bottom elevation of the flush gates are set at 1.0 m below the weir sill.

(c) Apron and Riprap

Concrete aprons, concrete blocks and gabion mattress riprap are placed for both downstream and upstream sides of the spillway to prevent scouring of the riverbed.

(d) Inlet

Inlets require a structure to easily control intake discharge, and prevention measures against foreign materials flowing into the canal. For these purposes, control gates, screen, inlet apron, etc., are installed.

(e) Foundation

According to the results of drilling investigation conducted in this study, the foundation is river sediments and assumably have sufficient bearing capacity. Sheet piles of approximately 2 m long are provided to the bottom of the river sediment layer for seepage prevention.

(5) Major Structural Features

Major structural features and design conditions are as follows:

Afterbay Reservoir	
Normal Water Level	EL 60.0 m
Low Water Level	EL 58.0 m
Required Storage Capacity	2.2×10^6 m^3
Intake Discharge (for Overall Plan)	
Left Bank	19.31 m^3/s
Right Bank	17.62 m^3/s
Design Flood	
Design Scale (Return Period)	50-year
Design Flood Discharge	3,200 m^3/s
High Water Level	EL 62.10 m
Dike Crest Elevation	EL 63.30 m
Riverbed Elevation	EL 54.30 m
Structural Dimensions of Weir	
Gate Type	Roller Gate
Sill Elevation	EL 55.30 m
Crest Elevation	EL 60.00 m
Length × Height × Unit	29.4 m × 4.7 m × 4 units

Main Irrigation Canal

Main irrigation canals proposed in the Initial Phase are as shown in Fig. 7.4.8 and Table 7.4.3, designed in the same manner as the Overall Development Plan. Major features are as presented in the following table.

Particulars	Unit	Left Bank Irrigation Canal
Canal Length	km	76.0
Design Discharge	m^3/s	7.85
Gradient		1/3,000
Max. Velocity	m/s	0.95
Lining		10-cm thick concrete lining side slopes with stone wet masonry footing and compacted earth on bottom

7.4.5 Construction Plan

(1) Kuantan Dam Construction Works

The damsite is located on the Kuantan River at around 7.5 km from Kotokombu and accessible only by boat. From the conceivable two alternative access routes, the left bank route (from Kotokombu) is selected considering topographical advantages and lesser construction cost. Layout plan of temporary construction facilities has been prepared, as shown in Fig. 7.4.9.

There are no serious constraints to obtain construction materials. Fine and coarse aggregates shall be collected from sandbars and river banks located nearby. Excavated materials of diversion tunnel and dam foundation shall also be utilized.

The resettlement of local inhabitants and relocation of roads and relevant structures in the reservoir area formed by the Kuantan Dam which lies mainly in West Sumatra Province are necessary before the commencement of construction works. Land to be acquired, residential houses and buildings to be evacuated are 2,410 ha, 1,170 units of houses, and 50 units of buildings, respectively.

The construction schedule is as shown in Fig. 7.4.10.

(2) Lubukjambi Intake Weir Construction Works

The weir site is located in a shortcut on the right bank of the Kuantan River around 13 km upstream from Lubukjambi. A village road aligned along the right riverbank of the Kuantan River leads to the village between the Alah and Pinang rivers. The layout plan of temporary construction facilities for the Lubukjambi Intake Weir Construction Works is shown in Fig. 7.4.11.

Material from sandbars in the Kuantan River and excavated materials from both the weir site and the shortcut are to be utilized as fine and coarse aggregates.

Land to be acquired as right-of-way for the shortcut including weir site is around 30 ha. The number of houses to be relocated is around 80, including small huts. After completion of the shortcut, the existing river course may be utilized as a resettlement area, if it is reclaimed. The construction schedule is as shown in Fig. 7.4.12.

(3) Lubukjambi Irrigation System Construction Works

The project area is on the left bank of the Indragiri River, from the downstream of the Lubukjambi Intake Weir down to Kampung Baru. The national highway from Talukkuantan and the provincial road from Talukkuantan to Japura are the major access to the project sites.

Right-of-way for headreaches and main canals has to be acquired and families to be affected have to be compensated and evacuated prior to the construction. Lands to be acquired are approximately 260 ha for right-of-way of canals. Houses to be evacuated are 480 houses including small huts. The construction schedule is as shown in Fig. 7.4.12.

7.4.6 Cost Estimate

(1) Project Cost

The project cost has been estimated based on the basic conditions, as discussed in Subsection 7.1.2. Tables 7.4.4 to 7.4.6 show the financial cost and disbursement schedule, respectively, as summarized in the following table.

Unit: Rp. 10^6

Item	Value
Construction Base Cost	507,371
Compensation Cost	29,335
Administration and Engineering Cost	77,573
Price Contingency	282,717
Physical Contingency	85,351
Sub-Total	982,347
Value Added Tax	98,235
Total	1,080,582

(2) Cost Allocation of Kuantan Dam

Kuantan Dam is a multipurpose structure for flood control, hydropower generation, irrigation water supply and river maintenance flow supply. It is necessary to allocate the cost among these uses to fix the prices of power and to determine the contribution required of flood mitigation beneficiaries.

In this respect, the construction cost of the Kuantan Dam is allocated to each purpose. The most commonly applied allocation method is the remaining-benefits and alternative justifiable-expenditure method. This method is applied for the present Study. Interest rate and project life are set at 10% and 50 years, respectively.

The procedure of calculation is as shown in Table 7.4.7 and summarized below.

(a) Capacity Allocation

The reservoir capacity allocation in the initial phase has been made as follows:

Unit: 10^6m^3

Capacity	Allocation	
	Dry Season (April-September)	Rainy Season (October-March)
Flood Control	400	793
Hydropower Generation	528	135
Irrigation	4	4
River Maintenance	213	213
Dead Storage	90	90
Sedimentation	335	335
Gross Storage	1,570	1,570

(b) Identification of Purpose

The purposes has been grouped, as follows:

River	Flood control and river maintenance flow supply
Hydropower	Hydropower generation and dead storage
Irrigation	Irrigation

The reason of allocating dead storage capacity to hydropower generation is that this dead storage capacity is created to maintain a higher reservoir water level for the benefit of hydropower generation.

(c) Alternate Single-Purpose Cost

Alternate single-purpose costs have been calculated for the purposes of river and irrigation at Rp. 253×10^9 (crest elevation of EL 119.4 m) and Rp. 180×10^9 (crest elevation of EL 93.5 m), respectively.

(d) Justifiable Expenditure

Justifiable expenditures have been calculated for the purposes of River (Flood Control and River Maintenance Flow), Hydropower and Irrigation, as follows:

Purpose	Justifiable Expenditure (Rp. 10^9)
Flood Control	300.9
River Maintenance Flow	212.0
Hydropower Generation	867.2
Irrigation	77.1

(e) Separable Cost

Separable costs for a single function have been calculated as the total project cost less the estimated cost with that function omitted. Those for river, hydropower and irrigation are Rp. 51.0×10^9, Rp. 12.0×10^9 and Rp. 1.0×10^9, respectively.

(f) Allocated Cost

The rates of allocation have been accordingly determined as follows (for calculation detail, refer to Table 7.4.4).

Purpose	Allocation Rate (%)	Allocated Cost (Rp. 10^9)	Single Purpose Cost (Rp. 10^9)	Total Cost (Rp. 10^9)
River	33.1	75.9	0.0	75.9
Hydropower	60.4	138.4	153.6	292.0
Irrigation	6.5	14.9	0.0	14.9
Total	100.0	229.2	153.6	382.8

7.4.7 Project Evaluation

(1) Economic Benefit

(a) Flood Control

Flood control benefit is defined as the reduction of inundation damage attributed to the proposed works. The reduction is obtained as the difference between the estimated inundation damage under the with- and the without-the-project situations.

Methodology, calculation conditions and estimation of average benefit are the same as those of the Bangkinang Area River Improvement Works. The annual average benefits of flood control by Kuantan Dam is accordingly estimated at Rp. $54,621\times10^6$.

(b) Irrigation Development

Unit economic value of benefit is estimated at Rp. 1,020,300/ha as net value of rice derived from deducing market price of production cost from farmer's gate price. Unit value of benefit for the existing irrigation area and benefit value have been calculated, as follows:

Category	Unit Benefit (Rp. 1,000)	Area (ha)	Benefit (Rp. 10^6)
Existing (Irrigated)	306.1 (30%)	1,670	511.2
Existing (Rainfed)	612.2 (60%)	376	230.2
Existing (Undeveloped)	1,020.3 (100%)	2,096	2,138.5
Net Additional Area	1,020.3 (100%)	5,234	5,340.3
Total		9,376	8,220.2

(c) Hydropower Generation

Economic benefit is estimated by means of the "least cost alternative method". In this method, the alternative facilities are the second best with the same characteristics as the hydropower development project with regard to power supply. The cost of alternative facilities is considered as the benefit.

Practically, kWh value (energy value) and kW value (power value) as the economic benefit of the hydropower generation plant is equivalent to kWh cost and kW cost of alternative power generation plant. In this project, a hypothetical diesel plant is assumed to be the alternative power generation plant. kWh and kW costs are estimated at US$318.14/kW and US$0.0178/kWh, respectively. The total economic benefit of the project has been estimated at Rp. $87,907\times10^6$ as follows:

Particulars	Value	Unit Benefit	Benefit (Rp. 10^6)
Output (90% Dependable)	94.4 MW	US$318.14/kW	65,320
Annual Generated Energy	583.4 GWh	US$0.0178/kWh	22,586
Total			87,906

Note: Conversion rate is US$1.00 = Rp. 2,175

(2) Economic Cost

The economic project cost is estimated at Rp. $613,636\times10^6$ based on the basic conditions discussed in Subsection 7.1.2.

(3) Economic Evaluation

The project has been evaluated from the economic viewpoint in terms of Economic Internal Rate of Return (EIRR), Benefit-Cost Ratio (B/C) and Net

Present Value (NPV). The opportunity cost of capital is assumed at 10% and applied to a discount rate for the calculation of B/C and NPV.

(a) Annual Cost-Benefit Flow

Annual cost-benefit flow is shown in Table 7.4.8. The benefit is assumed to accrue at the same level until the end of project life. The estimated operation, maintenance and replacement (OMR) cost is needed annually after project completion to keep duly the designed function.

(b) Economic Evaluation

The EIRR as well as B/C and NPV for the project is calculated on the annual cost-benefit flow. The economic viability is as follows:

Item	Value
EIRR	15.27%
B/C	1.74
NPV	Rp. $256{,}670\times10^{6}$

(c) Sensitivity Analysis

Sensitivity analysis has been carried out for the project on several cases of changes in the benefit or cost, as summarized below.

CASE	EIRR (%)	B/C	NPV (Rp. 10^{6})
Benefit, 5% down	14.79	1.66	228,947
Benefit, 10% down	14.23	1.58	198,742
Cost, 5% up	14.82	1.67	241,904
Cost, 10% up	14.33	1.59	224,657

(4) Financial Benefit (Revenue)

The financial evaluation has been conducted for hydropower generation at Kuantan Dam. Financial benefit has been considered to be revenue from consumers of electric power. Annual revenue has been calculated on the basis of the following assumptions.

(a) Unit Price of Revenue

In this study, it is assumed that average power rate is a unit price of revenue at Rp. 170/kWh which is estimated on the basis of historical total energy sold, total revenue and average power rate from 1984 to 1993 for the Pekanbaru Branch Office of PLN Region III.

(b) Annual Revenue

By taking the produced energy of 583.4 GWh in 2005 into account, the annual revenue of the project is estimated at Rp. $99{,}178 \times 10^6$.

(c) Increase of Average Power Rate

Usually, power rate increases by revision because of inflation, but the increase of power rate is not taken into account in the financial evaluation.

(5) Financial Cost

Financial cost of the project is estimated as real expenses of the project owner. In other works, financial cost is estimated by market price including contractor's profit, price contingencies and value added tax.

(6) Financial Evaluation

To calculate the indicators of Financial Internal Rate of Return (FIRR), B/C and NPV of the project, the annual cost-benefit flow has been estimated based on the disbursement schedule.

The financial benefit (revenue) for the Hydropower Generation Plan is assumed to be generated after the completion year 2004 and keep the same level until the end of project life.

(a) Annual Cost-Benefit Flow

Annual cost-benefit flow is shown in Table 7.4.9. The benefit is assumed to accrue at the same level until the end of project life. The estimated operation, maintenance and replacement (OMR) cost is needed annually after project completion to keep duly the designed function.

(b) Financial Evaluation

The FIRR as well as B/C and NPV for the project is calculated on the annual cost-benefit flow. The weighted average interest rate for long term loan is considered to be 8.3% per annum by referring to interest rates of international financial institutions like the Overseas Economic Cooperation Fund (OECF) of Japan at 2.6% per annum and interest rates of domestic banks at 14% per annum. Then, the discount rate of 8.3% is applied for the calculation of B/C and NPV. The financial viability is as follows:

Item	Value
FIRR	15.54%
B/C	2.22
NPV	Rp. $314{,}097 \times 10^6$

(c) Sensitivity Analysis

Sensitivity analysis has been carried out for the project on several cases of changes in the benefit or cost as summarized below.

CASE	FIRR (%)	B/C	NPV (Rp. 10^6)
Benefit, 5% down	14.32	1.98	268,425
Benefit, 10% down	13.76	1.87	239,815
Cost, 5% up	14.35	1.98	283,276
Cost, 10% up	13.87	1.89	269,518

(7) Project Justification

The EIRR of the Kuantan River Multipurpose Development Project shows 15.27%, and in any case of sensitivity analysis on case changes in the benefit or cost, it is more than 14.2% as presented above. The Kuantan River Multipurpose Development Project is therefore evaluated to be economically viable.

Furthermore, consideration is given to the exclusion of intangible benefits generated by the project such as saving of invaluable human lives that may possibly be lost by flooding, protection from possible injuries, and prevention of disease occurrence. If these intangible benefits are quantified, the EIRR can be a higher figure and viability of the project will increase.

The FIRR of the Hydropower Development Project shows 15.54%, and in any case of sensitivity analysis on case changes in the benefit or cost, it is over 13.7% as presented above. The Hydropower Development Project is therefore evaluated to be financially viable.

7.5 Rengat Area Flood Protection Works

7.5.1 Present Condition

The project area is located on the right bank of the Indragiri River at about 174 km point from the river mouth. The area is habitually flooded by the Indragiri River and this hampers the development of the area. Rengat Area is considered as the center of development of the Indragiri Hulu and Indragiri Hilir regencies.

7.5.2 Planning Criteria

The following planning criteria have been set for the formulation of the Rengat Area Flood Protection Works.

Purpose and Major Component of Project

The purpose of the project is to protect Rengat Area from flooding. Major components of the project are the ring dike and related structures.

Objective Area

The objective area for flood control has been determined based on the Detailed City Layout Plan of Rengat as well as considering the discussion with PU officials.

Design Scale

Design scale of 10-year return period shall be applied for the flood control in the area since this area is considered as urban area. The historical maximum flooding level shall also be considered for the determination of design high water level. The design scale for the interior drainage has been determined at 5-year return period.

Related Projects

The following projects are related to the formulation of flood protection in Rengat Area.

- Kuantan Dam Construction Works
- Kuantan-Indragiri River Improvement Project (Lubukjambi-Peranap Area and Peranap-Japura Area River Improvement Works)
- Indragiri-Gaung Floodway

Of these, the Kuantan Dam Construction Works and the Lubukjambi-Peranap Area and Peranap-Japura Area River Improvement Works are scheduled to be implemented after the completion of Rengat Area Flood Protection Works (refer to Implementation Schedule of Overall Development Plan). Accordingly, the condition without these two projects has been considered.

With regard to Indragiri-Gaung Floodway, the implementation schedule has not been finalized by the Indonesian Government. Accordingly, the condition without the floodway has been considered for the planning of Rengat Area Flood Protection Works. However, the effect of the floodway to the Rengat Area Flood Protection Works has been studied, as mentioned in subsequent paragraphs.

Design High Water Level and Design Discharge

Design high water level for the design scale of 10-year return period has to be determined based on the above condition. When the condition as mentioned above is considered, the flood in the Kuantan-Indragiri River flows down by flooding the riverine areas. Accordingly, the two-dimensional non-uniform flow calculation has been used to determine the high water level.

The highest flood water level at the pier of Rengat City when the 10-year return period flood flows is EL 7.0 m. The effect of floodway to the Gaung River is as evaluated below. The highest water level of EL 7.0 m in the case of no floodway is lowered to EL 6.90 m when the capacity of 500 m^3/s is given to the floodway. The difference is very small. Accordingly, the effect of Indragiri-Gaung Floodway has not been considered for the determination of high water level.

Historical high water levels at the same point are as follows. The flood water level has never exceeded the road surface of EL 7.240 m in the last 20 years but almost exceeded it several times. The water level during the flood in March 1995 (the highest in the past 10 years) was EL 6.744 m. The calculation result of EL 7.0 m of high water level is accordingly deemed appropriate. Design discharge of the Indragiri River is obtained from H-Q curve at Q = 2,850 m^3/s.

7.5.3 Study and Analysis

Optimization Study of Ring Dike

(1) Dike Alignment

Dike alignment is as shown in Fig. 7.5.1. The alignment has been determined to follow the Indragiri River Improvement Plan in the Overall Development Plan in the riverside, and considering the existing road alignment and the possible new road to Tembilahan in the land side.

(2) Longitudinal Profile and Cross Sections

Longitudinal profile and cross sections shall be planned according to the determined design high water level. In accordance with the Overall Development Plan of Indragiri River Improvement Project, the design high water gradient shall be 1/5,500. The longitudinal profile of the bank in the Indragiri River side has been thus determined at 1/5,500.

Proposed longitudinal profile and cross sections are presented in Figs. 7.5.2 and 7.5.3, respectively.

Inundation Analysis

Flood inundation analysis has been conducted to obtain inundation depth and duration for the calculation of flood protection benefit, as follows:

- The whole inundation area is divided into 250 m by 250 m mesh blocks which are equivalent to half minute of longitude and latitude.
- The average ground height of each mesh is obtained using the topographic map with a scale of 1/5,000 newly developed by JICA.
- The overflow discharge is given by the discharge volume as in the case of the Overall Development Plan.

Optimization Study for Interior Drainage

The proposed ring dike alignment will cross the existing drainage channels and create an interior drainage problem. Most streams in the Rengat area can discharge by gravity during low flows of the Indragiri River. During floods, however, the inland water is collected to lower areas and inundate the area since gravity flow through outlet sluices is impossible due to continuing high water level of the Indragiri River. A pumping station is thus required to discharge the interior water over the dike during floods.

(1) Design Scale

The design scale has been determined at 5-year return period based on the Flood Control Manual, CIDA-DPU, June 1993, in due consideration of the initial phase of the primary drainage system for urban areas with a population of less than 500,000.

(2) Retarding Basin

A retarding basin has been taken into consideration at the downstream part of the interior drainage area to minimize the capacity of the pump. The area of the retarding basin is 20 ha.

(3) Design Rainfall

Design rainfall for the interior drainage analysis has been determined based on three factors; namely, duration, probable amount and temporal distribution.

The duration of design rainfall is taken as ten days considering that the water level of Indragiri River at Rengat keeps the elevation higher than 6.5 m for approximately one week during a 5-year return period flood.

Probable 10-day rainfall amount of 205 mm and 230 mm have been obtained for 2-year and 5-year return period, respectively, based on the rainfall record at Japura, the nearest to the objective area.

Actually observed rainfall has been applied for temporal distribution of design rainfall.

(4) Establishment of Inundation Model

The inundation model has been established as follows. For this project, the interior drainage area is considered as a reservoir when a flood occurs. Under the present condition, there are no outlets to discharge rainfall in the area; the rainfall is simply stored. Under the with-a-pumping-station condition, the pumping station will drain the stored water.

Spatial distribution of inundation depth has been obtained using the same mesh blocks developed for the flood inundation simulation.

Optimization of Pump Capacity

Necessity and optimum capacity of the pumping station have been determined as below based on benefit and cost analysis.

(1) Calculation of Benefits

The benefits are calculated as flood damage reduction based on the difference in average annual flood damage with and without a pumping station.

The average annual flood damage can be computed by summation of damages obtained by multiplying damage expected at a given stage by the probability of occurrence of that stage.

The benefits are computed by the average annual damage reduction minus annual operation and maintenance which is assumed as 0.5 percent of total project costs (the estimation of total project costs is discussed later). The computation results are given in the table below.

Unit: Rp. 10^6

Particulars	Pump Capacity (m^3/s)						
	1	3	5	8	10	20	30
Average Annual Flood Damage Reduction	238	944	945	1,171	1,171	1,546	2,155
Annual Operation and Maintenance Cost	5	15	25	40	50	100	150
Annual Benefits	243	959	970	1,211	1,221	1,646	2,305

(2) Calculation of Costs

The annual costs have been computed assuming that project cost per pump capacity (m^3/s) is Rp. 10^9, as follows:

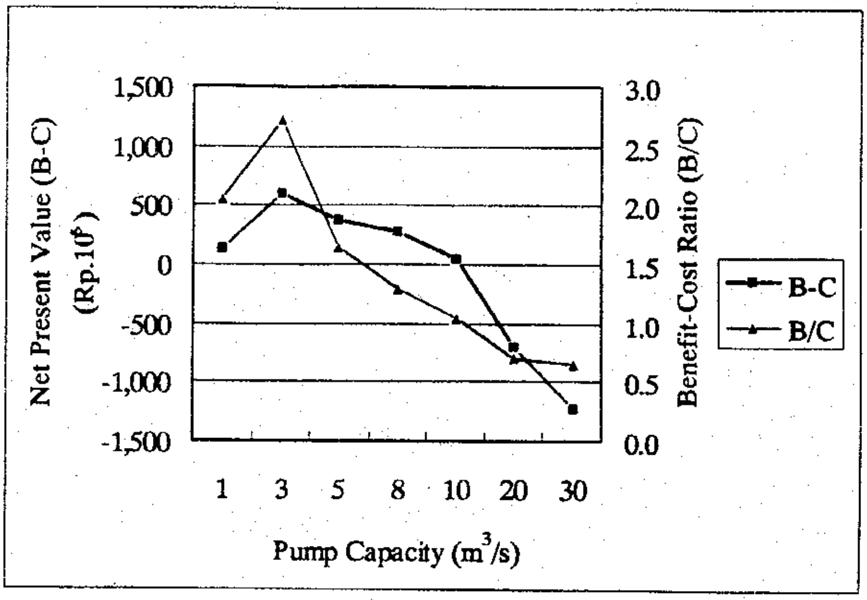
Unit: Rp. 10^6

Particulars	Pump Capacity (m^3/s)						
	1	3	5	8	10	20	30
Annual Cost	118	353	588	941	1,176	2,352	3,528

(3) Benefit and Cost Analysis

The Net Present Value (B-C) and Benefit Cost Ratio (B/C) are employed in evaluating alternatives for the interior drainage. Prescribed calculations of annual benefits and costs are used for selecting the optimum pump capacity as shown below.

The relation between pump capacity and the two indicators, i.e., Net Present Value (B-C) and Benefit-Cost Ratio (B/C) is illustrated below. This figure shows that B-C and B/C are the maximum at the pump capacity of 3 m^3/s, and concludes that the 3 m^3/s pump is the best choice in these alternatives. The area of about 20 ha with elevations of less than EL 3.0 m in the most downstream area of the Senggeris River has been utilized as a retarding basin, as shown in Fig. 7.5.1.



7.5.4 Preliminary Design

Flood control works include the construction of such structures as ring dike (earth dike and concrete wall dike), control gates, drainage pumping station, sluice and road bridge.

(1) Ring Dikes

Alignment of the northern part of ring dikes shall follow the alignment of the dike in the Overall Development Plan. The alignment in the southern side shall enclose the objective area, considering the possible route of the Pekanbaru-Tembilahan national road.

Generally, the ring dike shall be constructed of earth embankment with a 3 m wide crown, a freeboard of 1.2 m, and 1 : 2.0 (V : H) side slopes (refer to Fig. 7.5.4). Crown of dike can be used as maintenance road.

However, the city center of Rengat is close to the river and it is difficult to construct an earth dike. The height of dike required is low (about 1.2 m, equivalent to freeboard). Therefore, the concrete wall type of dike is proposed, as shown in Fig. 7.5.4.

(2) Dike Related Structures

Preliminary design of maintenance road, control gates, bridge and sluice have been conducted, as presented in Figs. 7.5.5 and 7.5.6.

(3) Drainage Pumping Station

A pumping station with the design capacity of 3.0 m^3/s is proposed at the eastern end of the area protected by ring dikes where there exist no houses at present.

Total pump head including losses due to screen, pipes, etc., is estimated to be approx. 3.5 m (HWL 6.0 - EL 3.0 + 0.5 m = 3.5 m). The following types of pump are commercially available for the estimated total pump head:

- Horizontal shaft axial flow pump
- Horizontal shaft mixed flow pump
- Vertical shaft axial flow pump
- Vertical shaft mixed flow pump
- Submersible motor pump

Among them, the submersible motor pump (3 units × 1.0 m^3/s unit capacity, 700 mm dia.) is recommended for reasons of economical installation cost, easy construction, operation and maintenance.

Fig. 7.5.7 shows the layout plan of proposed pumping station. Major facilities of pumping station consist of intake basin, main structure, surge tank, discharge sluiceway, mechanical control house, oil tank, pavement, parking lot, etc.

Pump units are planned to be operated by diesel generator sets at site. Manually collected garbage at screens are carried by horizontal and inclined belt conveyors.

7.5.5 Construction Plan

From Pekanbaru to Rengat, a new national highway of around 280 km through Japura is available. The town of Rengat faces the Indragiri River and its surrounding area is mainly swampy land. No access road is required in view of the location of the national highway and project sites, and the sequence of construction works.

Right-of-way for dikes and related structures has to be acquired and families to be affected have to be compensated and evacuated prior to construction. Lands to be acquired and houses to be evacuated are 40 ha and 20 houses, respectively.

The construction schedule is as shown in Fig. 7.5.8.

7.5.6 Cost Estimate

The project cost has been estimated based on the basic conditions, as discussed in Subsection 7.1.2. Tables 7.5.1 and 7.5.2 show the financial cost and disbursement schedule, respectively, as summarized in the following table:

Unit: Rp. 10^6

Item	Value
Construction Base Cost	28,817
Compensation Cost	280
Administration and Engineering Cost	4,336
Price Contingency	8,568
Physical Contingency	4,006
Sub-Total	46,007
Value Added Tax	4,601
Total	50,608

7.5.7 Project Evaluation

(1) Economic Benefit

Flood control benefit is defined as the reduction of inundation damage attributed to the proposed works. The reduction is obtained as the difference between the estimated inundation damage under the with- and the without-the-project situations.

Methodology, calculation conditions and estimation of annual average benefit are the same as those of the Bangkinang Area River Improvement Works. The annual average benefit is estimated at Rp. $5,044\times10^6$.

(2) Economic Cost

The economic project cost is estimated at Rp. $32,851\times10^6$ based on the basic conditions, as discussed in Subsection 7.1.2.

(3) Economic Evaluation

The project has been evaluated from the economic viewpoint in terms of Economic Internal Rate of Return (EIRR), Benefit-Cost Ratio (B/C) and Net Present Value (NPV). The opportunity cost of capital is assumed at 10% and applied to a discount rate for the calculation of B/C and NPV.

(a) Annual Cost-Benefit Flow

Annual cost-benefit flow is shown in Table 7.5.3. The benefit is assumed to accrue at the same level until the end of project life. The estimated operation, maintenance and replacement (OMR) cost is needed annually after project completion to keep duly the designed function.

(b) Economic Evaluation

The EIRR as well as B/C and NPV for the project is calculated on the annual cost-benefit flow. The economic viability is as follows:

Item	Value
EIRR	11.00%
B/C	1.11
NPV	Rp. $2,815\times10^6$

(c) Sensitivity Analysis

Sensitivity analysis is carried out for the project on several cases of changes in the benefit or cost, as summarized below.

CASE	EIRR (%)	B/C	NPV (Rp. 10^6)
Benefit, 5% down	10.52	1.06	1,444
Benefit, 10% down	10.03	1.00	72
Cost, 5% up	10.54	1.06	1,584
Cost, 10% up	10.12	1.01	354

(4) Project Justification

The EIRR of the Rengat Area Flood Protection Works shows 11.00%, and in any case of sensitivity analysis on case changes in the benefit or cost, it is more than 10.0% as presented above. The Rengat Area Flood Protection Works is therefore evaluated to be economically viable.

Furthermore, consideration is given to the exclusion of intangible benefits generated by the project such as saving of invaluable human lives that may possibly be lost by flooding, protection from possible injuries, and prevention of disease occurrence. If these intangible benefits are quantified, the EIRR can be a higher figure and viability of the project will increase.

7.6 All Projects

An integrated economic evaluation is conducted for all priority projects in the Feasibility Study. By this evaluation, the final judgment of feasibility is made possible for all projects.

7.6.1 Economic Evaluation

(1) Annual Cost-Benefit Flow

To calculate the indicators of EIRR, B/C and NPV of all projects, the annual cost-benefit flow is calculated by accumulation of the annual costs and benefits of all projects in the Feasibility Study consisting of the Flood Control, Water Resources Development and Hydropower Development projects (refer to Table 7.6.1).

(2) Integrated Evaluation

The EIRR as well as B/C and NPV for project is calculated on the annual cost-benefit flow. The opportunity cost of capital is considered to be 10% in the project. Then, the discount rate 10% is applied for the calculation of B/C and NPV. The economic viability is as follows:

EIRR	13.59%
B/C	1.46
NPV	Rp. $263,292 \times 10^6$

(3) Sensitivity Analysis

Sensitivity analysis is carried out for the project on several cases of changes in the benefit or cost as summarized below.

CASE	EIRR (%)	B/C	NPV (Rp. 10^6)
Benefit, 5% down	13.15	1.40	226,349
Benefit, 10% down	12.60	1.33	184,796
Cost, 5% up	13.17	1.41	239,744
Cost, 10% up	12.70	1.34	211,586

7.6.2 Project Justification

The EIRR of the projects as a whole shows 13.59%, and in any case of sensitivity analysis on case changes in the benefit or cost, it is more than 12.6% as presented above. The project for the Feasibility Study as a whole is therefore evaluated to be economically viable.

7.7 Environmental Analysis

7.7.1 Environmental Impact Analysis (ANDAL)

Objectives of ANDAL

The objectives of ANDAL Study are described in Subsection 5.15.2.

Present Environmental Condition of Priority Project Area

The present environmental conditions prevailing in the area for priority projects are as described below.

(1) Physical Conditions

(a) Land Use and Spatial Plan

The present land use of the sites of proposed priority projects are classified into four categories: settlement/home yard, paddy/upland field, plantation and forest.

According to the maps of the spatial plans, spatial land use plan in the area of priority project is as follows:

Kuok Intake Weir and the Rantauberangin Irrigation Canal belong to the area of plantation development, while the Bangkinang Area River Improvement Works belong to a buffer zone.

In the Indragiri river basin, the Kuantan reservoir area belongs to the protected zone, cultivation zone and buffer zone. The Lubukjambi Intake Weir, the irrigation canal and Rengat area belong to four zones: agriculture development zone, husbandry and agro industry development zone, plantation development zone, and other development and river buffer zone.

(b) Soil Type

Based on the field observation, the soil type found in the Kuok Intake Weir site and the Rantauberangin Irrigation Area is Podzols developed from alluvial deposits which were sedimented in the river.

Soil types in the Kuantan Reservoir area are Latosol, Podzol, Litosol from sediment crust and other types of Podzol originating from alluvial sediment. The fertility of soils is low.

Soil types in the Lubukjambi Intake Weir and Irrigation Area are Podzols formed from alluvium materials which are found in the wavy area at the upper part of the Indragiri River, while alluvial soils are seen in the lower part of the river. Soil fertility is from low to medium.

Soil types in Rengat area are alluvial soil which originated from river deposits and Gleysols and Organosols. Soil fertility is low to medium.

(2) Biological Conditions

(a) Terrestrial Flora

Thirty-one tree species were found in the area, but no endangered and protected species were included. The very common plantation trees of Rubber are found throughout the forest. It means the forest is almost a kind of secondary forest which has been exploited intensively or extensively. Some wild plants are currently being utilized by local people as building and furniture material.

(b) Terrestrial Fauna

A total of 18 species of mammals, 21 species of birds, 9 species of reptiles, 4 species of amphibians and 13 species of insects were found around the Kuok Intake Weir and the irrigation canal. A half of the mammals are protected species.

In the Kuantan reservoir and Lubukjambi irrigation areas, 24 species of mammals, 21 species of apes, 9 species of reptiles, 4 species of amphibians and 13 species of insects were found through the field observation and interview survey. Harimau (Sumatran tiger), beruang madu (Malayan bear), and gadja (Asian elephant) are designated as protected fauna..

(c) Aquatic Flora

According to the field observation and interview survey with people living nearby the river, macroaquatic flora has never been detected in the area. In the Indragiri River, five classes of phytoplankton, chrolophyceae, bacillariphyceae, cyanophyceae, rhodohyceae and charophyceae were found by sampling tests.

(d) Aquatic Fauna

The Kampar and Indragiri rivers have abundant species and enough resource of fishes. At least, 20 families and 91 species of fishes are listed. The registered rare species are Arowana and Patin Kunyit fish. Both are not found in the upper reaches of rivers.

In the Kampar River, four classes of zooplankton (Tricoptera and Annelida) and macrozoobenthos (Diptera and Tricoptera) were identified. In the Indragiri River, two classes of zooplankton (Copepoda, Crustacea), and macrozoobenthos (Diptera and Tricoptera) were identified.

(3) Socioeconomic and Cultural Conditions

(a) Population

Population in the study area is as discussed in CHAPTER 3.

(b) Land Ownership

Basically, lands do not belong to a single individual but to the community. Local customs and traditions shall be taken into consideration for resettlement and compensation. The community leader is a very important person for negotiations.

(c) Economic Structure and Cultural Assets

Agriculture, industry and plantations are the important sectors in the economy of the priority project areas. In upland areas, agriculture and home industry are the main sources of income of households. There is no specific cultural asset in areas related to the priority projects.

Identification of Environmental Impacts

The important environmental impacts were identified using an interaction matrix, a method to clarify and cover all relations between project works and environmental components. The identified impacts are shown in Tables 7.6.1 and 7.6.2. The identification of impacts was conducted in accordance with the work item in each stage of project implementation; namely, pre-construction stage, construction stage and post construction stage.

Evaluation of Environmental Impacts

The important environmental components identified before have been predicted quantitatively to determine the intensity and size of arising negative and positive impacts. The impacts have been evaluated by comparing the conditions before and after construction. In the evaluation of arising impacts, the degree of significance of impact shall be determined according to the seven main criteria specified in the Decree of the Minister of Population and Environmental Affairs No. 49, 1987.

The evaluation results for the Kampar and Indragiri river basins are shown in Tables 7.7.1 and 7.7.2, respectively.

Conclusion of ANDAL Study

(1) Kampar River Basin

In the Kampar river basin, the Kuok Intake Weir, the Rantauberangin Irrigation Canal and the Bangkinang Area River Improvement Works have been proposed as priority projects. The ANDAL study for priority projects concluded that the construction of facilities proposed in these priority projects will not present any serious damage to the natural and social environments.

(a) Land Acquisition and House Evacuation

The area of land acquisition for priority projects in the Kampar river basin is 417 ha and the number of house evacuation is 730 units. According to the interview survey, there is no strong objection among the inhabitants in the project site. Therefore, land acquisition and house evacuation can proceed with reasonable compensation for inhabitants' losses and assurance of firm countermeasures for the resettlement of people.

(b) Natural Environment

Impacts on the natural environment by the construction of proposed facilities are judged to be little.

(c) Social Environment

No important historical assets and cultural properties were found in the project area.

(2) Indragiri River Basin

In the Indragiri river basin, the Kuantan Dam, the Lubukjambi Intake Weir and Irrigation Canal, and the Rengat Area Flood Protection Works were proposed as priority projects. It was concluded through the ANDAL study that among them, the Lubukjambi Intake Weir and Irrigation Canal and the Rengat Area Flood Protection Works will not bring any serious impact on the social and natural environments. However, construction of the Kuantan Dam will bring negative impacts to people living in the reservoir area who have to be evacuated, as well as the terrestrial and aquatic fauna and flora.

(a) Land Acquisition and House Evacuation

The area of land acquisition for priority projects in the Indragiri river basin is 2,740 ha and the number of house evacuation is 1,720 units. Therefore, land acquisition and evacuation of inhabitants can be conducted with reasonable compensation and provision of countermeasures for the resettlement of people to assure livelihood measures and income after evacuation.

(b) Terrestrial Fauna

Terrestrial large mammals are distributed in the reservoir area, including 19 protected species such as tigers, tapir and bear. However, large mammals are considered to be able to escape from the reservoir area following the water level rising, and extermination of these species is considered not to take place.

(c) Aquatic Fauna

A protected species of Patin Kunyit is found in the Indragiri River except in the upper reaches from the damsite. Therefore, construction of the dam will not affect this protected species.

(d) Other Flora and Fauna

Serious negative impacts on the other flora and fauna was not identified with the construction of the dam.

(e) Other Environmental Impacts

Although negative impacts to air and water quality, public health, and historical assets and cultural properties are expected, such impacts are considered to be small, and construction of the dam will not bring any serious damage to these factors.

7.7.2 Environmental Management Plan (RKL)

<u>Objectives of RKL</u>

The objectives of RKL are as mentioned in Subsection 5.15.2.

<u>Schedule of RKL</u>

Environmental management shall commence from the beginning of project implementation and continue throughout the operation and maintenance period. In general, the environmental management shall be implemented according to the purposes and type of activities. If a preventive action is required, it shall be done before the activity, and if a curative action is required, it shall be done when the action takes place. The relation among the types of activities causing impacts, management location and management schedule are presented in Tables 7.7.3 and 7.7.4.

Environmental Management Approach

This shall consist of technical, economical and institutional approaches based on the ANDAL Study.

(1) Technical Approach

The technical approach aims to control or prevent the negative impacts that may arise in project activities, as follows:

- Eliminate erosion/sedimentation problems resulting from the project or environmental conditions.
- Eliminate erosion originating from land clearance by the rehabilitation of existing critical land.
- Decrease impacts of air quality and noise.
- Rehabilitate flora and fauna lost by the project.

(2) Economical Approach

Efforts shall be made to control social, economic and cultural problems, as follows:

- Create job opportunities for people therearound considering their experience and skill.
- Prevent or minimize impacts which may arise from approaching prominent historical assets.
- Promote public security with the participation of local agencies and local people in maintaining order.

(3) Institutional Approach

The action mentioned above shall be conducted in cooperation with the agencies related to environmental management under the coordination of the

Population and Environmental Affairs Bureau (BKLH) of District Level I, Riau and West Sumatra provinces, as formulated under the following laws:

- Law No. 4, 1982, Republic of Indonesia, regarding the provisions of Environment Management Principles; and
- Government Regulation No. 51 of 1993 on Environment Impact Analysis.

Resettlement of Inhabitants

Countermeasures for the resettlement of inhabitants to be evacuated from project sites are very important and indispensable for the smooth implementation of the projects. Since the largest number of inhabitants to be evacuated is at the Kuantan reservoir area, countermeasures for resettlement of inhabitants in the Kuantan reservoir is discussed here as a representative example.

(1) Public Perception about the Project

According to the interview survey at the Kuantan reservoir area, about 47% of the inhabitants approve the project, while only 1% is against. The remaining 52% of inhabitants are neutral. This ratio may change according to the compensation amount; therefore, reasonable compensation for land acquisition and evacuation of inhabitants is necessary.

(2) Possible Site for Resettlement

The following three sites have been identified as alternative resettlement areas for inhabitants to be evacuated:

- The first alternative is located at about 5 km southeast of the UPT Timpeh V transmigration resettlement area in Tanjung Gadang District. This is flat with an area of 45 km^2 and suitable for agricultural use. It is possible for all people (8,187 persons) in the reservoir area to move into this area. The West Sumatra Office of the Ministry of Transmigration also has a plan to expand the Timpeh V resettlement area to that place.

- The second alternative is located in the vicinity of Kunangan Village, near the reservoir area, around 7 km southwest of Batangkaring Village, also in Tanjung Gadang District. The place is somewhat undulated and near the concession of coal mining. Access to the Trans-Sumatra road is convenient.
- The third alternative is located 22 km eastward from the UPT Timpeh V transmigration resettlement area, between Tanjung-kambing Hill and Jao Village, very near the provincial boundary in Kota Baru District. The place is flat and suitable for agricultural use.

(3) Management after Resettlement

Living conditions and income level of evacuated inhabitants shall be maintained by providing necessary facilities and infrastructures in resettlement areas.

Implementation of RKL

(1) Managing Institution

The RKL of this project shall be carried out systematically by the related agencies or services, as follows:

- The Project Initiator shall be responsible for preparing the document of planning and the physical implementation.
- The Performing Contractor shall act as the performer of physical works and supplementary structures until completion. It shall also provide safety control and employment of local labor in the project.
- The Research Sector of the Regional Office of Public Works of West Sumatra and Riau provinces shall act as the manager of water supply and flood control for all interested groups, technically and administratively.
- The Forest Management Office of the Regencies of Kampar shall prevent and control critical lands.

(2) Structure, Scope and Work System of the Organization

(a) Organization for Environmental Management

- To use human resources efficiently, the RKL does not make a new organization, but increases the role of the existing organization.
- The scope of tasks and relevant responsibilities of some units will be increased to handle the environmental problems.
- The environmental problems being wide and complex requires cross-sectoral and coordinated management.

(b) Scope and Work System of the Organization

- To establish a coordinating institution as a management team which shall be responsible for planning, implementation and completion of the environmental management program.
- To carry out management activities separately and collectively with the related institutions and agencies.
- The initiator shall continuously carry out the agreed environmental management activities, namely, the preparation of action plan and other supporting documents, submitting them to the agencies or work units.
- The roles of other related agencies and/or work units such as the Irrigation Service, BRKLT, Agricultural Service and Public Works Service are directed to complete and stabilize the program and the action plan according to their condition.

<u>Funds</u>

The initiator is the Directorate of Irrigation Program Development of the Ministry of Public Works. The initiator will allocate the funds for the required environmental management, covering the following:

- The costs for land acquisition, including the costs for collection or dissemination of information, discussion meetings with local people, etc.
- The compensation costs for house evacuation.

- The costs for planning, supervision, implementation and operation tests of intake and other facilities.

The Performing Contractor shall allocate the funds related to health and safety of project workers and people. The District Government shall allocate the funds for supervising the landscape implementation. The Ministry of Public Works shall allocate the funds for providing guidance on planting system and method to increase the efficiency of water consumption and costs of supervision.

The Ministry of Forestry shall allocate the funds for planning, supervision and implementation of reforestation in critical lands and for the construction of check dams in river courses with potential to cause sediment load. The Ministry of Agriculture shall allocate the funds for guidance and performance of reforestation.

Supervision of Environmental Management Implementation

Environmental management implementation will be supervised by supervising institutions, as follows:

- The District Government, the National Land Affairs Agency of the Regencies of Kampar, Sawalunto/Sijunjung and Indragiri Hulu shall supervise the implementation of compensation for land acquisition and house evacuation to be carried out by the initiator.
- The District Government, the National Land Affairs Agency together with the Transmigration Service shall supervise and arrange the implementation of resettlement to new locations to be carried out by the initiator.
- The Health Service in related regencies in cooperation with the Ministry of Labor shall supervise the management of work safety, as well as public and project workers' health.
- The District Government and BRKLT (Land Conservation Training Center) shall supervise the planning and reforestation.
- The District Government shall supervise the implementation of household industrial training to be carried out by the Industrial Service.

The supervision of environmental management shall be carried out in the following manner:

- Evaluate materials for RKL, i.e.,. the technical conditions of physical work implementation, the operation standards, and the system maintenance.
- Evaluate preparations for environmental management activities, for instance, the reservoir operation plan, the rubbish disposal to the reservoir.
- Evaluate preparations made by the related agencies carrying out environmental management activities like one made by the Forestry Service and the Agricultural Service in charge of the reforestation of critical lands.
- Evaluate information delivered to the project, as well as from related agencies, regarding environmental management, in the form of letters, minutes of meeting, reports on job implementation and other related reports.

7.7.3 Environmental Monitoring Plan (RPL)

Objectives of RPL

The objectives of RPL are as mentioned in Subsection 5.15.2.

Environmental Monitoring Components

(1) Related Institutions

(a) Project Initiator

For the Project Initiator, environmental monitoring is used for evaluating the consistency of RPL with those specified in the RKL with the following purposes:

- To decrease claims from other groups affected by the Kampar River Basin Development Plan Project at the pre-construction, construction and post construction stages;
- To make use of funds, manpower and time effectively by adequate environmental management; and
- To predict significant impacts which are otherwise difficult to identify.

(b) Government and Initiator of Activities

In these two institutions, the objectives of preparing the RPL are:

- To consolidate the implementation of Law No. 4 of 1982 on the Main Conditions of Environmental Management and Government Regulation No. 29 of 1986 on Environmental Impact Assessment (AMDAL).
- To consolidate the implementation of Government Regulation No. 35 Chapter III, paragraph (2) of 1991 on rivers, where "River" is defined in paragraph (2) as a water source and as one of the natural sources having multipurpose functions for human life and existence. A river should be managed to increase its function and benefits, and its destructive power to the environment should be controlled.
- To develop positive impacts and to overcome activities with potential to cause negative impacts in Kampar River Basin Development Plan Project, and to provide simultaneous supervision and evaluation.
- To control environmental quality, increase social economy and regional income, assist in stabilizing the implementation of tourism program in compliance with the development program, and the Regional Layout General Plan (RUTRD).

(2) Environmental Monitoring Approach

The purpose of the RPL is to supervise and monitor the implementation of RKL in each activity at each project stage. Results of monitoring by institutions shall be submitted to related agencies or institutions for getting feedback. The environmental monitoring approach shall be made by reporting, supervision, monitoring and unexpected inspections as follows:

(a) Reporting

The reporting shall cover the notification on the schedule of project activities and implementation, compensation, monitoring and other relevant information, as well as minutes of meetings on the approval of designated activities. Periodical reports (daily, weekly or monthly) on supervision activities shall be prepared and submitted.

(b) Supervision

The supervision shall cover supervision on:

- Implementation of land acquisition;
- Implementation of irrigation system and dike as well as non-physical works which are assumed to have a potential to cause impacts;
- Implementation measure for air quality and noise;
- Operation of irrigation channel, application of cropping pattern and water allocation; and,
- Reforestation of critical land areas.

(c) Monitoring

Monitoring shall cover the evaluation of environmental management being implemented to examine whether it is appropriate or recommendable to implement field monitoring of environment factors affected by impacts, and periodical sampling for laboratory study.

(d) Unexpected Inspection

Unexpected inspection is to inspect the actual work implementation unexpectedly, particularly when a deviation in the environmental management implementation is indicated.

<u>Description of RPL</u>

Environmental monitoring is to be conducted on items in each stage of project implementation; namely, pre-construction stage, construction stage and post construction stage. Environmental factors to be monitored in each stage are presented in SECTOR V, ENVIRONMENTAL ANALYSIS.

CHAPTER 8 ORGANIZATION FOR OPERATION AND MAINTENANCE

8.1 General

8.1.1 Basic Concept

The Minister's law on government organization states that responsibilities on operation and maintenance of public works facilities should be decentralized and entrusted to related provincial government agencies. In accordance with Law No. 5 on Regional Government Administration, future operation and maintenance work will be transferred gradually from central government agencies to local government agencies.

In line with the decentralization policy, an institutional setup for all-inclusive water resources management work was introduced in Java Irrigation Improvement and Water Resources Management Project (JIWMP) in January 1993. Previously, operation and maintenance for public works facilities have been executed under the hierarchy classified into the central level, the provincial level and the district level. In addition to these existing organization levels, the basin-wide management level was newly proposed by the JIWMP to have an integrated approach to basin-wide water management works. The territorial jurisdiction of the basin-wide management level is placed within the watershed boundary (called "SWS" in the Indonesian term), so that it does not necessarily coincide with the existing administrative boundary.

Correspondingly, the hierarchy of the institutional setup is classified into the central level, the provincial level, the basin-wide management level, and the district level. In this hierarchy, emphasized are the roles of the basin-wide management level and the district level to promote the decentralization process.

The basic concept of the institutional setup proposed by JIWMP is considered to be suitable to formulate the operation and maintenance plan in the present study. Furthermore, the particular names or abbreviations for the organizational units introduceD in the JIWMP are commonly used by Indonesian government agencies, so that they are also adopted in this study.

8.1.2 Outline of Proposed Organization

The organization for operation and maintenance of flood control and water resources development facilities is proposed in this study as shown in Fig. 8.1.1. In this organization, each of the organization hierarchy levels will undertake the following roles in general:

- The central level will set up the national regulations specifying the technical and administrative standards for operation and maintenance of objective facilities.
- The provincial level will undertake the overall supervisory and coordination tasks for the objective operation and maintenance facilities.
- The basin-wide management level will execute the operation and maintenance for major facilities such as dams, weirs, and river channels that have strategic importance in the basin and/or require highly developed technology.
- The district level will execute the operation and maintenance for minor facilities other than the objects of the above basin-wide management level.

In the priority projects for feasibility study, the proposed basin-wide management level will have an integrated approach on operation and maintenance. Thus, the basin-wide management level will have a single management body. All dam reservoirs, weirs on the main stream and river channel located in the above river basins will then be operated and maintained in the basin-wide management level.

As for the district level, two districts will be involved in the organization for operation and maintenance, namely, Kabupaten Kampar and Indragiri Hulu. All minor flood control and water resources development facilities installed in these districts will be operated and maintained by each district government office.

8.2 Organization in Central Level

The organization in the central level will be composed of three units, namely, the technical management unit, the coordinating unit and the administrative unit. The specific roles and government agencies involved in these units are described below.

8.2.1 Technical Management Unit

This unit will prepare the nationwide technical criteria and carry out the technical guidance for operation/maintenance. The ministry in charge will be the Ministry of Public Works (MPW) and the following directorates/commission will take partial charge of technical management works, as follows:

- The Directorate of Technical Guidance (Bina Tech), DGWRD will take charge of the preparation of criteria and technical guidance related to flood control and water resources development facilities; and,
- The Dam Safety Commission established as an extra-departmental body of MPW will carry out general supervision on dam safety.

8.2.2 Coordinating Unit

A new National Water Council (NWC) is proposed as the central government coordinating unit. The NWC will be composed of representatives from relevant ministries and will resolve potential conflicts among the ministries.

8.2.3 Administrative Unit

The present Ministry of Home Affairs (MHA) will undertake the integrated supervision of administration to be carried out by each provincial government in Indonesia.

8.3 Organization in Provincial Level

The organization in the provincial level will be composed of four units, namely, the administrative unit, the coordinating unit, the technical management unit, and the water users associations. The specific roles and government agencies to be involved in these units are described below.

8.3.1 Administrative Unit

The Riau and West Sumatra provincial governments will be designated as the provincial leading supervisor and coordinator for all activities related to operation/maintenance. This designation of the Provincial Government will entail approval of annual operation/maintenance plans (including the implementation plan and the budgetary allocation plan), evaluation of performance, and licensing/authorization for surface water use.

8.3.2 Coordinating Unit

The competent provincial authority of the Ministry of Public Works (KANWIL) will be assigned, as a substructure of the MPW, to the Riau and West Sumatra provinces and will undertake the role of coordination of technical guidance provided from the central level to the provincial level.

8.3.3 Technical Management Unit

The Provincial Office for Public Works (DPUP) will undertake technical supervision on the execution of operation/maintenance based on the technical guidance provided from the central level.

8.3.4 Water Users Association

The Water Resources Committee (WRC) will be formed out of the existing provincial irrigation committee and expanded to a larger user committee accommodating all provincial water user groups such as the State Electricity Corporation (PLN) and the Water Supply Public Corporation (PAM). The WRC will undertake coordination and supervisory work on the annual water use of each water user group at the provincial level. Thus, the role of WRC is related solely to water resources development facilities but not to the flood control and urban drainage facilities.