concerned with farm mechanization as follows:

Positive Factors

a. no landless farm labourers, namely low availability of cheap farm labour,
b. low population pressure,
c. abundant land and water resources,
d. transmigrants from Java know how to utilize ox for land preparation and hauling farm products,
e. advanced farm mechanization system has started in West Sumatra which is near by, and
f. IFAD programme to promote ox ploughing extension is proceeding.

Negative Factors

a. low capital stock to purchase farm machinery, and
b. employment opportunity is available on large scale plantations near by.

Farm mechanization includes not only land preparation but also transplanting, harvesting, and post-harvesting. Unless mechanization of all farming activities is established, the enlargement of farm size can not be expected. Land preparation and threshing are relatively easy to mechanize and these are being mechanized to some extent in Java and West Sumatra. However, other work, namely transplanting and harvesting, have not yet been mechanized. Thus the enlargement of farming size is not easy under the present condition.

It is, therefor, recommended to establish a research center for efficient farm mechanization where appropriate and a practical mechanized farming system for local situation is studied under the proposed irrigation system. With this appropriate mechanization system developed in this center, the realization of cropping intensity increase and farm size enlargement can be smoothly promoted and thus the combination of the farm mechanization and production infrastructure development by the Project can effectively achieve the objective of the Project, namely increase in farmer income and regional food self-sufficiency.

3.9 Land Clearing and Reclamation

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

In order to promote on-farm facility development, Ministry of Agriculture has formulated the land development project consisting of two types of assistance to farmers, namely financial and technical assistance.

The financial assistance is composed of two types of credit. The first is pre-financing loan for working capital (KMKP) and the second is small investment credit.

The technical assistance, which is offered by UPP (Unit Pelaksana Proyek) of Director General of Food Crop Agriculture, is survey, design, guidance and supervision for construction works of on-farm facilities. The land reclamation unit is 1,000 ha and 2,000 ha for investigation. The period to implement the above works is within two years.

PTPT, which is under DPU, is another organization to coordinate between the transmigration office, UPP and agricultural office and to execute the transmigration programmes related with DPU.

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

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

3.10 Experimental Farm

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

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

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

4. Transmigration Plan

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

The proposed transmigration plan is explained in the following sections.

4.1 Land Allocation

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

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

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

Since the development of Lahan Usaha II is not smoothly proceeding under the present condition, the government is requested to implement various support services and subsidies such as credit, logging tools, farm mechanization support, etc.

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

4.2 Number of Required Transmigration Household

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

New Village 1:	400	H.H
New Village 2:	380	H.H
New Village 3:	450	H.H
New Village 4:	345	H.H
New Village 5:	235	H.H
New Village 6:	360	H.H
New Village 7:	84	H.H
Total	2,254	H.H

The locations of these transmigration areas are shown in Proposed Land Use Plan, Fig. 3.2.1.1 of the main report of Volume III. The total area occupied by the new transmigration villages is 5,320 ha which is 43.6 % of the Gross Area.

Common layout of transmigration villages are four, namely (a) scattered system, (b) group system, (c) long row system, and (d) circle system. In the Project Area, (b) and (c) were adopted for the existing transmigrant villages. In consideration of convenience for everyday life, farming, security, efficient land use, (b) group system and (c) long row system are also proposed in the Project.

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

4.3 Transmigration Schedule

According to the Transmigration Office of Riau Province, the implementation of transmigration can be conducted within 2 years. However, to have time reserve, it is assumed that the implementation of the transmigration plan takes four years. On the other hand, it is supposed that the Project takes two years for detailed design and five years for construction works. Therefore, after the start of detail design for the Project, the transmigration plan starts and during the third year of the Project construction, the transmigration plan will be completed.

New transmigrants can get job from the irrigation facility construction work and, when the Project construction work is terminated, the new transmigrants will get used to live in the new circumstances and settled.

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

Table 2.1 Agricultural Production, Cropping Season 1990 (Rainy Season)

	Wet land rice	Dry land rice	Maize	Cassava	Sweet Potato	Peanut	Mung beans	Soybean	Vegetables	Chili	Total (Ha)
1 Kota Lama											
Area(Ha)	0.0	70.0	2.5	2.0	2.0	0.0	2.0	0.0	8.0	1.5	88.0
Yield(ton/Ha)		0.9	2.0	15.0	1.3		0.7		0.9	0.9	
Prod'tn(ton)		63.0	5.0	30.0	2.6		1.3		7.2	1.2	
2 Kota Intan											
Area(Ha)	10.0	150.0	1.0	0.0	0.5	0.0	0.0	0.0	2.0	1.0	164.5
Yield(ton/Ha)	3.7	0.9	1.6		1.4				0.6	0.5	
Prod'tn(ton)	37.0	135.0	1.6		0.7				1.1	0.5	
3 Muara Dilam											
Area(Ha)	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
Yield(ton/Ha)					1.2						
Prod'tn(ton)					1.2						
4 SKP A											
Area(Ha)	2.0	68.0	7.0	9.5	27.0	5.5	1.0	7.5	6.0	3.5	137.0
Yield(ton/Ha)	0.9	1.0	1.9	18.0	1.4	0.6	0.7	0.8	0.7	1.3	
Prod'tn(ton)	1.8	64.0	13.0	171.0	37.8	3.3	0.7	5.9	3.9	4.3	
5 SKP F											
Area(Ha)	0.0	105.0	4.0	5.0	17.0	4.5	2.0	26.0	3.0	2.0	168.5
Yield(ton/Ha)		1.0	2.4	25.0	1.3	0.8	0.7	0.6	0.7	0.7	
Prod'tn(ton)		105.0	9.6	125.0	22.1	3.6	1.4	15.6	2.1	1.3	
6 SKP G											
Area(Ha)	0.0	224.0	8.0	4.0	15.0	4.0	7.0	42.0	3.0	1.5	308.5
Yield(ton/Ha)		1.5	1.6	14.0	1.5	0.9	0.5	0.6	0.7	0.5	
Prod'tn(ton)		327.0	12.8	56.0	22.5	3.8	3.5	23.1	1.9	0.8	
7 Kota Baru											
Area(Ha)	0.0	222.0	4.0	4.5	13.0	5.0	3.0	5.5	9.0	0.0	266.0
Yield(ton/Ha)		1.4	1.9	14.0	1.6	0.9	0.7	0.7	0.7		
Prod'tn(ton)		310.8	7.4	63.0	20.8	4.3	2.2	3.9	6.3		
8 Kota Raya											
Area(Ha)	15.0	266.0	6.5	7.0	31.0	6.0	5.0	7.0	10.0	10.5	364.0
Yield(ton/Ha)	1.6	1.0	1.9	15.0	1.6	0.8	0.6	0.8	0.7	0.8	
Prod'tn(ton)	24.0	252.7	12.3	105.0	49.6	4.8	3.8	5.3	7.0	8.4	
9 Muara Jaya											
Area(Ha)	0.0	55.0	6.0	5.0	41.0	3.0	1.0	4.0	4.0	2.0	121.0
Yield(ton/Ha)		1.5	2.2	15.0	1.5	0.7	0.6	0.8	0.9	0.7	
Prod'tn(ton)		82.5	13.3	75.0	61.5	2.0	0.6	3.1	3.6	1.4	
10 SKP B											
Area(Ha)	0.0	78.8	8.8	8.4	7.9	12.5	6.2	23.4	2.7	10.9	159.6
Yield(ton/Ha)		0.9	1.8	10.4	5.0	0.7	0.6	0.9	0.8	1.7	
Prod'tn(ton)		68.9	16.1	86.4	39.4	9.0	3.6	20.8	2.2	18.6	
Total/Average											0.0
Area(Ha)	27.0	1,238.8	47.8	45.4	155.4	40.5	27.2	115.4	47.7	32.9	
Yield(ton/Ha)	2.3	1.1	1.9	15.7	1.7	0.8	0.6	0.7	0.7	1.1	
Prod'tn(ton)	62.8	1,408.9	91.1	711.4	258.2	30.8	17.1	77.7	35.3	36.5	

Source: Programa Penyuluhan Pertania 1991/1992. BPP. Kota Lama and Agricultural Statistics of Kec. Kepunuhan. 1991

Note: Some figures of production are not equal to the multiplication of area and yield due to rounding of yield.

Table 2.2 Agricultural Production, Cropping Season 1991 (Dry Season)

	INSUS/INMUM						INMUM	UPSUS			Total
	Wet land rice	Dry land rice	Maize	Cassava	Sweet Potato	Peanut	Mung beans	Soybean	Vegetables	Chili	Area (Ha)
1 Kota Lama											
Area(Ha)	0.0	0.0	3.5	2.0	0.0	2.0	1.0	0.0	9.5	1.0	19.0
Yield(ton/Ha)			2.2	15.0		0.8	0.7		0.9	1.8	
Prod' tn(ton)			2.5	30.0		1.6	0.7		8.5	1.8	
2 Kota Intan											
Area(Ha)	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	4.0	1.0	6.0
Yield(ton/Ha)				15.0					0.7	1.3	
Prod' tn(ton)				15.0					2.8	1.3	
3 Muara Dilam											
Area(Ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yield(ton/Ha)											
Prod' tn(ton)											
4 SKP A											
Area(Ha)	12.0	3.0	12.0	8.5	2.0	3.0	1.0	15.0	9.0	4.5	70.0
Yield(ton/Ha)	1.8	0.9	2.4	18.0	9.5	0.9	0.6	0.8	0.9	1.4	
Prod' tn(ton)	21.6	2.7	28.8	153.0	19.0	2.5	0.6	12.3	7.7	6.3	
5 SKP F											
Area(Ha)	0.0	5.0	7.5	5.0	0.0	2.0	2.0	65.0	7.5	2.5	96.5
Yield(ton/Ha)		0.6	2.2	15.0		0.7	0.7	0.9	0.9	1.3	
Prod' tn(ton)		3.1	16.5	75.0		1.4	1.4	60.5	6.0	3.2	
6 SKP G											
Area(Ha)	0.0	9.0	14.0	20.0	2.0	8.0	4.5	120.0	8.0	2.5	188.0
Yield(ton/Ha)		0.7	2.0	14.0	5.0	0.7	0.5	0.9	0.7	1.4	
Prod' tn(ton)		6.6	28.0	280.0	10.0	5.6	2.3	109.2	5.0	3.5	
7 Kota Baru											
Area(Ha)	14.0	12.5	8.0	9.5	0.0	2.0	4.0	15.0	11.0	2.0	78.0
Yield(ton/Ha)	2.2	0.8	2.0	14.0		0.8	0.7	0.7	0.7	1.5	
Prod' tn(ton)	30.8	10.0	16.0	133.0		1.5	2.8	11.1	7.7	3.0	
8 Kota Raya											
Area(Ha)	1.0	9.0	20.0	10.0	2.0	4.5	2.0	12.5	14.0	4.0	79.0
Yield(ton/Ha)	2.1	0.8	1.9	16.0	8.0	0.8	0.8	0.7	0.8	1.6	
Prod' tn(ton)	2.1	6.8	38.0	160.0	16.0	3.6	1.6	9.3	11.0	6.4	
9 Muara Jaya											
Area(Ha)	17.0	29.0	13.0	21.0	4.0	5.5	4.5	19.0	9.0	3.0	125.0
Yield(ton/Ha)	2.8	0.9	1.9	16.0	8.6	0.8	0.8	0.8	0.9	1.6	
Prod' tn(ton)	47.6	26.4	24.7	336.0	34.0	4.4	3.8	15.8	7.9	4.8	
Total/Average											
Area(Ha)	44.0	67.5	78.0	77.0	10.0	27.0	19.0	246.5	72.0	20.5	661.5
Yield(ton/Ha)	2.3	0.8	2.0	15.4	7.9	0.8	0.7	0.9	0.8	1.5	
Prod' tn(ton)	102.1	55.6	154.5	1,182.0	79.0	20.6	13.2	218.2	56.6	30.3	
10 SKP B (Ha)*	0.0	4.6	17.6	na	na	12.1	na	52.7	na	na	

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

Note: Some figures of production are not equal to the multiplication of area and yield due to rounding of yield.

na: Data not available

*: estimated from the ratios of those crops for cropping season

Table 2.3 Crop Productivity per Hectare, 1991

(Unit: Kg)

village	Irrig. Paddy	Rainfed Paddy	Upland Paddy	Soybean	Peanut	Maize	Cassava	Chili	Mung bean
New Village									
Kota Baru		833	799	571	2,565*	594	15,335		
Kota Raya			917	403	528	995	1,810	333	
Kota Jaya			623	295	631	825		485	
Old Village									
Kota Intan	3,141		1,340						
Muara Dilam			806	828					
Trans. Village									
SKP A			1,192	496	458	367		2,000	369
SKP B			986	1,100	889	590			46*
SKP F			608	538	192	972			
SKP G			886	1,490	939	1,840		2,590*	
All Villages**	3,141	833	901	679	631	858	9,004	409	369

*: These figures seem to be unrealistic and erroneous.

**: These are weighted averages of sample numbers and the extream figures were excluded.

Sourec: Farm Economy Survey, JICA, 1992

Table 2.4 Estimated Present Agricultural Production in the Project Area

Crops	Area(Ha)*	Yeild(t/Ha)**	Production(ton)
Wet Season	1,905		
Wet land paddy			
Irrigated paddy	10	3.1	31.0
Rainfed paddy	17	0.8	13.6
Upland paddy	1,239	0.9	1,115.1
Maize	48	0.9	43.2
Peanut	41	0.6	24.6
Soybean	115	0.7	80.5
Rubber			
planted in 1990	160		
harvested in 1990	275	0.8	220.0
Dry Season	464		
Wet land paddy			
Rainfed paddy	44	0.8	35.2
Upland paddy	68	0.9	61.2
Maize	78	0.9	70.2
Peanut	27	0.6	16.2
Soybean	247	0.7	172.9

Area*: adopted from the statistics fo Programa Penyuluhan Pertanian 1991/92, BPP, Kota Lama

Yield**: The yeilds of wet season was estimated from Farm Economy Survey, 1992, JICA.
The yields of dry season were regarded as same as that of wet season.

Cropping intensity is 124 %.

Note: Agricultural production here is limited to paddy, maize, peanut, soybean, and rubber which are mainly planted in continuously cultivated land, this area is potential irrigable area. On the other hand cassava, sweet potato, mung bean, chili and vagetables are mainly planted in home yard which is difficult to develop for irrigation.

Table 2.5 Small Scale Plantation Crops, 1990/1991 (April to March)

	Rubber (ton)	Coconut (nut)	Coffee (kg)	Clove (kg)
1 Kota Lama				
Planted Area (Ha)	30.0	1.3	5.0	0.0
Harvested Area (Ha)	60.0	13.0	2.0	6.9
Production	57.5	43,680.0	119.0	88.0
2 Kota Intan				
Planted Area (Ha)	30.0	6.4	5.0	0.0
Harvested Area (Ha)	215.0	9.3	1.9	
Production	165.0	14,170.0	104.5	
3 Muara Diram				
Planted Area (Ha)	0.0	0.0	0.0	0.0
Harvested Area (Ha)				
Production				
4 SKP A				
Planted Area (Ha)	0.0	2.7	0.1	0.0
Harvested Area (Ha)				
Production				
5 SKP F				
Planted Area (Ha)	0.0	8.4	4.0	0.0
Harvested Area (Ha)				
Production				
6 SKP G				
Planted Area (Ha)	0.0	38.4	3.3	0.0
Harvested Area (Ha)				
Production				
7 Kota Baru				
Planted Area (Ha)	5.0	54.6	4.4	11.3
Harvested Area (Ha)		17.0	1.4	4.8
Production		30,780.0	560.0	0.0
8 Kota Raya				
Planted Area (Ha)	18.0	78.8	5.1	16.5
Harvested Area (Ha)		18.0	3.4	7.0
Production		43,235.0	1,005.0	129.0
9 Muara Jaya				
Planted Area (Ha)	76.5	39.1	3.1	9.4
Harvested Area (Ha)		25.0	1.1	0.0
Production		30,325.0	1,185.0	1.2
10 SKP B	na	na	na	na
Total/Average				
Planted Area (Ha)	159.5	229.7	30.0	37.2
Harvested Area (Ha)	275.0	82.3	9.8	18.7
Production	222.5	162,190.0	2,973.5	218.2
Yield per Ha	0.8	1,970.7	303.4	11.7

Source: Programa Penyuluhan Pertania 1991/1992, BPP, Kota Lama

Note: Some figures of production are not equal to the multiplication of area and yield due to rounding.

na: Data not available

Table 2.6 Farm Inputs and Labour Requirement per Hectare for Major Crops -Present-

	Unit	Irrig. Paddy			Lowland Paddy			Upland Paddy			Soybean			Peanut	Maize		
1 Seed	Kg	31			42			40			39			64	28		
2 Fertilizer																	
Urea	Kg	31			65			36			39			13	50		
TSP	Kg	24			58			24			50			6	9		
KCL	Kg	3			0			6			16			0	5		
Organic matter	Kg	0			1120			129			0			79	0		
3 Agrochemicals																	
Insecticides	cc	1470			1530			757			0			609	223		
Rodenticides	g	3.1			0			40			0			0	0		
Herbicides	cc							33			0			0	0		
4 Labour		Own	Hired	Total	Own	Hired	Total	Own	Hired	Total	Own	Hired	Total	Own	Own	Hired	Total
Nursery/Seeding	man-day	2.4	0	2.4	3.7	0	3.7	12.9	6.5	19.4	7.3	4.3	11.6	15.7	5	0.3	5.3
Land Prepar'tn	man-day	37.5	10.4	47.9	56.1	6.9	63	39.5	13.6	53.1	25.7	1.6	27.3	51.8	36.6	0.2	36.8
Transplanting	man-day	16.6	1.3	17.9	14.7	1.7	16.4	0	0	0	0	0	0	0	0	0	0
Ferti.Appli.	man-day	1.9	0	1.9	4.5	0	4.5	1.5	0	1.5	2.8	0	2.8	0	3.1	0.4	3.5
Ag-chemi.Appli.	man-day	4	0	4	3.5	0	3.5	1.9	0	1.9	3.7	0	3.7	3.1	0.8	0	0.8
Weeding	man-day	24.5	1.1	25.6	33.9	1	34.9	26.7	6	32.7	22.3	1.9	24.2	38	10.5	0.7	11.2
Harvesting	man-day	13.7	0.3	14	10.1	0.8	10.9	13.2	6	19.2	9.6	2	11.6	12.4	7.3	0.7	8
Hauling	man-day	1.2	0.1	1.3	1.5	0.2	1.7	1.6	0.3	1.9	1.2	0	1.2	0.2	1.7	0.1	1.8
Thresh/Drying	man-day	11.4	1	12.4	8.1	0.5	8.6	4.7	1	5.7	7.9	0.9	8.8	7.8	17.5	0.1	17.6
Water Control	man-day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		113.2	14.2	127.4	136.1	11.1	147.2	102	33.4	135.4	80.5	10.7	91.2	129	82.5	2.5	85
				0			0			0			0				0
5 Animal Power	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Farm Economy Survey 1992. JICA
and some figures were adjusted on the basis of the filled survey and interviews.

Table 2.7 Farm tools owned by Farm Household, 1991
(Unit: Quantity possesed per farm household)

Tool	Unit Price(Rp)	Original Village	New Village	Transmig. Village	All Village
Cow	402,000		0.90		0.41
Sprayer	58,300	0.21	0.07		0.06
Thresher	890,000		0.01		0.01
Hoe	7,600	1.79	2.59	2.56	2.48
Plough	53,400		0.28		0.13
Sickle	3,300	1.21	2.14	1.68	1.83
Ani-ani	500	1.26	1.64	1.87	1.75
Harrow	4,300		0.48	0.29	0.34
Knife	3,700	1.84	2.09	2.06	2.05
Dible	2,810	0.89		0.47	0.31

Source: Farm Economy Survey 1991, JICA

Table 3.1 Proposed Land Use in the Gross Area

(unit: ha)

	Present Land Use		Proposed Land Use in Gross Area		
	Survey Area	Gross Area	Area to be developed	Non devlop'nt Area	Total proposed Land Use
Paddy	1,266	548	5,926	-	5,926
Irrigated	(10)	(0)	(5,296)	-	(5,296)
Rainfed	(17)	(2)	(0)	-	(0)
Upland	(1,239)	(546)	-	-	-
Secondary Crops	204	91	2,374	-	2,374
Primary Forest	17,495	5,268	-	304	304
Secondary Forest	10,301	3,094	-	751	751
Bush/Grass Lands	5,938	2,325	-	244	244
Alang Alang Lands	2,039	532	-	-	-
Plantation Area	3,093	-	-	-	-
Village Area	1,000	342	1,720	342	2,062
Right-of-way	-	-	539	-	539
Total	41,336	12,200	10,559	1,641	12,200

Table 3.2 Farm Inputs and Labour Requirement per Hectare for Major Crops -With Project-

	Unit	Irrig. Paddy	Soybean	Peanut	Maize
1 Seed	Kg	30	40	60	30
2 Fertilizer					
Urea	Kg	200	100	50	200
TSP	Kg	100	200	100	75
KCL	Kg	50	50	50	50
Lime	Kg	0	0	300	0
3 Agrochemicals					
Insecticides	cc	3000	3000	2000	2000
Rodenticides	g	100	100	100	100
Fungicides	cc	1000	0	0	0
4 Labour		Total	Total	Total	Total
Nursery/Seeding	man-day	4	15	15	15
Land Prepar'tn	man-day	20	16	16	16
Transplanting	man-day	25	0	0	0
Ferti.Appli.	man-day	4	4	4	4
Ag-chemi.Appli.	man-day	4	3	3	3
Weeding	man-day	30	30	30	30
Harvesting	man-day	40	40	40	40
Hauling	man-day	2	2	2	2
Thresh/Drying	man-day	3	6	10	6
Water Control	man-day	5	4	4	4
Total		137	120	124	120
5 Animal Power	day	20	16	16	16

Remarks:
Farm inputs and labour requirement of the crops have been estimated on the basis of the present inputs and requirement studied through Farm Economy Survey, the recommendation of the Riau agricultural extension office and the similar project.

Table 3.3 Proposed Land Use and Anticipated Crop Production...............

	Present						Future in Gross Area					
	Survey Area			Gross Area			With Project			Without Project		
	Area (ha)	Yield (t/ha)	Prod'tn (t)	Area (ha)	Yield (t/ha)	Prod'tn (t)	Area (ha)	Yield (t/ha)	Prod'tn (t)	Area (ha)	Yield (t/ha)	Prod'tn (t)
Rainy Season												
Paddy	1.266			548			5,926			548		
Irrigated	10	3.1	31	0	3.1	0	5.926	5.0	29.630	0	3.5	0
Rainfed	17	0.8	14	2	0.8	2	-	-	-	2	0.9	2
Upland	1.239	0.9	1.115	546	0.9	491	-	-	-	546	1.0	546
Secondary Crop*	204	0.7	143	91	0.7	64	2,374	1.6	3.798	91	0.7	64
Sub-total	1,470			639			8,300			639		
Dry Season												
Paddy	116			34			5,926			34		
Irrigated	0		0	0		0	5.926	5.5	32.593	0	3.5	0
Rainfed	44	0.8	35	12	0.8	10	-	-	-	12	0.9	11
Upland	72	0.9	65	22	0.9	20	-	-	-	22	1.0	22
Secondary Crop*	444	0.7	311	339	0.7	237	2.374	1.6	3.798	339	0.7	237
Sub-total	560			373			8.300			373		
Total												
Paddy	1.382		1.260	582		522	11.852		62.223	582		581
Secondary Crop	648		454	430		301	4.748		7.596	430		301

*: Production of secondary crops is estimated in terms of soybean.

Table 3.4 Farm Inputs and Labour Requirement per Hectare for Major Crops -Without Project-

	Unit	Irrig. Paddy			Lowland Paddy			Upland Paddy			Soybean			Peanut
1 Seed	Kg	31			42			40			39			64
2 Fertilizer														
Urea	Kg	31			65			36			39			13
TSP	Kg	24			58			24			50			6
KCL	Kg	3			0			6			16			0
Organic matter	Kg	0			1120			129			0			79
3 Agrochemicals														
Insecticides	cc	1470			1530			757			0			609
Rodenticides	g	3.1			0			40			0			0
Herbicides	cc							33			0			0
4 Labour		Own	Hired	Total	Own	Hired	Total	Own	Hired	Total	Own	Hired	Total	Own
Nursery/Seeding	man-day	2.4	0.0	2.4	3.7	0.0	3.7	12.9	6.5	19.4	7.3	4.3	11.6	15.7
Land Prepar'tn	man-day	37.5	10.4	47.9	56.1	6.9	63.0	39.5	13.6	53.1	25.7	1.6	27.3	51.8
Transplanting	man-day	16.6	1.3	17.9	14.7	1.7	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ferti.Appli.	man-day	1.9	0.0	1.9	4.5	0.0	4.5	1.5	0.0	1.5	2.8	0.0	2.8	0.0
Ag-chemi.Appli.	man-day	4.0	0.0	4.0	3.5	0.0	3.5	1.9	0.0	1.9	3.7	0.0	3.7	3.1
Weeding	man-day	24.5	1.1	25.6	33.9	1.0	34.9	26.7	6.0	32.7	22.3	1.9	24.2	38.0
Harvesting	man-day	15.4	0.3	15.7	11.4	0.9	12.3	14.9	6.8	21.7	9.6	2.0	11.6	12.4
Hauling	man-day	1.4	0.1	1.5	1.7	0.2	1.9	1.9	0.3	2.2	1.2	0.0	1.2	0.2
Thresh/Drying	man-day	12.8	1.1	13.9	9.1	0.6	9.7	5.3	1.1	6.4	7.9	0.9	8.8	7.8
Water Control	man-day	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		116.5	14.3	130.8	138.6	11.3	149.9	104.6	34.3	138.9	80.5	10.7	91.2	129.0
5 Animal Power	day	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Farm Economy Survey 1992, JICA
and some figures were adjusted on the basis of the filled survey and interviews.

Table 3.5 Labour Balance Study

Farm size: 1.75 Ha

(Unit: person/day)

Season	Availabl Labour Force	Wet Season Paddy	Dry Season Paddy	Wet Palawija Peanut	Wet Palawija Soybean	Dry Palawija Peanut	Dry Palawija Soybean	Total	Balance
Cultivated Area (Ha)		1.25	1.25	0.25	0.25	0.25	0.25	3.5	
JAN (1)	2.80	0.86		0.25	0.25			1.36	1.44
(2)	2.80	0.86		0.19	0.19			1.24	1.56
(3)	2.80	0.84		0.19	0.19			1.22	1.58
FEB (1)	2.80	0.47		0.19	0.19			0.85	1.95
(2)	2.80	1.55		0.28	0.26			2.09	0.71
(3)	2.80	1.18		0.28	0.26			1.72	1.08
MAR (1)	2.80	1.13		0.28	0.26			1.67	1.13
(2)	2.80	1.13	0.15	0.26	0.24			1.78	1.02
(3)	2.80	1.13	0.37	0.26	0.24			2.00	0.80
APR (1)	2.80	1.10	0.64	0.26	0.24	0.09	0.09	2.42	0.38
(2)	2.80		1.37			0.16	0.16	1.69	1.11
(3)	2.80		1.37			0.16	0.16	1.69	1.11
MAY (1)	2.80		1.40			0.16	0.16	1.72	1.08
(2)	2.80		1.65			0.33	0.33	2.31	0.49
(3)	2.80		1.45			0.33	0.33	2.11	0.69
JUN (1)	2.80		1.55			0.25	0.25	2.05	0.75
(2)	2.80		0.84			0.19	0.19	1.22	1.58
(3)	2.80		0.86			0.19	0.19	1.24	1.56
JUL (1)	2.80		0.84			0.19	0.19	1.22	1.58
(2)	2.80		0.47			0.28	0.26	1.01	1.79
(3)	2.80		1.55			0.28	0.26	2.09	0.71
AUG (1)	2.80		1.18			0.28	0.26	1.72	1.08
(2)	2.80		1.13			0.26	0.24	1.63	1.17
(3)	2.80		1.13			0.26	0.24	1.63	1.17
SEP (1)	2.80		1.13			0.26	0.24	1.63	1.17
(2)	2.80		1.10					1.10	1.70
(3)	2.80							0.00	2.80
OCT (1)	2.80	0.15						0.15	2.65
(2)	2.80	0.37						0.37	2.43
(3)	2.80	0.64						0.64	2.16
NOV (1)	2.80	1.37		0.09	0.09			1.55	1.25
(2)	2.80	1.37		0.16	0.16			1.69	1.11
(3)	2.80	1.40		0.16	0.16			1.72	1.08
DEC (1)	2.80	1.65		0.16	0.16			1.97	0.83
(2)	2.80	1.45		0.33	0.33			2.11	0.69
(3)	2.80	1.55		0.33	0.33			2.21	0.59
Peak Labour Requirement		1.65	1.65	0.33	0.33	0.33	0.33	2.29	0.38

Remarks:

Family Labour Force(age of above 10): 3.2

Available Labour Force: 2.8

Ratio of Workable Days: 0.85, namely 25.5 days out of 30 days

Fig. 2.1 Present Cropping Pattern

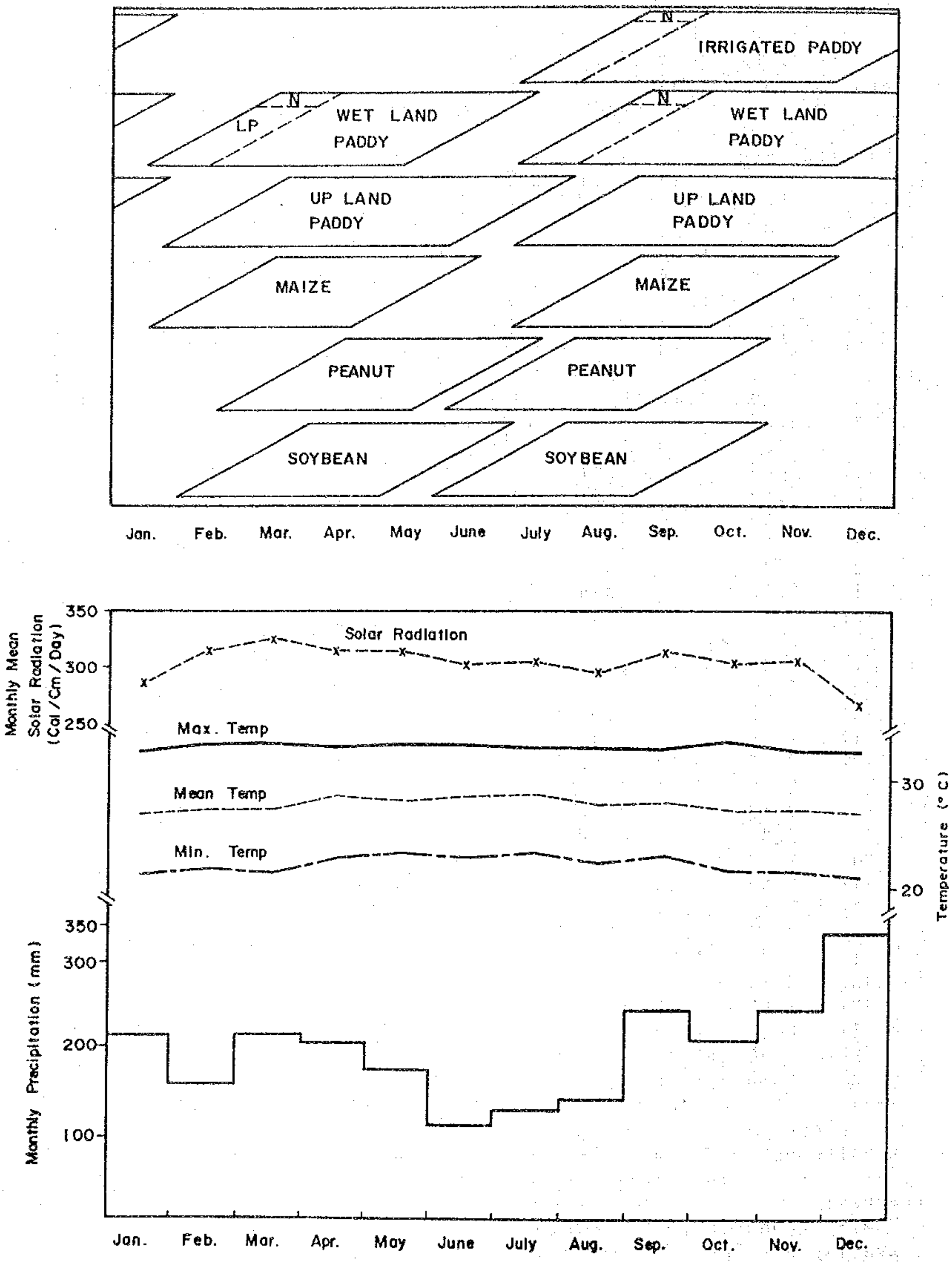
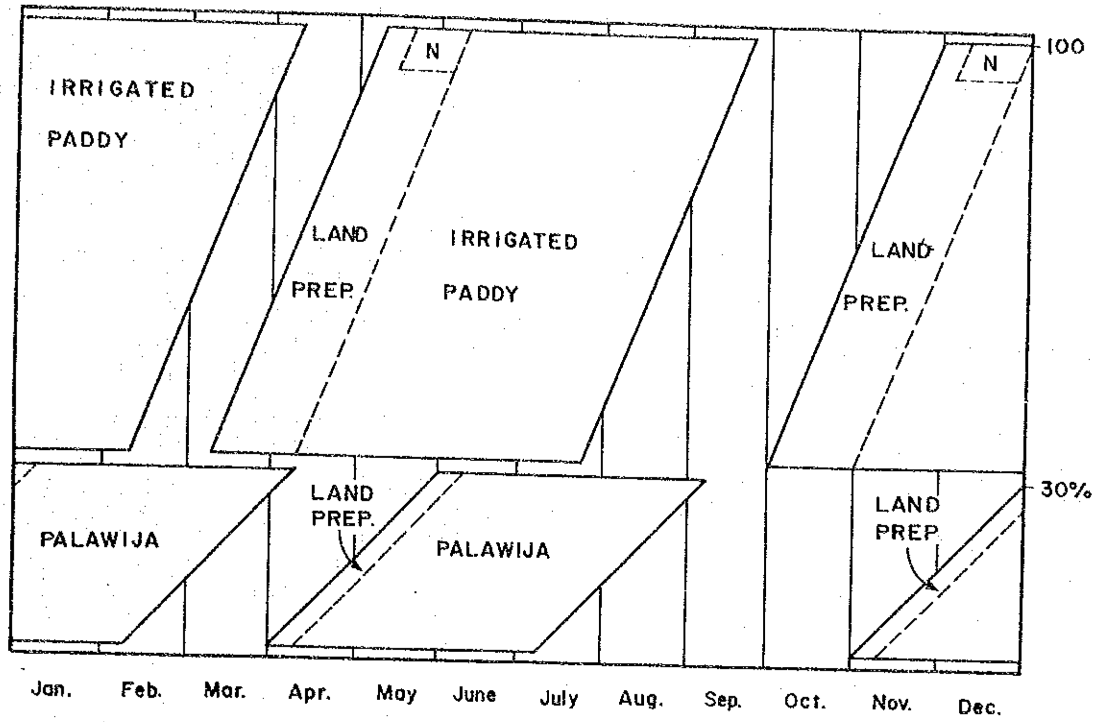
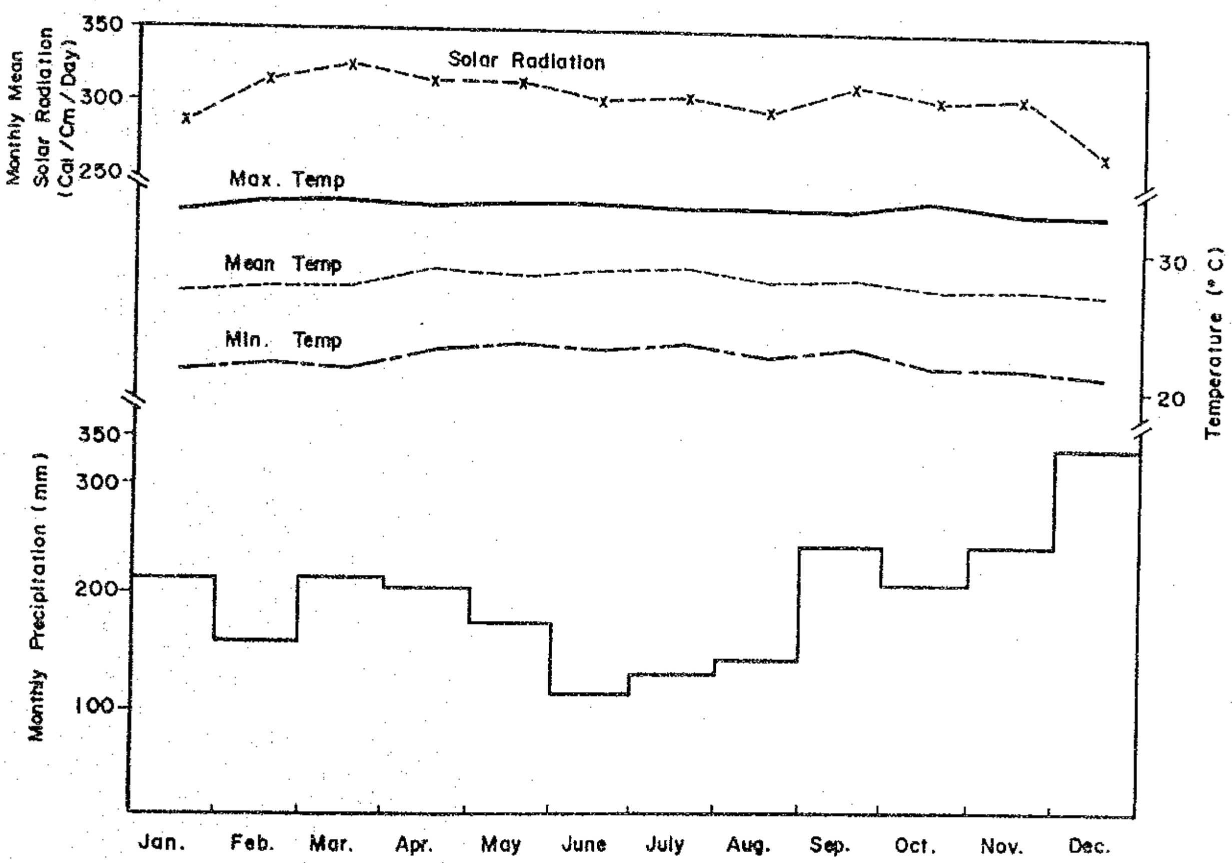


Fig. 3.1 Proposed Cropping Pattern





ANNEX E

IRRIGATION AND DRAINAGE

ANNEX E : IRRIGATION AND DRAINAGE

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CHAPTER 1 FORMULATION OF BASIC DEVELOPMENT PLAN

1.1 General

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

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

In the succeeding chapters, development plan is studied and formulated based on the following basic planning concept.

1.2 Basic Concept

The basic planning concept applied for the irrigation and drainage plan in the project are defined as follows:

1) Full use of available water resources of the Rokan Kiri river for irrigation development without provision of reservoir
2) No adverse effects on the downstream water users by implementation of the project
3) Introduction of gravity irrigation and gravity drainage systems in the project
4) Technical and economic soundness

1.3 Definition of the Area during the Phase II Survey

On the basis of the Phase II Field Work from January 12 to March 26, 1992, the Project Area for the Priority Area has been delineated which is surrounded by the administrative boundary of the Kepunuhan and Kunto Darussalam Sub-districts. The villages included are 11 villages of Kunto Darussalam Sub-district (Kota Lama, Kota Intan, Muara Dilam, Pagaran Tapah, Teluk Sono, SKP A, SKP F, SKP G, Kota Baru, Kota Raya, and Muara Jaya) and one transmigration village (SKP B) of Kepunuhan Sub-district. The extent of the Project Area is 942 km^2. Within this Project Area, the Survey Area is also delineated on the basis of the areas of the water intake facility, canal construction and topography survey.

1.4 Present Condition of Gross Area

In the gross area, an estimated 2,336 families are living of which 1,120 are transmigrants families and 1,216 are families of local people. The transmigrants are living in four settlement units : SKP-B, SKP-G, SKP-F(left bank area), and SKP-A(right bank area), while local people in four units(left bank area) : one unit in Muara Dilam, one unit settled from Teluk Sono, and two units for Kota Lama.

The present situation of land use in the area is shown in the following table:

Present Land Use in the Gross Area

Land Use	Left Bank		Right Bank		Total	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Primary Forest	2,876	35.7	2,392	57.8	5,268	43.2
Secondary Forest	2,332	28.9	762	18.4	3,094	25.4
Bush/Grass Lands	1,787	22.2	538	13.0	2,325	19.1
Alang[2] Lands	193	2.4	339	8.2	532	4.4
Paddy Fields	0	0.0	2	0.0	2	0.0
Upland Crops	552	6.8	85	2.1	637	5.2
Plantation Area	0	0.0	0	0.0	0	0.0
Residential Area	322	4.0	20	0.5	342	2.8
Total	8,062	100.0	4,138	100.0	12,200	100.0

1.5 Objective of Development

In the area, there is an increasing need to stabilize the production of crops for food in the wet season and increase that in the dry season. To meet these irrigation needs, the increase of irrigation water supply and the extension of irrigation area must be realized. Among several measures under consideration, the development of new sources of water supply is the most important measure to be adopted as future plans.

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

- The unit yields of paddy
- The annual cropping intensity of paddy
- The area of paddy fields as much as possible

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

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

1.6 Delineation of the Lower Rokan Kiri Project Area

1.6.1 Factors for Project Formulation

Delineation of the Project Area is made from broad and comprehensive viewpoints paying attention to the related factors such as water sources available for irrigation, agricultural conditions, land use, soil and land suitability, influence of flood, and drainage conditions, as well as socio-economic conditions,etc.

In addition to the above factors, the most decisive factors for the project formulation works are considered to be the following:

- i) To stabilize livelihood of the transmigrants who have already settled and local people in the area by supplying irrigation water as well as by draining excess water.
- ii) To support the Government's settlement program by providing irrigation facilities and drainage facilities for transmigrants and local farmers to be settled.

The objective area is located in the first priority area selected in the Overall Irrigation Development Plan Study, and as mentioned in Chapter 1.1, the Project Area is defined as 942 km^2.

Most of the Project Area is covered by the detailed aerophoto maps at scale 1:5,000, and by the topographical maps at scale 1:2,000.

1.6.2 Factors for Delineation of Gross Area to be Developed

In the delineation of the area, the following factors are taken into considerations :

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

Based on the results of surveys in the field, and studies and analyses concerning the various fields, the estimates of the gross area of the Project are made based on the following conditions:

(1) Location of water source

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

- To select approximate locations of water source facilities presupposing elevation and location of the highest part of potential irrigation areas, and
- To regard a confluence of rivers as an important location where economical runoff can be collected.

Based on this concept, locations of water sources for the project were surveyed, paying attention to the following items:

a) Sufficient water available to irrigate land
b) Flow condition at intake site to be proposed(river and riverbanks stability)
c) Easiness of water conveyance
d) Easiness of construction
e) Extent of inundation after completion of intake facility

(2) Intake water level

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

Based on the above considerations, the intake water level was estimated to be about EL.46 m to EL.47 by calculating the following items:

a) Headlosses in the tertiary system
b) Canal length and slope in the main system
c) Headlosses for structures in the main system
d) Headlosses in the headworks

As for the inundation area, rise of water level will be accommodated in the present river reservation cross section in the case when about EL.46 m of the intake water level is employed.

(3) Canal alignment

The following considerations are made for canal alignment in the project:

- To choose straight and shorter canal routes linking water source facility sites to potential irrigation areas.

- To balance cut and fill portions of canal section, and
- To select higher canal routes in consideration of locations of canal structures.

Taking the above considerations into account, the following items were checked by the use of the aerophoto maps with 1:5,000 scale and topographical map with scale 1:2,000:

- To make preliminary alignment on the above maps
- To check the ground levels in the alignment
- To employ the main canal routes as high as possible
- To decide the diversion structure sites with the required water level for the secondary canals and tertiary canals
- To estimate the size of the area commanded at diversion structures

(4) Drainage

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

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

The cross sections of drainage rivers should be wide and the drainage canals should be connected to the drainage rivers. To facilitate the drainage canals in the transmigration settlement areas, the cross sections should be wide and the drainage canals are aligned in straight as long as possible.

(5) Irrigable area

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

Landslopes of the irrigable area with an average fall of less than 5% is adopted considering paddy cultivation.

The land to be developed slopes gently in north direction with an average fall of less 5%, with no major discontinuities of slope.

The land with more than 5% is out of gross area in the project.

(6) Water source

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

The maximum command area by the use of the Rokan Kiri river to meet the irrigation demand of the proposed cropping patterns including paddy and palawija is estimated at 40,000 ha through water balance study. A detailed description of the water balance study is given in Section 3.2.9.

1.6.3 Delineation of the Project Area

The project area is delineated on the detailed aerophoto map at scale 1:5,000 and topographical map at scale 1:2,000 by reference of physical boundaries such as roads and rivers. As a result, the delineated project area is 12,200 ha in gross. That is, the gross area of the Project is 12,200 ha.

The net irrigable area in the area is estimated following the next steps. However, what mentions specially is that the plan is made taking the transmigrants to be settled into account.

(1) Land allocated to a family unit

In accordance with transmigration policy, each family was allocated 2.0 ha of land of which 1.75 ha was intended a s farmland, and 0.25 ha was as a houseplot/garden. In addition, 0.25 ha was allocated per family for public facilities. The items of allocated land is as follows:

- 1.75 ha for farmland
- 0.25 ha for a houseplot/garden
- 0.25 ha for public facilities

Total= 2.25 ha

(2) Number of households in the area

The number of households in the area is estimated including the transmigrants to be settled as follows:

a)	Transmigrants :	1,120	households
b)	Local farmers :	1,216	"
c)	Transmigrants to be settled :	2,254	"
	Total	4,590	households

(3) Land for right-of-way to be allocated by each family

In order to estimate the ratio of the net irrigable area to the gross irrigable area, the farmland(1.75 ha), and the land allocated to a family unit(2.0 ha) plus the land for public facilities and right-of-way to be allocated by each family are used.

The land for right-of-way to be offered by each family is calculated by dividing the land of right-of-way for the main system and drainage system by the total number of households in the area.

On the other hand, the land of right-of-way for the main system and drainage system in the area is estimated at about 500 ha by using the canal sections and canal lengths of the above systems.

Namely, the land for right-of-way to be offered by each family is calculated as follows:

500/4,590=0.11 ha

Therefore, a holding area of a family unit which is used for estimation of the ratio of the net irrigable area is 2.36 ha as follows:

- 1.75 ha for farmland
- 0.25 ha for a houseplot/garden
- 0.25 ha for public facilities
- 0.11 ha for right-of-way

Total=2.36 ha

Ratio of the land to be allocated to a family unit to the farmland(1.75 ha) is calculated as follows:

$$1.75/2.36=0.741$$

While, a holding area per family for local farmers existing out of the gross area is 1.86 ha as follows:

- 1.75 ha for farmland
- 0.11 ha for right-of-way

Total=1.86 ha

(4) Gross irrigable area

The total gross area is calculated as follows:

Gross area for:

a)	Transmigrants :	1,120×2.36=2,643	ha
b)	Local farmers : (Muara Dilam & Teluk Sono)	750×2.36=1,771	ha
c)	Local farmers : (Kota Lama-1 & 2)	466×1.86= 867	ha
d)	Transmigrants : to be settled	2,254×2.36=5,320	ha
e)	Substitute(for Kota Intan)	300	ha
f)	Other land(unsuitable land: river, depression,etc.)	1,299	ha
	Total	12,200	ha

(5) Net irrigable area

The net irrigable area is calculated as follows:

Net irrigable area for:

a)	Transmigrants :	1,120×1.75 =1,959	ha
b)	Local farmers :	(750+466)×1.75=2,126	ha
c)	Transmigrants : to be settled	2,254×1.75 =3,945	ha
	Total	8,300	ha

CHAPTER 2 STUDY ON DEVELOPMENT PLAN

2.1 General

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

Comparison of suitable sources of water supply is made from technical and economical points of view following the procedures of plan formulation as mentioned below.

2.2 Principles for Water Supply Plan Formulation

In formulating water supply plans, the following principles are defined as guidelines:

1) Adequacy and reliability of water supply
2) Technical and economic soundness
3) Lowest practicable cost of water and services
4) Efficient operation and management

Basically, planning a water supply system involves determination of water requirements and finding suitable sources of water supply. In the above items, water availability has already been studied and assessed in the fields of hydrology and irrigation.

2.2.1 Water Availability and Scheme Sizing

As described in Chapter 3, the maximum development potential area of the available river run-off of the Rokan Kiri river is assessed using the following estimated discharges.

In order to assess the maximum development potential area of the available river run-off of the Rokan Kiri river, the water balance study is made. The water balance assessment is made on the following 10-day basis of the river discharge occurring once in five years non-exceedance and irrigation water requirements in accordance with the proposed cropping patterns of double cropping of paddy and palawija a year.

The peak diversion water requirement in the 2nd crop is estimated at 1.58 l/sec/ha and the total irrigable area is estimated at about 40,000 ha from the river discharge. Therefore, the subsequent study is made based this discharges.

River Discharge Estimated

(Unit : m³/s)

Month	Monthly Ave. Discharge	1/5 Probable Ave. Discharge	Planning 10 day Min. Discharge
Jan.	191.7	117.9	106.7
Feb.	157.1	92.9	85.2
Mar.	166.6	103.3	97.0
Apr.	188.7	113.7	107.4
May	159.1	107.2	86.0
Jun	98.4	69.3	60.9
Jul.	72.6	56.6	54.4
Aug.	73.6	49.8	49.3
Sep.	107.3	62.7	57.3
Oct.	125.0	77.2	67.4
Nov.	192.9	104.5	90.9
Dec.	227.5	147.9	128.4

2.2.2 Irrigable Area

To decided approximate location of water source facility, and the location of potential irrigation area, several trials are made presupposing elevations of both locations of water source and irrigation area.

As a result, the size of irrigable area is decided on crest elevation level basis as follows:

Size of Irrigable Area by Crest Elevation

	Crest elevation	Left bank	Right bank
1)	47.0 m	16,060 ha	9,610 ha
2)	46.0 m	15,590 ha	9,610 ha

2.2.3 Water Supply Case Study

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

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

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

The location of the above water source facilities is shown in Fig. LOCATION OF INTAKES FOR ALTERNATIVE PLANNING.

2.3 Alternative Study on Water Sources

2.3.1 Free Intake without Diversion Weir (Case-1)

(1) Basic requirements for selection of free intake site

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

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

Therefore, the outside of a meander bend in the river is the most preferable from the viewpoint of preventing inflow of sand. It is important to make sure that the water level would not be lower than design intake level in the future.

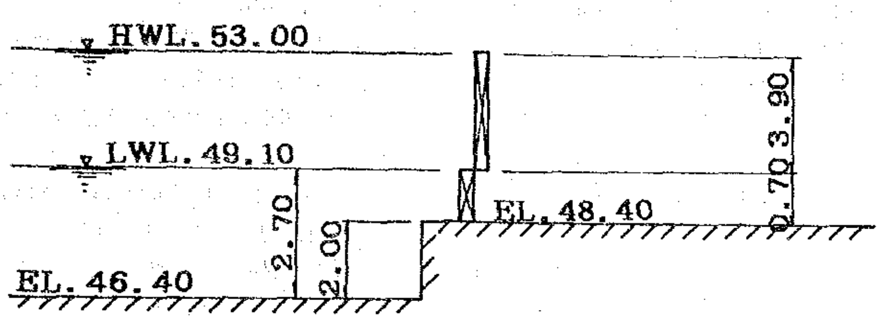
(2) Location of free intake

Considering the above mentioned and ensuring the required water level at the first diversion, the location of free intake site is selected about 8 km upstream from Sukadamai.

(3) Considerations for design of free intake

The sill elevation of the free intake is decided based on the minimum drought discharge in the past. The desirable sill elevation of the intake is to be set more than 0.6 of water depth above the present riverbed.

Generally, the water level of the river during wet season is considerably higher than the water level of dry season. Therefore, the type of double slide gate is introduced in order to prevent intrusion of sand. Irrigation water flowing over the lower gate is usually derived.



(4) Basic statistics of facility

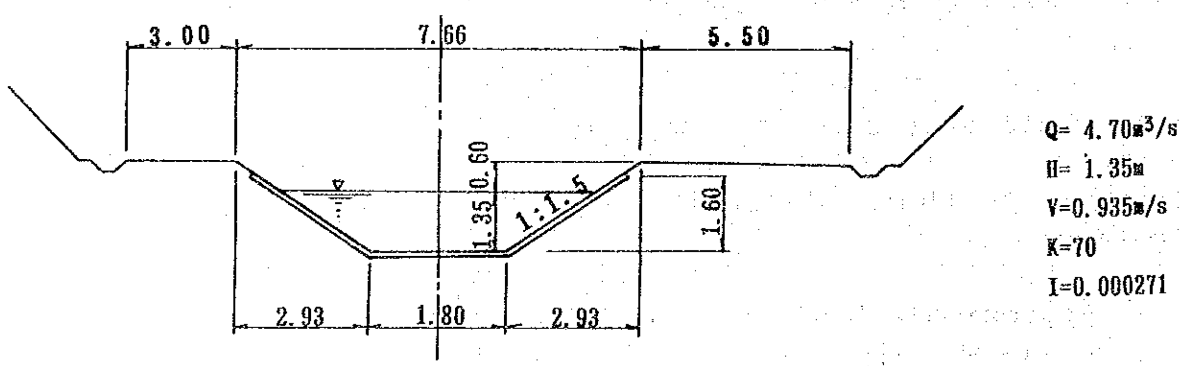
Approximate basic statistics of the free intake are shown as follows:

Approximate Basic Statistics of Free Intake

1)	River width	:	77.0 m
2)	River bed elevation	:	EL.46.4 m
3)	Draughty water level	:	WL.49.10m
4)	Ordinary water level	:	WL.50.45m

5)	Flood water level	:	WL.53.00m
6)	River bed slope	:	1/2,100
7)	Water depth	:	2.70m (49.10 -46.40=2.70)
8)	Design flood discharge (one hundred year probability of flood discharge)	:	2,180 m³/sec
9)	Sill elevation of intake	:	48.4 m (46.40+0.6x2.70=48.4)
10)	Design intake water level	:	49.1 m (low water level)
11)	Catchment area	:	3,240 km2
12)	Headreach canal	:	24.0 km
13)	Required water level at first diversion	:	WL.41.60m
14)	Difference of canal bed elevation	:	6.86m (24,000 x 1/3,500=6.86)
15)	Loss head of intake	:	0.40m
16)	Required intake water level	:	41.60+6.86+0.40=WL.48.86m < WL.49.10m (drought water level) .....OK.

The cross section of headreach canal and its properties are shown as follows:



2.3.2 Headworks (Case-2)

(1) Basic requirements for selection of headworks site

The location of headworks is selected paying attention to the following items:

a) Sufficient water available to irrigate land
b) Flow condition at weir site to be proposed(river and riverbanks stability)
c) Easiness of water conveyance
d) Easiness of weir construction
e) Extent of inundation after completion of weir

(2) Location of headworks

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

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

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

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

At the weir site, it is preferable that higher parts of both riverbanks are approaching to the river, because they can be used for dikes. From the view point of accessibility to the weir site during construction, they can be used for approaching roads. Based on the above reasons, the Site 1.,and Site 2. were proposed for the weir location.

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

a) The riverbed slope is about 1/2,100 upstream from Site 1. Therefore, much rise of water level can not be expected if the weir location is shifted 1 km upstream from Site 1. to Site 2. Namely, moving the weir location upstream will result in only about 50 cm higher than required intake water level assuming the same weir height.

b) According to the field survey, the river channel just upstream from Site 2. has shifted right bank side recently. The river condition at the Site 2 is unstable.

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

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

(A) Movable Weir equipped with Steel Gates (Case-2.1)

(1) Considerations for design of movable weir

The movable weir should be so designed that the required water level be kept at the abstraction of irrigation water and flood discharge be released safely at the time of flood.

The elevation of the crest is decided paying the attention to the above and the rise of water level after completion of the weir as follows:

1)	Length of the head reach	:	13.0 km
2)	Water level at the first diversion	:	WL.41.60 m
3)	Head loss of the head reach	:	3.71m (13,000 × 1/3,500)
4)	Head loss at the intake	:	0.40 m
5)	Allowance at the crest	:	0.10 m
6)	Elevation of the crest	:	46.00 m 41.60+3.71+0.40+0.10 =EL.45.81 → EL.46.00

(2) Basic statistics of facility

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

Approximate basic statistics of the movable weir are shown as follows:

Approximate Basic Statistics of Movable Weir

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

(B) Rubber Dam (Case-2.2)

(1) Considerations for design of rubber dam

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

1)	Type of rubber dam	:	Air inflated type
2)	Height	:	4.30 m
3)	Crest elevation	:	EL.46.00 m
4)	Span & number of dam bodies	:	19.70 m × 4 spans

(2) Basic statistic of facility

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

Comparison of rubber dam and steel gate is shown in Table 2.1. The layout of rubber dam is shown in Fig.2.2 LAYOUT OF RUBBER DAM.

2.3.3 Pumping Station (Case-3)

(1) Basic requirements for selection of pumping station

The location is selected after the consideration of the following items:

- The location where the pipe line is the shortest
- The location where the pump station can be installed in higher place to avoid the influence of the flood.
- The location where is near from the existing road.
- The location where it is easy for the canal system to be connected to the pipe line of the pump station.

(2) Location of pumping station

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

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

Due consideration of the above, the pump station is planned to be installed at the left bank of the Rokan Kiri river at Kotalama.

(3) Considerations for design of pumping station

To prevent silt from being sucked in pump,a silt basin should be installed in front of a suction tank. The motor should be installed where it is not submerged during flood.

The pumping station is planned based on the following design properties:

1) Design suction water level : WL.33.00m

2)	Design release water level (water level at 1st diversion)	:	WL.42.00m
3)	Length of pipe line from pumping station to diversion	:	1.1 km

Design of pipe line

Q=9.35 m3/sec
D=2,600 mm
V=Q/A=1.76 m/sec

where	Q	:	Design discharge (m3/sec) 9.35m3/sec
	D	:	Diameter of pipe 2,600 mm
	A	:	Cross section area of pipe 5.31m2
	V	:	Velocity (m/sec)

In the case of pressure delivery of water by pump, the recommended design velocity for pipe is as follows:

D (mm)=1,600-3,000 V(m/sec)=1.4-2.5

(4) Basic statistics of facility

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

Approximate Basic Statistics of Pumping Station

1)	Design discharge	:	9.35 m^3/sec (561 m^3/min)
2)	Kind of pump	:	Vertical mixed flow pump
3)	Pipe loss around pump	:	1.60m
4)	Friction loss of pipe line	:	1.40m
5)	Total pump head	:	12 m (42.00-33.00+1.60 +1.40=12.00m)
6)	Diameter & no. of pumps	:	ϕ1,200 mm × 3 nos
7)	Power supply	:	Diesel engine
8)	Horse power of engine	:	830 ps × 3 nos
9)	Pipe line	:	ϕ2,600 mm, l=1.1 km

The layout of pumping station is shown in Fig.2.3 LAYOUT OF PUMP

STATION.

2.4 Economic Comparison

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

Comparison of Construction Cost

Unit : Rp. x 10^6

Item	Case-1	Case-2		Case-3
		Case-2.1	Case-2.2	
	Free Intake	Movable Weir	Rubber Dam	Pumping Station
Weir & Intake	5,057	19,351	21,202	-
Head reach	15,388	8,316	8,316	-
Pump	-	-	-	15,303
Pump Station & Civil works	-	-	-	895
Pipe line	-	-	-	13,047
Total	20,448	27,667	29,518	29,245

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

The fuel cost for pumping station is calculated as shown in the Table 2.2 Basic Data on Fuel Cost for Pumping Station.

2.5 Conclusion

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

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

Intake dischage is calculated as follws:
$Q=8.40 \times 0.70 \times 0.8=4.70\ m^3/sec$
8.40m=Intake width
0.70m=Water depth
0.80m/sec=Velocity
Thus, irrigable area=4.70 x 1000/1.58
=2,970 ha
Cost per ha=Rp.20,448 mill/2,970
=Rp.6.9 mill/ha

2) Case-2.1 : As mentioned in the above table, this case is the most economical. In addition, the following points are distinguished:
It is possible to take a stable amount of water by means of gate control.
Much attention must be paid on operating gates at the time of flood to avoid the extension of the inundation area.
Cost per ha=Rp.27,667 mill/5,930
=Rp.4.7 mill

3) Case-2.2 : The characteristics of this case are almost the same as the Case-2.1. However, this case is less economical than the Case-2.1.
In this case, it is difficult to get spare parts of the rubber dam in Indonesia, when it gets out of order.
Cost per ha=Rp.29,518 mill/5,930
=Rp.5.0 mill

4) Case-3 : This case is the most uneconomical as shown in the above table.
The running cost for the diesel engines of pumps is also expensive compared with the other cases. The following cost has not included fuel cost yet.
Cost per ha=Rp.29,245 mill/5,930
=Rp.4.9 mill

As a result of the above study, the Case-2.1 is most economical.

CHAPTER 3 IRRIGATION WATER REQUIREMENTS

3.1 General

In order to assess the maximum development potential area of the available river run-off of the Rokan Kiri river, the water balance study is made. The water balance assessment is made on the 10-day basis of the river discharge occurring once in five years non-exceedance and irrigation water requirements in accordance with the following cropping patterns of double cropping of paddy and palawija a year.

3.1.1 Ten Day River Discharge at the Proposed Weir Site

Ten day flows occurring once in five years at the proposed weir site is used for the study (See Table 3.1 Ten Day River Discharge).

3.1.2 Cropping Pattern

The following cases are studied by staggering 10 days of the start of land preparation to find out the optimum cropping pattern. The starting dates of land preparation are selected based on the prevailing cropping practices in and around the area.

Start of Land Preparation by Case

Case	Paddy		Palawija	
	1st Crop	2nd Crop	1st Crop	2nd Crop
(1) Case 1	Feb.11	Sep. 1	Mar. 1	Sep.21
(2) Case 2	Feb.21	Sep.11	Mar.11	Oct. 1
(3) Case 3	Mar. 1	Sep.21	Mar.21	Oct.11
(4) Case 4	Mar.11	Oct. 1	Apr. 1	Oct.21
(5) Case 5	Mar.21	Oct.11	Apr.11	Nov. 1

3.2 Irrigation Water Requirements

Irrigation water requirements are estimated using the meteorological data and rainfall data at Pasirpangarayan where has long observed data comparing other observatories around the project.

3.2.1 Evapotranspiration

Ten day crop evapotranspiration is obtained using Modified Penman Method.

The detailed calculation procedures are shown in Table 3.2 Calculation of Reference Crop Evaporation (Eto) by Modified Penman Method. The calculation is made based on the latitude(1^0 N) and the elevation (35 m) of the project site.

The explanation of the items in the table is as follows:

1)	Tmean	:	Mean temperature (^{0}C)
2)	Rel.Hum(mean)	:	Mean relative humidity(%)
3)	ea	:	Mean saturation water vapor pressure(mb)
4)	U2	:	Total wind run at 2m height(km/day)
5)	W	:	Weighing factor
6)	n/N	:	Sunshine ratio(%)
7)	N	:	Bright sunshine hours(hours)
8)	Ra	:	Extra-terrestrial radiation (mm/day)
9)	f(t)	:	Correction for temperature on longwave radiation
10)	ed	:	Mean actual water vapor pressure(mb)
11)	ea-ed	:	Vapor pressure(mb)
12)	f(u)	:	Wind related function
13)	n	:	Sunshine(hours)
14)	Rns	:	Net shortwave radiation(mm/day)
15)	f(ed)	:	Correction for vapor pressure on long wave radiation
16)	f(n/N)	:	Correction for ratio actual and maximum bright sunshine hours
17)	Rnl	:	Net longwave radiation(mm/day)
18)	Rn	:	Net radiation(mm/day)
19)	Eto*	:	Reference crop evapotranspiration

unadjusted for day and night-time weather conditions(mm/day)

No adjustment of Eto* is made based on the general climatic conditions such as day and night time wind and humidity condition in the project.(Sources : Figure 4, the Guideline for predicting Crop Water Requirements prepared by FAO).

3.2.2 Effective Rainfall

In order to calculate water requirements for irrigation plan, effective rainfall is estimated.

The rainfall data at Pasirpangarayan are used for the estimate because the location is close to the benefitted area and observation period is enough long to use(from 1970 to 1991, 21 years in total).

Probability analysis is carried out to decide the base year of one of five year non-exceedance rainfall,which is made by Iwai's Method. As a result, 1/5 year non-exceedance annual rainfall is 2,132mm, which is correspond to the rainfall in 1982. Accordingly, the year 1982 is decided as the base year.

Effective daily rainfall is calculated by multiplying 70% by daily rainfall of 1982(See Table 3.3 Effective Rainfall at Pasirpangarayan).

As for effective rainfall which is used for the calculation of field water requirements for upland crops, it is calculated with the USDA Soil Conservation Service method as shown in DESIGN STANDARD. In the calculation, effective storage and storage factor are assumed to be 75mm and 1.00 respectively. The effective rainfall calculated is shown in Table 3.4 Effective Rainfall for Palawija.

3.2.3 Percolation

According to the soil analysis of the project, soil in the project has a close resemblance to soil in the Batang Kumu Project from the view point of soil texture. Moreover, the project is covered with Cambisol which is extending widely over the area, and white sandy soil. Considering the above fact, the percolation rate is assumed to be 3mm/day.

As for percolation in the calculation of water requirements for palawija, the percolation is accounted for in the irrigation efficiency(DESIGN STANDARD).

3.2.4 Land Preparation Water Requirements

(1) Land preparation period: 60 days
(2) Water requirements for land preparation: 350mm

Water requirements for land preparation of rice fields are taken at 300mm, including (1) presaturation of the soil, (2) puddling of the soil, and (3) water requirements for nurseries. The above 300mm figure assumes light texture soil.

At the start of transplanting, another 50mm water layer is added. In total, this leads to 350mm for land preparation and an initial water layer after planting.

(3) Water requirements for land preparation

For the calculation of the irrigation requirements during land preparation, Van de Goor and Zijlstra's formula is used:

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

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 ET_0 during land preparation (mm/day)

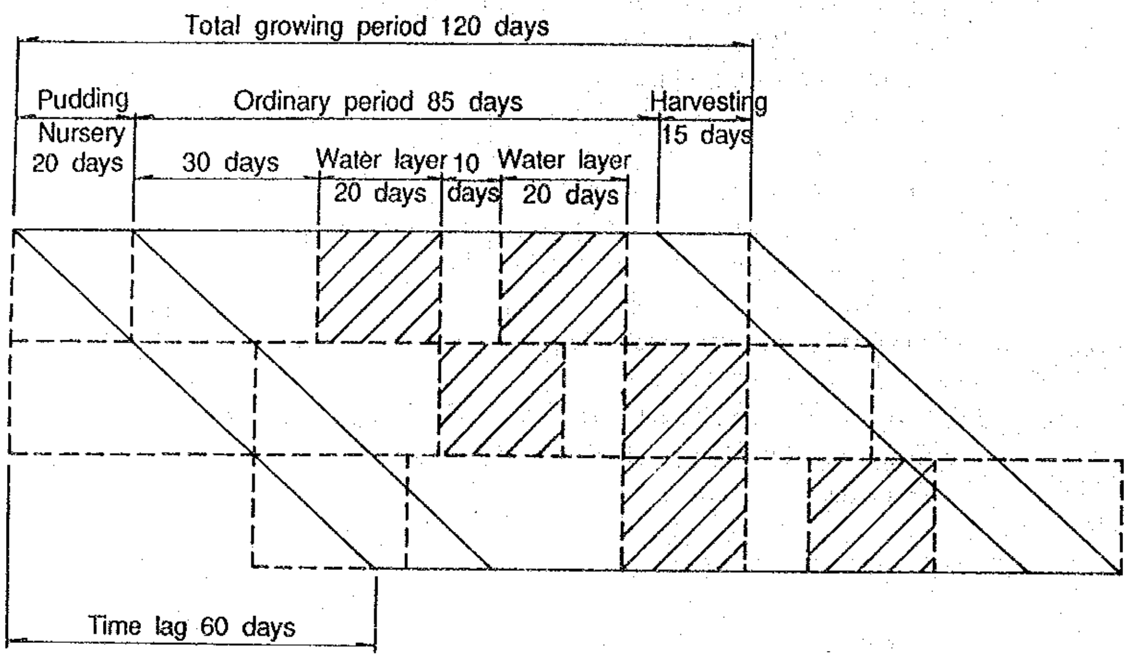
k : MT/S
T: land preparation period (days)
S: presaturation requirements

3.2.5 Water Layer Replacement

Because of no data available, 2 replacements, each of 50mm at about 1 month and 2 months after transplanting are considered according to IRRIGATION DESIGN STANDARDS published by Directorate General of Water Resources Development, Ministry of Public Works(hereinafter called DESIGN STANDARDS).

A schematic cropping pattern with the layer replacement is shown as below:

SCHEMATIC CROPPING PATTERN



Remarks:

1. Rectangular shapes show actual farming period at each unit.
2. Inclined line is representative farming period for the whole area.
3. Commencement period of puddling is staggered in 60 days, and paddy cultivation is performed in 3 groups.

3.2.6 Consumptive Use

The consumptive use is calculated as

$$Etc=kc \times Eto$$

Where:

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

(1) Evapotranspiration

For evaporation computation, the modified Penman formula was used taking into account the meteorological data in Pasirpagarayan.

(2) Crop coefficients

The crop coefficients for rice and upland crop given by FAO are used for the calculation (Sources: Table A.2.2, DESIGN STANDARDS).

Crop Coefficient for Paddy and Soybeans

		Crop Coefficient (Paddy)	Crop Coefficient (Soybeans)
Growth Period		95 days	90 days
Month	10 days		
1st	1	1.1	0.5
	2	1.1	0.75
	3	1.1	0.75
2nd	1	1.05	1.0
	2	1.05	1.0
	3	1.05	1.0
3rd	1	0.95	0.82
	2	0.95	0.82
	3	0.0	0.45
4th	1	0.0	

In the area, the high varieties of Sentani and PB42 are prevailing. Therefore, the crop coefficient for the high variety(HYV) was employed.

3.2.7 Irrigation Diversion Requirements

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 reclamation areas. No data on irrigation efficiency in and around the area are available yet.

For this project, the following irrigation efficiencies are adopted:

Headreach, main and secondary canals	:	80%
Tertiary system	:	70%

An irrigation efficiency of 55% for paddy has been assumed with reference to the above figures, while irrigation efficiency of 50% for upland crops is adopted according to DESIGN STANDARD.

The results of water requirements calculation are summarized in the following tables:

Table 3.6	Calculation of Diversion Requirements for Paddy (3 Blocks) (Case 1 to Case 5)
Table 3.7	Calculation of Diversion Requirements for Palawija (3 Blocks) (Case 4 Start of 1st : Apr. 1, and 2nd Crop : Oct.21)
Table 3.8	Comparison of Diversion Requirements
Table 3.9	Unit Water Requirements on Block Basis (Case 4) (Paddy + Palawija)
Table 3.10	Unit Water Requirements for Palawija on Block Basis (Case 1 to Case 5)

The items used in the tables are explained as follows:

1)	Eto	:	Reference crop evaportanspiration (mm/day)
2)	P	:	Percolation (mm/day)
3)	Re	:	Effective rainfall (mm/day)
4)	AWLR	:	Average water layer replacement (mm/day)

5) ACC : Average crop coefficient
6) LPA : Land preparation area
7) CA : Crop area
8) LPWR : Water requirements for land preparation (mm/day)
9) Etc : Consumptive use (mm/day)
10) NLPR : Net land preparation requirements (mm/day)
11) NFR1, 2 : Net field water requirements (mm/day)
12) Div. Req. : Diversion requirements (l/sec/ha)

3.2.8 Facility Capacity

To decide the facility capacity, the case 4 in the following table which shows the minimum in both diversion requirement for headreach and diversion requirement for main system is adopted. The detailed calculation is shown in the above Table 3.8, Table 3.9, and Table 3. 10.

Maximum Diversion Requirements

	Div. req. for headreach (l/sec/ha)	Div. req. for main system (l/sec/ha)	Start of cropping practice (paddy)	(palawija)
(1) Case 1	1.65	2.46	1)Feb.11 2)Sep. 1	1)Mar. 1 2)Sep.21
(2) Case 2	1.60	2.25	1)Feb.21 2)Sep.11	1)Mar.11 2)Oct. 1
(3) Case 3	1.60	2.17	1)Mar. 1 2)Sep.21	1)Mar.21 2)Oct.11
(4) Case 4	1.58	2.17	1)Mar.11 2)Oct. 1	1)Apr. 1 2)Oct.21
(5) Case 5	1.66	2.17	1)Mar.21 2)Oct.11	1)Apr.11 2)Nov. 1

3.2.9 Result of Study

As a result of the study, the maximum potential development area by the use of the Rokan Kiri river water source is estimated at about 40,000 ha in net in the case 4. Table 3.11 Estimation of Potential Irrigable Area shows the potential area of each case.

CHAPTER 4 Irrigation and Drainage Plan

4.1 General

Facility plan for irrigation and drainage is formulated based on the topographical maps with scale 1:5,000, and 1:2,000. As mentioned in CHAPTER 2, water source facility has been decided from technical and economical points of view. Therefore, the principal irrigation and drainage facilities are studied in this chapter as follows.

1) Movable Weir
2) Irrigation canal and related structures
3) Drainage canal

4.2 Movable Weir

Design and hydraulic calculation for movable weir is made as follows:

(1) Basic statistics of movable weir

Basic statistics of the movable weir are shown as follows:

1)	River bed elevation	:	EL 41.70m
2)	Crest elevation	:	EL 46.00m
3)	Weir height	:	4.30m
4)	Weir length	:	118.00m
5)	Intake water level	:	NWL.45.90m
6)	Flood water level	:	HWL.48.70m
7)	Flood discharge	:	2,200 m^3/sec (1 in 100 year probability)
8)	Elevation of river bank	:	EL 50.20m
9)	Freeboard	:	1.50m(1/100 y. probability)
10)	Type of weir	:	Movable type
11)	Flood sluice	:	Roller gate (24 m × 4 gates)
12)	Scouring sluice	:	Roller gate (5 m × 2 gates)
13)	Intake	:	Sluice gate (2 m × 3.4 m × 2 gates)
14)	Design intake discharge	:	9.35 m^3/sec
15)	Fishway	:	Step type, width 2.00m length

16) Catchment area : 3,267 km^2

(2) Length of crest

According to Irrigation Design Standards (Headworks) published by Directorate General of Water Resources Development, Ministry of Public Works(hereinafter called DESIGN STANDARDS), the maximum length of the weir between its abutments should not exceed 1.2 times the average river width. Thus, the weir length is decided as follows:

B'=1.2 × 100m=120m (Average river width=100m)
B =24.0m × 4+5.0m × 2+2.5m × 4+2.0m=118.0m < B'
Width of Flood Sluice=24.0m × 4 gates
Width of Scouring Sluice=5.0m × 2 gates
Width of Pier=2.5m × 4 piers + 2.0m × 1 pier

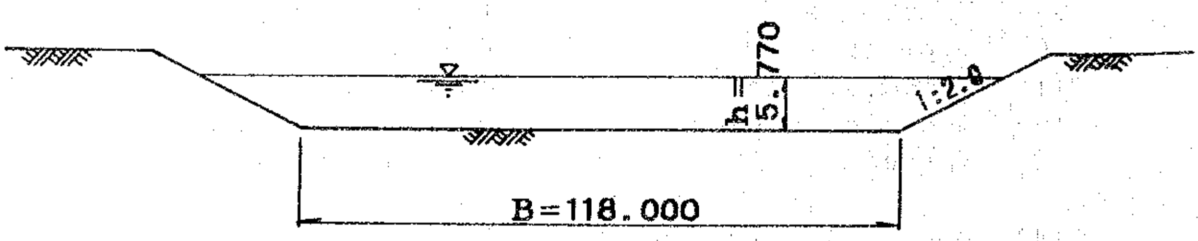
Therefore, B=118.0m is adopted.

(3) Hydraulic calculation at the time of flood

Calculation for water depth during flood is made at the cross section of canal in the coupure.

1)	Discharge	Q=2,200 m^3/sec
2)	Longitudinal slope of canal	I=1/2,100
3)	Side slope of canal	Z=1 : 2.0
4)	Canal width	B=118.0 m
5)	Coefficient of Roughness	n=1/45=0.022

Cross Section of Coupure Section



$A=Bh + Z^{h}2$ $\quad\quad$ $P=B+2h(1+Z^2)^{1/2}$

$R=A/P$

$Q=A \times V$ (m^3/sec) $\quad\quad$ $V=1/n \cdot R^{2/3} \cdot I^{1/2}$

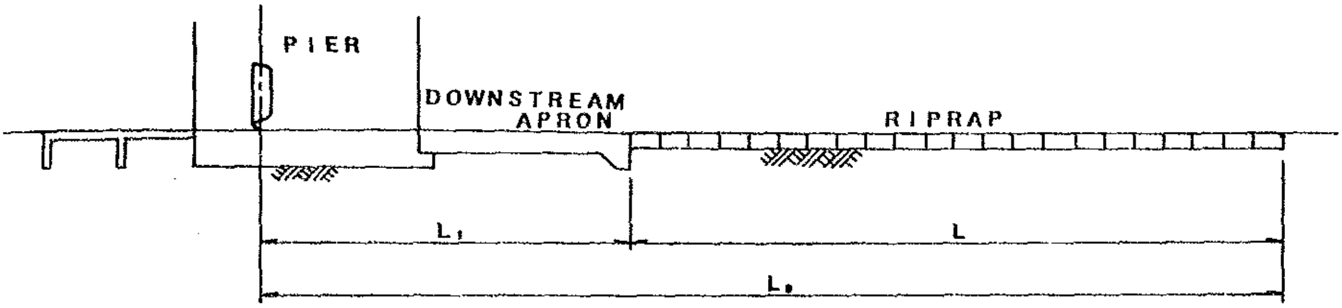
$=0.9820$

Calculation of water depth is shown in Table 4.1.

(4) Flood sluice

(a) Study of apron

An upstream concrete apron is found for headworks on pervious sand or gravel foundations.



The length of downstream apron is calculated by the following formula:

$L_1 = 0.9c(D_1)^{1/2}$

where L_1: length of downstream apron (m)

c : Bligh's coefficient (coarse sand 12)

D_1: height from apron surface of downstream end to gate crest(m) (46.00-41.6=4.40m)

$L_1 = 0.9 \times 12 \times (4.40)^{1/2} = 22.65 \rightarrow 25.0$m

The length of riprap is calculated as follows:

$L_B = 0.67c(Ha \cdot q)^{1/2} \cdot f$

where L_B: total length of protection including length of apron L_1 and length of riprap L (m)

c : Bligh's coefficient (coarse sand 12)

H_a: height from draughty water level of

downstream side to gate crest (m)
(46.00-42.56=3.44m)

q : unit quantity of design flood discharge (m3/sec/m) (2,200 m3/s/118m=18.64 m3/sec/s)

f : safety factor (movable weir 1.5)

$L_B=0.67 \times 12 \times (3.44 \times 18.64)^{1/2} \times 1.5=96.57 \rightarrow 100.0m$
$L=L_B-L_1=100.0-25.0=75.0m$

(b) Study of creep length

The creep length is examined by the Bligh's method and Lane's method as follows:

Bligh's method

$L \geq c \cdot \Delta h$

where L: length of creep length measured along the foundation of the weir (m)
c: Bligh's coefficient (coarse sand 12)
Δh: maximum head difference at upstream and downstream sides (m) (46.00-41,60=4.40m)

$c \cdot \Delta h=12 \times 4.40=52.8m$
$L=2.5+15.0+13.5+1.0+1.41+2.5=35.91m < 52.8m$

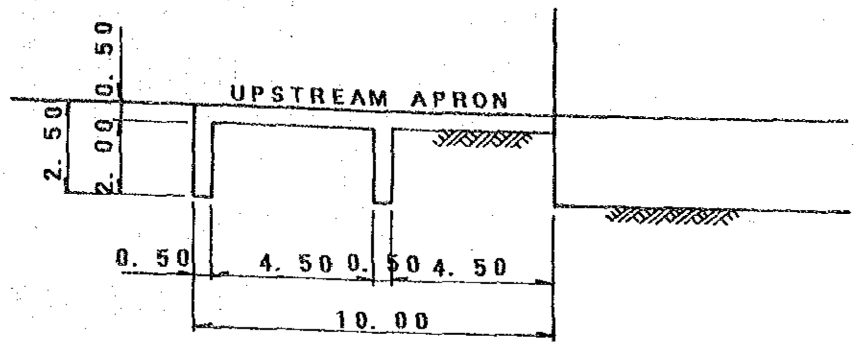
Lane's method

$L' \geq c' \cdot \Delta h$

where L': length of weighted creep length (m)
$L'=\Sigma l_v+1/3\Sigma l_h$
c': Lane's creep ratio (coarse sand 6.0)

$c' \cdot \Delta h=6.0 \times 4.40=26.4m$
$L'=2.5+1.0+1.41+2.5+1/3 \times (15.0+13.5)=16.91m < 26.4m$

According to the above calculation, the creep length is not enough to meet the formulas of Bligh and Lane. In addition to providing an increased length of path of percolation, the apron provides space for the several rows of sheet piling sometimes required. Generally, it is secured by using cut-off wall, upstream apron, etc. However, it is difficult to drive sheet piles from geological view point. Therefore, longer upstream apron should be provided to make creep length long.



When upstream apron is provided like the above figure, creep length can be calculated as follows:

Bligh's method

$\Sigma L=35.91+(10.0+2.5+2.0 \times 3)=54.41m > 52.8m$......OK.

Lane's method

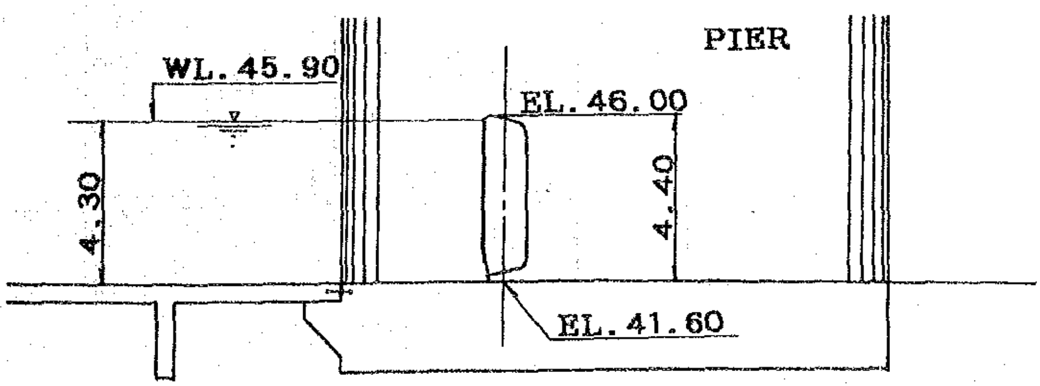
$\Sigma L'=16.91+(2.5+2.0 \times 3+1/3 \times 10.0)=28.74m$.......OK.

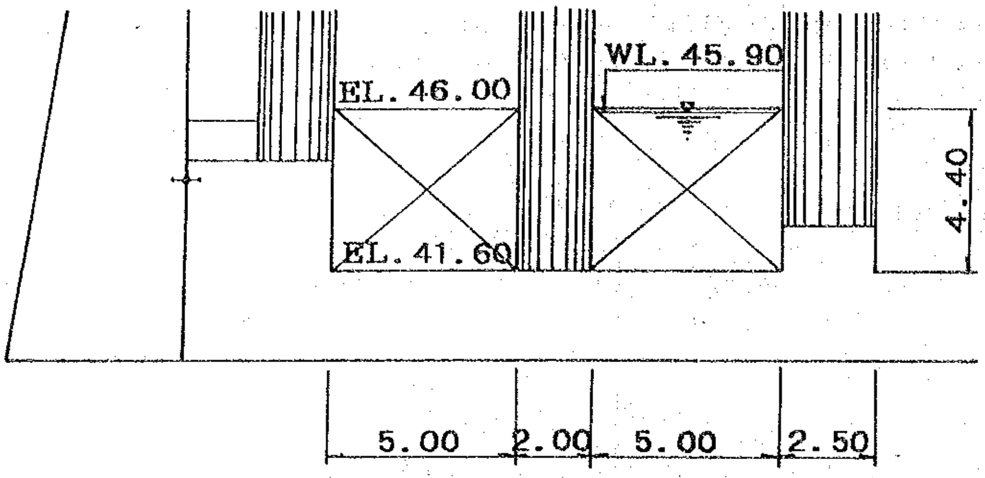
(5) Scouring sluice

The scouring sluice should be provided at the intake side to prevent sediment inflow and to remove sediment deposited in front of the intake. Therefore, jet flow is required at the scouring sluice so as to flash sediment.

The following features of scouring sluice are provided:

1) No. of spans N=2 gates
2) Span B=5.00m
3) Bed elevation EL. 41.60m





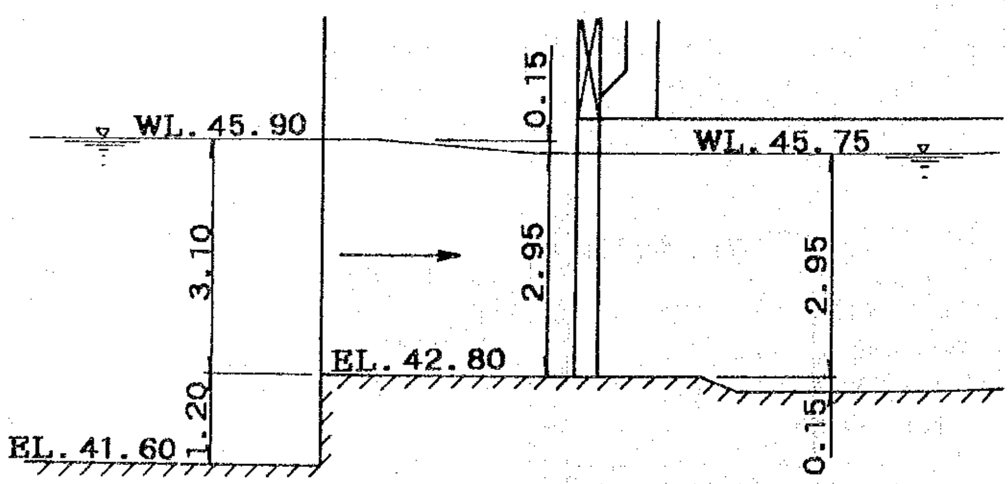
(6) Intake

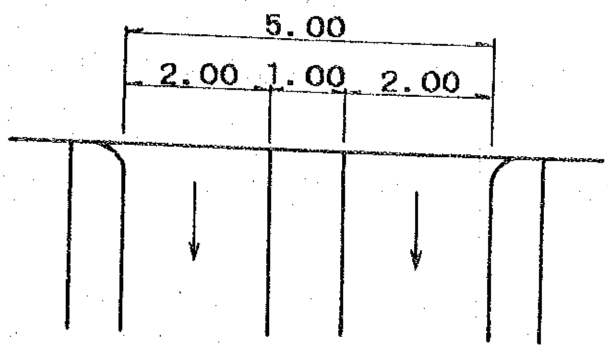
1) Design intake discharge Q=9.35 m3/sec

2) Inlet elevation

The inlet elevation should be 1.0m higher than the base elevation of the scouring sluice to prevent sands from entering the canal.
The height from the riverbed to the inlet elevation should be more than 1/6 of the maximum flood depth of the river.

$H=1/6 \times (48.70-41.60)=1.18 \rightarrow 1.20m > 1.00m$....OK.
Water depth at the inlet =3.10-0.15=2.95m
Intake head loss=0.15m





3) Design width of inlet

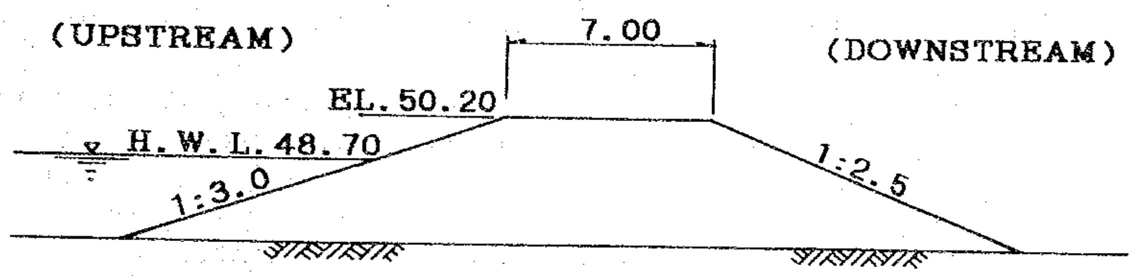
$B=Q/(H \cdot V)$

where B: total width of the inlet (m)
Q: design intake discharge (m3/sec)
H: water depth at the inlet (m)
V: inflow velocity (m3/sec) (0.6-1.0m/s 0.8m/sec)

B'=9.35/(2.95 × 0.8)=3.96m → 4.00m
Width of each gate=4.00m/2 gates=2.00m

(7) Sub-dike

Section of sub-weir is assumed as follows:



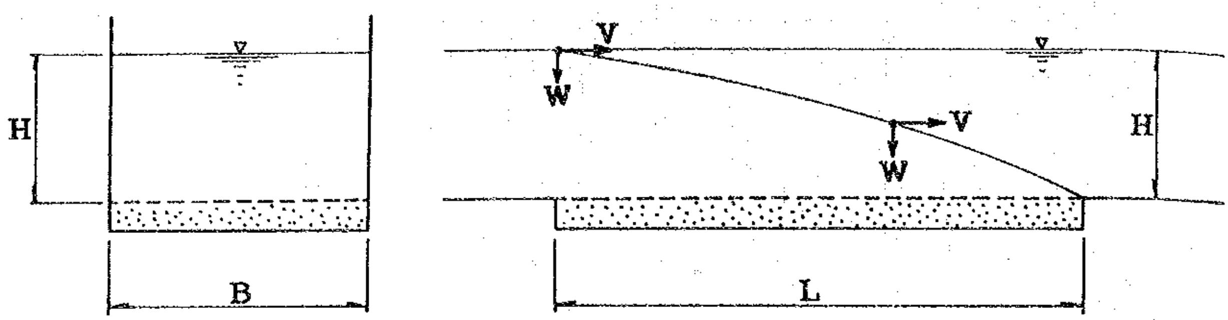
(8) Sand trap

(a) Relation between velocity and grain diameter

$$V_d=10 \times d^{0.5}$$

where V_d: Average Velocity (m/sec)
d : Grain Diameter (m)

(b) Dimension of sand trap (length and width)



$H/W=L/V$
$V=Q/H \cdot B$
$L=(H \cdot V/W)F$

where
H: Depth of Canal Flow (m)
W: Falling Velocity of Sediment Particle (m/s)
L: Length of Sediment Trap (m)
V: Flowing Velocity of Water (m/sec)
Q: Canal Discharge (m3/sec)
B: Width of Sediment Trap (m)
F: Safety Rate (1.5-2.0)

Q_{max}=9.35 m3/sec B=12.60m
V=Q/H· B=0.247m/sec
H=3.00m (Considering flush canal)

(c) Relation between length of sediment trap and grain diameter under the condition of maximum canal discharge

Length of Sediment Trap and Grain Diameter

d(m)	V_d(m/sec)	W(m/sec)	H(m)	L(m)	
0.00640	0.800	0.360	3.00	4.12	(*1)
0.00090	0.300	0.095	3.00	15.62	(*2)
0.00030	0.173	0.030	3.00	49.47	(*3)
0.00007	0.084	0.004	3.00	371.03	(*4)

From the above table, the following matters can be pointed out:

1) The maximum grain size flowing from the Intake is 6.4mm. (*1)
2) The maximum grain size of bed load following under the condition of minimum water velocity is 0.9mm. (*2)
3) In the case of the application of grain material (0.3mm) produced in Japan, the required length of Sediment Trap gets 50.0m.(*3)
4) In the case of the application of grain material (0.07mm) produced in Indonesia, the required length of Sediment Trap gets 371.0m. (*4)

Judging from the above study, the following points are concluded:

1) The actual length of Sediment Trap is limited by the conditions such as geological condition, necessity of drainage canal for blow off.
2) The function as a sand trap shall be employed instead of the one as a sediment trap.
3) The available grain size to be applied shall be within the range of 0.3mm to 6.4mm.
4) Taking into account the above point, the length of Sand Trap shall be 50.00m.

4.3 Canals

4.3.1 Canal Alignment

The following considerations are made for canal alignment in the project:

- To choose straight and shorter canal routes linking water source facility sites to potential irrigation areas.
- To balance cut and fill portions of canal section,and
- To select higher canal routes in consideration of locations of canal structures.

Taking the above considerations into account, the following items were checked by the use of the aero-photo maps with 1:5,000 scale:

- To make preliminary alignment on the above map.
- To check the ground levels in the alignment
- To employ the main canal routes as high as possible
- To decide the diversion structure sites with the required water level for the secondary canals and tertiary canals
- To estimate the size of the area commanded at diversion structures

4.3.2 Canal System

(1) Head reach canal

The head reach canal conveys water from the headworks with intake port on the left bank to the first diversion structure which divert water into the left main canal on the left bank side and the right main canal on the right bank side. The canal will be about 13 km long and will be aligned on the left bank through Kota Intan village along the Rokan Kiri river.

The first diversion will be installed with water level about 41.5 m near the road leading from Kota Lama to the transmigration areas on the left bank, and the location will be about 2.4 km from the ferry port.

(2) Main canal

After taking off from the first diversion, the left main canal(L=about 16 km) will run along the transmigration road, and directs to the transmigration settlement areas: SKP.F, SKP.G, and SKP.B. At the end of the left main canal(BL 13), the water level will be about 33 m.

The right main canal(L=about 19 km) will convey irrigation water to the right bank area crossing the Rokan Kiri river through a siphon.
The siphon of length 150m and capacity up to 4.36 m3/sec will cross the river at a suitable site identified near Kotalama.

The main canal will run along the hill which is stretching along the right bank of the Rokan Kiri river from Kotalama. At the end of the right main canal(BR 21), the water level will be about 28 m.

(3) Secondary canal

The secondary canals in the left bank area will run along the terrain ridges to the SKP B, G, and F. after diverted from the diversion works of the left main canal.

In the right bank area, the main canal will be aligned along the road which runs on the terrain ridge, and the irrigable area is extending over on either side of the road. Therefore, the secondary canals will be installed along the ridges of both sides of the road.

4.3.3 Canal Capacity

The canal capacity is decided based on the diversion requirements for headreach and for main system which are mentioned in Chapter 3.

Irrigation water distribution diagram is shown in Fig. 4.1.

Command Area and Canal Discharge

	Headreach	Main Canal	
		Left	Right
Command Area (ha)	8,300	5,485	2,815
Discharge (m3/sec)	9.35	8.48	4.36

4.3.4 Design and Hydraulic Calculation

For the design of canal sections, the flow is considered as uniform flow, for which the Strickler Manning formula is applied as follows (the following parameters are used for trapezoidal cross-section of the canal):

(1) Flow formula

$V = kR^{2/3}I^{1/2}$

$R = A/P$, $A = (b+mh)h$, $P = b+2h(m^2+1)^{1/2}$

$Q = VA$, $b = nh$

where

Q	:	canal discharge (m3/sec)
V	:	flow velocity (m/sec)
A	:	wet cross-section (m2)
R	:	hydraulic radius (m)
P	:	wet perimeter (m)
b	:	bottom width (m)
h	:	water depth (m)
I	:	energy gradient (canal slope)
k	:	Strickler roughness coefficient ($m^{1/3}$/sec)
m	:	side slope 1 vertical : m horizontal

(2) Strickler roughness coefficient

Roughness coefficient for the irrigation canal design are presented in the following table(Source: DESIGN STANDARD) :

Strickler Roughness Coefficient

design discharge in m3/sec	k in $m^{1/3}$/sec
Q>10	45
5<Q<10	42.5
1<Q<5	40
Q<1 and tertiary canal	35

(3) Canal side slope

The minimum side slopes for canals in well compacted fill are shown in the following table:

Canal Side Slope

water depth + freeboard D(m)	minimum side slope
D≤1.0	1:1
1.0<D≤2.0	1:1.5
D>2.0	1:2

(4) Freeboard

The minimum freeboard applied in main and secondary canals are related to the design discharge of the canal as shown in the following table:

Minimum Freeboard

Q in m3/sec	Freeboard in m
<0.5	0.40
0.5-1.5	0.50
1.5-5.0	0.60
5.0-10.0	0.75
10.0-15.0	0.85
>15.0	1.00

Hydraulic profile of headreach and left and right main canals is shown in Fig. 4.2.

Calculation of canal slope gradient is shown in Table 4.2.

4.3.5 Structural Considerations

The head reach canal and main canal will have to be thin concrete lining because of the importance, need to ensure its security, and soil conditions.

The secondary canals will be earthen canal. If embankment is required, material will be conveyed from the hills around either bank of the Rokan Kiri river near Kotalama.

4.3.6 Principal Irrigation System Components

The principal irrigation system components are given in the Table 4.3 which shows the length of the headreach canal, the main canals, and the secondary canals and number of structures such as bridges, drainage culverts, diversions, turnouts, spillways, drops, checks, and siphon.

In the table, the following abbreviated letters are used:

HRC	:	Headreach canal
LMC	:	Left main canal
RMC	:	Right main canal
LSC	:	Left secondary canal
RSC	:	Right secondary canal
Brdg.	:	Bridge
Dr.Cul-vert	:	Drainage culvert
Div.	:	Diversion

4.4 Basic Plan for Drainage System

4.4.1 Drainage System

Provision of a suitable drainage facility is one of the most important factor to improve agricultural productivity in the low-lying land of the project.

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

4.4.2 Design Discharge

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

Design capacity for rice fields is calculated using the following conditions.

a. Return period for design discharge : 5 years
b. 3 day consecutive rainfall at Kota Lama : 202 mm
c. Design discharge :

$Q_1 = 1.62 \times Dm \times A^{0.92}$ $(A \geq 400$ ha)

$Q_1 = Dm \times A$ $(A < 400$ ha)

where, Q_1 : Design discharge (l/s)
Dm : Drainage modules (l/s/ha)
A : Drainage area (ha)

The drainage modules is taken 8.64 l/s/ha. If the drainage area is less than 400 ha, the drainage discharge per unit area is taken as constant

As to the drainage requirement at non-rice fields such as villages, roads and non-agri land, Mc-Mach empirical formula (by Porsida/Harza) will be applied as follows ;

$$Q_2 = 0.023 \times c \times i \times A^{4/5} \times S^{1/5}$$

where, Q_2 : design discharge from non-rice fields (m^3/s)
c : runoff coefficient = 0.8
i : rainfall intensity (cm/hr)
R_{24} (1/5) = 155 mm/day = 0.646 cm/hr
R_{24} (1/25)= 214 mm/day = 0.892 cm/hr
A : drainage area $(A < 10{,}000$ ha)
S : average ground slope of drainage area

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

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

Maximum 3 Day Consecutive Rainfall at Kotalama

Year / Month	1983	1984	1985	1986	1987	1988	1989	1990	1991
Jan.	-	141.2	91.7	117.8	38.0	100.0	130.5	112.0	27.0
Feb.	4.3	44.4	66.0	111.1	50.8	120.0	70.0	45.0	35.5
Mar.	26.0	126.5	66.0	114.5	115.2	125.0	85.0	54.5	78.5
Apr.	42.0	90.9	68.9	71.2	70.3	0.0	80.0	57.0	86.5
May	65.0	112.0	162.9	135.1	99.0	40.0	45.0	103.5	73.0
Jun.	157.4	68.2	31.5	48.3	142.0	95.0	46.0	72.0	62.0
Jul.	101.1	71.7	69.7	64.6	25.0	95.0	70.0	83.0	20.0
Aug.	82.2	24.3	-	81.0	18.0	75.0	60.0	16.0	9.5
Sep.	221.6	69.1	-	78.9	40.0	97.0	55.0	60.0	27.0
Oct.	128.1	243.3	-	-	90.0	133.2	50.0	80.0	71.0
Nov.	105.1	94.8	-	-	146.0	40.0	115.0	195.0	80.0
Dec.	122.2	124.5	-	-	80.0	130.0	50.0	95.0	63.5
Max.	221.6	243.3	162.9	135.1	146.0	133.2	130.5	195.0	86.5

Probability analysis for 3 day rainfall
by Iwai method

Return period	3 day consecutive rainfall (mm)
25	257.0
20	250.2
10	227.6
5	202.1
2	158.0

4.4.3 Dimension of Drainage Canal

- Earthen type is adopted for the drainage canals taking decrement of the construction cost.
- The design water level is equal to ground revel.
- Dikes and inspection road are provided along the drainage canal.
- The maximum velocity is set as the same as the

conveyance canal.

- Free board is taken from irrigation design standard KP- 03 "CANALS".
- Side slope : every excavation depth D

$D < 1.0$ m	1:1.0
$1.0 \text{ m} \le D < 1.5$ m	1:1.5
$1.5 \text{ m} \le D$	1:2.0

- Width-depth ratio : $b/h = 1$ to 15
- Strikler's roughness coefficient :
  - $h \ge 1.5$ m : $K = 30$
  - $h < 1.5$ m : $K = 25$

Calculation results are shown in the following tables:

Table 4.4 TABLE OF DIMENSION FOR DRAINAGE CANAL
Table 4.5 CALCULATION OF DRAINAGE CANAL SLOPE GRADIENT
Table 4.6 BILL OF QUANTITIES OF DRAINAGE CANAL

4.4.4 Length of Drainage Canals

Length of Drainge Canals

Place	Nos.	Total length (Km)	Nos. of Structure Bridge	Drop
Left bank	10	38.3	11	6
Right bank	4	17.9	2	0
Total	14	56.2	13	6

4.5 Construction Materials

The cost and transport of construction materials has a significant impact on the cost of irrigation development. Therefore, construction materials should be used as much as possible which can be locally obtained.

The soil forming the hills around either bank of the Rokan Kiri river near Kotalama will make excellent embankment fill if properly compacted.

The Rokan Kiri river will provide adequate materials for concrete. Suitable sand and gravel sizes for concrete are available at the river bed of the proposed weir site. However, large sizes of river stones which are used for a weir body are not available around the weir site. According to information, they can be obtained at the site of about 15 km to 20 km upstream from the proposed weir site.

As there is little industry in and around the area, all manufactured items such as gates, reinforcement bars, concrete piles, pipes etc. will have to be brought from Jakarta. Usually, these will be by road transport using Ujung Batu-Kotalama road which is currently poor condition. Improvements to this road is required as soon as possible for the implementation of the project.

4.6 Operation and Maintenance Plan

4.6.1 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

1) Headworks

The water management and control at headworks should be performed so that a diversion weir and an intake part can be functioned safely and rationally. A scouring sluice gate to remove sedimentation is operated on managing person's judgement. During the flood period, a scouring sluice gate functions as the flood sluice gate to let flood discharge flow. In an intake part, opening and closing of gate are controlled so as to secure necessary amount of intake water.

2) Canals and related structures

Water management and control in canals should be performed so that diversion structures and check gates can be functioned safely and rationally. At a diversion structure, water level, rate of flow and opening degree of gate are checked. At the same time, it shall be prohibited for farmers to operate or break facilities voluntarily for their purposes. At a check gate, water-level shall be watched for proper distribution.

In respect to canal management, it is important to ensure such facilities as headworks, canals and structures are always kept in good condition for securing proper and functional distribution. In principle, headreach and main systems should be well managed by the administration and tertiary systems should be well managed by irrigation associations or beneficial farmers.

(2) Items to be checked for Maintenance

Most of the earth canals without periodical maintenance require to remove sedimentation which results in thick growth of waterweeds and loss of a designed cross-sectional area of flow.

Facility maintenance consists of 2 functions; regular facility maintenance and emergency facility maintenance.

1) Regular facility maintenance: Staff of management office should regularly inspect facilities and if he finds any damage, he should make a report to a management office. If damage is heavy, he should arrange a temporary repair as soon as possible. It is another his duty to make repair plan of canal structures periodically.
2) Emergency facility maintenance : Emergency facility maintenance should be performed when damage is heavy. A facility should be repaired at once by using materials obtained on site to avoid further extension of damage.

Main items of inspections and works for facility maintenance are as follows:

1) As damaged gates result in scour of embankments, a functioning of scouring sluice gates of headworks should be regularly inspected.
2) Weir bodies of headworks should be inspected whether cracks, piping or peelings of surfaces occur or not.
3) Erosion of ripraps is considered to be inevitable.

However, if ripraps are washed away, new ripraps should be constructed at once and if necessary the construction lengths should be extended. Without ripraps, piping will occur and lowering of the foreaprons will be resulted.

4) Sediment, wateweeds and suspended solids should be removed.
5) Freeboard of canals should be cleaned.
6) Trees and plants growing at joints in concrete works should be removed.
7) Sediment on gate sills of diversion structures and turnouts should be removed.
8) Joints between earth canals and concrete works should be checked.
9) Gates, safety bars and handrails should be regularly coated.
10) Full opening and full closing of gates should be checked and parts of gates should be lubricated.
11) Stoplogs for gates should be reserved.

(3) Proposed Operation/Water Management

In the project, the rotation block is divided into three: two blocks for left bank irrigable area, and one block for right bank irrigable area. Water division for rotational irrigation is controlled at the first diversion.

Preparation of irrigation schedule, rotational irrigation, gate control during floods and record keeping should be made. Following minimum system operation with supports of extension workers(PPL) should be made by farmer's O&M groups in the schemes as a first step

1) Seasonal irrigation schedules should be prepared through discussions in regular general meetings, and the schedule must be informed to every group members.
2) When rotational irrigation is applied, rotation order and irrigation time of respective blocks should be decided through discussions in irregular meetings. In the project, the rotation block is divided into three(3).
3) The above operation/water management activities should be recorded in order to improve these activities.

(4) Proposed Maintenance

Following minimum system maintenance with supports of PPL should be made by farmer's O&M groups in the schemes as a first step :

1) Periodic system maintenance schedules should be prepared through discussions in regular general meetings, and the schedule must be informed to every group members.
2) When special maintenance works such as concrete works and gate replacement are required, it is proposed to open a general meeting to discuss and decide required material, its procurement/repair method, its budgetary preparation and repair schedule.
3) When emergency repair is required in case of floods and so on, it is proposed that the group leader or irrigator conduct the repair and the repair be completed within a right period by available group members in order to minimize the system damages.
4) The above maintenance activities should be recorded in order to improve these activities.

4.6.2 Operation and Maintenance at Farm Level

The target of O & M at farm level is to improve and strengthen the situation for which the beneficiary farmers in the Project Area will be able to operate and maintain their irrigation and drainage systems technically and financially in accordance with the government's laws/regulations.

In order to achieve the above target, the following approach has been formulated:

1) Promotion/encouragement of authorized P3A organization.
2) Strengthening the financial background of P3A organization (introduction of reasonable water charge).
3) Extension of written O & M regulations to P3A organization.
4) Extension of improved operation/water management including irrigation schedule, rotational irrigation and record keeping,
5) Extension of improved maintenance including structure repair works and record keeping,

6) Improvement of rural extension system for O&M and training of rural extension workers(PPL).

On the basis of the above basic approach, respective improvement/strengthening plans have been formulated and are explained below :

4.6.3 Establishment of O & M Organization

After completion of the construction works, operation and management office should be established which will be responsible for the operation and maintenance of all facilities. The operation and maintenance from the tertiary blocks to peripheral facilities will be entrusted to the water user's association (P3A) and farmers.
The main works of the office is summarized as follows:

1) Formulation of irrigation schedule
2) Collection and analysis of data
3) Water supply control and canal system management
4) Guidance in technique for irrigation associations and benefiting farmers
5) General affairs and accountancy

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

1) Operation section
   - Planning of irrigation schedule
   - Water distribution
   - Control of water delivery
   - Hydrological measurement
   - Data collection and data 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 cashier

- General affair services

The O & M office will be set up at the Project site. 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 office should be one. Namely, these work is performed under the control of the central office. On the other hand, water delivery and scheduling of each area are performed by branch offices.

The irrigation supervisor will be responsible for operation and management of the irrigation system through the above mentioned sections. The staff necessary for the O & M office are estimated at about 120 persons including water management engineers, hydrologist, mechanics, drivers/operators, accountant,etc.

4.6.4 Organizatin Supported by the Government

It is essential to extend O & M to the farmers through extension workers (PPL) in collaboration with Provincial Irrigation Services at Kabupaten level(PUD) as well as Bupati's office and it is required for Provincial Agricultural Services(PRAS) to train PPLs.

4.6.5 Farmer's Contribution to O & M

According to the farm economy survey, the farmer attitudes regarding to the proposed irrigation development is positive and encouraging. 88% of the farmers expressed their willingness to join the irrigation scheme. 94% of farmers are willing to pay the irrigation fee of Rp.1,000-50,000 per hectare per year.

Considering the above situation, farmer's contribution should be taken into account for O & M after due deliveration with beneficiaries.

4.6.6 O & M Equipment

The O & M equipment required for during the O & M stage are bulldozer, motor grader, vehicles, measuring instrument, etc. Required equipment are mentioned in 4.3 Operation and Maintenace of the Project.

Table 2.1 Comparison of rubber dam and steel gate

Item	Rubber dam	Steel gate	
		Slide type	Flap type
Deflation	Deflating operating is only by opening exhaust valves of air/water. Because of its simple mechanisms, reliability of deflation is high.	Opening operation is lifting leaf body by wire rope or spindle. It's safe during flood time, because leaf is lifted higher than levee height.	Deflating Operation is done by hydraulic pressure. Sometimes inperfect deflation occur, when sedimentation is downstream.
Flow ability	Because of its possibility of long span, flow interruption by piers is low.	Check ratio of flow by piers is higher than rubber dam	←
Water stop	Water stop ability is fine. By its overflow structure, closure ability is also fine.	Regularly changing of packing is necessary.	←
Civil structure	Because of its light structure and overflow system, foundation works etc. can be simplified.	Because of its high piers and underflow system, sub-structure and foundation works are big.	Because of its low piers and overflow system, foundation works can be relatively small.
Durability	Rubber dam has good weather-ability and abrasion resistance, and rarely deteriorates. From actual results and experimental results, rubber dam has same durability as steel gate.	Steel gate is durable for 50 years equivalent by proper operation and maintenance.	←
Influence of sedimentation	Because of its overflow system, scouring ability is worse than that of slide type gate. When sedimentation occurs, sediment can be flushed out to a considerable extent by repeating inflation and deflation.	Because of its underflow system, slide gates have good scouring ability.	Because of its over flow system, scouring ability of flap type gate is worse than that of slide gate. Sometimes imperfect deflation occurs, when sediment gathers at downstream.
Water level control	As weir height varies depend on the upstream and downstream water level, control facilities become complicated. It is necessary to consider the vibration during high overflow and V-notch in case of air-filled type.	Because gate can be set at every opening point, control is easy.	←
Operation and maintenance	Painting is unnecessary. Outer examination is more difficult than slide type gate. Repairing is relatively easy.	Regularly painting is necessary. Outer examination is easy.	Regularly painting is necessary. Outer examination is more difficult than slide type gate.

Table 2.2 Basic Data on Fuel Cost for Pumping Station

Fuel consumption per hour for maximum irrigation requirements:
180 l/hr x 3 nos=540 l/hr

The annual water requirements are estimated 14,458 m3/ha/year based on the proposed cropping pattern.

As the cultivation area is 8,300 ha in this pumping plan, the annual total water requirements (Q) is as follows:

Q=14,458 x 8,300=120,000,000 m3

It becomes 41% of 294,861,600 m3 which is the annual total water quantity calculated by the maximum irrigation requirement all through a year.

Thus, the quantity of annual fuel consumption is estimated as follows:

540 l/hr x 24 hr x 365 days x 0.41=1,939,000 l/year

Annual cost is as follows:

1,939,000 l/year x Rp.346/l=Rp.670,894,000

Table 3.1 Ten Day River Discharge

Period	Discharge (m3/sec)	Period	Discharge (m3/sec)
Jan. 1	140.0	Jul. 1	58.5
2	108.0	2	57.1
3	106.7	3	54.4
Feb. 1	99.6	Aug. 1	50.7
2	85.2	2	49.5
3	94.2	3	49.3
Mar. 1	109.7	Sep. 1	57.3
2	97.0	2	61.7
3	103.3	3	69.2
Apr. 1	122.0	Oct. 1	67.4
2	111.8	2	72.6
3	107.4	3	90.2
May 1	131.7	Nov. 1	113.6
2	106.0	2	90.9
3	86.0	3	108.9
Jun. 1	81.4	Dec. 1	165.6
2	65.7	2	151.8
3	60.9	3	128.4

Table 3.2 Calculation of Reference Crop Evaporation (ETo) by Modified Penman Method

CALCULATION	Jan. 1.	Jan. 2.	Jan. 3.	Feb. 1.	Feb. 2.	Feb. 3.	Mar. 1.	Mar. 2.	Mar. 3.	Apr. 1.	Apr. 2.	Apr. 3.	May 1.	May 2.	May 3.	June 1.	June 2.	June 3.
[1]. Latitude 1° N																		
[2]. Tmax (° C)	32.00	31.80	32.50	32.70	32.80	32.80	32.40	32.70	33.40	33.40	33.60	33.40	33.40	33.60	33.80	33.50	33.60	33.60
[3]. Tmin (° C)	21.20	20.60	20.70	21.10	21.50	21.60	21.50	21.80	21.90	22.80	22.60	22.30	23.00	23.20	22.70	22.10	22.60	23.10
(4). Tmean (° C)	26.6	26.2	26.6	26.9	27.2	27.2	27.0	27.3	27.7	28.1	28.1	27.9	28.2	28.4	28.3	27.9	28.1	28.4
(5). Rel.Hum(mean) (%)	85.50	84.20	85.20	85.60	87.90	87.90	87.10	87.80	86.70	86.30	86.80	86.40	86.10	86.80	85.00	86.60	84.30	81.90
[6]. ea (mbar)	34.90	34.00	34.90	35.50	36.10	36.10	35.70	36.30	37.20	38.00	38.00	37.60	38.30	38.70	38.50	37.60	38.00	38.70
[7]. U2 (km/day)	31.50	32.30	34.00	37.10	37.60	42.30	33.80	34.90	34.40	30.30	32.20	29.80	31.40	29.40	31.00	28.60	34.30	31.00
[8]. (1-W)	0.24	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
[9]. W	0.76	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
[10]. n/N (%)	32.20	34.90	40.80	42.50	46.60	47.80	32.90	49.00	50.00	47.40	49.20	52.50	48.50	49.10	51.00	55.70	57.90	59.00
[11]. N (hours)	12.00	12.00	12.00	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.20	12.20	12.20
[12]. Ra (mm/day)	14.90	14.90	14.90	15.40	15.40	15.40	15.70	15.70	15.70	15.30	15.30	15.30	14.50	14.50	14.50	14.10	14.10	14.10
[13]. f(t)	16.00	15.90	16.00	16.10	16.10	16.10	16.10	16.20	16.20	16.30	16.30	16.30	16.30	16.40	16.40	16.30	16.30	16.40
(14). ed (mbr)	29.84	28.63	29.73	30.39	31.73	31.73	31.09	31.87	32.25	32.79	32.98	32.49	32.98	33.59	32.73	32.56	32.03	31.70
(15). ea-ed (mbar)	5.06	5.37	5.17	5.11	4.37	4.37	4.61	4.43	4.95	5.21	5.02	5.11	5.32	5.11	5.77	5.04	5.97	7.00
(16). f(u)	0.36	0.36	0.36	0.37	0.37	0.38	0.36	0.36	0.36	0.35	0.36	0.35	0.35	0.35	0.35	0.35	0.36	0.35
(17). n (hours)	3.86	4.19	4.90	5.14	5.64	5.78	3.98	5.93	6.05	5.74	5.95	6.35	5.87	5.94	6.17	6.80	7.06	7.20
(18). Rns (mm/day)	4.59	4.74	5.07	5.34	5.58	5.65	4.88	5.83	5.89	5.59	5.69	5.88	5.36	5.39	5.49	5.59	5.71	5.76
(19). f(ed)	0.13	0.14	0.13	0.12	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.11	0.11	0.11	0.12
(20). f(n/N)	0.39	0.41	0.47	0.48	0.52	0.53	0.40	0.54	0.55	0.53	0.54	0.57	0.54	0.54	0.56	0.60	0.62	0.63
(21). Rnl (mm/day)	0.80	0.90	0.97	0.97	0.96	0.98	0.76	1.00	0.99	0.92	0.94	1.02	0.93	0.91	0.99	1.07	1.14	1.19
(22). Rn (mm/day)	3.79	3.84	4.11	4.37	4.62	4.67	4.12	4.83	4.90	4.66	4.75	4.86	4.43	4.48	4.50	4.52	4.56	4.57
(23). Eto* (mm/day)	3.31	3.36	3.57	3.78	3.90	3.95	3.53	4.06	4.18	4.01	4.07	4.15	3.84	3.86	3.94	3.88	4.01	4.09

File name : TABLE-6.WJ2

Note [ ] : Data, ( ) : Calculation

Table 3.2 Calculation of Reference Crop Evaporation (ETo) by Modified Penman Method (Continued)

CALCULATION	July 1.	July 2.	July 3.	Aug. 1.	Aug. 2.	Aug. 3.	Sept. 1.	Sept. 2.	Sept. 3.	Oct. 1.	Oct. 2.	Oct. 3.	Nov. 1.	Nov. 2.	Nov. 3.	Dec. 1.	Dec. 2.	Dec. 3.
[1]. Latitude 1° N																		
[2]. Tmax (° C)	37.20	33.20	33.40	33.00	33.30	33.10	36.90	32.70	32.60	33.60	33.30	33.20	32.50	32.70	32.30	32.80	32.40	32.40
[3]. Tmin (° C)	23.20	22.50	23.20	21.80	22.10	21.80	22.20	22.20	21.70	21.20	21.30	21.40	21.60	20.80	21.70	21.10	21.70	21.40
(4). Tmean (° C)	30.2	27.9	28.3	27.4	27.7	27.5	29.6	27.5	27.2	27.4	27.3	27.3	27.1	26.8	27.0	27.0	27.1	26.9
(5). Rel.Hum(mean) (%)	83.20	83.90	82.40	81.60	82.10	83.70	84.20	83.10	83.50	84.20	84.40	83.90	85.40	85.00	85.20	84.90	87.00	78.20
[6]. ea (mbar)	42.90	37.60	38.50	36.50	37.20	36.80	41.50	36.80	36.10	36.50	36.30	36.30	35.90	35.30	35.70	35.70	35.90	35.50
[7]. U2 (km/day)	36.40	29.90	35.30	36.40	28.30	34.90	33.30	33.10	33.60	33.90	32.00	29.20	30.90	32.70	32.20	29.90	31.20	29.40
[8]. (1-W)	0.22	0.23	0.23	0.24	0.23	0.24	0.22	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
[9]. W	0.78	0.77	0.77	0.76	0.77	0.77	0.78	0.77	0.76	0.76	0.76	0.76	0.75	0.76	0.76	0.76	0.76	0.76
[10]. n/N (%)	58.70	49.60	51.60	47.70	47.70	43.40	44.40	46.70	42.00	49.20	45.10	41.50	41.60	50.20	41.50	39.20	38.60	32.70
[11]. N (hours)	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.00	12.00	12.00
[12]. Ra (mm/day)	14.20	14.20	14.20	14.90	14.90	14.90	15.30	15.30	15.30	15.40	15.40	15.40	15.00	15.00	15.00	14.60	14.60	14.60
[13]. f(t)	16.80	16.30	16.40	16.20	16.20	16.20	16.60	16.20	16.10	16.20	16.20	16.20	16.10	16.10	16.10	16.00	16.10	16.10
(14). ed (mbr)	35.69	31.55	31.72	29.78	30.54	30.80	34.94	30.58	30.14	30.73	30.64	30.46	30.66	30.01	30.42	30.31	31.23	27.76
(15). ea-ed (mbar)	7.21	6.05	6.78	6.72	6.66	6.00	6.56	6.22	5.96	5.77	5.66	5.84	5.24	5.29	5.28	5.39	4.67	7.74
(16). f(u)	0.37	0.35	0.37	0.37	0.35	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.35	0.36	0.36	0.35	0.35	0.35
(17). n (hours)	7.10	6.00	6.24	5.77	5.77	5.25	5.37	5.65	5.08	5.95	5.46	5.02	5.03	6.07	5.02	4.70	4.63	3.92
(18). Rns (mm/day)	5.79	5.30	5.41	5.46	5.46	5.22	5.42	5.55	5.28	5.73	5.49	5.28	5.15	5.64	5.15	4.88	4.85	4.53
(19). f(ed)	0.09	0.12	0.12	0.13	0.12	0.12	0.09	0.12	0.13	0.12	0.12	0.12	0.12	0.13	0.12	0.13	0.12	0.14
(20). f(n/N)	0.63	0.55	0.56	0.53	0.53	0.49	0.50	0.52	0.48	0.54	0.51	0.47	0.47	0.55	0.47	0.45	0.45	0.39
(21). Rnl (mm/day)	0.93	1.04	1.06	1.10	1.06	0.97	0.77	1.04	0.97	1.07	1.01	0.95	0.94	1.13	0.95	0.91	0.85	0.91
(22). Rn (mm/day)	4.86	4.27	4.35	4.35	4.40	4.25	4.64	4.51	4.31	4.66	4.49	4.33	4.22	4.51	4.20	3.98	4.00	3.62
(23). Eto* (mm/day)	4.37	3.77	3.92	3.90	3.92	3.80	4.14	4.01	3.79	4.04	3.89	3.78	3.65	3.88	3.64	3.48	3.43	3.40

File name : TABLE-6.WJ2

File name : TABLE-6.WJ2

Note [ ] : Data, ( ) : Calculation

Table 3.3 Effective Rainfall at Pasir Pangarayan (Unit:mm)

DATE	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
1	14.0	0.0	0.0	0.0	16.5	7.7	0.0	0.0	1.8	18.9	9.8	0.0
2	1.8	6.7	32.2	0.0	18.2	9.5	0.0	0.0	4.9	0.0	1.1	0.0
3	25.2	8.1	0.0	34.3	11.2	14.7	0.0	0.0	8.4	0.0	0.0	15.5
4	4.2	0.0	13.3	44.8	18.2	7.4	36.4	0.0	0.0	0.0	0.0	0.0
5	8.4	18.9	0.0	0.0	0.0	12.3	6.0	0.0	0.0	7.4	0.0	0.0
6	3.9	0.0	26.6	14.0	3.9	15.1	2.5	0.0	0.0	0.0	42.0	0.0
7	4.2	4.0	0.0	1.4	11.9	0.0	3.2	0.0	0.0	43.4	5.3	1.5
8	0.0	0.0	0.0	35.0	3.5	0.0	0.0	0.0	0.0	0.0	30.5	0.0
9	0.0	2.8	4.6	0.0	17.5	0.0	0.0	0.0	0.0	2.8	0.0	0.0
10	0.0	1.1	0.0	8.1	0.0	0.0	0.0	22.4	1.1	7.0	1.8	0.0
SUB-TO	47.6	41.4	76.7	137.6	84.4	58.8	48.0	22.4	14.4	60.6	80.5	17.0
11	0.0	0.0	26.6	0.0	0.0	0.0	0.0	0.7	9.1	33.6	7.7	0.0
12	4.9	0.0	4.2	12.3	0.0	2.8	0.0	9.5	0.0	0.0	0.0	6.3
13	8.4	0.0	0.0	0.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0	27.3
14	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	3.5	3.2	0.0	5.3	0.0	12.6	0.0	0.0	8.8	0.0	6.3	5.6
16	0.0	0.0	0.0	30.8	13.3	15.4	1.5	0.0	21.0	13.3	2.8	21.7
17	0.0	0.0	5.6	30.8	11.9	0.0	1.8	0.0	7.0	20.3	3.2	7.7
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	21.0
19	0.0	0.0	10.5	14.0	0.0	0.0	0.4	0.4	0.0	4.6	0.0	3.2
20	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	7.4
SUB-TO	16.8	3.2	46.9	107.1	36.4	30.8	3.6	10.5	51.1	71.8	20.0	100.1
21	0.0	0.0	3.2	3.9	9.8	0.0	27.0	0.0	28.0	0.0	6.0	17.9
22	0.0	0.0	4.1	35.0	16.8	2.8	0.0	1.4	0.0	0.0	2.8	32.6
23	0.0	0.0	6.7	3.2	0.0	0.0	0.0	14.0	0.0	2.5	0.0	0.0
24	0.0	0.0	2.5	0.0	4.2	0.0	0.0	0.0	0.7	3.9	0.0	17.5
25	0.0	10.5	7.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	1.1	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
27	0.0	0.0	1.4	0.0	0.0	11.2	0.0	0.0	0.0	0.0	19.6	2.8
28	0.0	0.0	1.4	0.0	1.4	0.0	0.0	0.0	3.5	11.2	0.0	32.2
29	0.0		1.4	10.5	2.8	0.0	0.0	2.8	4.9	0.0	20.3	0.0
30	10.2		0.0	2.1	0.0	0.0	0.0	8.4	20.3	0.0	4.2	1.4
31	3.2		16.8		0.0		0.0	0.0		6.0		4.2
SUB-TO	13.3	10.5	46.1	63.0	35.7	14.0	27.0	26.6	57.4	18.0	52.9	115.5
TOTAL	91.7	55.2	169.6	307.7	172.9	111.3	78.5	59.5	124.6	169.2	163.2	232.6

Table 3.4 Effective Rainfall for Palawija

Period	Eto mm/d	Eto*days	Ave. Monthly Eto (mm)	Monthly Mean Rainfall (mm)	Ave. Monthly Effect. Rainfall	Daily Effect. Rainfall (mm)
JAN. 1	3.3	33.00				3.40
JAN. 2	3.4	34.00				3.40
JAN. 3	3.6	39.60	106.60	214.20	105.30	3.40
FEB. 1	3.8	38.00				3.40
FEB. 2	3.9	39.00				3.40
FEB. 3	3.9	35.10	112.10	153.40	97.90	3.30
MAR. 1	3.5	35.00				3.80
MAR. 2	4.1	41.00				3.80
MAR. 3	4.2	46.20	122.20	216.30	117.80	3.80
APR. 1	4.0	40.00				3.90
APR. 2	4.1	41.00				3.90
APR. 3	4.2	42.00	123.00	206.70	118.40	3.90
MAY. 1	3.8	38.00				3.70
MAY. 2	3.9	39.00				3.70
MAY. 3	3.9	42.90	119.90	178.40	113.60	3.60
JUN. 1	3.9	39.00				2.40
JUN. 2	4.0	40.00				2.40
JUN. 3	4.1	41.00	120.00	104.60	71.50	2.40
JUL. 1	4.4	44.00				2.90
JUL. 2	3.8	38.00				2.90
JUL. 3	3.9	42.90	124.90	134.20	90.20	2.90
AUG. 1	3.9	39.00				2.90
AUG. 2	3.9	39.00				2.90
AUG. 3	3.8	41.80	119.80	134.80	89.50	2.90
SEP. 1	4.1	41.00				3.80
SEP. 2	4.0	40.00				3.80
SEP. 3	3.8	38.00	119.00	252.90	115.20	3.80
OCT. 1	4.0	40.00				3.80
OCT. 2	3.9	39.00				3.80
OCT. 3	3.8	41.80	120.80	214.90	116.60	3.70
NOV. 1	3.6	36.00				3.60
NOV. 2	3.9	39.00				3.60
NOV. 3	3.6	36.00	111.00	257.40	108.80	3.60
DEC. 1	3.5	35.00				3.40
DEC. 2	3.4	34.00				3.40
DEC. 3	3.4	37.40	106.40	350.90	105.10	3.40

File Name : TABLE-8.WJ2

Table 3.5 Irrigation Water Requirements during Land Preparation

Period (1)	Eto mm/d (2)	Eo mm/d (3)	P mm/d (4)	M mm/d (5)	k (6)	M*e**k (7)	e**k-1 (8)	IR mm/d (9)
JAN. 1	3.3	3.6	3.0	6.6	0.852	15.550	1.345	11.6
JAN. 2	3.4	3.7	3.0	6.7	0.867	16.033	1.379	11.6
JAN. 3	3.6	4.0	3.0	7.0	0.895	17.031	1.447	11.8
FEB. 1	3.8	4.2	3.0	7.2	0.923	18.073	1.517	11.9
FEB. 2	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
FEB. 3	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
MAR. 1	3.5	3.9	3.0	6.9	0.881	16.526	1.413	11.7
MAR. 2	4.1	4.5	3.0	7.5	0.966	19.723	1.626	12.1
MAR. 3	4.2	4.6	3.0	7.6	0.980	20.297	1.664	12.2
APR. 1	4.0	4.4	3.0	7.4	0.951	19.162	1.589	12.1
APR. 2	4.1	4.5	3.0	7.5	0.966	19.723	1.626	12.1
APR. 3	4.2	4.6	3.0	7.6	0.980	20.297	1.664	12.2
MAY. 1	3.8	4.2	3.0	7.2	0.923	18.073	1.517	11.9
MAY. 2	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
MAY. 3	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
JUN. 1	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
JUN. 2	4.0	4.4	3.0	7.4	0.951	19.162	1.589	12.1
JUN. 3	4.1	4.5	3.0	7.5	0.966	19.723	1.626	12.1
JUL. 1	4.4	4.8	3.0	7.8	1.008	21.483	1.740	12.3
JUL. 2	3.8	4.2	3.0	7.2	0.923	18.073	1.517	11.9
JUL. 3	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
AUG. 1	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
AUG. 2	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
AUG. 3	3.8	4.2	3.0	7.2	0.923	18.073	1.517	11.9
SEP. 1	4.1	4.5	3.0	7.5	0.966	19.723	1.626	12.1
SEP. 2	4.0	4.4	3.0	7.4	0.951	19.162	1.589	12.1
SEP. 3	3.8	4.2	3.0	7.2	0.923	18.073	1.517	11.9
OCT. 1	4.0	4.4	3.0	7.4	0.951	19.162	1.589	12.1
OCT. 2	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
OCT. 3	3.8	4.2	3.0	7.2	0.923	18.073	1.517	11.9
NOV. 1	3.6	4.0	3.0	7.0	0.895	17.031	1.447	11.8
NOV. 2	3.9	4.3	3.0	7.3	0.937	18.612	1.553	12.0
NOV. 3	3.6	4.0	3.0	7.0	0.895	17.031	1.447	11.8
DEC. 1	3.5	3.9	3.0	6.9	0.881	16.526	1.413	11.7
DEC. 2	3.4	3.7	3.0	6.7	0.867	16.033	1.379	11.6
DEC. 3	3.4	3.7	3.0	6.7	0.867	16.033	1.379	11.6

File Name : TABLE-7.WJ2

Table 3.6 Calculation of Diversion Requirements for Paddy (3 Blocks) (Case 1)

Period	Eto (mm/day)	P (")	Re (")	AWLR (")	ACC	LPA	CA	LPWR (")	ETc (")	NLPR (")	NFR1 (")	NFR2 (")	NFR*Days (mm)	Div. Req. (1/sec/ha)
Jan. 1	3.30	3.00	4.80		1.05		0.33	11.60	3.47	0.00	0.55	0.55	5.50	0.12
. 2	3.40	3.00	1.70	0.83	0.95		0.33	11.60	3.23	0.00	1.49	2.32	23.20	0.49
. 3	3.60	3.00	1.20	0.77	0.95		0.33	11.80	3.42	0.00	1.72	2.49	27.42	0.52
Feb. 1	3.80	3.00	4.10					11.90	0.00	0.00	0.00	0.00	0.00	0.00
. 2	3.90	3.00	0.30			0.67		12.00	0.00	7.84	0.00	7.84	78.40	1.65
. 3	3.90	3.00	1.30			0.67		12.00	0.00	7.17	0.00	7.17	64.52	1.51
Mar. 1	3.50	3.00	7.70		1.10	0.33	0.33	11.70	3.85	1.32	0.00	1.32	13.20	0.28
. 2	4.10	3.00	4.70		1.10	0.33	0.33	12.10	4.51	2.44	0.93	3.37	33.70	0.71
. 3	4.20	3.00	4.20		1.10	0.33	0.67	12.20	4.62	2.64	2.29	4.93	54.24	1.04
Apr. 1	4.00	3.00	13.80	0.83	1.08	0.33	0.67	12.10	4.32	0.00	0.00	0.83	8.30	0.17
. 2	4.10	3.00	10.70	0.83	1.08	0.33	0.67	12.10	4.43	0.46	0.00	1.29	12.90	0.27
. 3	4.20	3.00	6.30	0.83	1.07		1.00	12.20	4.49	0.00	1.19	2.02	20.20	0.43
May 1	3.80	3.00	8.40	1.67	1.03		1.00	11.90	3.91	0.00	0.00	1.67	16.70	0.35
2	3.90	3.00	3.60	0.83	1.03		1.00	12.00	4.02	0.00	3.42	4.25	42.50	0.89
3	3.90	3.00	3.20	1.53	1.00		0.67	12.00	3.90	0.00	2.48	4.01	44.10	0.84
Jun. 1	3.90	3.00	5.90	1.67	1.00		0.67	12.00	3.90	0.00	0.67	2.34	23.40	0.49
. 2	4.00	3.00	3.10		1.05		0.33	12.10	4.20	0.00	1.35	1.35	13.50	0.28
. 3	4.10	3.00	1.40	0.83	0.95		0.33	12.10	3.90	0.00	1.81	2.64	26.40	0.56
Jul. 1	4.40	3.00	4.80	0.83	0.95		0.33	12.30	4.18	0.00	0.79	1.62	16.20	0.34
. 2	3.80	3.00	0.40					11.90	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.90	3.00	2.50					12.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug. 1	3.90	3.00	2.20					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 2	3.90	3.00	1.10					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.80	3.00	2.40					11.90	0.00	0.00	0.00	0.00	0.00	0.00
Sep. 1	4.10	3.00	1.40			0.67		12.10	0.00	7.17	0.00	7.17	71.70	1.51
. 2	4.00	3.00	5.10			0.67		12.10	0.00	4.69	0.00	4.69	46.90	0.99
. 3	3.80	3.00	5.70		1.10	0.33	0.33	11.90	4.18	2.05	0.49	2.53	25.30	0.53
Oct. 1	4.00	3.00	6.10		1.10	0.33	0.33	12.10	4.40	1.98	0.43	2.41	24.10	0.51
. 2	3.90	3.00	7.20		1.10	0.33	0.67	12.00	4.29	1.58	0.06	1.64	16.40	0.35
. 3	3.80	3.00	2.10	0.77	1.08	0.33	0.67	11.90	4.10	3.40	3.69	7.86	86.43	1.65
Nov. 1	3.60	3.00	8.10	0.83	1.08	0.33	0.67	11.80	3.89	1.22	0.00	2.05	20.50	0.43
. 2	3.90	3.00	2.00	0.83	1.07		1.00	12.00	4.17	0.00	5.17	6.00	60.00	1.26
. 3	3.60	3.00	5.30	1.67	1.03		1.00	11.80	3.71	0.00	1.41	3.08	30.80	0.65
Dec. 1	3.50	3.00	1.70	0.83	1.03		1.00	11.70	3.61	0.00	4.91	5.74	57.40	1.21
. 2	3.40	3.00	10.00	1.67	1.00		0.67	11.60	3.40	0.00	0.00	1.67	16.70	0.35
. 3	3.40	3.00	10.50	1.53	1.00		0.67	11.60	3.40	0.00	0.00	1.53	16.83	0.32

File name : TABLE-41.WJ2

Table 3.6 Calculation of Diversion Requirements for Paddy (3 Blocks) (Case 2)

Period	Eto (mm/day)	P (")	Re (")	AWLR (")	ACC	LPA	CA	LPWR (")	ETc (")	NLPR (")	NFR1 (")	NFR2 (")	NFR*Days (mm)	Div. Req. (1/sec/ha)
Jan. 1	3.30	3.00	4.80	1.67	1.00		0.67	11.60	3.30	0.00	1.01	2.68	26.80	0.56
. 2	3.40	3.00	1.70		1.05		0.33	11.60	3.57	0.00	1.61	1.61	16.10	0.34
. 3	3.60	3.00	1.20	0.77	0.95		0.33	11.80	3.42	0.00	1.72	2.49	27.42	0.52
Feb. 1	3.80	3.00	4.10	0.83	0.95		0.33	11.90	3.61	0.00	0.83	1.66	16.60	0.35
. 2	3.90	3.00	0.30					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.90	3.00	1.30			0.67		12.00	0.00	7.17	0.00	7.17	64.52	1.51
Mar. 1	3.50	3.00	7.70			0.67		11.70	0.00	2.68	0.00	2.68	26.80	0.56
. 2	4.10	3.00	4.70		1.10	0.33	0.33	12.10	4.51	2.44	0.93	3.37	33.70	0.71
. 3	4.20	3.00	4.20		1.10	0.33	0.33	12.20	4.62	2.64	1.13	3.77	41.46	0.79
Apr. 1	4.00	3.00	13.80		1.10	0.33	0.67	12.10	4.40	0.00	0.00	0.00	0.00	0.00
. 2	4.10	3.00	10.70	0.83	1.08	0.33	0.67	12.10	4.43	0.46	0.00	1.29	12.90	0.27
. 3	4.20	3.00	6.30	0.83	1.08	0.33	0.67	12.20	4.54	1.95	0.83	3.61	36.10	0.76
May 1	3.80	3.00	8.40	0.83	1.07		1.00	11.90	4.07	0.00	0.00	0.83	8.30	0.17
2	3.90	3.00	3.60	1.67	1.03		1.00	12.00	4.02	0.00	3.42	5.09	50.90	1.07
3	3.90	3.00	3.20	0.77	1.03		1.00	12.00	4.02	0.00	3.82	4.59	50.46	0.97
Jun. 1	3.90	3.00	5.90	1.67	1.00		0.67	12.00	3.90	0.00	0.67	2.34	23.40	0.49
. 2	4.00	3.00	3.10	1.67	1.00		0.67	12.10	4.00	0.00	2.61	4.28	42.80	0.90
. 3	4.10	3.00	1.40		1.05		0.33	12.10	4.31	0.00	1.95	1.95	19.50	0.41
Jul. 1	4.40	3.00	4.80	0.83	0.95		0.33	12.30	4.18	0.00	0.79	1.62	16.20	0.34
. 2	3.80	3.00	0.40	0.83	0.95		0.33	11.90	3.61	0.00	2.05	2.88	28.80	0.61
. 3	3.90	3.00	2.50					12.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug. 1	3.90	3.00	2.20					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 2	3.90	3.00	1.10					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.80	3.00	2.40					11.90	0.00	0.00	0.00	0.00	0.00	0.00
Sep. 1	4.10	3.00	1.40					12.10	0.00	0.00	0.00	0.00	0.00	0.00
. 2	4.00	3.00	5.10			0.67		12.10	0.00	4.69	0.00	4.69	46.90	0.99
. 3	3.80	3.00	5.70			0.67		11.90	0.00	4.15	0.00	4.15	41.50	0.87
Oct. 1	4.00	3.00	6.10		1.10	0.33	0.33	12.10	4.40	1.98	0.43	2.41	24.10	0.51
. 2	3.90	3.00	7.20		1.10	0.33	0.33	12.00	4.29	1.58	0.03	1.61	16.10	0.34
. 3	3.80	3.00	2.10		1.10	0.33	0.67	11.90	4.18	3.40	3.74	7.14	78.52	1.50
Nov. 1	3.60	3.00	8.10	0.83	1.08	0.33	0.67	11.80	3.89	1.22	0.00	2.05	20.50	0.43
. 2	3.90	3.00	2.00	0.83	1.08	0.33	0.67	12.00	4.21	3.30	3.49	7.62	76.20	1.60
. 3	3.60	3.00	5.30	0.83	1.07		1.00	11.80	3.85	0.00	1.55	2.38	23.80	0.50
Dec. 1	3.50	3.00	1.70	1.67	1.03		1.00	11.70	3.61	0.00	4.91	6.58	65.80	1.38
. 2	3.40	3.00	10.00	0.83	1.03		1.00	11.60	3.50	0.00	0.00	0.83	8.30	0.17
. 3	3.40	3.00	10.50	1.53	1.00		0.67	11.60	3.40	0.00	0.00	1.53	16.83	0.32

File name : TABLE-42.WJ2

Table 3.6 Calculation of Diversion Requirements for Paddy (3 Blocks) (Case 3)

Period	Eto (mm/day)	P (")	Re (")	AWLR (")	ACC	LPA	CA	LPWR (")	ETc (")	NLPR (")	NFR1 (")	NFR2 (")	NFR*Days (mm)	Div. Req. (l/sec/ha)
Jan. 1	3.30	3.00	4.80					11.60	0.00	0.00	0.00	0.00	0.00	0.00
. 2	3.40	3.00	1.70	1.67	1.00		0.67	11.60	3.40	0.00	3.15	4.82	48.20	1.01
. 3	3.60	3.00	1.20	1.53	1.00		0.67	11.80	3.60	0.00	3.62	5.15	56.63	1.08
Feb. 1	3.80	3.00	4.10		1.05		0.33	11.90	3.99	0.00	0.95	0.95	9.50	0.20
. 2	3.90	3.00	0.30	0.83	0.95		0.33	12.00	3.71	0.00	2.11	2.94	29.40	0.62
. 3	3.90	3.00	1.30	0.83	0.95		0.33	12.00	3.71	0.00	1.78	2.61	23.53	0.55
Mar. 1	3.50	3.00	7.70			0.67		11.70	0.00	2.68	0.00	2.68	26.80	0.56
. 2	4.10	3.00	4.70			0.67		12.10	0.00	4.96	0.00	4.96	49.60	1.04
. 3	4.20	3.00	4.20		1.10	0.33	0.33	12.20	4.62	2.64	1.13	3.77	41.46	0.79
Apr. 1	4.00	3.00	13.80		1.10	0.33	0.33	12.10	4.40	0.00	0.00	0.00	0.00	0.00
. 2	4.10	3.00	10.70		1.10	0.33	0.67	12.10	4.51	0.46	0.00	0.46	4.60	0.10
. 3	4.20	3.00	6.30	0.83	1.08	0.33	0.67	12.20	4.54	1.95	0.83	3.61	36.10	0.76
May 1	3.80	3.00	8.40	0.83	1.08	0.33	0.67	11.90	4.10	1.16	0.00	1.99	19.90	0.42
2	3.90	3.00	3.60	0.83	1.07		1.00	12.00	4.17	0.00	3.57	4.40	44.00	0.93
3	3.90	3.00	3.20	1.53	1.03		1.00	12.00	4.02	0.00	3.82	5.35	58.82	1.13
Jun. 1	3.90	3.00	5.90	0.83	1.03		1.00	12.00	4.02	0.00	1.12	1.95	19.50	0.41
. 2	4.00	3.00	3.10	1.67	1.00		0.67	12.10	4.00	0.00	2.61	4.28	42.80	0.90
. 3	4.10	3.00	1.40	1.67	1.00		0.67	12.10	4.10	0.00	3.82	5.49	54.90	1.16
Jul. 1	4.40	3.00	4.80		1.05		0.33	12.30	4.62	0.00	0.93	0.93	9.30	0.20
. 2	3.80	3.00	0.40	0.83	0.95		0.33	11.90	3.61	0.00	2.05	2.88	28.80	0.61
. 3	3.90	3.00	2.50	0.77	0.95		0.33	12.00	3.71	0.00	1.39	2.16	23.74	0.45
Aug. 1	3.90	3.00	2.20					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 2	3.90	3.00	1.10					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.80	3.00	2.40					11.90	0.00	0.00	0.00	0.00	0.00	0.00
Sep. 1	4.10	3.00	1.40					12.10	0.00	0.00	0.00	0.00	0.00	0.00
. 2	4.00	3.00	5.10					12.10	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.80	3.00	5.70			0.67		11.90	0.00	4.15	0.00	4.15	41.50	0.87
Oct. 1	4.00	3.00	6.10			0.67		12.10	0.00	4.02	0.00	4.02	40.20	0.85
. 2	3.90	3.00	7.20		1.10	0.33	0.33	12.00	4.29	1.58	0.03	1.61	16.10	0.34
. 3	3.80	3.00	2.10		1.10	0.33	0.33	11.90	4.18	3.40	1.84	5.24	57.64	1.10
Nov. 1	3.60	3.00	8.10		1.10	0.33	0.67	11.80	3.96	1.22	0.00	1.22	12.20	0.26
. 2	3.90	3.00	2.00	0.83	1.08	0.33	0.67	12.00	4.21	3.30	3.49	7.62	76.20	1.60
. 3	3.60	3.00	5.30	0.83	1.08	0.33	0.67	11.80	3.89	2.15	1.06	4.04	40.40	0.85
Dec. 1	3.50	3.00	1.70	0.83	1.07		1.00	11.70	3.75	0.00	5.05	5.88	58.80	1.24
. 2	3.40	3.00	10.00	1.67	1.03		1.00	11.60	3.50	0.00	0.00	1.67	16.70	0.35
. 3	3.40	3.00	10.50	0.77	1.03		1.00	11.60	3.50	0.00	0.00	0.77	8.47	0.16

File name : TABLE-43.WJ2

Table 3.6 Calculation of Diversion Requirements for Paddy (3 Blocks) (Case 4)
(Case 4 Start of 1st Crop : Mar.11, 2nd Crop : Oct. 1)

Period	Eto (mm/day)	P (")	Re (")	AWLR (")	ACC	LPA	CA	LPWR (")	ETc (")	NLPR (")	NFR1 (")	NFR2 (")	NFR*Days (mm)	Div. Req. (l/sec/ha)
Jan. 1	3.30	3.00	4.80	0.83	1.03		1.00	11.60	3.40	0.00	1.60	2.43	24.30	0.51
. 2	3.40	3.00	1.70	1.67	1.00		0.67	11.60	3.40	0.00	3.15	4.82	48.20	1.01
. 3	3.60	3.00	1.20	1.53	1.00		0.67	11.80	3.60	0.00	3.62	5.15	56.63	1.08
Feb. 1	3.80	3.00	4.10		1.05		0.33	11.90	3.99	0.00	0.95	0.95	9.50	0.20
. 2	3.90	3.00	0.30	0.83	0.95		0.33	12.00	3.71	0.00	2.11	2.94	29.40	0.62
. 3	3.90	3.00	1.30	0.83	0.95		0.33	12.00	3.71	0.00	1.78	2.61	23.53	0.55
Mar. 1	3.50	3.00	7.70					11.70	0.00	0.00	0.00	0.00	0.00	0.00
. 2	4.10	3.00	4.70			0.67		12.10	0.00	4.96	0.00	4.96	49.60	1.04
. 3	4.20	3.00	4.20			0.67		12.20	0.00	5.36	0.00	5.36	58.96	1.13
Apr. 1	4.00	3.00	13.80		1.10	0.33	0.33	12.10	4.40	0.00	0.00	0.00	0.00	0.00
. 2	4.10	3.00	10.70		1.10	0.33	0.33	12.10	4.51	0.46	0.00	0.46	4.60	0.10
. 3	4.20	3.00	6.30		1.10	0.33	0.67	12.20	4.62	1.95	0.88	2.83	28.30	0.60
May 1	3.80	3.00	8.40	0.83	1.08	0.33	0.67	11.90	4.10	1.16	0.00	1.99	19.90	0.42
2	3.90	3.00	3.60	0.83	1.08	0.33	0.67	12.00	4.21	2.77	2.42	6.02	60.20	1.27
3	3.90	3.00	3.20	0.77	1.07		1.00	12.00	4.17	0.00	3.97	4.74	52.17	1.00
Jun. 1	3.90	3.00	5.90	1.67	1.03		1.00	12.00	4.02	0.00	1.12	2.79	27.90	0.59
. 2	4.00	3.00	3.10	0.83	1.03		1.00	12.10	4.12	0.00	4.02	4.85	48.50	1.02
. 3	4.10	3.00	1.40	1.67	1.00		0.67	12.10	4.10	0.00	3.82	5.49	54.90	1.16
Jul. 1	4.40	3.00	4.80	1.67	1.00		0.67	12.30	4.40	0.00	1.74	3.41	34.10	0.72
. 2	3.80	3.00	0.40		1.05		0.33	11.90	3.99	0.00	2.17	2.17	21.70	0.46
. 3	3.90	3.00	2.50	0.77	0.95		0.33	12.00	3.71	0.00	1.39	2.16	23.74	0.45
Aug. 1	3.90	3.00	2.20	0.83	0.95		0.33	12.00	3.71	0.00	1.49	2.32	23.20	0.49
. 2	3.90	3.00	1.10					12.00	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.80	3.00	2.40					11.90	0.00	0.00	0.00	0.00	0.00	0.00
Sep. 1	4.10	3.00	1.40					12.10	0.00	0.00	0.00	0.00	0.00	0.00
. 2	4.00	3.00	5.10					12.10	0.00	0.00	0.00	0.00	0.00	0.00
. 3	3.80	3.00	5.70					11.90	0.00	0.00	0.00	0.00	0.00	0.00
Oct. 1	4.00	3.00	6.10			0.67		12.10	0.00	4.02	0.00	4.02	40.20	0.85
. 2	3.90	3.00	7.20			0.67		12.00	0.00	3.22	0.00	3.22	32.20	0.68
. 3	3.80	3.00	2.10		1.10	0.33	0.33	11.90	4.18	3.23	1.68	4.91	54.01	1.03
Nov. 1	3.60	3.00	8.10		1.10	0.33	0.33	11.80	3.96	1.22	0.00	1.22	12.20	0.26
. 2	3.90	3.00	2.00		1.10	0.33	0.67	12.00	4.29	3.30	3.54	6.84	68.40	1.44
. 3	3.60	3.00	5.30	0.83	1.08	0.33	0.67	11.80	3.89	2.15	1.06	4.04	40.40	0.85
Dec. 1	3.50	3.00	1.70	0.83	1.08	0.33	0.67	11.70	3.78	3.30	3.40	7.53	75.30	1.58
. 2	3.40	3.00	10.00	0.83	1.07		1.00	11.60	3.64	0.00	0.00	0.83	8.30	0.17
. 3	3.40	3.00	10.50	1.53	1.03		1.00	11.60	3.50	0.00	0.00	1.53	16.83	0.32

File name : TABLE-44.WJ2