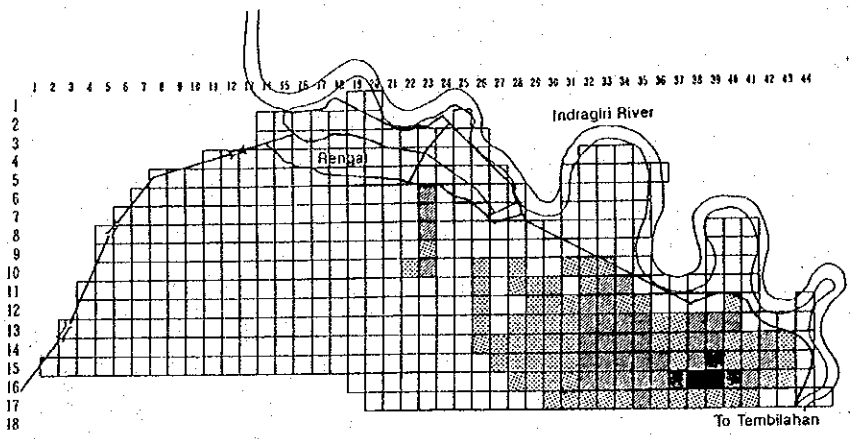
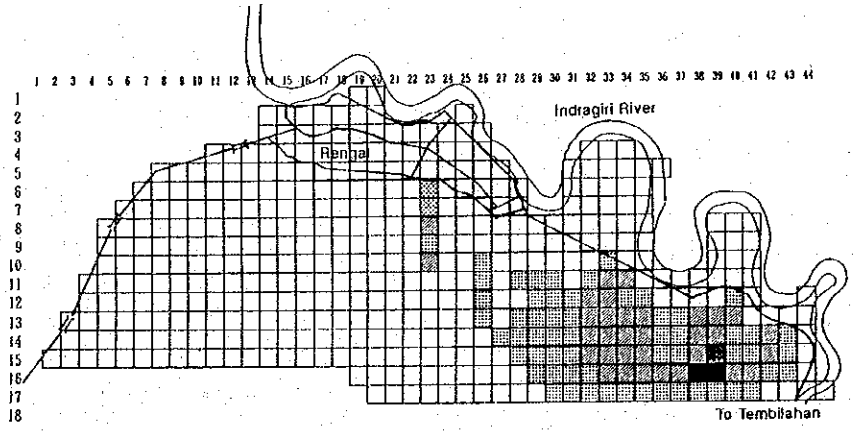
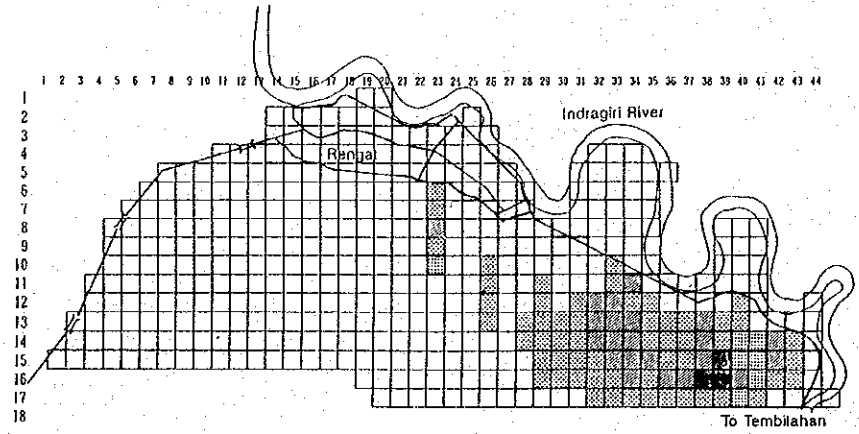
Inundation Elevation of 4.4m : Pump capacity of 3 and 5m³/s at 2-year return period and 8 and 10m³/s at 5 and 10-year periods



Inundation Elevation of 4.3m : Pump capacity of 8 and 10m³/s at 2-year return period and 20m³/s at 10-year return period



Inundation Elevation of 4.2m : Pump capacity of 20m³/s at 5-year return period



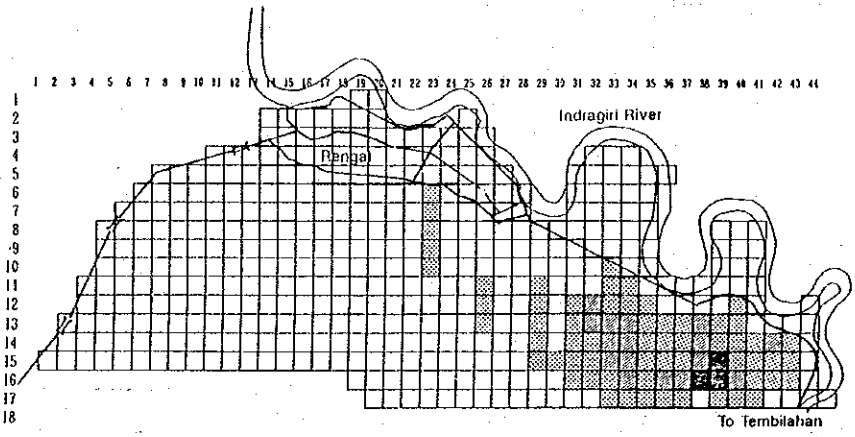
SCALE 1 : 100,000

LEGEND Inundation depth : H

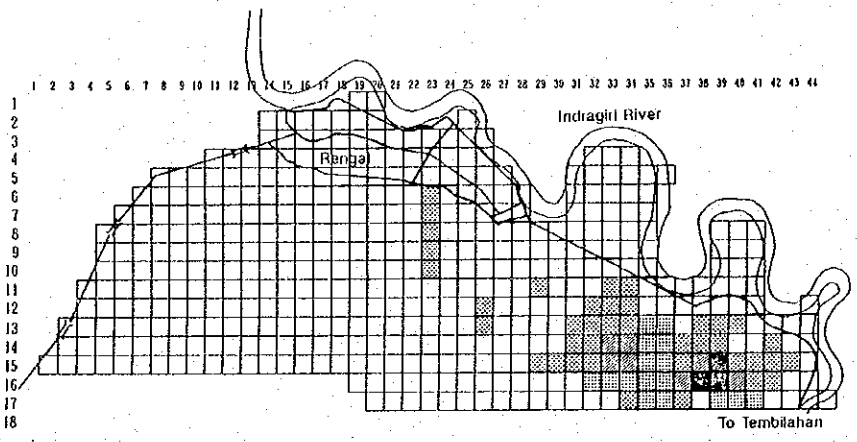
☐ H=0m ▨ H<0.5m ▩ 0.5m<H<1m ▩ 1m<H<1.5m ■ 1.5m<H<2m

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. VI.6.9 INUNDATION DEPTH FOR (2/3) DIFFERENT PUMP CAPACITY AT EACH RETURN PERIOD

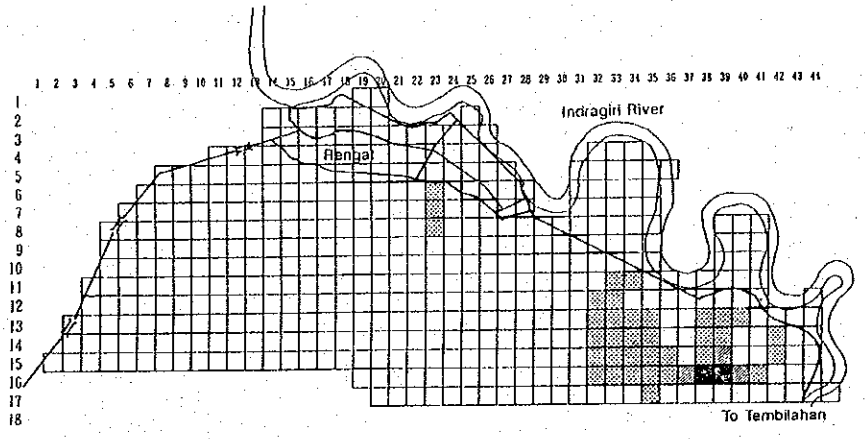
Inundation Elevation of 4.1m : Pump capacity of 20m³/s at 2-year return period and 30m³/s at 10-year return period



Inundation Elevation of 4.0m : Pump capacity of 30m³/s at 5-year return period



Inundation Elevation of 3.9m : Pump capacity of 30m³/s at 2-year return period



SCALE 1 : 100,000

LEGEND Inundation depth : H

H=0m | H<0.5m | 0.5m<H<1m | 1m<H<1.5m | 1.5m<H<2m

THE STUDY ON KAMPAR-INDRAGIRI RIVER BASIN DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. VI.6.9 INUNDATION DEPTH FOR (3/3) DIFFERENT PUMP CAPACITY AT EACH RETURN PERIOD

VII IRRIGATION DEVELOPMENT PLAN

SECTOR VII
IRRIGATION DEVELOPMENT PLAN

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CHAPTER 1 AGRICULTURAL BACKGROUND IN STUDY AREA

1.1 Agricultural Production

At present there are about 150,000 ha of cultivated lands for paddy fields and rainfed fields in the study area. The main food crops in the study area are rice, maize, cassava, soybeans and groundnuts. Rice is an essential food crop and most cultivated areas are occupied by rice. There was, however, a severe shortage of rice supply in Riau Province and about 200,000 tons of rice is bought annually from West Sumatra, North Sumatra and other provinces. Rice self-sufficiency was, therefore, a very important goal in the former Fifth Five-Year Development Plan (PELITA V) in Riau Province.

In the study area in West Sumatra Province, most of the irrigable areas have already been developed, and even five croppings per two years are practiced locally. Most of the rice produced in the study area is exported to Riau Province. As for the study area in Riau Province, rice is planted mainly upland in the Kampar and Indragiri Hulu Kabupatens, and in wetland in the Indragiri Hilir Kabupaten. In the Kampar and Indragiri river basins, the productivity of all crops is relatively high as those of rainfed but still less than the national average of approx. 4 tons per hectare. Crop production in the study area is summarized as below (refer to Table VII.1.1).

SUMMARY OF CROP PRODUCTION IN STUDY AREA
(IN 1992/1993)

Unit: ton/ha

Crop	West Sumatra Province	Riau Province	Total
Wetland Rice	5.4	3.8	9.2
Upland Rice	2.4	2.2	4.6
Maize	2.6	2.0	4.6
Soybean	1.4	1.2	2.6
Cassava	18.9	14.4	33.3
Sweet Potato	16.6	8.5	25.1
Groundnut	2.0	1.1	3.1
Pepper (Chili)	3.4	1.1	4.5
Cowpea	2.1	1.3	3.4
Cucumber	8.8	5.8	14.6
Eggplant	9.3	5.5	14.8
Tomato	9.4	14.4	23.8
Green Pea	1.1	1.1	2.2

Main vegetables produced in the study area are chili (pepper), beans, cucumber, eggplant and tomato which can grow under hot and dry climate. In Riau Province, leafy vegetables are brought mainly from West and North Sumatra regions. Fruits are produced mainly in small scale like homeyards, not in large scale plantations. The main fruits are banana, orange, pineapple, durian, and rambutan.

Current farming methods practiced in the study area have been studied through interviewing farmers. Typical farming methods and calendars are explained in succeeding sections.

1.1.1 Wetland Paddy

Wetland paddy is divided into rainfed and irrigated paddy. Most of the wetland paddy in West Sumatra Province is irrigated and enjoys a high yield of 5.4 ton/ha in 1992/1993, while production is slightly lower in Riau Province, namely 3.8 ton/ha. In wetland paddy in tidal irrigation areas, the yield is as low as 2.0 ton/ha due to poor drainage and unfavorable soil conditions.

As for the study area in West Sumatra Province, even five croppings per two years are are made. In the study area in Riau Province, the cropping calendar in nearly all the areas in the existing irrigation projects in the Kampar and Indragiri Hulu river basins is timed to coincide planting with the onset of the drawdown of the river water levels. Land preparation usually starts one month ahead of the planting period. Double-cropping is dominant in the Kampar river basin, while it is single cropping in the Indragiri river basin. Generally, the nursery period is 15 to 25 days. In wetland paddy areas only the transplanting method is practiced despite the relatively scarce labor force.

In the study area, both high yield varieties (HYV) and local varieties are used. HYVs are planted at areas with less than 600 m of elevation in West Sumatra Province.

For land preparation mechanization is marginal. Manual and oxen plowing is practiced in the study area, not tractor. Harvesting is carried out by sickle and ani-ani (a kind of Indonesian sickle), and the harvest is dried at the farmer's yard or paddy field. The harvested rice is immediately threshed by mainly manual or pedal thresher and then rice is dried.

1.1.2 Dry Land Paddy

Dry land paddy is practiced mainly in intermediate areas of the study area. The rice is sown by direct seeding in September/October to December/January. The varieties used are both local varieties and HYV. The yield is relatively high at 2.2 ton/ha and 2.4 ton/ha in Riau and West Sumatra provinces, respectively, due to well distributed rainfall.

1.1.3 Secondary Crops

The General Intensification Program (INMUM program) for crops is being undertaken by the Agricultural Services for Food Crops and thus the modern varieties and more intensive cultivation method are gradually being practiced.

Maize is the most important secondary crop, followed by soybean, cassava, groundnut, beans and sweet potato in descending order. The cultivation method of secondary crops is relatively primitive and mixed cropping is often practiced. Land

preparation is done by hand like rice cultivation, and slashing, grass burning and direct seeding is often carried out. Varieties used are mostly local and fertilizer usage is minimal. The yield is, however, relatively high, especially that of beans. The reasons for this high yield are presumably preferable soil condition and reliable rainfall.

1.2 Transmigration Program

Transmigration from Java Island to Sumatra Island is being promoted by the national government and Riau Province in the study area is one of the destinations. The transmigration program is conducted in accordance with the basic national development plans as a means of manpower development and balanced distribution of the population aiming at promoting regional development.

On the other hand, the potential area for further agricultural development in West Sumatra Province is limited owing to topographic constraints, according to the chief of the Transmigration Office in Padang. In the case of the study area in West Sumatra Province, promotion of transmigration is very difficult because of persistent customary law (Adat). Therefore, new transmigration settlement schemes cannot be planned in this area.

Transmigration in the study area can be categorized into two: general transmigration and plantation-oriented transmigration. The former is oriented to produce food crops as its major income source with some tree crops as its secondary income source. The latter is oriented to produce tree crops as its main income source.

Under the general transmigration program, a total of 2.0 ha of land is given to each transmigrant family. The details of land components are as follows:

Homeyard	0.25 ha
Land I	1.00 ha for rice cultivation (land clearing to be conducted by the Department of Transmigration and land leveling to be done by transmigrant)
Land II	0.75 ha for free cropping (land clearing and leveling to be conducted by transmigrant)

Transmigration for industry is included in the general transmigraiton and is povided 0.1 ha of land per household. Plantation-oriented transmigrants also obtain 2.5 ha of land including 0.5 ha of homeyard. The land will be used for plantation crops production under nucleus estate production system.

The number of transmigrants in the study area have totaled about 16,650 households up to present except for the transmigration areas transferred from the Ministry of Transmigration to the jurisdiction of the provincial government to become the new villages.

In the study area, nine resettlement areas are proposed for local people who live in Kota Panjang area to be submerged by dam construction.

The realization of the transmigration settlement schemes and the targets of Pelita VI in the Study Area is shown in Table VII.1.2. Among the transmigration schemes in the study area, only the Pasir Jambu scheme is included in the irrigation project in the Kampar Kanan river basin.

1.3 Irrigation Development

1.3.1 Study Area in West Sumatra Province

Irrigation development in the study area in West Sumatra Province is discussed in detail as below.

(1) Cropping Conditions

Most irrigation areas in the study area in West Sumatra Province have already been developed, and even five croppings per two years are practiced locally. Most of the rice produced are exported to Riau Province.

The present cropping conditions prevailing in the study area in West Sumatra Province were obtained from the PU branch offices in districts in the study area. The main crop is paddy, and the frequency of wet paddy cropping is shown below on district basis:

Limapuluh Kota District	5 croppings per 2 years
Agam District	Double-cropping, locally 5 croppings per 2 years
Tanah Datar District	Double-cropping (area higher than EL 600m); 5 croppings per 2 year (area lower than EL 600m)
SWL/ Sijunjung District	Double-cropping (Irrigation water is enough, but farmers prefer double-cropping according to traditional farming practices.)
Solok District	Double-cropping and 5 croppings per 2 year (irrigated area)

(2) Irrigation System

There are three categories of irrigation system: simple, semi-technical and technical. The present irrigation system in the study area in West Sumatra is shown in Table VII.1.3 and summarized in the table below.

NUMBER OF IRRIGATION PROJECTS BY IRRIGATION SYSTEM
(GOVERNMENTAL PROJECTS)

River Basin	Simple Irrigation	Semi-technical Irrigation	Technical Irrigation	Total
Kampar	15	6	1	22
Indragiri	236	91	10	337
Total	251	97	11	359

The definition of simple irrigation system, semi-technical irrigation system, and technical irrigation system is given in Table VII.1.4, based on the design standards published by the Directorate General of Water Resources Development, Ministry of Public Works, Indonesia.

In simple irrigation system, water supply is neither measured nor regulated. Consequently, surplus water is spilt into the drains. Generally, simple irrigation system is employed where water is always abundant and slopes are moderate to steep. These systems are generally located in areas with higher elevations. Therefore, there is little need to introduce more complicated techniques to supply and distribute water. However, there is wastage of water.

Out of 251 schemes with simple irrigation system, 84 schemes (about 35% of the total simple irrigation system schemes) derive irrigation water from the rivers by using free intakes. Judging from the facts mentioned above, it can be assumed that the study area in West Sumatra Province is rich in water resources.

The patchy development of paddy fields in the area suggests that there are physical constraint such as broken topography. From the viewpoint of land slope for paddy field formation, land with about 2% land slope is preferable. However, there are many simple irrigation system schemes, and terraced paddy fields are found in the study area. This shows that land exceeding the preferable land slope for paddy field formation are cultivated for wet paddy. According to the PU branch offices, there are no potential areas to be newly developed for wet paddy cultivation in the future.

In addition to the governmental projects, the following village irrigation projects have already been developed in the study area in West Sumatra Province. Village irrigation projects in the study area are given in Table VII.1.5. The future irrigable areas in the Study Area in West Sumatra Province are summarized below (refer to Fig. VII.1.1).

FUTURE IRRIGABLE AREAS IN STUDY AREA
(WEST SUMATRA PROVINCE)

River Basin	District	Governmental Projects			Existing Village Irrigation Area (ha)	Total Future Irrigable Area (ha)
		Existing Irrigated Area (ha)	Future Increase in Irrigation Area (ha)	Total Irrigable Area (ha)		
Kampar	Limapuluh Kota	2,502	576	3,078	702	3,780
Indragiri	Limapuluh Kota	12,818	437	13,255	10,263	23,518
	Agam	4,385	0	4,385	395	4,780
	T.Datar	12,694	820	13,514	7,801	21,315
	Sijunjung	5,665	6,612	12,277	4,289	16,566
	Solok	17,079	919	17,998	5,266	23,264
	Sub-Total	52,641	8,788	61,429	28,014	89,443
Total		55,143	9,364	64,507	28,716	93,223

1.3.2 Study Area in Riau Province

Irrigation development in the study area in Riau Province is detailed as below.

(1) Cropping Conditions

The cropping calendar in nearly all the areas in the existing irrigation projects in the Kampar and Indragiri Hulu river basins is timed to coincide planting with the onset of the drawdown of river water levels (refer to Figs. VII.1.2, and VII.1.3). Land preparation usually starts about one month ahead of the planting period. In the Kampar river basin, double-cropping is dominant, while in the Indragiri river basin single cropping is prevailing.

(2) Irrigation System

The present level of all the governmental irrigation systems prevailing in the study area belongs to semi-technical irrigation system. There exists 59 governmental irrigation schemes (35 schemes in the Kampar river basin and 24 schemes in the Indragiri river basin).

Some projects are located in the hilly areas or the skirts of hills extending over the upper reaches of the study area. The existing irrigation schemes depend on tributaries of the Kampar and Indragiri rivers for sources of water supply. As diversion weirs have been constructed on these tributaries at the foot of hills, their catchment areas are small. Consequently, the quantity of water available in these tributaries is limited. In dry season, the available natural flow of these small rivers is extremely small and quite often run dry. In addition, effective utilization of limited river discharge cannot be achieved with semi-technical irrigation system.

In addition to the governmental projects, the following village irrigation projects have already been developed in the study area in Riau Province. Village irrigation projects in the study area are given in Table VII.1.5.

The future irrigable areas in the study area in Riau Province is summarized as below (refer to Fig. VII.1.1).

TOTAL IRRIGABLE AREA IN FUTURE IN STUDY AREA (RIAU PROVINCE)

River Basin	District	Governmental Projects			Existing Village Irrigation Area (ha)	Total Future Irrigable Area (ha)
		Existing Irrigated Area (ha)	Future Increase in Irrigation Area (ha)	Total Irrigable Area (ha)		
A. Kampar						
(1) Kampar Kanan	Kampar	3,975	6,035	10,010	20	10,030
(2) Kampar Kiri	Kampar	157	1,000	1,157	5	1,162
	Indragiri Hulu*	9	12,359	12,368	35	12,403

(3) Kampar	Kampar	-	-	-	152	152
Sub-Totals	Kampar	4,132	7,035	11,167	177	11,344
	Indragiri Hulu*	9	12,359	12,368	35	12,403
B. Indragiri	Indragiri Hulu*	3,310	4,604	7,914	348	8,262
Total		7,451	23,998	31,449	560	32,009

* Upper reaches of Indragiri River

Up to the present, some irrigation schemes have not fully achieved their development targets due to the following reasons:

- Financial reason;
- Step by step development of paddy fields by the Ministry of Agriculture;
- Limitation of river discharge; and
- Limitation of labor force.

Despite the fact that the quantity of available river water is limited, irrigation water is directly supplied to fishponds from the irrigation canal, and is released from the fishponds to the lower part at many scheme sites. There are many command areas to be irrigated by canals with small gradient. If fishponds are constructed near such canals, it is very difficult for the water to flow back to canals from inlets of fishponds. Fishpond owners are apt to consider running water condition as prerequisite to breed fish. Such condition makes intake water impossible to use for the irrigation purpose. Without any thorough understanding of these people, effective use of water will not be accomplished even with provision of complete main systems.

1.4 Swamp Development

Soils of swamp areas in the study area in Riau Province can be broadly divided into alluvial soil and peat soil. Alluvial soils distributed along the rivers are suitable for agricultural development and therefore rice cultivation by way of tidal irrigation system is extensively applied in the coastal areas of the Indragiri River taking advantage of much difference between high and low water level due to tidal fluctuation. Peat soil is found in-between areas of alluvial soil along the rivers. Details of swamp development in the study area in Riau Province are given in Table VII.1.6

1.4.1 Tidal Irrigation System

In tidal irrigation areas, drainage improvement is the most important factor because the drainage condition of soils considerably affects the yield. Drainage improvement works in these areas have been carried out for 20 to 30 years.

Tidal irrigation areas are located in the Indragiri Hilir and Indragiri Hulu districts. There exists no tidal irrigation project in the Kampar District. Out of a total potential tidal irrigation area of 254,673 ha, about 75% of the land is used at present.

1.4.2 Non-Tidal Irrigation System

Non-tidal irrigation systems exist in both Kampar and Indragiri Hulu districts. In the Indragiri Hilir District, only tidal irrigation has been developed. The potential non-tidal irrigation area is 6,624 ha in which 3,006 ha has already been developed.

CHAPTER 2 BASIC STRATEGY FOR IRRIGATION DEVELOPMENT

2.1 General

Basic Concept of Irrigation Development Plan

In accordance with the approach presented in SECTOR VIII, WATER RESOURCES DEVELOPMENT PLAN, the agricultural development study concentrates on irrigation development to assess the water demand for the Water Resources Development Plan. With the above-mentioned background, the irrigation water demand for the existing and the future farmland which presently has development plans are studied and incorporated into the necessary capacity of the water source. The study on agriculture and irrigation potential in the study area is a major component of the overall water resources plan.

Irrigation Development in West Sumatra

The PU office in West Sumatra Province which is responsible for irrigation development has not formulated new irrigation projects in the study area in REPELITA VI. According to the PU office in Padang, the new irrigation projects in REPELITA VI have been planned for areas along the Indian Ocean. There is no irrigation scheme newly formulated in the study area.

According to the chief of the Transmigration Office in Padang, potential areas for agriculture development in West Sumatra Province are limited owing to topographic constraints. In addition to this fact, in the case of the study area in West Sumatra Province, promotion of transmigration is very difficult because of persistent customary law (Adat). Therefore, that new projects could not be planned in this area.

Judging from the facts mentioned in Section 1.3, it is assumed that due to topographical conditions, patchy development of paddy fields has been carried out in the study area, neglecting the preferable landslope for paddy field formation. Therefore, it may be difficult to formulate new irrigable areas. From the viewpoint of wet paddy field provision, the study area in West Sumatra Province has reached the developed condition.

Swamp Area

In the swamp areas of Riau Province, paddy cultivation is mainly carried out during rainy season, and farmers work in coconut plantations during the dry season. According to the Swampy Irrigation Project Office in Riau Province, water for paddy cultivation during rainy season is fully supplied with rainfall. Therefore, irrigation water is not required for swamp areas. Accordingly, the swamp areas are excluded from the Study.

Objective Area

The objective area of the irrigation development plan should be the study area in Riau Province excluding swamp areas.

2.2 Objectives of Irrigation Development

Based on the basic study on irrigation and drainage, the objectives of irrigation development are set up as follows:

- To provide a stable means of livelihood for local people and transmigrants already settled in the areas by supplying irrigation water and draining excess water;
- To contribute to regional needs by increased rice production with the aim of achieving rice self-sufficiency in Riau Province; and
- To support the program of the Government by providing irrigation and drainage facilities for local farmers and transmigrants already settled.

There exist vital needs to stabilize foodcrop production especially rice in wet seasons and to augment it during dry seasons in Riau Province. In the irrigation sector, necessary actions to meet such requirements comprise increase in irrigation water supply and expansion of irrigation command areas. Of prospective measures, new water resources development is the most essential to be taken up in future action programs.

Irrigation development should aim to maximize the potential agricultural benefits through efficient use of available land and water resources and to establish the rice production base. To increase rice production, the following items should be increased.

- The area of paddy fields.
- The unit yields of paddy.
- The annual cropping intensity of paddy.

2.3 Basic Development Concept

Water supply plans should be guided by the following principles:

- Adequacy and reliability of water supply;
- Technical and economic soundness;
- Lowest practicable cost of water and services; and
- Efficient operation and management.

An important increase occurs when technical irrigation has been introduced. This assures the water input. Once the water input is assured, substantial additional production increases may be realized by such program as SUPRA INSUS (Super Special Intensification Program).

Although irrigation facilities can generate large impact to raise agricultural productivity, the investment for irrigation can not generate full return without appropriate agricultural supporting services and other integrated project components. Agricultural support services must be well conducted in order to realize the full potential of the projects. Agricultural support services required are as follows:

- Water users association;
- Agricultural extension service;

- Agricultural cooperative in order to supply farm inputs;
- Farmer s credit services; and
- Integrated pest management system, etc.

In addition, the need of a pilot farm plan should be considered to support new irrigation development.

From the viewpoint of future water supply to objective irrigation development areas, watershed management is required. The clearing of forest land on steep slopes in upper reaches of rivers has caused serious soil erosion in watersheds and flooding downstream in Riau Province. The degradation of these catchments, which for the most part have their upper reaches in West Sumatra, gives a threat on lowland paddy fields in Riau Province.

Sedimentation due to soil erosion along the provincial boundary will affect the storage volumes of the reservoirs to be constructed. Therefore, the successful erosion control will necessitate considerable inter-provincial collaboration.

CHAPTER 3 OVERALL IRRIGATION DEVELOPMENT PLAN

3.1 Review of Existing Irrigation Development Plan

The PU office in Riau Province formulated irrigation development plans which are summarized in Table VII.3.1. The plans aim to support the programs of sustaining the impressive development in expansion of irrigation infrastructure, and to ensure self sufficiency in food crop production. Out of the plans, the Rantauberangin Irrigation Development Project (the Kampar river basin) and the Lubukjambi Irrigation Development Project (the Indragiri river basin) were selected as the objective irrigation development projects taking the following items into consideration:

- These areas are located downstream of the Kotapanjang Dam which is under construction and the Kuantan Dam which is proposed to be constructed.
- Many existing irrigation schemes are located within these areas, and most of the existing schemes will suffer from irrigation water deficit when they reach the target of development in the future (refer to Subsection 3.6.3). For the proper functioning of existing irrigation schemes having water shortage problems, water sources derived from the dams to be constructed can be utilized to provide them with enough water.
- Available land for irrigation development are found in these areas, and expansion of the irrigable area is expected using abundant water sources from dams.
- Data concerning various fields in the Rantauberangin Irrigation Development Project and the Lubukjambi Irrigation Development Project required for the irrigation development study are available and they were compared with those in other areas. They have already been arranged by the PU office in Riau and the PU branch offices in Bangkinang (the regional capital of Kampar District) and Rengat (the regional capital of the Indragiri Hulu District) which will be the managing offices for the objective irrigation development projects.

The Rantauberangin Irrigation Development Project (Gross Irrigable Area: 40,000 ha) and the Lubukjambi Irrigation Development Project (Gross Irrigable Area: 50,000 ha) are categorized in the Project Not Identified Yet in Table VII.3.1. Except these two projects, one scheme size of the remaining projects in the Project Not Identified Yet and the Project Already Identified in the above table ranges from 700 ha to 15,000 ha.

EXISTING IRRIGATION DEVELOPMENT PLANS FORMULATED BY PU. IN RIAU

River Basin	Project Not Identified Yet		Project Already Identified	
	No. of Projects	Gross Irrigable Area (ha)	No. of Projects	Gross Irrigable Area (ha)
(1) Kampar	3	55,000	0	0
(2) Indragiri	6	68,000	7	42,500

The preliminary assessment of the planned projects has been made by desk study using the project inventories, data available and the thematic maps. In order to confirm project viability, site visits and brief investigation studies have been performed taking particular account of irrigation.

However, since demarcation of the potential areas was carried out by using topographic maps at 1:50,000 scale, the project areas have not been exactly delineated yet because of insufficient indication of elevations and indistinct contour lines of the topographic maps which are very important materials in the case of the map study.

3.2 Assessment of New Irrigation Development Project Areas

Before studying the irrigation development plan, the irrigation development potential for the objective irrigation development projects is assessed based on the following factors:

- Agroclimatic conditions;
- Water availability;
- Land and suitable soils;
- Farmer s motivation and farming skill;
- Crop productivity;
- Labor force availability;
- Farm input availability; and
- Accessibility to the scheme area.

According to climatic conditions, the objective irrigation development projects belong to the tropical zone with slight temperature fluctuation throughout the year. It is characterized with high temperatures, abundant rainfall and a clear division of the year into two seasons, dry and wet.

Apart from uneven distribution of rainfall throughout the year, the climatic and soil conditions are favorable for growing second and even third crops. These conditions make it possible for practicing continuous cultivation throughout the year. From the viewpoint of temperature conditions, quality of soils, and the volume of rainfall, the proposed areas are very suitable for paddy cultivation. This will be possible only with the introduction of irrigation system which will also help to stabilize rainy season crops and expand dry season crops.

The main point of the new irrigation development plan is to irrigate the areas throughout a year, introducing double crops. A year-round reliable supply of irrigation water can be expected because of abundant water sources.

In the above factors, soil condition, farmer s motivation, and accessibility were intensively surveyed at sites. The success of any agricultural development is fundamentally dependent on farmers adopting the schemes and their motivation and capability to prepare the land and to plant crops. Access and marketing will have a profound effect on construction and development of a scheme.

From the viewpoint of project formulation, these plans can incorporate many existing schemes with the objective irrigation development projects. To maximize

the effect of the objective irrigation development projects, supplemental water supply to the existing irrigation schemes with a water shortage problem in its water source can be introduced by the utilization of water source for the new schemes. In the formulation of the objective irrigation development projects, incorporation of the existing schemes with a water shortage problem located close to the objective schemes is essential.

3.3 General Description of New Irrigation Development Projects

At present, floods cause considerable damage in areas along the Kampar and Indragiri rivers, especially, agriculture. Most of the fertile lands are habitually inundated. Some of these lands have turned into swamps. In the proposed areas, the yields of paddy are affected by floods spreading over the areas along the rivers. High floods with water level up to approximately 1.2 m to 1.5 m above the ground occur almost every 5 years.

If flood water levels are brought down by 1.2 m to 1.5 m at Bangkinang and Lubukjambi, flooding of these areas will almost be eliminated. The existing irrigation schemes in the proposed areas suffer from the scarcity of water during dry seasons. Therefore, the construction of reservoirs on the Kampar and Kuantan rivers will serve the purpose of flood control as well as irrigation water supply. Thus, irrigation will ensure the first crops, making it possible to introduce the second and even third crops during dry seasons.

The soils of these areas are formed on loose alluvial deposits able to produce good yields. Reduction of areas suffering from floods to the minimum level is the most important aspect here. In the proposed areas, the yields of paddy are affected by floods spreading over the area along the right and left banks of the Kampar river and the Indragiri river. The duration of floods varies from several days to one week. If a flood coincides the harvest time of paddy, crops are either totally destroyed or the yields are considerably decreased.

The irrigation system to be applied in proposed areas is to provide irrigation water and supplement the existing irrigation schemes throughout the year. The problems of irrigation of areas during dry seasons should be solved together with flood control.

3.3.1 Rantauberangin Irrigation Development Project (Kampar River Basin)

The proposed project is to be situated at either bank of the Kampar Kanan River which runs through the center of Bangkinang, the regional capital of Kampar District. Both banks are comparatively flat areas, extending from the skirt of the hills at Rantauberangin Town to the confluence of the Kampar Kanan and Kampar Kiri rivers. The elevation of the area ranges from around EL 40.0 m to EL 10.0 m. Most of the area is inhabited, except the Pasir Jambu transmigration settlement scheme area.

The existing governmental irrigation schemes (10 schemes: 5,171 ha in the left bank area, and 12 schemes: 4,338 ha in the right bank area), and the existing drainage and

swamp development schemes (4 schemes: 2,975 in the left bank area) are included in the objective project formulation. The total area is about 40,000 ha, which has been estimated by the PU office in Riau (refer to Tables VII.3.1 and VII.3.2).

The main canal will be aligned along the skirts of the hills. From the viewpoint of topographical constraints, if the irrigation system will be introduced, the drainage system also should be employed in order to derive more effect from irrigation.

The roads run along both banks of the Kampar Kanan River. Therefore, the project is accessible during the construction period.

3.3.2 Lubukjambi Irrigation Development Project (Indragiri River Basin)

The proposed project is to be situated at either bank of the Indragiri River. Both banks are comparatively flat areas, extending from the skirts of the hills at Lubukambacang Town to Japura. The elevation of the area ranges from around EL 40.0 m to EL 5.0 m. Most of the area is inhabited.

The existing governmental irrigation schemes (12 existing schemes:4,142 ha in the left bank area, and 8 existing schemes:2,230 ha in the right bank area) are included in the objective project formulation. The total area is about 50,000 ha, which has been estimated by the PU office in Riau (refer to Tables VII.3.1 and VII.3.2).

The main canal will be aligned along the skirts of the hills. From the viewpoint of topographical constraints, if the irrigation system will be introduced, the drainage system also should be employed in order to derive more effect from irrigation.

The road runs only on the left bank of the Indragiri River. Therefore, a new road should be aligned on the right bank area.

3.4 Irrigation Development Plan

3.4.1 Basic Considerations for the Formulation of Irrigation Development Plan

To maximize the effect of the new irrigation development projects, supplemental water supply to the existing irrigation schemes with a water shortage problem should be introduced by the utilization of water source for the projects. In formulating the irrigation development projects, the existing schemes with water shortage problems are incorporated.

For this purpose, the following items should be implemented before completion of the objective irrigation development projects:

- Introduction of technical irrigation system to the existing irrigation systems. Effective utilization of limited river discharge cannot be achieved with semi-technical irrigation system.
- Construction of related infrastructures.

In studying the irrigation development projects, gravity irrigation method with a reservoir is regarded as the basic concept. In addition, the following factors are taken into consideration:

- Location and water level of intake weirs;
- Water requirements; and
- Land suitability.

To decide on the approximate location of headwork facilities, the following considerations are given to the first factor:

- Selection of approximate locations of water source facilities presupposing elevation and location of the highest part of potential irrigation areas;
- Presupposition of canal slope considering irrigation water conveyance to peripheral paddy fields; and
- Elevation of downstream areas, free from perennial inundation due to the provision of a multipurpose dam formulated by the Study.

As for the canal alignment, the following considerations are made for the irrigation development projects:

- To choose straight and shorter canal routes linking water source facility sites to potential irrigation areas; and
- To select higher canal routes in consideration of location of canal structures.

Based on the results of field reconnaissance and analyses concerning various fields, the gross area of the new schemes are estimated, based on the conditions spelled out in the succeeding subsections.

3.4.2 Dimensions of Facilities for Rantauberangin Irrigation Development Project

(1) Weir Crest Elevation

The intake weir crest elevation of the Rantauberangin Irrigation Development Project has been studied and set at EL 40.0 m, considering the tailrace water level of the Kotapanjang Dam at EL 41.0 m.

(2) Primary Canal Length

Based on the above factors and gravity command, the alignment of primary canals was set as shown in Fig. VII.3.2 with the following canal lengths:

- Left Bank Primary Canal : 84 km
- Right Bank Primary Canal : 40 km
- Total : 124 km

3.4.3 Dimensions of Facilities for Lubukjambi Irrigation Development Project

(1) Weir Crest Elevation

The location of headworks for the Lubukjambi Irrigation Development Project has been studied and set at EL 60.0 m.

(2) Primary Canal Length

Based on the above factors and gravity command, the alignment of primary canals was set as shown in Fig. VII.3.3 with the following canal lengths:

- Left Bank Primary Canal : 119 km
- Right Bank Primary Canal : 123 km

Total : 242 km

3.5 Objective Irrigable Areas

Identification of the objective irrigable areas was made from broad and comprehensive viewpoints paying attention to factors such as water sources available for irrigation, agricultural conditions, land use, soil and land suitability, influence of flood, and drainage conditions.

Within the objective project areas, certain areas cannot be irrigated including land located out of command area, and land outside riverbanks, land with soil unsuitable for cultivation, roads, settlements, etc. Since only topographical maps on 1 : 50,000 scale are available, the ratio of net irrigable area to gross area is defined as about 60% by referring to past experiences of the PU office in Riau Province.

3.5.1 Framework of Rantauberangin Irrigation Development Project

(1) The existing irrigation schemes to be included in the development project

Left Bank Area (L)	Right Bank Area (R)
(1) Sei Silam	(1) Kuok I
(2) Kuok II	(2) Sei Maki
(3) Bancah Labi	(3) Salo Baru
(4) Pangoan	(4) Salo Tg. Beliti
(5) Uwai	(5) Bt. Bangkinang
(6) Telo	(6) Ranah Singkuang
(7) Sei Tanang	(7) Dukung Anak
(8) Muara Jalai	(8) Penyesawan
(9) Pasir Jambu	(9) Sei Siran
(10) Sasapan II	(10) Sei Tibun
	(11) Petapahan
	(12) Sei Tambang
Left Bank Area : 5,171 ha	
Right Bank Area : 4,338 ha	
Total Irrigable Area : 9,509 ha	

(2) The existing drainage and swamp development scheme to be included in the development project

(1) Poro I & II (L)
(2) R. Pantai Marpoyan (L)

(3) R. Kubang Sialang (L)
(4) R. Lintaga (L)

Total Irrigable Area : 2,975 ha

(3) Net additional area (including the existing drainage and swamp development schemes, excluding the existing irrigation schemes)

Left Bank Area	10,517 ha
Right Bank Area	277 ha
Total Area	10,794 ha

(4) Total irrigable area (including all the existing schemes)

Left Bank Area	15,688 ha
Right Bank Area	4,615 ha
Total Area	20,303 ha

3.5.2 Framework of Lubukjambi Irrigation Development Project

(1) The existing irrigation schemes to be included in the development project

(1)	Lb. Ambacang II (L)	(11)	Baserah I (L)
(2)	Lb. Ambacang I (L)	(12)	Rw. Ambacang (L)
(3)	Gunung (L)	(13)	Kinali (R)
(4)	Petapahan Toar (L)	(14)	Seb. Gunung (R)
(5)	Sei Jering (L)	(15)	Seb. Taluk II (R)
(6)	Sentajo I (L)	(16)	Sei Paing (R)
(7)	Sentajo II (L)	(17)	Sei Sarik (R)
(8)	Simandolak (L)	(18)	Rumbio Taluk (R)
(9)	Pauh Pangean (L)	(19)	Rawang Udang (R)
(10)	Baserah II (L)	(20)	Danau Koto Rajo (R)
Left Bank Area	:	4,142 ha	
Right Bank Area	:	2,230 ha	
Total Irrigable Area	:	6,372 ha	

(2) Net additional area

Left Bank Area	12,875 ha
Right Bank Area	10,902 ha
Total Area	23,777 ha

(3) Total irrigable area (including all the existing schemes)

Left Bank Area	17,017 ha
Right Bank Area	13,132 ha
Total Area	30,149 ha

The irrigation area and primary canal length to be covered on overall plan stage is tabulated in Table VII.3.2.

3.6 Irrigation Water Requirement for Overall Plan

3.6.1 Factors for Calculation of Irrigation Water Requirement

In order to decide which existing scheme should be augmented with the new water source, water balance assessment is preliminarily made for the existing schemes on 15-day basis of the runoff discharge occurring once in five years non-exceedance. In the case when the assessed development scale is less than the nominal irrigable area of the existing scheme, irrigation water for the scheme should be augmented with the new water source.

Basically, planning a water supply system involves determination of water requirements and finding suitable sources of water supply. In accordance with the above considerations, irrigation water requirements are calculated as follows.

Irrigation water requirements were estimated using the meteorological data at Pasar Kampar Station (Kampar river basin) and Sentajo Station (Indragiri river basin) which are located close to the center of the irrigation development project areas in each basin. Since data were not available at Sentajo throughout the whole observation period, the data at Peranap Station were used to supplement the unavailable data.

(1) Effective Rainfall

In order to calculate water requirements for the irrigation development plan, effective rainfall is estimated using the rainfall data in Rantauberangin, Lubukjambi, and West Sumatra region in the study area. For the study, 15-day effective rainfall is adopted at 70% of the 15-day rainfall with a 20% probability of non-exceedance (refer to Table VII.3.3)

(2) Percolation

According to the reports (Water Management at Ranah Singkuan Irrigation Project, Uwai Irrigation in the Kampar District, and Simandolak Irrigation Project in the Indragiri Hulu District) prepared by Bogor Institute of Agriculture (IPB) in 1985, 1986 and 1987, percolation of actual measurement ranges from 1.0 to 1.8 mm/day, locally 2.1 mm/day. Considering this fact, the percolation rate is assumed to be 2 mm/day for the present condition.

On the other hand, the percolation rate is assumed to be 3 mm/day for the future condition on the assumption that drawdown of the river water level can be expected due to the provision of dams and, subsequently, drainage condition will be completely improved.

(3) Evapotranspiration

For computation of 15-day crop evapotranspiration, the modified Penman formula is used, taking into account the meteorological data at Pasar Kampar Station (Kampar river basin) and Sentajo Station (Indragiri river basin), and the approximate latitude and elevation of the project sites.

Reference crop evapotranspiration is calculated based on the Guideline for Predicting Crop Water Requirements prepared by the Food and Agriculture Organization of the United Nations (FAO) using the meteorological data shown in Table VII.3.4.

The detailed calculation procedures are shown in Table VII.3.5. The items used in the table are defined as follows:

- Tmean : Mean temperature (°C)
- Rel. Hum (mean) : Mean relative humidity (%)
- ea : Mean saturation water vapor pressure (mb)
- U2 : Total wind run at 2m height (km/day)
- W : Weighing factor
- n/N : Sunshine ratio (%)
- N : Bright sunshine hours (hour)
- Ra : Extra-terrestrial radiation (mm/day)
- f(t) : Correction for temperature on longwave radiation
- ed : Mean actual water vapor pressure (mb)
- ea-ed : Vapor pressure (mb)
- f(u) : Wind related function
- n : Sunshine (hours)
- Rns : Net shortwave radiation (mm/day)
- f(ed) : Correction for vapor pressure on long wave radiation
- f(n/N) : Correction for ratio - actual and maximum bright sunshine hours
- Rnl : Net long wave radiation (mm/day)
- Rn : Net radiation (mm/day)
- Eto* : Reference crop evapotranspiration unadjusted for day and night-time weather conditions (mm/day)

No adjustment of Eto* is made because the data on the general climatic conditions such as day and night time wind and humidity condition in the project sites are not available.

(4) Crop Coefficients

The crop coefficients for rice recommended by FAO are used for the calculation. In the project areas, the high yield varieties are prevailing. Therefore, the crop coefficient for the high yield variety (HYV) was employed.

CROP COEFFICIENT FOR PADDY

Month	Crop Coefficient
First Month	1.1
Second Month	1.1
Mid-season	1.05
Last 3-4 weeks	0.95

Conditions: Humid Asia, Light to moderate wind.

(5) Water Requirements for Land Preparation

- Land preparation period : 45 days
- Water requirements for land preparation : 250 mm

Water requirement for land preparation of rice fields is taken at 200 mm, including (1) presaturation of the soil, (2) puddling of the soil, and (3) water requirements for nurseries. At the start of transplanting, another 50 mm water layer is added. In total, this leads to 250 mm for land preparation and an initial water layer after planting.

(6) Irrigation Water Requirements during Land Preparation

For the calculation of irrigation water requirements during land preparation, Van de Goor and Zijilstra's formula is used. (Refer to Table VII.3.6.)

$$IR = Me^k/(e^k - 1)$$

where;

IR : irrigation requirement at field level (mm/day)
M : water requirements to compensate for evaporation and percolation of the fields already saturated (mm/day)

$$M=E_0+P$$

E_0 is open water evaporation taken at 1.1 Eto during land preparation (mm/day)

P : percolation (mm/day)
Eto : reference crop evapotranspiration (mm/day)
k : MT/S
T : land preparation period (days)
S : presaturation requirements (mm)

(7) Water Layer Replacement

Since there was no data available on water layer replacement, 2 replacements, 50 mm each at about 1 month and 2 months after transplanting are employed according to Irrigation Design Standards published by the Directorate General of Water Resources Development, Ministry of Public Works.

(8) Consumptive Use

The consumptive use is calculated as

Etc=kc x Eto

where;

Etc.	:	crop evapotranspiration (mm/day)
Eto	:	reference crop evapotranspiratin (mm/day)
kc	:	crop coefficient

(9) Irrigation Efficiency

Irrigation diversion requirements are calculated by considering operation loss and conveyance loss. It is difficult to estimate an irrigation efficiency for irrigation development in new land . No data on irrigation efficiency in and around the area are available yet. For this project, the following irrigation efficiencies are adopted:

- Primary, and secondary canals : 80%
- Tertiary system : 70%

An irrigation efficiency of 55% for wet paddy has been assumed with reference to the above figures.

(10) Base Year

The base year which correspond to occurrence once in five years non-exceedance is required to produce the irrigation planning. It is set up by the use of unit diversion water requirements for 1981-1992 in present condition.

The cropping calendars in nearly all the areas in the existing irrigation projects in the Kampar and Indragiri river basins are used (refer to Figs. VII.1.2 and VII.1.3). In the Kampar river basin, double-cropping is dominant, while it is single-cropping in the Indragiri river basin.

The assumptions given below were adopted for the formulation of schematic cropping pattern and calculation of unit diversion water requirements in the present condition. The schematic cropping patterns applied to the study are

presented in Fig.VII.3.4, and the results of unit diversion water requirement calculation are in Table VII.3.7.

- The percolation rate is assumed to be 2 mm/day for the present condition.
- Double-cropping is adopted in the Kampar river basin, while single-cropping is adopted in the Indragiri river basin in accordance with the prevailing farming practices in the basins.
- The starting dates of land preparation are assumed as:

River Basin	1st Crop	2nd Crop
Kampar Kiri	Feb. 16	Sep. 1
Indragiri	Feb. 16	No cropping

- Variety to be applied : High yield variety (PB42, etc.)
- Period of land preparation : 45 days
- Total growing period : 120 days
- Nursery and puddling period : 15 days
- Period of surface drainage and harvesting : 20 days
- Commencement period of puddling is staggered in 45 days, and paddy cultivation is performed in 3 groups.

The Base Year of each project is given as follows:

- Rantauberangin Irrigation Development Project : 1988
- Lubukjambi Irrigation Development Project : 1986

3.6.2 Optimization of Cropping Pattern

(1) Procedures to find out Optimum Cropping Pattern

In order to find out the optimum cropping pattern which minimize the total diversion requirements for the additional net irrigable area plus the irrigable area of the existing irrigation schemes which can not be covered with their own water sources, unit water requirements in the base year are calculated by staggering the starting date of land preparation in 15 days firstly.

To grasp the future water demand for the projects, water balance computation is made for the existing projects. In the case when the assessed development scale is less than the nominal irrigable area of the existing scheme, irrigation water for the scheme should be augmented with the new water source. Before drawing a conclusion on the optimum cropping pattern, the following studies are required.

(2) Calculation of Water Requirements

The proposed cropping pattern has been formed as the most appropriate pattern on the basis of the study of the present cropping pattern, the recommendation by the Agricultural Office in Kampar and Indragir Hulu districts, the cropping pattern of similar projects, irrigation water availability, various aspects of agronomic factors and profitability.

In the proposed cropping patterns, rice cultivation in the dry season starts with sowing in March/April and is harvested in August/September, while wet season rice cropping is from October to February/March. Crop selection for irrigation is paddy-paddy only, which is recommended by Agricultural Office in Kampar and Indragiri Hulu districts.

The assumptions given below were adopted for the calculation of water requirements. The results of unit diversion water requirement calculation are given in Table VII.3.8.

- The irrigation area (refer to Table VII.3.2)
- The percolation rate is assumed to be 3 mm/day for future condition.
- Double-cropping is employed for both Kampar and Indragiri river basins.
- The starting dates of land preparation: The following cases were studied by staggering the starting dates of land preparation in 15 days:

STARTING DATES OF LAND PREPARATION BY CASE

Study Cases	Rantauberangin Irrigation Development Project		Lubukjambi Irrigation Development Project	
	1st Crop	2nd Crop	1st Crop	2nd Crop
Case 1	Feb. 16	Sep. 1	Feb. 16	Sep. 1
Case 2	Jan. 1	July 16	Jan. 1	Jul. 16
Case 3	Jan. 16	Aug. 1	Jan. 16	Aug. 1
Case 4	Feb. 1	Aug. 16	Feb. 1	Aug. 16
Case 5	Mar. 1	Sep. 16	Mar. 1	Sep. 16
Case 6	Mar. 16	Oct. 1	Mar. 16	Oct. 1
Case 7	Apr. 1	Oct. 16	Apr. 1	Oct. 16
Case 8	Apr. 16	Nov. 1	-	-

Note: In the case of Lubukjambi Irrigation Development Project, Case 8 was not studied because optimum cropping pattern appeared in Case 6.

- Variety to be applied : High yield variety (PB42, etc.)
- Period of land preparation : 45 days
- Total growing period : 120 days
- Nursery and puddling period : 15 days
- Period of surface drainage and harvesting : 20 days

- Commencement period of puddling is staggered in 45 days, and paddy cultivation is performed in 3 groups.

(3) Water Balance Study for the Existing Schemes

Water balance study was made for the existing irrigation schemes by using the above unit water requirements and the specific discharge at intake sites to estimate the quantities of water deficit supplemented by the new water sources. The focal points taken into account are the dependable flows of river discharge at the water source sites for the existing schemes and irrigation water requirements using the proposed cropping patterns. After the deficits were calculated, they were compared with each other. By referring to the results of hydrological analysis, water availability at intake sites was reviewed for the existing irrigation schemes on the basis of non-exceedance probable discharge in five years (refer to Table VII.3.9).

(4) Optimum Cropping Pattern

In order to find out the optimum cropping pattern, the total diversion requirements were calculated, combining water requirements for the additional net irrigable area with the additional supply for the existing irrigation schemes having a water shortage problem.

The summary of calculation results is shown in Table VII.3.10. In the table, the cropping pattern which shows the minimum value of total water requirements is defined as the optimum cropping pattern. The optimum cropping pattern selected was the case which has the smallest water requirement for the 1st or 2nd crop.

3.6.3 Design Water Requirement

Water Requirement

The total water requirements corresponding to the optimum cropping pattern are given Table VII.3.10 and summarized in the table below.

Irrigation Development Project (River Basin)	Optimum Case	Starting Date of Land Preparation		Water Requirement	
		1st Crop	2nd Crop	Left Bank	Right Bank
1. Rantauberangin (Kampar)	Case 7	Apr. 1	Oct.16	20.69 m^3/sec	4.80 m^3/sec
2. Lubukjambi (Indragiri)	Case 6	Mar.16	Oct. 1	19.31 m^3/sec	17.62 m^3/sec

Water Deficit

According to the results of water balance study, the following existing irrigation schemes will have irrigation water deficit in the optimum cropping pattern. Supplemental water supply for each scheme is included in the water requirement calculated.

(1) Rantauberangin Irrigation Development Project (Kampar River Basin)

All the existing irrigation schemes will have irrigation water deficit.

(2) Lubukjambi Irrigation Development Project (Indragiri River Basin)

Left Bank Area	Right Bank Area
1. Lb. Ambacang II	1. Kinali
2. Lb. Ambacang I	2. Seb. Gunung
3. Gunung	3. Seb. Taluk II
4. Sei Jering	4. Sei Paing
5. Sentajo II	5. Sei Sarik (R)
6. Simandolak	6. Rawang Udang
7. Baserah II	7. Danau K. Rajo
8. Rw. Ambacang	

The design water requirement in the optimum cropping pattern was calculated by combining water requirements for the additional net irrigable area with the additional supply for existing irrigation schemes having a water shortage problem as shown in Table VII.3.11.

3.7 Selection of Irrigation Area for Priority Projects

Priority projects to be urgently implemented have been selected from the Overall Development Plan. Two irrigation areas were selected for the priority projects in consideration of the following items:

- Early realization of existing irrigation schemes;
- Accessibility to project area in consideration of construction and marketing of the products;
- Population increase impact within the target year;
- Existence of some water users associations in the existing irrigation schemes; and
- Higher economic viability.

The priority project areas selected are shown in Figs. VIII.3.5 and VII.3.6, as follows:

- Either bank area from Kuok Intake Weir to Danau Bingkuang Bridge in the Rantauberangin Irrigation Development Project; and
- The left bank area from Lubkjambi Intake Weir to Kampung Baru in the Lubukjambi Irrigation Development Project.

3.7.1 Priority Projects for Rantauberangin Irrigation Development Project

Zoning

The objective area for Rantauberangin Irrigation Development Project is divided into the following three zones to examine the priority of development and to draw a realistic implementation schedule:

Left Bank Upstream Area	Area on the left bank of the Kampar Kanan River from Kuok Intake Weir to Danaubingkuang Bridge.
Left Bank Downstream Area	Area on the left bank of the Kampar Kanan River from Danaubingkuang Bridge to the downstream end.
Right Bank Area	Area on the right bank of the Kampar Kanan River from Kuok Intake Weir to Danaubingkuang Bridge.

Areas by category, Net Present Value (B-C) and Benefit Cost Ratio (B/C) are calculated as follows:

Name of Area	Left Bank Upstream	Left Bank Downstream	Right Bank
Area (ha)			
Existing	5,171	0	4,338
Irrigated	1,837	0	1,822
Rainfed	553	0	375
Undeveloped	2,781	0	2,141
New	4,429	6,088	277
Total Area	9,600	6,088	4,615
Cost (Rp.$\times 10^6$)	61,553	62,803	31,867
Benefit (Rp.$\times 10^6$)	82,171	61,814	32,385
B-C (Rp. $\times 10^6$)	20,618	(-) 989	518
B/C	1.33	0.98	1.02

Note: Discount rate is 10%.

It has been finally concluded that areas with higher economic viability would be given higher priority for implementation. The left bank upstream area and the right bank area, namely, the area on both banks from Kuok Intake Weir to Danaubingkuang Bridge are accordingly included in the priority projects. The left bank downstream area will be developed after completion of the upstream area. The following aspects have been considered for this conclusion:

- Net Present Value (B-C) and Benefit Cost Ratio (B/C) in the left bank downstream area is low and lower priority is given to this area.
- Agricultural labor force in this area as of 2004, the target completion year for priority projects, is estimated at approximately 31,000 people. The

development area of about 15,000 ha is deemed appropriate considering 2 persons/ha in the advance irrigation practice.

- In this area, irrigation development is to be carried out in combination with the flood control of the Kampar Kanan River, otherwise, no benefit would be expected. Implementation of the improvement for the whole stretch of the Kampar Kanan River requires much longer period.

Priority Project

The objective area for irrigation development in the feasibility study is accordingly defined as the area on the right and left banks from Kuok Intake Weir to Danaubingkuang Bridge, as follows:

Unit: ha

Area	Left Bank	Right Bank	Total
Existing Irrigation Schemes to be Included	5,171	4,338	9,509
Irrigated	1,837	1,822	3,659
Rainfed	553	375	928
Undeveloped	2,781	2,141	4,922
Existing Drainage and Swamp Development Scheme to be Included	0	0	0
Net Additional Area	4,429	277	4,706
Total Area	9,600	4,615	14,215

The existing irrigation schemes to be included in the priority project are listed below and details are presented in Table VII.3.12.

(1)	Sei Silam (L)	(12)	Sei Maki (R)
(2)	Kuok II (L)	(13)	Salo Baru (R)
(3)	Bancah Labi (L)	(14)	Salo Tg. Beliti (R)
(4)	Pangoan (L)	(15)	Bt. Bangkinang (R)
(5)	Uwai (L)	(16)	Ranah Singkuang (R)
(6)	Telo (L)	(17)	Dukung Anak (R)
(7)	Sei Tanang (L)	(18)	Penyesawan (R)
(8)	Muara Jalai (L)	(19)	Sei Sirah (R)
(9)	Pasir Jambu (L)	(20)	Sei Tibun (R)
(10)	Sasapan II (L)	(21)	Petapahan (R)
(11)	Kuok I (R)	(22)	Sei Tambang (R)
Total Left Bank Area : 5,171 ha (10 schemes)			
Total Right Bank Area : 4,338 ha (12 schemes)			
Total Irrigable Area : 9,509 ha (22 schemes)			

3.7.2 Priority Projects for Lubukjambi Irrigation Development Project

Zoning

The objective area for Lubukjambi Irrigation Development Project is divided into the following three zones as discussed in Section 3.6 to examine the priority of development and to draw a realistic implementation schedule.

Left Bank Upstream Area	Area on the left bank of the Kuantan River from Lubukjambi Intake Weir to Kampung Baru (near Cerenti).
Left Bank Downstream Area	Area in the left bank of the Kuantan River from Kampung Baru to the downstream end.
Right Bank Area	Area in the right bank of the Kuantan River from Lubukjambi Intake Weir to the downstream end.

Areas by category and Net Present Value (B-C) and Benefit Cost Ratio (B/C) are calculated as follow:

Name of Area	Left Bank Upstream	Left Bank Downstream	Right Bank
Area (ha)			
Existing	4,142	0	2,230
Irrigated	1,670	0	1,515
Rainfed	376	0	65
Undeveloped	2,096	0	650
New	5,234	7,641	10,902
Total Area	9,376	7,641	13,132
Cost (Rp.×10^6)	81,557	102,562	157,309
Benefit (Rp.×10^6)	81,802	77,582	122,303
B-C (Rp.×10^6)	245	(-) 24,980	(-) 35,006
B/C	1.00	0.76	0.78

Note: Discount rate is 10%.

It has been finally concluded that higher priority would be given to the implementation of the left bank upstream area. The left bank downstream area and the right bank area will be developed after completion of the upstream area. The following aspects have been considered:

- Net Present Value (B-C) and Benefit Cost Ratio (B/C) in the right bank area is low and lower priority is given to this area.
- Benefit Cost Ratio (B/C) of the left bank downstream area is below 1.0 and lower priority is given to this area.
- Agricultural labor force in this area as of 2004, the target completion year for priority projects, is estimated at approximately 41,000 people. In this

respect, areas of up to 20,000 ha could be developed considering 2 persons/ha in the advance irrigation practice.

Unit: ha

Area	Left Bank
Existing Irrigation Schemes to be Included	4,142
Irrigated	1,670
Rainfed	376
Undeveloped	2,096
Existing Drainage and Swamp Development Scheme to be Included	0
Net Additional Area	5,234
Total Area	9,376

The existing irrigation schemes to be included in the priority project are listed below and details are presented in Table VII.3.12.

(1)	Lb. Ambacang II (L)	(7)	Sentajo II (L)
(2)	Lb. Ambacang I (L)	(8)	Simandolak (L)
(3)	Gunung (L)	(9)	Pauh Pangean (L)
(4)	Petapahan Toar (L)	(10)	Baserah II (L)
(5)	Sei Jering (L)	(11)	Baserah I (L)
(6)	Sentajo I (L)	(12)	Rw. Ambacang (L)
Total Left Bank Area : 4,142 ha (12 schemes)			
Total Right Bank Area : - ha (- schemes)			
Total Irrigable Area : 4,142 ha (12 schemes)			

CHAPTER 4 FEASIBILITY STUDY

4.1 General

In the study for the Overall Development Plan, factors required for the calculation of irrigation water requirements were considered and optimum cropping patterns were setup. Accordingly, the water requirement for priority projects was calculated.

As for operation and maintenance of irrigation projects, water users' associations, locally called P3A (Perkumpulan Petani Pemakai Air), have already been organized in the existing irrigation schemes to be incorporated in the new projects. After completion of construction works, the project executing office will be reorganized into the O&M office which will be responsible for the operation and maintenance of all facilities, covering the irrigation facilities up to tertiary blocks. The operation and maintenance between the tertiary blocks and terminal facilities will be entrusted to the farmers' water user group and the farmers themselves.

4.2 Irrigation Water Requirement for Priority Projects

4.2.1 Objective Site for Priority Projects

The priority project areas used for the calculation of water requirements are summarized below. Details are in Section 3.7.

(1) Rantauberangin Irrigation Development Project

(a) The existing irrigation schemes to be included

- Left Bank Area : 5,171 ha (10 schemes)
- Right Bank Area : 4,338 ha (12 schemes)

Total : 9,509 ha (22 schemes)

(b) Net additional area

- Left Bank Area : 4,429 ha
- Right Bank Area : 277 ha

Total : 4,706 ha

(c) Total net irrigable area

- Left Bank Area : 9,600 ha
- Right Bank Area : 4,615 ha

Total Area : 14,215 ha

(2) Lubukjambi Irrigation Development Project

(a) The existing irrigation schemes to be included

- Left Bank Area : 4,142 ha (12 schemes)
- Right Bank Area : - ha

Total : 4,142 ha (12 schemes)

(b) Net additional area

- Left Bank Area : 5,234 ha
- Right Bank Area : - ha

Total : 5,234 ha

(c) Total net irrigable area

- Left Bank Area : 9,376 ha
- Right Bank Area : - ha

Total area : 9,376 ha

4.2.2 Optimum Cropping Pattern

The following starting dates of land preparation are adopted, based on the study of irrigation water requirements for the Overall Development Plan. Details are Subsection 3.6.2.

Irrigation Development Project (River Basin)	Optimum Case	Starting Date of Land Preparation	
		1st Crop	2nd Crop
1. Rantauberangin (Kampar)	Case 7	Apr. 1	Oct.16
2. Lubukjambi (Indragiri)	Case 6	Mar.16	Oct. 1

4.2.3 Total Water Requirement

The total water requirements are calculated combining water requirements for the additional net irrigable area with additional supply for the existing irrigation schemes having a water shortage problem.

The summary of calculation results is shown in Table VII.3.13. The optimum case which has the smallest amount of water requirement was selected.

4.2.4 Design Water Requirement

Water Requirement

The total water requirements corresponding to the optimum cropping pattern are given in Table VII.3.13 as summarized below.

Irrigation Development Project (River Basin)	Optimum Case	Starting Date of Land Preparation		Water Requirement	
		1st Crop	2nd Crop	Left Bank	Right Bank
1. Rantauberangin (Kampar)	Case 7	Apr. 1	Oct.16	11.31 m^3/sec	4.80 m^3/sec
2. Lubukjambi (Indragiri)	Case 6	Mar.16	Oct. 1	7.85 m^3/sec	- m^3/sec

Water Deficit

According to the results of the water balance study, the following existing irrigation schemes will have irrigation water deficits in the optimum cropping pattern.

(1) Rantauberangin Irrigation Development Project (Kampar River Basin)

All the existing irrigation schemes will have irrigation water deficit.

(2) Lubukjambi Irrigation Development Project (Indragiri River Basin)

The project is situated only in the left bank area as given below. There is no project in the right bank area.

Left Bank Area	
1. Lb. Ambacang II	5. Sentajo II
2. Lb. Ambacang I	6. Simandolak
3. Gunung	7. Baserah II
4. Sei Jering	8. Rw. Ambacang

The design water requirement in the optimum cropping pattern is calculated by combining water requirements for the additional net irrigable area with the additional supply for the existing irrigation schemes having a water shortage problem as shown in Table VII.3.14.

4.3 Operation and Maintenance Plan

4.3.1 Operation and Maintenance for Facilities

Operation and maintenance is divided into such functions as operation of water control to intake, convey and divert water, and maintenance of facilities by inspection, improvement, repair and removal of obstacles to water supply.

(1) Items to be Checked for Operation

(a) Headworks

Water management and control at headworks should be performed so that intake weirs and other facilities will function safely and rationally. Flushing gates to remove sediment are operated on managing person's judgment. During flood period, the weir and flushing gates shall be opened to discharge flood to the downstream. Intake gates shall be controlled so as to ensure the necessary amount of intake water.

(b) Canals and Related Structures

Water management and control in canals should be performed so that diversion structures and check gates will function safely and rationally. At diversion structures, water level, rate of flow and opening degree of gate are to be checked. Furthermore, farmers shall be prohibited to operate or break into facilities for their purposes. At check gates, water level shall be watched for proper distribution.

With respect to canal management, facilities such as headworks, canals and structures shall always be kept in good condition to ensure proper and functional distribution. In principle, the main system has to be managed well by administration offices and tertiary system, by irrigation associations or farmer beneficiaries.

(2) Items to be Checked for Maintenance

Since periodical maintenance has not been carried out, a thick growth of water weeds are found in most of the earth canals and a lot of sediment is found in canal beds due to erosion of canal sidewalls which cause loss of design cross sectional area of flow.

Maintenance of facilities consists of: regular and emergency maintenance as discussed below.

(a) Regular maintenance of facilities

Personnel of the management office should conduct regular inspection of facilities and if any damage is found, should report the damage to the management office. If damage is heavy, temporary repair should be arranged as soon as possible. A periodical repair plan of canal structures should be prepared.

(b) Emergency maintenance of facilities

Emergency maintenance of facilities should be performed when damage is heavy. Damaged facilities should be repaired immediately by using materials obtained on site to avoid further damage.

The main items of inspection and maintenance work are as follows:

- Weir body of headworks should be inspected for cracks, piping or peeling of surfaces.
- Erosion of ripraps is considered to be inevitable after floods. However, if ripraps have been washed away, new ripraps should be constructed immediately and, if necessary, construction lengths should be extended. Without ripraps, lowering of foreaprons will result.
- Sediment, water weeds and suspended solids should be removed.
- Freeboard of canals should be cleaned.
- Trees and plants growing at joints in concrete structures should be removed.
- Sediment on gate sills of diversion structures and turnouts should be removed.
- Joints between earth canals and concrete structures should be checked.
- Gates, safety bars and handrails should be regularly paint-coated.
- During non-irrigation period, full opening and full closing of gates should be checked and parts of gates should be lubricated.
- Spare stoplogs for gates should be prepared.

(3) Proposed Operation and Water Management

Rotational irrigation schedule, gate control operation during floods and records-keeping should be performed. The following minimum system operations supported by extension workers should be performed by farmers' O&M groups in the projects as a first step.

- Seasonal irrigation schedules should be prepared through discussions in regular general meetings.
- When rotational irrigation is applied, rotation order and irrigation time of respective blocks should be decided through discussions. In the projects, the rotation block is to be divided into three.
- The above operation and water management activities should be recorded in order to improve activities.

(4) Proposed Maintenance

The following minimum system maintenance with the support of extension workers should be made by farmers' O&M groups in the projects as a first step:

- Periodical system maintenance schedule should be prepared through discussions in regular general meetings, and the schedule must be informed to every group members
- When special maintenance works such as concrete works and gate replacement are required, a general meeting should be held promptly to

discuss and decide on the materials required, procurement and repair methods, preparation of budget and repair schedule.

- When emergency repair is required in case of floods and so on, the group leader or irrigation operator and group members available should conduct the emergency repair promptly within a reasonable period to minimize damage to the irrigation system.
- The above maintenance activities should be recorded in order to improve these activities.

4.3.2 Operation and Maintenance at Farm Level

The objective of O&M at the farm level is to improve and strengthen the situation where farmer beneficiaries in projects are able to operate and maintain their irrigation and drainage systems technically and financially in accordance with government laws and regulations. To achieve the above objective, the following approach has been formulated:

- Promotion and encouragement of authorized farmer associations.
- Strengthening of financial background of farmer associations (introduction of reasonable water charges, if possible).
- Improvement of rural extension system for O&M and training of rural extension workers.

Based on the above basic approach, improvement and strengthening plans have been formulated as explained below.

4.3.3 Establishment of O&M Organization

After completion of construction works, the operation and management office to be responsible for operation and maintenance of all facilities should be established. The operation and maintenance from the tertiary blocks to peripheral facilities are to be entrusted to the water user associations and farmers. The main functions and responsibilities of the operation and management office are summarized below.

- Formulation of irrigation schedule;
- Collection and analysis of data;
- Water supply control and canal system management;
- Technical guidance for irrigation associations and farmer beneficiaries; and
- General affairs and accountancy.

The proposed office organization shall have four sections: operation section, repair and maintenance section, farmer's assistance section and administrative section, the functions of which are summarized below.

(1) Operation Section

- Planning of irrigation schedule
- Water distribution
- Control of water delivery
- Hydrological measurements
- Data collection and processing

(2) Repair and Maintenance Section

- Repair and maintenance of facilities and equipment
- Management and inspection of facilities and equipment

(3) Farmers' Assistance Section

- Guidance and training of water users
- Monitoring and evaluation

(4) Administrative Section

- Personnel services
- Accounting and cashiering
- General affairs services

The O&M office will be set up at the projects sites. For smooth and effective water supply, the service area for water management is divided into two areas: the left bank area and the right bank area. However, to grasp overall irrigation planning and scheduling over the whole area, the operation of these O&M offices should be integrated, i.e., the works shall be performed under the control of a central office. On the other hand, water delivery and scheduling of each area are to be performed by branch offices.

The irrigation supervisor is to be responsible for operation and management of the irrigation system through the above mentioned sections. The staff required for the O&M office are categorized as below.

(1) General Manager

(2) Operations Section

(a) Central Station

- Irrigation Supervisor (Irrigation Engineer)
- Assistant irrigation supervisors
- Hydrologist
- Computer Operator
- Measurement assistant

(b) Field Station

- Irrigation inspectors (Head of field station)
- O&M personnel

Standard coverage of activities for O&M personnel is shown below, based on the standards of the Public Works Office in Java.

Intake Weir	1 person (p)
Operation of Irrigation Water	1 p/700 ha
Check for Canal	
Main Canal	1 p/5 km
Secondary Canal	1 p/6 km
Drainage Canal	1 p/10 km

Check for Structures	
Main Canal	1 p/40 units
Secondary Canal	1 p/60 units
Check for Inspection Road	
Main Canal	1 p/18 km
Secondary Canal	1 p/15 km
Drainage Canal	1 p/15 km

- Measurement assistant

(3) Repair and Maintenance Section

- Construction Engineer
- Assistant Construction Engineer
- Field Supervisor
- Mechanic
- Assistant Mechanic
- Driver/Operator

(4) Farmers' Assistance Section

- Agronomist
- Monitoring Eexpert/Assistant Agronomist
- Enumerator for project benefit monitoring and evaluation

(5) Administrative Section

- Administrative Officer
- Accountant
- Clerk
- Typist
- Storekeeper
- Janitor

4.3.4 Organization Supported by the Government

It is essential to extend O&M to farmers through extension workers in collaboration with the Provincial Irrigation Service at the district level as well as subdistrict offices, and Provincial Agricultural Service offices are required to train extension workers.

It has been the policy of the Government that O&M of tertiary and on-farm facilities is the responsibility of farmers through the water users association, (P3A). The farmers' group already organized in project areas will be converted into a water users' association.

In view of the need for farmers' involvement from an early stage of the project, it is essential that water user associations are formed during the preconstruction stages. Before completion of project facilities, a water users' association will be established in each village with technical and operational guidance from the O&M office and the agricultural extension office.

In forming water users' associations, the following steps shall be taken:

- The first step will be to identify the names of probable water users association members based on the provisional field layout of tertiary facilities; and
- The second step will be to hold meetings among concerned farmers to elect group leaders and form the executive body for each water users association.

After the formation of each water users' association, the layout of tertiary and on-farm irrigation and drainage facilities will be finalized. A water users' association is usually established along administrative boundaries which do not necessarily coincide with tertiary unit boundaries, covering an area of 30 to 100 ha and 20 to 60 members. In addition to O&M responsibilities, water user associations are also responsible for drawing up seasonal programs for equitable distribution of water within their respective command areas.