PART II

Pre-feasibility Study on the Selected Areas

CHAPTER 1 PRIORITY AREA SELECTION

Under this "Project on Formulation of Irrigation Development and Management Strategy for Food Security in the Republic of Indonesia (the Project)", a nationwide strategy of irrigation development and management for the whole Indonesia with the target year 2044 has been formulated as presented in Part I of this report. Further, the Project requires the JICA team to conduct a preliminary feasibility study (pre-FS) for the selected priority areas. Through a series of discussions with the Indonesian counterparts, 4 areas have been selected as top priority areas for the conduct of pre-FS. Following describe the process of selecting the top 4 priority areas:

1.1 Criteria of Selecting Top 4 Priority Areas

To start selecting the top 4 priority areas for the conduct of pre-FS, the following overall criteria were raised and agreed upon by both the JICA team and counterpart organization, DILL of DGWR.

1) Scale in hectarage: Minimum 10,000 ha for new development, and 50,000 ha for rehabilitation/ modernization project,
2) Scale in investment: Minimum 100 MUS$ (about 1.5 trillion Rp) per area,
3) New development: 3-5 new areas located side by side, or within one river territory, can be grouped as one project if one new development project cannot be more than the 10,000 ha scale, and the area to be newly developed should be located in existing rainfed paddy areas (easy to develop irrigation) or in fully suitable area considering the possibility of surface/gravity irrigation,
4) Rehabilitation: 3-5, or even more, rehabilitation projects can be selected and grouped in one package if one rehabilitation project cannot be more than the 50,000 ha,
5) Dam: NO dam project is undertaken considering social and environmental issues nowadays; however, if the dam were to be constructed by the Government of Indonesia, it would be accepted for the canal network development and expansion of the beneficial area,
6) Other donors: No overlap with other donors, and
7) New capital: The government of Indonesia has a plan to move the capital from the current Jakarta to the eastern part of Kalimantan, which should be considered in selecting priority areas.

In relation to the above criteria of 1) and 2), the DGWR has developed a large number of new irrigation schemes and rehabilitated them as well during the last 5-year development term, 2015-19. In fact, the central government, DGWR, has developed approximately 130,000 ha of new irrigation schemes and rehabilitated about 670,000 ha total areas for 2015-19; namely, with annual averages of 27,000 ha for new development and 130,000 ha for rehabilitation respectively. With such huge achievement by the government itself, the schemes which would involve donor(s) should be of large scale, e.g., each more than 10,000 ha and 50,000 ha, with more than 100 MUS$ investment each, respectively for the new development and the rehabilitation.

Concerning the above criteria of 3) and 4), though, it may be difficult to secure such large development and rehabilitation areas by one scheme. To cope with this limitation, a couple number to several number of potential sites can be grouped and be developed or rehabilitated as one project. Those sites, however, should basically be located side-by-side or otherwise within one river territory area, or within neighboring river territory areas from the implementation point of view.

In relation to the above criterion of 5), in principle, a new irrigation development, which needs dam construction would not be undertaken taking into account social and environmental issues nowadays.

To develop a new dam at a certain scale, lots of concerns such as land acquisition, resettlement, natural environmental change, etc. may cause an unforeseen delay in the realization of such projects. Thus, no irrigation project associated with new dam construction would not be basically taken up. Further, to avoid duplication or overlapped investment, a project which has already been earmarked by a donor shall not be undertaken by this pre-FS, as indicated under criterion 6).

Lastly, concerning Criterion 7), in line with the government plan of moving the capital from the current Jakarta to an eastern[1] part of Kalimantan, DGWR requested the JICA team to look for new irrigation development area(s) with a target of minimum 50,000 ha in the eastern part of Kalimantan as far as there is potential. This is to supply enough stable food of rice to the new capital population in the future. To respond to this request, the JICA team would also examine the possibility of developing new irrigation schemes in the eastern part of Kalimantan island.

1.2 Top 4 Priority Areas Selected

Through a series of discussions with the Indonesian counterparts while referring to the above criteria, 4 areas have been selected as top priority areas for the conduct of the preliminary feasibility study. The 4 areas are such as Lampung province (BBWS Mesuji Sekampung), Kalimantan East province (BWS Kalimantan I), Central Java province (BBWS Pemali Juana) and South Sulawesi province (BBWS Pompengan Jeneberang). The former 2 areas envisage new irrigation development while the latter 2 areas are to undertake rehabilitation and also modernization of existing irrigation schemes. The irrigation areas identified are summarized as follows, and the selection process is elaborated in the following sections:

Table 1.2.1 List of the Selected Four Priority Areas for Preliminary Feasibility Study

Province	B/BWS	Service Area (Net), ha	Mode of Development	Remarks
Lampung	Mesuji Sekampung	56,886	New Development	Komering extension (4-1)
Kalimantan East	Kalimantan I	53,915	New Development	3 places (KT2, 31&32, 4)
Central Java	Pemali Juana	134,362	Rehab./ Modernization	Total 11 schemes
South Sulawesi	Pompengan Jeneberang	49,829	Rehabilitation	Total 5 schemes

Source: JICA Project Team

1.2.1 Priority Areas for New Development

Water resources potential as well as land potential have been assessed over Indonesia during the first stage of this Project. As a sum of the two essential potentials, i.e., water resources potential and land potential, irrigation development potential has been finally presented as discussed in 'Part I 8.2 Irrigation Development Potential based on Land and Water Potentials'. Priority areas for the conduct of pre-FS on the new development schemes shall be selected out of the high irrigation potential areas.

Figure 1.2.1 shows the irrigation potential by 5 levels with 'A' being the highest while 'E' showing the lowest potential. The map indicates that a large extent of the highest irrigation potential can be found in the southern part of Sumatera island, south-eastern part of Kalimantan island, and south-western part of Sulawesi island. The Eastern part of Kalimantan island, where the new capital is to be constructed, has the irrigation potential classified as 'B', 2nd highest irrigation potential.

Therefore, responding to the DGWR's request, Kalimantan east can be selected as one of the new irrigation development potential areas (see the blue circle in the figure below). Following the Kalimantan East, the southern part of Sumatera is selected for new irrigation development (see the blue circle in the figure below), as the potential is very high and of a large extent than that of the south-

[1] The new capital is planned to construct over such two Kabupatens (regencies) of Penajam Paser and Kutai Kartanegara, located in south-western direction from Samalinda city, East Kalimantan Province.

western part of Sulawesi.

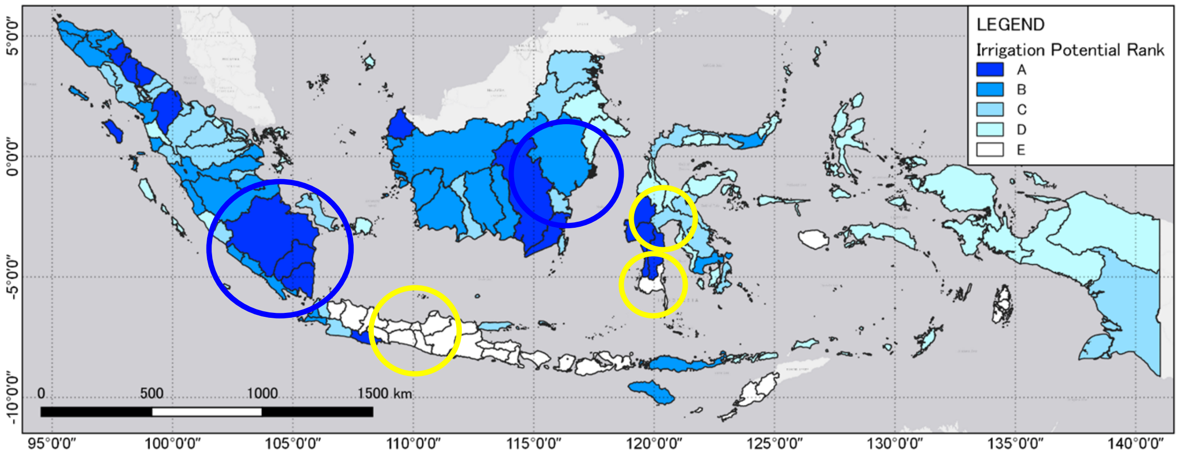


Figure 1.2.1 Irrigation Development Potential Classified into 4 Ranks
Source: JICA Project Team
Note: Blue circle shows the priority areas for new development,
and yellow circle does the priority areas for rehabilitation/ modernization.

1.2.2 Priority Areas for Rehabilitation/ Modernization

Rehabilitation/ modernization projects should, by its nature, be targeted in such areas where lots number of irrigation projects had been implemented so far, and thus there should be lots number of existing irrigation projects which have been deteriorated to some extent whereby requiring rehabilitation/ repair/ modernization. In this regard, Java island should be selected with the highest priority where the irrigation ratio for paddy has already reached as high as 75% (BPS data for 2015), and probably followed by Sulawesi island having an irrigation ratio of 68% (BPS, 2015)[2].

Through a series of discussions of DILL officers/staff, Central Java province and South Sulawesi province were identified as the potential rehabilitation/ modernization areas (see the yellow circle in Figure 1.2.1), in which there are many existing irrigation schemes and also there are high needs of rehabilitating existing schemes. The JICA team visited the BBWS offices in charge of the river territories for the 2 potential provinces in February-March 2020, and had discussed with the officers/staff in order to identify irrigation schemes that need rehabilitation.

Based on the discussions above, the following irrigation schemes have been identified as the target schemes for rehabilitation as listed in Table 1.2.1 for Central Java province and in Table 1.2.2 for South Sulawesi province. Namely, in the Central Java province, total 11 schemes were identified for rehabilitation with a total existing irrigation area of about 134,000 ha, while in South Sulawesi province, total 5 schemes were selected with a total irrigation area of approximately 50,000 ha (for the detail location, see relevant location maps in Chapter 3 and Chapter 5 respectively).

Of the irrigation schemes identified for rehabilitation in Central Java province, such 3 schemes as DI Sidorejo, DI Sedadi and DI Klambu were targeted for modernization The 3 schemes are supplied irrigation water from Kedung Ombo dam, and during the last 5-year mid-term, rehabilitation was brought about to an extent. With the rehabilitation works already done, BBWS and JICA team had agreed, for this time, to formulate a modernization plan in addition to rehabilitation as still required.

[2] As a reference, irrigation ratio of Sumatera island is 48% (BPS, 2015) and that of Kalimantan island is in fact only 16% (BPS, 2015), both of which may indicate more potential for new irrigation development rather than potential of rehabilitation in those 2 islands.

Table 1.2.2 List of Irrigation Schemes for Rehabilitation/ Modernization in Central Java Province

DI_ID	Scheme Name	Type	Service Area, ha	Water Resource
1	DI Pemali	Rehabilitation	26,952	Sungai Pemali
2	DI Kumisik	ditto	3,940	Sungai Kluwut
3	DI Gung	ditto	6,632	Waduk Cacaban
4	DI Cacaban	ditto	7,439	Waduk Cacaban
5	DI Rambut	ditto	7,634	Waduk Cacaban
6	DI Sungapan	ditto	7,086	Sungai Waluh
7	DI Comal	ditto	8,882	Sungai Comal
8	DI Kedung Asem	ditto	4,353	Sungai Kuto
9	DI Sidorejo	Modernization	7,938	Waduk Kedung Ombo
10	DI Sedadi	ditto	16,055	Waduk Kedung Ombo
11	DI Klambu	ditto	37,451	Waduk Kedung Ombo
	Total		134,362	

Source: BBWS Pemali Juana, DGWR

Table 1.2.3 List of Irrigation Schemes for Rehabilitation in South Sulawesi Province

DI_ID	Scheme Name	Type	Service Area, ha	Water Resource
1	DI Kelara Karalloe	Rehabilitation	10,000	Sungai Kelara & Sungai Karalloe
2	DI Lekopancing	ditto	3,626	Sungai Lekopancing
3	DI Bantimurung	ditto	6,513	Sungai Bantimurung
4	DI Lamasi	ditto	11,506	Sungai Lamasi
5	DI Kalaena	ditto	18,184	Sungai Kalaena & Sungai Singgeni
	Total		49,829	

Source: BBWS Pompengan Jeneberang, DGWR

CHAPTER 2 PRE-FEASIBILITY STUDY: LAMPUNG PROVINCE (SUMATERA)

One of the top 4 priority areas selected is Lampung province for new irrigation development. This chapter undertakes preliminary feasibility study (pre-FS) for Lampung province, for which the BBWS in charge are Mesuji Sekampung being the majority and partly Sumatera VIII. The pre-FS examines potential of new irrigation development within the province from the viewpoint of land and water resources potential, as well as from agricultural point of view. The pre-FS also includes economic analysis for recommended projects.

2.1 Status of the Project Area

2.1.1 Spatial Settings, and Salient Features

Lampung province is located in the most south-eastern corner of Sumatera island, which is, as shown in the following maps, covered by 2 BBWS offices, i.e., Mesuji Sekampung in charge of river territory of 01.45.A3 and Sumatera VIII (01.43A2). It has a short border with the province of Bengkulu to the northwest, and a longer border with the province of South Sumatra (Sumatera Selatan) to the north. The province extends over an area of 35,376.50 sq.km and is located between the latitudes of 105°45'-103°48 'E and 3°45'-6°45' S.

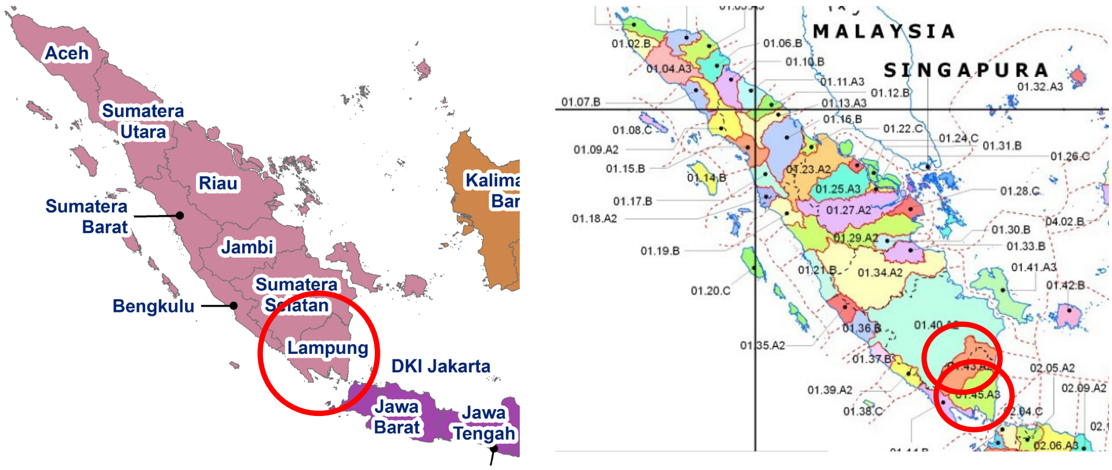


Figure 2.1.1 Location of the Lampung Province and BBWS Offices in Charge

Source: Directorate General of Water Resources

Lampung's natural terrain varies depending on the location. Along the coast in the west and the south is an area of rolling hills connected to the Bukit Barisan mountain range, running throughout Sumatra from north to south. In the center of the province is mostly lowland while the areas close to the coast in the east, along with the shores of the Java Sea are very flat and are occupied with many lowlands. With this topography, major crops in the province include Robusta coffee beans, cocoa beans, coconuts and cloves. This has resulted in a thriving agricultural sector with large scale plantation companies.

The province had a population of 8,109,601 at the 2015 Census, the latest official estimate (as of 2019), with three-quarters of that being descendants of Javanese, Madurese, and Balinese migrants. These migrants came from more densely populated islands, in search of available land, as well as being part of the national government's Indonesian transmigration program, of which Lampung was one of the earliest and most significant transmigration destinations.

In this Lampung province, the JICA team at first contacted BBWS Mesuji Sekampung office (01.45.A3) in order to identify specific areas where new irrigation schemes can be developed. Through the discussions with the BBWS office and also with the DILL headquarters, several potential sites for new development were proposed, and the JICA team with the BBWS staff conducted field visits to physically observe the possibility of establishing new irrigation schemes.

The potential sites are summarized in Table 2.1.1 and shown in Figure 2.1.2. Of the 6 potential sites proposed, No.3 to No.6 sites were excluded from the candidate pre-FS sites due to their small sizes of potential areas. Thus, the JICA Team, BBWS office and DILL headquarters had agreed upon to explore the development potential of Komering extension area and Giham-Tahmi area, and conduct the pre-FS accordingly. As a result of the pre-FS, the Team has arrived at a recommendation to develop Komering Extension Area No.4-1 whose potential net irrigation area is estimated as almost 70,000 ha.

Table 2.1.1 Summary of the Potential Sites in Lampung Province

No.	Name of Irrigation Scheme	Potential Area*, ha	Remarks
1	Komering Extension (Extension No.4 area)	Over 90,000 **Ext. No.4-1; over 70,000** Ex. No.4-2: about 12,000 Ex. No.4-4: about 12,000	Extension from existing Komering DI in BBWS Sumatra VIII (Ext. No.4 is located in BBWS Mesuji Sekampung)
2	Giham-Tahmi**	About 6,700 + 2,600	Completely new area, but very hilly
3	Pidada Tulang Bawang (extension)	About 2,000-3,000	Lowland
4	Dente Teladas	About 3,500	DD finished in 2015
5	Rumbia Extension	About 15,000	On-going by the Government fund
6	Sekumpung (modernization, under study)	-	Only modernization

Note: * the potential area in this table is tentative and indicative only. ** Giham and Tahmi sites are located side by side, and accordingly these 2 sites are undertaken as one irrigation potential site.
Source: Based on the information from BBWS Mesuji Sekampung

2.1.2 Rainfall and River Discharge

As afore-mentioned, pre-FS is conducted on the 2 potential sites of Komering extension area and Giham and Tahmi area (see Table 2.1.1). In this section, rainfall and river discharge condition are examined by River Territory, by target watershed and the potential irrigation schemes of Komering extension and Giham/Tahmi. The watershed area is delineated based on the DEMNAS provided by Badan Informasi Geospasial (BIG), and it should be noted that the location of the DI. Komering[1], an existing irritation scheme, and its proposed beneficial area (Tulang Bawang) to which the irrigation water is provided from the DI Komering, are on different river territory in terms of their watershed area.

The locations of each watershed, beneficial area, available rainfall and discharge stations are shown in Figure 2.1.3. There are many available rainfall

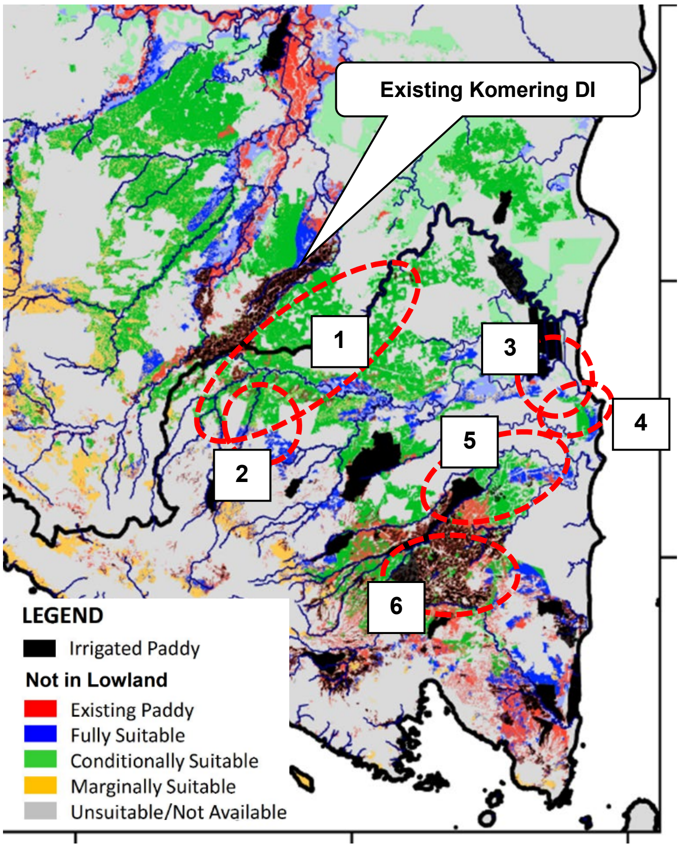


Figure 2.1.2 Location of Potential Sites for New Development
Source: BBWS Mesuji Sekampung

[1] DI Komering is an existing irrigation scheme which was constructed in the upstream area of Komering river across the South Sumatra and Lampung provinces. JICA has funded the construction of Komering Irrigation Project based on the Master Plan formulated in 1979. The Komering Irrigation Project consists of three stages. The stages I and II were completed before, and the Phase III, covering 8,500 ha of the Lempuing area, is on-going and scheduled to complete in 2023. By the completion of the three stages, total irrigation area is expected to be 72,639 ha.

records in the target area, and discharge records of Komering river and Giham river are available. In addition, watershed area of DI. Komering, the existing irrigation scheme, is much larger than that of Giham-Tahmi irrigation scheme, the former of which is 4,305 sq.km whereas the latter of which is only 290 sq.km.

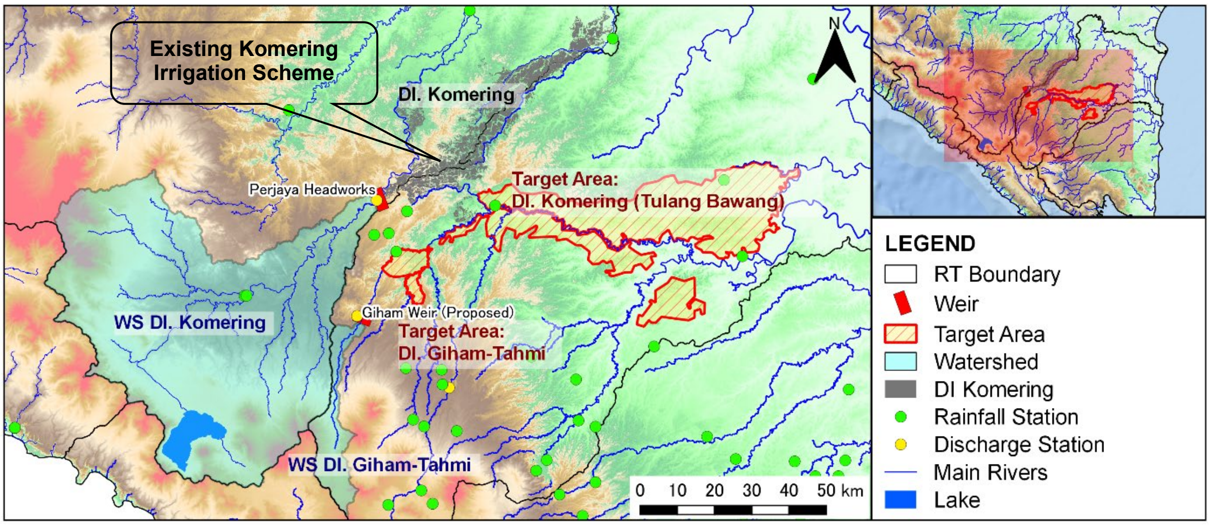


Figure 2.1.3 Location Map of Komering Extension Area (Tulang Bawang), Giham-Tahmi Irrigation Scheme and Available Rainfall and Discharge Stations

Source: JICA Project Team

1) Rainfall Condition

Average Monthly Rainfall (P_{ave}) and 80% exceeding probability rainfall ($P_{80\%}$) are shown for the target river territories and irrigation schemes. In addition, rainfall amount on the beneficiary area, the source of effective rainfall for paddy cultivation is also calculated (it is attached in Appendix). In this target area, average annual rainfall is calculated at around 2,100 mm to 2,500 mm, and 80% exceeding probability rainfall comes to approximately 1,300 mm to 1,400 mm. The rainfall distribution shows a clear dry season (June to October) and wet season (November to April), which is a typical rainfall distribution pattern called “Monsoon Type” showing up in the South of Sumatera and also Java Island.

Table 2.1.2 Average Rainfall (P_{ave}) by River Territory and Watershed Area (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1.40.A2	WS MSBL*	261	253	301	266	208	166	160	152	172	241	300	306	2787
-	Komering	254	276	282	252	179	142	110	140	131	147	275	263	2451
1.43.A2	WS Mesuji Tulangbawang	240	255	286	202	151	128	119	100	107	139	189	274	2190
-	Giham	240	276	271	232	137	112	92	88	105	114	216	236	2120

Note: MSBL as Musi-Sugihan-Banyuasin-Lemau Source: JICA Project Team

Table 2.1.3 80% Exceeding Probability Rainfall ($P_{80\%}$) by River Territory and Watershed Area (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1.40.A2	WS MSBL*	166	162	200	179	126	85	76	56	62	120	197	207	1635
-	Komering	157	188	175	153	106	70	44	43	41	69	180	171	1396
1.43.A2	Mesuji Tulangbawang	158	199	185	136	100	62	44	28	39	63	127	192	1331
-	Giham	157	217	174	151	91	53	31	22	40	50	148	165	1298

Note: MSBL as Musi-Sugihan-Banyuasin-Lemau Source: JICA Project Team

2) Discharge Condition

According to the Standard of Irrigation Planning - Irrigation Network Planning (MPWH 2013, hereinafter called KP-01), 80% exceeding probability of discharge ($Q_{80\%}$) is applied to estimate the water potential for the purpose of deciding the design discharge. In addition, 95% exceeding probability of discharge ($Q_{95\%}$) should be calculated in order to determine the discharge for the river maintenance purpose, complying with the Government regulation concerning river, No.38, 2011.

The calculation is based on the probability analysis, which was elaborated in Chapter 5 of Part I with actual discharge records for the Komering river and Giham river. Monthly records are summarized in Table 2.1.4 and Table 2.1.5, and P80% and Q80% by the target watersheds are illustrated in Figure 2.1.4. The results show both watersheds have similar tendency in rainfall and river discharge, approximately 100 mm/month Q80% discharge during wet season and 30 mm/month to 50 mm/month Q80% discharge during dry season respectively with approximately 910 - 960 mm annual discharge.

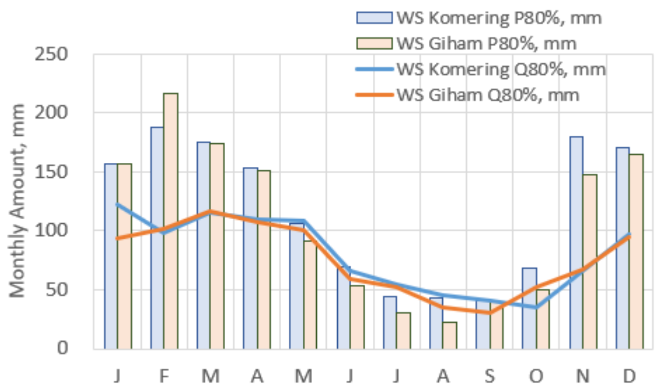


Figure 2.1.4 Rainfall (P80%) and Discharge (Q80%) in the Target Watersheds
Source: JICA Project Team

Table 2.1.4 River Discharge Condition in the Watershed Komering (4,305 km²)

Item	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Qave	mm	159	134	155	151	150	93	73	66	69	91	114	153	1407
Q80%	mm	122	99	115	110	109	66	55	45	41	35	66	98	959
	m^3/s	196	176	185	182	174	110	88	73	68	56	109	157	-
Q95%	mm	89	76	89	87	70	50	43	33	28	19	22	71	677

Source: JICA Project Team

Table 2.1.5 River Discharge Condition in the Watershed Giham-Tahmi (290 km²)

Item	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Qave	mm	207	193	180	158	145	100	95	66	64	102	120	209	1639
Q80%	mm	94	101	116	108	101	59	52	35	31	53	67	94	911
	m^3/s	10.0	11.9	12.4	11.8	10.7	6.5	5.5	3.8	3.4	5.6	7.3	10.0	-
Q95%	mm	55	64	83	80	76	40	34	6.1	1.1	5.8	44	55	543

Source: JICA Project Team

2.1.3 Current Agriculture in Lampung Province

This section describes an overview of agriculture (especially paddy and palawija cultivation) for the entire Lampung Province and for the three Kabupatens, namely Tulang Bawang, Tulang Bawang Barat and Way Kanan where the proposed project area (Komering Ext. 4) is located.

Agriculture in Lampung Province is positioned as the most important industrial sector since as much as 30% of Gross Regional Domestic Product (GRDP) by current market price as of 2018 came from the agriculture sector[2]. Food crops cultivated are mainly paddy on the wetland, and also maize and cassava cultivated as palawija. In addition, such estate crops as rubber, coffee, oil palm, etc. are widely cultivated in the Lampung Province.

1) Agricultural Land Use

Table 2.1.6 shows the agricultural land area with the entire Lampung Province and three Kabupatens where the Project area is located. As of 2015, Lampung Province has 1.2 million ha of agricultural land, of which 31% (380,000 ha) is classified as wetland. Wetland paddy and Palawija are cultivated in this wetland, of which 51% (190,000 ha) are classified as irrigated agricultural land. By Kabupaten,

[2] BPS-Statistics of Lampung Province, Lampung Province in Figures, 2019

irrigation development is progressing in Way Kanan and Tulang Bawang Barat, with 65% and 72% being irrigated farmland, respectively. Tulang Bawang has not been irrigated as of 2015.

Figure 2.1.5 is the visual depiction of the current land use for the Project area (land use map available at ATR/BPN was superimposed on Google Earth map). As shown, there are lots number of dry farmlands (uplands) including palm and rubber plantation farms with a vast area of 56,832 ha. In addition, bush forests are distributed to some extent, yet the total area comes only to 6,375 ha.

Table 2.1.6 Agricultural Land Area in Project Area, Lampung Province (2015), Unit: 1,000 ha

Kabupaten	Wetland			Agricultural dryland				Total
	Irrigation	Non-irrigation	Sub-total	Dry field/ Garden	Unirrigated/ Shifting cultivation	Temporarily unused	Sub-total	
Tulang Bawang	0	36.8	36.8	68.1	0	2.9	71.0	107.8
Tulang Bawang Barat	8.0	3.1	11.1	41.7	0	2.9	44.5	55.6
Way Kanan	12.7	6.7	19.4	91.8	0	21.6	113.4	132.8
Lampung Province	**191.9**	**185.5**	**377.5**	**749.1**	**0**	**69.9**	**819.0**	**1196.5**

Source: Land Area by Utilization 2015 (BPS, 2016)

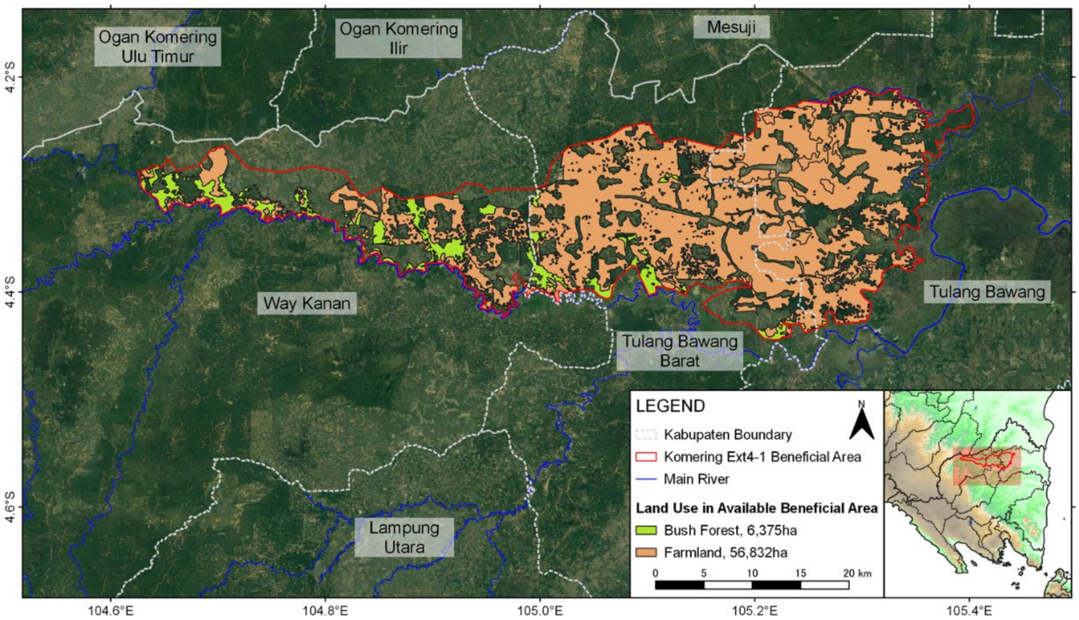


Figure 2.1.5 Agricultural Land Use Map in Project Area (Komering Ext. 4)

Source: ATR/BPN

2) Paddy Production

Table 2.1.7 shows the harvested area, yield and production of wetland paddy over the past three years (2015-2017). The harvested area has increased over the years in all the 3 Kabupatens. On the other hand, in terms of yield, both Way Kanan and Tulang Bawang Barat achieved such yield equal to or higher than the average of Lampung Province (5.18 ton/ha) as of 2017, while the yield of Tulang Bawang was low (4.49 ton/ha). This might be due to the progress of irrigation development, and the yield of Tulang Bawang, which basically applied rainfed cultivation practice, is significantly lower than the others.

Table 2.1.7 Harvest area, Yield and Production Volume of Paddy in Project Area, Lampung Province

Kabupaten	Harvested area (1,000 ha)			Yield (ton/ha)			Production (1,000 ton)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
Tulang Bawang	50.1	63.2	73.4	4.85	4.60	4.49	242.7	291.0	329.2
Tulang Bawang Barat	18.2	18.6	21.6	4.87	5.15	5.15	88.4	95.8	111.3
Way Kanan	31.9	38.3	40.8	4.67	5.47	5.37	149.2	209.1	219.3
Lampung Province	660.6	736.9	789.3	5.29	5.20	5.18	3496.5	3831.9	4090.7

Source: Lampung Province in Figures (BPS-Statistics of Lampung Province, 2016-2018)

Figure 2.1.6 shows the crop intensity of wetland paddy in Lampung Province and the 3 Kabupatens as of 2015. The average crop intensity in Lampung Province is 175%, which means multiple cropping in a year has been widely practiced. For Way Kanan and Tulang Bawang Barat, it is lower than the average, though the crop intensity has reached already to 164%. While crop intensity of Tulang Bawang was only 136% due to the rainfed paddy cultivation practice, hence there must be a limitation of available water in the Tulang Bawang.

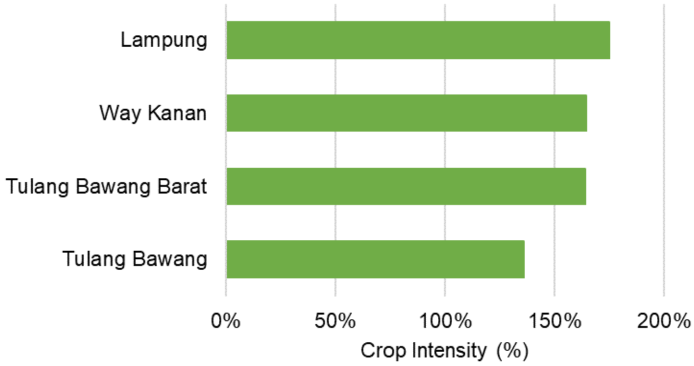


Figure 2.1.6 Crop Intensity of Paddy in Project Area, Lampung Province (2015)
Source: BPS-Statistics of Lampung Province, 2016

In recent years, creation and extension of improved varieties of rice in Indonesia have been remarkable and have greatly contributed to the increase in the yield of paddy. Figure 2.1.7 shows the share of rice varieties which are cultivated in Lampung Province as of 2017. The most used rice variety is Ciherang with a 46% share, followed by Mekongga (11.3%) and Inpari 30 Ciherang Sub 1 (10.8%). These top three rice varieties are all high yield varieties released in the 2000s. While the share of IR64, which was one of the major varieties in the Country, shares only 4.6%, and thus substitution with high-yield varieties is in progress effectively.

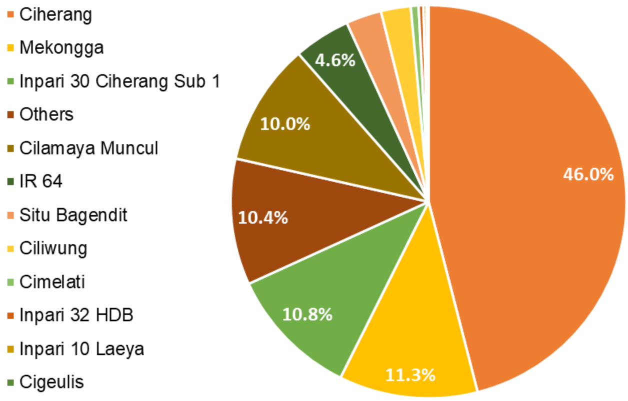


Figure 2.1.7 Share of rice varieties in Lampung Province (2017)
Source: Planted area of new superior paddy varieties year 2017 (Directorate of Seedling, Directorate General of Food Crops, Ministry of Agriculture, 2018)

3) Palawija Production

The types of Palawija, which is the secondary crop of paddy, vary depending on the regional cropping system. Figure 2.1.8 shows the top three crops in Lampung Province. In Lampung Province, the harvested areas of maize and cassava are similar, with 290,000 ha and 280,000 ha, respectively. The third crop is soybean, which is cultivated at about 8,000 ha. Soybean is counted as a strategic food crop in the country as well as rice and maize, though, it is in the situation that the promotion may not has been necessarily well.

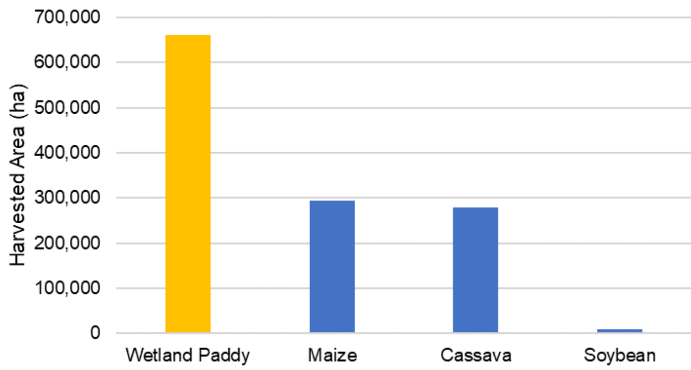


Figure 2.1.8 Harvested Area of Top 3 Palawija in Lampung Province (2015)
Source: BPS-Statistics of Lampung Province, 2016

4) Issues in Agricultural Activities

The agricultural sector in Lampung Province is a major industrial sector that contributes to 30% of GRDP as afore-mentioned. Wetland paddy is the most popular cultivated crops in Lampung Province, and thanks to the progress of irrigation development and the strategic introduction of high-yielding rice varieties, the harvested area, yield, and production volume are showing steady growth.

On the other hand, poverty in rural areas, where the community depends mainly on agricultural activities, remains an issue in Lampung Province, mainly due to complex limitations faced by farmers in accessing capital, land, technology, etc. (Fitriani et al. 2017[3]). Under this situation, agricultural promotion from the viewpoint of improving the livelihood of farmers in rural areas is essential. In addition, considering that new irrigation development (extension of Komering Irrigation Scheme) is planned under this Project, issues associated with new agricultural resettlement should be considered. The following are a list of possible issues:

- ✓ **Insufficient capital** for purchasing agricultural inputs and for securing agricultural land, facilities, and machineries,
- ✓ **Inexperienced management practices** of paddy cultivation and irrigation water use for new farmers and migrants,
- ✓ **Lower profitability (due to higher labor cost)** of paddy cultivation as compared with estate crops and horticultural crops, and
- ✓ **Lower market access** (under-developed farm roads, collection system and shipping facilities, etc.)

2.2 Agriculture Development Plan

This section describes the agricultural development plan for project implementation in Lampung Province. The plan consists of a land use plan, a cropping pattern, and a target paddy yield. In addition, necessary activities to carry out this agricultural development plan will be proposed.

2.2.1 Proposed Land Use Plan

The Project area in Lampung Province falls in three Kabupatens, namely Tulang Bawang, Tulang Bawang Barat and Way Kanan. The Project is designed to develop 56,886 ha of irrigated land through new irrigation development, that is the expansion of the existing Komering Irrigation Scheme.

Table 2.2.1 shows the land use plan for the Project area. With the development of irrigation facilities, it is planned that in the future it will be possible to introduce double cropping system on newly irrigated land. In the introduced double cropping system, paddy is cultivated as the 1st crop, and paddy or Palawija is cultivated as the 2nd crop depending upon the water availability. As a result, the cropping intensity for paddy and Palawija are expected to be 113% and 87%, respectively, resulting in a total cropping intensity to reach 200%.

Table 2.2.1 Land Use Plan in Project Area, Lampung Province

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
Tulang Bawang Tulang Bawang Barat Way Kanan	DI Komering Ext 4	New	56,886	1st	Paddy	Plan	56,886	100	100
				2nd	Paddy	Plan	7,413	13	13
					Palawija	Plan	49,473	87	87

Source: JICA Project Team

2.2.2 Proposed Cropping Pattern

Table 2.2.2 shows the cropping pattern in the project area. The cropping pattern is determined depending on the agricultural environment (regional climate, weather conditions, etc.) and the usable amount of irrigation water in the target area. With the implementation of new irrigation development, the first

[3]Fitriani et al., Lampung Rural Agriculture: Opportunities and Challenges, JoFSA Vol.1, No.2, 2017

cropping season in the target area will be able to start in early February. By introducing paddy cultivation in the first cropping season, the cropping intensity is expected to reach 100% (56,886 ha). The second cropping season will be able to start in early October. By introducing paddy cultivation, the cropping intensity is expected to reach 13% (7,413 ha). In addition, by introducing the cultivation of Palawija, the cropping intensity is expected to reach 87% (49,473 ha). In total of both first and second cropping seasons, cropping intensity is expected to reach 200%.

Table 2.2.2 Cropping Pattern (Draft) in Project Area, Lampung Province

Cropping Period	2nd				1st				-				Cropping Intensity
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Plan	Paddy (C.I.13%)	Palawija (C.I.87%)			Paddy (C.I.100%)								Paddy 113% Palawija 87% Total 200%

Source: JICA Project Team

2.2.3 Target Paddy Yield in the Future

1) Setting of Base Yield

Table 2.2.3 shows the base yield of paddy in the Project area. Due to the development of new irrigation in this area, the yield of paddy, which is the baseline, will be 0 t/ha. According to the annual statistics of Lampung Province published by BPS, the average yield of paddy in the last four years (2014-2017) was 5.23 t/ha for the whole Lampung Province. On the other hand, the average yield of paddy for the 3 Kabupatens where the Project area is located was only 4.92 t/ha with a relatively large ratio of rain-fed paddy cultivation.

Table 2.2.3 Base Yield in Project Area, Lampung Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)	Base Yield (t/ha)
Tulang Bawang Tulang Bawang Barat Way Kanan	DI Komering Ext 4	New	4.92	0.0
Lampung Province	-	-	5.23	-

Source: Lampung Province in Figures (BPS-Statistics of Lampung Province, 2015-2018)

2) Setting of Upper Limit Yield (Target Yield)

The results of the BPS crop cutting survey and other studies have shown that paddy yield depends not only on irrigation conditions, but also on the cultivar and amount of fertilizer applied (see Part 1, Chapter 3). In other words, in addition to irrigation maintenance, appropriate rice cultivation and management practices are necessary to increase paddy yield. In the newly irrigated areas, irrigated rice cultivation is newly introduced, thus the cultivation management practices should start with the introduction of basic farming methods. Therefore, the maximum yield is set using Scenario 1 as shown in Table 4.2.4.

Table 2.2.4 Applied Scenario for Upper Limit Yield (Target Yield) in Project Area, Lampung Province

Type		Scenario	Assumption	Setting Criteria
New Development	→	**1. Conventional agricultural practice**	**Maintain the conventional agricultural management practices as it is**. Newly introduction of superior seeds and fertilizer inputs beyond the current condition **are not expected.**	Using data from the SURVEI UBINAN TANAMAN PANGAN 2014, 2016, 2017 (BPS, 2014, 2016 and 2017), the upper limit has been set to the average of the top 25% yield (75th percentile of Tukey's Hinges) for each island under irrigation and non-irrigation in 2014, 2016 and 2017.

Source: JICA Project Team

Applying the scenario shown in Table 2.2.4, the maximum yield of Lampung province is 5.90 t/ha, that is an increase of 12.8% from the current average of 5.23 t/ha. This rate of increase will be applied to the Project area (DI Komering Ext. 4) to set the upper limit yield (5.55 t / ha) as shown in Table 2.2.5.

Table 2.2.5 Target Yield in Project Area, Lampung Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)	Target Yield (t/ha)	Increment (%)
Tulang Bawang Tulang Bawang Barat Way Kanan	DI Komering Ext 4	New	4.92	5.55	-
Lampung Province	-	-	5.23	5.90	12.81

Source: Lampung Province in Figures (BPS-Statistics of Lampung Province, 2015-2018)

3) Setting of Yield Increase with Time Course

As with the upper limit yield (target yield), the yield increase of paddy with time course is expected to differ depending on whether appropriate paddy cultivation management practices are introduced or not. For this reason, the yield increase with time course will be set using the scenario shown in Table 2.2.6 for the Project area where new irrigation development will be carried out.

Table 2.2.6 Applied Scenario for Yield Increase with Time Course in Project Area, Lampung Province

Type		Scenario	Assumption	Setting Criteria
New Development	→	**1. Conventional agricultural practice**	**The yield growth will change gradually**, without relying on short-term policy support such as further R&D, extension support, and subsidy.	Gradual growth is assumed to be logarithmic: the yield curve will be connected by a logarithmic curve for the yield from 1980 to the present (2017), and the yield will be increased to the upper limit yield along this curve.

Source: JICA Project Team

Table 2.2.7 shows the transition of the paddy yield after the start of the project. The yield increase is considered to be constant when and after the yield has reached to the upper limit (target yield)[4]. In estimating this target yield, although partial water flow may be made during the design + project implementation period of total 8 years and cultivation may be partially started, considering the safety side, the yield is set to zero (no cultivation is done) for the first 8 years. In addition, although paddy cultivation is expected to start in the entire beneficiary area after the completion of the Project, considering the temporary decline in soil fertility in newly developed agricultural land, the target yield is set to downward to about one-third in the 9th year (1.64 t/ha) and to about two-thirds in the 10th year (3.28 t/ha).

[4] Note that, however in this estimation, yield in the Project area has not reached to the upper limit even 15 years after the start of the Project.

Table 2.2.7 Yield Increase with Time Course in Project Area, Lampung Province

Base Yield (t/ha)	Years after project has been started															Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.64	3.28	4.92	4.93	4.95	4.96	4.98	5.55
Stage	Design＋Project Implementation								Operation & Maintenance							-

Source: JICA Project Team

4) Setting of Target Yield Other than Paddy

The types of Palawija, which is the secondary crop, vary depending on the cropping pattern in each region. In Lampung Province, maize and cassava are the main cultivated Palawija, as shown in Figure 2.1.8. In the Project area where new irrigation development will be carried out, the introduction of maize cultivation is expected for convenience, and the base yield shall be set at the same level as the current situation (that is, the cultivated area is expected to increase due to irrigation development, but the yield is not expected to increase).

Table 2.2.8 Base Yield (Maize) in Project Area, Lampung Province

Kabupaten	DI Name	Type	Type of Palawija	Base Yield (t/ha)
Tulang Bawang Tulang Bawang Barat Way Kanan	DI Komering Ext 4	New	Maize	4.35

Source: Lampung Province in Figures (BPS-Statistics of Lampung Province, 2015 and 2016)

2.2.4 Recommended Activities for Agriculture Development

In order to realize the proposed land use plan, cropping pattern, and target yield mentioned above, it is necessary to take countermeasures against the current issues in the Project area and the issues that become apparent through the development of new irrigation. This section proposes a possible approach for agriculture development as a countermeasure.

Table 2.2.9 shows the issues and countermeasures for agriculture development in the Project area. In the Project area, new farmers and migrants are expected to enter along with the development of new irrigation. Therefore, an issue that needs special attention is the lack of capital. One possible countermeasure to this issue is a government funding through the introduction of subsidy and/or loan programs. In addition, since it is necessary for new farmers and migrants to acquire agricultural management and water management practices for the new cropping system, it is essential for the government and/or the private sector to expand extension services.

Furthermore, as a regional feature of Lampung Province, the cultivation of estate crops (e.g. coffee and oil palms) and horticultural crops is already active, and the cultivation of paddy and Palawija usually presents less profit than those. This low profitability is due mainly to high labor costs, and it can be assumed that the introduction of agricultural machinery (e.g., tractor and harvesters) to reduce labor costs and the introduction of ICT tools to increase labor productivity will be effective. In addition, market access is often an issue in rural areas, and it is desired to strengthen market competitiveness by improving rice collection system and rice milling facilities, and to improve market accessibility by improving farm roads and shipping systems.

In the Project, by implementing these high-priority measures in parallel with irrigation development, it will be possible to realize the proposed land use plan, cropping pattern, and target yield, which in turn can be expected to contribute to the promotion of agriculture in the region.

Table 2.2.9 Issues and Countermeasures for Agriculture Development in Project Area, Lampung Province

Possible Issues	Countermeasures (Basic Approach)	Expected Effects
✓ **Insufficient capital** for purchasing agricultural inputs and for securing agricultural land, facilities, and machineries	✓ Introduction of subsidy program for securing agricultural inputs (quality seeds, fertilizers etc.) which is prerequisite to new farmers, migrants and/or farmers' groups	✓ Agricultural inputs will be secured
	✓ Introduction of loan program for securing working capital which is essential to start-up the agricultural activities	✓ Working capital will be secured
✓ **Inexperienced management practices** of paddy cultivation and irrigation water use for new farmers and migrants	✓ Strengthening the governmental/ private extension services of basic farming practices to build the capacity of new farmers, migrants and/or farmers' groups	✓ Capacity of agriculture management practices will be improved
	✓ Strengthening the organizational capacity of Water Users Groups	✓ Capacity of water use will be improved
✓ **Lower profitability** (due to higher labor cost) of paddy cultivation compared with estate crops and horticultural crops	✓ Introduction of agricultural machineries to reduce labor cost	✓ Labor cost will be reduced
	✓ Introduction of ICT tools to modernize agricultural practices and increase labor productivity	✓ Labor productivity (operating profits) will be increased
✓ **Lower market access** (undeveloped farm roads, aggregation system and shipping facilities, etc.)	✓ Introduction of market-oriented approach to new farmers, migrants and/or farmers' groups	✓ Market competitiveness will be increased
	✓ Improvement of aggregation system	
	✓ Improvement of milling facilities	
	✓ Improvement of farm roads	✓ Market accessibility will be improved
	✓ Improvement of shipping system	

Source: JICA Project Team

2.3 Irrigation Development and Management Plan

2.3.1 Irrigation Area Delineation: Komering Extension Scheme (Extension No.4-1 to No.4-3)

The beneficiary area is located in a water territory area called 'WS Mesuji-Tulangbawang', and composed of three areas; namely, Komering Extension 4-1, Extension 4-2, and Extension 4-3. The location map and basic profile of the target area is summarized in Figure 2.3.1. The target area can be regarded as a wide flat area with EL.23.5m of mean elevation and 2.7% of mean slope.

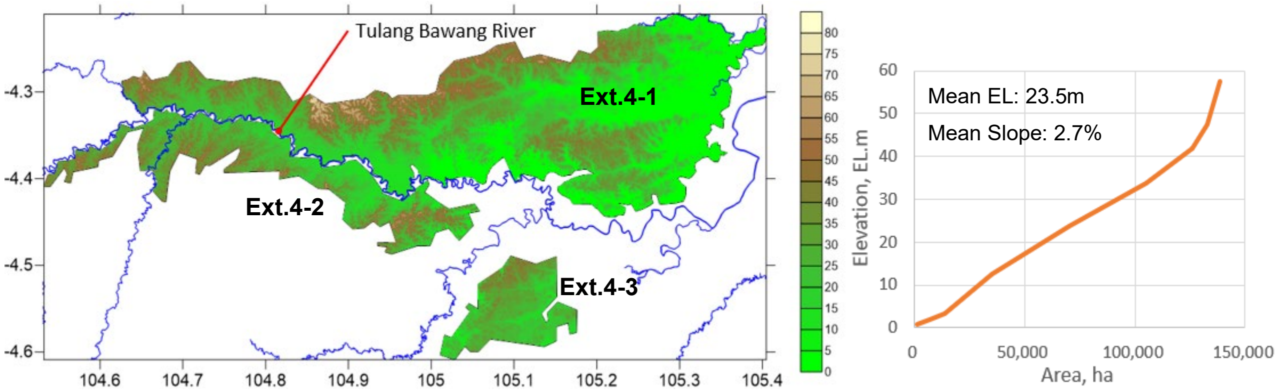


Figure 2.3.1 Elevatoin Map of the Komering Extension Target Area and its Elevation Profile

Source: JICA Project Team

To delineate the beneficial area from the gross target area, the factors described in Table 2.3.1 are considered. In this target area, it seems clear that there are many areas occupied by sugarcane and palm plantations which have not been reflected in the latest land use map provided by ATR/BPN. Therefore, plantation areas are at first delineated by visual check with latest satellite (Google Earth) images to remove those plantation areas. Also, the net beneficial area is calculated by taking 90% of the gross beneficial area complying with the KP-01 (MPWH 2013). Note that the plantation areas, detected manually by visual Google Earth reading, shall be precisely identified and reassessed in future consideration, e.g., FS stage.

Table 2.3.1 Factors to Delineate the Beneficial Area of Tulang Bawang Area from the Target Area

Factors	Explanation	Source
(1) Protection Forest	Any type of forest that cannot be converted to farmland is removed from the beneficial area. Its details are described in Part1 Chapter4.	Ministry of Environment and Forestry and Statistics of Ministry of Forestry (2013)
(2) Peat	Area where the peat thickness is more than 200cm is eliminated from the beneficial area.	Sub Directorate of Lowland, DILL
(3) Flood Risk	High risk flood area where index shows more than 0.6 is removed based on the result of flood risk assessment provided by BNPB.	Indonesian National Board for Disaster Management (BNPB 2016)
(4) Sugarcane Plantation (5) Palm Plantation	Sugarcane and Palm plantation areas are detected by visual check with latest satellite images.	Google Earth and JICA Project Team
(6) Plantation Concession (Cultivation Right)	concession areas, namely, business land use rights (Hak Guna Usaha) and land usage rights (Hak Pakai) are manually detected by BHUMI.atrbpn.	Ministry of Agrarian and Spatial Planning / National Land Agency (ATR/BPN) available at https://bhumi.atrbpn.go.id/
(7) Residential Area	Recognized as “Building area” in cities by land use map is removed from available area	National land use data (1:50,000) provided by ATR/BPN
(8) Water Body	Rivers, reservoirs, lakes are also removed as non-developable area	

Source: JICA Project Team

The result of the factor filtering is summarized in Table 2.3.2. Based on the factors (1) to (3), most of the target areas can be judged available for irrigation development; however, based on the visual check from the satellite images, sugarcane plantation and palm plantation areas currently occupy 9,579 ha and 12,599 ha in the target area respectively as depicted in Figure 2.3.2. Furthermore, as latest land use data for Komering Extension 4-1, the plantation concession area is manually re-confirmed based on the web-based spatial dataset provided by ATR-BPN (BHUMI.atrbpn available at https://bhumi.atrbpn.go.id/).

As the result, net beneficial area is calculated at 56,886 ha, 11,137 ha and 10,023 ha respectively in the Komering Extension 4-1, 4-2 and 4-3 (see Table 2.3.2). Since Komering Ext 4-1 occupies approximately 57,000 ha in net, we recommend that the Ext 4-1 should be given the highest priority to develop new irrigation scheme in Lampung province.

Table 2.3.2 Target Area and Detected Area of Each Factor (Komering Extension)

Area	Target Area	(1) Protection Forest	(2) Peat	(3) High Flood Risk	(4) Sugarcane Plantation	(5) Palm Plantation
Komering Ext 4-1	100,290 ha	12 ha	0 ha	118 ha	9,577 ha	12,605 ha
Komering Ext 4-2	26,807 ha	0 ha	0 ha	0 ha	4,898 ha	8,698 ha
Komering Ext 4-3	12,908 ha	0 ha	0 ha	0 ha	0 ha	25 ha

Area	Target Area	(6) Plantation Concession (Cultivation Right)	(7) Building Area	(8) Water Body	Beneficial Area (Gross)	Beneficial Area (Net: Gross * 0.9)
					Considering factors (1) to (8)	
Komering Ext 4-1	100,290 ha	6,673 ha	11,418 ha	3,023 ha	**63,207 ha**	**56,886 ha**
Komering Ext 4-2	26,807 ha	N/A	1,391 ha	146 ha	11,950 ha	11,137 ha
Komering Ext 4-3	12,908 ha	N/A	1,747 ha	0 ha	10,755 ha	10,023 ha

Source: JICA Project Team

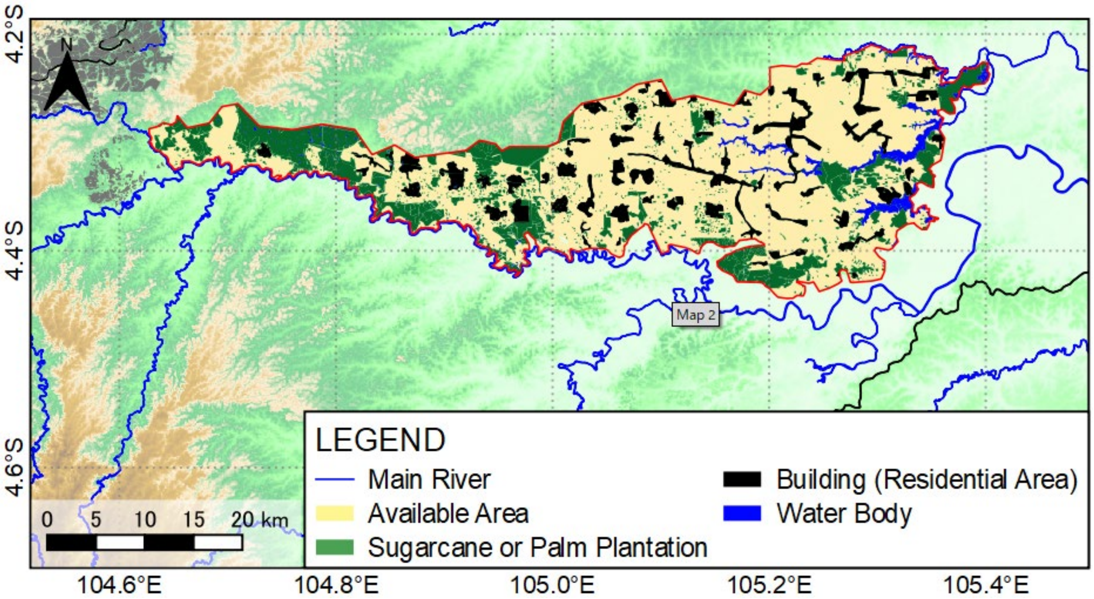


Figure 2.3.2 Location Map of the Beneficial Area in Komering Extension No.4-1

Source: JICA Project Team

2.3.2 Irrigation Area Delineation: Giham-Tahmi Irrigation Scheme

Another target irrigation area is examined in the upstream area of Kabupaten Way Kanan along the Giham river. Due to its mountainous topography, the target area contains a lot of steep and high elevation areas, presenting difficulties in irrigation development. This area shows the mean elevation of EL.67.2m and mean slope of 13.0%, much steeper than the Komering extension area of 2.7% (see Figure 2.3.3).

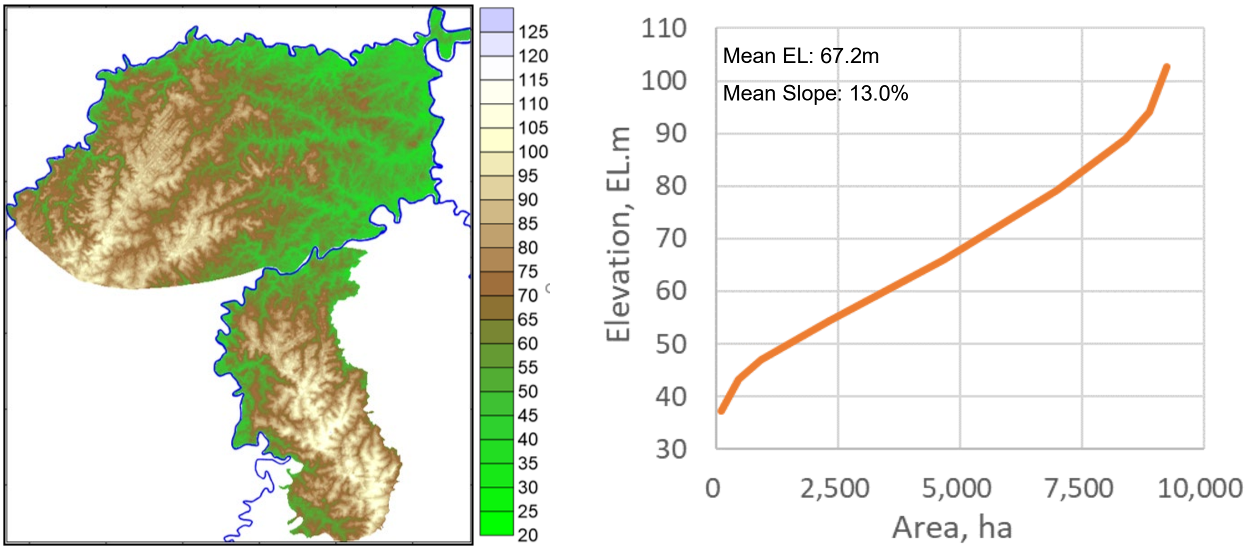


Figure 2.3.3 Elevation Map of the Giham-Tahmi Target Area and its Elevation Profile

Source: JICA Project Team

In this preliminary feasibility study, intake is designed on the Giham river where the elevation is EL.80m considering the balance of river longitudinal section, design canal length and surrounding topography, and therefore the beneficial area is restricted only in such areas where elevation should be around less than EL.70 m, to which gravity irrigation can be introduced, and the slope of the topography where paddy field is to be opened should be less than 5% from the view point of constructing new paddy fields by cut and bank earthen work.

In addition to these 2 decisive factors, i.e., elevation limitation and slope limitation, such factors as protection forest, peat area, flood risk area, and plantation areas are also examined and excluded in delineating the beneficial area of Giham-Tahmi irrigation scheme. These factors to filter the target area into the beneficiary area are summarized in Table 2.3.3, most of which are the same as those applied in examining the Komering Extension area except for the elevation and slope limitations.

As summarized in Table 2.3.3, though unavailable area for irrigation development is not so widely spread from the viewpoint of protection forest, land use, flood and peat conditions (factor (1) to (5)), strong topographic restriction (factor (6) and (7)) makes a lot of target area unavailable for irrigation development. As a result, gross and net beneficial areas which can be developed are calculated only at 3,485 ha and 3,136 ha respectively in the Giham-Tahmi irrigation scheme area (see Table 2.3.4). This net beneficial area is approximately only one-third of the identified target area, which is around 9,337 ha (see the areas segregated by purple colored zone, which cannot be benefited, in Figure 2.3.4).

Table 2.3.3 Target Area and Detected Area of Each Factor(Giham-Tahmi Irrigation Scheme)

Area	Target Area	(1) Protection Forest	(2) Land Use*: Plantation
Giham-Tahmi	9,337 ha	116 ha	709 ha
Area	(3) Land Use*: Mining	(4) Peat	(5) High Flood Risk
Giham-Tahmi	0 ha	0 ha	0 ha
Area	(6) Elevation (> EL.70m)	(7) Slope (> 5%)	
Giham-Tahmi	4,094 ha	2,821 ha	

*Note: for the land use map, the data source is ATR/BPN, which has no detail data available that if it is already planted or not.

Table 2.3.4 Beneficial Area (Giham-Tahmi Irrigation Scheme)

Area	Beneficial Area (Gross)	Beneficial Area (Net: Gross * 0.9)
	Considering factors (1) to (7), applied value	
Giham-Tahmi	**3,485 ha**	**3,136 ha**

Source: JICA Project Team

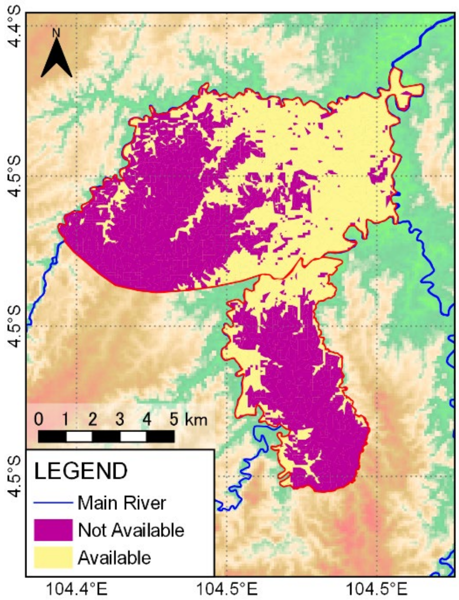


Figure 2.3.4 Location Map of the Beneficial Area in Giham-Tahmi Source: JICA Project Team

2.3.3 Available Water for Irrigation and Irrigable Area

This section discusses the methodology and the result of water balance calculation using water discharge (Q80%) and water demand such as RKI, river maintenance, and irrigation. The methodology is almost the same as the one in Part I but the applied data are more localized here in this section. Table 2.3.5 shows the differences of the methodologies of water balance calculation between Part I, which is on basis of river territory, and localize one that is irrigation scheme-wise in this Part II.

Table 2.3.5. Methodologies for the Water Balance Calculation in Part 1 and Part 2

Item	Part I	Part II
Design Rainfall (P80, P95) Effective Rainfall (P_E)	By River Territory	By Watershed of intake facilities and beneficial area
Design Cropping Pattern	Based on BPS record by province (2015)	Based on actual cropping pattern by Kabupaten and rainfall pattern, or design cropping pattern based on past report (Rencana)
Design Discharge (Q80) River Maintenance Flow (Q95)	Based on the linear equation between rainfall and discharge	Based on the actual record, or Study result on Rencana by watershed
Water Demand	RKI, river maintenance, fishpond, livestock and irrigation water demand by River Territory	Based on Rencana data (Kabupaten-wise or sub-basin-wise data)
Potential Area	Cropping pattern which makes largest potential is applied	Followed by the design cropping pattern

Source: JICA Project Team

1) Komering Extension Scheme No.4-1

The materials applied to the water balance calculation are summarized in the following Table 2.3.6. Most of the materials are Kabupaten-wise data collected from the Rencana PSDA Musi Sugihan Banyuasin Lemau (2017). In this examination, the data related to Komering Extension Scheme are such as for Ogan Komering Ulu (OKU), Ogan Komering Ilir (OKI), and for Ogan Komering Ulu Selatan (OKU Selatan). Also, it should be noted that the irrigation area of the existing Komering Scheme is set at 72,639 ha, considering additional irrigation area of the on-going Yen Loan project under Phase 3.

Table 2.3.6 Materials Utilized for the Water Demand Calculation (Komering Extension No.4-1)

No.	Data	Source	Remarks
1	RKI Demand	Rencana PSDA Musi Sugihan Banyuasin Lemau, 2017	Monthly estimated value in 2021 by Kabupaten (values in OKI, OKU Timur, and OKU Selatan are selected)
2	Fishpond Water Demand	Rencana PSDA Musi Sugihan Banyuasin Lemau, 2017	There are more than 30,000 ha of fishpond in OKI, but it is not considered because fishpond area is located on a different basin.
3	Livestock Water Demand	Rencana PSDA Musi Sugihan Banyuasin Lemau, 2017	There is no water demand based on the source.
4	River Maintenance	Government regulation concerning river, No.38, 2011	Q95% of the actual measurement records is applied
5	Command Area of DI. Komering	Sub Directorate of Lowland (DILL)	72,639 ha is applied considering after the ongoing project in DI. Komering.
6	Cropping Pattern	Rencana PSDA Musi Sugihan Banyuasin Lemau, 2017	Paddy-Paddy-Palawija (Cropping Intensity = 300%)
7	Irrigation Water Demand	Standard of Irrigation Planning (KP-01), 2013	Monthly base Calculation

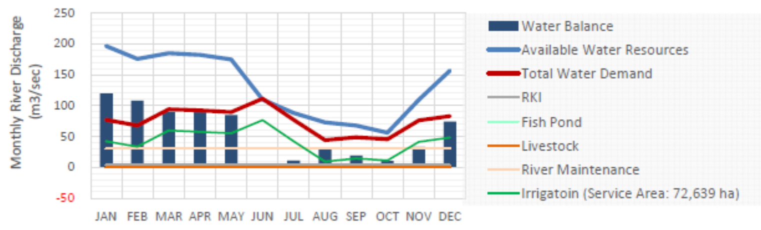
Source: JICA Project Team

The calculation results are summarized in Table 2.3.7. Even upon commission of the on-going Yen Loan project of Komering Scheme (Phase 3), the result of monthly water balance shows enough amount of available water for further irrigation development, which can realize twice cropping in a year, without any storage facilities (see “3. Water Balance” in Table 2.3.7).

Table 2.3.7 Water Balance Calculation for Komering Extension Area No.4

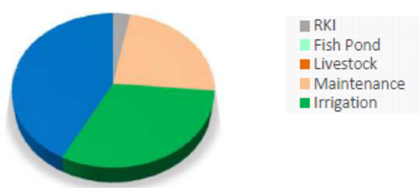
Irrigation Scheme Name: DI Komering (Modified cropping pattern) DI Watershed Area: 4,305 km2 Water Source: Sungai Komering Considering Komering Irrigation Project (Phase3)

	(Unit)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1 Available Water Resources														
1.1 Rainfall P_{ave}	(mm)	254	276	282	252	179	142	110	140	131	147	275	263	2,451
1.2 Rainfall $P_{80\%}$	(mm)	157	188	175	153	106	70	44	43	41	69	180	171	1,396
1.3 Discharge Q_{ave}	(m^3/sec)	255.00	239.00	249.00	250.00	241.00	155.00	117.00	106.00	114.00	146.00	190.00	246.00	192.12
1.4 Discharge $Q_{80\%}$	(m^3/sec)	196.35	175.59	184.66	182.27	174.43	109.90	87.87	72.79	67.58	56.17	109.25	156.75	130.92
2 Water Demand														
2.1 RKI														
Population	(10^3person)	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	-
Demand	(m^3/sec)	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96
2.2 Fish Pond														
Pond Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3 Livestock														
Demand	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4 River Maintenance														
Demand ($Q_{MIN95\%}$)	(m^3/sec)	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64
2.5 Irrigatoin (Service Area: 72,639 ha)														
Irrigated Paddy Planted Area	(ha)	72,639	72,639	72,639	72,639	72,639	72,639	36,320	0	0	0	36,320	72,639	-
Irrigated Palawija Planted Area	(ha)	0	0	0	0	0	0	0	72,639	72,639	72,639	0	0	-
Demand for Paddy Production	(m^3/sec)	42.13	33.22	59.52	57.53	54.97	76.64	42.09	0.00	0.00	0.00	41.35	48.12	-
Demand for Palawija Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.49	14.24	10.99	0.00	0.00	-
Demand (Net)	(m^3/sec)	42.13	33.22	59.52	57.53	54.97	76.64	42.09	9.49	14.24	10.99	41.35	48.12	40.85
3 Water Balance	(m^3/sec)	119.62	107.78	90.54	90.15	84.87	(1.33)	11.19	28.70	18.75	10.58	33.30	74.04	55.48
4 Potential Area														
4.1 Case 1 (Paddy-Paddy)		Paddy - I	Paddy - II								Paddy - I			-
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.66	1.10	0.38	0.73	0.83	-	-	-	-	1.43	0.42	0.60	
Potential Area	(ha)	182,236	97,922	239,293	124,041	102,488	-	-	-	-	7,413	79,957	122,815	
4.2 Case 2 (Paddy with Palawija-Palawija)		Paddy - I	Paddy - II								Paddy - I			-
		Palawija										Palawija		
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.66	1.10	0.38	0.73	0.83	-	-	-	-	1.43	0.42	0.60	
Potential Area	(ha)	7,413	97,922	239,293	124,041	102,488	-	-	-	-	7,413	7,413	7,413	
Unit Water Demand of Palawija	(m^3/sec/1000ha)	0.17	-	-	-	-	-	-	-	-	-	0.15	0.23	
Potential Area	(ha)	665,289	-	-	-	-	-	-	-	-	-	200,055	304,138	



Monthly Water Balance

Available Water Resources: 4,129 MCM
Potential Water Resources: 1,750 MCM



Annual Water Balance

Case1	Season-I	Season-II
Water Potential Area (Paddy)	7,413 ha	97,922 ha
Water Potential Area (Palawija)	0 ha	0 ha

Case2	Season-I	Season-II
Water Potential Area (Paddy)	7,413 ha	97,922 ha
Water Potential Area (Palawija)	200,055 ha	0 ha

With the monthly water balance surplus, maximum irrigation potential area is calculated at "4 Potential Area" in Table 2.3.7. The result indicates that 97,922 ha of paddy field can be developed as additional irrigation area during wet season. On the other hand, the water potential area of additional paddy field during dry season comes only to 7,413 ha, around 12% of total irrigation area (58,795 ha). This means, during dry season, the basin cannot provide enough water to cover the new development area.

The main reason of such a small water potential during dry season is a remarkable water requirement for land preparation for paddy cultivation during the small water surplus month, that is October. Therefore, another case which plants Palawija from November to January is also proposed as Case 2. Palawija needs shorter period of cultivation, thus it can start from November, one month after the paddy cultivation. In this Case 2, as much as 200,055 ha of additional palawija can be planted from the viewpoint of water availability.

Table 2.3.8 Comparison of Beneficial Area and Water Potential Area (Komering Extension No.4-1)

Case	Season (Month)	Beneficial Area (1) (Net ha)	Water Potential Area (2)			
			Paddy, (ha)	Palawija, (ha)	Paddy, (ha)	Ratio (2)/(1) (%)
Case 1	Season I (Oct to Jan)	56,886	7,413	0	7,413	12.6%
	Season II (Feb to May)	56,886	97,922	0	97,922	>100%
Case 2	Season I (Oct to Jan)	56,886	7,413	200,055	207,468	>100%
	Season II (Feb to May)	56,886	97,922	0	97,922	>100%

Source: JICA Project Team

2) Giham-Tahmi Irrigation Scheme

Table 2.3.9 summarizes the materials employed in the water demand calculation for the Giham-Tahmi Irrigation Scheme. Giham River, the water resource of the Giham-Tahmi Irrigation scheme, is a part of the Tulang Bawang River which flows along the Komering Extension Scheme. However, the water resource for the Komering Extension Scheme is completely different from the Giham River. Therefore, the water demand for the Giham-Tahmi irrigation scheme can be independently calculated, not considering Komering Extension Scheme.

Table 2.3.9 Material utilized for the Water Demand Calculation (Giham-Tahmi Irrigation Scheme)

No.	Data	Source	Remarks
1	RKI Demand	Rencana PSDA Mesuji Tulang Bawang, 2016	Monthly estimated value in Kabupaten Way Kanan (2024) is applied
2	Fishpond Water Demand	Rencana PSDA Mesuji Tulang Bawang, 2016	There is no information on the source
3	Livestock Water Demand	Rencana PSDA Mesuji Tulang Bawang, 2016	There is no information on the source
4	River Maintenance	Government regulation concerning river, No.38, 2011	Q95% of based on the actual measurement records is applied

Source: JICA Project Team

After calculating the water balance, design cropping pattern is made to determine the water potential area for new irrigation development. The calculation result is shown in Table 2.3.10, and the comparison between the beneficial area and water potential area is summarized in Table 2.3.11. Although a reservoir is planned to be constructed in the target watershed from 2026-2035 according to Rencana (2016), the water resource is already enough to provide the beneficial area for both wet and dry season without any storage facilities.

Table 2.3.10 Comparison of Beneficial Area and Water Potential Area (Giham-Tahmi Irrigation Scheme)

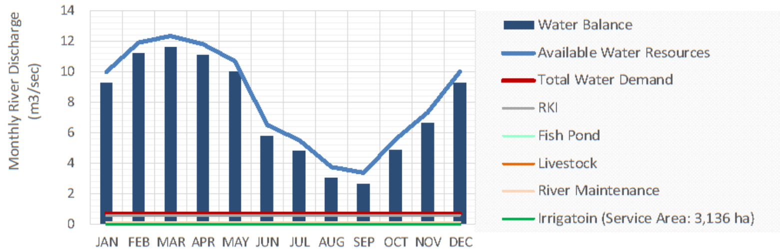
Case	Season (Month)	Beneficial Area (1) (ha)	Water Potential Area (2)			
			Paddy, (ha)	Palawija, ha	Total, ha	Ratio (2)/(1) (%)
Case 1	Season I (Nov to Feb)	3,136	5,486	0	5,486	>100%
	Season II (Mar to Jun)	3,136	5,707	0	5,707	>100%

Source: JICA Project Team

Table 2.3.11 Water Balance Calculation for Giham-Tahmi Irrigation Scheme

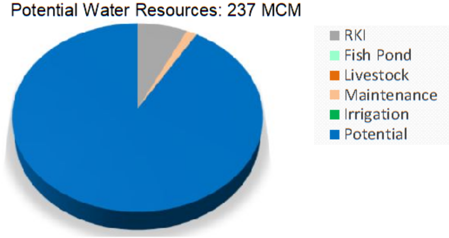
Irrigation Scheme Name: DI Giham | DI Watershed Area: 290 km2 | Water Source: Way Giham

	(Unit)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1 Available Water Resources														
1.1 Rainfall P_{ave}	(mm)	240	276	271	232	137	112	92	88	105	114	216	236	2,120
1.2 Rainfall $P_{80\%}$	(mm)	157	217	174	150	91	53	31	22	40	50	148	165	1,298
1.3 Discharge Q_{ave}	(m^3/sec)	22.00	22.68	19.13	17.32	15.41	10.96	10.07	7.03	7.06	10.78	13.22	22.16	14.78
1.4 Discharge $Q_{80\%}$	(m^3/sec)	9.99	11.90	12.35	11.81	10.71	6.53	5.52	3.77	3.38	5.58	7.34	10.00	8.22
2 Water Demand														
2.1 RKI														
Population	(10^3person)	432	432	432	432	432	432	432	432	432	432	432	432	-
Demand	(m^3/sec)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
2.2 Fish Pond														
Pond Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3 Livestock														
Demand	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4 River Maintenance														
Demand ($Q_{MIN95\%}$)	(m^3/sec)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
2.5 Irrigatoin (Service Area: 3,136 ha)														
Irrigated Paddy Planted Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Irrigated Palawija Planted Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand for Paddy Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand for Palawija Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand (Net)	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 Water Balance	(m^3/sec)	9.29	11.20	11.65	11.11	10.00	5.82	4.81	3.06	2.68	4.87	6.64	9.30	7.52
4 Potential Area														
4.1 Case 1 (Paddy-Paddy)		Paddy - I		Paddy - II								Paddy - I		-
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.75	0.36	1.06	0.47	0.91	1.02	-	-	-	-	1.21	0.38	
Potential Area	(ha)	12,381	31,107	10,988	23,638	10,990	5,707	-	-	-	-	5,486	24,475	



Monthly Water Balance

Available Water Resources: 259 MCM
Potential Water Resources: 237 MCM



Annual Water Balance

	Paddy - I	Paddy - II
Water Potential Area (Case-1):	5,486 ha	5,707 ha

2.3.4 Preliminary Irrigation New Development (Komering Extension Scheme No.4-1)

In this section, preliminary design of diversion facility and primary canal is examined based on the design discharge calculated with the beneficial area and unit water requirement for the Komering Extension Scheme No.4-1. Table 2.3.12 summaries the design discharge with the net beneficial area of 56,886 ha for the Komering Extension Scheme No.4-1. As for the unit water requirement for the calculation, the maximum monthly value of the year considering the effective rainfall amount is applied.

Table 2.3.12 Design Discharge (Komering Extension Scheme No.4-1)

DI Name	Beneficial Area (Net), ha	Unit Water Demand (m^3/s/1000ha)	Design discharge (Max Water Demand), m^3/s	Remarks
	(1)	(2)	(3) = (1) * (2) / 1000	
Komering Ext. 4-1	56,886	1.10 (Nov)	62.61	

Source: JICA Project Team

1) Preliminary Design of Diversion Weir

Water resources for the new development area, Komering Extension Scheme No.4-1, is expected to be the Komering river, which is also the source of the existing Komering irrigation scheme areas. Thus, the irrigation water will be diverted from the existing Perjaya Headworks in the Komering river to the Komering Extension No.4-1 beneficial area.

As shown in the following Figure 2.3.5, the new intake is proposed to construct at just upstream area of the existing intake. Then, the irrigation water flows into the sedimentation ponds, which will be constructed beside the existing one. After the sedimentation ponds, irrigation water will be conveyed into the primary canal, which will be newly constructed at the right side of the existing Komering Main Canal. The primary canal newly constructed is proposed to be composed of four sections (see Figure 2.3.7 for the primary canal).

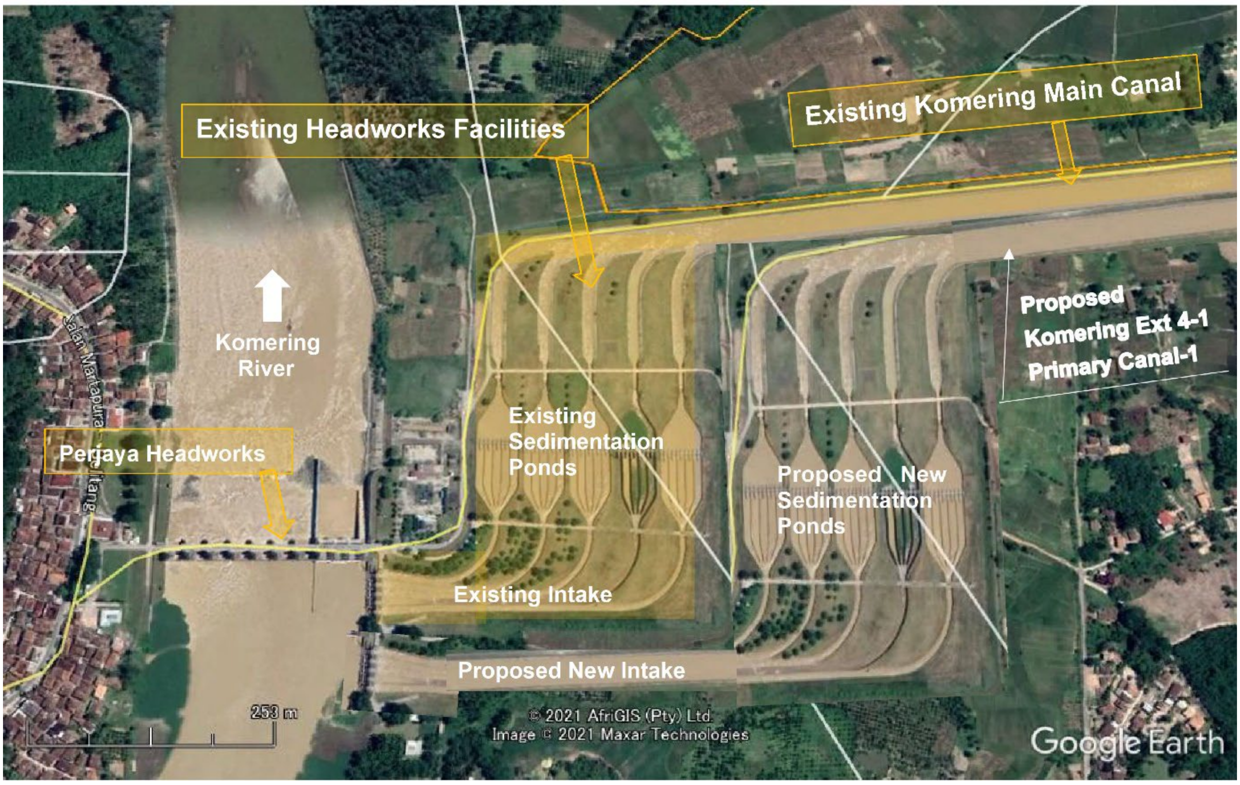


Figure 2.3.5 Plan of the Intake and Primary Canal of Komering Extension Scheme No.4-1
Source: JICA Project Team (based on Google Earth map)

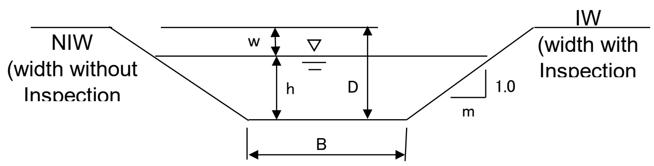
2) Preliminary Design of Primary Canals

Primary canal should be so designed capable of conveying designed water amount from the diversion weir point to the beneficiary area. Earth canal with trapezoid shape is selected from the viewpoint of cost effectiveness considering the huge length of canals, and the longitudinal and cross section of the canals are designed complying with the Standard of Irrigation Planning – Canals (KP-03, MPWH 2013). The basic design parameters of the primary canal are now determined as in Table 2.3.13 with a typical cross section of the primary canal.

Table 2.3.13 Design Parameters of Primary Canals in Komering Ext4-1 (Preliminary Design Level)

DI Name	Canal Name	Canal Length	Design Discharge	Strickler roughness Coefficient	Water Depth	Free board	Total Height	Side Slope	Ratio B/h	Bed Width	Levee Width		Bed Gradient	Velocity
		Km	Q	K (1/n)	h	w	D	1:m	n	B	IW	NIW	S	V
			m³/s	m^1/3/s	m	m	m	-	-	m	m	m	-	m/s
Komering Ext4-1	Primary -1	33.7	62.61	45.0	2.15	1.00	3.15	2.00	9.31	20.00	5.00	3.50	1/3000	1.20
	Primary -2	44.7	62.61	45.0	2.15	1.00	3.15	2.00	9.31	20.00	5.00	3.50	1/3000	1.20
	Primary -3	34.6	25.0	45.0	1.80	1.00	2.80	2.00	5.26	12.00	5.00	3.50	1/4000	0.89
	Primary -4	35.9	25.0	45.0	1.80	1.00	2.80	2.00	5.26	12.00	5.00	3.50	1/4000	0.89
Remarks				KP-03 Table 3-1		KP-03 Table 3-5	D = h+w	KP-03 3.3.2 Sandy loam	KP-03 Table A.2.1	KP-03 Table A.2.2	Pavement with 3.0m			

Source: JICA Project Team calculated based on KP-03 (MPWH 2013)



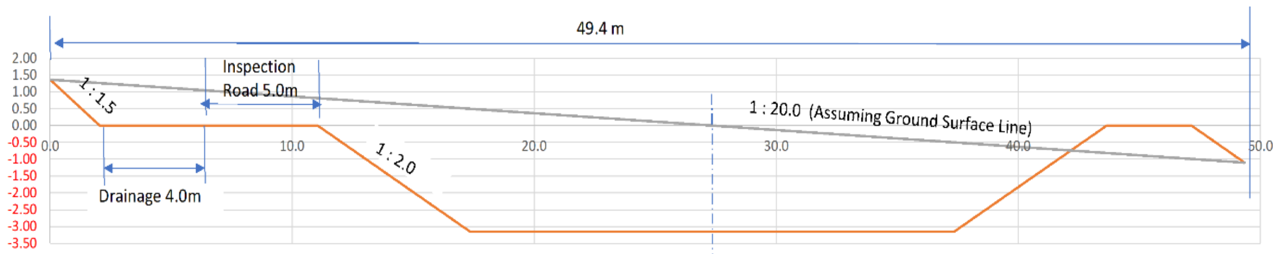


Figure 2.3.6 A Typical Cross Section of Primary Canal (Komering Extension No.4-1)

Source: JICA Project Team

3) Preliminary Canal Network Planning

The alignment of the primary canal is almost decisively decided by the topographic condition, namely, the canal should be aligned running down through the highest places of the beneficiary area. In this sense, the primary canal is in most cases aligned running far away from the river. Then, there should be a number of secondary canals all branching from the primary canal and running down to the lower elevation direction, e.g., in most cases towards river direction. Tertiary canals are branching from the secondary canals, and running again down to the lower elevation direction.

In Indonesia, a typical tertiary canal is designed to cover 100 ha of beneficiary area, which is relatively large as compared to the practices in other Asian countries, e.g., max. 100 acres (40ha) in Myanmar, 50 ha in the Philippines. For the secondary canals, no standard area coverage by one secondary is defined in Indonesia, and neither in other Asian countries. Therefore, examples in existing irrigation schemes in Central Java province and South Sulawesi province are referred, and the Team proposes a coverage area of 1,000ha should be allocated to each secondary canal as a standard.

Based on the assumption that one secondary canal is allocated 1,000ha beneficial area, expected number of secondary canals are summarized in Table 2.3.14. In fact, by applying 1,000 ha to each secondary canal, there should be a total of 57 secondary canals, but taking into account the topographic conditions, there could be total 51 secondary canals as illustrated in Figure 2.3.7.

Table 2.3.14 also shows the expected number of tertiary canals, to which each 100ha is allocated, and the number of expected beneficially farmers based on a government resettlement guideline, in which 1.75ha[5] of crop land should be given to each of the settlers. The Komering Extension Scheme No.4-1 is expected to have 569 tertiary canals, and there will be about 32,500 beneficiary farmers upon full commissioning.

Table 2.3.14 Preliminary Setting for Canal Network with Expected Beneficiary Farmer Numbers

Irrigation Scheme	Gross Area, ha	Net Area, ha	No. of Secondary	No. of Tertiary	No. of Farmers
Komering Ext.4-1	63,207	56,886	51 * (57)	569	32,500

Note: * by applying 1,000 ha to each secondary canal, there will be 58 secondary canals, but with topographic conditions considered, the Team proposes total 51 secondary canals as in the following map.
Source: JICA Project Team

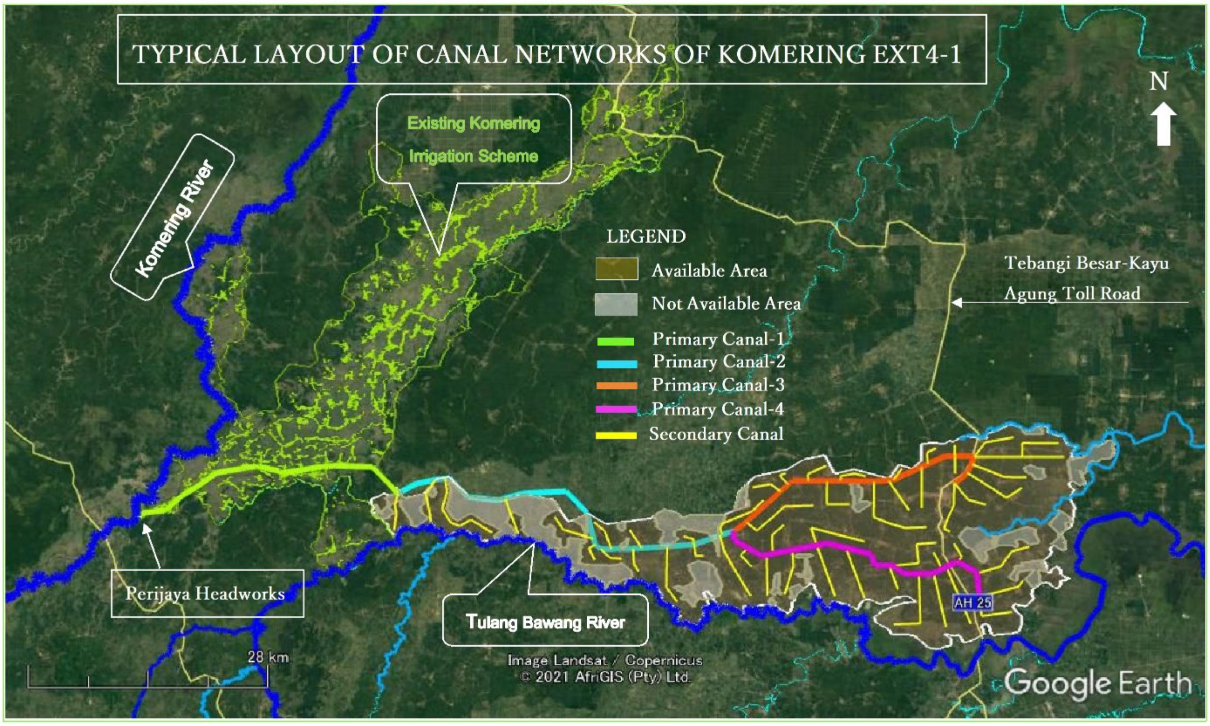


Figure 2.3.7 Typical Layout of Primary Canal and Secondary Canals (Komering Extension No.4-1)
Source: JICA Project Team (based on Google Earth map)

2.4 Preliminary Cost Estimation, Implementation Schedule, and Project Evaluation

2.4.1 Preliminary Cost Estimation

In Lampung province, Komering Extension Area (No.4-1) has been prioritized the highest to develop, covering an extensive area of 56,886 ha in net. The current land use is mostly occupied with forest, woodland, and bush land, while plantation areas with concession license, mostly palm or sugarcane, and protected forest areas are all excluded from the designed irrigable area. It means that the development of the irrigation schemes requires opening the land, making paddy plots including terracing in areas

[5] According to Bab XVII : Transmigrasi – Bappenas, and Rukmadi (1984: 67), farmer trans-migrants have the right to acquire land of at least two hectares, use of which is divided as follows: 0.25 (one-quarter) hectare used for houses and yards and 1.75 (one three-quarter) hectare used for cultivation and/or paddy fields.

where the topography shows more than 5% slope in general.

With above conditions, the construction cost for the Komering Ext. No.4-1 would relatively be higher than conventional case where existing rainfed paddy areas are to be irrigated with new irrigation canal networks. Likewise, implementation schedule should be longer than the conventional cases, in which land opening and paddy plot development are not required.

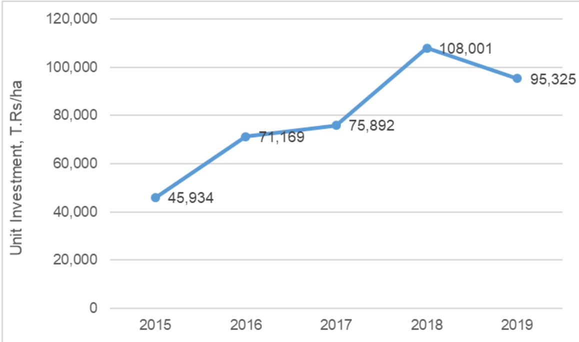


Figure 2.4.1 Unit Development Cost of New Irrigation Schemes from 2015-2019

Source: Directorate of General of Water Resources

DGWR has newly developed about 1 million ha of new irrigated lands during the last 5-year development term (2014-2019) with a total cost of 29.6 trillion Rs composed of surface irrigation and lowland tidal irrigation schemes. Taking up only the surface irrigation schemes and excluding extremely low unit cost lower than 28 million Rs/ha (about 2000 $/ha) and also extremely high unit more than 420 million Rs/ha (about 30,000 $/ha), the screened unit cost is estimated as in the Figure 2.4.1 (for detail, refer to the discussion in 8.6.1 Detail Cost under the Current 5-year Medium-Term Development Plan).

As the Komering Extension No.4-1 are is completely new one, the Team refers to the highest development cost, i.e. 108 million Rs/ha. In addition to this unit development cost, such associated costs as opening of the land and making of paddy plot, survey and design, and administration as well as contingencies are required in order to develop new irrigation systems. Referring to general practices, those associated costs are counted as additional percentage ratio indicated below and calculated in Table 2.4.1.

1) Development cost: 108,001 thousand Rs/ha
2) Land acquisition/ development: 20% of the development cost
3) Survey and Design: 10% of the development cost plus land acquisition/ development
4) Administration: 5% of develop't cost, acquisition/ develop't plus survey & design
5) Contingency (physical): 5% of develop't cost, acquisition/ develop't plus survey & design
6) Contingency (price inflation): 5% of develop't cost, acquisition/ develop't plus survey & design

The overall unit development cost for the Komering Extension No.4-1 area arrives at 164 million Rs/ha (11,714 US$/ha). With the total net development area of 56,886 ha, the total investment cost for the new area development comes to 9,329 billion Rs, equivalent to about 666 million US$.

Table 2.4.1 Estimation of Unit Development Cost for Komering Extension No.4-1 Area

	Particulars	Cost, thousand Rs/ha	Multiplier	Remarks
1	Unit Development Cost (original)	108,001	-	Refer to Figure 2.4.1
2	Land Acquisition/Development	21,600	20%	Against above No.1
3	Survey and Design	12,960	10%	Against above sum No.1- No.2
4	Administration, etc.	7,128	5%	Against above sum No.1- No.3
5	Contingency (Physical)	7,128	5%	Against above sum No.1- No.3
6	Contingency (Price Inflation)	7,128	5%	Against above sum No.1- No.3
7	Total of above	163,946	152%	Sum of No.1-6
8	Say (thousand Rs/ha)	**164,000**	152%	Rounded up
9	@14000	**11,714**	$/ha	
10	Total Net Irrigation Area (ha)	**56,886**	Ha	Net irrigable area
11	Total Cost in Rs	**9,329 billion Rs**		Whole project cost for 56,886 ha
12	Total Cost in US$ (@14,000)	**666 million US$**		Whole project cost for 56,886 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

2.4.2 Implementation Schedule

Construction period of a project depends upon the size of the project, namely, the larger a project is, the longer construction period it requires. In many cases, however, a new irrigation development project is usually scheduled to complete within 5 years for the purpose of generating benefits at an earliest possible time, not letting the beneficiaries wait so long. Also, shorter period of construction is required from the economic point of view, namely, the earlier the benefit starts accruing, the bigger return the project can produce.

The Komering Extension scheme is in fact very large in its scale, developing almost 57,000 ha of land and also the development includes opening of the land for paddy cultivation. Such huge scale land development would definitely require longer implementation period. With this, the JICA team proposes to set total 8 years for the implementation of the Komering Extension No.4-1 project, longer than general practices. It means that survey and designing should be completed within the first 2 years in parallel with land acquisition, and then the construction follows. The construction is scheduled to complete by the end of 8th year and the planting of paddy would start from the 9th year (see Table 2.4.2).

Table 2.4.2 Overall Implementation Schedule (8 years for implementation)

Construction Year	1	2	3	4	5	6	7	8	-	-	-	-	-	Remarks
Benefit Year	-	-	-	-	-	-	-	-	1	2	3	4	5	
Survey & Design									Paddy planting to start, and the yield reaches the current level at the 3rd year.			Paddy yield gradually to increase.		
Construction														
Construction for Upstream Parts														
Construction for Midstream Parts														
Construction for Downstream Parts														
Land Acquisition														

Source: JICA Project Team

In cases, partial commissioning may be tried, e.g. a part of main canal would start irrigating an upstream beneficial area from 6th year, and a midstream beneficial area from 7th year, so on so forth. However, this partial commissioning is not taken in this pre-FS stage for the sake of simplifying the implementation schedule, and accordingly the whole beneficial area of net 56,886 ha is assumed to produce paddy from the 9th year. It is also noted that the paddy yield starts at a very preliminary level, and increases gradually as the farmers get used to paddy production (refer to 2.2 Agriculture Development Plan).

2.4.3 Project Economic Evaluation

The economic analysis is carried out to assess the economic feasibility of the project. The analysis compares the project benefit accrued by implementing the project and the cost that are necessary for the project implementation. Following are the preconditions of the economic evaluation, benefits that will show up by implementing the project as well as the economic return as expressed by EIRR:

1) Preconditions of the Evaluation

Preconditions to conduct the economic evaluation are elaborated as follows:

- ✓ Referring to other similar projects in the irrigation/agriculture sector, the economic life of the project is designed as 35 years (8 years construction and 27 years operation). Namely, economic evaluations are examined over this period considering the initial investments costs, operation and maintenance costs, and expected benefits to accrue.
- ✓ EIRR (Economic Internal Rate of Return) is applied for the evaluation criteria. For the opportunity cost of capital, which is the cut-off rate to judge economic feasibility, 10% is applied referring to

the practices of international donner organizations such as the World Bank, ADB, and JICA[6]. Also, B/C ratio (Benefit Cost Ratio) and NPV (Net Present Value) are calculated for the references.

- ✓ For the conversion from financial prices to economic ones, standard conversion factor (0.9) is applied for all types of prices except for farm labor (0.6) considering the imperfect competitive labor market in the rural economy.
- ✓ All project costs and benefits are calculated in Indonesian Rupees (IDR), and the foreign exchange rate of 1 USD = 14,000 IDR is applied as of January 2022. All prices are standardized into the price level as of 2019 fiscal year.
- ✓ For the operation and maintenance cost, 500,000 IDR per ha is applied in financial price[7] (i.e., 450,000 IDR per ha in economic price).
- ✓ Transfer costs such as taxes and debts are not considered in the economic evaluation as they are "zero-sum" when aggregating all the costs and benefits among stakeholders in the economy.

2) Expected Benefit and its Evaluation Cases

The calculation of economic benefits takes into account the benefits to be generated by the increase in the planting areas and by the increase in yields of paddy rice as well as those of upland crops (i.e., Palawija crops) after commencing the crop cultivations in the irrigated farmlands. The expected benefits are calculated in the folloiwng two evaluation cases, depending on the future prospective of the agriculture to be extended.

- ✓ **The Effect on the Opening of Irrigable Areas:** with the project, thanks to the irrigation water coming after constructing the new irrigation systems, the irrigable areas in which the beneficiary farmers can cultivate paddy rice and Palawija crops are expected to newly open.
- ✓ **The Effect on the Yields Increase:** with the project, the organization of water users associations (WUA) and agriculture extension activities enable timely planting and proper water management, which leads to yield increase.

In the base scenario (the Case 0), the evaluation takes into account both the effect on the opening in irrigable areas and the effects on yield increase up to the conventional agriculture practice level by the introduction of superior seeds and fertilizer inputs.

In the alternative scenario (the Case 1), the evaluation case takes into account only the effect on the opening in irrigable areas with the initially expected yields. The scenario assumes that the yield does not increase as expected due to external factors such as the stagnation of research & development and extension services. In this scenario, it is assumed that the initial yields will continue in the future.

Table 2.4.3 Two Evaluation Cases in the Analysis (Komering Extension No.4-1)

Case	Name of the Scenario	The Effects to be considered
Case 0	Base Scenario (Suggested Scenario)	Considering the effect on the opening of irrigable areas with the effect on the yield increase (up to Conventional Agriculture Practice level).
Case 1	Alternative Scenario	Considering only the effect on the opening of irrigable areas. In this case, the initially set yields are to continue.

Source: JICA Project Team

[6] JICA (2012) "Survey for Maximum Utilization of Irrigation Water Indonesia: Final Report" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 28 years of economic life of the project (3 years for the construction and 25 years for the operation). Also, JICA (2004) "The Study on Comprehensive Recovery Program of Irrigation Agriculture in the Republic of Indonesia" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 30 years of economic life of the project.

[7] According to the interview to BBWS Pemali Juana in Central Java, AKNOP (Irrigation Operation and Maintenance Unit) suggests 500,000 IDR per ha as the standard and desirable unit maintenance cost of irrigation facilities including personnel costs, dredging costs, and repairment costs.

3) Calculation and Economic Conversion of the Project Benefits

For the purpose of economic analysis, information of calculation basis have been collected and estimated from different sources as; 1) the base and target yields have been set by referring to BPS-Statistics of Lampung Province, 2015-2018 (See Chapter 2.2 for more detail), and 2) the prices of paddy and maize, as the representative crop of Palawija, have been set by referring to the results of price monitoring conducted by BPS Lampung Province (2018-2020) as summarized in Table 2.4.4 and Table 2.4.5:

Table 2.4.4 The Base and The Target Paddy Yields (Lampung Province)

Irrigation Scheme	Type	Service Area (Ha)	Paddy Rice							Maize
			Base Yield (t/ha)	Years after project has been started (till 35 years)						Base Yield (t/ha)
				(1st~8th)	(9th)	(10th)	(11th)	(12th)	(13th)	
DI Komering Ext 4	New Rehabilitation	56,886	0.0	1.64	3.28	4.92	4.93	4.95	4.96	4.35
All Lampung Province		56,886	0.0	1.64	3.28	4.92	4.93	4.95	4.96	4.35

Source: JICA Project Team

Table 2.4.5 Applied Paddy and Maize Prices in the Evaluation (Lampung Province)

Months and Average	Paddy Rice				Maize (Palawija)			
	2018	2019	2020	Average	2018	2019	2020	Average
January	-	5,547	5,571	5,559	2,500	2,900	3,918	3,106
February	-	5,305	5,700	5,503	2,500	2,900	3,814	3,071
March	-	-	5,704	5,704	2,500	2,900	3,301	2,900
April	-	4,600	4,942	4,771	2,500	2,900	2,600	2,667
May	-	-	4,671	4,671	2,500	2,900	2,335	2,578
June	-	4,694	4,567	4,631	2,900	2,900	2,434	2,745
July	-	5,023	5,032	5,028	2,900	2,900	2,582	2,794
August	-	5,127	5,190	5,159	2,900	2,900	2,471	2,757
September	-	5,361	5,185	5,273	2,900	2,900	2,469	2,756
October	-	5,381	-	5,381	2,900	2,920	2,773	2,864
November	-	5,416	-	5,416	2,900	2,980	2,831	2,904
December	5,379	5,291	-	5,335	2,900	2,980	-	2,940
Average	5,379	5,175	5,174	5,243	2,733	2,915	2,866	2,838
In Economic Price (x 0.9)				4,718	In Economic Price (x 0.9)			2,554
Rounded				4,720	Rounded			2,550

Source: The results of price monitoring by BPS Lampung Province (2018-2020)

The per hector farming cost is estimated by referring to the standard cost ratio against the cropping revenue per hector. The applied standard cost ratios are estimated based on the BPS "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy and Maize 2017" (national level statistics) with some necessary modifications considering the farming practices in the project area. It implies that the farming cost is assumed to proportionally increase depending on the yield level. Table 2.4.6 shows the farming cost under the base yield:

Table 2.4.6 Estimation of Unit Farming Cost for Per-ha Cultivation of Paddy and Maize (Lampung Province)

Item	(Wetland) Paddy		Palawija (Maize)	
	Financial	Economic	Financial	Economic
Standard Profit Ratio per Revenue	0.31	0.71	0.35	0.64
Standard Cost Ratio per Revenue	0.69	0.29	0.65	0.36
Base Yield per Ha (ton per ha)	4.92	4.92	4.35	4.35
The Local Prices of Paddy and Maize (IDR per kg)	5,243	4,720	2,838	2,550
Estimated Revenue per ha (000' IDR per ha)	25,796	23,222	12,345	11,093
Estimated Cost per ha (000' IDR per ha)	17,799	6,734	8,024	3,993
Estimated Profit per ha (000' IDR per ha)	7,997	16,488	4,321	7,099

Source: JICA Project Team based on BPS, "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy and Maize 2017"

The target cultivated areas by crop are set in line with the land use plan for the target service area and also the cropping pattern with the project implemented (See Chapter 2.2 for more detail). With the cultivated areas to be realized with the project, the benefits are to accrue through paddy rice and Palawija production from the base year till 35th year.

4) Economic Conversion of Project Cost

For the economic analysis, the project cost should be converted to economic price by applying standard conversion factor (0.9). The economic analysis does not take into account any price escalation because there is large uncertainty in the price escalation in the future. Table 2.4.7 shows the converted economic costs to be entered in the economic evaluation:

Table 2.4.7 Economic Conversion of Development Cost and O&M Cost for Komering Extension No.4-1

No.	Particulars	Cost, thousand Rs/ha	Multiplier	Remarks
1	Unit Development Cost (original)	108,001	-	Refer to Figure 2.4.1
2	Land Acquisition/Development	21,600	20%	Against above No.1
3	Survey and Design	12,960	10%	Against above sum No.1- No.2
4	Administration, etc.	7,128	5%	Against above sum No.1- No.3
5	Contingency (Physical)	7,128	5%	Against above sum No.1- No.3
6	Contingency (Price Inflation)	7,128	5%	Against above sum No.1- No.3
7	Total of above	163,946	152%	Sum of No.1-6
8	Total without Price Contingency	156,818	145%	Deduction of No.6 from No.7
9	Unit Economic Development Cost	141,136	130%	No. 8 x 0.9
10	Total Net Irrigation Area (ha)	56,886	Ha	Net irrigable area
11	Total Financial Cost in Rs	8,920 billion Rs		Whole project cost for 56,886 ha
12	Total Economic Cost in Rs (x 0.9)	**8,029 billion Rs**		Whole project cost for 56,886 ha
13	Unit O&M Cost per ha	500		Suggested O&M cost by AKNOP
14	O&M Cost in Rs	28,443 million Rs		Whole O&M cost for 56,886 ha
15	Economic O&M Cost in Rs (x 0.9)	**25,599 million Rs**		Whole O&M cost for 56,886 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

5) Evaluation Results

In order to examine the economic validity of the Project, EIRR, B/C, and NPV have been calculated. The calculated EIRR is 10.68%; B/C ratio is 1.08 and the NPV is 468 billion IDR for the base scenario (Case 0). An alternative scenario (Case 1), where the evaluation does not consider any yield increase, has provided such results of 10.57%, 1.07, and 394 billion IDR for the EIRR, B/C ratio, and NPV respectively (see Table 2.4.8). According to the evaluation result, the Project is judged to be economically feasible under the base scenario since the EIRR (10.68%) exceeds the opportunity cost of capital (10.0%), and the Project is still economically feasible even under the alternative scenario (EIRR: 10.57%).

Table 2.4.8 Results of the Project Economic Analysis for Komering Extension No.4-1

Particulars	Case 0	Case 1 (no yield increase)
EIRR, %	10.68	10.57
B/C Ratio	1.08	1.07
NPV, million IDR	467,965	394,098

Source: JICA Project Team

CHAPTER 3 PRE-FEASIBILITY STUDY: CENTRAL JAVA PROVINCE (JAVA ISLAND)

One of the top 4 priority areas selected is Central Java province for irrigation rehabilitation with, to certain extent, modernization. This chapter undertakes preliminary feasibility study (pre-FS) for the Central Java province, for which the BBWS in charge is Pemali Juana. The pre-FS examines potential of extending irrigable area and/or cropping intensity with rehabilitation and modernization on the existing irrigation facilities from the viewpoint of land and water resources potential, as well as from agricultural point of view. The pre-FS also includes preliminary cost-estimation, benefit estimation and economic analysis for recommended projects.

3.1 Status of the Project Area

3.1.1 Spatial Settings, and Salient Features

Central Java (Jawa Tengah in Bahasa) province is located in the middle of the island of Java, and its administrative capital is Semarang. It is bordered by West Java in the west, the Indian Ocean and the Special Region of Yogyakarta in the south, East Java in the east, and the Java Sea in the north. It has a total area of 32,548 sq.km, with a population of 34,552,500 in mid-2019 (BPS 2019), making it the third-most populous province in both Java and Indonesia after West Java and East Java.

Though the province extends both to Java Sea in its norther direction and also to Indian Ocean to the southern direction, the BBWS office, called Pemali Juana, covers only the northern side of the province where there are lots number of existing irrigation systems developed since long time ago (see Figure 3.1.1). The northern coastal region of Central Java has a narrow lowland showing very conducive environment for paddy cultivation. In the Brebes area, it is 40 km wide from the coast, while in Semarang, it is only 4 km wide. This plain continues with the depression of Semarang-Rembang in the east.

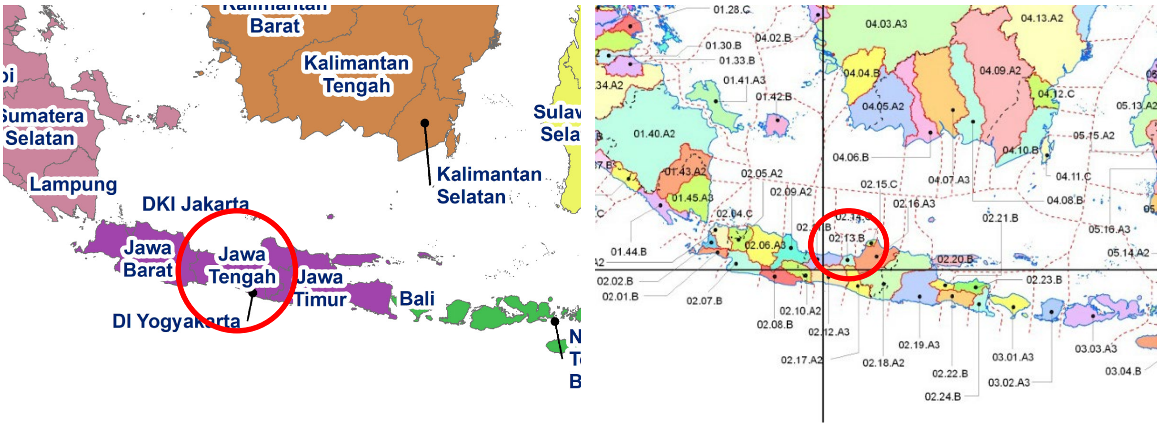


Figure 3.1.1 Location of the Central Java Province and BBWS Jurisdictional Watershed Area

Source: Directorate General of Water Resources

Much of the Central Java province carries a fertile agricultural land. The primary food crop is wet season rice. An elaborate irrigation network of canals, aqueducts and reservoirs has greatly contributed to Central Java's the rice-growing capacity over the centuries. In fact, nowadays, there are many paddy fields supported by irrigation, whose paddy yield reaches more than 6-7 tons per hectare. Other crops, also mostly grown in lowland areas on small peasant landholdings, are corn (maize), cassava, peanuts (groundnuts), soybeans, and sweet potatoes. Those crops are often cultivated during dry season, called Parawija, with little amount of irrigation water or otherwise with residual water in the soil.

In this Central Java province, the JICA team at first contacted BBWS Pemali Juana office in charge of northern part watershed within the province in order to identify specific existing irrigation schemes where rehabilitation and/or modernization project needs to be implemented. Through the discussions with the BBWS office, number of potential sites for rehabilitation/ modernization were proposed as there are in fact many existing irrigation schemes in there. With preliminary information provided, the JICA team with the BBWS staff conducted field visits to physically observe the current conditions of proposed irrigation schemes for rehabilitation/ modernization.

BBWS shared the information of their irrigation schemes, and explained that 1) irrigation schemes located in western part have been constructed longtime ago including colonialization era, and no major rehabilitation works have been done while schemes in eastern side have been given some rehabilitation during the last 5-year mid-term development period (2014-2019), suggesting that modernization may now be needed.

Also, there are already 5 schemes that ADB plans to undertake rehabilitation works. Excluding the ADB earmarked projects and such schemes still in good conditions, the Team and BBWS/DILL have selected the schemes illustrated in Figure 3.1.2 and listed in Table 3.1.1 for rehabilitation and modernization. Modernization will be undertaken for those 3 schemes of Sidorejo, Sedadi, and Klambu (see encircled schemes), whose water source is Kedung Ombo dam.

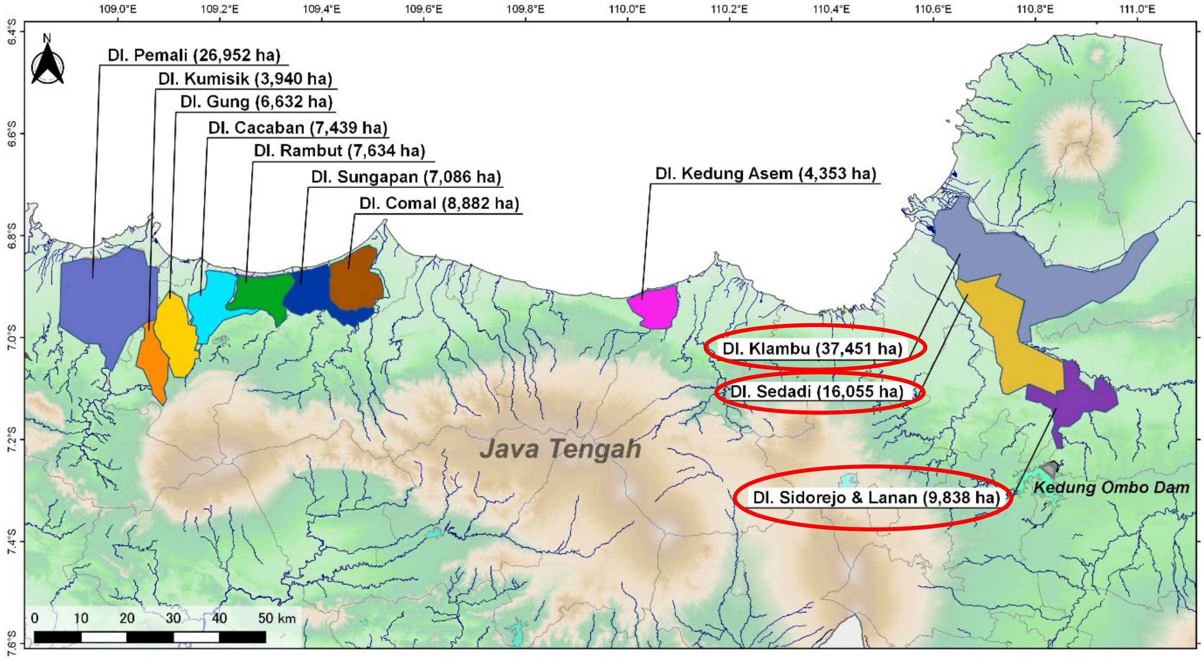


Figure 3.1.2 Location Map of Target Irrigation Schemes for Rehabilitation and Modernization

Note: Summed irrigation area of Sidorejo and Lanan is 9,838 ha, while the area only for the Sidorejo scheme is 7,938ha.
Source: BBWS Pemali Juana, and JICA Project Team

Table 3.1.1 Irrigation Schemes for Rehabilitation and Modernization in Central Java Province

No.	Irrigation Scheme	Service Area (ha)	Remarks
1	Pemali	26,952	
2	Comal	8,882	
3	Sungapan	7,086	
4	Rambut	7,634	Water provided from Cacaban dam
5	Gung	6,632	Ditto
6	Cacaban	7,439	Ditto
7	Kumisik	3,940	Ditto
8	Kedung Asem	4,353	
9	Sidorejo	7,938	Modernization, provided water from Kedung Ombo dam
10	Sedadi	16,055	Modernization, provided water from Kedung Ombo dam
11	Klambu	37,451	Modernization, provided water from Kedung Ombo dam
	Total	134,362	

Source: BBWS Pemali Juana,

3.1.2 Rainfall and River Discharge

This section examines the rainfall and discharge condition by River Territory and by target watersheds associated with existing irrigation schemes. Watershed area is delineated based on the location of existing weirs and DEMNAS data provided by Badan Informasi Geospasial (BIG). Watershed areas are summarized in Table 3.1.2 and shown in Figure 3.1.2 and Figure 3.1.3. There are irrigation schemes which share the same watershed area and, in cases, dam such as DI Kuimisik, DI Sidorejo and DI Sedadi.

The number of available discharge stations is limited in the target area, therefore, considering the geographic position and data reliability such as record year length and size of watershed area, two reliable discharge stations are selected to estimate monthly discharge of each watershed, namely, the discharge station "Pemali Notog" for the watershed in WS Pemali Comal and discharge station "Kedung Ombo" for the watershed in WS Bodri Kuto and WS Jratunseluna.

Table 3.1.2 Watershed Area in the Target Irrigation Schemes

DI Name	Area, km^2	Remarks	DI Name	Area, km^2	Remarks
Pemali	856		Comal	514	
Kumisik	91	part of Pamali watershed	Kedung Asem	341	
Gung	156		Sidorejo	620	Including Kedung Ombo dam, part of Klambu watershed and Sedadi wateshed
Cacaban	157	Including Cacaban dam			
Rambut	158		Sedadi	847	part of Klambu watershed
Sungapan	160		Klambu	3,041	

Source: JICA Project Team

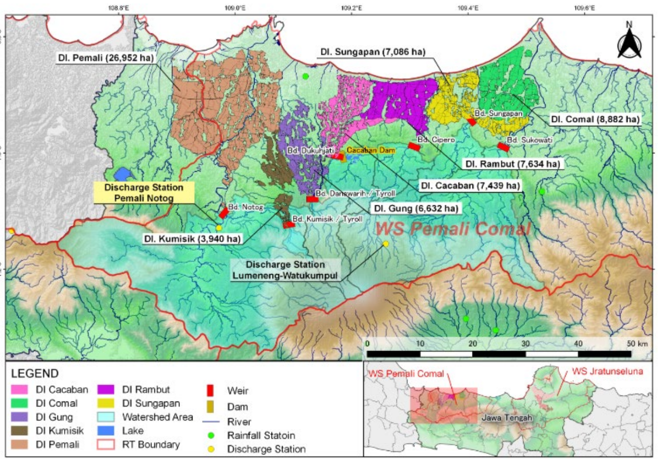


Figure 3.1.3 Location Map of Available Rainfall and Discharge Stations (WS Pemali Comal)

Source: JICA Project Team

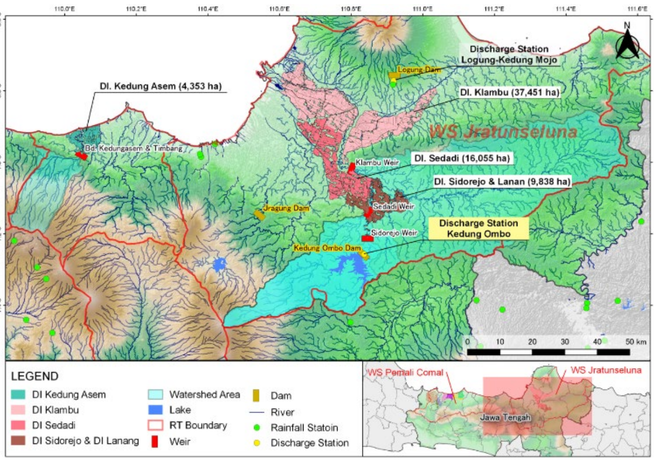


Figure 3.1.4 Location Map of Available Rainfall and Discharge Stations (WS Bodri Kuto and WS Jratunseluna)

Source: JICA Project Team

1) Rainfall Condition

Average monthly rainfall (P_{ave}) and 80% exceeding probability rainfall ($P_{80\%}$) are shown by the watershed of target river territories and by irrigation scheme (see Tables 3.1.3 and 3.1.4). In addition, rainfall amount on the beneficiary area, the source of effective rainfall, is also calculated (see the result in Appendix). In this target area, average annual rainfall varies place by place, ranging from 1,700 mm to 2,600 mm, and 80% exceeding probability rainfall is approximately in a range of 850 mm to 1,700 mm. As the same as Lampung Province, rainfall pattern shows a clear dry season (June to October) and wet season (November to April), which is a typical rainfall distribution called "Monsoon Type" appearing in Java and also South of Sumatera Island.

Table 3.1.3 Monthly Average Rainfall (P_{ave}) by River Territory and Watershed Area of the Target Irrigation Schemes (unit: mm)

Code	Watershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2.11.B	WS Pemali Comal	343	322	273	229	177	144	124	104	114	190	265	292	2577
-	Pemali	293	347	242	231	164	151	162	106	145	199	250	312	2603
-	Comal	215	253	164	158	123	115	113	84	111	137	174	219	1868
-	Sungapan	256	305	198	177	140	122	123	93	126	144	186	252	2122
	Rambut	306	289	202	131	96	66	58	37	32	55	126	211	1611
	Gung	265	321	208	201	150	142	150	108	138	173	217	278	2347
	Cacaban	347	334	232	151	108	73	68	40	35	63	141	244	1835
	Kumisik	253	301	203	194	146	140	147	106	134	167	207	266	2264
2.13.B	WS Bodri Kuto	332	313	223	196	146	106	76	70	98	165	228	274	2228
-	Kedung Asem	186	233	143	148	111	96	95	77	102	118	147	177	1632
2.16.A3	WS Jratunseluna	305	282	209	184	131	100	83	74	93	140	196	259	2056
-	Sidorejo	209	259	153	167	101	92	87	72	112	108	165	182	1707
	Sedadi	205	255	152	162	100	90	85	71	107	107	162	180	1676
	Klambu	253	321	196	192	121	103	89	76	112	122	187	222	1994

Note: WS Pemali Comal and WS Bodri Kuto are the River Territories having Code concerned, while others are all irriation schemes. WS means Wilayah Sungai, that is River Territory.
Source: JICA Project Team

Table 3.1.4 Monthly 80% Exceeding Probability Rainfall ($P_{80\%}$) by River Territory and Watershed Area of the Target Irrigation Schemes (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2.11.B	WS Pemali Comal	231	217	189	157	96	50	37	24	21	74	162	210	1468
-	Pemali	195	250	172	157	97	60	48	25	26	82	148	237	1499
-	Comal	146	182	116	116	68	44	31	18	21	58	120	163	1083
-	Sungapan	175	205	137	119	68	37	33	19	20	59	111	175	1157
	Rambut	208	199	141	81	49	18	18	9	5	22	61	146	957
	Gung	175	235	148	142	91	62	44	25	26	72	140	217	1376
	Cacaban	236	230	162	90	54	18	23	10	5	25	62	167	1081
	Kumisik	167	223	145	140	91	63	42	25	26	70	138	211	1341
2.13.B	WS Bodri Kuto	212	196	144	137	81	34	26	20	30	61	148	182	1270
-	Kedung Asem	128	139	83	102	57	34	30	19	27	39	90	121	868
2.16.A3	WS Jratunseluna	178	168	128	110	57	30	20	16	21	52	110	162	1052
-	Sidorejo	134	151	106	103	43	30	24	12	15	42	99	113	873
	Sedadi	131	146	106	99	43	29	24	12	15	41	99	113	859
	Klambu	155	201	115	105	47	33	21	16	22	45	101	128	989

Note: WS Pemali Comal, WS Bodri Kuto and WS Jratunseluna are the River Territories having Code concerned, while others are all irriation schemes. WS means Wilayah Sungai, that is River Territory.
Source: JICA Project Team

2) Discharge Condition

According to the Standard of Irrigation Planning, Irrigation Network Planning (MPWH 2013, hereinafter called KP-01), 80% exceeding probability of discharge (Q80%) is applied to estimate the water potential for irrigation development. The data is available at the station Pemali Notog and the station Kedung Ombo. It should be noted that the other stations near the target area contain an uncertainty due to the small scale of watershed area, e.g., smaller than 100 sq.km such as Lumeneng-Watukumpul station and Logung-Kedung Mojo station. In general, the smaller the watershed area is, the lesser the correction is in between the rainfall and discharge,.

Calculated monthly discharge records are summarized in Table 3.1.5 and the relation between rainfall and discharge in the main watershed is comparatively illustrated in Figure 3.1.4. The calculation is based on the probability analysis, which methodology is the same as the one described in Chapter 5 in Part I, with actual discharge records. Compared with the discharge pattern in Lampung province (refer to Figure 2.1.3 in Chapter 2, Part II), water scarcity during dry season tends to be more severe with smaller volume of discharge and longer period of dry season.

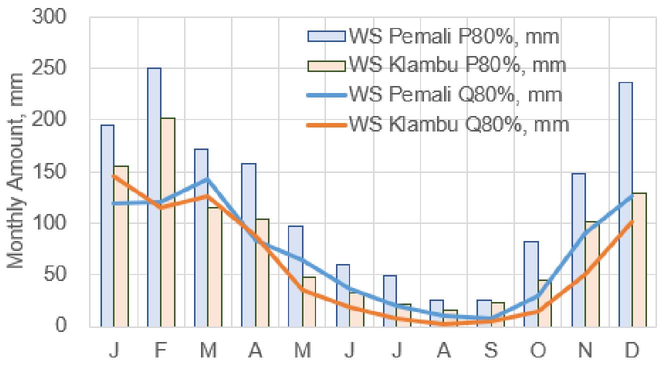


Figure 3.1.5 Rainfall (P80%) and Discharge (Q80%) in the Main Watersheds Source: JICA Project Team

Table 3.1.5 Monthly 80% Exceeding Probability Discharge ($Q_{80\%}$) by Target Irrigation Scheme (unit: m^3/s)

Name	Area, km^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pemali	856	38.2	42.8	45.7	27.3	20.5	12.3	6.3	3.2	2.7	9.4	29.9	40.5
Comal	514	23.0	25.7	27.5	16.4	12.3	7.4	3.8	1.9	1.6	5.7	18.0	24.3
Sungapan	160	7.1	8.0	8.5	5.1	3.8	2.3	1.2	0.6	0.5	1.8	5.6	7.6
Rambut	158	7.1	7.9	8.4	5.0	3.8	2.3	1.2	0.6	0.5	1.7	5.5	7.5
Gung	156	6.9	7.8	8.3	5.0	3.7	2.2	1.1	0.6	0.5	1.7	5.4	7.4
Cacaban	157	7.0	7.9	8.4	5.0	3.8	2.3	1.2	0.6	0.5	1.7	5.5	7.4
Kumisik	91	4.1	4.6	4.9	2.9	2.2	1.3	0.7	1.3	0.3	1.0	3.2	4.3
Kedung Asem	341	18.6	16.2	16.0	11.4	4.5	2.4	0.9	0.2	0.7	1.8	6.6	12.9
Sidorejo	620	33.8	29.4	29.2	20.8	8.2	4.4	1.7	0.4	1.3	3.3	12.0	23.4
Sedadi	847	46.1	40.2	39.8	28.4	11.2	6.0	2.6	0.5	1.7	4.5	16.4	32.0
Klambu	3,041	166	144	143	102	40.1	21.5	8.2	1.9	6.2	16.0	59.0	115

Source: JICA Project Team

3.1.3 Current Agriculture in Central Java Province

Central Java is known as one of the granary provinces in Indonesia. Agriculture is one of the most important industrial sectors in the province, contributing 14% of GRDP by current market price in 2018[1], higher than the national average of 12.5%. The agricultural sector is also the largest absorber of employment in the province, responsible for 4.2 million jobs (24.4%).

Food crops are mainly cultivated in wetland paddy fields, where maize, cassava, and mung beans are grown as Palawija. Central Java also has a high potential for horticultural crops, with onions, cabbages, and potatoes being widely cultivated. Estate crops such as oil palm are also widely cultivated. The following is a brief description of agriculture in Central Java and in the seven Kabupaten (modernization sites: Grobogan and Demak; rehabilitation sites: Pemalang, Tegal, Brebes, Kendal, and Batang) where the target irrigation sites are located.

1) Agricultural Land Use

Table 3.1.6 shows the agricultural land use in Central Java Province and in the seven Kabupaten where the target irrigation schemes are located. 1.7 million ha of agricultural land is available in Central Java Province as of 2015, of which more than half (57% or 970,000 ha) is classified as wetland. In terms of Kabupaten, all five Kabupaten where the rehabilitation site is located have high irrigation coverage above the provincial average, with Kendal and Batang exceeding 90%. On the other hand, Grobogan

[1] BPS-Statistics of Jawa Tengah Province, Jawa Tengah Province in Figures, 2019

and Demak, where modernization sites are located, have 41.5% and 68.4% respectively.

Table 3.1.6 Agricultural Land Area in Project Area, Central Java Province (2015), Unit: 1,000 ha

Kabupaten	Wetland			Agricultural dryland				Total
	Irrigation	Non-irrigation	Sub-total	Dry field/ Garden	Unirrigated/ Shifting cultivation	Temporarily unused	Sub-total	
Grobogan	33.2	46.9	80.2	19.1	-	0.0	19.1	99.3
Demak	33.5	15.5	49.0	12.4	-	0.0	12.4	61.4
Pemalang	30.9	6.8	37.7	15.8	1.1	0.3	17.2	54.9
Tegal	29.8	7.0	36.9	8.4	-	-	8.4	45.2
Brebes	46.8	15.4	62.3	14.6	-	0.0	14.7	77.0
Kendal	23.8	1.5	25.3	22.8	-	-	22.8	48.1
Batang	18.7	1.6	20.4	21.2	-	-	21.2	41.5
Central Java	**682.2**	**283.0**	**965.3**	**712.1**	**18.5**	**3.6**	**734.3**	**1,699.5**

Source: Land Area by Utilization 2015 (BPS, 2016)

2) Paddy Production

Table 3.1.7 shows the harvested area, yield, and production of wetland paddy for the last three years (2015, 2017, and 2018). The harvested area has slightly increased in the two Kabupaten where the modernization sites are located, while there is a decreasing trend in the five Kabupaten where the rehabilitation sites are located. Yields are generally high, but there is a general downward trend. In all years, the yields in Grobogan and Demak, where the modernization sites are located, are above the average for Central Java, while the yields in the five Kabupaten, where the rehabilitation sites are located, are below the average.

Table 3.1.7 Harvest area, Yield and Production Volume of Paddy in Project Area, Central Java Province

Kabupaten	**Harvested area (1,000 ha)**			**Yield (ton/ha)**			**Production (1,000 ton)**		
	2015*	**2017**	**2018**	**2015***	**2017**	**2018**	**2015***	**2017**	**2018**
Grobogan	123.4	135.9	125.5	6.37	6.25	5.83	786.0	848.9	732.2
Demak	94.9	95.7	113.1	6.67	6.52	6.10	632.8	623.4	689.9
Pemalang	82.0	90.4	74.8	5.31	5.03	4.82	435.3	454.5	360.2
Tegal	62.4	65.7	32.5	6.03	5.69	5.63	376.0	373.5	182.8
Brebes	99.9	103.2	91.0	5.78	5.56	5.24	576.7	573.7	477.1
Kendal	43.3	45.3	36.3	6.65	5.31	5.16	287.9	240.4	187.2
Batang	40.6	45.9	34.0	4.87	4.86	4.64	197.6	223.0	158.0
Central Java	1,804.6	1,933.6	1,680.4	6.10	5.74	5.66	11,006.6	11,067.6	9,512.4

Note: * data for year 2016 is not publicized, and therefore data for 2915 is referred in this table.
Source: Jawa Tengah Province in Figures (BPS-Statistics of Jawa Tengah Province 2016-2019)

Figure 3.1.5 shows the crop intensity of wetland paddy in Central Java and seven Kabupaten as of 2015. For Central Java as a whole, the paddy rice cropping rate is 187%, indicating that almost all sites have multiple cropping in a year. Especially in Demak (194%), a modernization site, and Pemalang (218%) and Batang (199%), rehabilitation sites, the crop intensity is higher than the provincial average.

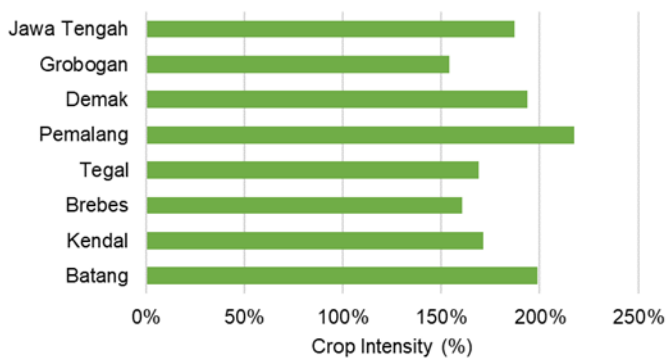


Figure 3.1.6 Crop Intensity of Paddy in Project Area, Central Java Province (2015)
Source: BPS-Statistics of Jawa Tengah Province, 2016

In recent years, the production and diffusion of improved rice varieties in Indonesia have been remarkable, contributing significantly to the increase in paddy rice yields. Figure 3.1.6 shows the share of rice varieties grown in Central Java as of 2017. The most used rice variety in the region is Ciherang with a high share of 40.3%. On the other hand, in Central Java, IR64 is the preferred rice variety with a high share (22.9%), followed by Situ Bagendit (14.2%) and Mekongga (8.4%). With the exception of IR64, all of these top rice varieties are high-yielding varieties released in the 2000s, suggesting that although the substitution of high-yielding varieties is progressing, IR64's share remains strong in the province, which has long promoted rice cultivation as the granary of Indonesia.

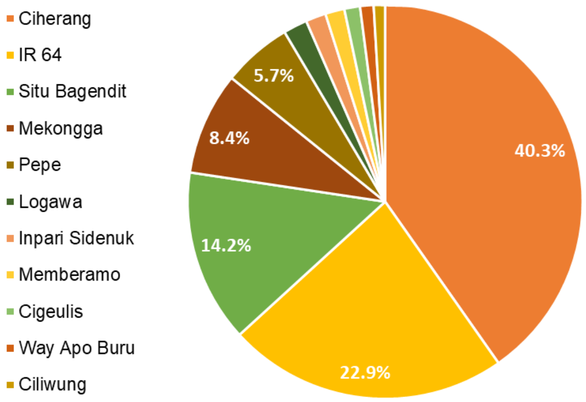


Figure 3.1.7 Share of rice varieties in Lampung Province (2017)
Source: Planted area of new superior paddy varieties year 2017 (Directorate of Seedling, Directorate General of Food Crops, Ministry of Agriculture, 2018)

3) Palawija Production

The type of Palawija, which is a secondary crop to paddy, varies depending on the cropping system in the region. Figure 3.1.7 shows the harvested area of the top three Palawija in Central Java. In Central Java, the largest area is maize (542,800 ha), followed by cassava (150,000 ha) and then Mung beans (82,000 ha). Although soybean, like rice and maize, is counted as a strategic food crop in the country, it is the fifth most harvested crop in the region after groundnut, thus the promotion of its production has not always been successful.

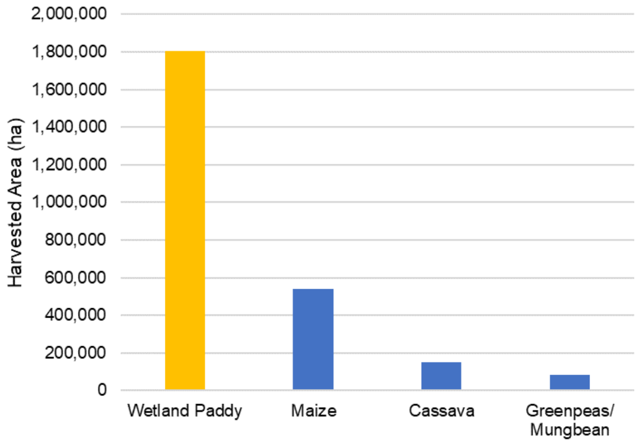


Figure 3.1.8 Harvested Area of Top 3 Palawija in Central Java Province (2015)
Source: BPS-Statistics of Jawa Tengah Province, 2016

4) Issues in Agricultural Activities

In Central Java, 14% of the GRDP is contributed by the agricultural sector, which is higher than the national average of 12.5%. Paddy is the main crop grown in the province, and irrigation development has already progressed, resulting in a high paddy rice cultivation rate. However, in recent years, the growth of rice cultivation area, yield, and production has slowed down and is declining in some areas. Furthermore, although the mechanization of agriculture is being promoted throughout Indonesia, the number of cases of its introduction at the field level is still limited, and there is room for improvement, especially in mechanization (intensification and efficiency) from harvesting to rice milling.

Figure 3.1.8 shows the trend of the agricultural working population in Central Java over the past decade. While the province's overall working population

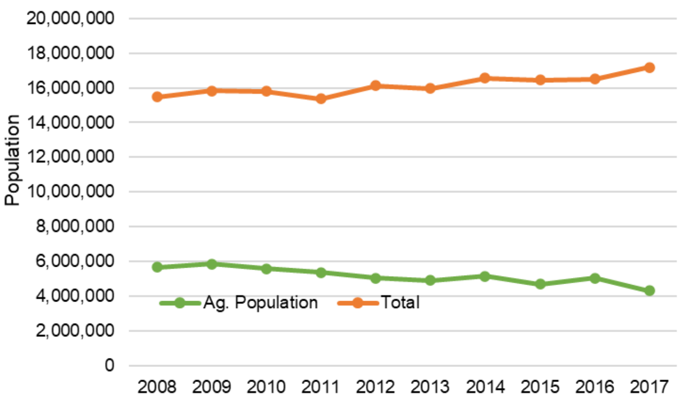


Figure 3.1.9 Agricultural Labor Force in Central Java Province
Source: Statistical Yearbook of Indonesia 2008-2017 (BPS, 2008-2017)

has shown a steady increase over the past decade, the agricultural working population has been on a downward trend, i.e, 37% of the population engaged in the agricultural sector in 2008, but decreasing to 25% as of 2017.

As urbanization progresses, people are moving away from agriculture, and thus securing agricultural labor force in the agricultural sector will become a challenge. In addition to the decrease in labor force, the conversion of agricultural land to other uses has also become an issue in recent years, and it is necessary to enforce policies of protecting existing paddy fields from the perspective of food security. The following is a list of possible issues:

- ✓ Decline in agricultural labor force,
- ✓ Decrease in farmland due to conversion of farmland to other uses,
- ✓ Low profitability of rice cultivation as compared to estate and horticultural crops (high labor cost ratio in production cost), and
- ✓ Low post-harvest quality.

3.2 Agriculture Development Plan

This section describes the agricultural development plan for the implementation of the new irrigation development in Central Java Province. The agricultural development plan consists of land use plan, cropping pattern, and target yield, and it also proposes the necessary activities to implement and realize this plan.

3.2.1 Proposed Land Use Plan

The irrigation schemes in Central Java province are located in seven Kabupaten (modernization sites: Grobogan and Demak, rehabilitation sites: Pemalang, Tegal, Brebes, Kendal, and Batang). In the project, among the existing irrigation schemes, the modernization of irrigation facilities is carried out in Kedung Ombo area (Sidorejo, Sedadi and Klambu irrigation schemes), and rehabilitation in Pemali and Kumisik irrigation schemes, Cacaban area (Gung, Cacaban and Rambut irrigation schemes), Sungapan, Comal and Kedung Asem irrigation schemes.

Table 3.2.1 shows the proposed land use plan for modernization project sites and Table 3.2.2 shows the proposed land use plan for rehabilitation project sites. With the modernization and rehabilitation of irrigation facilities, the irrigation efficiency will be improved and the cropping area will be increased. As a result, the total area of paddy and Palawija in the target area of the modernization project is expected to increase by 5,207 ha and 3,199 ha, respectively. The total area of paddy and Palawija area in the target sites of the rehabilitation project is expected to increase by 5,878 ha and 4,708 ha, respectively.

Table 3.2.1 Land Use Plan in Project Area (Modernization Sites), Central Java Province

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
Grobogan	DI Sidorejo	Modern	7,938	1st	Paddy	Current	7,938	100	
						Plan	7,938	100	-
				2nd	Paddy	Current	7,938	100	
						Plan	7,938	100	-
				3rd	Palawija	Current	5,579	73	
						Plan	6,283	79	6
Grobogan-Demak	DI Sedadi	Modern	16,055	1st	Paddy	Current	11,757	73	
						Plan	12,826	80	7
					Palawija	Current	206	1	
						Plan	225	1	0
				2nd	Paddy	Current	15,230	95	
						Plan	15,950	99	-

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
					Palawija	Current	105	1	
						Plan	105	1	-
				3rd	Palawija	Current	11,321	71	
						Plan	12,350	77	6
Grobogan-Demak	DI Klambu	Modern	37,451	1st	Paddy	Current	28,932	77	
						Plan	31,562	84	7
					Palawija	Current	1,222	3	
						Plan	1,333	4	1
				2nd	Paddy	Current	34,857	93	
						Plan	35,378	99	6
					Palawija	Current	2,073	6	
						Plan	2,073	6	-
				3rd	Paddy	Current	2,941	8	
						Plan	3,208	9	1
					Palawija	Current	16,680	45	
						Plan	18,196	49	4

Source: JICA Project Team

Table 3.2.2 Land Use Plan in Project Area (Rehabilitation Sites), Central Java Province

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
Tegal - Brebes	DI Pemali	Rehab	26,952	1st	Paddy	Current	20,537	76	
						Plan	22,591	84	8
					Palawija	Current	4,339	16	
						Plan	4,361	16	-
				2nd	Paddy	Current	8,747	32	
						Plan	9,622	36	4
					Palawija	Current	14,979	56	
						Plan	16.475	61	6
				3rd	Paddy	Current	131	0	
						Plan	144	1	1
					Palawija	Current	16,994	63	
						Plan	18,691	69	6
Tegal - Brebes	DI Kumisik	Rehab	3,940	1st	Paddy	Current	3,687	94	
						Plan	3,890	99	5
					Palawija	Current	50	0	
						Plan	50	0	-
				2nd	Paddy	Current	3,167	80	
						Plan	3,484	88	8
					Palawija	Current	81	2	
						Plan	86	2	-
				3rd	Paddy	Current	341	9	
						Plan	375	10	1
					Palawija	Current	478	12	
						Plan	526	13	1
Tegal	Cacanan DI Gung DI Cacaban DI Rambut	Rehab	21,705	1st	Paddy	Current	17,644	81	
						Plan	18,207	84	3
					Palawija	Current	3,068	14	
						Plan	3,121	14	-
				2nd	Paddy	Current	9,396	43	
						Plan	10,069	46	3
					Palawija	Current	6,344	29	
						Plan	6,514	30	1
				3rd	Paddy	Current	1,941	9	
						Plan	2,135	10	1
					Palawija	Current	8,525	39	
						Plan	9,137	42	3
Pemalang	DI Sungapan	Rehab	7,086	1st	Paddy	Current	5,668	80	

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
						Plan	6,235	88	8
					Palawija	Current	440	6	
						Plan	483	7	1
				2nd	Paddy	Current	6,737	95	
						Plan	6,760	95	-
					Palawija	Current	326	5	
						Plan	326	5	-
				3rd	Palawija	Current	390	6	
						Plan	407	6	0
Pemalang	DI Comal	Rehab	8,882	1st	Paddy	Current	3,710	42	
						Plan	4,081	46	4
					Palawija	Current	133	1	
						Plan	141	2	1
				2nd	Paddy	Current	8,775	99	
						Plan	8,775	99	-
					Palawija	Current	107	1	
						Plan	107	1	-
				3rd	Palawija	Current	320	4	
						Plan	333	4	-
Kendal - Batang	DI Kedung Asem	Rehab	4,353	1st	Paddy	Current	4,303	99	
						Plan	4,303	99	-
					Palawija	Current	50	1	
						Plan	50	1	-
				2nd	Paddy	Current	3,454	79	
						Plan	3,454	79	-
					Palawija	Current	899	21	
						Plan	899	21	-
				3rd	Palawija	Current	4,353	100	
						Plan	4,353	100	-

Source: JICA Project Team

3.2.2 Proposed Cropping Pattern

The cropping pattern should be determined according to the agricultural production environment (local climate, weather conditions, etc.) and the amount of irrigation water available in the target area. Table 3.2.3 shows the proposed cropping plan for the existing irrigated areas of the modernization project. The current cropping pattern in the existing irrigated areas of the modernization project is a three-season cropping system: first season (October-January), second season (February-May), and third season (June-September).

The first and second seasons are dominated by rice cultivation, while the third season is dominated by Palawija cultivation (maize in the area). The plan is to increase the rice and Palawija cropping area by maintaining the current cropping seasons and cropping patterns, while aiming to improve the water supply function by rehabilitating facilities and dredging canal sediments together with introduction of improved water management technologies to make better use of uncultivated paddy fields.

Table 3.2.4 shows the proposed cropping pattern for the existing irrigated areas for the rehabilitation project. The current cropping pattern is similar to that of the irrigated area under the modernization project: rice cultivation in the first and second seasons, and mainly Palawija cultivation (maize in the same area) in the third season. As for the cropping plan, the project aims to increase the area of rice and Palawija cropping by improving the water supply function through rehabilitation and dredging of irrigation canals as well as introducing improved water management technologies, aiming at advanced utilization of uncultivated paddy fields.

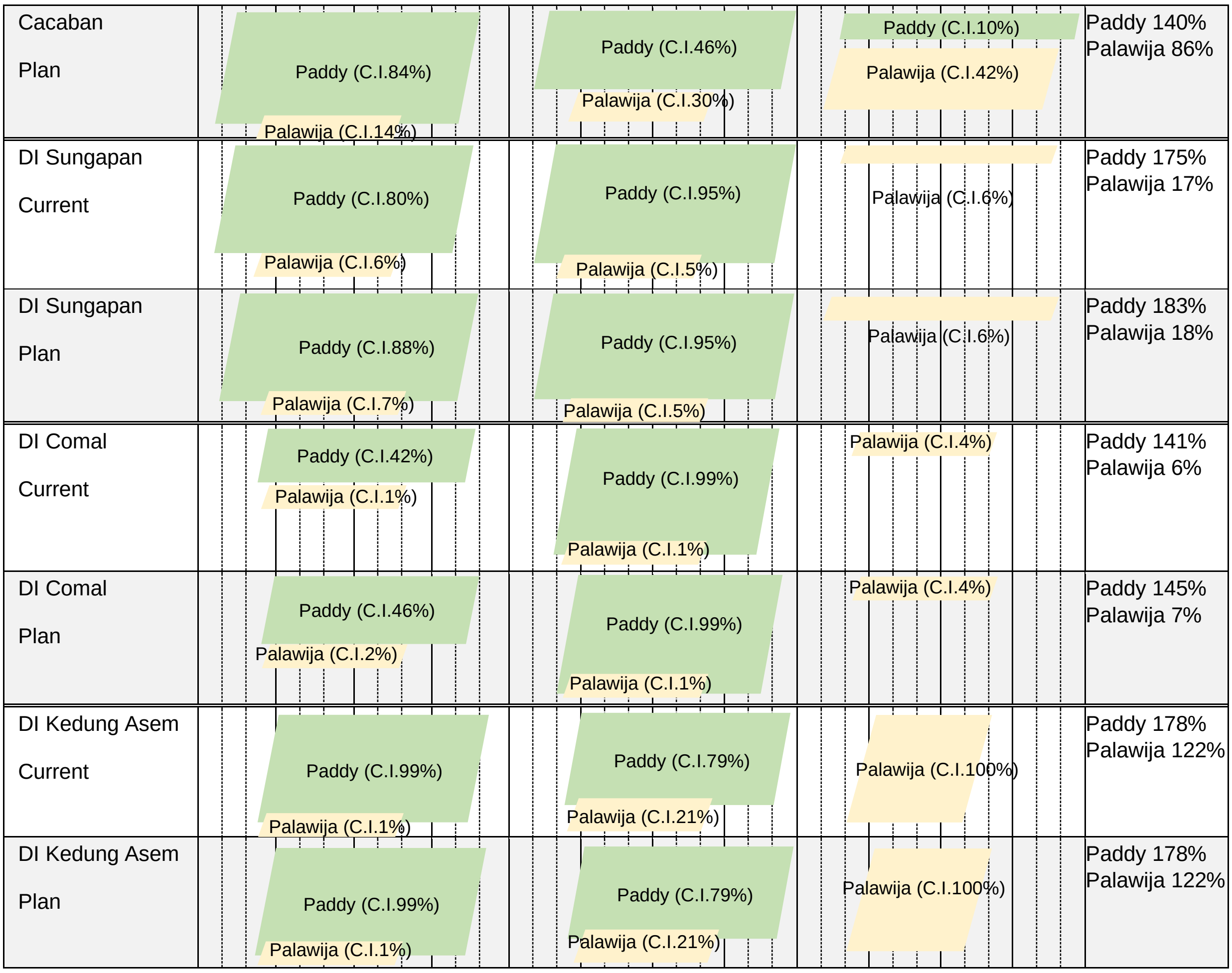
Table 3.2.3 Cropping Pattern (Draft) in Project Area (Modernization), Central Java Province

Cropping Period	1st (Oct, Nov, Dec, Jan)	2nd (Feb, Mar, Apr, May)	3rd (Jun, Jul, Aug, Sep)	Cropping Intensity
DI Sidorejo Current	Paddy (C.I.100%)	Paddy (C.I.100%)	Palawija (C.I.73%)	Paddy 200% Palawija 73%
DI Sidorejo Plan	Paddy (C.I.100%)	Paddy (C.I.100%)	Palawija (C.I.79%)	Paddy 200% Palawija 79%
DI Sedadi Current	Paddy (C.I.73%) Palawija (C.I.1%)	Paddy (C.I.95%) Palawija (C.I.1%)	Palawija (C.I.71%)	Paddy 168% Palawija 73%
DI Sedadi Plan	Paddy (C.I.80%) Palawija (C.I.1%)	Paddy (C.I.99%) Palawija (C.I.1%)	Palawija (C.I.77%)	Paddy 179% Palawija 79%
DI Klambu Current	Paddy (C.I.77%) Palawija (C.I3%)	Paddy (C.I.93%) Palawija (C.I.6%)	Paddy (C.I.8%) Palawija (C.I45%)	Paddy 178% Palawija 54%
DI Klambu Plan	Paddy (C.I.84%) Palawija (C.I.4%)	Paddy (C.I.94%) Palawija (C.I.6%)	Paddy (C.I.9%) Palawija (C.I49%)	Paddy 187% Palawija 59%

Source: JICA Project Team

Table 3.2.4 Cropping Pattern (Draft) in Project Area (Rehabilitation), Central Java Province

Cropping Period	1st (Oct, Nov, Dec, Jan)	2nd (Feb, Mar, Apr, May)	3rd (Jun, Jul, Aug, Sep)	Cropping Intensity
DI Pemali Current	Paddy (C.I.76%) Palawija (C.I.16%)	Paddy (C.I.32%) Palawija (C.I.56%)	Palawija (C.I.63%)	Paddy 108% Palawija 135%
DI Pemali Plan	Paddy (C.I.84%) Palawija (C.I.16%)	Paddy (C.I.36%) Palawija (C.I.61%)	Paddy (C.I.1%) Palawija (C.I.69%)	Paddy 121% Palawija 146%
DI Kumisik Current	Paddy (C.I.94%)	Paddy (C.I.80%) Palawija (C.I.2%)	Paddy (C.I.9%) Palawija (C.I.12%)	Paddy 183% Palawija 14%
DI Kumisik Plan	Paddy (C.I.99%)	Paddy (C.I.88%) Palawija (C.I.2%)	Paddy (C.I.10%) Palawija (C.I.13%)	Paddy 197% Palawija 15%
Cacaban Current	Paddy (C.I.81%) Palawija (C.I.14%)	Paddy (C.I.43%) Palawija (C.I.29%)	Paddy (C.I.9%) Palawija (C.I.39%)	Paddy 133% Palawija 82%



Source: JICA Project Team

3.2.3 Target Paddy Yield in the Future

1) Setting of Base Yield

Table 3.2.5 shows the base yield of paddy in the project areas in Central Java Province. The BPS statistics do not distinguish between irrigated paddy and rainfed paddy, but since most of the paddy cultivation in Kabupaten/Kota, where the target irrigation schemes are located, the paddy yield is considered to be approximately the same as the irrigated paddy yield. The average yield of paddy rice in the province is 5.80 tons/ha.

Table 3.2.5 Base Yield in Project Area, Central Java Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)
Grobogan	DI Sidorejo	Modernization	5.99
Grobogan-Demak	DI Sedadi		6.18
Grobogan-Demak	DI Klambu		6.18
Tegal - Brebes	DI Pemali	Rehabilitation	5.64
Tegal - Brebes	DI Kumisik		5.64
Tegal	Cacaban		5.65
Pemalang	DI Sungapan		5.11
Pemalang	DI Comal		5.11
Kendal - Batang	DI Kedung Asem		5.27
Central Java Province	-	-	5.80

Source: Jawa Tengah Province in Figures (BPS-Statistics of Jawa Tengah Province, 2015-2019)

2) Setting of Upper Limit Yield (Target Yield)

The results of the BPS survey and other studies have shown that paddy yield depends not only on irrigation conditions, but also on the cultivar and amount of fertilizer applied (see Part I, Chapter 3). In other words, in addition to irrigation maintenance, appropriate paddy cultivation management techniques (good varieties and appropriate fertilizer management) are necessary to increase paddy yield. In existing irrigated areas, irrigated rice cultivation has already been long practiced, and rice farmers have a certain level of cultivation know-how, so it is desirable to introduce advanced cultivation management practices. For this reason, the upper limit of yield is set using Scenario 2 shown in Table 3.2.6.

Table 3.2.6 Applied Scenario for Upper Limit Yield (Target Yield) in Project Area, Central Java Province

Type		Scenario	Assumption	Setting Criteria
Modernization **Rehabilitation**	→	**2. Good agricultural practice**	**Agricultural management practice is improved.** Under policy support such as further R&D, extension support, and subsidy, it is expected that new introduction of high-yielding superior seeds and increase of fertilization input **is promoted.**	1. Using data from the SURVEI UBINAN TANAMAN PANGAN 2014, 2016, 2017 (BPS, 2014, 2016 and 2017), extract farmers who are using fertilizer at 430 kg/ha or more and using superior or hybrid seeds. 2. Using the data of the extracted farmers, the upper limit has been set to the average of top 25% yield (75th percentile of Tukey's Hinges) for each island under irrigation and non-irrigation in 2014, 2016 and 2017.

Source: JICA Project Team

Applying the scenario shown in Table 3.2.6, the maximum yield in Central Java is 6.53 t/ha, which is an increase of 12.6% from the current average of 5.80 t/ha. This increase rate is applied to all irrigated schemes to calculate the target yield for each irrigated scheme. (See Table 3.2.7)

Table 3.2.7 Target Yield in Project Area, Central Java Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)	Target Yield (t/ha)	Increment (%)
Grobogan	DI Sidorejo	Modernization	5.99	6.74	
Grobogan-Demak	DI Sedadi		6.18	6.96	
Grobogan-Demak	DI Klambu		6.18	6.96	
Tegal - Brebes	DI Pemali	Rehabilitation	5.64	6.35	
Tegal - Brebes	DI Kumisik		5.64	6.35	
Tegal	Cacaban		5.65	6.36	
Pemalang	DI Sungapan		5.11	5.75	
Pemalang	DI Comal		5.11	5.75	
Kendal - Batang	DI Kedung Asem		5.27	5.93	
Central Java province	-	-	5.80	6.53	12.59

Source: Jawa Tengah Province in Figures (BPS-Statistics of Jawa Tengah Province, 2015-2019)

3) Setting of Yield Increase with Time Course

Similar to the upper limit yield (target yield), the increase in rice yield over time is assumed to vary depending on whether or not appropriate paddy cultivation management practices are introduced. Therefore, the yield increase over time is set using Scenario 2 shown in Table 3.2.8 for the existing irrigated area.

Table 3.2.8 Applied Scenario for Yield Increase with Time Course in Project Area, Central Java Province

Type		Scenario	Assumption	Setting Criteria
Modernization **Rehabilitation**	→	**2. Good agricultural practice**	**The yield growth is rapidly progressed** by strategic policy support such as further R & D, extension services and subsidy, which encourages new introduction of high-	The recent rapid progress in yield increase is assumed to be continued in future, the yield will be increased to the upper limit by the linear slope of the yields as of

Type	Scenario	Assumption	Setting Criteria
		yielding superior seeds and increase of fertilizer input.	1997 and 2015.

Source: JICA Project Team

Table 3.2.9 to Table 3.2.17 show the trend of yield in the existing irrigation schemes after the start of the project. In the present estimation, there is no irrigated area that reaches the maximum yield in 10 years after the start of the project. In the estimation of the target yield, it is assumed that the project will be designed and implemented over a period of five years, and that no yield increase will be expected in the first two years for design.

Table 3.2.9 Yield Increase with Time Course in Project Area (DI Sidorejo), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.99	5.99	5.99	6.03	6.06	6.10	6.14	6.17	6.21	6.25	6.28	6.74
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.10 Yield Increase with Time Course in Project Area (DI Sedadi), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
6.18	6.18	6.18	6.22	6.25	6.29	6.33	6.37	6.41	6.44	6.48	6.96
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.11 Yield Increase with Time Course in Project Area (DI Klambu), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
6.18	6.18	6.18	6.22	6.25	6.29	6.33	6.37	6.41	6.44	6.48	6.96
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.12 Yield Increase with Time Course in Project Area (DI Pemali), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.64	5.64	5.64	5.67	5.71	5.74	5.78	5.81	5.85	5.88	5.92	6.35
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.13 Yield Increase with Time Course in Project Area (DI Kumisik), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.64	5.64	5.64	5.67	5.71	5.74	5.78	5.81	5.85	5.88	5.92	6.35
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.14 Yield Increase with Time Course in Project Area (Cacaban), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.65	5.65	5.65	5.68	5.72	5.75	5.79	5.82	5.86	5.89	5.93	6.36
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.15 Yield Increase with Time Course in Project Area (DI Sungapan), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.11	5.11	5.11	5.14	5.17	5.20	5.23	5.27	5.30	5.33	5.36	5.75

Stage	Design＋Project Implementation	Operation & Maintenance	-

Source: JICA Project Team

Table 3.2.16 Yield Increase with Time Course in Project Area (DI Comal), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.11	5.11	5.11	5.14	5.17	5.20	5.23	5.27	5.30	5.33	5.36	5.75
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 3.2.17 Yield Increase with Time Course in Project Area (DI Kedung Asem), Central Java Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.27	5.27	5.27	5.30	5.33	5.37	5.40	5.43	5.46	5.50	5.53	5.93
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

4) Setting of Target Yield Other than Paddy

The type of Palawija, which is a secondary crop of paddy, varies depending on the cropping system in the area. As shown in Figure 3.1.8, maize is the main back crop in Central Java Province. In the case of irrigation improvement or irrigation development, maize is expected to be the secondary crop, and the yield is set at the current level (i.e., increase in cropped area is expected due to irrigation improvement, but increase in yield is not expected).

Table 3.2.18 Base Yield (Maize) in Project Area, Central Java Province

Kabupaten	DI Name	Type	Type of Palawija	Base Yield (t/ha)
Grobogan	DI Sidorejo	Modernization	Maize	5.91
Grobogan-Demak	DI Sedadi		Maize	6.79
Grobogan-Demak	DI Klambu		Maize	6.79
Tegal - Brebes	DI Pemali	Rehabilitation	Maize	6.49
Tegal - Brebes	DI Kumisik		Maize	6.49
Tegal	Cacaban		Maize	6.76
Pemalang	DI Sungapan		Maize	3.51
Pemalang	DI Comal		Maize	3.51
Kendal - Batang	DI Kedung Asem		Maize	6.58

Source: Jawa Tengah Province in Figures (BPS-Statistics of Jawa Tengah Province, 2015 and 2016)

Regarding the selection of Palawija, it is desirable to introduce crops with high farm profitability considering the agricultural production environment such as water availability and soil conditions. In fact, one of the reasons why soybean production area is sluggish despite that the soybean is designated as one of the strategic crops at present is the low farm profitability (2021, Krisdiana, R et.al.[2]). It may be easy for the beneficiary farmers to accept such crops that are highly marketable as horticultural crops including shallot and chili and also sweet potatoes which has been in high demand as a processed product for export in recent years (2021, SK Dermoredjo et. al.[3]).

3.2.4 Recommended Activities for Agriculture Development

In order to achieve and realize the aforementioned agricultural development plan (land use plan, cropping pattern, and target yield), it is necessary to take measures to address the current issues in the target development area. The following is a suggested approach for agricultural development that may

[2] Krisdiana, R. et al., Financial Feasibility and Competitiveness Levels of Soybean Varieties in Rice-Based Cropping System of Indonesia. Sustainability 2021, 13, 8334.
[3] SK Dermoredjo et. al., Sweet potato agribusiness development strategy to improve farmers' income. 2021 IOP Conf. Ser.: Earth Environ. Sci. 653 012003

serve as a countermeasure.

Table 3.2.19 shows the challenges of agricultural development in the existing irrigation schemes in Central Java Province and possible countermeasures. In this area, the outflow and decrease of agricultural labor force has become apparent due to urbanization, and one of the issues that need special attention is the shortage of agricultural labor force. One possible solution to this problem is to provide administrative support to new farmers by introducing subsidies and loan programs.

In addition, training and registration of agricultural service providers to encourage the outsourcing of labor-intensive tasks such as tillage, harvesting, and processing will help to address the decline in the labor force. Further, in order to curb the decrease in farmland due to the conversion of farmland, which is also caused by urbanization, the promotion of agro-politan spatial planning, strategic community-wide promotion of rice cultivation, and the promotion of regulations on the conversion of farmland through the appropriate implementation of sustainable food farmland (LP2B) will be measures to halt the decrease of farmland.

In rice cultivation management, it may be effective to increase profitability through the introduction of agricultural machinery (tractors, harvesters, etc.) to reduce labor costs and the introduction of ICT tools to increase labor productivity. In addition, improvements in collection and shipping systems and rice milling facilities are expected to enhance market competitiveness by adding value.

By implementing these high-priority measures in parallel with the irrigation development (modernization and rehabilitation project), this project will make it possible to realize the land use plan, cropping plan, and target yield, which in turn is expected to contribute to the promotion of agriculture in the region.

Table 3.2.19 Issues and Countermeasures for Agriculture Development in Project Area, Central Java Province

Possible Issues	Countermeasures (Basic Approach)	Expected Effects
✓ Decline in agricultural labor force	✓ Introduce subsidy programs to ensure that new farmers, including women and youth, and/or farmer groups have the agricultural inputs they need (e.g., high-quality seeds, fertilizer).	✓ Increase in new entries by supporting initial investment (capital input)
	✓ Training and registration of agricultural service providers (wage farming businesses)	✓ Outsource the work
✓ Decrease in farmland due to conversion of farmland to other uses	✓ Promote agro-politan spatial planning	✓ Granting incentives
	✓ Protection of agricultural land through proper implementation of sustainable food farmland (LP2B).	✓ Restricting diversion and providing incentives
✓ Paddy cultivation is less profitable than estate and horticultural crops (due to the high labor ratio in production costs)	✓ Promotion of mechanized agriculture (modernization and labor saving)	✓ Reduction of labor costs
	✓ Introduction of modern agricultural production management technologies through the use of ICT tools	✓ Increase in labor productivity
✓ Low post-harvest quality	✓ Strengthen collection and shipping systems	✓ Strengthen market competitiveness by adding value
	✓ Improvement of rice milling facilities	

Source: JICA Project Team

3.3 Irrigation Development and Management Plan

3.3.1 Irrigation Area Delineation

Irrigation schemes in Central Java province, under BBWS Pemali Juana, are for the rehabilitation and modernization, and do not contain any expansion or new development due to no land which is able to develop or expand for irrigation purpose. It is however noted that irrigated cropping area may be enlarged within the irrigation scheme area if water can be newly generated thanks to the rehabilitation and modernization works. Irrigation area is therefore delineated by the spatial data provided by DILL.

Their location and area are shown in Figure 3.1.2 and Figure 3.1.3 afore-mentioned. In addition, mean elevation and slope are calculated based on DEMNAS, and summarized in Table 3.3.1 as a reference.

Table 3.3.1 Mean Elevation and Slope of the target Irrigation schemes in Central Java Province

DI Name	Mean Elevation (EL.m)	Mean Slope (%)	DI Name	Mean Elevation (EL.m)	Mean Slope (%)
Pemali	9.1	1.7	Comal	6.5	3.0
Kumisik	70.7	2.6	Kedung Asem	6.0	1.6
Gung	59.4	2.3	Sidorejo	6.1	1.6
Cacaban	19.4	1.9	Sedadi	11.6	1.4
Rambut	10.7	2.4	Klambu	26.3	1.4
Sungapan	9.9	2.5	-	-	-

Source: JICA Project Team

3.3.2 Available Water for Irrigation and Irrigable Area

Water availability is defined as the saving water amount after an improvement of irrigation efficiency has been made. In this examination, the overall irrigation efficiency of the target irrigation schemes for rehabilitation is assumed to be 50% and increase to 55% with improvement, whereas the efficiency of irrigation schemes for modernization starts at 55% and increases to 60%, which corresponds to the standard of the irrigation efficiency described in KP-01 (MPWH 2013). Of all the target irrigation schemes in Central Java province, DI. Sidorejo, DI. Sedadi and DI. Klambu are the target for modernization (see Figure 3.1.3), while the others for rehabilitation.

As for the other inputs for calculation, it is mainly the same as the ones described in Part I except for seasonal planted area and functional area of each irrigation scheme, which were all provided from the relevant BBWS. The source of input for calculation is summarized in Table 3.3.2.

Table 3.3.2 Calculation Condition for Water Availability in Central Java Province

Input	Description
Irrigation Efficiency	Assuming it improves from 50% to 55% on the irrigation schemes for rehabilitation, and 55% to 60% on the one for modernization (improvement in irrigation efficiency is assumed to realize on water conveyance phase).
Functional Area	Applying the values defined in the Ministry Regulation PUPR No 14 / PRT / M / 2015
Planted area	Applying actual planted area in 2019/2020 based on the Form 2B-RTI provided by BBWS
Cropping Pattern	Applying actual cropping pattern in 2019/2020 based on the Form 2B-RTI provided by BBWS in addition to the interview result from BBWS Staff for details
Ohers (eg. Evapotranspiration, Crop Consumptive Use, etc)	Applying the same as the one described in Part 1

Source: JICA Project Team

The calculation results are shown in Table 3.3.3 (details calculation sheet for monthly planted area and water demand is attached in Appendix). The impact on rehabilitation and modernization can be larger in the months which require much amount of water such as October (for land preparation with relatively small effective rainfall) and February to May (small effective rainfall). In total, the results show that the annual saving water amount of the target irrigation schemes (total service area: 134,362 ha) in Central Java province reaches as much as 189.7 MCM.

Table 3.3.3 Monthly Saving Water Amount of the Target Irrigation Schemes in Java Tengah

DI Name	Service Area (ha)	Monthly Saving Water Amount with Improvement (MCM)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pemali	26,952	0.00	1.59	1.24	2.32	2.21	0.71	1.02	0.82	0.05	8.11	4.17	1.30	23.54
Comal	8,882	0.74	2.62	1.71	2.35	2.69	0.01	0.02	0.02	0.01	1.55	0.81	0.87	13.40
Sungapan	7,086	0.87	1.73	1.12	1.75	1.99	0.02	0.02	0.02	0.01	2.35	1.24	1.11	12.24
Rambut	7,634	0.38	0.25	0.20	0.34	0.35	-	-	-	-	2.32	1.28	0.69	5.81
Gung	6,632	0.11	0.63	0.30	1.04	1.36	0.76	0.65	0.80	0.58	2.21	1.14	0.35	9.93
Cacaban	7,439	0.16	0.54	0.49	0.87	0.85	0.36	0.35	0.39	0.24	2.59	1.42	0.53	8.80
Kumisik	3,940	0.06	0.37	0.11	0.56	0.82	0.15	0.11	0.16	0.13	1.41	0.66	0.15	4.70

DI Name	Service Area (ha)	Monthly Saving Water Amount with Improvement (MCM)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kedung Asem	4,353	0.72	0.90	0.65	0.75	0.89	0.17	0.25	0.20	-	1.80	0.73	0.87	7.93
Sidorejo	7,938	1.46	2.09	1.37	1.80	2.13	0.18	0.27	0.22	-	2.78	1.49	1.68	15.46
Sedadi	16,055	2.08	3.61	2.37	3.06	3.90	0.37	0.53	0.42	-	4.05	2.04	2.23	24.65
Klambu	37,451	5.26	8.75	5.94	7.37	9.16	1.53	1.55	1.64	0.96	10.0	5.33	5.71	63.21
Total	134,362	11.8	23.1	15.5	22.2	26.4	4.3	4.8	4.7	2.0	39.2	20.3	15.5	189.7

Source: JICA Project Team

With those saving water amount, additional irrigable area, or additional cropping area, can now be calculated. Maximum planted area is set as the current service area defined by the Ministry Regulation PUPR No.14/PRT/M/2015 since extra area for a new development or expansion of service area can hardly be available within the Central Java province. However, based on the data about the latest planted area obtained from the relevant BBWS, most of the target irrigation schemes are not fully utilized. Moreover, even if farmland is fully utilized, it is still useful to stabilize the planted area during such period of strong El Niño, which could cause a severe drought.

Table 3.3.4 shows the planted area by irrigation scheme before improvement, meaning the current planted area, while Table 3.3.5 indicates the areas which can be planted with improvement of irrigation efficiency by rehabilitation and/or modernization. With the improvement of irrigation efficiency, it can be found that there is an increase in terms of planted area as shown in Table 3.3.6. By rehabilitation and modernization of the target irrigation schemes, annual total planted area is expected to increase by 18,474 ha (Season 1: 7,712 ha, Season 2: 4,798 ha and Season 3: 5,964 ha) which is 14% increase in cropping intensity in total.

Table 3.3.4 Planted Area by Irrigation Scheme; Before Improvement (Central Java)

DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija + Sugarcane), ha			Planted Area (Total), ha			CI, %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Pemali	26,952	10E	2E	6E	20537	8747	131	4339	14979	16994	24876	23726	17125	244
Comal	8,882	10E	2E	6E	3710	8775	0	133	107	320	3843	8882	320	147
Sungapan	7,086	10E	2E	6E	5668	6737	0	440	326	390	6108	7063	390	191
Rambut	7,634	10E	2E	6E	5628	1181	0	1013	1146	0	6641	2327	0	117
Gung	6,632	10E	2E	6E	5616	5202	1431	1016	1176	4756	6632	6378	6187	289
Cacaban	7,439	10E	2E	6E	6400	3013	510	1039	4022	3769	7439	7035	4279	252
Kumisik	3,940	10E	2E	6E	3687	3167	341	50	81	478	3737	3248	819	198
Kedung Asem	4,353	10E	2E	6E	4303	3454	0	50	899	4353	4353	4353	4353	300
Sidorejo	7,938	10E	2E	6E	7938	7938	0	0	0	5759	7938	7938	5759	273
Sedadi	16,055	10E	2E	6E	11757	15230	0	206	105	11321	11963	15335	11321	241
Klambu	37,451	10E	2E	6E	28932	34857	2941	1222	2073	16680	30154	36930	19621	232
Total	134,362	-	-	-	104176	98301	5354	9508	24914	64820	113684	123215	70174	229

Note: S as season (S1 starting from early October, S2 from early February, and S3 from early June),
Source: BBWS Pemali Juana

Table 3.3.5 Planted Area by Irrigation Scheme; After Improvement (Java Tengah)

DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija + Sugarcane), ha			Planted Area (Total), ha			CI %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Pemali	26,952	10E	2E	6E	22591	9622	144	4361	16475	18691	26952	26096	18835	267
Comal	8,882	10E	2E	6E	4081	8775	0	141	107	333	4222	8882	333	151
Sungapan	7,086	10E	2E	6E	6235	6760	0	483	326	407	6718	7086	407	201
Rambut	7,634	10E	2E	6E	6191	1299	0	1066	1213	0	7257	2512	0	128
Gung	6,632	10E	2E	6E	5616	5456	1574	1016	1176	5058	6632	6632	6632	300
Cacaban	7,439	10E	2E	6E	6400	3314	561	1039	4125	4079	7439	7439	4640	262
Kumisik	3,940	10E	2E	6E	3890	3484	375	50	86	526	3940	3569	901	213
Kedung	4,353	10E	2E	6E	4303	3454	0	50	899	4353	4353	4353	4353	300

DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija + Sugarcane), ha			Planted Area (Total), ha			CI %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Asem														
Sidorejo	7,938	10E	2E	6E	7938	7938	0	0	0	6283	7938	7938	7938	279
Sedadi	16,055	10E	2E	6E	12826	15950	0	225	105	12350	13051	16055	12350	258
Klambu	37,451	10E	2E	6E	31562	35378	3208	1333	2073	18196	32895	37451	21405	245
Total	134,362	-	-	-	111632	101430	5863	9764	26583	70276	121396	128013	76138	242

Note: S as season (S1 starting from early October, S2 from early February, and S3 from early June),
Source: JICA Project Team

Table 3.3.6 Planted Area by Irrigation Scheme; Increase in Planted Area (Java Tengah)

DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija + Sugarcane), ha			Planted Area (Total), ha			CI, %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Pemali	26,952	10E	2E	6E	2045	875	13	22	1496	1697	2076	2370	1710	23
Comal	8,882	10E	2E	6E	371	0	0	8	0	13	379	0	13	4
Sungapan	7,086	10E	2E	6E	567	23	0	43	0	17	610	23	17	9
Rambut	7,634	10E	2E	6E	563	118	0	53	67	0	616	185	0	10
Gung	6,632	10E	2E	6E	0	254	143	0	0	302	0	254	445	11
Cacaban	7,439	10E	2E	6E	0	301	51	0	103	310	0	404	361	10
Kumisik	3,940	10E	2E	6E	203	317	34	0	5	48	203	321	82	15
Kedung Asem	4,353	10E	2E	6E	0	0	0	0	0	0	0	0	0	0
Sidorejo	7,938	10E	2E	6E	0	0	0	0	0	524	0	0	524	7
Sedadi	16,055	10E	2E	6E	1069	720	0	19	0	1029	1088	720	1029	18
Klambu	37,451	10E	2E	6E	2630	521	267	111	0	1516	2741	521	1784	13
Total	134,362	-	-	-	7456	3129	509	256	1669	5456	7712	4798	5964	14

Note: S as season (S1 starting from early October, S2 from early February, and S3 from early June),
Source: JICA Project Team

3.3.3 Preliminary Irrigation Rehabilitation Planning

1) Structures and Facilities in the Target Irrigation schemes

The 11 Irrigation schemes to be targeted for preliminary irrigation design have many irrigation structures and facilities composed of diversion weir and/or structure, primary canal, secondary canal, tertiary canal as such, and also water level control weir (or regulator gate), drop structure, syphon, spillway, and further water gages for the purpose of proper operation, etc. Table 3.3.7 summarizes those major structures and facilities by scheme, and also examples of main structures in each scheme are shown in the Figure 3.3.1:

Table 3.3.7 Major Irrigation Facilities in Each of the 11 Target Schemes

Item	Unit	Pemali	Comal	Sungapan	Rambut	Gung	Cacaban	Kumisik	Kedung Asem	Sidorejo	Sedadi	Klambu
Dam	Nos	0	0	0	0	0	0	0	1	0	0	0
Weir	Nos	5	1	1	1	1	1	3	4	2	1	1
Division Structure	Nos	1	2	2	1	4	4	1	9	5	8	19
Drop Structure	Nos	68	25	12	31	45	7	8	34	5	15	11
Gate	Nos	10	8	3	0	4	1	2	7	10	3	9
Intake	Nos	177	57	57	39	150	68	35	144	125	118	411
Pump	Nos	1	0	0	0	0	0	0	0	0	0	0
Aqueduct	Nos	9	8	1	1	7	7	18	9	25	5	27
Culvert	Nos	96	50	9	3	38	45	10	126	158	12	115
Slope Channel	Nos	0	0	1	0	3	1	1	0	0	0	0
Spillway	Nos	25	25	13	5	13	18	2	31	81	32	53
Syphon	Nos	13	0	2	2	0	3	4	6	26	3	14
Tunnel	Nos	0	0	0	0	0	0	0	0	18	0	0
Water Gauge	Nos	48	1	5	0	26	8	0	33	19	22	19
Primary Canal	km	8.5	9.5	14.6	12.9	8.8	0.5	15.5	6.9	6.3	13.4	91.7
Secondary Canal	km	200.2	56.2	43.6	34.8	97.6	39.4	16.7	54.0	34.0	17.3	272.7
Tertiary& Quarter	km	120.4	144.3	2.9	2.4	5.2	3.8	0.0	74.4	64.7	57.7	19.1

Item	Unit	Pemali	Comal	Sungapan	Rambut	Gung	Cacaban	Kumisik	Kedung Asem	Sidorejo	Sedadi	Klambu
Canal												
Supply Canal	km	3.0	0.0	0.0	0.0	0.0	21.2	2.0	0.1	0.0	0.6	0.0
Drainage Canal	km	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.4	3.9	0.8

Note: The above table does not reflect all the structures as the database do not have relevant all the data.
Source: PUPR ePAKSI database (as of 27.1.2022)[4]

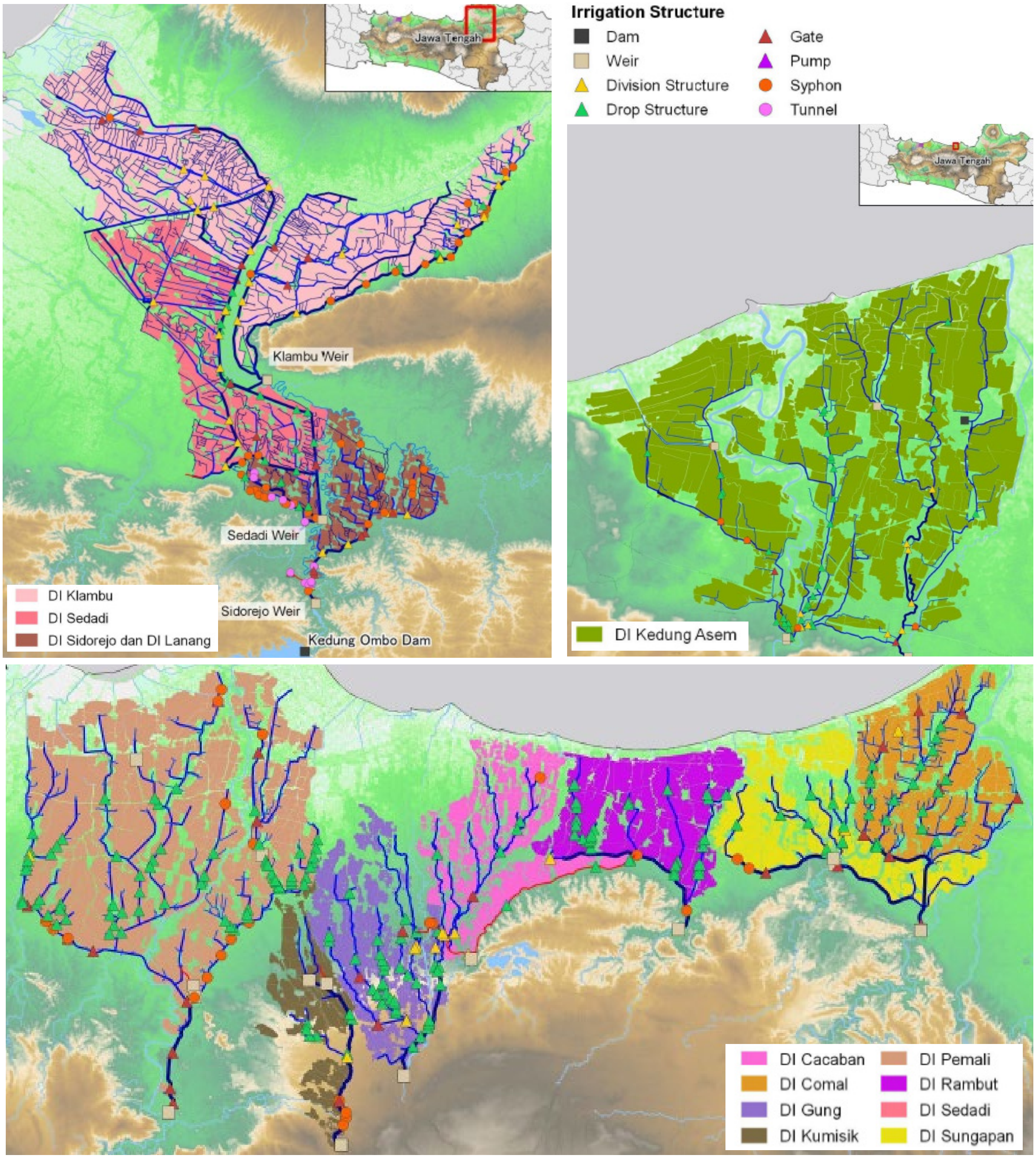


Figure 3.3.1 Main Structures in Target Irrigation Schemes
Source: PUPR ePAKSI database, and JICA Project Team

4 ePAKSI is the geo-spatial database for irrigation service areas and their facilities operated by PUPR (URL: http://103.211.51.198/). After registration by PUPR to access the site, Point (Facilities), Line (Canal), and Polygon (Service Area) data are available by each irrigation scheme in the country. Some of the data are now under preparation, so it should be noted that the data was obtained on 28th January 2022.

2) Target Structures and Facilities to be Rehabilitated

In the 11 target irrigation scheme, surveys were conducted on the structural and functional soundness of the existing irrigation facilities with the help of BBWS offices, identifying the necessity of rehabilitation. The following table shows the number of surveyed facilities: primary canals, secondary canals, irrigation facilities including weirs, diversion works, and inspection roads, and also mechanical structures including gates and operation equipment.

Table 3.3.8 Facilities Surveyed in Each of the Target Schemes

Items		DI Name	Pemali	Comal	Sungapan	Rambut	Gung	Cacaban	Kumisik	Kedung Asem	Sidorejo	Sedadi	Klambu
		Area (ha)	26,952	8,882	7,086	7,634	6,632	7,439	3,940	4,353	7,938	16,055	37,451
Canal & IP Road	Primary Canal	Nos	1	1	2	1	1	1	1	1	2	2	3
		Length (m)	8,638	8,999	19,701	13,357	8,850	454	15,547	5,550	24,247	48,955	102,776
	Secondary Canal	Nos	30	9	8	9	14	9	5	9	20	22	61
		Length (m)	185,527	100,388	43,114	31,278	121,114	38,232	19,643	51,628	68,537	89,780	307,793
	Inspection Road	Length (m)	192,165	109,387	62,815	44,635	129,964	38,686	35,190	57,178	92,784	138,735	410,569
Civil Structure & Mechanical	Weir	Nos	5	1	1	1	2	1	3	5	2	1	1
	Off-take Structure	Nos	23	58	61	39	104	60	36	105	112	102	168
	Others (Culvert,	Nos	66	26	18	18	26	56	37	56	247	29	71
	Mechanical Structure	Nos	26	66	69	40	106	59	45	108	114	106	166

Source: BBWS Pemali Juana, and JICA Project Team

3) Evaluation Indicator for Facility Soundness

For the survey of existing irrigation facilities, the JICA team has introduced an evaluation indicator to identify the soundness of the structures and facilities in order to determine the necessity of rehabilitation and the level of measures toward extending the service period of those ones. The evaluation indicator presents 5 levels of ranking, as shown in the table below, based on Japanese guidelines and corresponding to the 5 ranks used in the major irrigation facility survey conducted in Indonesia. The replacement rates of canal length linked to the ranks are set by the JICA team to estimate the degree of rehabilitation.

Table 3.3.9 Evaluation Indicators for Structure and Facility Conditions

Soundness (Rank)	Facility Condition		Estimated Measures (Proposed Works)
	Canal & Civil Facilities (Turnout, Syphon, Culvert, Drop, Bridge, etc.)	Machinery Equipment (Gates, Motors, O/M equipment, etc.)	
S-5 (PR)	Almost no deformation Status	No abnormality is found	No measures required
S-4 (PB)	A state in which minor deformation is observed	Minor deformation is observed, but the machine No hindrance to	Observation required (Continuous monitoring)
S-3 (PS)	Deformation is noticeable	If left unattended, the function will be hindered. A state that requires countermeasures when it comes out.	Repair・reinforcement (Countermeasures against deterioration)
S-2 (RB)	Conditions with deformations that affect the structural stability of the facility	A state in which the function is impaired. A state that requires urgent measures due to significant performance degradation	Required Reinforcement・repair (Urgent deterioration measures)
S-1 (PA)	A condition in which there are multiple alterations that significantly affect the structural stability of the facility. There is a high risk that facility functions will be lost or significantly reduced in the near future. Reinforcement is difficult to deal with economically and the facility needs to be renewed	The reliability of equipment, etc. have declined significantly, making it difficult to provide financial support for repairs. There is a high risk that equipment will lose its function in the near future. A state in which the performance of the original function and the social function is significantly reduced overall.	Update (Renew)

Source: BBWS Pemali Juana, and JICA Project Team

Soundness Ranking Explanation in Indonesian （The replacement rates of canal length are set by project team）
S-1 (PA) : = Asset Renewal (Pembaruan Aset) : 100% replace for canal rehabilitation
S-2 (RB) : = Heavy Rehabilitation (Rehab Berat) : Approximately 70% replace
S-3 (PS) : = Medium Repair (Perbaikan Sedang) : Approximately 30% replace
S-4 (PB) : = Periodic Maintenance (Pemeliharaan Berkala) : Approximately 10% replace
S-5 (PR) : = Routine Maintenance (Pemeliharaan Rutin) : No replace

4) Result of Evaluation

The results of the evaluation for facility soundness in each scheme are summarized in the table below (for detail, refer to the Appendix). For reference, IKSI scores for 2017 are also shown. It should be noted that these scores are for assessing the current status, and not for the purpose of ranking the implementation.

Table 3.3.10 Evaluation Results of the Facility Soundness in Each Scheme

No.	DI Name	Beneficial Area (ha)	Soundness Ranking			Inspection Road Length to be Asphalt Pavement (m)	IKSI score (2017)	
			Canal	Civil & Mech	Over All		Facility	Total
1	Pemali	26,952	3.90	4.27	4.02	192,165	31.38	70.88
2	Comal	8,882	3.40	4.14	3.65	109,387	33.00	78.25
3	Sungapan	7,086	3.00	3.03	3.01	62,815	29.39	74.88
4	Rambut	7,634	2.90	2.94	2.91	44,635	29.91	69.80
5	Gung	6,632	2.80	4.45	3.35	129,964	38.43	79.73
6	Caycaban	7,439	3.80	3.27	3.62	38,686	31.09	73.06
7	Kumisik	3,940	3.40	3.79	3.53	35,190	31.79	72.97
8	Kedung Asem	4,353	3.00	3.21	3.07	57,178	30.39	73.35
9	Sidorejo	7,938	3.30	3.79	3.46	92,784	31.92	74.94
10	Sedadi	16,055	3.80	3.82	3.81	138,735	31.34	74.24
11	Klambu	37,451	3.60	3.81	3.67	410,569	31.39	71.13
Total		**134,362**	**-**	**-**	**3.62**	**1,312,108**	-	-

Note: “Total” of IKSI score includes evaluations of social issues.
Source: BBWS Pemali Juana, and JICA Project Team

The soundness ranking of “Canal” has been calculated as the average considering the evaluation and the length of each canal. The soundness ranking of “Civil & Mech” is the simple average calculated on basis of the each facility’s evaluation result. Furthermore, “Over All” soundness ranking has been calculated by giving a weight of 2/3 on the “Canal” and 1/3 on the “Civil & Mech”, taking into account the ratio of construction cost in general. “Total”, i.e., the overall ranking for the 11 irrigation schemes is calculated by the ranking of each area with the weight of the beneficial area (ha).

According to the average rank of facility soundness for each irrigation scheme, it is assessed that the deterioration of irrigation facilities is moderately progressing in the entire scheme, with Rambut area being the most deteriorated (2.91 for the overall ranking) while Pemali being the least (4.02 for the overall ranking). However, the evaluatio of “Over All” comes to 3.62 for those 11 irrigation schemes corresponding to 3.02 in South Sulawesi (refer to 5.3.3), thus it can be clearly said that the facilities in this province are relatively less deteriorated, and modernization should be implemented gradually as well as rehabilitation.

5) Rehabilitation Length of Inspection Roads

As with the irrigation facilities, the canal inspection roads were also assessed for soundness. In the irrigation facility rehabilitation plan, it is considered necessary to rehabilitate and/or upgrade the inspection roads as well as the irrigation facilities, and the above table also shows the road length, which is calculated for the need of rehabilitation and/or upgrading based on the evaluation results (see the most right column of the table).

The length of the pavement of the inspection road is basically onsidered the same as the canal length. Based on the soundness of the road, if the existing road is paved with concrete or asphalt and is ranked "S-5", rehabilitation is not required. In the case of other rankings, it is assumed that 10-100% of the road length should be rehabilitated or upgraded depending on the soundness ranking.

6) Canal Rehabilitation Plans

In terms of investment scale for the rehabilitation, canals will require the biggest part of it than the structures and facilities in most cases according to the past rehabilitation works implemented by DGWR. Therefore, this section discusses the planning for the rehabilitation of existing canals, and the following shall be considered first in the planning:

a) Follow the existing canal size, cross-sectional shape, and lining (structure and material),
b) Estimate the causes of deterioration, malfunctions, and accidents in the facility, and plan the corresponding rehabilitation,
c) Rehabilitation will be within the existing site,
d) The canal inclines should be designed to ensure appropriate flow velocities and bottom width-depth ratios for lining and sediment in the rehabilitated canals, and structures such as water level regulators shall be installed as necessary,
e) At the primary (main) canals and secondary canals, the lining should be applied to the sides and also the bottom of the canals,
f) The type of the canal lining should be selected taking into account the present type and the recommendations in the design standard Kp-03 Channel-eng, 4.2. For the primary canals, though the standard recommends stone pair (wet masonry) lining, the concrete lining is preferable when the flow volume is large and the water depth is deep as the collapse is often found in many places. On the other hand, in the secondary canals, if stones can be easily procured around the site, it seems appropriate to rehabilitate the canal by stone pair (plastering wet masonry), which is commonly found at present. In addition, construction works should be implemented during the period when there is no/lean water in the canals to avoid interrupting the farming. The preparation of precast concrete panels in advance is one way to shorten the construction period, and
g) Along with primary canals and secondary canals, the inspection road should be rehabilitated and/or upgraded. The width of those roads should be designed according to the design standard Kp-03 Channel-eng, 3.3.5, although depending on the flow discharge, it will be basically 5.0m for the primary canals and 3.0m for the secondary canals. In addition, the pavement shall be made of asphalt and the width should be 3.0m.

The proposed typical cross-section of canal rehabilitation, concrete lining, and wet masonry lining are shown below:

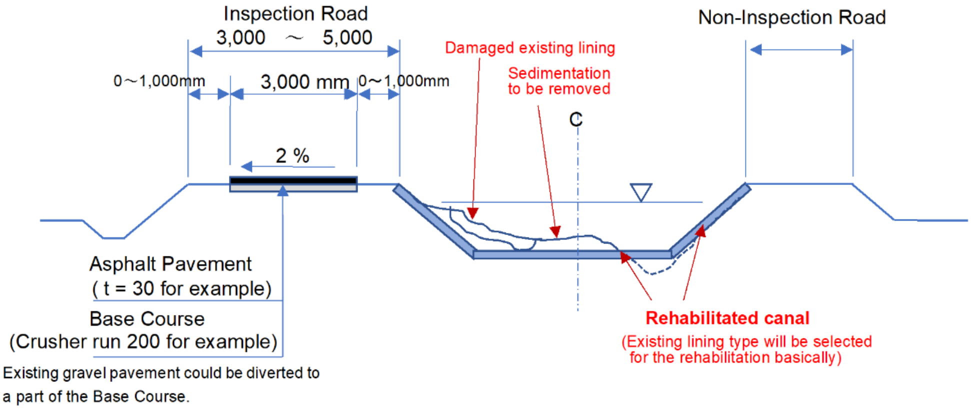


Figure 3.3.2 Conceptual Design of Canal Rehabilitation and Upgrading

Source: JICA Project Team

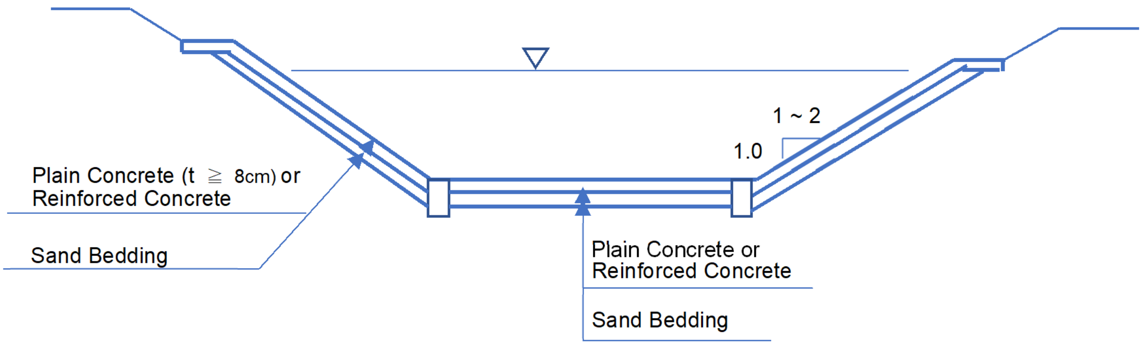


Figure 3.3.3 Typical Cross-Section of Concrete Lining Canal

Source: JICA Project Team

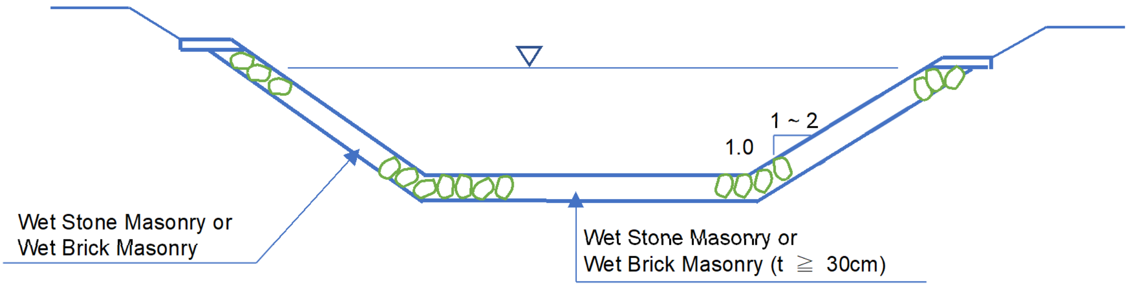


Figure 3.3.4 Typical Cross-Section of Wet Masonry Lining Canal

Source: JICA Project Team

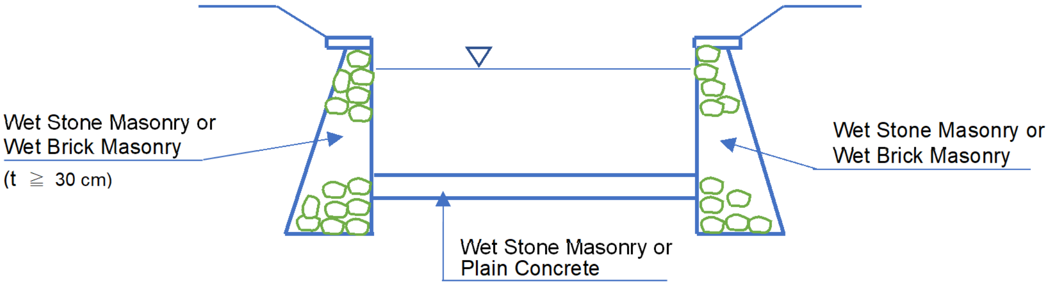


Figure 3.3.5 Typical Cross-Section of Wet Masonry Lining Canal Retaining Wall Type

Source: JICA Project Team

As mentioned above, the present surface of the canal is earth or wet masonry which coefficient of roughness is relatively bigger, and for the rehabilitation, the canal surface should be covered by highly watertight materials in order to prevent leakages. When the lining is made of materials with a small coefficient of roughness, such as concrete, the flow velocity would increase and the water level may become lower and not reach enough height for distribution.

Here, assuming an earthen canal with a depth of 2.5 m and a bottom width of 10.0 m as a typical cross section of the present canal, the water depths corresponding to the following rehabilitation measures and different bottom widths (10.0 m, 8.6 m, 7.0 m, 6.0 m, 5.8 m) are estimated and shown in the table below:

Rehab-1: Lining the entire surface with concrete,
Rehab-2: Lining the entire surface with wet masonry,
Rehab-3: Lining the side walls with concrete and the bottom with wet masonry,
Rehab-4: Lining the side walls with wet masonry and the bottom with concrete,
Rehab-5: Lining the side walls with concrete and the bottom remains earth, and
Rehab-6: Lining the side walls with wet masonry and the bottom remains earth.

Table 3.3.11 Water Depth for Each Rehabilitation Condition

Lining Type	Concrete Lining	Wet Masonry	Earth w/certain grass	(Source: Japanese design guideline for Canal, 2014)			
Coefficient of roughness n	0.015	0.025	0.030				
Case	Side Wall	Base	Water Depth H (m, % for Original 2.5m)				
			B=10.0m	B=8.6m	B=7.0m	B=6.0m	B=5.8m
Original	Earth w/certain grass	Earth w/certain grass	2.50	2.84	3.47	4.07	4.22
			100%	114%	139%	163%	169%
Rehab-1	Concrete Lining	Concrete Lining	1.56	1.76	2.10	2.41	2.49
			63%	70%	84%	97%	**100%**
Rehab-2	Wet Masonry	Wet Masonry	2.21	2.50	3.03	3.53	3.66
			88%	**100%**	121%	141%	147%
Rehab-3	Concrete Lining	Wet Masonry	2.02	2.26	2.68	3.07	3.17
			81%	90%	107%	123%	127%
Rehab-4	Wet Masonry	Concrete Lining	1.81	2.06	2.52	2.97	3.08
			72%	83%	101%	119%	123%
Rehab-5	Concrete Lining	Earth w/certain grass	2.24	2.50	2.97	3.40	3.51
			89%	100%	119%	136%	140%
Rehab-6	Wet Masonry	Earth w/certain grass	2.41	2.72	3.29	3.83	3.97
			96%	109%	132%	153%	159%

Source: JICA Project Team

When the water level in the present canal to be 100% as designed, that of the entire concrete lining would be lower to 63% (Rehab-1, B=10.0m) and that of the entire wet masonry lining would be lower to 88% (Rehab-2, B=10.0m), namely in both cases, the water level will be lower due to the rehabilitation. It is necessary to carefully evaluate in the detail design of the rehabilitation how the hydraulic conditions such as flow velocity and water depth would change and how these changes would affect water management and facility maintenance. In general, following measures against lowering of the water level with the introduction of canal lining are proposed as;

a) In the case of entire rehabilitation by lining, design the canal cross section and gradient to ensure the appropriate flow velocity and water depth. If necessary, to ensure enough water level for distribution, new canal structures, e.g., weirs or gates to raise the water level, should be installed (see the lower inset of Figure 3.3.6) or otherwise there may a need of making the canal longitudinal gradient to be gentler in combination of introduction of drop structures (see the upper inset of Figure 3.3.6).

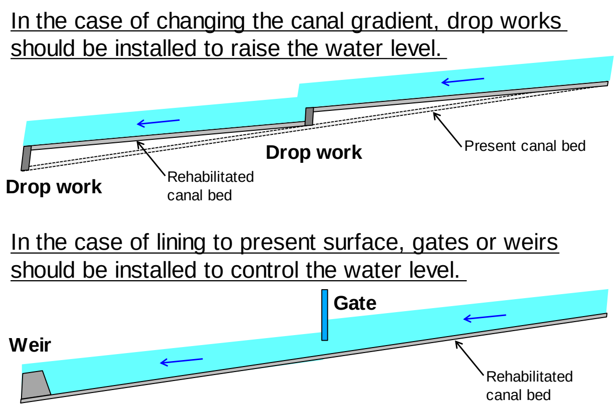


Figure 3.3.6 Images of Raising the Water Level
source: JICA Project Team

b) In case of partial rehabilitation with canal lining, if the flow velocity increases and the water level becomes lower, the following measures should be considered;
   - Select the lining materials with high coefficient of roughness such as the wet masonry,
   - Use the existing structures e.g. division works or gates, etc. to adjust the flow velocity and the water level,
   - Install new canal structures e.g. weirs or gates, etc. and,
   - Make narrower the canal section to raise the water level, and in this case, it is necessary to evaluate carefully the effect of the lining by simulating the flow condition at the upstream and downstream sides of the rehabilitated reaches of canals.

The table above also shows the water level and degree of its changes when the present canal bed (B=10.0m) is to be narrowed to 8.6m - 5.8m, with the conditions of discharge and gradient being the same as the original one. In the case of concrete lining, the water level would be the same as the original one under the canal bed narrowed to 5.8m, and for wet masonry, it comes to 8.6m to ensure the same water level as the original.

Narrowing of the canal bed should be implemented for a certain length, and thus there will be newly created spaces which can be available for other roles such as construction of inspection road. However, compared to partial rehabilitation, the amount of filling soil into the space would be larger and the construction cost would increase. Since the degree of canal bed narrowing varies depending on the lining method and the length of rehabilitation of canal, it is necessary to examine the design plan with hydraulic simulation also taking into account construction cost.

In this rehabilitation plan, although basically the same approach would be applied where a lining exists, the concrete lining would be installed to the relatively large canal (e.g., design discharge over $5m^3/s$), and the wet masonry lining would be installed to the others. If the water level is likely to be lowered as a result of the lining, the changing of lining material, using the existing structures, narrowing the canal bed, and installing new canal structures should be considered as counter-measures.

7) Civil Structures and Associated Mechanical Equipment Rehabilitation Plan

Planning for the rehabilitation of existing civil structures and also associated mechanical equipment, e.g. gates, should be based on the following considerations and procedures;

a) Follow the existing facility size, shape, materials, and functions,
b) Estimate the causes of deterioration, malfunctions, and accidental collapses if any for the structures, and plan the corresponding rehabilitation as required (e.g. installing trash-racks to cope with garbage accumulation in the canals and in front of structures),
c) Rehabilitation should be planned and implemented within the existing site,
d) Survey the conditions of the ground around the structures to be rehabilitated and plan the necessary measures for temporary facilities required for the construction, and environmental consideration,
e) Survey the occurrence of unusual hydraulic events around the structures and plan the necessary measure, and
f) Inspect the wear, corrosion, vibration, noise, operation failure, malfunctions, etc., and plan the necessary measures.

3.3.4 Irrigation Modernization: 3 Irrigation Schemes under Kedung Ombo Dam

Irrigation modernization is planned for such 3 irrigation systems as 1) Sidorejo, 2) Sedadi, and 3) Klambu, which are all under the Kedung Ombo dam commissioned in 1991 with the total reservoir capacity of 6.88 billion CUM. Modernization here is presented as a preliminary feasibility study level on top of the required rehabilitation works as discussed in the previous ‘sub-chapter 3.3.3’.

1) Modernization Planning in line with Five Pillars

The government of Indonesia formulated a policy to update irrigation schemes under the concept of “Irrigation Modernization”. In line with the policy, the DGWR has prepared and presented 5 pillars as a guide to pursue in the planning as well as the implementation of the modernization. The 5 pillars are briefed in Table 3.3.12 and illustrated in Figure 3.3.7, covering

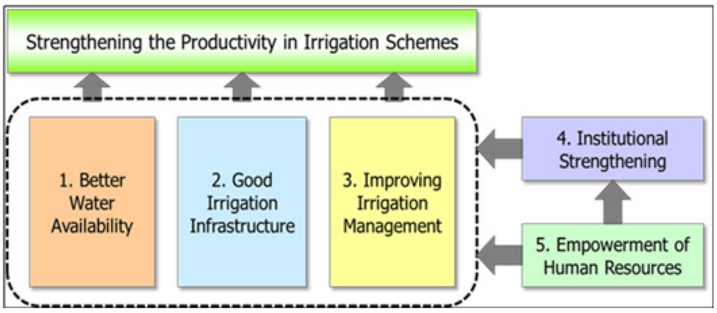


Figure 3.3.7 Five Pillars for Irrigation Modernization
Source: Directorate General of Water Resources

both hard structure improvement and software improvement including human resources development. In sum, the pillars are together meant to envisage the high performance of the irrigation systems. The modernization planning for the 3 irrigation systems are conducted based on the 5 pillars as below:

Table 3.3.12 Five Pillars for Irrigation Modernization Policy

Pillars	Basic Policy
1) Water availability	To secure necessary water resources stably in the watershed and irrigation area.
2) Infrastructure	To improve irrigation facilities in view of better irrigation management.
3) Irrigation management	To improve information and communication networks required for better irrigation management.
4) Institutions	To strengthen related irrigation organizations, e.g., government/ farmers/ related agencies.
5) Human recourses	To develop human resources in view of better irrigation management.

Source: POKOK- POKOK Modernisasi Irrigasi, DGWR (2014)

2) Modernization in Line with Pillar 1: Water Availability

Pillar 1 addresses the security of necessary water resources, meaning there should be a need for increasing water availability. To generate and avail of more water within the same catchment area, what should come first may be the effective utilization of water resources as much as possible, or in other words, reduction or minimization of unused water. There is an example which shows the gap in between how much water is required for crops and how much water has been actually discharged into canals. Figure 3.3.8 shows an experimental result conducted in Lampung province, revealing;

- ✓ As shown in the upper chart, there is a clear difference between actual canal discharges and the discharges planned based on crop water requirement at one canal in an irrigation system of Lampung province. Actual discharge volume (WL-FC1) in April and May is less than that of planned (Plan-WL) while the actually discharged volume into the canal is more than that planned during July and August (winter season).
- ✓ As in the lower chart, the experiment suggested that adjustment of the actual discharges according to the crop water requirement, or the planned one, with reference to the chart could provide an opportunity of saving the water by 10% during the winter season.

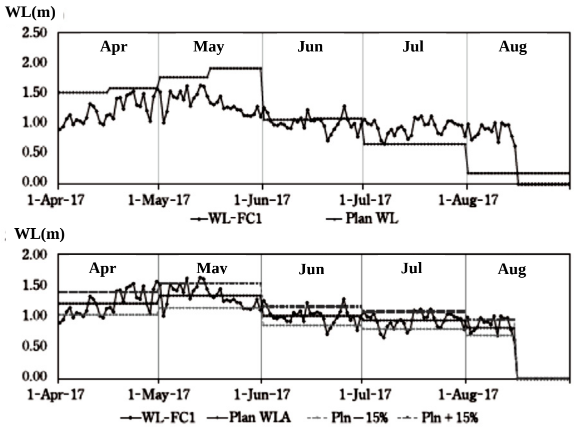


Figure 3.3.8 Planed Water Level and Actual Water Level at An Irrigation Canal in Lampung Province

Source: Introduction of Simple Irrigation Telemetry System for Southeast Asia, 2018, Matsubara et al

In fact, there are lots number of water gauges already installed in the 3 irrigation systems as indicated in Figure 3.3.9. The first step for the modernization with respect to Pillar 1 should be to; 1) establish where not available and/or calibrate where already available 'water level – discharge carve', so-called H-Q curve, 2) conduct a similar experiment as afore-mentioned, and 3) adjust the existing water discharge plans in such a way of minimizing the gap between the planned and actual discharges. With this process introduced, there could be an opportunity of effectively use irrigation water, thus minimizing the unused water, which can be stored in the Kedung Ombo dam reservoir.

In addition to the above, in line with the rehabilitation as planned under Pillar 2, there will also be saved water thanks to the improved facilities. For example, by improving the conveyance and distribution efficiencies through rehabilitation of the existing facilities and improving the water management system, the current amount of water usage will be reduced, and accordingly, newly available water will be generated. The increasing rates of newly available water are estimated as below (also see the discussions of 3.3.2 Available Water for Irrigation and Irrigable Area);

The increasing rate of water supply by the rehabilitation: (irrigation efficiency)
Present=50%, After rehabilitation=55%, Difference=5%, Increasing rate=10% (=5 / 50)

The increasing rate of water supply by the modernization: (Irrigation efficiency)
After rehabilitation=55%, After modernization=60%, Difference=5%, Increasing rate=9% (=5 / 55)

Ensuring the newly available water contributes to the high utilization of unused paddy fields in the irrigation area, namely, by means of increasing the cropping area for rice and Palawija crops. It is desirable to prioritize the supply of the newly available water to areas where the current rice cropping rate is less than 100%, followed by the supply to Palawija crops. Further, if excess water is generated beyond the designed functional area, it can be stored in the dam, Kedung Ombo dam reservoir.

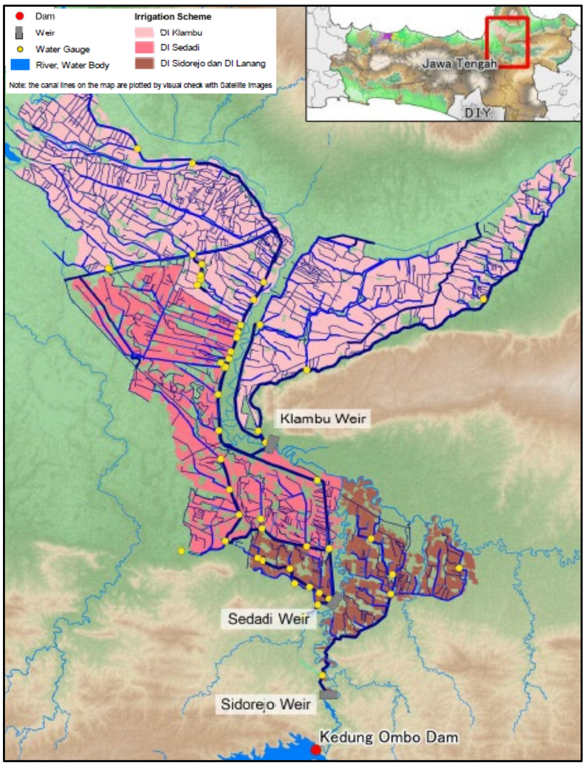


Figure 3.3.9 Location of Measuring Points
Source: PUPR ePAKSI database and JICA Project Team

2) Modernization in Line with Pillar 2: Infrastructure Improvement

The basic policy of this pillar is to improve irrigation facilities (dams, intakes, main canals, branch canals, water control facilities, O&M facilities, inspection roads, extension canals, etc.), which can lead to better water management (for the rehabilitation component, see '3.3.3 Preliminary Irrigation Rehabilitation Planning'). This pillar addresses the need for rehabilitation for the existing facilities, which not only help to restore the required functions and reduce leakage from canals, but also reduce the workload of O&M.

Furthermore, along with the rehabilitation, it is required to improve the monitoring and control system for the purpose of improving the operation of the irrigation system. This can be done by, e.g. installation of water level and discharge volume gauges and improvement of communication network for collecting data. In addition, it is important to formulate a rehabilitation and replacement plan for the long-term utilization of irrigation facilities.

3) Modernization in Line with Pillar 3: Irrigation Management Improvement

The basic policy of this pillar is to improve the system of information and communication networks required for better irrigation management. Improvement of the system in existing irrigation schemes contributes to efficient water use, namely, the creation of surplus water and this is also related to 1) Water availability.

In this preliminary feasibility study, the Team would like to incorporate a satellite image analysis, by which BBWS can know how much areas are irrigated, planted, cropped and harvested, into the water management system. At present, it is already possible to monitor the latest status of watering and cropped areas in the irrigation field by analyzing published satellite images (SAR or Optical images). It is proposed to manage water supply by considering the progress of watering and planted areas detected by almost on-time satellite image analysis. At the same time, such satellite image analysis can identify which areas have not been well irrigated or not planted well, to which irrigation water should be more delivered.

Table 3.3.13 summarizes the publicly available satellite imaging systems, accessible by anyone free of charge. As in the table, almost within one-day, these data can be available, and with analysis taking approximately 1-2 day, the BBWS office in charge of operation of the irrigation systems can know the progress of the watering as well as the progress of cropped areas as exampled in Figure 3.3.10. With reference to the satellite images, the BBWS can improve water management by adjusting the discharges according to the progress of the watering and cropping.

Table 3.3.13 Publicly Available Satellite Imaging Systems

Operation	Name	Method	Type	Resolution	Interval	Data release	Remarks
USGS	Landsat-8	Optical	Level1	30m	16days	Within 24 hours	TOA
USGS	Landsat-8	Optical	Level2	30m	16days	14-16 days later	SR
ESA	Sentinel-2	Optical	Level-1C	10m	5days	Within 6 hours	TOA
ESA	Sentinel-2	Optical	Level-2A	10m	5days	Within 8 hours	BOA
ESA	Sentinel-1	SAR	SLC	5m×20m	12days	Within 24 hours	Northbound orbit (or Southbound orbit)
ESA	Sentinel-1	SAR	GRD	10m	12days	Within 24 hours	Northbound orbit (or Southbound orbit)

TOA: Top of Atmosphere BOA: Bottom of Atmosphere SR: Surface Reflectance
Source: JICA Project Team

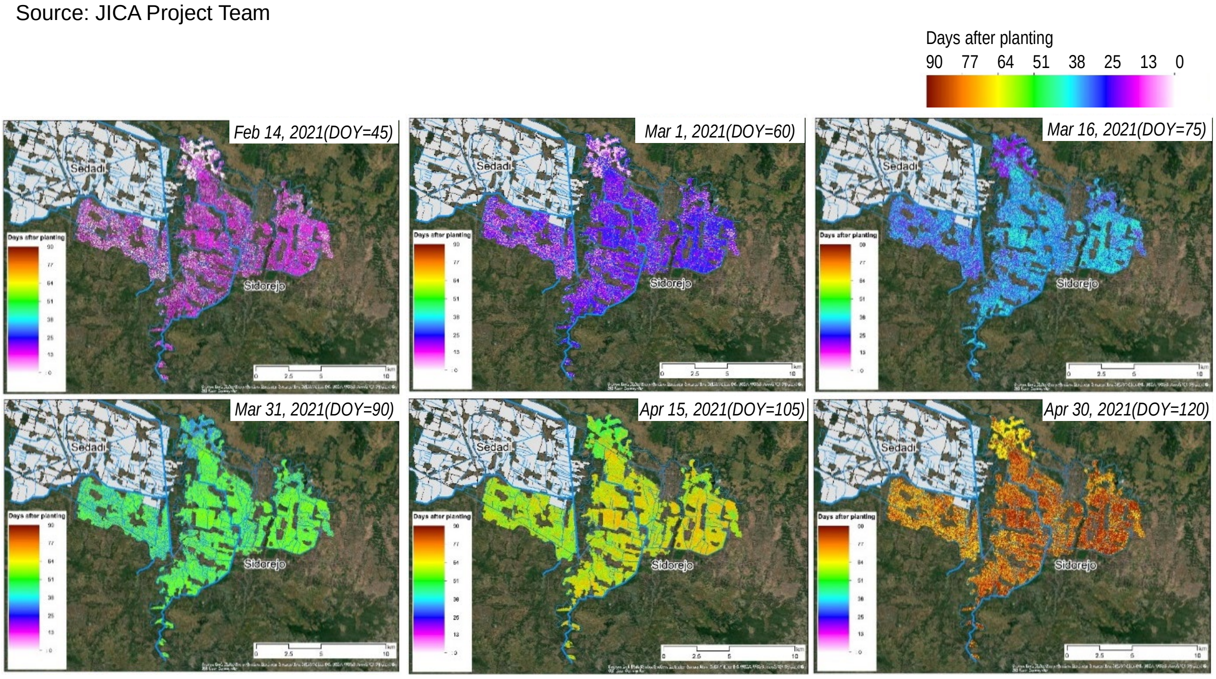


Figure 3.3.10 Sample of Satellite Images for Planting Area in Sidorejo DI
Note: DOY stands for days of year, e.g. DOY 45 means 45th date of the year, February 14.
Source: JICA Project Team

Furthermore, by accumulating satellite images and discharge monitoring data, the data could be utilized for irrigation planning and thus modification of water supply operation plan for the following year. The report mentioned above (Introduction of Simple Irrigation Telemetry System for Southeast Asia, 2018, Matsubara et al) has indicated that it is possible to reduce more than 10% of water supply in the following year's irrigation by considering the actual supply in the previous years. By incorporating the satellite image analysis into the monitoring and operation system as in Figure 3.3.11, better irrigation management ensuring water saving and reduction of unused water could be realized. To sustain the appropriate irrigation management, introducing the O&M manual/ guidelines and development of human resources are of course necessary.

4) Modernization in Line with Pillars 4 & 5: Institutions and Human Resources

The basic policies of these pillars address institutional strengthening and empowerment of human resources in the field of irrigation management. To improve irrigation performance by institution, there are mainly 3 options in terms of irrigation management: 1) government management, 2) farmers' management, and 3) joint management, together with capacity development and enhancement of concerned human resources.

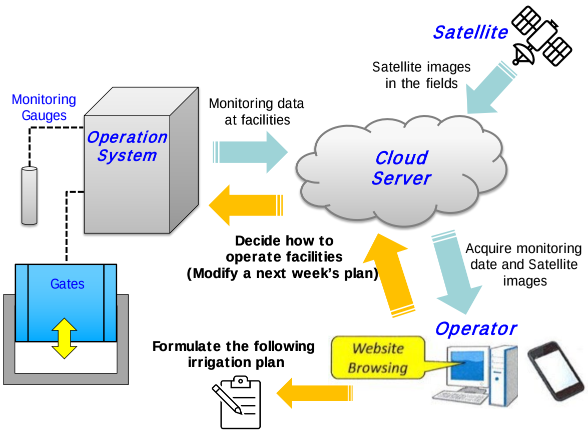


Figure 3.3.11 Image of Water Management System

Source: JICA Project Team

Several countries, where there are large scale national irrigation systems, have chosen joint management by both parties of the government and the beneficiary farmers, in which transfer of the responsibility, or a part of the responsibility, of irrigation management has been made from the government to the farmers' organizations. This handing over of irrigation management is known as irrigation management transfer, so-called IMT, and this is recommended as the potential breakthrough in enhancing the irrigation performance with the rehabilitation completed.

Under this IMT, the upper portion managed by the government should be, in principle, the dams, intakes, main canals, branch canals, big secondary canals, and the related irrigation facilities, while the lower portion managed by the farmers' organizations should small-medium secondary canals, tertiary canals, direct outlets from the secondary canals, and the interconnected irrigation facilities including on-farm watercourses.

Looking at the current set up of irrigation management by the government (BBWS) and farmers organization, e.g. P3A, GP3A, it is basically stated in the farmers organization's article of incorporation and by-laws that the farmers organization shall be in charge of operation and maintenance of their jurisdictional area covered by the organization. In this regard, in fact, P3A shall maintain tertiary canals and associated facilities, and then GP3A shall maintain the secondary canal, from which the organization can take irrigation water, together with the associated facilities. Yet, the latter case has not taken place to date. It means that IMT shall specifically be installed at the level of secondary canals.

Figure 3.3.12 shows the mode of IMT example in the canal systems. Upon the rehabilitation completed, the red-colored canals such as main canal, big secondary canals with facilities are basically to be operated and maintained by the government (BBWS), while the blue-colored canals and facilities, e.g. small-medium secondary canals, by the farmers' organization.

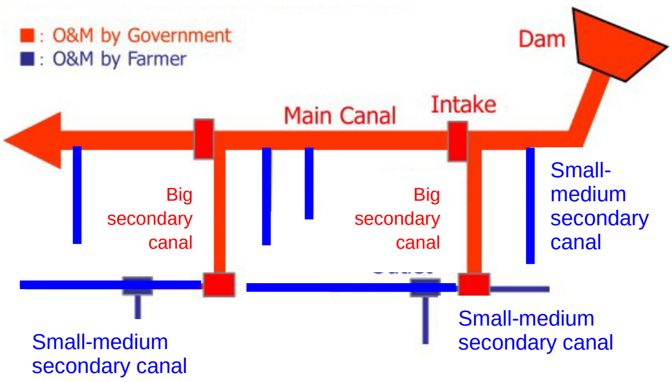


Figure 3.3.12 Conceptual Plan for Joint Irrigation Management

Source: JICA Project Team

The advantages of the IMT are considered as an achievement of efficient operation and maintenance, and reduction of O&M costs. For the government, frequent minor maintenance by the end water users can reduce the necessity of large-scale rehabilitation to be organized by the government. In addition, reduction of the government maintenance expenses allows them to invest more in the primary construction and rehabilitation needs within the same system or in other parts of the country. Finally, it leads to the increment not only of agricultural productivity, but also overall benefits related to irrigated agriculture.

In addition to above, from the perspective of human resource development, it is necessary to prepare manuals for operation, regular inspection, and maintenance to be implemented by the government and farmer's organization respectively with the introduction of IMT and institutionalize a system to share and disseminate these manuals. Furthermore, it is also required to introduce a series of training programs to improve technical and managerial skills as exampled below:

Table 3.3.14 Training Programs Required for Human Resource Development

Program	Description
O&M	Learning about the role, structure, how to operate, inspect, and maintain for each facility.
Organizational Management	Learning about the appropriate organizational management, cooperation, and coordination systems.
Water Management	Learning about the modernized water management method using new-technology (e.g. satellite images) which can reflect the field condition almost seamlessly.

Source: JICA Project Team

3.4 Preliminary Cost Estimation, Implementation Schedule, and Project Evaluation

3.4.1 Preliminary Cost Estimation

In Central Java province, there are total 11 irrigation schemes identified for rehabilitation and modernization, composed of 8 schemes for rehabilitation and 3 schemes for modernization. The current land use is of course whole cultivated, in that wet paddy is planted during rainy season while paddy with irrigation water or Parawija in case of irrigation water not available are planted during dry season. Sometimes, parts of lands may be left uncultivated during dry season due to non-availability of water.

The DGWR has implemented large scale rehabilitation works nationwide during the last 5-year mid-term development period from 2015 – 2019, covering about 3 million ha. The unit rehabilitation cost for those large-scale rehabilitation projects ranged from very minimal cost to very high rehabilitation cost. Excluding extremely low rehabilitation unit cost of less than 7 million Rp/ha (about 500 $/ha) and also extremely high rehabilitation cost higher than 140 million Rp/ha (about 10,000 $/ha), the screened rehabilitation unit cost is estimated as in the Figure 3.4.1 (for detail, refer to the discussion in 8.6.1 Detail Cost under the Current 5-year Medium-Term Development Plan).

Figure 3.4.1 indicates that the unit rehabilitation cost ranges from 14 million Rp to as high as about 40 million Rp per hectare. It may be assumed that the rehabilitation project during the years 2015-2019 had been started in easier rehabilitation works, then moved to complex ones. Minor rehabilitation works, or urgent repair-like works, had been implemented in those targeted irrigation schemes as a matter of fact during the last 5 years. Therefore, the Team takes the average unit rehabilitation cost for the 5 years rehabilitation projects, which comes to 22,142 thousand Rp per hectare as the base rehabilitation cost required. Also, this unit rehabilitation cost applies to the 3 target schemes for modernization.

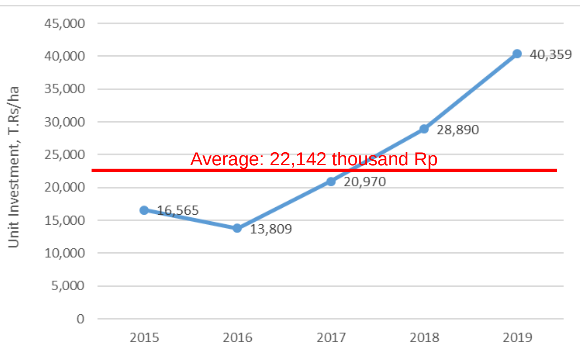


Figure 3.4.1 Unit Rehabilitation Cost of Screened Rehabilitated Schemes from 2015-2019

Source: Directorate of General of Water Resources

In addition to the unit rehabilitation cost above-mentioned, such associated costs as survey and design, administration and also contingencies composed of both physical and cost inflation must be counted in order to implement rehabilitation and modernization projects. Referring to general practices, those associated costs are counted by additional percentage ratio indicated below and calculated in Table 3.4.1.

1) Rehabilitation cost: 22,142 thousand Rp/ha
2) Survey and Design: 10% of the rehabilitation cost
3) Administration: 5% of rehabilitation cost, plus survey & design
4) Contingency (physical): 5% of rehabilitation cost, plus survey & design
5) Contingency (price inflation): 5% of rehabilitation cost, plus survey & design

The unit rehabilitation cost for the total 11 irrigation schemes in Central Java province arrives at 28 million Rp/ha (2,000 US$/ha). With the total net rehabilitation target area of 134,362 ha, the total investment cost for rehabilitation comes to 3,762 billion Rp, equivalent to about 269 million US$.

Table 3.4.1 Estimation of Unit Rehabilitation Cost for Central Java Province

No.	Particulars	Cost, thousand Rp/ha	Multiplier	Remarks
1	Unit Rehabilitation Cost (original)	22,142	-	Refer to Figure 3.4.1
2	Survey and Design	2,214	10%	Against above No.1
3	Administration, etc.	1,218	5%	Against above sum No.1-2
4	Contingency (Physical)	1,218	5%	Against above sum No.1-2
5	Contingency (Price Inflation)	1,218	5%	Against above sum No.1-2
6	Total of above	28,018	126%	Sum of No.1-5
7	Say (thousand Rp/ha)	**28,000**	126%	Rounded up
8	@14000	**2,000**	$/ha	
9	Total Net Irrigation Area (ha)	**134,362**	ha	Net irrigable area
10	Total Cost in Rp	**3,762 billion Rp**		Whole project cost for 134,362 ha
11	Total Cost in US$	**269 million US$**		Whole project cost for 134,362 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

3.4.2 Implementation Schedule

Required period of rehabilitation works depends upon the volume of the facilities to be rehabilitated, namely, the larger the volume is, the longer project period it requires. In many cases, however, typical rehabilitation project is usually scheduled to complete within 5 years for the purpose of generating benefits at an earliest possible time, not letting the beneficiaries wait so long and also from the economic point of view, namely, the earlier the benefit starts accruing, the bigger return the rehabilitation project can produce. In addition, as most of the rehabilitation works rarely require specific civil works technically difficult, lots number of contractors including, to some extent, local contractors could be engaged, leading to shortening the project period.

Thus, the Team sets 5 years according to the general practices for the rehabilitation project in the Central Java province, composed of first 1 year for the survey and design while the rest 4 years for the implementation of rehabilitation works. The rehabilitation works are to start from the 2nd year and partial benefit is planned to accrue from the 3rd year gradually according to the area where rehabilitation works had been completed in the preceding year. The rehabilitation works are scheduled to complete by the end of 5th year and the whole area could be benefitted from the 6th year (see Table 3.4.2).

Table 3.4.2 Overall Implementation Schedule (5 years for implementation)

Rehabilitation Year	1	2	3	4	5	-	-	-	-	-	Remarks
Benefit Year	-	-	1	2	3	4	5	6	7	8	
Survey & Design											
Rehabilitation Works											
Benefit on the 1st one-quarter area											
Benefit on the 2nd one-quarter area											
Benefit on the 3rd one-quarter area											
Benefit on the 4th one-quarter area											

Source: JICA Project Team

3.4.3 Project Economic Evaluation

The economic analysis is carried out to assess the economic feasibility of the project. The analysis compares the project benefit accrued by implementing the project and the cost that are necessary for the project implementation. Following are the preconditions of the economic evaluation, benefits that will show up by implementing the project as well as the economic return as expressed by EIRR:

1) Preconditions of the Evaluation

Preconditions to conduct the economic evaluation are elaborated as follows:

- ✓ Referring to other similar projects in the irrigation/agriculture sector, the economic life of the project is designed as 35 years (5 years construction and 30 years operation). Namely, economic evaluations are examined over this period considering the initial investments costs, operation and maintenance costs, and expected benefits to accrue.
- ✓ EIRR (Economic Internal Rate of Return) is applied for the evaluation criteria. For the opportunity cost of capital, which is the cut-off rate to judge economic feasibility, 10% is applied referring to the practices of international donner organizations such as the World Bank, ADB, and JICA[5]. Also, B/C ratio (Benefit Cost Ratio) and NPV (Net Present Value) are calculated for the references.
- ✓ For the conversion from financial prices to economic ones, standard conversion factor (0.9) is applied for all types of prices except for farm labor (0.6) considering the imperfect competitive labor market in the rural economy.
- ✓ All project costs and benefits are calculated in Indonesian Rupees (IDR), and the foreign exchange rate of 1 USD = 14,000 IDR is applied as of January 2022. All prices are standardized into the price level as of 2019 fiscal year.
- ✓ For the rehabilitation project, there is no incremental operation and maintenance fee.
- ✓ Transfer costs such as taxes and debts are not considered in the economic evaluation as they are "zero-sum" when aggregating all the costs and benefits among stakeholders in the economy.

2) Expected Benefit and its Evaluation Cases

The economic analysis is carried out to assess the economic feasibility of the project. The analysis compares the project benefit accrued by implementing the project and the cost that are necessary for the project implementation. Following are the preconditions of the economic evaluation, benefits that will show up by implementing the project as well as the economic return as expressed by EIRR:

- ✓ **The Effect on the Increase of Irrigable Areas:** with the project, thanks to the incremental irrigation water coming after the rehabilitation of the existing irrigation systems, the irrigable areas in which the beneficiary farmers can cultivate paddy rice and Palawija crops are expected to increase.
- ✓ **The Effect on the Yields Increase:** with the project, the organization of water users associations (WUA) and agriculture extension activities enable timely planting and proper water management, which leads to yield increase.

In the base scenario (the Case 0), the evaluation takes into account both the effect on the increase in

[5] JICA (2012) "Survey for Maximum Utilization of Irrigation Water Indonesia: Final Report" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 28 years of economic life of the project (3 years for the construction and 25 years for the operation). Also, JICA (2004) "The Study on Comprehensive Recovery Program of Irrigation Agriculture in the Republic of Indonesia" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 30 years of economic life of the project.

irrigable areas and the effects on yield increase up to the good agriculture practice level by the promotion of high-yielding superior seeds and fertilizer inputs.

In the alternative scenario (the Case 1), the scenario assumes that the yield does not increase as expected due to external factors such as the stagnation of research & development and extension services. In this scenario, it is assumed that the increment of the target yield is reduced by 20%.

Table 3.4.3 Two Evaluation Cases in the Analysis (Central Java)

Case	Name of the Scenario	The Effects to be considered
Case 0	Base Scenario (Suggested Scenario)	Considering the effect on the increase of irrigable areas by irrigation efficiency increase, with the effect on the yield increase (up to Good Agriculture Practice level).
Case 1	Alternative Scenario	Considering the effect on the increase of irrigable areas by irrigation efficiency increase, and the effect on the yield increase which is reduced by 20% compared to the base scenario.

Source: JICA Project Team

3) Calculation and Economic Conversion of the Project Benefits

For the purpose of economic analysis, information of calculation basis have been collected and estimated from different sources as; 1) the base and target yields have been set by referring to BPS-Statistics of Central Java Province, 2015-2018, and 2) the prices of paddy and maize, as the representative crop of Palawija, have been set by referring to the results of price monitoring conducted by BPS Central Java Province (2018-2020) as summarized in Table 3.4.4 and Table 3.4.5:

Table 3.4.4 Base and The Target Paddy Yields (Central Java)

Irrigation Scheme	Type	Service Area (Ha)	Paddy Rice						Maize
			Base Yield (t/ha)	Years after project has been started (till 35 years)					Base Yield (t/ha)
				1st	2nd	3rd	4th	5th	
DI Sidorejo	Modern ization	7,938	5.99	5.99	5.99	6.03	6.06	6.10	5.91
DI Sedadi		16,055	6.18	6.18	6.18	6.22	6.25	6.29	6.79
DI Klambu Kanan		37,451	6.18	6.18	6.18	6.22	6.25	6.29	6.79
DI Klambu Wilalung			6.18	6.18	6.18	6.22	6.25	6.29	6.79
DI Klambu Kiri			6.18	6.18	6.18	6.22	6.25	6.29	6.79
All Modernization		61,444	6.16	6.16	6.16	6.16	6.20	6.23	6.27
DI Pemali	Rehabil itation	26,952	5.64	5.64	5.64	5.67	5.71	5.74	6.49
DI Comal		8,882	5.11	5.11	5.11	5.14	5.17	5.20	3.51
DI Sungapan		7,086	5.11	5.11	5.11	5.14	5.17	5.20	3.51
DI Rambut		7,634	5.65	5.65	5.65	5.68	5.72	5.75	6.76
DI Gung		6,632	5.65	5.65	5.65	5.68	5.72	5.75	6.76
DI Cacaban		7,439	5.65	5.65	5.65	5.68	5.72	5.75	6.76
DI Kumisik		3,940	5.64	5.64	5.64	5.67	5.71	5.74	6.49
DI Kedung Asem		4,353	5.27	5.27	5.27	5.3	5.33	5.37	6.58
All Rehabilitation		72,918	5.50	5.50	5.50	5.50	5.53	5.57	5.60
All Central Java		134,362	5.85	5.85	5.85	5.85	5.88	5.92	5.95

Source: JICA Project Team
Note: The base and target yields of all Central Java are calculated as the weighted averages of the service areas.

Table 3.4.5 Applied Paddy and Maize Prices in the Evaluation (Central Java)

Months and Average	Paddy Rice				Maize (Palawija)			
	2018	2019	2020	Average	2018	2019	2020	Average
January	6,539	4,904	5,519	5,654	3,850	4,845	-	4,348
February	5,586	4,851	5,537	5,325	3,697	4,711	-	4,204
March	5,061	4,688	5,150	4,966	3,645	4,669	-	4,157
April	4,926	4,709	4,675	4,770	3,676	4,703	-	4,189
May	4,984	4,924	4,725	4,878	3,783	4,726	-	4,255
June	4,866	4,945	4,923	4,911	3,791	4,677	-	4,234
July	4,860	4,959	5,010	4,943	3,831	4,658	-	4,245
August	5,205	5,110	4,685	5,000	3,953	4,706	-	4,329

Months and Average	Paddy Rice				Maize (Palawija)			
	2018	2019	2020	Average	2018	2019	2020	Average
September	5,305	5,540	4,769	5,205	4,154	4,788	-	4,471
October	5,324	5,778	4,789	5,297	4,191	4,811	-	4,501
November	5,731	5,810	4,920	5,487	4,336	4,755	-	4,546
December	5,836	5,885	4,950	5,557	4,496	4,794	-	4,645
Average	5,403	5,367	4,971	**5,247**	3,950	**4,737**	-	4,344
In Economic Price (x 0.9)				4,722	In Economic Price (x 0.9)			4,263
Rounded				**4,720**	Rounded			**4,260**

Source: The results of price monitoring by BPS Central Java Province (2018-2020)
Note: For maize price, the average price as of 2019 is applied to standardize into 2019 price level.

The per hector farming cost is estimated by referring to the standard cost ratio against the cropping revenue per hector. The applied standard cost ratios are estimated based on the BPS "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy and Maize 2017" (national level statistics) with some necessary modifications considering the farming practices in the project area. It implies that the farming cost is assumed to proportionally increase depending on the yield level. Table 3.4.6 shows the farming cost under the base yield:

Table 3.4.6 Estimation of Unit Farming Cost for Per-ha Cultivation of Paddy and Maize (Central Java)

Item	(Wetland) Paddy		Palawija (Maize)	
	Financial	Economic	Financial	Economic
Standard Profit Ratio per Revenue	0.31	0.71	0.35	0.64
Standard Cost Ratio per Revenue	0.69	0.29	0.65	0.36
Base Yield per Ha (ton per ha)	5.85	5.85	6.27	6.27
The Local Prices of Paddy and Maize (IDR per kg)	5,247	4,720	4,737	4,260
Estimated Revenue per ha (000' IDR per ha)	30,695	27,612	29,701	26,710
Estimated Cost per ha (000' IDR per ha)	21,180	8,007	19,306	9,616
Estimated Profit per ha (000' IDR per ha)	9,515	19,605	10,395	17,095

Source: JICA Project Team based on BPS, "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy and Maize 2017"

The target cultivated areas by crop are set in line with the land use plan for the target service area and also the cropping pattern with the project implemented (See Chapter 3.2 for more detail). With the cultivated areas to be realized with the project, the benefits are to accrue through paddy rice and Palawija production from the base year till 35th year.

Table 3.4.7 Base and Target Cultivated Areas by Crop (Central Java)

Province	Type	Service Area, ha	Paddy				Palawija			
			Without	With	Increment		Without	With	Increment	
			Ha	Ha	Ha	%	ha	Ha	Ha	%
Central Java	Modernization	61,444	109,593	114,800	5,207	4.8	37,186	40,565	3,379	9.1
	Rehabilitation	72,918	98,238	104,125	5,887	6.0	61,876	66,060	4,184	6.8
	Total	134,362	207,831	218,925	11,094	5.3	99,062	106,625	7,563	7.6

Source: JICA Project Team

4) Economic Conversion of Project Cost

For the economic analysis, the project cost should be converted to economic price by applying standard conversion factor (0.9). The economic analysis does not take into account any price escalation because there is large uncertainty in the price escalation in the future. Table 3.4.8 shows the converted economic costs to be entered in the economic evaluation:

Table 3.4.8 Economic Conversion of Development Cost and O&M Cost (Central Java)

No.	Particulars	Cost, thousand Rp/ha	Multiplier	Remarks
1	Unit Rehabilitation Cost (original)	22,142	-	Refer to Figure 3.4.1
2	Survey and Design	2,214	10%	Against above No.1
3	Administration, etc.	1,218	5%	Against above sum No.1-2
4	Contingency (Physical)	1,218	5%	Against above sum No.1-2
5	Contingency (Price Inflation)	1,218	5%	Against above sum No.1-2
6	Total of above	28,018	126%	Sum of No.1-5

No.	Particulars	Cost, thousand Rp/ha	Multiplier	Remarks
7	Say (thousand Rp/ha)	**28,000**	126%	Rounded up
8	Total without Price Contingency	26,800	121%	Deduction of No.5 from No.7
9	Unit Economic Development Cost	24,120	109%	No. 8 x 0.9
10	Total Net Irrigation Area (ha)	134,362	ha	Net irrigable area
11	Total Financial Cost in Rp	3,601 billion Rp		Whole project cost for 134,362 ha
12	Total Economic Cost in Rp (x 0.9)	**3,241 billion Rp**		Whole project cost for 134,362 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

5) Evaluation Results

In order to examine the economic validity of the Project, EIRR, B/C, and NPV have been calculated. The calculated EIRR is 16.22%; B/C ratio is 1.75 and the NPV is 2.0 trillion IDR for the base scenario (Case 0). An alternative scenario (Case 1), where the evaluation considers the increment of the target yield is reduced by 20%, has provided such results of 15.11%, 1.60, and 1.6 trillion IDR for the EIRR, B/C ratio, and NPV respectively (see Table 3.4.9). According to the evaluation result, the Project is judged to be economically feasible under the base scenario since the EIRR (16.22%) exceeds the opportunity cost of capital (10.0%), and the Project is still economically feasible even under the alternative scenario (EIRR: 15.11%).

Table 3.4.9 Results of the Project Economic Analysis (Central Java)

Particulars	Case 0	Case 1 (80% Yield Increase)
EIRR, %	16.22	15.11
B/C Ratio	1.75	1.60
NPV, million IDR	1,981,911	1,581,030

Source: JICA Project Team

CHAPTER 4 PRE-FEASIBILITY STUDY: KALIMANTAN EAST PROVINCE

One of the top 4 priority areas selected is Kalimantan East province for new irrigation development. This chapter undertakes preliminary feasibility study (pre-FS) for the Kalimantan East province, for which the BWS in charge is Kalimantan III. The pre-FS examines potential of new irrigation development within the province from the viewpoint of land and water resources potential, as well as from agricultural point of view. The pre-FS also includes economic analysis for recommended projects.

4.1 Status of the Project Area

4.1.1 Spatial Settings, and Salient Features

Kalimantan East province is located in an eastern part of Kalimantan island, which is, as shown in the following maps, covered by BWS office of Kalimantan III in charge of watershed of 04.13.A2. The province is planned to host the future capital city of Indonesia that will be built on the border of Kutai Kartanegara and Penajam North Paser regencies. The Kalimantan East province has a total area of 127,347 sq.km, and is the second least densely populated province in Kalimantan island. The province lies between 113°44'E and 119°00'E, and between 2°33'N and 2°25'S, and shares a maritime border to the east with West Sulawesi and Central Sulawesi, and shares land border to the west with Kalimantan West and Kalimantan Central provinces while to its south with Kalimantan South province.

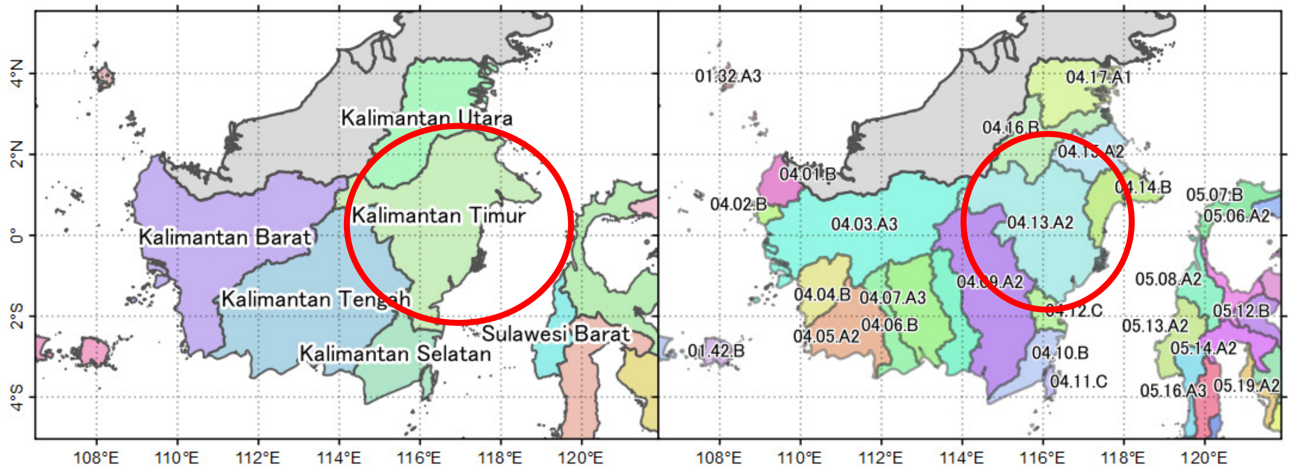


Figure 4.1.1 Location of the Kalimantan East Province and BBWS Jurisdictional Watershed Area

Source: Directorate General of Water Resources

The province is known as a storehouse of timber and mining, and has hundreds of rivers which are scattered across almost all the province. The rivers are in fact main means of transportation in addition to land transport, with the longest river being the Mahakam. The province was once endorsed with rich natural forests, but illegal logging has removed much of the original ones. At present, the province economy heavily depends on earth resources such as oilfield exploration, natural gas, coal and gold. Other developing economic sectors include agriculture and tourism.

The province had a population of about 3.03 million at the 2010 Census. The most populous ethnic group in Kalimantan East is the Javanese (about 30%, based on 2010 Census) which is spread in almost all the province, especially the transmigration areas to urban areas. The second largest ethnic is named Bugis (18%), which occupy many coastal areas and urban areas. The third largest Ethnicity is Banjar (14%) who are quite dominant in the city of Samarinda and Balikpapan. As represented by Javanese being the majority, Kalimantan East is a major destination of transmigration from Java island as well as from Sulawesi island.

In this Kalimantan East province, the JICA team contacted BWS Kalimantan III office (04.13.A2) in order to identify specific areas where new irrigation schemes can be developed. Through the discussions with the BWS office and also with the DILL headquarters, several potential sites for new development were proposed, and the JICA team with the BWS staff conducted field visits to physically observe the possibility of establishing new irrigation schemes.

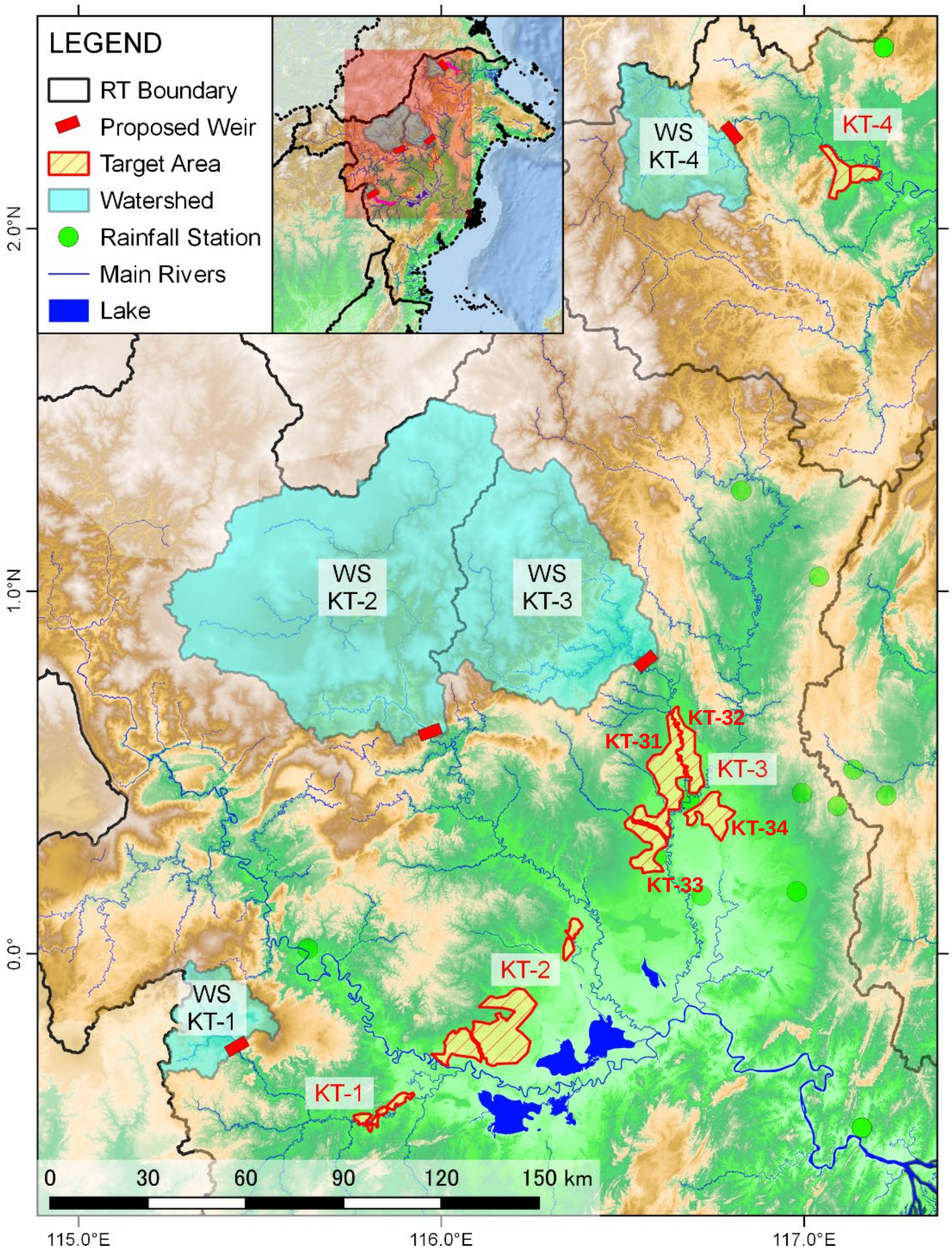


Figure 4.1.2 Potential Sites Identified in Kalimantan East Province

Source: JICA Project Team based on BWS Kalimantan III Office

The potential sites are shown in Figure 4.1.2 and summarized in Table 4.1.1. There are 4 potential areas, among which the KT-3 area is further divided into 4 sub-areas. Thus, there are total 7 potential areas in this Kalimantan East province. The JICA Team, BWS office and DILL headquarters had agreed upon to explore the development potential for all the 7 sites, and conduct the preliminary feasibility study accordingly.

As a result of the pre-FS, the Team has arrived at a recommendation to develop KT-2, KT-31, KT-32, and KT-4 whose total potential net irrigation area can be estimated at over 50,000 ha, the target scale of DGWR for the Kalimantan East province. Thus, KT-1, KT-33 and KT-34 sites were excluded from the candidate development area due to its small size for the case of KT-1 and due to the existence of large protection forest area as well as large plantation area for the case of KT-33 and KT-34, which cannot be developed for irrigation purpose.

Table 4.1.1 Summary of the Potential Sites in Kalimantan East Province

No.	Name of Irrigation Scheme	Potential Area*, ha	Remarks
1	KT-1	4,000	Small area, thus not considered
2	**KT-2**	**38,000**	
3	KT-3 (Total of KT-31, 32, 33, 34)	51,646	Total of the following 4 sub-areas
3.1	**KT-31**	**21,501**	
3.2	**KT-32**	**10,376**	
3.3	KT-33	9,824	Large protection forest and plantation areas exist
3.4	KT-34	9,945	ditto
4	**KT-4**	**9,540**	
	Total of KT2, KT31, KT32, KT4	79,417	DGWR's target is 50,000 ha in Kalimantan East Province

Note: * the potential area in this table is tentative and indicative only.
Source: Based on the information from BWS Kalimantan III and Satellite image analysis by JICA team

4.1.2 Rainfall and River Discharge

This section summarizes the rainfall and discharge condition by River Territory and by specific potential site for the purpose of irrigation development in Kalimantan East province. As the first step, the watershed area is delineated based on the DEMNAS provided by Badan Informasi Geospasial (BIG), which defines each area as 708 sq.km, 6,104 sq.km, 3,299 sq.km, 1,227 sq.km for KT-1, KT-2, KT-3 and KT-4 respectively.

The location map of each watershed, beneficial area, available rainfall stations are shown in afore-mentioned Figure 4.1.2. Some rainfall records are available around the target area; however, not within the watershed area. In addition, as a matter of fact, there is no reliable discharge record around the target areas. Therefore, analysis results described in Rencana WS Mahakam (2019) and Rencana WS Berau Kelai (2019) are referred to in exploring the rainfall and river discharge to be utilized for the irrigation development.

1) Rainfall Condition

Average monthly rainfall (P_{ave}) and 80% exceeding probability rainfall ($P_{80\%}$) are shown for the target river territories and the potential irrigation schemes. In addition, rainfall amounts on the beneficiary areas, which are the source of effective rainfall, are also calculated (see Appendix for the result). In these target areas, the average annual rainfall ranges from around 2,500 mm to 3,200 mm, and 80% exceeding probability rainfall is approximately in the rage of 1,600 mm to 2,100 mm. The monthly rainfall is constantly high with small peak from October to May, which falls in Equator type metrology.

Table 4.1.2 Monthly Average Rainfall (P_{ave}) by River Territory and Watershed Area (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
4.13.A2	WS Mahakam	250	233	261	258	249	215	200	181	189	220	261	269	2787
-	KT-1	296	283	272	306	309	244	210	198	166	229	361	338	3212
-	KT-2	278	246	248	255	248	213	198	177	189	239	272	286	2848
-	KT-3	278	214	236	240	237	214	193	162	189	242	241	287	2732
4.15.A2	WS Berau Kelai	250	226	236	204	212	199	180	170	184	212	230	240	2544
-	KT-4	254	218	213	217	208	209	214	200	227	248	234	257	2699

Source: JICA Project Team

Table 4.1.3 Monthly 80% Exceeding Probability Rainfall ($P_{80\%}$) by River Territory and Watershed Area (mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
4.13.A2	WS Mahakam	170	141	173	169	165	130	102	81	97	126	170	184	1709
-	KT-1	222	196	196	221	221	140	100	86	82	133	261	249	2106
-	KT-2	199	158	164	170	169	127	107	89	94	138	186	203	1804
-	KT-3	192	129	151	154	152	129	110	89	96	140	161	200	1703
4.15.A2	WS Berau	177	145	135	123	143	126	113	99	91	122	150	167	1590

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	Kelai													
-	KT-4	180	144	96	107	148	142	146	115	111	135	130	168	1624

Source: JICA Project Team

2) Discharge Condition

The discharge of 80% exceeding probability ($Q_{80\%}$) is estimated on basis of the result of past analysis described in Pola for WS Mahakam (2017) and WS Berau Kelai (2019). Monthly records are summarized in Table 4.1.4 and Table 4.1.5 together with Figure 4.1.3. The discharge volume behaves differently depending on the River Territory, in which the river belongs. For example, discharge volume on the irrigation schemes in WS Mahakam shows relatively higher one than that of the irrigation scheme in WS Berau Kelai especially from February to June.

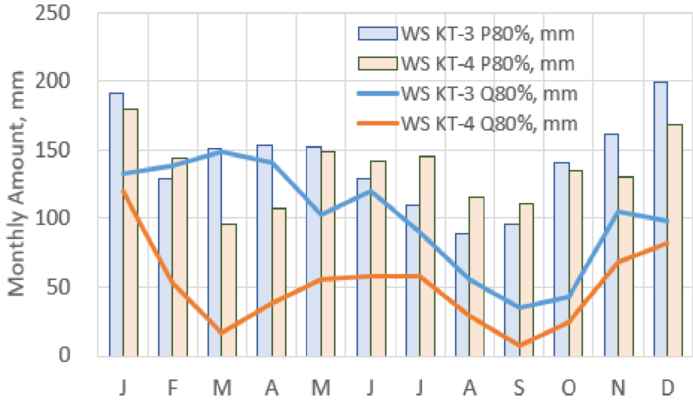


Figure 4.1.3 Rainfall (P80%) and Discharge (Q80%) in the Main Watersheds

Source: JICA Project Team

It is also noted that the water resource of the target areas should not be selected from the Mahakam river due to economic, environmental, and ecological reasons, i.e. there are huge amount boats/vessels transporting coals through Mahakam river, and there are freshwater dolphins in the river. In anyway, the watershed area identified for the potential irrigation sites are still very large and therefore discharge volume in cum/sec becomes very high. Due to this hydrological condition, the countermeasures against flood should be taken more significant than the ones against water scarcity.

Table 4.1.4 Monthly 80% Exceeding Probability Discharge ($Q_{80\%}$) by Target Irrigation Scheme (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
4.13.A2	WS Mahakam	118	151	170	154	112	120	84	51	36	38	110	91	1236
-	KT-1	154	210	192	202	150	130	82	54	30	41	169	123	1536
-	KT-2	138	170	160	155	114	118	88	56	35	42	120	100	1297
-	KT-3	133	138	148	140	103	120	90	56	35	43	105	99	1211
4.15.A2	WS Berau Kelai	118	53	23	44	53	51	45	25	6	22	79	81	602
-	KT-4	121	53	16	38	55	58	58	29	8	24	69	82	611

Source: JICA Project Team

Table 4.1.5 Monthly 80% Exceeding Probability Discharge ($Q_{80\%}$) by Target Irrigation Scheme (unit: m^3/sec)

Name	Area, km^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KT-1	708	40.3	61.4	50.7	55.1	39.7	35.6	21.7	14.3	8.2	10.7	46.3	32.5
KT-2	6,030	310.0	423.1	361.0	361.4	257.8	274.3	198.7	125.9	81.0	94.7	280.2	225.2
KT-3	3,190	158.3	182.2	176.8	172.7	123.0	147.4	107.5	66.6	43.6	51.0	128.8	117.3
KT-4	1,210	54.4	26.5	7.4	17.8	25.0	27.0	26.4	13.0	3.6	11.0	32.1	36.9

Source: JICA Project Team

4.1.3 Current Agriculture in Kalimantan East Province

The province of Kalimantan East has been developing underground oil fields and is now a refueling station for oil and natural gas. As a result, the most important industrial sector is the mining sector, which accounts for about half of the GRDP by current market price as of 2018, followed by the processing and construction industries, with agriculture accounting for only 8%[1].

Food crops in the province are mainly grown in paddy fields in wetlands. Maize, cassava, and sweet potatoes are grown as Palawija, but their areas are limited. Estate crops such as rubber, coconut palm, coffee, pepper, cocoa, and oil palm are also widely cultivated in Kalimantan East, with all government, private, and farmer cultivated areas totaling 1.35 million hectares as of 2018. Below is an overview of agriculture (especially paddy and Palawija cultivation) in the entire province of East Kalimantan and in the four Kabupaten (Kutai Barat, Kutai Kartanegara, Kutai Timur, and Berau) where the newly planned schemes (KT schemes) are located.

1) Agricultural Land Use

Table 4.1.6 shows the agricultural land use of four Kabupaten, where the entire Kalimantan East province and the newly planned areas are located. As of 2015, there are 1.11 million hectares of agricultural land in East Kalimantan, of which only 5% (57,000 ha) is classified as wetland. Paddy rice and Palawija are grown in these wetlands, and 23.5% (190,000 ha) of the wetlands are classified as irrigated farmland. In the wetlands, many agricultural land uses are dependent on rainwater.

Table 4.1.6 Agricultural Land Area in Project Area, East Kalimantan Province (2015), Unit: 1,000 ha

Kabupaten	Wetland			Agricultural dryland				Total
	Irrigation	Non-irrigation	Sub-total	Dry field/ Garden	Unirrigated/ Shifting cultivation	Temporarily unused	Sub-total	
Kutai Barat	1.1	4.0	5.1	28.2	57.1	199.4	284.7	289.8
Kutai Kartanegara	5.7	16.2	21.9	49.0	13.7	253.4	316.1	338.0
Kutai Timur	2.1	3.9	6.0	41.6	29.5	74.7	145.8	151.8
Berau	2.8	2.1	4.9	31.1	15.2	81.1	117.3	122.3
East Kalimantan Province	**13.4**	**43.6**	**57.0**	**200.0**	**162.5**	**695.1**	**1,057.7**	**1,114.7**

Source: Land Area by Utilization 2015 (BPS, 2016)

Table 4.1.7 shows the current land use in the newly planned areas. The target area consists of lowland (bush/forest) and dryland (bush) for KT-2 and KT-3, and dryland (bush/forest) for KT-4. In each of these areas, there is no agricultural production activity and the land will have to be newly opened and developed.

Table 4.1.7 Current Land Use in Newly Developed Areas

DI	Wetland		Dryland		Others	Total
	Bush	Forest	Bush	Forest		
KT-2	9,658	17,594	9,089	0	0	36,341
KT-3	5,123	679	8,309	626	166	14,903
KT-4	0	0	2,191	6,471	0	8,662
Total	**14,780**	**18,274**	**19,589**	**7,097**	**166**	**59,906**

Source: ATR/BPN

2) Paddy Production

Table 4.1.8 shows the harvested area, yield and production of wetland paddy fields for the last three years (2015-2017). The harvested area is not on an increasing trend and is either constant or slightly decreasing. On the other hand, in terms of yield (2015 data only), Kutai Kartanegara and Berau have achieved yields above or similar to the average for East Kalimantan (4.78 t/ha), while Kutai Barat and Kutai Timur have shown lower yields.

[1] BPS-Statistics of Kalimantan Timur Province, Kalimantan Timur Province in Figures, 2019

Table 4.1.8 Harvest area, Yield and Production Volume of Paddy in Project Area, East Kalimantan Province

Kabupaten	Harvested area (1,000 ha)			Yield (ton/ha)			Production (1,000 ton)		
	2015	2016	2017	2015	2016	2017	2015	2016	2017
Kutai Barat	1.0	1.3	1.1	4.29	-	-	4.5	-	-
Kutai Kartanegara	34.0	26.4	33.3	5.11	-	-	173.8	-	-
Kutai Timur	5.6	3.0	4.4	4.96	-	-	27.6	-	-
Berau	4.9	4.7	4.8	4.23	-	-	20.9	-	-
East Kalimantan Province	69.1	54.4	71.4	4.78	-	-	330.0	-	-

Source: Lampung Province in Figures (BPS-Statistics of Lampung Province, 2016-2018)

Figure 4.1.4 shows the crop intensity of wetland paddy in East Kalimantan and the four Kabupaten as of 2015. In East Kalimantan, the average crop intensity is 121%, which means that the areas where multiple rice cropping is practied in a year are limited. In addition, when looking at the crop intensity of Kabupaten, only Kutai Kartanegara is able to plant paddy more than once a year, while the planting rate of the other three Kabupaten is less than 100%. In other words, most of the schemes have adopted Parawija cultivation, which requires less water, instead of rice cultivation, which requires more water.

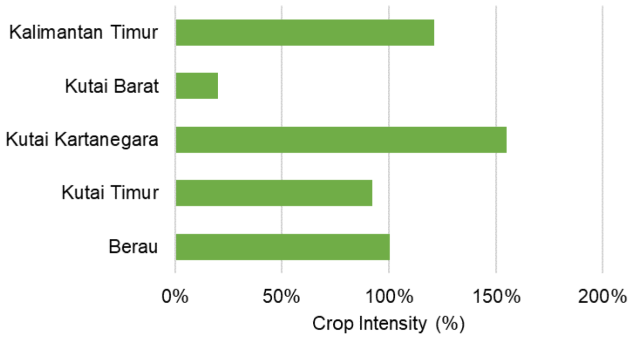


Figure 4.1.4 Crop Intensity of Paddy in Project Area, Kalimantan East Province (2015)

Source: BPS-Statistics of Kalimantan East Province, 2016

Figure 4.1.5 shows the share of rice varieties grown in Kalimantan East as of 2017. Ciherang is the most popular rice variety in the region with a share of 48.2%, followed by Cibogo (19.2%) and Mekongga (11.7%). These top three varieties are all high-yielding varieties that were released in the 2000s. The share of IR64, which used to be the major rice variety in Indonesia, shares only 7.7%, indicating that the substitution of high-yielding varieties is progressing in the Kalimantan East province.

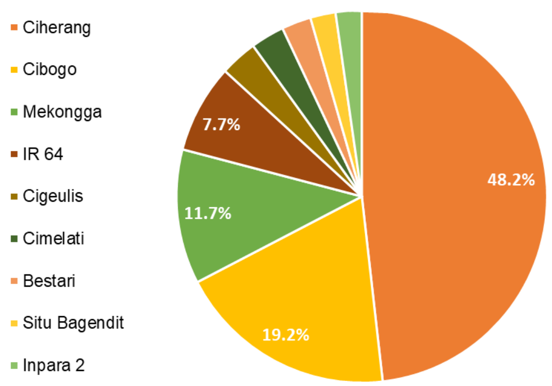


Figure 4.1.5 Share of rice varieties in East Kalimantan Province (2017)

Source: Planted area of new superior paddy varieties year 2017 (Directorate of Seedling, Directorate General of Food Crops, Ministry of Agriculture, 2018)

3) Palawija Production

The type of Palawija, a secondary crop to paddy, varies according to the cropping system in the region. Figure 4.1.6 shows the harvested area of the top three Palawija crops in Kalimantan East. In Kalimantan East, Palawija cultivation is limited. The top two crops are maize and cassava, with similar harvested areas of 2,307 ha and 2,384 ha, respectively, while the third is sweet potato, which is grown on 978 ha only. Although Palawija cultivation is generally positioned as a secondary crop to rice, the

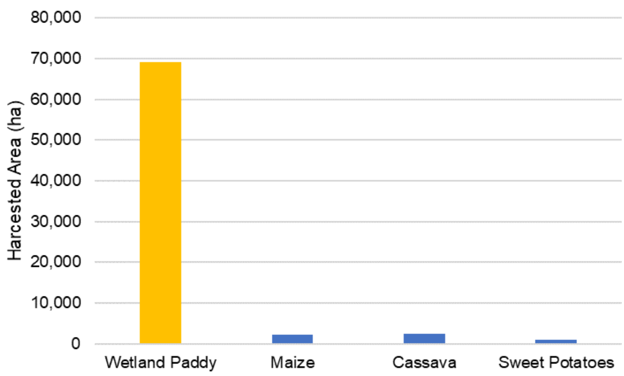


Figure 4.1.6 Harvested Area of Top 3 Palawija in East Kalimantan Province (2015)

Source: BPS-Statistics of East Kalimantan Province, 2016 harvest area indicates that the cropping pattern in the province is based on one crop of rice or Palawija per year.

4) Issues in Agricultural Activities

Agriculture in Kalimantan East is an industry that accounts for only 8% of the GRDP, and from the perspective of increasing staple food production, the promotion of rice cultivation is desired in the future. However, from the view point of water use, the cultivation of rice, which has a high water requirement, is limited at present, and it is necessary to expand the planted area through irrigation development.

In addition, estate crops (rubber, coconut, coffee, pepper, cocoa, oil palm) and horticultural crops (cucumber, pepper) are widely cultivated in the region, which make the rice cultivation less competitive in the crop market in terms of income. Therefore, it is necessary to promote rice cultivation in the region from a policy perspective, i.e., by providing generous government subsidies to new rice farmers. In addition, considering the fact that new irrigation development is planned for this project, it is necessary to consider the challenges associated with new agricultural development. The following are a list of possible issues:

- ✓ **Limited farm capital** to purchase farm inputs and equipment, secure farmland, facilities, and farm machinery for new rice farming
- ✓ **Inexperienced paddy cultivation management** techniques and irrigation water use experience of new farmers and migrants
- ✓ **Low profitability** of rice cultivation compared to estate and horticultural crops grown in the region (high labor cost ratio in production cost).
- ✓ **Low market accessibility** due to inadequate farm roads, poor collection and shipping systems, poor distribution systems, etc.

4.2 Agriculture Development Plan

This section describes the agricultural development plan for the implementation of the new irrigation development in Kalimantan East Province. The agricultural development plan consists of a land use plan, a cropping pattern, and a target yield, and it also proposes the necessary activities to implement and realize this plan.

4.2.1 Proposed Land Use Plan

The new irrigation scheme in Kalimantan East Province is located across four Kabupaten (Kutai Barat, Kutai Kartanegara, Kutai Timur, and Berau). In the project, 53,915 ha of irrigated farmland will be developed through new irrigation development (KT Scheme). Table 4.2.1 shows the proposed land use plan for the new irrigation area. With the development of irrigation facilities, it will be possible to introduce two cropping seasons in the newly irrigated farmland in the future. The two-season cropping system to be introduced is paddy-paddy, resulting in crop coverage of 100% and 100% in the first and second cropping seasons, respectively, with a total coverage of 200%.

Table 4.2.1 Land Use Plan in Project Area, Kalimantan East Province

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
Kutai Barat Kartenegara	DI KT-2	New	32,707	1st	Paddy	Plan	32,707	100	100
				2nd	Paddy	Plan	32,707	100	100
Kutai Timur	DI KT-3	New	13,413	1st	Paddy	Plan	13,413	100	100
				2nd	Paddy	Plan	13,413	100	100
Berau	DI KT-4	New	7,796	1st	Paddy	Plan	7,796	100	100
				2nd	Paddy	Plan	7,796	100	100

Source: JICA Project Team

4.2.2 Proposed Cropping Pattern

Table 4.2.2 shows the proposed cropping plan for the newly irrigated areas. The cropping plan shall be determined according to the agricultural production environment (local climate, weather conditions, etc.) and the amount of available irrigation water in the target area. With the implementation of irrigation development, the first cropping season in the target area will be able to start in early March. With the introduction of paddy cultivation in the first cropping season, the crop intensity is expected to reach 100% (53,915 ha). The second cropping season will be able to start in early November, and by introducing paddy cultivation, the paddy crop intensity is expected to reach 100% (53,915 ha). Based on the above, a 200% crop intensity can be achieved through the introduction of a two-crop season paddy - paddy cultivation system.

Table 4.2.2 Cropping Pattern (Draft) in Project Area, Kalimantan East Province

Cropping Period		2nd				1st							Cropping Intensity
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Plan			Paddy (C.I.100%)				Paddy (C.I.100%)						1st Paddy 100% 2nd Paddy 100% Total 200%

Source: JICA Project Team

4.2.3 Target Paddy Yield in the Future

1) Setting of Base Yield

Table 4.2.3 shows the base yield of paddy in the planned irrigated area. Since this area will be newly irrigated and developed, the base yield of paddy is set at 0 t/ha. According to the annual statistics of Kalimantan East published by BPS, the average paddy yield for the past two years (2014-2015) is 4.82 t/ha for the whole Kalimantan East province. On the other hand, the average yield in Kabupaten, where the new irrigation schemes are located, is 4.69t/ha in DI KT-2, 4.74t/ha in DI KT-3, and 4.23t/ha in DI KT-4.

Table 4.2.3 Base Yield in Project Area, Kalimantan East Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)	Base Yield (t/ha)
Kutai Barat Kartenegara	DI KT-2	New	4.69	0.0
Kutai Timur	DI KT-3	New	4.74	0.0
Berau	DI KT-4	New	4.23	0.0
Kalimantan Timur Province (Avg.)	-	-	4.82	-

Source: Kalimantan Timur Province in Figures (BPS-Statistics of Lampung Province, 2015-2016).

2) Setting of Upper Limit Yield (Target Yield)

The results of the BPS crop cutting survey and other studies have shown that paddy yield depends not only on irrigation conditions, but also on the cultivar and amount of fertilizer applied (see Part 1, Chapter 3). In other words, in addition to irrigation maintenance, appropriate rice cultivation and management practices are necessary to increase paddy yield. In the newly irrigated areas, irrigated rice cultivation is newly introduced, thus the cultivation management practices should start with the introduction of basic farming methods. Therefore, the maximum yield is set using Scenario 1 as shown in Table 4.2.4.

Table 4.2.4 Applied Scenario for Upper Limit Yield (Target Yield) in Project Area, Kalimantan East Province

Type		Scenario	Assumption	Setting Criteria
New Development	→	**1. Conventional agricultural practice**	**Maintain the conventional agricultural management practices as it is**. Newly introduction of superior seeds and fertilizer inputs beyond the current condition **are not expected.**	Using data from the SURVEI UBINAN TANAMAN PANGAN 2014, 2016, 2017 (BPS, 2014, 2016 and 2017), the upper limit has been set to the average of the top 25% yield (75th percentile of Tukey's Hinges) for each island under irrigation and non-irrigation in 2014, 2016 and 2017.

Source: JICA Project Team

Applying the scenario shown in Table 4.2.4, the maximum yield of Kalimantan province East is 5.30 t/ha, that is an increase of 10.0% from the current average of 4.82 t/ha. This rate of increase will be applied to the Project area (KT-2, KT-3, and KT-4) to set the upper limit yields of 5.16, 5.21 and 4.65 t/ha respectively for the 3 areas as shown in Table 4.2.5.

Table 4.2.5 Target Yield in Project Area, Kalimantan East Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)	Target Yield (t/ha)	Increment (%)
Kutai Barat Kartenegara	DI KT-2	New	4.69	5.16	-
Kutai Timur	DI KT-3	New	4.74	5.21	-
Berau	DI KT-4	New	4.23	4.65	-
Kalimantan East Province (Avg.)	-	-	4.82	5.30	10.0

Source: Kalimantan Timur Province in Figures (BPS-Statistics of Lampung Province, 2015-2016).

3) Setting of Yield Increase with Time Course

Similar to the upper limit yield (target yield), the increase in paddy yield over time is assumed to vary depending on whether appropriate cultivation and management practices are introduced or not. Therefore, the increase in yield over time will be set using Scenario 1 shown in Table 4.2.6 for the newly developed areas.

Table 4.2.6 Applied Scenario for Yield Increase with Time Course in Project Area, E. Kalimantan Province

Type		Scenario	Assumption	Setting Criteria
New Development	→	**1. Conventional agricultural practice**	**The yield growth will change gradually**, without relying on short-term policy support such as further R&D, extension support, and subsidy.	Gradual growth is assumed to be logarithmic: the yield curve will be connected by a logarithmic curve for the yield from 1980 to the present (2017), and the yield will be increased to the upper limit yield along this curve.

Source: JICA Project Team

Table 4.2.7 to Table 4.2.9 shows the transition of the paddy yield after the start of the project. The yield increase is considered to be constant when and after the yield has reached to the upper limit (target yield)[2]. In estimating the increase in yield over time, it is assumed that partial water supply will be provided during the 8-year design + implementation period and cultivation will start. Although rice production is expected in all the beneficiary areas from the ninth year, the target yield will be revised downward to 1/3 in the ninth year and 2/3 in the tenth year in consideration of the poor soil property for rice cultivation and inadequate management of newly developed farmland.

[2] Note that, however in this estimation, yield in the Project area has not reached to the upper limit even 15 years after the start of the Project.

Table 4.2.7 Yield Increase with Time Course in Project Area (DI KT-2), Kalimantan East Province

Base Yield (t/ha)	Years after project has been started															Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.56	3.13	4.69	4.71	4.72	4.74	4.75	5.16
Stage	Design＋Project Implementation								Operation & Maintenance							-

Source: JICA Project Team

Table 4.2.8 Yield Increase with Time Course in Project Area (DI KT-3), Kalimantan East Province

Base Yield (t/ha)	Years after project has been started															Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.58	3.16	4.74	4.76	4.77	4.79	4.80	5.21
Stage	Design＋Project Implementation								Operation & Maintenance							-

Source: JICA Project Team

Table 4.2.9 Yield Increase with Time Course in Project Area (DI KT-4), Kalimantan East Province

Base Yield (t/ha)	Years after project has been started															Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.41	2.82	4.23	4.25	4.26	4.27	4.29	4.65
Stage	Design＋Project Implementation								Operation & Maintenance							-

Source: JICA Project Team

4.2.4 Recommended Activities for Agriculture Development

In order to achieve and realize the aforementioned agricultural development plan (land use plan, cropping pattern, and target yield), it is necessary to take measures to address the current issues in the target development area and the issues that will emerge with the new irrigation development. The following approaches for agricultural development are proposed as possible countermeasures.

Table 4.2.10 shows the challenges and possible countermeasures for agricultural development in the newly irrigated areas. Those areas are currently covered by bush and forest and are expected to be newly developed and settled with the development of irrigated farmland. Therefore, one of the issues that need special attention is that the government should give priority to generous subsidies for new rice farmers to provide incentives for cultivation and settlement. This could be addressed by government support through the introduction of subsidies and loan programs. In addition, since new farmers and migrants need to learn crop and water management techniques in new irrigated farmland, it is essential that the government and private sector should expand their technical extension services.

In addition, as a regional characteristic of Kalimantan East, estate crops (rubber, coconut palm, coffee, pepper, cocoa, oil palm) and horticultural crops (cucumber, pepper) are actively cultivated, and there are concerns that rice cultivation in the scheme, where new irrigation development is underway, may be less profitable than these crops. It is concerned that rice cultivation in the newly developed irrigated area will be less profitable than those cultivations. This low profitability is mainly due to the high labor cost ratio in the production cost, and the introduction of agricultural machinery (tractors, harvesters, etc.) to reduce labor cost and ICT tools to increase labor productivity would be effective.

Furthermore, market access may be an issue due to the fact that the area is newly developed. It is desirable to strengthen market competitiveness by improving intensive collection and shipping systems and rice milling facilities in parallel with irrigation improvement, and to improve market accessibility by improving farm roads and distribution systems. Thus, this project is expected to contribute to the promotion of rice cultivation in the region by realizing the land use plan, cropping plan, and target yield through the implementation of these high priority measures in conjunction with irrigation development.

Table 4.2.10 Issues and Countermeasures for Agriculture Development in Project Area, Kalimantan East Province

Possible Issues	Countermeasures (Basic Approach)	Expected Effects
✓ Lack of funds to secure agricultural materials and equipment, farmland, facilities, and farm machinery	✓ Introduce subsidy programs to ensure that new farmers, migrants, and/or farmer groups have the agricultural inputs they need (e.g., high-quality seeds, fertilizer).	✓ Secure initial investment (input funds)
	✓ Introduce a loan program to secure essential working capital to start agricultural activities.	✓ Securing working capital
✓ Irrigated rice cultivation management technology and irrigation water management technology for new farmers and migrants who are inexperienced or inexperienced	✓ Strengthening government or private agricultural extension services for new farmers, migrants, and/or farmer groups to acquire basic crop management skills.	✓ Improve agricultural production management capacity
	✓ Strengthening the capacity of water management organizations	✓ Improve water management capacity
✓ Paddy cultivation is less profitable than estate and horticultural crops (due to the high labor ratio in production costs)	✓ Promotion of mechanized agriculture	✓ Reduction of labor costs
	✓ Introduction of modern agricultural production management technologies through the use of ICT tools	✓ Increase in labor productivity
✓ Reduced access to markets (undeveloped farm roads, aggregation systems, shipping facilities, etc.)	✓ Adopting a market-oriented approach	✓ Improve market competitiveness
	✓ Strengthen collection and shipping systems	
	✓ Improvement of rice milling facilities	
	✓ farm road maintenance	✓ Improved market access
	✓ Strengthen distribution system	

Source: JICA Project Team

4.3 Irrigation Development and Management Plan

4.3.1 Irrigation Area Delineation

First of all, considering the suitability for land conversion into paddy field and its spatial extent, the four target areas have been identified based on the result of land potential analysis as concluded in the afore-mentioned Figure 4.1.2. In addition, data on plantation and mining concession areas provided by BWS Kalimantan III have also been considered since there are many concession areas in Kalimantan East province, wherein further development for the purpose of cultivating paddy cannot be realized.

The target areas in WS Mahakam, i.e. KT-1, KT-2 an KT-3, are located nearby the lowland area in Lake Cascade System of Mahakam (see Figure 4.3.1), and accordingly impact from the flood needs to be well considered. According to the past study in this area, i.e., Pengelolaan SDA Danau Kaskade Jempang, Semayang, Melintang di Provinsi Kalimantan Timur, the flood in 2007 is the

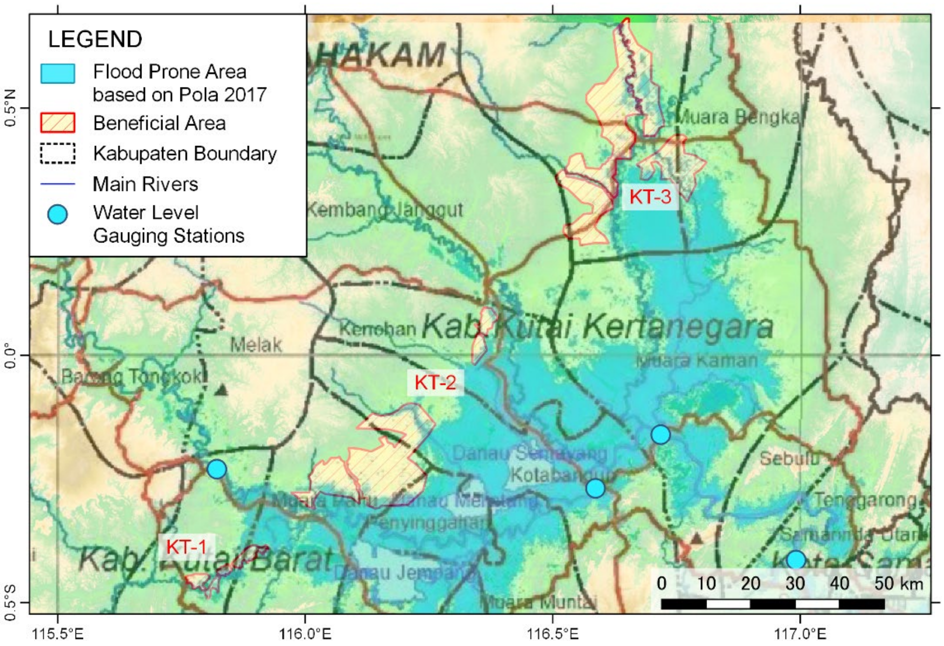


Figure 4.3.1 Analysis Result on Flood Prone Area in WS Mahakam

Source: Pola WS Mahkam (2017)

biggest event from the water level record, which return period is estimated as once in 50 years. In this preliminary feasibility study, the analyzed inundation area by the flood 2007 was applied to grasp the flood prone areas. Factors to be considered to delineate the beneficial areas in Kalimantan East province are summarized in Table 4.3.1.

Table 4.3.1 Factors to Delineate the Beneficial Areas within Kalimantan East Province

Factors	Explanation	Source
(1) Protection Forest	Any type of forest that cannot be converted to farmland is removed from the beneficial area. Its details are described in Part 1 Chapter 4.	Ministry of Environment and Forestry and Statistics of Ministry of Forestry (2013)
(2) Plantation Concession (already planted)	Concession area for the of plantation is defined. The area is classified into already planted and not planted yet, which indicates the current status of current land utilization, and the one with already planted is removed from the beneficiary area.	BWS Kalimantan III
(3) Plantation Concession (not planted yet)		BWS Kalimantan III
(4) Mining Concession	Concession area for the license holders of long-standing Coal Constructs of Work (PKP2B) and Mining Business License (IUP) is removed from the beneficial area.	BWS Kalimantan III
(5) Peat Distribution	Area where the peat thickness is more than 200cm is eliminated from the beneficial area. (as a reference for development suitability, peat distribution area less than 200cm thickness is also shown)	Sub Directorate of Lowland (DILL)
(6) Elevation	Based on the flood inundation area in 2007, the elevation under EL.10m is defined as flood prone areas. This does not restrict the beneficiary area, but it is considered if most areas are defined as flood prone area.	Pengelolaan SDA Danau Kaskade Jempang, Semayang, Melintang di Provinsi Kalimantan Timur (BWS Kalimantan III, 2017) Pola WS Mahkam (2017)

Source: JICA Project Team

The location maps and basic profiles of each target area are summarized in Figure 4.3.2 to Figure 4.3.5 (KT-3 is divided into 4 areas, KT-31 to KT-34 by main rivers). The target areas in WS Mahakam (KT-1, KT-2 and KT-3) are located on the inland lowland area (peripheral of Mahakam lake cascade system), whose mean elevation is EL.10m to EL.14m. As for KT-4 in WS Berau Kelai, the target area is located on a little higher area where the mean elevation is around EL.26m. Regarding slope conditions, mean slope indicates some places are not very flat based on DEMNAS (mean slope is 4.8% as smallest in KT-2 and 10.0% as largest in KT-4), so the ground leveling is required to some extent after detailed field survey in next stage.

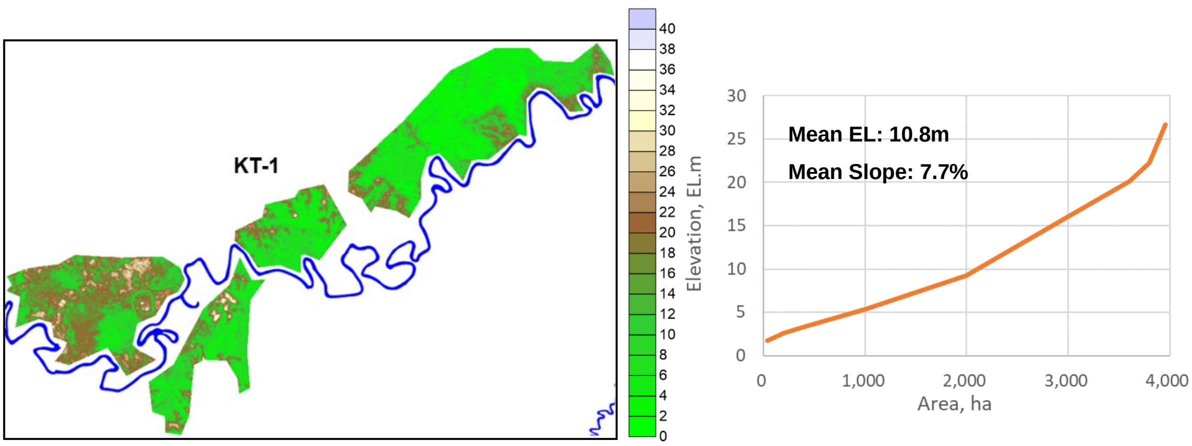


Figure 4.3.2 Elevation Map of the DI. KT-1 Target Area and its Elevation Profile

Source: JICA Project Team

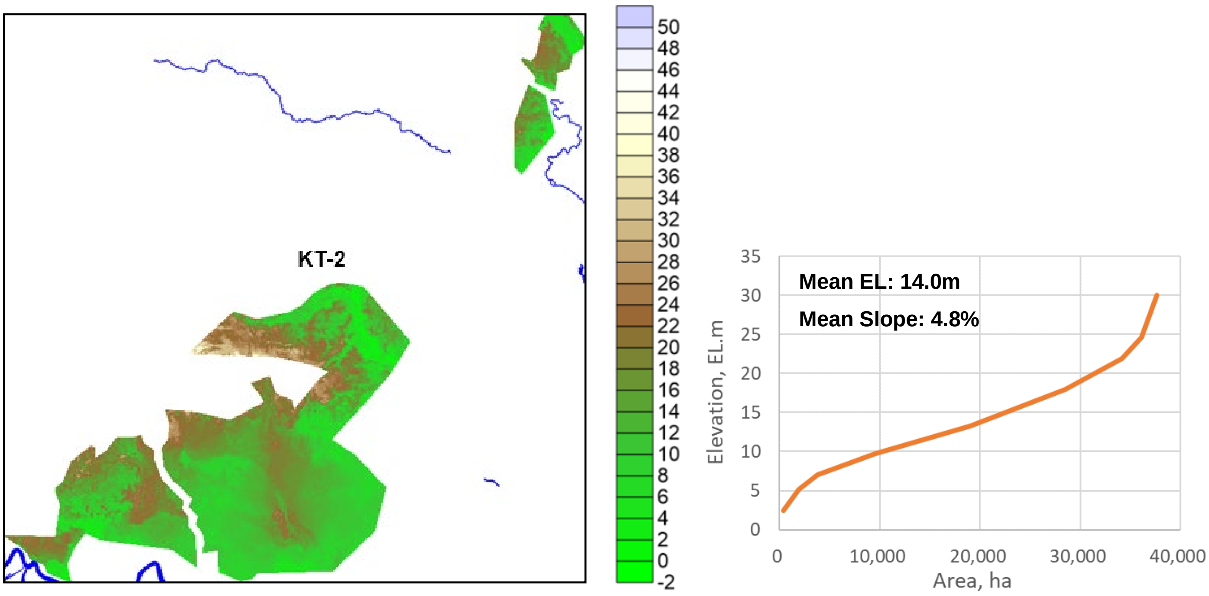


Figure 4.3.3 Elevation Map of the DI. KT-2 Target Area and its Elevation Profile

Source: JICA Project Team

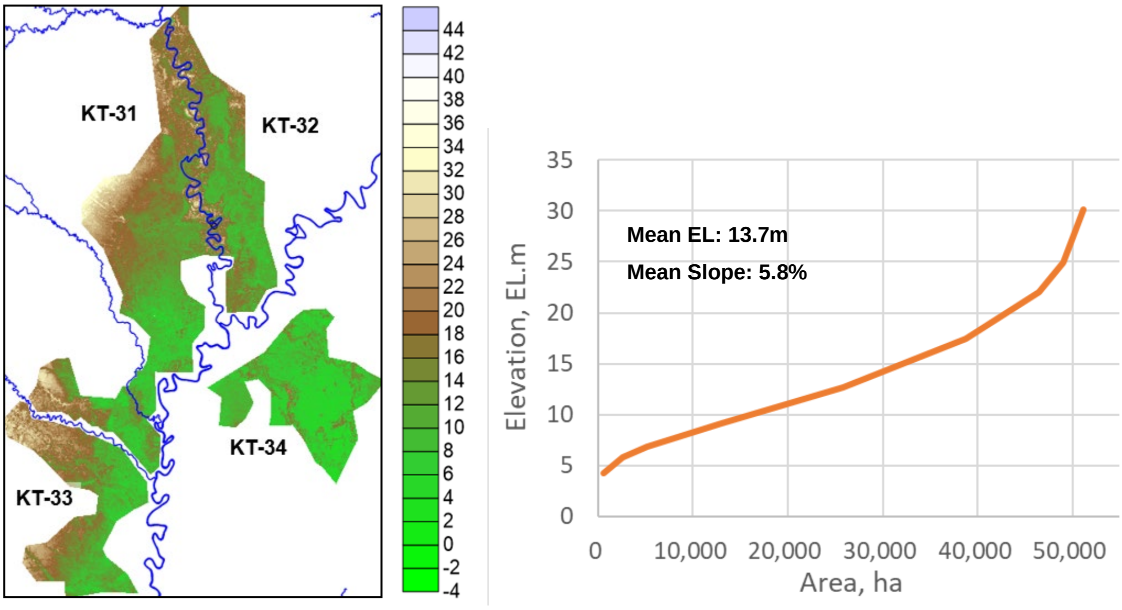


Figure 4.3.4 Elevation Map of the DI. KT-3 Target Area and its Elevation Profile

Source: JICA Project Team

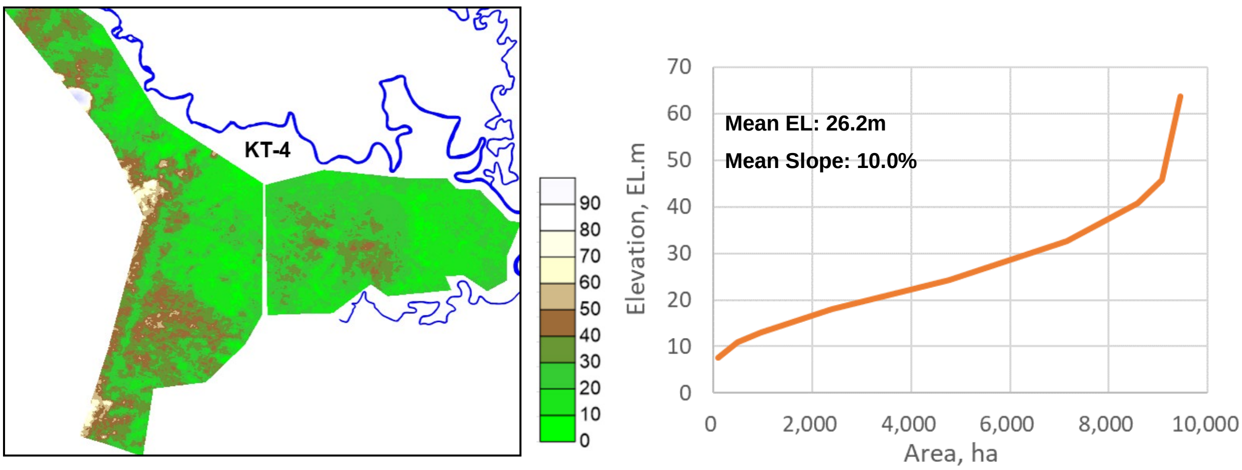


Figure 4.3.5 Elevation Map of the DI. KT-4 Target Area and its Elevation Profile

Source: JICA Project Team

The result of area delineation is summarized in Table 4.3.2 and Table 4.3.3. It should be noted that there are some overlapped areas by different factors (e.g. unrealistic condition such that plantation and mining concession areas are registered on the same area), which makes estimation of beneficial area not simply expressed by “Target area minus sum of each factor areas”. This occurs because each factor is based on different survey and different sources. Therefore, applied spatial data should be verified by field survey especially for overlapped area in the next stage.

In this preliminary feasibility study, three factors, namely, (1) protection forest, (2) plantation concession area (already planted), and (4) mining concession are considered NOT to include in the potential beneficial areas, and other factors are utilized as a reference only. It is also noted that the plantation concession area (not planted yet) is considered here as available area for irrigation development[3], and therefore negotiation on land acquisition and/or conversion of land utilization is required before the implementation of irrigation development.

The result indicates that the beneficial areas in Kalimantan East province become half the identified original potential areas considering the factor (1), (2), and (4). In fact, KT-3 is the biggest affected area by those factors because the plantation concession area (already planted) covers almost half the target area of KT-3. Especially for the area KT-33 and KT-34, protection forest is also widely distributed, which results in only 383 ha and 1,870 ha as gross beneficial area, respectively.

Table 4.3.2 Target Area and Detected Area of Each Factor (Kalimantan Timur)

Area	Target Area (ha)	Protection Forest	Plantation Concession (already planted)	Plantation Concession (not planted yet)	Mining Concession	Peat Distribution (less than 200cm)	Elevation (less than EL.10m)
		(1)	(2)	(3)	(4)	(5)	(6)
KT-1	4,000 ha	0 ha	294 ha	677 ha	515 ha	867 ha	2,133 ha
KT-2	38,000 ha	0 ha	978 ha	21,878 ha	1,315 ha	31,541 ha	10,191 ha
KT-3	51,646 ha	9,200 ha	23,797 ha	8,192 ha	3,408 ha	15,453 ha	16,181 ha
KT-31	21,501 ha	1,390 ha	10,828 ha	5,460 ha	3,408 ha	4,661 ha	4,402 ha
KT-32	10,376 ha	0 ha	2,739 ha	2,732 ha	0 ha	4,970 ha	1,839 ha
KT-33	9,824 ha	5,147 ha	4,802 ha	0 ha	0 ha	3,661 ha	2,271 ha
KT-34	9,945 ha	2,663 ha	5,429 ha	0 ha	0 ha	2,161 ha	7,555 ha
KT-4	9,540 ha	19 ha	869 ha	1,441 ha	0 ha	0 ha	342 ha
Total	103,186 ha	9,220 ha	25,939 ha	32,188 ha	5,238 ha	47,861 ha	28,847 ha

Source: JICA Project Team

Table 4.3.3 Beneficial Area (Kalimantan East Province)

Area	Beneficial Area (Gross-1)	Beneficial Area (Net-1: Gross-1 * 0.9)	Beneficial Area (Gross-2)	Beneficial Area (Net-2: Gross-2 * 0.9)
	Considering factors (1), (2) & (4), applied value		Considering factors (1), (2), (4) & (6), reference value	
KT-1	3,620 ha	**3,258 ha**	3,620 ha	3,258 ha
KT-2	36,341 ha	**32,707 ha**	26,774 ha	24,096 ha
KT-3	17,156 ha	**15,441 ha**	11,863 ha	10,676 ha
KT-31	7,266 ha	**6,540 ha**	4,636 ha	4,173 ha
KT-32	7,637 ha	**6,873 ha**	6,537 ha	5,883 ha
KT-33	383 ha	**345 ha**	69 ha	62 ha
KT-34	1,870 ha	**1,683 ha**	621 ha	559 ha
KT-4	8,662 ha	**7,796 ha**	8,365 ha	7,529 ha
Total	65,780 ha	**59,202 ha**	50,622 ha	45,560 ha
KT2+KT31+KT32+KT4	59,906 ha	**53,915 ha**	46,312 ha	41,681 ha
Area	Beneficial Area (Gross-3)	Beneficial Area (Net-3:Gross-3*0.9)	Beneficial Area (Gross-4)	Beneficial Area (Net-4: Gross-4 * 0.9)

[3] In fact, there are huge areas already registered as plantation concession area over whole Kalimantan island. It means if we consider whole plantation concession areas to exclude from the potential beneficial area, there is very little potential to secure large land area for new irrigation development. In addition, although there are lots number of registered plantation concession areas since long sometime ago, much of those areas have not been actually planted to date. Therefore, the JICA team has decided to include the plantation concession areas (NOT yet planted) as a part potential beneficial area.

	Considering factors (1) to (4) & (6), reference value		Considering all factors, reference value	
KT-1	2,943 ha	2,649 ha	2,568 ha	2.311 ha
KT-2	10,574 ha	9,516 ha	2,128 ha	1,916 ha
KT-3	6,579 ha	5,921 ha	4,643 ha	4,179 ha
KT-31	1,641 ha	1,477 ha	1,593 ha	1,434 ha
KT-32	4,249 ha	3,824 ha	2,505 ha	2,255 ha
KT-33	69 ha	62 ha	36 ha	32 ha
KT-34	621 ha	559 ha	509 ha	458 ha
KT-4	6,976 ha	6,278 ha	6,976 ha	6,278 ha
Total	27,072 ha	23,364 ha	16,316 ha	14,684 ha
KT2+KT31+KT32+KT4	23,439 ha	21,716 ha	13,202 ha	12,373 ha

Source: JICA Project Team

Figure 4.3.6 shows the available area for irrigation development by site. KT-1 is in relatively good condition for development except for the south area where the plantation and mining concession areas cover much of KT1. Most areas in KT-2 and KT-4 are also estimated to be available for irrigation development, with a few areas being occupied by plantation and mining concession areas. Regarding KT-3, however, much area especially KT-33 and KT-34 are occupied by plantation concession area. Considering that those areas have a disadvantage in terms of flood risk, KT-33 and KT-34 should be excluded from the beneficiary area.

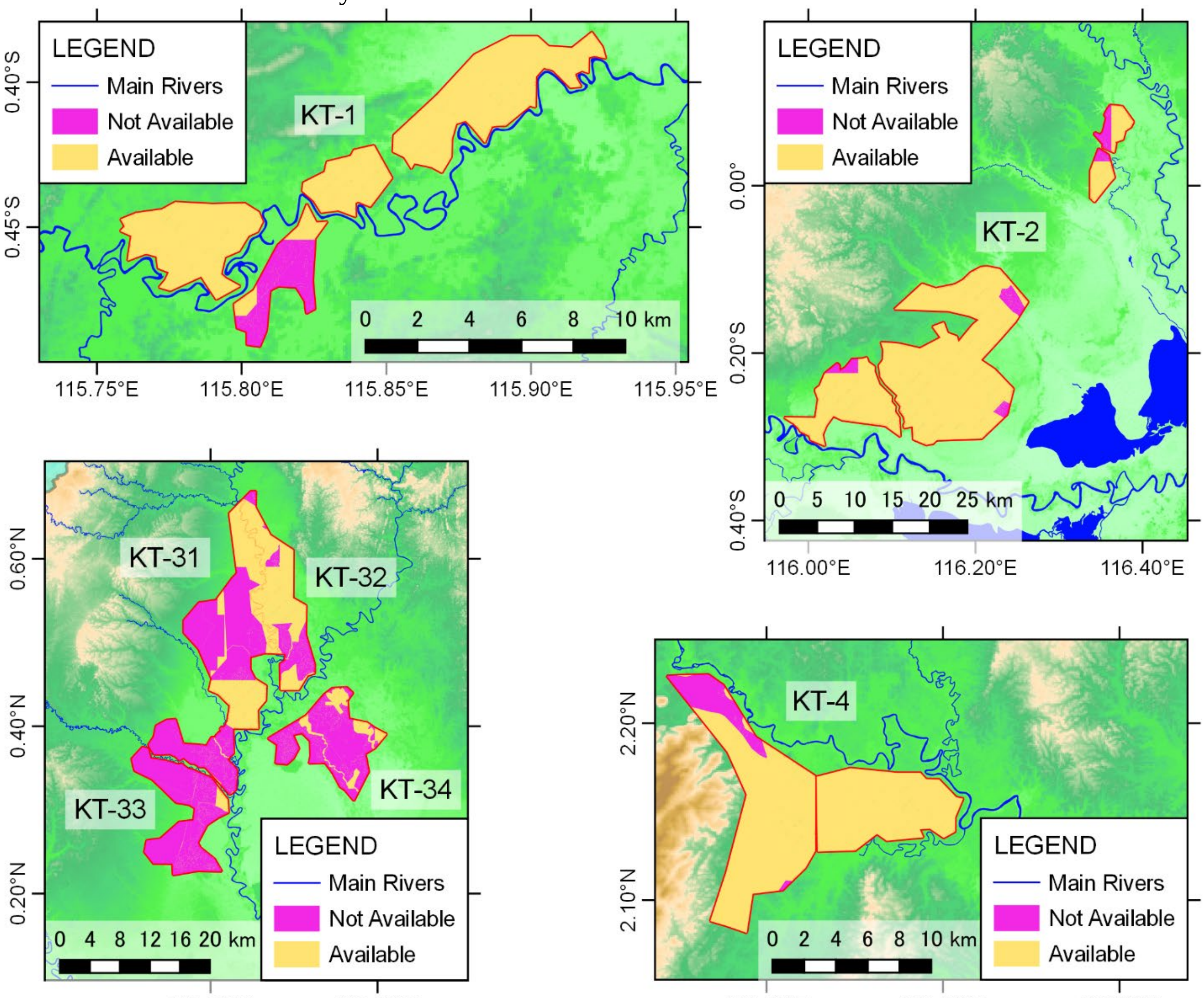


Figure 4.3.6 Available Areas for New Irrigation Development (Kalimantan East Province)

Source: JICA Project Team

Applying the net beneficial area as 90% of its gross area according to KP-01 (MPWH 2013), the total available net area from the aspect of land condition comes to 3,258 ha in KT-1, 32,707 ha in KT-2, 15,441 ha in KT-3, and 7,796 ha in KT-4, which total area reaches as much as 59,202 ha in net. Among the sites, KT-1 shows only around 3,000 ha, and further KT-33 and KT-34 lie on a smaller area, e.g. 345 ha and 1,683 ha net only. Excluding the KT-1, KT-33 and KT-34, we can still secure more than 50,000 ha net complying with DGWR request which is to develop at least 50,000 ha of new irrigated paddy land near the new capital of Indonesia. Therefore, the Team recommends to develop KT-2, KT-31, KT-32 and KT-4, totaling to 53,915 ha in net (see Table 4.3.3)

4.3.2 Available Water for Irrigation and Irrigable Area

This section describes the methodology and the result of water balance calculation by irrigation scheme using water discharge (Q80%) and water demand such as RKI and river maintenance. Water demand for existing irrigation scheme is not considered in this examination as there is no existing irrigation scheme in and around the beneficial area. The methodology is almost the same as the one in Part I but the applied data is more localized. Table 4.3.4 shows the differences in the methodologies of water balance calculation between Part I (river territory-wise) and Part 2 (irrigation scheme-wise).

Table 4.3.4 Methodologies for the Water Balance Calculation in Part 1 and Part 2 (Kalimantan East)

Item	Part 1 (MP)	Part 2 (Pre-FS)
Design Rainfall (P80, P95) Effective Rainfall (P_E)	By River Territory	By Watershed of intake facilities and beneficial area
Design Cropping Pattern	Based on BPS record by province	Existing cropping pattern is not necessary to be applied because there is no major irrigation schemes around the beneficial area. Only water demand for plantation is considered as constant value.
Design Discharge (Q80) River Maintenance Flow (Q95)	Based on the linear equation between rainfall and discharge	Based on the available analysis result based on Pola study
Water Demand	RKI, river maintenance, fishpond, livestock and irrigation water demand by River Territory	Based on Pola data (sub-basin-wise and Kabupaten-wise data)
Potential Area	Cropping pattern which makes largest potential is applied	Assuming two times paddy cropping, minimum potential values on each crop season are applied

Source: JICA Project Team

The material applied to the water balance calculation is summarized in the Table 4.3.5. Most materials are available from the Pola PSDA WS Mahakam (2017) and WS Berau Kelai (2019). In this examination, such values in relevant administrative unit such as Kabupaten, Kecamatan, or relevant watershed unit such as DAS[4] and sub-DAS are applied. Regarding the water demand in KT-1 to KT-3, the data are available only by the DAS Mahakam, which watershed area is as large as 77,423 sq.km. Therefore, water demand is calculated by the ratio of watershed area between DAS Mahakam and each target basin. As for KT-4, most detailed data available in Pola PSDA Berau Kelai is applied, which is relevant DAS-wise data for RKI demand and relevant Kecamatan-wise data for the fishpond and livestock demand.

Table 4.3.5 Material Utilized for the Water Demand Calculation (Kalimantan Timur)

No.	Data	Source	Remarks
1	RKI Demand	Pola PSDA WS Mahakam (2017) and Pola PSDA WS Berau Kelai (2019)	Monthly estimated value in 2016 by relevant sub-basin (KT1 to KT-3: DAS Mahakam, KT-4: values in Sub-DAS Laay Mahakam, Segah Hulu and Segah). Water Demand for Tourism is incorporated into the Industry sector.
2	Fishpond Water Demand	Pola PSDA WS Mahakam (2017) and Pola PSDA WS Berau Kelai (2019)	DAS-wise data (KT-1 to KT-3) or Kabupaten-wise data (KT-4) described in Pola is utilized
3	Livestock Water Demand	Pola PSDA WS Mahakam (2017) and Pola PSDA WS Berau Kelai (2019)	DAS-wise data (KT-1 to KT-3) or Kecamatan-wise data (KT-4) described in Pola is utilized.

[4] Concerning the definition of watershed area by the scale in Indonesia, Wilayah Sungai (WS), the biggest watershed scale area, is translated to River Territory in English, which is divided into number of Daerah Aliran Sungai (DAS), and the DAS is further divided into number of small DAS, that is called sub-DAS.

No.	Data	Source	Remarks
4	River Maintenance	Government regulation concerning river, No.38, 2011	Q95% of the actual measurement records is applied
5	Water Demand for Plantation	Pola PSDA WS Mahakam (2017)	Irrigation Demand for plantation is utilized if specified in Pola.
6	Irrigation Water Demand	Standard of Irrigation Planning (KP-01), 2013	Monthly base Calculation

Source: JICA Project Team

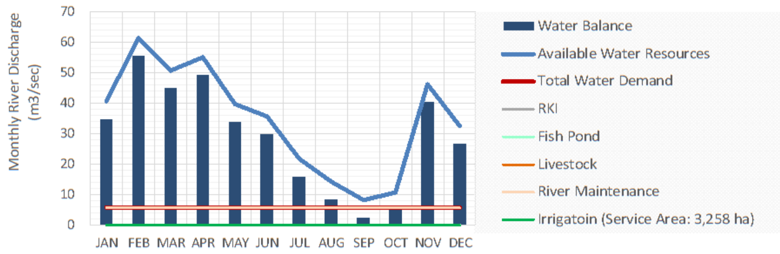
The calculation results are shown in Table 4.3.6 to Table 4.3.9. The current water utilization within the Kalimantan East province is very small due to lower population, less urbanization and few existing irrigation systems, which account for less than 1% of total water resources, and therefore the biggest water demand is for river maintenance. The available water resources for irrigation development are thus estimated to be 28.76 cum/s in KT-1, 194.45 cum/s in KT-2, 95.49 cum/s in KT-3, and 23.40 cum/s in KT-4 in terms of annual average discharge.

Table 4.3.6 Water Balance Calculation for KT-1 Irrigation Scheme

Calculation Sheet on Water Potential by DI (1 / 4)

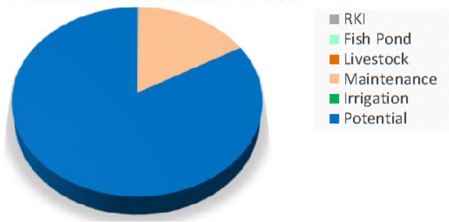
Irrigation Scheme Name: KT-1 | DI Watershed Area: 708 km^2 | Service Area: 3,258 ha | Water Source: Nyuatan

	(Unit)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1 Available Water Resources														
1.1 Rainfall P_{ave}	(mm)	296	283	272	306	309	244	210	198	166	229	361	338	3,212
1.2 Rainfall $P_{80\%}$	(mm)	222	196	196	221	221	140	100	86	82	133	261	249	2,106
1.3 Discharge Q_{ave}	(m^3/sec)	54.32	88.68	70.37	76.34	55.33	61.96	45.61	32.83	16.80	18.47	63.94	44.14	52.07
1.4 Discharge $Q_{80\%}$	(m^3/sec)	40.59	61.40	50.73	55.08	39.71	35.63	21.72	14.27	8.24	10.71	46.28	32.50	34.50
2 Water Demand														
2.1 RKI														
Population	(10^3person)	26	26	26	26	26	26	26	26	26	26	26	26	-
Demand	(m^3/sec)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
2.2 Fish Pond														
Pond Area	(ha)	713	713	713	713	713	713	713	713	713	713	713	713	-
Demand	(m^3/sec)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.3 Livestock														
Demand	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4 River Maintenance														
Demand ($Q_{MIN95\%}$)	(m^3/sec)	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65	5.65
2.5 Irrigatoin (Service Area: 3,258 ha)														
Irrigated Plantation Area	(ha)	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	-
Irrigated Palawija Planted Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand for Plantation	(m^3/sec)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	-
Demand for Palawija Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand (Net)	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 Water Balance	(m^3/sec)	34.85	55.65	44.98	49.34	33.96	29.88	15.98	8.52	2.50	4.96	40.54	26.75	28.76
4 Potential Area														
4.1 Case 1 (Paddy-Paddy)		Paddy - I		Paddy - II								Paddy - I		-
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.52	0.59	1.02	0.24	0.49	0.62	-	-	-	-	1.04	0.08	
Potential Area	(ha)	67,260	94,278	44,029	204,412	69,586	48,113	-	-	-	-	39,033	326,079	



Monthly Water Balance

Available Water Resources: 1,088 MCM
Potential Water Resources: 907 MCM



Annual Water Balance

	Paddy - I	Paddy - II
Water Potential Area (Case-1):	**39,033 ha**	**44,029 ha**

Calculation Sheet on Water Potential by DI (2 / 4)

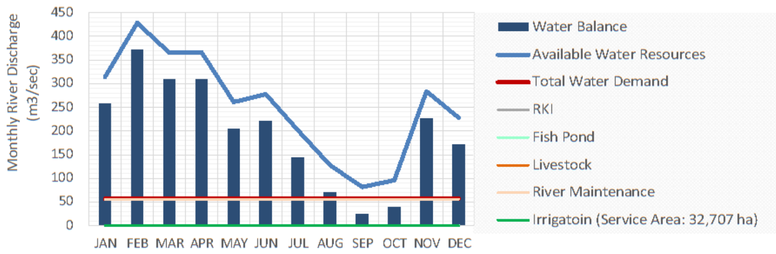
Table 4.3.7 Water Balance Calculation for KT-2 Irrigation Scheme

Irrigation Scheme Name: KT-2

DI Watershed Area: 6,030 km^2
Service Area: 32,707 ha

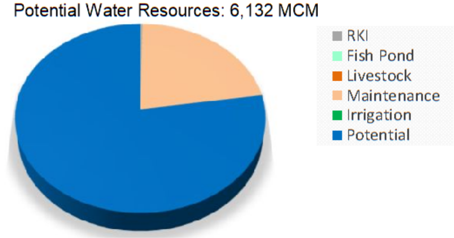
Water Source: Belayan

	(Unit)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1 Available Water Resources														
1.1 Rainfall P_{ave}	(mm)	278	246	248	256	248	213	198	177	189	239	272	286	2,848
1.2 Rainfall $P_{80\%}$	(mm)	199	158	164	170	169	127	107	89	94	138	186	203	1,804
1.3 Discharge Q_{ave}	(m^3/sec)	438.60	663.54	553.59	550.09	382.73	465.10	371.72	253.41	164.45	166.00	414.91	321.97	393.27
1.4 Discharge $Q_{80\%}$	(m^3/sec)	313.84	428.30	365.41	365.88	260.94	277.70	201.11	127.46	81.99	95.85	283.65	227.96	251.06
2 Water Demand														
2.1 RKI														
Population	(10^3person)	224	224	224	224	224	224	224	224	224	224	224	224	-
Demand	(m^3/sec)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2.2 Fish Pond														
Pond Area	(ha)	6,075	6,075	6,075	6,075	6,075	6,075	6,075	6,075	6,075	6,075	6,075	6,075	-
Demand	(m^3/sec)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2.3 Livestock														
Demand	(m^3/sec)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.4 River Maintenance														
Demand ($Q_{MIN95\%}$)	(m^3/sec)	55.81	55.81	55.81	55.81	55.81	55.81	55.81	55.81	55.81	55.81	55.81	55.81	55.81
2.5 Irrigatoin (Service Area: 32,707 ha)														
Irrigated Plantation Area	(ha)	24,554	24,554	24,554	24,554	24,554	24,554	24,554	24,554	24,554	24,554	24,554	24,554	-
Irrigated Palawija Planted Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand for Plantation	(m^3/sec)	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	-
Demand for Palawija Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand (Net)	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 Water Balance	(m^3/sec)	257.23	371.69	308.79	309.26	204.33	221.08	144.49	70.84	25.38	39.24	227.03	171.35	194.45
4 Potential Area														
4.1 Case 1 (Paddy-Paddy)		Paddy - I		Paddy - II								Paddy - I		-
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.77	0.99	1.27	0.49	0.72	0.70	-	-	-	-	1.38	0.30	
Potential Area	(ha)	334,861	374,537	242,411	625,120	284,725	317,707	-	-	-	-	164,766	577,032	



Monthly Water Balance

Available Water Resources: 7,918 MCM
Potential Water Resources: 6,132 MCM



Annual Water Balance

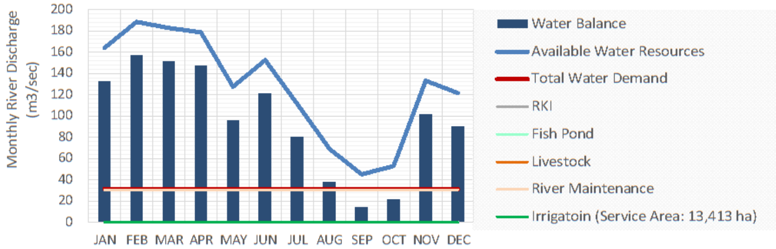
	Paddy - I	Paddy - II
Water Potential Area (Case-1):	164,766 ha	242,411 ha

Calculation Sheet on Water Potential by DI (3 / 4)

Table 4.3.8 Water Balance Calculation for KT-3 Irrigation Scheme

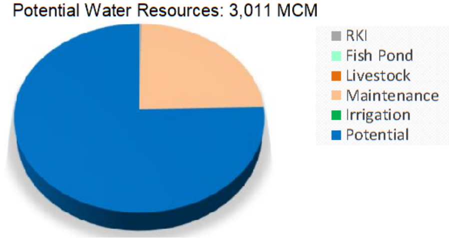
Irrigation Scheme Name: KT-3 | DI Watershed Area: 3,190 km^2 | Service Area: 13,413 ha | Water Source: Kelimjau

	(Unit)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1 Available Water Resources														
1.1 Rainfall P_{ave}	(mm)	278	214	236	240	237	214	193	162	189	242	241	287	2,732
1.2 Rainfall $P_{80\%}$	(mm)	192	129	151	154	152	129	110	89	96	140	161	200	1,703
1.3 Discharge Q_{ave}	(m^3/sec)	236.94	312.87	284.76	278.44	197.79	253.26	195.10	125.27	88.81	90.86	198.78	174.72	202.21
1.4 Discharge $Q_{80\%}$	(m^3/sec)	163.70	188.39	182.87	178.58	127.24	152.41	111.21	68.92	45.12	52.78	133.24	121.35	126.64
2 Water Demand														
2.1 RKI														
Population	(10^3person)	118	118	118	118	118	118	118	118	118	118	118	118	-
Demand	(m^3/sec)	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
2.2 Fish Pond														
Pond Area	(ha)	3,214	3,214	3,214	3,214	3,214	3,214	3,214	3,214	3,214	3,214	3,214	3,214	-
Demand	(m^3/sec)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2.3 Livestock														
Demand	(m^3/sec)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.4 River Maintenance														
Demand ($Q_{MIN95\%}$)	(m^3/sec)	30.73	30.73	30.73	30.73	30.73	30.73	30.73	30.73	30.73	30.73	30.73	30.73	30.73
2.5 Irrigatoin (Service Area: 13,413 ha)														
Irrigated Plantation Area	(ha)	12,990	12,990	12,990	12,990	12,990	12,990	12,990	12,990	12,990	12,990	12,990	12,990	-
Irrigated Palawija Planted Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand for Plantation	(m^3/sec)	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	-
Demand for Palawija Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand (Net)	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 Water Balance	(m^3/sec)	132.54	157.23	151.71	147.43	96.08	121.25	80.05	37.76	13.96	21.62	102.08	90.19	95.49
4 Potential Area														
4.1 Case 1 (Paddy-Paddy)		Paddy - I		Paddy - II								Paddy - I		-
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.64	0.91	1.14	0.44	0.66	0.61	-	-	-	-	1.30	0.25	
Potential Area	(ha)	207,954	172,662	132,585	338,566	144,652	198,804	-	-	-	-	78,389	354,835	



Monthly Water Balance

Available Water Resources: 3,994 MCM
Potential Water Resources: 3,011 MCM



Annual Water Balance

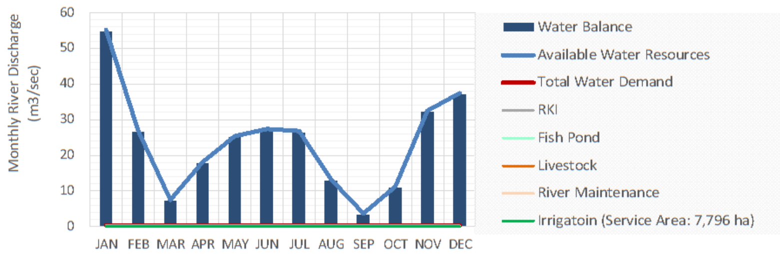
	Paddy - I	Paddy - II
Water Potential Area (Case-1):	**78,389 ha**	**132,585 ha**

Calculation Sheet on Water Potential by DI (4 / 4)

Table 4.3.9 Water Balance Calculation for KT-4 Irrigation Scheme

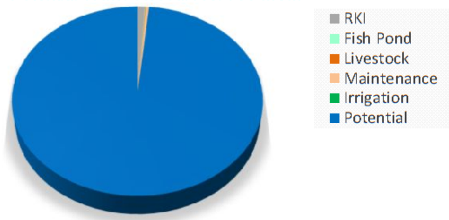
Irrigation Scheme Name: KT-4 DI Watershed Area: 1,210 km^2 Service Area: 7,796 ha Water Source: Berau

	(Unit)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
1 Available Water Resources														
1.1 Rainfall P_{ave}	(mm)	254	218	213	217	208	209	214	200	227	248	234	257	2,699
1.2 Rainfall $P_{80\%}$	(mm)	180	144	96	107	148	142	146	115	111	135	130	168	1,624
1.3 Discharge Q_{ave}	(m^3/sec)	78.02	40.61	16.57	36.55	35.60	40.21	39.45	22.88	7.45	20.57	58.48	57.25	37.80
1.4 Discharge $Q_{80\%}$	(m^3/sec)	55.23	26.87	7.50	18.07	25.38	27.39	26.78	13.21	3.65	11.21	32.55	37.45	23.79
2 Water Demand														
2.1 RKI														
Population	(10^3person)	31	31	31	31	31	31	31	31	31	31	31	31	-
Demand	(m^3/sec)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2.2 Fish Pond														
Pond Area	(ha)	1,461	1,461	1,461	1,461	1,461	1,461	1,461	1,461	1,461	1,461	1,461	1,461	-
Demand	(m^3/sec)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2.3 Livestock														
Demand	(m^3/sec)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2.4 River Maintenance														
Demand ($Q_{MIN95\%}$)	(m^3/sec)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2.5 Irrigatoin (Service Area: 7,796 ha)														
Irrigated Plantation Area	(ha)	4,927	4,927	4,927	4,927	4,927	4,927	4,927	4,927	4,927	4,927	4,927	4,927	-
Irrigated Palawija Planted Area	(ha)	0	0	0	0	0	0	0	0	0	0	0	0	-
Demand for Plantation	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand for Palawija Production	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Demand (Net)	(m^3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 Water Balance	(m^3/sec)	54.84	26.49	7.12	17.69	25.00	27.00	26.40	12.83	3.27	10.82	32.17	37.07	23.40
4 Potential Area														
4.1 Case 1 (Paddy-Paddy)		Paddy - I			Paddy - II							Paddy - I		-
Unit Water Demand of Paddy	(m^3/sec/1000ha)	0.46	0.68	-	1.22	0.51	0.80	0.73	-	-	-	1.15	0.17	
Potential Area	(ha)	120,085	38,957	-	14,493	48,723	33,947	36,145	-	-	-	27,952	216,125	



Monthly Water Balance

Available Water Resources: 750 MCM
Potential Water Resources: 738 MCM



Annual Water Balance

	Paddy - I	Paddy - II
Water Potential Area (Case-1):	**27,952 ha**	**14,493 ha**

According to the calculation result afore-mentioned, monthly water potential area and the irrigable area are calculated assuming two times paddy cropping. Design cropping pattern is determined based on the current cropping pattern practice within the province and also the monthly discharge pattern, maximizing irrigable area in each irrigation scheme. Table 4.3.10 summarizes the water potential area by season for the irrigation schemes of KT-1 to KT-4. The result indicates that water potential area is large enough comparing to the beneficial area determined by land condition afore-mentioned. Thus, the net beneficial areas presented in the afore-mentioned Table 4.3.3 can be secured from the viewpoint of water resource potential.

Table 4.3.10 Comparison of Beneficial Area and Water Potential Area (Kalimantan East Province)

DI Name	Season (Month)	Beneficial Area (1)*, (ha)	Water Potential Area (2)			
			Paddy, ha	Palawija, ha	Total (ha)	Ratio (2)/(1) (%)
KT-1	Season I (Nov to Feb)	3,258	39,033	0	39,033	>100%
	Season II (Mar to Jun)	3,258	44,029	0	44,029	>100%
KT-2	Season I (Nov to Feb)	32,707	164,766	0	164,766	>100%
	Season II (Mar to Jun)	32,707	242,411	0	242,411	>100%
KT-3 (KT-31 & KT-32)	Season I (Nov to Feb)	13,413	78,389	0	78,389	>100%
	Season II (Mar to Jun)	13,413	132,585	0	132,585	>100%
KT-4	Season I (Nov to Feb)	7,796	27,952	0	27,952	>100%
	Season II (Apr to Jul)	7,796	14,493	0	14,493	>100%

*Beneficial area is applied in Net-1 values in Table 4.3.3, which total beneficial area arrives at 53,915 ha.
Source: JICA Project Team

4.3.3 Preliminary Irrigation New Development

In this section, preliminary design of diversion weirs and canals is examined based on the design discharge calculated with the beneficial area and unit water requirement. Table 4.3.11 summaries the design discharge for each of the 3 irrigation schemes. As for the unit water requirement for the calculation, the maximum monthly value of the year considering the effective rainfall amount is applied.

Table 4.3.11 Design Discharge (Kalimantan East Province)

DI Name	Beneficial Area (Net), ha	Unit Water Demand (m^3/s/1000ha)		Design discharge (Max Water Demand), m^3/s	Remarks
	(1)	(2)		(3) = (1) * (2) / 1000	
KT-2	32,707	1.38	(Nov)	45.14	
KT-3	13,413	1.30	(Nov)	17.44	Sum of (KT-31 + KT-32)
KT-4	7,796	1.22	(Apr)	9.51	

Source: JICA Project Team

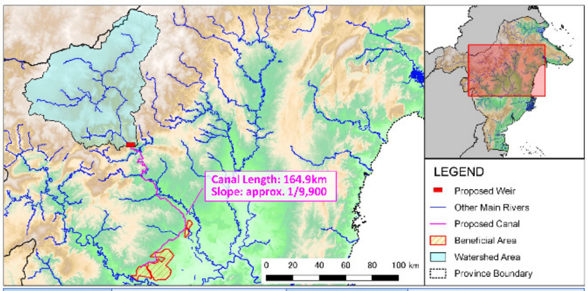
1) Preliminary Design of Diversion Weirs

The locations of diversion weirs should be designed by considering the following conditions; 1) selection of water resource river, 2) canal alignment (location and length of canals), 3) determination of intake water level, 4) confirmation of intake water amount, and 5) confirmation on the necessity of a reservoir. Through this process, design parameters such as location of weirs, intake water levels, length of canals, etc. are preliminary proposed as below (see Figures 4.3.7 to 4.3.9 and in Tables 4.3.12 to 16). Based on the result of water potential evaluation, all the required water amount can be availed without any storage facilities.

- ✓ For the KT-2 new irrigation scheme, the diversion point is set at a far upstream of 165km from the beneficial area with a catchment area of 6,100 sq.km. The weir elevation is proposed at around 38.5m, from which the diverted water is delivered to the beneficial area extending over an area with the elevations of 10m to 20m.

- ✓ The KT-31 and KT-31 irrigation area is to have the diversion weir at an upstream of 22.4km from the beginning point of beneficiary area. The weir is planned at an elevation of 27.6m, and the diverted water will be delivered to KT-31 and KT-32 beneficiary areas respectively by each of the primary canals.

✓ The KT-4 irrigation scheme's diversion weir will be set at an upstream point of 69km from the beginning point of the beneficiary area, and the weir's elevation is to be at 52.8m. With this relatively high elevation for the diversion point, the beneficial area will extend over an area with the elevations of 10 m up to 40 m.



DI Name	KT-2	Watershed Area	6,104 km^2
Kabupaten	Kutai Kartenegara	Canal Length (Slope)	164.9 km (approx. 1/9,900)
Weir Location	115.9713° E, 0.6053° N	Beneficial Area	Judge1: 32,707 ha (Net)
Weir Elevation	EL.38.5m	Target EL of Beneficial Area	EL.10m – EL.20m (Mean: EL.14.0m)

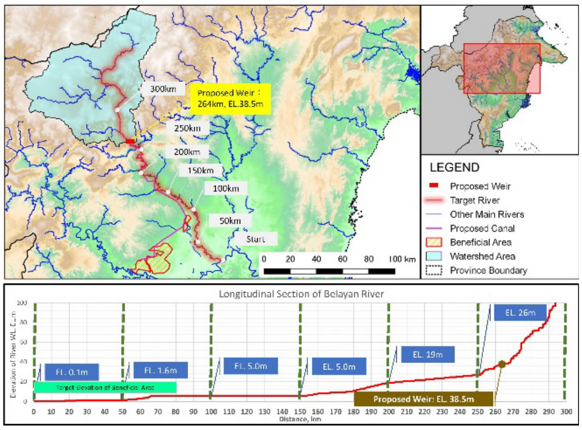
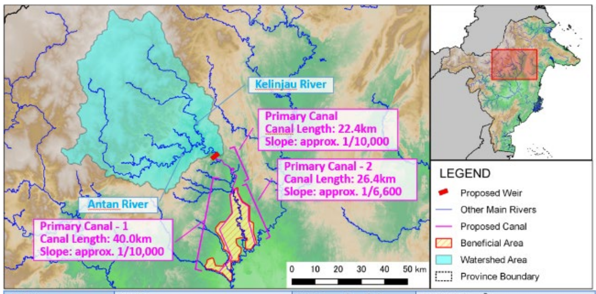


Figure 4.3.7 Basic Condition and River Profile for DI KT-2

Source: JICA Project Team



DI Name	KT-3	Watershed Area	3,299 km^2
Kabupaten	Kutai Timur	Canal Length (Slope)	Primary: 22.4 km Primary1: 40.0 km Primary2: 26.4 km (approx. 1/6,600 - 1/10,000)
Weir Location	116.5679° 0.8018° N	Beneficial Area	Max 14,903 ha (Gross)
Weir Elevation	EL.27.6m	Target EL of Beneficial Area	EL.10m – EL.20m (Mean: EL.13.7m)

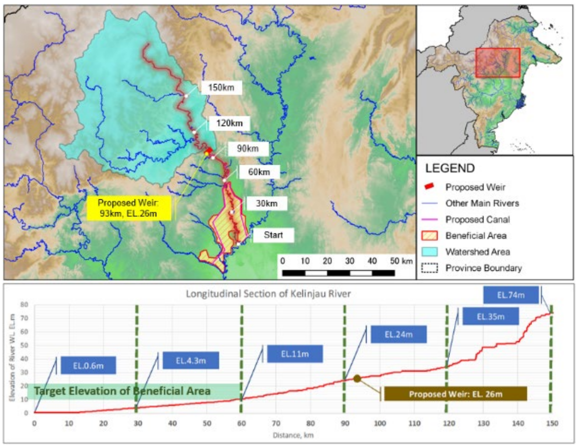
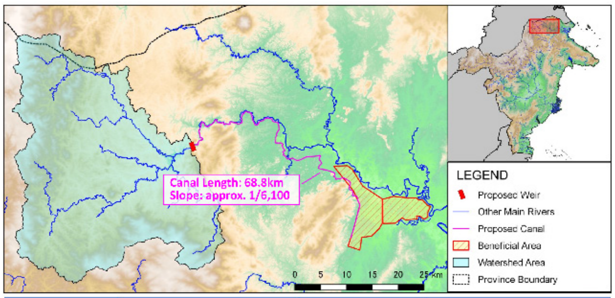


Figure 4.3.8 Basic Condition and River Profile for DI KT-3

Source: JICA Project Team



DI Name	KT-4	Watershed Area	1,227 km^2
Kabupaten	Berau	Canal Length (Slope)	68.8 km (approx. 1/6,100)
Weir Location	116.7962° E, 2.2607° N	Beneficial Area	Judge1: 7,796 ha (Net)
Weir Elevation	EL.52.8m	Target EL of Beneficial Area	EL.10m – EL.40m (Mean: EL.26.2m)

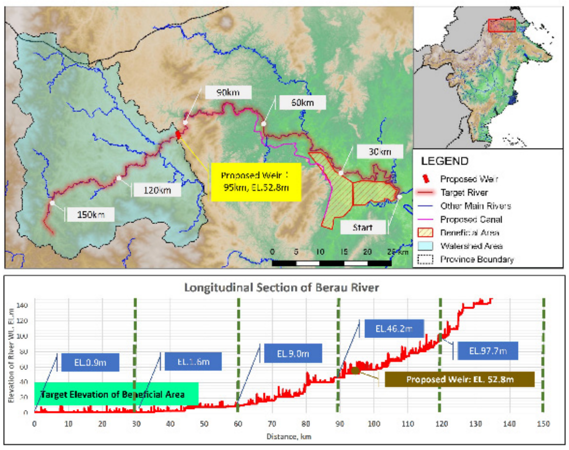


Figure 4.3.9 Basic Condition and River Profile for DI KT-4

Source: JICA Project Team

Flood discharge volume at the location of diversion wears should be estimated based on the KP-01

(MPWH 2013) applying Melchior method. Melchior method is an empirical one to estimate the correlation between rainfall amount and discharge volumes for a specified watershed area larger than 100 sq.km, and requires such parameters as rainfall amount, watershed shape and area, river length and river gradient. The calculation results are shown in Table 4.3.12, and the return period of 1 in 25 years (Q25) is applied for the purpose of designing diversion weir (KP-02, MPWR 2013):

Table 4.3.12 Flood Discharge at the Location of Diversion Weirs

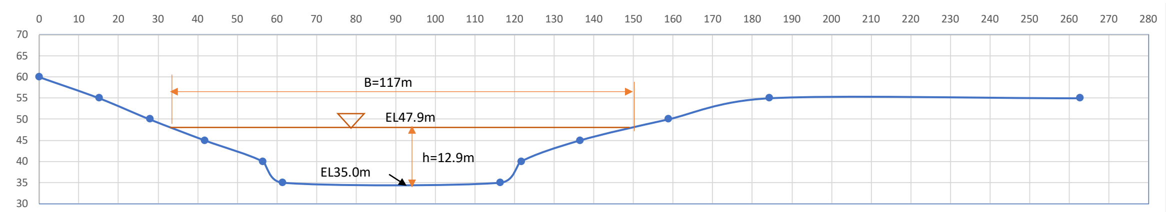
DI Name	Beneficial Area, ha	Watershed Area, sq.km	Peak Flood Discharge, cum/s				
			Q5	Q25	Q50	Q100	Q1000
KT-2	32,707	6,030	2,194	2,724	2,909	3,076	3,522
KT-3	13,413	3,190	1,604	1,992	2,127	2,248	2,574
KT-4	7,796	1,210	581	793	891	995	1,396

Source: KP-01 (MPWH 2013)

With the flood discharges afore-mentioned, the hydraulic parameters at each weir location should also be calculated referring to the assumed river cross sections. Corresponding river water levels with the river discharge at different return period are calculated based on Manning formula with 0.040 for roughness coefficient assuming gravel bed and based on the river longitudinal gradient estimated at the weir locations. Following tables summarize the hydraulic parameters at the diversion weir locations:

Table 4.3.13 Hydraulic Parameters at the Weir Location of DI KT-2

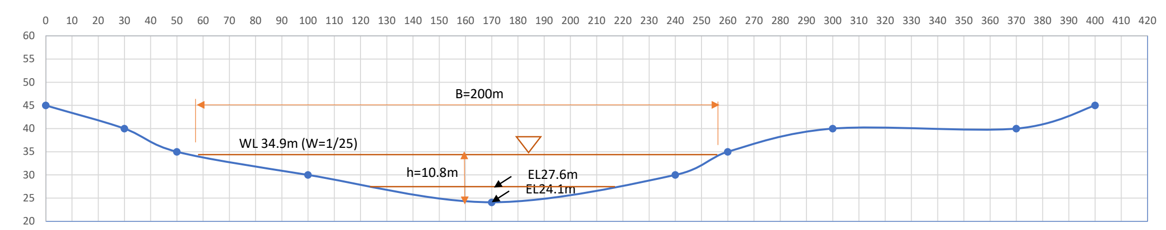
Return Period	Discharge	Roughness Coefficient	Riverbed Slope	Water Level	Water Depth	Cross Section Area	Breadth of River	Flow Velocity
	Q	n	S	WL	h	A	B	V
	m^3/s	$s/m^{1/3}$	(-)	(EL.m)	(m)	(m^2)	(m)	(m/s)
Q5	2,194	0.04	1/1,400	45.9	10.9	796.98	112.09	2.47
Q25	2,724	0.04	1/1,400	47.9	12.9	1,012.12	127.99	2.67
Q50	2,909	0.04	1/1,400	48.4	13.4	1,073.02	131.29	2.71
Q100	3,076	0.04	1/1,400	48.7	13.7	1,119.02	134.10	2.75
Q1000	3,522	0.04	1/1,400	49.7	14.7	1,238.19	140.96	2.84
Qave	295.3	0.04	1/1,400	38.3	3.3	170.30	40.73	1.73



Note: The cross section of the river was produced from the DEMNAS provided by Badan Informasi Geospasial (BIG), https://tanahair.indonesia.go.id/demnas/#/, Source: JICA Project Team

Table 4.3.14 Hydraulic Parameters at the Weir Location of DI KT-3

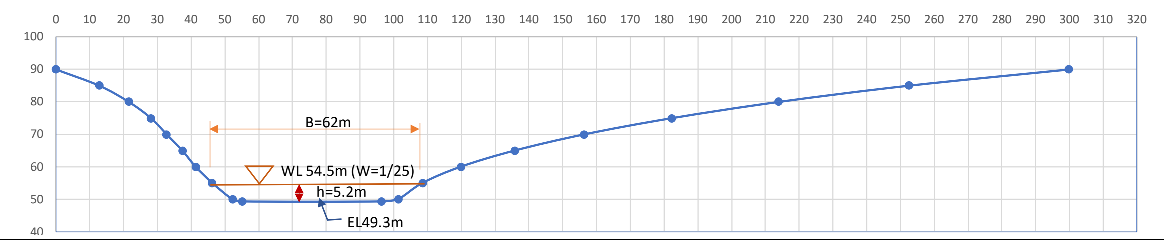
Return Period	Discharge	Roughness Coefficient	Riverbed Slope	Water Level	Water Depth	Cross Section Area	Breadth of River	Flow Velocity
	Q	n	S	WL	h	A	B	V
	m^3/s	$s/m^{1/3}$	(-)	(EL.m)	(m)	(m^2)	(m)	(m/s)
Q5	1,604	0.04	1/2,500	34.0	9.9	1,047.56	195.48	1.53
Q25	1,992	0.04	1/2,500	34.9	10.8	1,216.72	205.35	1.64
Q50	2,127	0.04	1/2,500	35.1	11.0	1,273.23	208.48	1.67
Q100	2,248	0.04	1/2,500	35.4	11.3	1,323.03	211.19	1.70
Q1000	2,574	0.04	1/2,500	36.0	11.9	1,453.73	218.15	1.77
Qave	125.8	0.04	1/2,500	27.2	3.1	165.75	88.63	0.76



Note: The cross section of the river was produced from the DEMNAS provided by Badan Informasi Geospasial (BIG), https://tanahair.indonesia.go.id/demnas/#/, Source: JICA Project Team

Table 4.3.15 Hydraulic Conditions of the River at the Weir Location in DI KT-4

Return Period	Discharge	Roughness Coefficient	Riverbed Slope	Water Level	Water Depth	Cross Section Area	Breadth of River	Flow Velocity
	Q	n	S	WL	H	A	B	V
	m^3/s	$s/m^{1/3}$	(-)	(EL.m)	(m)	(m^2)	(m)	(m/s)
Q5	581	0.04	1/800	53.5	4.2	226.89	46.01	2.56
Q25	793	0.04	1/800	54.5	5.2	282.88	50.08	2.80
Q50	891	0.04	1/800	54.9	5.6	307.70	51.89	2.90
Q100	995	0.04	1/800	55.3	6.0	333.48	53.77	2.98
Q1000	1,396	0.04	1/800	56.7	7.4	428.94	60.71	3.25
Qave	31.0	0.04	1/800	50.1	0.8	33.93	32.28	0.91



Note: The cross section of the river was produced from the DEMNAS provided by Badan Informasi Geospasial (BIG), https://tanahair.indonesia.go.id/demnas/#/, Source: JICA Project Team

Preliminary design of the diversion weirs is proposed as follows; 1) Floating type is selected assuming that the foundation is of permeable, 2) Movable gate is selected including sluices and spillway in order to secure the same cross section area as natural river and to minimize the change in river course during flooding, considering that the weirs are to be installed in low flat area, and 3) Flood return period for the weirs and downstream embankment for canals is set at 1 in 25 years complying with KP-02 (MPWH 2013). Based on those conditions, design parameters of the diversion weirs are calculated as in the following table with a typical standard section and its plan illustrated below:

Table 4.3.16 Design Parameters of Intake Weir for New Development Area in Kalimantan East

DI Name		Design Intake Discharge	Elevation of Beneficial Area	Primary Canal Length	Planned Canal Bed Slope	Canal Head Loss	Required WL at Weir	Required Riverbed EL	Location of Intake Weir (Coordination)	
		Q	EL	L	S	H	WL	EL	Lat.	Lon
		m^3/s	M	km	-	m	m	m	Degree	Degree.
KT-2		45.14	20.0	164.9	1/9,900	17.5	38.5	35.0	0.605317	115.97133
KT-3	Total	17.44	-	91.6	-	6.6	27.6	24.1	0.801816	116.56794
	Primary	17.44	20.0	22.4	1/10,000	2.4				
	Primary-1	8.50	20.0	41.4	1/10,000	4.2				
	Primary-2	8.94	20.0	27.8	1/6,600	4.2				
KT-4		9.51	40.0	68.8	1/6,100	11.8	52.8	49.3	2.260640	116.79620

Note: 5% of the canal head loss is added as the additional head loss required for, e.g., extra canal length and incidental structural head losses (e.g. syphon). The required water level at weir is added by 1m considering head loss for water distribution and others on top of the elevation of the beneficial area. Source: KP-03 (MPWH 2013)

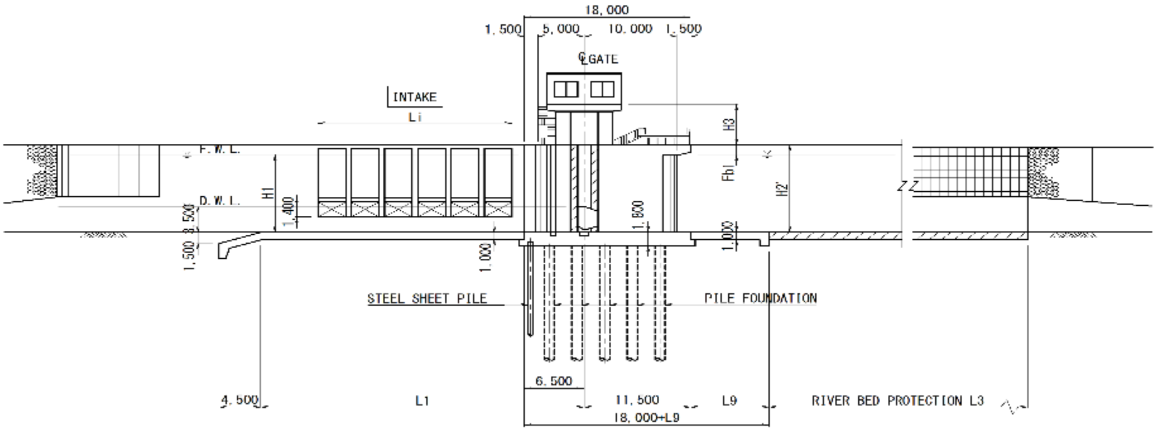


Figure 4.3.10 Typical Standard Section of the Weirs (Example of KT-3)

Source: JICA Project Team

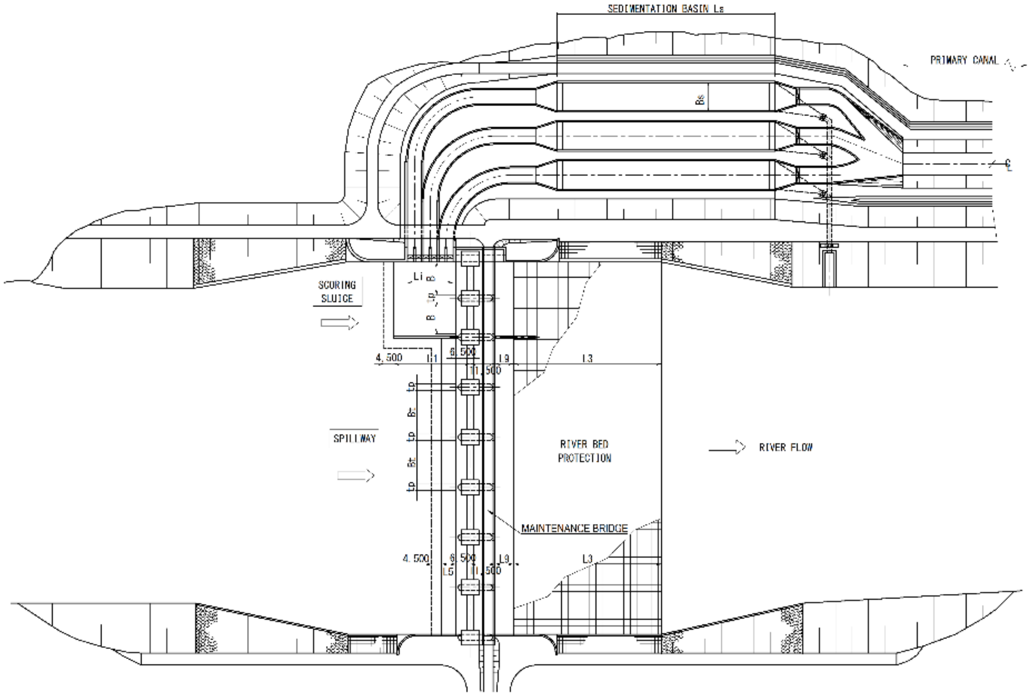


Figure 4.3.11 Typical Standard Plan of the Weirs (Example of KT-3)
Source: JICA Project Team

2) Preliminary Design of Primary Canals

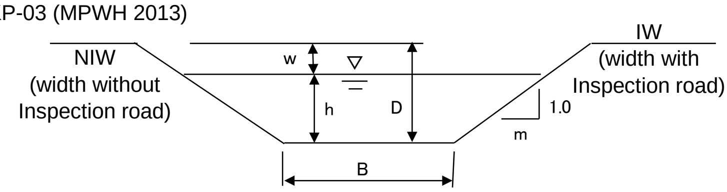
Primary canal, including main canals, should be so designed capable of conveying designed water amount from the diversion weir point to the beneficiary area. Earth canal with trapezoid shape is selected from the viewpoint of cost effectiveness considering the huge length of canals, and the longitudinal and cross section of the canals are designed complying with the Standard of Irrigation Planning – Canals (KP-03, MPWH 2013).

With reference to the KP-03 (MPWH 2013), basic design parameters of the primary canals are determined as in Table 4.3.17 with a typical cross section of KT-2 primary canal. Note that a little gentle canal bed gradient against the standard gradient determined by KP-03 is recommended for KT-3. This is because enough amount of water resources cannot be secured in case that the standard gradient is applied as the standard gradient makes the weir location far upstream than the confluence of Antan River and Kelinjau River (for the rivers, see Figure 4.3.8).

Table 4.3.17 Design Parameters of Primary Canals in Kalimantan Timur (Preliminary Design Level)

DI Name		Design Discharge	Strickler roughness Coefficient	Water Depth	Free board	Total Height	Side Slope	Ratio B/h	Bed Width	Levee Width		Bed Gradient	Velocity
		Q	K (1/n)	h	w	D	1:m	n	B	IW	NIW	S	V
		m^3/s	$m^{1/3}/s$	m	m	m	-	-	m	m	m	-	m/s
KT-2		45.14	45.0	2.33	1.00	3.33	2.00	9.90	23.00	5.00	3.50	1/9,900	0.701
KT-31&32	Primary	17.44	45.0	2.02	1.00	3.02	2.00	5.25	10.60	5.00	3.50	1/10,000	0.591
	Primary1	8.50	42.5	1.83	0.75	2.58	1.50	3.56	6.50	5.00	2.00	1/10,000	0.504
	Primary2	8.94	42.5	1.70	0.75	2.45	1.50	3.71	6.30	5.00	2.00	1/6,600	0.594
KT-4		9.51	40.0	1.70	0.75	2.45	1.50	3.80	6.50	5.00	2.00	1/6,100	0.620
Remarks			KP-03 Table3-1	KP-03 3.3.1 b/h≧10, Table3-5		D = h+w	KP-03 3.3.2 Sandy loam	KP-03 Figure A.2.1		Pavement with 3.0m			

Source: JICA Project Team calculated based on KP-03 (MPWH 2013)



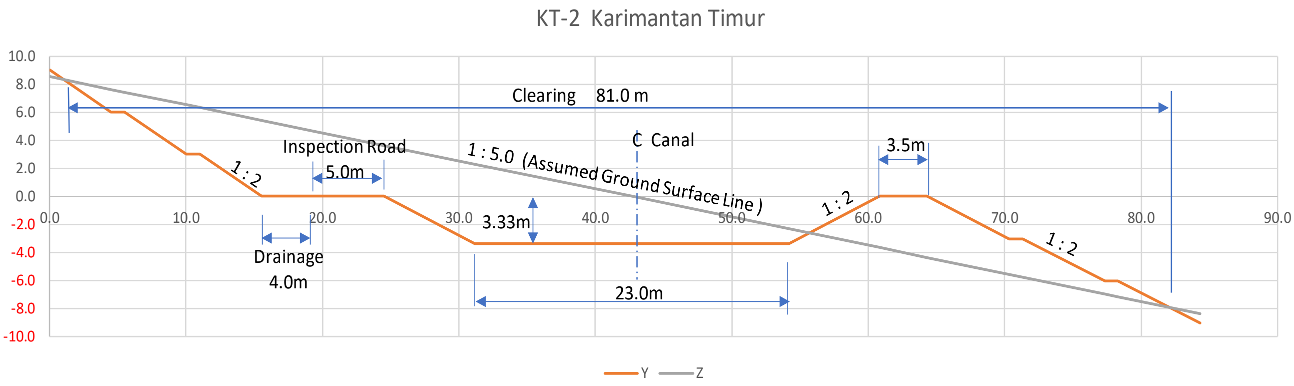


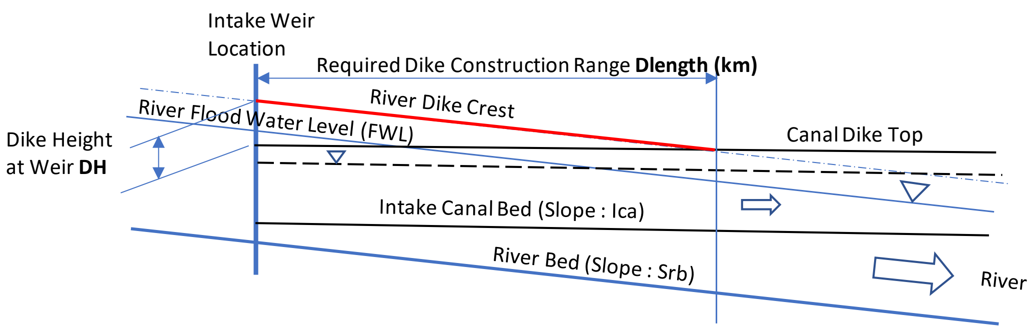
Figure 4.3.12 A Typical Cross Section of Primary Canal (DI KT-2)
Source: JICA Project Team

Canal dike height in some areas are lower than the flood water level, which requires the flood dike to prevent the canals being damaged from flood. Therefore, required length of flood dike should be calculated based on the preliminary design parameters of canals, river bed slope, and flood water level at 1 in 25 year return period. Dimensions of the canal dikes are summarized in the following table:

Table 4.3.18 Preliminary Design of Canal Kikes for Flood Prevention

DI Name	Flood water level (1/25) at weir	Freeboard for flood dike	River dike crest elevation at weir	River bed slope	Intake water level at weir	Free board pf canal	Canal dike elevation at weir	Required dike height at weir	Canal bed slope	Required dike length
	FWL (m)	Fbr (m)	DikEL (m)	Srb	IWK (m)	D (m)	CLE (m)	DH (m)	Ica	Dlen (km)
KT-2	47.9	1.2	49.1	1/1,400	38.50	1.00	39.50	9.60	1/9,900	15.7
KT-3	34.9	1.0	35.9	1/2,500	27.60	1.00	28.60	7.30	1/10,000	24.3
KT-4	54.5	1.0	55.5	1/800	52.80	0.75	53.55	1.95	1/6,100	1.8

Source: JICA Project Team calculated based on KP-03 (MPWH 2013)



3) Preliminary Canal Network Planning

Canal networks is composed of primary canal, including main canal, then secondary canal and tertial canal in general cases in Indonesia. In this pre-feasibility study, primary canal is the one which conveys the water from the diversion point first to the beginning point of the beneficially area, and then to the end point of the beneficiary area. Then, the secondary canals are the ones branching from the primary canal, and distributing the irrigation water over extensive beneficial lands. Further, to make use of the water by the farmers, there should be one more cascaded canals, which are called tertiary canals.

The alignment of the primary canal is almost decisively decided by the topographic condition, namely, the canal should be aligned running down through the highest places of the beneficiary area. In this sense, the primary canals are in most cases aligned running far away from the river. Then, there should be a number of secondary canals all branching from the primary canal and running down to the lower elevation direction, e.g., in most cases towards river direction. Tertiary canals are branching from the secondary canals, and running again down to the lower elevation direction.

In Indonesia, a typical tertiary canal is designed to cover 100 ha of beneficiary area, which is relatively large as compared to the practices in other Asian countries, e.g., max. 100 acres (40ha) in Myanmar, 50 ha in the Philippines. For the secondary canals, no standard area coverage by one secondary is defined in Indonesia, and neither in other Asian countries. Therefore, examples in existing irrigation schemes in Central Java province and South Sulawesi province are referred to as indicated in Table 4.3.19. From those typical examples, the Team proposes a coverage area of 1,000ha should be allocated to each secondary canal as average.

Table 4.3.19 Typical Examples for Secondary Canals in Central Java and South Sulawesi Provinces

Particulars	Central Java Province			South Sulawesi Province			
	SIDOREJO	SEDADI	KLAMBU-KIRI	Kelara Karraloe	Bantimurung	Lamasi	Kalaena
Farmland Area (ha)	7,938	16,055	20,709	7,815	6,513	11,456	16,946
No. of Secondary Canals	8	8	4	3	6	11	3
Av. Area of Secondary C	992	2,007	5,177	2,605*	1,086	1,041	5,649
*No. of Tertiary Canals	63	63	110	51	58	235	102
Av. Area of Tertiary Canals	126	255	188	153	112	49	166

* Note: Average areas of Klambu-Kiri and Kelara Karraloe are very large, more than 5,000ha, and this is because there are sub-secondary canals below the secondary canal, and therefore the area coverage for those 2 schemes should not be referred to.
Source: BBWS Pemali Juana (Central Java Province) and Pompengan Jeneberang (South Sulawesi Province)

Based on the assumption that one secondary canal is allocated 1,000ha beneficial area, expected number of secondary canals are summarized in Table 4.3.20 with the expected number of tertiary canals, to which each 100ha is allocated (see Figure 4.3.13 as an example of canal network of KT-31 and KT-32). Table 4.3.20 also shows expected number of beneficially farmers based on a government resettlement guideline, in which 1.75ha[5] of crop land be given to settlers. The total for the 3 schemes indicates that there will be as many as about 38,000 beneficially farmers irrigating their farmlands with total 676 tertiary and 69 secondary canals.

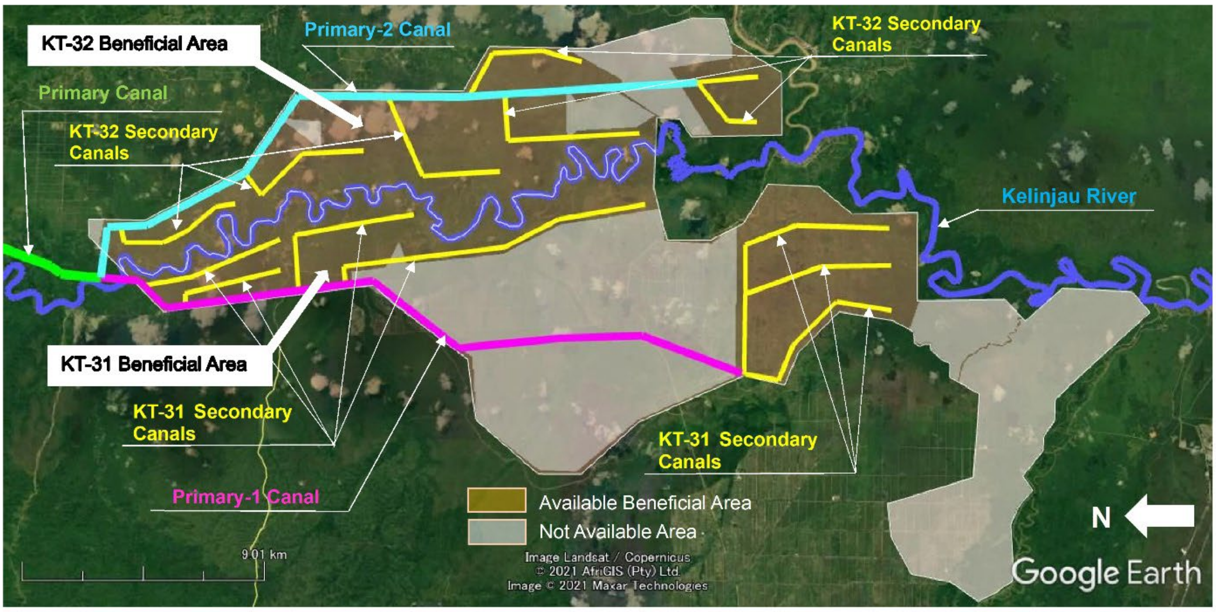


Figure 4.3.13 Typical Layout of Primary Canal and Secondary Canals (DI KT-31 & KT-32)
Source: JICA Project Team

[5] According to Bab XVII : Transmigrasi – Bappenas, and Rukmadi (1984: 67), farmer trans-migrants have the right to acquire land of at least two hectares, use of which is divided as follows: 0.25 (one-quarter) hectare used for houses and yards and 1.75 (one three-quarter) hectare used for cultivation and/or paddy fields.

Table 4.3.20 Preliminary Setting for Canal Network with Expected Beneficiary Farmer Numbers

Irrigation Scheme	Gross Area, ha	Net Area, ha	No. of Secondary	No. of Tertiary	No. of Farmers
KT-2	36,341	32,707	33	328	18,690
KT-31&32	14,903	13,413	14	135	7,665
KT-31	7,266	6,540	7	66	3,737
KT-32	7,637	6,873	7	69	3,927
KT-4	8,662	7,796	8	78	4,455
Total	59,906	53,915	55	541	30,810

Source: JICA Project Team

4.4 Preliminary Cost Estimation, Implementation Schedule, and Project Evaluation

4.4.1 Preliminary Cost Estimation

In Kalimantan East province, new areas of KT-2, KT-31, KT-32 and KT-4 have been prioritized the highest to develop, covering an extensive area of 53,915 ha in net. The current land use is mostly occupied with forest, woodland, and bush land, while plantation areas with concession license, mostly palm or sugarcane, and protected forest areas are all excluded from the designed irrigable area. It means that the development of the irrigation schemes requires opening the land, making paddy plots including terracing in areas where the topography shows more than 5% slope in general.

With above conditions, the construction cost for the Kalimantan East province would relatively be higher than conventional case where existing rainfed paddy areas are to be irrigated with new irrigation canal networks. Likewise, implementation schedule should be longer than the conventional cases, in which land opening and paddy plot development are not required.

DGWR has newly developed about 1 million ha of new irrigated lands during the last 5-year development term (2014-2019) with a total cost of 29.6 trillion Rs composed of surface irrigation and lowland tidal irrigation schemes. As the target schemes are completely new one, the Team refers to the highest development cost for major surface irrigation schemes, that is 108 million Rs/ha. In addition to this unit development cost, associated costs are counted as additional percentage ratio indicated below and calculated in Table 4.4.1.

1) Development cost: 108,001 thousand Rs/ha
2) Land acquisition/ development: 20% of the development cost
3) Survey and Design: 10% of the development cost plus land acquisition/ development
4) Administration: 5% of develop't cost, acquisition/ develop't plus survey & design
5) Contingency (physical): 5% of develop't cost, acquisition/ develop't plus survey & design
6) Contingency (price inflation): 5% of develop't cost, acquisition/ develop't plus survey & design

The overall unit development cost for the target schemes in the Kalimantan East province arrives at 164 million Rs/ha (11,714 US$/ha). With the total net development area of 53,915 ha, the total investment cost for the new area development comes to 8,842 billion Rs, equivalent to about 632 million US$.

Table 4.4.1 Estimation of Unit Development Cost for Kalimantan East Province

	Particulars	Cost, thousand Rs/ha	Multiplier	Remarks
1	Unit Development Cost (original)	108,001	-	Refer to Figure 2.4.1
2	Land Acquisition/Development	21,600	20%	Against above No.1
3	Survey and Design	12,960	10%	Against above sum No.1- No.2
4	Administration, etc.	7,128	5%	Against above sum No.1- No.3
5	Contingency (Physical)	7,128	5%	Against above sum No.1- No.3
6	Contingency (Price Inflation)	7,128	5%	Against above sum No.1- No.3
7	Total of above	163,946	152%	Sum of No.1-6
8	Say (thousand Rs/ha)	**164,000**	152%	Rounded up
9	@14000	**11,714**	$/ha	
10	Total Net Irrigation Area (ha)	**53,915**	ha	Net irrigable area

	Particulars	Cost, thousand Rs/ha	Multiplier	Remarks
11	Total Cost in Rs	8,842 billion Rs		Whole project cost for 53,915 ha
12	Total Cost in US$ (@14,000)	632 million US$		Whole project cost for 53,915 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

4.4.2 Implementation Schedule

Construction period of a project depends upon the size of the project, namely, the larger a project is, the longer construction period it requires. In many cases, however, a new irrigation development project is usually scheduled to complete within 5 years for the purpose of generating benefits at an earliest possible time, not letting the beneficiaries wait so long. Also, shorter period of construction is required from the economic point of view, namely, the earlier the benefit starts accruing, the bigger return the project can produce.

The target schemes in Kalimantan East province are in fact very large in its scale, developing more than 50,000 ha of land and also the development includes opening of the land for paddy cultivation. Such huge scale land development would definitely require longer implementation period. With this, the JICA team proposes to set total 8 years for the implementation of the new irrigation schemes in the province, longer than general practices. It means that survey and designing should be completed within the first 2 years in parallel with land acquisition, and then the construction follows. The construction is scheduled to complete by the end of 8th year and the planting of paddy would start from the 9th year (see Table 4.4.2).

Table 4.4.2 Overall Implementation Schedule (8 years for implementation)

Construction Year	1	2	3	4	5	6	7	8	-	-	-	-	-	Remarks
Benefit Year	-	-	-	-	-	-	-	-	1	2	3	4	5	
Survey & Design									Paddy planting to start, and the yield reaches the current level at the 3rd year.			Paddy yield gradually to increase.		
Construction														
Construction for Upstream Parts														
Construction for Midstream Parts														
Construction for Downstream Parts														
Land Acquisition														

Source: JICA Project Team

In cases, partial commissioning may be tried, e.g. a part of main canal would start irrigating an upstream beneficial area from 6th year, and a midstream beneficial area from 7th year, so on so forth. However, this partial commissioning is not taken into account for this pre-FS stage for the sake of simplifying the implementation schedule, and accordingly the whole beneficial area of net 53,915 ha is assumed to produce paddy from the 9th year. It is also noted that the paddy yield starts at a very preliminary level, and increases gradually as the farmers get used to paddy production (refer to 4.2 Agriculture Development Plan).

4.4.3 Financial and Economic Terms of Project Cost and Benefit

The economic analysis is carried out to assess the economic feasibility of the project. The analysis compares the project benefit accrued by implementing the project and the cost that are necessary for the project implementation. Following are the preconditions of the economic evaluation, benefits that will show up by implementing the project as well as the economic return as expressed by EIRR:

1) Preconditions of the Evaluation

Preconditions to conduct the economic evaluation are elaborated as follows:

- ✓ Referring to other similar projects in the irrigation/agriculture sector, the economic life of the project is designed as 35 years (8 years construction and 27 years operation). Namely, economic evaluations are examined over this period considering the initial investments costs, operation, and maintenance costs, and expected benefits to accrue.

- ✓ EIRR (Economic Internal Rate of Return) is applied for the evaluation criteria. For the opportunity cost of capital, which is the cut-off rate to judge economic feasibility, 10% is applied referring to the practices of international donner organizations such as the World Bank, ADB, and JICA[6]. Also, the B/C ratio (Benefit-Cost Ratio) and NPV (Net Present Value) are calculated for the references.
- ✓ For the conversion from financial prices to economic ones, the standard conversion factor (0.9) is applied for all types of prices except for farm labor (0.6) considering the imperfect competitive labor market in the rural economy.
- ✓ All project costs and benefits are calculated in Indonesian Rupees (IDR), and the foreign exchange rate of 1 USD = 14,000 IDR is applied as of January 2022. All prices are standardized into the price level as of the 2019 fiscal year.
- ✓ For the operation and maintenance cost, 500,000 IDR per ha is applied in financial price[7] (i.e., 450,000 IDR per ha in economic price).
- ✓ Transfer costs such as taxes and debts are not considered in the economic evaluation as they are "zero-sum" when aggregating all the costs and benefits among stakeholders in the economy.

2) Expected Benefit and its Evaluation Cases

The calculation of economic benefits takes into account the benefits to be generated by the increase in the planting areas and by the increase in yields of paddy rice after commencing the crop cultivations in the irrigated farmlands. The expected benefits are calculated in the following two evaluation cases, depending on the future perspective of agriculture to be extended.

- ✓ **The Effect on the Opening of Irrigable Areas:** with the project, thanks to the irrigation water coming after constructing the new irrigation systems, the irrigable areas in which the beneficiary farmers can cultivate paddy rice are expected to newly open.
- ✓ **The Effect on the Yields Increase:** with the project, the organization of water users associations (WUA) and agriculture extension activities enable timely planting and proper water management, which leads to yield increase.

In the base scenario (the Case 0), the evaluation takes into account both the effect on the opening in irrigable areas and the effects on yield increase up to the conventional agriculture practice level by the introduction of superior seeds and fertilizer inputs.

In the alternative scenario (the Case 1), the evaluation case takes into account only the effect on the opening in irrigable areas with the initially expected yields. The scenario assumes that the yield does not increase as expected due to external factors such as the stagnation of research & development and extension services. In this scenario, it is assumed that the initial yields will continue in the future.

---

6 JICA (2012) "Survey for Maximum Utilization of Irrigation Water Indonesia: Final Report" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 28 years of economic life of the project (3 years for the construction and 25 years for the operation). Also, JICA (2004) "The Study on Comprehensive Recovery Program of Irrigation Agriculture in the Republic of Indonesia" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 30 years of economic life of the project.

7 According to the interview to BBWS Pemali Juana in Central Java, AKNOP (Irrigation Operation and Maintenance Unit) suggests 500,000 IDR per ha as the standard and desirable unit maintenance cost of irrigation facilities including personnel costs, dredging costs, and repairment costs.

Table 4.4.3 Two Evaluation Cases in the Analysis (East Kalimantan)

Case	Name of the Scenario	The Effects to be considered
Case 0	Base Scenario (Suggested Scenario)	Considering the effect on the opening of irrigable areas with the effect on the yield increase (up to Conventional Agriculture Practice level).
Case 1	Alternative Scenario	Considering only the effect on the opening of irrigable areas. In this case, the initially set yields are to continue.

Source: JICA Project Team

3) Calculation and Economic Conversion of the Project Benefits

For the purpose of economic analysis, information of calculation basis have been collected and estimated from different sources as; 1) the base and target yields have been set by referring to BPS-Statistics of Kalimantan Timur, 2015-2018 (See Chapter 4.2 for more detail), and 2) the prices of paddy have been set by referring to the results of price monitoring conducted by BPS Kalimantan Timur (2018-2020) as summarized in Table 4.4.4 and Table 4.4.5:

Table 4.4.4 Base and The Target Paddy Yields (Kalimantan East)

Irrigation Scheme	Type	Service Area (Ha)	Base Yield (t/ha)	Paddy Rice					
				Years after Project has been started (till 35 years)					
				(1st ~8th)	(9th)	(10th)	(11th)	(12th)	(13th)
DI KT-2	New Development	32,707	4.69	0	1.56	3.13	4.69	4.71	4.72
DI KT-31		6,540	4.74	0	1.58	3.16	4.74	4.76	4.77
DI KT-32		6,873	4.74	0	1.58	3.16	4.74	4.76	4.77
DI KT-4		7,796	4.23	0	1.41	2.82	4.23	4.25	4.26
All East Kalimantan		53,915	4.64	0	1.54	3.09	4.64	4.66	4.67

Source: JICA Project Team
Note: The base and target yields of all East Kalimantan are calculated as the weighted averages of the service areas.

Table 4.4.5 Applied Paddy Prices in the Evaluation (Kalimantan East)

Months and Average	Paddy Rice			
	2018	2019	2020	Average
January	5,810	6,000	-	5,905
February	5,550	6,015	-	5,783
March	5,488	5,717	-	5,602
April	4,783	5,463	-	5,123
May	4,888	5,147	-	5,017
June	4,981	5,229	-	5,105
July	4,862	5,671	-	5,266
August	4,977	5,520	-	5,248
September	5,150	5,257	-	5,204
October	5,069	5,533	-	5,301
November	5,731	5,692	-	5,712
December	5,871	5,914	-	5,893
Average	5,263	5,597	-	5,430
In Economic Price (x 0.9)				5,037
Rounded				5,040

Source: The results of price monitoring by BPS East Kalimantan Province (2018-2020)

The per hector farming cost is estimated by referring to the standard cost ratio against the cropping revenue per hector. The applied standard cost ratios are estimated based on the BPS "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy 2017" (national level statistics) with some necessary modifications considering the farming practices in the project area. It implies that the farming cost is assumed to proportionally increase depending on the yield level. Table 4.4.6 shows the farming cost under the base yield:

Table 4.4.6 Estimation of Unit Farming Cost for Per-ha Cultivation of Paddy (East Kalimantan)

Item	(Wetland) Paddy	
	Financial	Economic
Standard Profit Ratio per Revenue	0.31	0.71
Standard Cost Ratio per Revenue	0.69	0.29
Base Yield per Ha (ton per ha)	4.64	4.64

Item	(Wetland) Paddy	
	Financial	Economic
The Local Prices of Paddy and Maize (IDR per kg)	5,597	5,040
Estimated Revenue per ha (000' IDR per ha)	25,970	23,386
Estimated Cost per ha (000' IDR per ha)	17,919	6,782
Estimated Profit per ha (000' IDR per ha)	8,051	16,604

Source: JICA Project Team based on BPS, "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy 2017"

The target cultivated areas by crop are set in line with the land use plan for the target service area and also the cropping pattern with the project implemented (See Chapter 4.2 for more detail). With the cultivated areas to be realized with the project, the benefits are to accrue through paddy rice production from the base year till 35th year.

4) Economic Conversion of Project Cost

For the economic analysis, the project cost should be converted to economic price by applying standard conversion factor (0.9). The economic analysis does not take into account any price escalation because there is large uncertainty in the price escalation in the future. Table 4.4.7 shows the converted economic costs to be entered in the economic evaluation:

Table 4.4.7 Economic Conversion of Development Cost and O&M Cost for Kalimantan East

No.	Particulars	Cost, thousand Rs/ha	Multiplier	Remarks
1	Unit Development Cost (original)	108,001	-	Refer to Figure 2.4.1
2	Land Acquisition/Development	21,600	20%	Against above No.1
3	Survey and Design	12,960	10%	Against above sum No.1- No.2
4	Administration, etc.	7,128	5%	Against above sum No.1- No.3
5	Contingency (Physical)	7,128	5%	Against above sum No.1- No.3
6	Contingency (Price Inflation)	7,128	5%	Against above sum No.1- No.3
7	Total of above	163,946	152%	Sum of No.1-6
8	Total without Price Contingency	156,818	145%	Deduction of No.6 from No.7
9	Unit Economic Development Cost	141,136	130%	No. 8 x 0.9
10	Total Net Irrigation Area (ha)	53,915	ha	Net irrigable area
11	Total Financial Cost in Rs	8,455 billion Rs		Whole project cost for 53,915 ha
12	Total Economic Cost in Rs (x 0.9)	**7,609 billion Rs**		Whole project cost for 53,915 ha
13	Unit O&M Cost per ha	500		Suggested O&M cost by AKNOP
14	O&M Cost in Rs	26,958 million Rs		Whole O&M cost for 53,915 ha
15	Economic O&M Cost in Rs (x 0.9)	**24,262 million Rs**		Whole O&M cost for 53,915 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

5) Evaluation Results

In order to examine the economic validity of the Project, EIRR, B/C, and NPV have been calculated. The calculated EIRR is 13.62%; B/C ratio is 1.50 and the NPV is 2.6 trillion IDR for the base scenario (Case 0). An alternative scenario (Case 1), where the evaluation does not consider any yield increase, has provided such results of 13.47 %, 1.47, and 2.4 trillion IDR for the EIRR, B/C ratio, and NPV respectively (see Table 4.4.8). According to the evaluation result, the Project is judged to be economically feasible under the base scenario since the EIRR (13.62%) exceeds the opportunity cost of capital (10.0%), and the Project is still economically feasible even under the alternative scenario (EIRR: 13.47 %).

Table 4.4.8 Results of the Project Economic Analysis for Kalimantan East

Particulars	Case 0	Case 1 (no yield increase)
EIRR, %	13.62	13.47
B/C Ratio	1.50	1.47
NPV, million IDR	2,594,162	2,448,455

Source: JICA Project Team

CHAPTER 5 PRE-FEASIBILITY STUDY: SOUTH SULAWESI PROVINCE

One of the top 4 priority areas selected is South Sulawesi province for irrigation rehabilitation. This chapter undertakes preliminary feasibility study (pre-FS) for the South Sulawesi province. The pre-FS examines potential of extending irrigable area and/or cropping intensity with rehabilitation on the existing irrigation facilities from the viewpoint of land and water resources potential, as well as from agricultural point of view. The pre-FS also includes preliminary cost-estimation, benefit estimation and economic analysis for recommended rehabilitation projects.

5.1 Status of the Project Area

5.1.1 Spatial Settings, and Salient Features

South Sulawesi (Sulawesi Selatan) is a province extending over the southern peninsula of Sulawesi island. The province is bordered by Central Sulawesi and West Sulawesi to the north, the Gulf of Bone and Southeast Sulawesi to the east, Makassar Strait to the west, and Flores Sea to the south. The 2010 Census estimated the population as 8,032,551, making South Sulawesi the most populous province in the island, i.e., 46% of the population of Sulawesi is in the South Sulawesi, and the 6th most populous province in Indonesia. By mid 2019, the population was estimated to have risen to 8,851,200 (BPS).

The province is located at 4°20'S and 120°15'E, covering an area of 46,717.48 sq.km, and the BBWS office in charge is called Pompengan Jeneberang, which takes responsibility for water resources development, irrigation development and management in this area (see Figure 5.1.1). The BBWS covers several number of watershed areas as indicated in the right map of Figure 5.1.1, and the headquarters office is located at Makassar, the capital of the province.

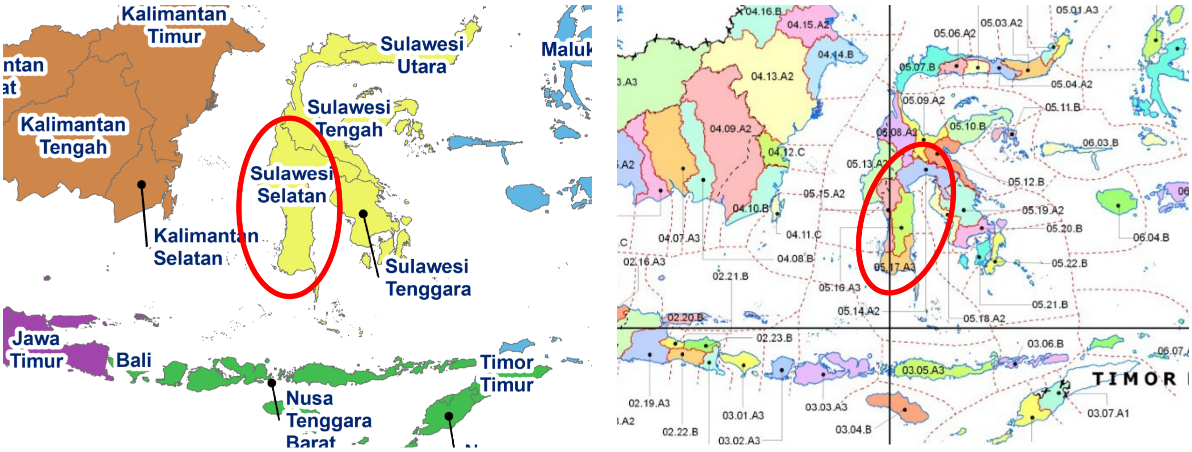


Figure 5.1.1 Location of the South Sulawesi Province and BBWS Jurisdictional Watershed Area

Source: Directorate General of Water Resources

The economy of the province is based on agriculture, fishing, and mining of gold, magnesium, iron and other metals. The province is in fact one of the national rice granaries, producing as much as 6.1 million tons in 2017 (BPS, 2018), which is designated for local consumption and also for distribution to other eastern areas of the island with even exports to Malaysia, to the Philippines, and to Papua New Guinea. The locations of the largest rice production include Bone district and Luwu district which are the target of the rehabilitation project undertaken in this chapter.

In this South Sulawesi province, the JICA team at first contacted BBWS Pompengan Jeneberang office in order to identify specific existing irrigation schemes where rehabilitation and/or modernization project needs to be implemented. Through the discussions with the BBWS office and also with the DILL headquarters, number of potential sites for rehabilitation were proposed as there are many existing irrigation schemes in there. With preliminary information provided, the JICA team with the BBWS staff conducted field visits to physically observe the current conditions of proposed irrigation schemes for rehabilitation.

BBWS shared the information of their irrigation schemes, and explained that 1) there are irrigation schemes to be funded by the World Bank[1] and ADB[2], which should be set aside from the JICA pre-FS, 2) no major rehabilitation works have been done on most of the irrigation schemes so far except for minor repair and maintenance works during the last 5-year mid-term development period (2014-19), suggesting that rehabilitation should be prioritized rather than modernization in the South Sulawesi province. Excluding the donor earmarked projects, the Team and BBWS/DILL have selected total 5 schemes, 3 in southern part of the province and 2 in northern part, as illustrated in Figure 5.1.2:

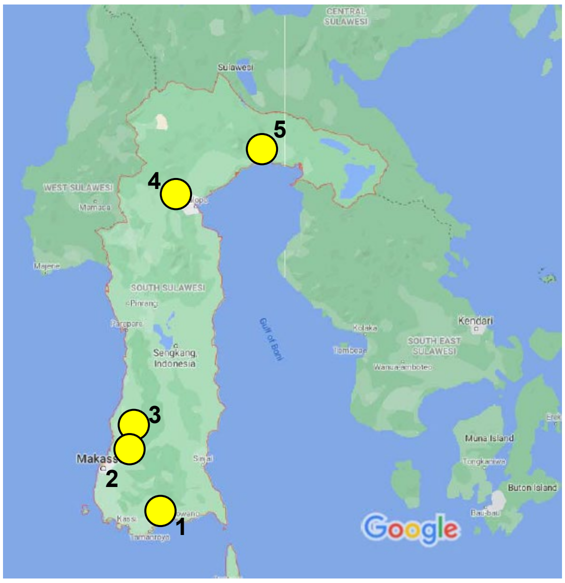


Figure 5.1.2 Location Map of the Target Irrigation Schemes for Rehabilitation

Source: BBWS and JICA Team, base map by Google

Table 5.1.1 List of the Target Irrigation Schemes

No.	Scheme Name	Beneficial Area, ha
1	Kelara-Karalloe	10,000
2	Leko Pancing	3,626
3	Bantimurung	6,513
4	Lamasi	11,506
5	Kalaena	18,184
	Total	**49,829**

Note: Numbers refer to the ones in Figure 5.1.2

5.1.2 Rainfall and River Discharge

This section examines the rainfall and discharge condition by the watersheds associated with the target existing irrigation schemes. Watershed area is delineated based on the location of existing weirs and DEMNAS data provided by Badan Informasi Geospasial (BIG). Watershed areas are shown in Figure 5.1.3 and Figure 5.1.4 respectively for the irrigation schemes located in the southern part and located in the northern part of the province, and summarized in Table 5.1.2.

The target irrigation beneficial areas and those watersheds belong to WS Pompengan Larona for the irrigation schemes of Lamasi and Kalaena) and WS Jeneberang for Kerala-Kallaroe, Leco

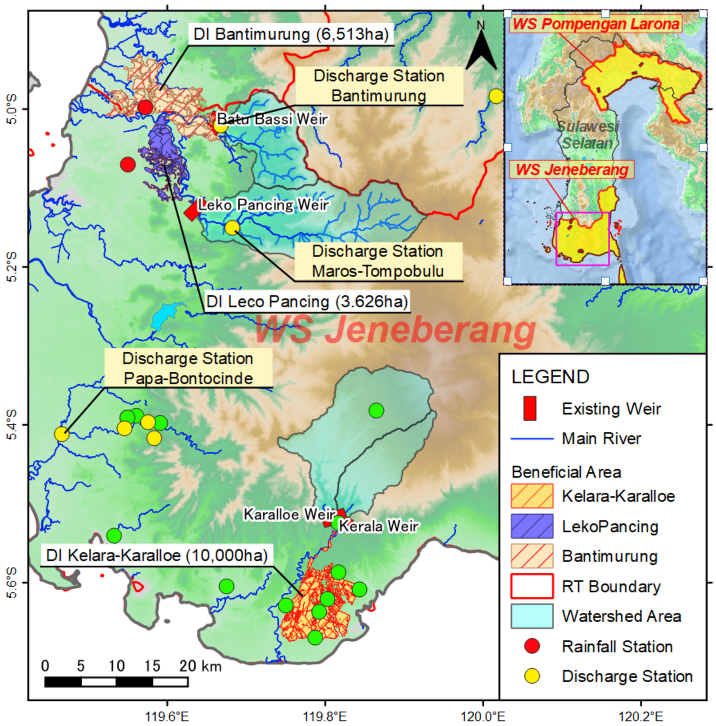


Figure 5.1.3 Location Map of Available Rainfall and Discharge Stations (WS Jeneberang) Source: JICA Project

[1] Strategic Irrigation Modernization and Urgent Rehabilitation Project (Project Implementation Period; August 2018 – June 2024)

[2] Accelerating Infrastructure Delivery through Better Engineering Services Project (ESP), Implementation period ; December 2016 - December 2019 (to be extended)

Pancing and Bantimurung. It should be noted that there are two diversion weirs to provide the water to the irrigation scheme Kerala-Karalloe, and a dam was constructed in 2021 on the watershed of Karalloe. Figures 5.1.3 and 5.1.4 also show the location of rainfall and discharge stations, which can be referred to in estimating the design rainfall and design discharge. It is, however, noted that for the DI Kelara-Karalloe and DI Lamasi, no discharge station is available on the relevant rivers, and therefore the nearest reliable stations (namely Papa-Bontocinde station for DI Kelara Karalloe and Kanjiro-Pompalangit station for DI Lamasi) are selected as a reference discharge station.

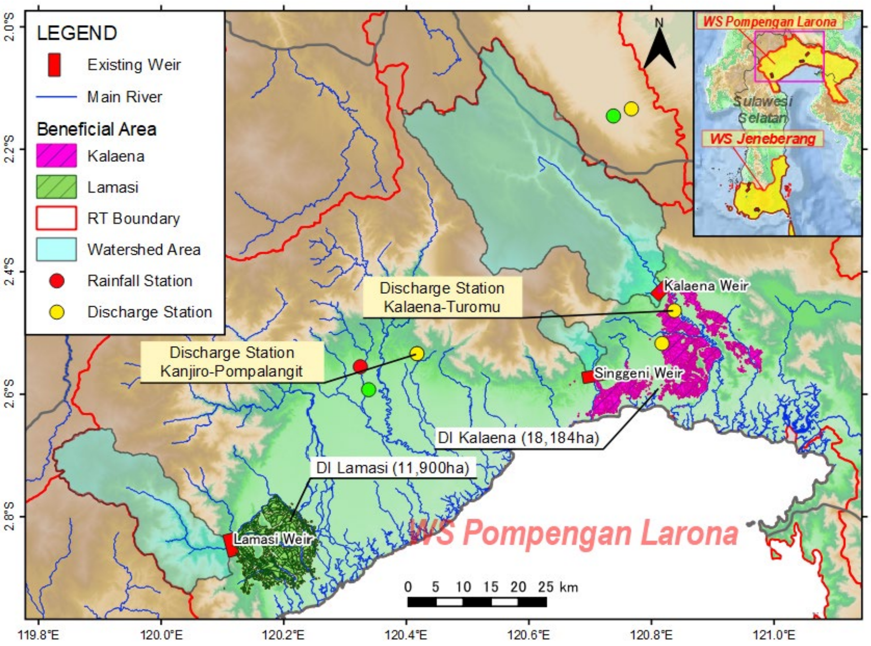


Figure 5.1.4 Location Map of Available Rainfall and Discharge Stations (WS Pompengan Larona) Source: JICA Project Team

Table 5.1.2 Watershed Areas Related to the Target Irrigation Schemes

Scheme Name	Area, km^2	Remarks	Scheme Name	Area, km^2	Remarks
Kelara-Karalloe	281	Total area of WS Kelara & WS Karalloe	Lamasi	399	
Leko Pancing	278		Kalaena	1,062	
Bantimurung	111		Singgeni	62	Supplemental water resource on DI Karaena

Source: JICA Project Team

1) Rainfall Condition

Average monthly rainfall (P_{ave}) and 80% exceeding probability rainfall ($P_{80\%}$) are at first estimated for design purpose. The average annual rainfall amount is very much different by River Territory, with 1,650 mm to 2,050 mm for the watersheds in WS Jeneberang (South side of South Sulawesi), and 2,750 mm to 3,200 mm for the watersheds in WS Pompengan Larona (North side of South Sulawesi). Monthly rainfall distribution is also different between the watersheds in WS Pompengan Larona and WS Jeneberang. The watersheds in WS Jeneberang show clear dry season (from July until October) and wet season (from November until March), whereas unclear trend is seen in the watersheds in WS Pompengan Lalona especially during dry season with a certain amount of rainfall, thus the rainfall distribution type may be categorized as equator type rather than monsoon type.

Table 5.1.3 Monthly Average Rainfall (P_{ave}) by River Territory and Watershed Area of the Target Irrigation Schemes (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
5.14.A2	WS Pompengan Larona	409	371	312	287	242	220	177	150	158	196	286	391	3200
-	Lamasi	216	270	274	293	253	271	189	152	156	209	209	284	2775
-	Kalaena	208	282	297	307	281	270	203	160	165	217	224	263	2878
-	Singgeni	225	312	308	318	329	312	225	191	191	256	236	287	3190
5.17.A3	WS	153	170	186	192	188	181	173	151	140	131	159	163	1987

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	Jeneberang													
-	Kerala	319	224	198	121	66	100	40	29	40	83	132	328	1679
-	Kallaloe	320	226	198	126	67	98	40	29	41	79	136	330	1689
-	Leco Pancing	347	264	219	143	70	99	41	29	43	82	19	342	1829
-	Bantimurung	355	310	232	158	88	115	62	48	62	106	172	356	2065

Note: River Territory means WS (Wilayah Sungai) having a specify Code no. as indicated in above table, within which there are number of watershed areas, e.g. Lamasi, Kalaena, Singgeni under the River Territory of WS Pompengan Larona.
Source: JICA Project Team

Table 5.1.4 Monthly 80% Exceeding Probability Rainfall ($P_{80\%}$) by River Territory and Watershed Area of the Target Irrigation Schemes (unit: mm)

Code	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
5.14.A2	WS Pompengan Larona	241	201	167	135	111	99	66	43	43	75	125	213	1519
-	Lamasi	153	186	195	205	176	191	106	64	70	87	117	190	1741
-	Kalaena	147	195	211	215	197	190	114	68	74	91	126	176	1803
-	Singgeni	159	216	219	223	230	220	126	81	85	107	133	192	1990
5.17.A3	WS Jeneberang	91	85	101	117	86	109	92	64	66	57	90	86	1046
-	Kerala	200	135	137	68	29	32	7	3	6	23	78	208	926
-	Kallaloe	202	136	137	70	29	32	7	3	6	22	80	209	933
	Leco Pancing	243	169	145	95	40	34	9	4	7	28	85	240	1099
-	Bantimurung	246	218	154	104	49	54	15	7	8	40	96	272	1263

Note: River Territory means WS (Wilayah Sungai) having a specify Code no. as indicated in above table, within which there are number of watershed areas, e.g. Kerala, Kallaloe, Leco Pancing, and Bantimurung under the River Territory of WS Jeneberang.
Source: JICA Project Team

2) Discharge Condition

Given the discharge records in and around the target irrigation schemes by the BBWS Pompengan Jeneberang, probability analysis for the 80% exceeding probability discharge (Q80%) is calculated complying with KP-01 (MPWH 2013). As for DI Kalaena, DI Leko Pancing and DI Bantimurung, discharge record on the same river is utilized to calculate the monthly discharge volume, whereas the discharge for DI Lamasi and DI Kelara Karalloe are estimated from the discharge record of the neighbor reliable station.

Monthly discharge amount is shown in Table 5.1.5. Being similar to the trend of rainfall distribution, the discharge distribution pattern is classified into 2 types, monsoon type for DI Kerala-Karalloe, DI Leko Pancing and DI Bantimurung, and equator type for DI Lamasi and DI Kalaena. Figure 5.1.5 illustrates the difference in rainfall pattern and discharge pattern by the type. Compared to the discharge distribution in DI Kelara Karalloe, DI Kalaena (Equator type) has relatively constant discharge even in May to November.

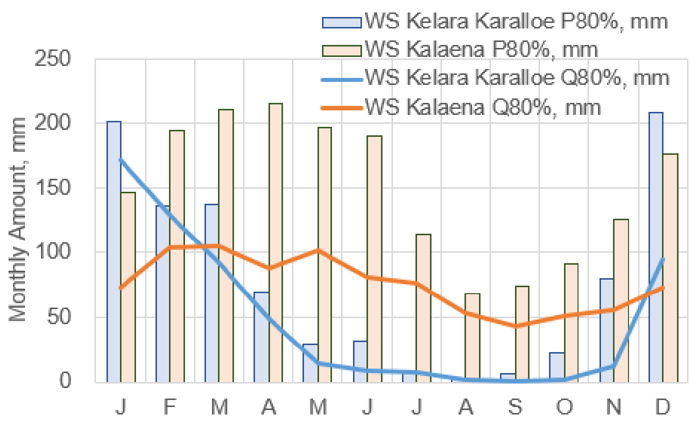


Figure 5.1.5 Rainfall (P80%) and Discharge (Q80%) in the main watersheds (Sulawesi Selatan) Source: JICA Project Team

Table 5.1.5 Monthly 80% Exceeding Probability Discharge ($Q_{80\%}$) by Target Irrigation Scheme (unit: m^3/s)

DI Name	Area, km^2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lamasi	399	24.5	25.3	31.2	25.1	21.7	18.0	162	10.5	8.9	9.0	12.4	24.7
Kalaena	1,062	29.0	45.5	41.5	36.2	40.5	33.3	30.4	21.4	17.7	20.2	23.0	28.9

DI Name	Area, km²	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala-Karalloe	211	18.0	15.0	9.7	5.3	1.5	1.0	0.8	0.2	0.1	0.2	1.3	10.0
Leko Pancing	278	34.2	19.1	19.9	12.0	8.0	4.9	2.5	1.3	0.9	1.5	3.1	17.4
Bantimurung	111	13.6	7.6	7.9	4.8	3.2	2.0	1.0	0.5	0.4	0.6	1.2	6.9

Source: JICA Project Team

5.1.3 Current Agriculture in South Sulawesi Province

Agriculture in South Sulawesi is regarded as the most important industrial sector, with the agricultural sector contributing 22.5% to its GRDP by current market price as of 2018[3]. Food crops are mainly grown in wetland, with maize and cassava also grown as Palawija. Estate crops such as cocoa, coconut, and coffee are also widely grown in South Sulawesi. The following is an overview of agriculture (especially paddy and Palawija cultivation) in South Sulawesi and in the four Kabupaten (Jeneponto, Maros, Luwu, and Luwu) where the target irrigation schemes (DI Kelara Karalloe, DI Lekopancing, DI Bantimurung, DI Lamasi, and DI Kalaena) are located.

1) Agricultural Land Use

Table 5.1.6 shows the agricultural land use in South Sulawesi and in the four Kabupaten where the target irrigation schemes are located. 1.34 million hectares of agricultural land is available in South Sulawesi as of 2015, of which almost half (47%, 630,000 ha) is classified as wetland. Paddy and Palawija are grown in these wetlands, of which 61% (380,000 ha) is classified as irrigated agricultural land. By Kabupaten, Luwu and Luwu Timur have made progress in irrigation development, with 88% and 95% of their land under irrigation, respectively. Janeponto and Maros are also above the provincial average, with 68% and 63% under irrigation, respectively.

Table 5.1.6 Agricultural Land Area in Project Area, South Sulawesi Province (2015), Unit: 1,000 ha

Kabupaten	Wetland			Agricultural dryland				Total
	Irrigation	Non-irrigation	Sub-total	Dry field/ Garden	Unirrigated/ Shifting cultivation	Temporarily unused	Sub-total	
Janeponto	11.5	5.4	16.8	36.0	1.0	0.0	37.1	53.9
Maros	16.4	9.6	25.9	12.8	12.1	1.5	26.4	52.4
Luwu	32.7	4.4	37.0	29.0	3.4	11.8	44.1	81.2
Luwu Timur	21.6	1.3	22.9	31.3	10.5	1.2	43.0	65.9
South Sulawesi Province	**383.5**	**244.6**	**628.1**	**526.7**	**106.7**	**83.0**	**716.4**	**1,344.6**

Source: Land Area by Utilization 2015 (BPS, 2016)

2) Paddy Production

Table 5.1.7 shows the harvested area, yield, and production of wetland paddy in 2015 (Note that for South Sulawesi, the statistical data of harvested area, yield, and production of wetland paddy fields have not been updated after 2015). In terms of yield, the yields in Maros and Luwu Timur are above the average for South Sulawesi (5.32 t/ha), while the yields in Janeponto and Luwu are low.

Table 5.1.7 Harvest area, Yield and Production Volume of Paddy in Project Area, South Sulawesi Province

Kabupaten	Harvested area (1,000 ha)	Yield (ton/ha)	Production (1,000 ton)
	2015	2015	2015
Janeponto	19.4	4.96	96.2
Maros	52.4	5.90	309.2
Luwu	61.9	4.93	305.2
Luwu Timur	37.6	5.56	209.2
South Sulawesi Province	995.3	5.32	5,292.2

Source: Sulawesi Selatan Province in Figures (BPS-Statistics of Sulawesi Selatan Province 2018)

3 BPS-Statistics of Sulawesi Selatan Province, Sulawesi Selatan in Figures, 2019

Figure 5.1.6 shows the crop intensity of wetland paddy in South Sulawesi and the four Kabupaten as of 2015. In South Sulawesi, the average crop intensity is 164%, indicating that multiple cropping in a year is widely practiced; the three Kabupaten except Janeponto are higher than the average of the whole province, with Maros achieving a 200% cultivation rate. Janeponto, on the other hand, has only 115%, suggesting that less water is available than in other schemes, resulting in a lower crop intensity.

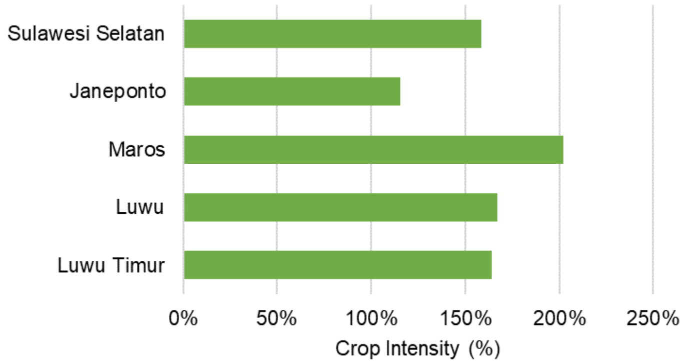


Figure 5.1.6 Crop Intensity of Paddy in Project Area, South Sulawesi Province (2015)

Source: BPS-Statistics of Sulawesi Selatan Province, 2016z

Figure 5.1.7 shows the share of rice varieties grown in South Sulawesi as of 2017. The most used rice variety in the region is Ciherang with a share of 29.1%, followed by Cigeulis (21.6%) and Ciliwung (11.7%). Of these top three varieties, Ciherang and Cigeulis are high-yielding varieties released in the 2000s. Ciliwung, on the other hand, is a variety that has been used since the 1980s and has still maintained a high market share.

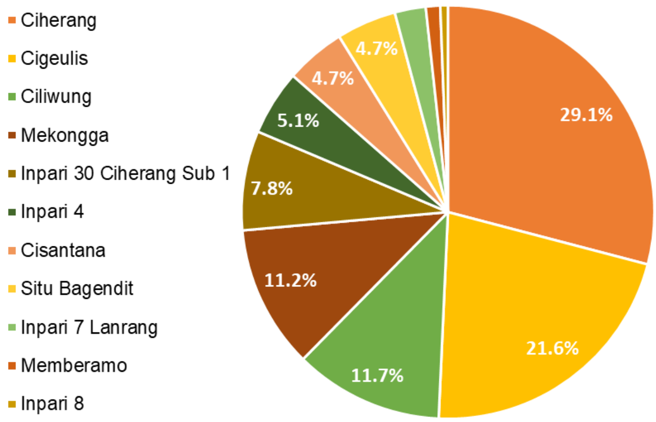


Figure 5.1.7 Share of rice varieties in South Sulawesi Province (2017)

Source: Planted area of new superior paddy varieties year 2017 (Directorate of Seedling, Directorate General of Food Crops, Ministry of Agriculture, 2018)

3) Palawija Production

The type of Palawija, which is a secondary crop of paddy, varies according to the cropping system in the region. Figure 5.1.8 shows the harvested area of the top three Palawija in South Sulawesi. In South Sulawesi, the largest crop area is maize with 295,000 ha, while the second largest crop area is limited, with 38,000 ha for soybean and 27,000 ha for cassava. In the province, the crop intensity of paddy is as high as 164% due to the development of irrigation, indicating that two cropping seasons of paddy is the major cropping pattern in wetland in this province.

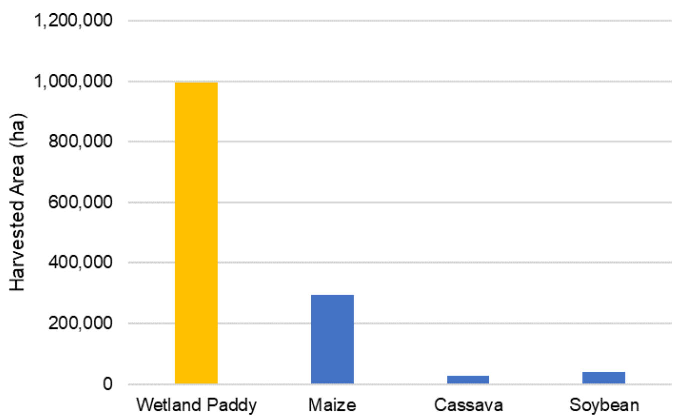


Figure 5.1.8 Harvested Area of Top 3 Palawija in South Sulawesi Province (2015)

Source: BPS-Statistics of Sulawesi Selatan Province, 2016

4) Issues in Agricultural Activities

Agriculture is a major industrial sector in South Sulawesi, accounting for 22.5% of the GRDP. Paddy is the main cultivated crop in the province, which has maintained a high paddy crop intensity due to the progress in irrigation development, and the strategic introduction of high-yielding rice varieties in recent years has resulted in a steady increase in the production.

The agricultural labor force in South Sulawesi has been changing in recent years. Figure 5.1.9 shows the trend of the agricultural labor force in South Sulawesi over the past 10 years. While the province's overall workforce has shown steady growth over the decade, the agricultural workforce has been on a downward trend, from almost half (51%) of the total workforce engaged in the agricultural sector in 2008 to 38% in 2017. As urbanization progresses, people are moving away from agriculture, and securing the agricultural labor force in the agricultural sector will become a challenge. In addition, not only is the labor force decreasing, but the conversion of agricultural land to other uses has also become an issue in recent years, making it necessary to adopt policies to protect existing paddy fields from the perspective of food security. The following is a list of possible issues:

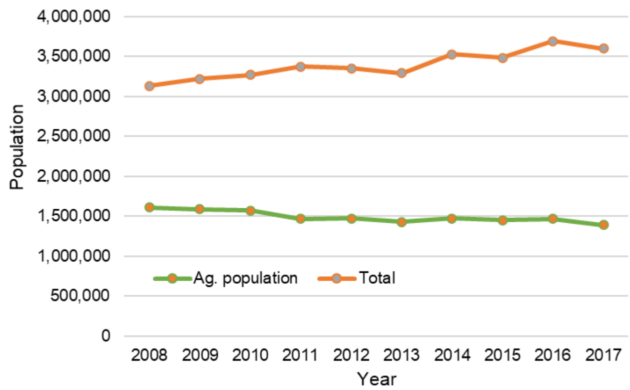


Figure 5.1.9 Agricultural Labor Force in South Sulawesi Province
Source: Statistical Yearbook of Indonesia 2008-2017 (BPS, 2008-2017)

- ✓ Decline in agricultural labor force,
- ✓ Decrease in farmland due to conversion of farmland to other uses,
- ✓ Low profitability of rice cultivation compared to estate and horticultural crops (high labor cost ratio in production cost), and
- ✓ Low post-harvest quality.

5.2 Agriculture Development Plan

This section describes the agricultural development plan for the implementation of the rehabilitation project of existing irrigation facilities in South Sulawesi Province. The agricultural development plan consists of a land use plan, a cropping pattern, and a target yield, and it also proposes the necessary activities to implement and realize this plan.

5.2.1 Proposed Land Use Plan

The existing irrigation schemes in South Sulawesi are located across four Kabupaten (Jeneponto, Maros, Luwu and Luwu Timur). The project will consider preparing a project plan with rehabilitation as a major component for the existing irrigation schemes (Kelara Karalloe, Lekopancing, Bantimurung, Lamasi and Kalaena irrigation schemes). Table 5.2.1 shows the proposed land use plan for the existing irrigation schemes. The rehabilitation of the irrigation facilities will improve irrigation efficiency and increase the cropping area. As a result, the total paddy rice production area in the existing irrigated area and the crop area in Palawija are expected to increase by 2,780 ha and 105 ha, respectively.

Table 5.2.1 Land Use Plan in Project Area, South Sulawesi Province

Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
Jeneponto	DI Kelara Karalloe	Rehab	10,000	1st	Paddy	Current	7,199	72	
						Plan	7,919	80	8
				2nd	Paddy	Current	5,500	56	
						Plan	6,050	61	5
					Palawija	Current	1,045	10	
						Plan	1,150	11	1
Maros	DI Lekopancing	Rehab	3,626	1st	Paddy	Current	2,463	68	
						Plan	2,709	75	7
					Palawija	Current	146	4	

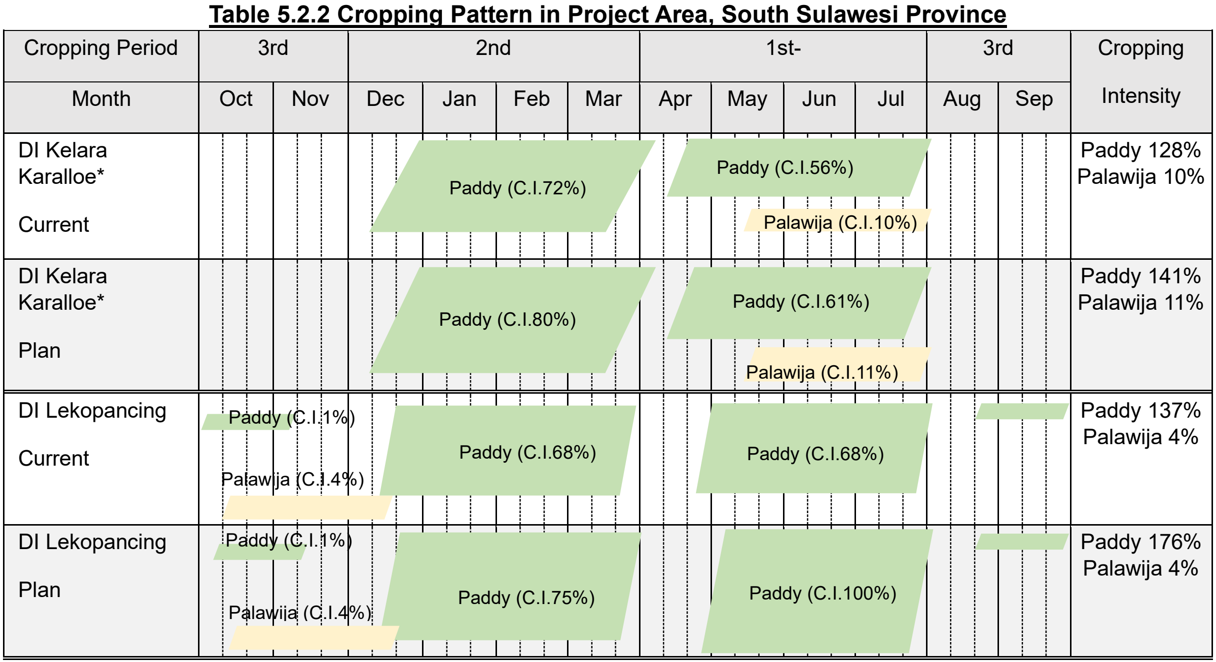
Kabupaten	DI Name	Type	Service Area (ha)	Period	Crop	Current /Plan	Area Planted (ha)	Cropping Intensity (%)	Increment (%)
						Plan	146	4	-
				2nd	Paddy	Current	2,463	68	
						Plan	3,626	100	32
				3rd	Paddy	Current	25	1	
						Plan	28	1	-
Maros	DI Bantimurung	Rehab	6,513	1st	Paddy	Current	6,513	100	
						Plan	6,513	100	-
				2nd	Paddy	Current	6,122	94	
						Plan	6,122	94	-
					Palawija	Current	391	6	
						Plan	391	6	-
				3rd	Paddy	Current	980	15	
						Plan	1,078	17	2
Luwu	DI Lamasi	Rehab	11,506	1st	Paddy	Current	11,506	100	
						Plan	11,506	100	-
				2nd	Paddy	Current	11,506	100	
						Plan	11,506	100	-
Luwu Timur	DI Kalaena Singgeni	Rehab	18,184	1st	Paddy	Current	18,184	100	
						Plan	18,184	100	-
				2nd	Paddy	Current	18,184	100	
						Plan	18,184	100	-

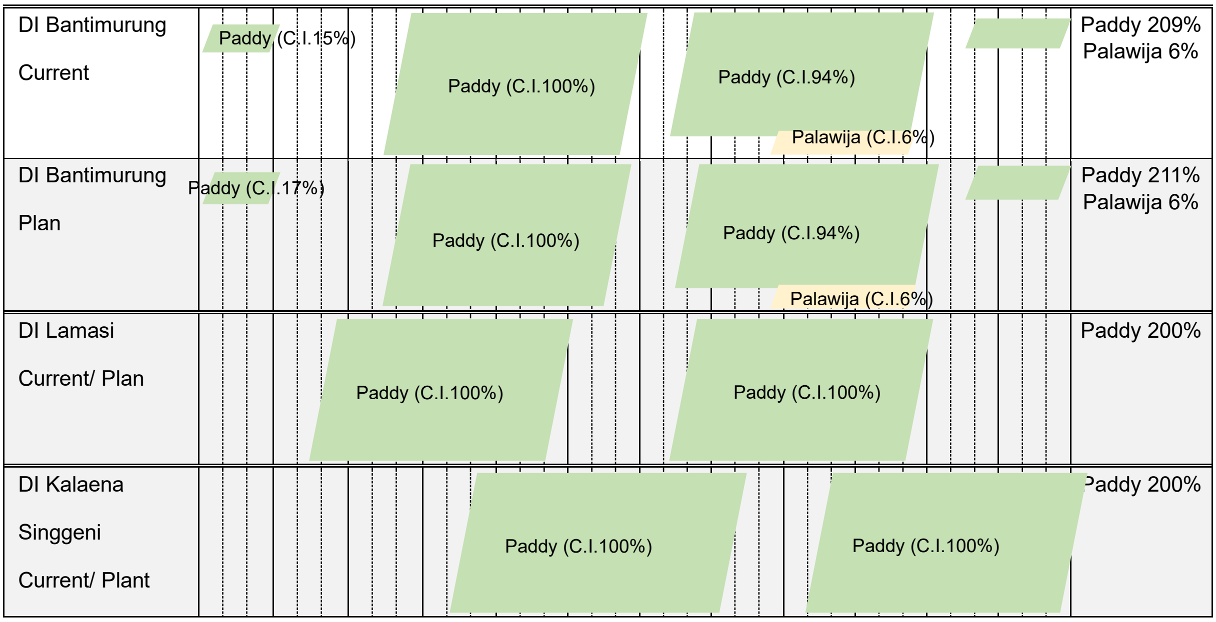
Source: JICA Project Team

5.2.2 Proposed Cropping Pattern

Table 5.2.2 shows the proposed cropping pattern for the existing irrigated areas. The cropping pattern should be determined according to the agricultural production environment (local climate, weather conditions, etc.) and the amount of irrigation water available in the target area. The current cropping pattern in the existing irrigated areas in South Sulawesi province is a two-season paddy-paddy cropping system (December-March and April-July), and in the third season, paddy or Palawija (maize, soybean, sweet potato, beans, and watermelon in the area) is cultivated in a very small area.

Table 5.2.2 Cropping Pattern in Project Area, South Sulawesi Province





* Cropping Pattern in DI Kerala Karalloe in plan does not consider the impact of the dam operation. It is expected to be greatly improved when it is considered, which should be examined in the FS stage

Source: JICA Project Team

5.2.3 Target Paddy Yield in the Future

1) Setting of Base Yield

Table 5.2.3 shows the base yield of paddy in the existing irrigated schemes in South Sulawesi. Although the BPS statistics do not distinguish between irrigated and rainfed paddy, since the majority of paddy cultivation in Kabupaten/Kota, where the existing irrigated schemes are located, is irrigated paddy, the paddy yield is considered to be approximately the same as the irrigated paddy yield. The average yield of paddy in the province is 5.30 tons/ha.

Table 5.2.3 Base Yield in Project Area, South Sulawesi Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)
Jeneponto	DI Kelara Karalloe	Rehabilitation	5.11
Maros	DI Lekopancing		5.73
Maros	DI Bantimurung		5.73
Luwu	DI Lamasi		4.95
Luwu Timur	DI Kalaena		5.44
Sulawesi Selatan Province	-	-	5.30

Source: Sulawesi Selatan Province in Figures (BPS-Statistics of Sulawesi Selatan Province, 2015-2018)

2) Setting of Upper Limit Yield (Target Yield)

The results of the BPS crop cutting survey and other studies have shown that paddy rice yield depends not only on irrigation conditions, but also on the cultivar and amount of fertilizer applied (see Part I, Chapter 3). In other words, in addition to irrigation maintenance, appropriate paddy cultivation management practices (good varieties and appropriate fertilizer management) are necessary to increase paddy yield. In the target irrigation areas, irrigated paddy cultivation has already been long practiced, thus rice farmers have a certain level of cultivation know-how, so it is desirable to introduce advanced cultivation management practices. Therefore, the upper limit of monoculture yield is set using the scenario 2 shown in Table 5.2.4.

Table 5.2.4 Applied Scenario for Upper Limit Yield (Target Yield) in Project Area, South Sulawesi Province

Type		Scenario	Assumption	Setting Criteria
Rehabilitation	⇨	**2. Good agricultural practice**	**Agricultural management practice is improved.** Under policy support such as further R&D, extension support, and subsidy, it is expected that new introduction of high-yielding superior seeds and increase of fertilization input **is promoted.**	1. Using data from the SURVEI UBINAN TANAMAN PANGAN 2014, 2016, 2017 (BPS, 2014, 2016 and 2017), extract farmers who are using fertilizer at 430 kg/ha or more and using superior or hybrid seeds. 2. Using the data of the extracted farmers, the upper limit has been set to the average of top 25% yield (75th percentile of Tukey's Hinges) for each island under irrigation and non-irrigation in 2014, 2016 and 2017.

Source: JICA Project Team

When the scenario shown in Table 5.2.4 is applied, the maximum yield in South Sulawesi is calculated at 5.90 t/ha, which is an increase of 11.3% from the current average of 5.30 t/ha. This increase is applied to all the target irrigation schemes to set the target yield for each of the irrigated schemes (see Table 5.2.5).

Table 5.2.5 Target Yield in Project Area, South Sulawesi Province

Kabupaten	DI Name	Type	Avg. Yield (t/ha)	Target Yield (t/ha)	Increment (%)
Jeneponto	DI Kelara Karalloe	Rehabilitation	5.11	5.69	
Maros	DI Lekopancing		5.73	6.38	
Maros	DI Bantimurung		5.73	6.38	
Luwu	DI Lamasi		4.95	5.51	
Luwu Timur	DI Kalaena		5.44	6.06	
South Sulawesi Province	-	-	5.30	5.90	11.32

Source: Sulawesi Selatan Province in Figures (BPS-Statistics of Sulawesi Selatan Province, 2015-2018)

3) Setting of Yield Increase with Time Course

Similar to the upper limit yield, the increase in paddy yield over time is assumed to vary depending on whether or not appropriate paddy cultivation management practice is introduced. Therefore, the yield increase over time is set using Scenario 2 shown in Table 5.2.6 for the existing irrigated areas.

Table 5.2.6 Applied Scenario for Yield Increase with Time Course in Project Area, South Sulawesi Province

Type		Scenario	Assumption	Setting Criteria
Rehabilitation	⇨	**2. Good agricultural practice**	**The yield growth is rapidly progressed** by strategic policy support such as further R & D, extension services and subsidy, which encourages new introduction of high-yielding superior seeds and increase of fertilizer input.	The recent rapid progress in yield increase is assumed to be continued in future, the yield will be increased to the upper limit by the linear slope of the yields as of 1997 and 2015.

Source: JICA Project Team

Table 5.2.7 to Table 5.2.11 show the trend of paddy yield in the target irrigation schemes after the start of the project. In the estimation, there is no irrigated area that reaches the maximum yield in 10 years after the start of the project. In the estimation of the target yield, it is assumed that the project will be designed and implemented over a period of five years, and no yield increase will be expected in the first two years for design.

Table 5.2.7 Yield Increase with Time Course in Project Area (DI Kelara Karalloe), South Sulawesi Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.11	5.11	5.11	5.15	5.18	5.22	5.25	5.29	5.33	5.37	5.40	5.69
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 5.2.8 Yield Increase with Time Course in Project Area (DI Lekopancing), South Sulawesi Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.73	5.73	5.73	5.77	5.81	5.85	5.89	5.93	5.97	6.02	6.06	6.38
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 5.2.9 Yield Increase with Time Course in Project Area (DI Bantimurung), South Sulawesi Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.73	5.73	5.73	5.77	5.81	5.85	5.89	5.93	5.97	6.02	6.06	6.38
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 5.2.10 Yield Increase with Time Course in Project Area (DI Lamasi), South Sulawesi Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
4.95	4.95	4.95	4.98	5.02	5.05	5.09	5.13	5.16	5.20	5.23	5.51
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

Table 5.2.11 Yield Increase with Time Course in Project Area (DI Kalaena), South Sulawesi Province

Base Yield (t/ha)	Years after project has been started										Max Yield (t/ha)
	1	2	3	4	5	6	7	8	9	10	
5.44	5.44	5.44	5.48	5.52	5.56	5.59	5.63	5.67	5.71	5.75	6.06
Stage	Design＋Project Implementation					Operation & Maintenance					-

Source: JICA Project Team

4) Setting of Target Yield Other than Paddy

The type of Palawija, which is a secondary crop of paddy, varies depending on the cropping system in the area. As shown in Figure 5.1.8, maize is the major secondary crop in South Sulawesi. Maize is expected to be the secondary crop in the target area, and the yield is set at the current level (i.e., the increase in cropped area is expected due to irrigation improvement, but the increase in yield is not expected).

Table 5.2.12 Base Yield (Maize) in Project Area, South Sulawesi Province

Kabupaten	DI Name	Type	Type of Palawija	Base Yield (t/ha)
Jeneponto	DI Kelara Karalloe	Rehabilitation	Maize	5.49
Maros	DI Lekopancing	Rehabilitation	Maize	4.67
Maros	DI Bantimurung	Rehabilitation	Maize	4.67

Source: Sulawesi Selatan Province in Figures (BPS-Statistics of Sulawesi Selatan Province, 2015 and 2016)

Regarding the selection of Palawija, it is desirable to introduce crops with high farm profitability considering the agricultural production environment such as water availability and soil conditions. In fact, one of the reasons why soybean production area is sluggish despite that the soybean is designated as one of the strategic crops at present is the low farm profitability (2021, Krisdiana, R et.al.[4]). It may be easy for the beneficiary farmers to accept such crops that are highly marketable as horticultural crops including shallot and chili and also sweet potatoes which has been in high demand as a processed product for export in recent years (2021, SK Dermoredjo et. al.[5]).

5.2.4 Recommended Activities for Agriculture Development

In order to achieve and realize the aforementioned agricultural development plan (land use plan, cropping pattern, and target yield), it is necessary to take measures to address the current issues in the target area. The following is a suggested approach for agricultural development that may serve as countermeasures.

Table 5.2.13 shows the challenges of agricultural development in the existing irrigation schemes of South Sulawesi Province and possible countermeasures. In this scheme, the outflow and decrease of agricultural labor force has become apparent with the urbanization, and one of the issues that need special attention is the shortage of agricultural labor force. One possible solution to this problem is to provide administrative support for new farmers by introducing subsidies and loan programs.

In addition, training and registration of agricultural service providers to encourage the outsourcing of labor-intensive tasks such as tillage, harvesting, and processing will help to address the decline in the labor force. Besides, in order to curb the decrease in farmland due to the conversion of farmland, which is also caused by urbanization, the promotion of agro-politan spatial planning, strategic community-wide promotion of rice cultivation, and the promotion of regulations on the conversion of farmland through the appropriate implementation of sustainable food farmland (LP2B) will be the measures to halt the decrease in farmland.

In cultivation management practices, it may be effective to increase profitability through the introduction of agricultural machinery (tractors, harvesters, etc.) to reduce labor costs and the introduction of ICT tools to increase labor productivity. Further, improvements in collection and shipping systems and rice milling facilities are expected to enhance market competitiveness by adding value.

By implementing these high-priority measures in parallel with the irrigation development (rehabilitation project), this project will make it possible to realize the land use plan, cropping pattern, and target yield, which in turn is expected to contribute to the promotion of agriculture in the region.

Table 5.2.13 Issues and Countermeasures for Agriculture Development in Project Area, South Sulawesi Province

Possible Issues	Countermeasures (Basic Approach)	Expected Effects
✓ Decline in agricultural labor force	✓ Introduce subsidy programs to ensure that new farmers, including women and youth, and/or farmer groups have the agricultural inputs they need (e.g., high-quality seeds, fertilizer).	✓ Increase in new entrants by supporting initial investment (capital input)
	✓ Training and registration of agricultural service providers (wage farming businesses)	✓ Outsource the work
✓ Decrease in farmland due to conversion of farmland to other uses	✓ Promote agro-politan spatial planning	✓ Granting incentives
	✓ Protection of agricultural land through proper implementation of sustainable food farmland (LP2B).	✓ Restricting diversion and providing incentives

4 Krisdiana, R. et al., Financial Feasibility and Competitiveness Levels of Soybean Varieties in Rice-Based Cropping System of Indonesia. Sustainability 2021, 13, 8334.
5 SK Dermoredjo et. al., Sweet potato agribusiness development strategy to improve farmers' income. 2021 IOP Conf. Ser.: Earth Environ. Sci. 653 012003

Possible Issues	Countermeasures (Basic Approach)	Expected Effects
✓ Paddy cultivation is less profitable than estate and horticultural crops (due to the high labor ratio in production costs)	✓ Promotion of mechanized agriculture (labor-saving)	✓ Reduction of labor costs
	✓ Introduction of modern agricultural production management technologies through the use of ICT tools	✓ Increase in labor productivity
✓ Low post-harvest quality	✓ Strengthen collection and shipping systems	✓ Strengthen market competitiveness by adding value
	✓ Improvement of rice milling facilities	

Source: JICA Project Team

5.3 Irrigation Development and Management Plan

5.3.1 Irrigation Area Delineation

Irrigation schemes in South Sulawesi province, under BBWS Pompengan Jeneberang, are for the rehabilitation only, and do not contain any expansion or new development due to no land availability for irrigation purpose. It is however noted that irrigated cropping area may be enlarged within the irrigation scheme area if water can be newly generated by the rehabilitation works. Irrigation area is therefore delineated by the spatial data provided by DILL. Their location and area are shown in Figure 5.1.3 and Figure 5.1.4 afore-mentioned. In addition, mean elevation and slope are calculated based on DEMNAS, and summarized in Table 5.3.1 as a reference.

Table 5.3.1 Mean Elevation and Slope of the target Irrigation schemes in Sulawesi Selatan

DI Name	Mean Elevation (EL.m)	Mean Slope (%)	DI Name	Mean Elevation (EL.m)	Mean Slope (%)
Lamasi	17.8	2.0	Kalaena	14.9	0.7
Kerala-Karalloe	64.1	1.8	Leko Pancing	8.7	0.4
			Bantimurung	4.2	0.4

Source: JICA Project Team

5.3.2 Available Water for Irrigation and Irrigable Area

Water availability newly generated is defined as the water amount to be saved after an improvement of irrigation efficiency has been made. In this examination, the overall irrigation efficiency of the irrigation schemes is assumed to be 50% and increases to 55% upon improvement with rehabilitation, which corresponds to the standard of the irrigation efficiency described in KP-01 (MPWH 2013).

As for the other inputs for calculation, it is mainly the same as the ones described in Part I, except for seasonal planted area and functional area of each irrigation scheme, which were all provided from the BBWS Pompengan Jeneberang. The source of input for calculation is summarized in Table 5.3.2.

Table 5.3.2 Calculation Condition for Water Availability in Sulawesi Selatan

Input	Description
Irrigation Efficiency	Assuming it improves from 50% to 55% on the irrigation schemes for rehabilitation (improvement in irrigation efficiency is assumed to realize on water conveyance phase.
Functional Area	Applying the values defined in Ministry Regulation PUPR No 14 / PRT / M / 2015
Planted Area	Applying actual planted area in 2019/2020 based on the Form 2B-RTI provided by BBWS
Cropping Pattern	Applying actual cropping pattern in 2019/2020 based on the Form 2B-RTI provided by BBWS in addition to the interview result from BBWS Staff for details
Others (eg. Evapotranspiration, Crop Consumptive Use, etc)	Applying the same as the one described in Part 1

Source: JICA Project Team

The calculation results are shown in Table 5.3.3 (details calculation sheet for monthly planted area and water demand is shown in Appendix). The impact by rehabilitation tends to be larger during dry season (June to August) when much amount of water is necessary for irrigation. In total, annual saving water amount of the target irrigation schemes (total service area: 49,829 ha) reaches to an amount of 74.48 MCM. As for Kerala-Karalloe irrigation scheme, where a new dam is now completed, the positive impact of rehabilitation will become larger after stable water distribution has been realized by the new dam.

Table 5.3.3 Monthly Saving Water Amount of the Target Irrigation Schemes in Sulawesi Selatan

DI Name	Service Area (ha)	Monthly Saving Water Amount after Improvement (MCM)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Lamasi	11,506	1.93	1.22	0.44	1.83	1.35	0.79	2.49	1.15	-	-	2.58	1.63	15.41
Kalaena	18,184	3.52	1.98	1.88	1.89	0.64	2.98	3.78	5.42	5.92	1.81	-	-	29.82
Kerala-Karalloe	10,000	1.01	1.25	1.59	2.03	1.72	1.58	1.93	0.71	-	-	-	1.23	13.05
Leko Pancing	3,626	-	0.25	0.40	0.82	0.61	0.72	0.82	0.01	0.01	0.02	0.02	0.46	4.12
Bantimurung	6,513	0.45	0.49	1.10	1.82	1.74	1.58	2.05	1.04	0.38	0.36	0.25	0.81	12.07
Total	49,829	6.91	5.19	5.42	8.39	6.06	7.65	11.06	8.33	6.30	2.19	2.85	4.13	74.48

Source: JICA Project Team

Actual planted area and cropping pattern based on the BBWS report in South Sulawesi are summarized in Table 5.3.4, and the irrigable area after rehabilitation is shown in Table 5.3.5. In the irrigation scheme of Leko Pancing, 1,055 ha of 3,626 ha is currently not functioning due to bad condition of connecting canals. In this examination, those connecting canals are assumed to be fixed and all the irrigation areas be available for paddy production during wet season (season 2) based on the monthly water balance calculation.

The increase in planted area between before and after improvement is summarized in Table 5.3.6. Annual total planted area is expected to increase by 2,885 ha (Season 1: 966 ha, Season 2: 1,818 ha and Season 3: 101 ha) which is 6% increase in cropping intensity in total.

Table 5.3.4 Planted Area by Irrigation Scheme; Before Improvement (South Sulawesi)

DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija), ha			Planted Area (Total), ha			CI, %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Lamasi	11,506	11M (9E*)	4M		11,506	11,506					11,506	11,506		200
Kalaena	18,184	1M	6M		18,184	18,184					18,184	18,184		200
Kelara-Karalloe	10,000	12M	4M (5M*)		7,199	5,500			1,045		7,199	6,545		137
Leko Pancing	3,626	12E (10E*)	4E (5E*)	8E	2,463	2,463	25	146			2,609	2,463	25	141
Bantimurung	6,513	12M	4M	8M	6,513	6,122	980		391		6,513	6,513	980	215
Total	49,829	-	-	-	45,865	43,775	1,005	146	1,436	0	46,011	45,211	1,005	185

Note: S as season (E as Early, M as Middle and L as Late of the Month)
Cropping pattern in (*) is for Palawija
Source: BBWS Jeneberang and BBWS Pompengan Larona

Table 5.3.5 Planted Area by Irrigation Scheme; After Improvement (South Sulawesi)

DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija), ha			Planted Area (Total), ha			CI, %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Lamasi	11,506	11M (9E*)	4M		11,506	11,506					11,506	11,506		200
Kalaena	18,184	1M	6M		18,184	18,184					18,184	18,184		200
Kelara-Karalloe	10,000	12M	4M (5M*)		7,919	6,050			1,150		7,919	7,200		151
Leko Pancing	3,626	12E (10E*)	4E (5E*)	8E	2,709	3,626	28	146			2,855	3,626	28	180
Bantimurung	6,513	12M	4M	8M	6,513	6,122	1,078		391		6,513	6,513	1,078	217
Total	49,829	-	-	-	46,831	45,488	1,106	146	1,541		46,977	47,029	1,106	191

Note: S as season (S1 starting from early October, S2 from early February, and S3 from early June)
Cropping pattern in (*) is for Palawija
Source: JICA Project Team

Table 5.3.6 Planted Area by Irrigation Scheme; Increase in Planted Area (South Sulawesi)

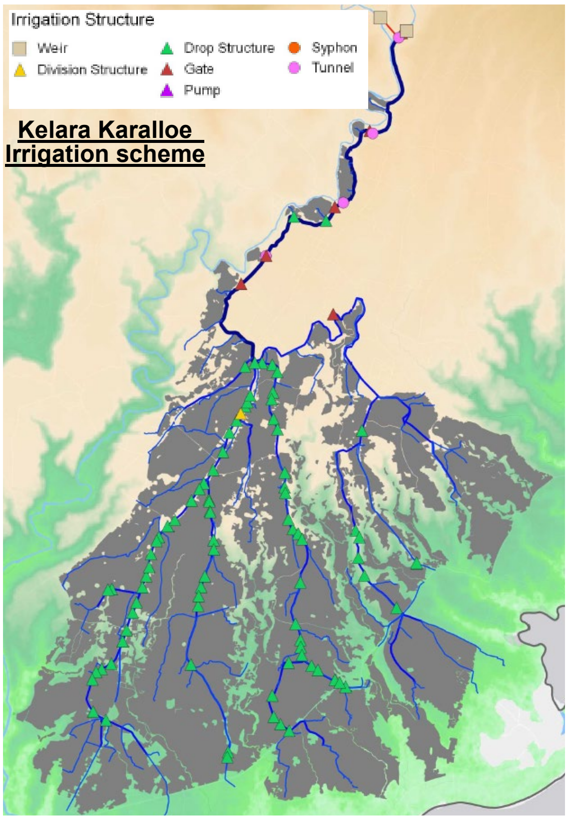
DI Name	Service Area (ha)	Cropping Pattern			Planted Area (Paddy), ha			Planted Area (Palawija), ha			Planted Area (Total), ha			CI, %
		S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	
Lamasi	11,506	11M (9E*)	4M		0	0		0	0		0	0		0
Kalaena	18,184	1M	6M		0	0		0	0		0	0		0
Kelara-Karalloe	10,000	12M	4M (5M*)		720	550		105	0		720	655		14
Leko Pancing	3,626	12E (10E*)	4E (5E*)	8E	246	1,163	3	0	0		246	1,163	3	39
Bantimurung	6,513	12M	4M	8M	0	0	98	0	0		0	0	98	2
Total	49,829	-	-	-	966	1,713	101	105	0		966	1,818	101	6

Note: S as season (S1 starting from early October, S2 from early February, and S3 from early June)
Cropping pattern in (*) is for Palawija
Source: JICA Project Team

5.3.3 Preliminary Irrigation Rehabilitation Planning

1) Structures and Facilities in the Target Irrigation schemes

The 5 Irrigation schemes to be targeted for the preliminary rehabilitation planning have many irrigation structures and facilities composed of diversion weir and/or structure, primary canal, secondary canal, tertiary canal as such, and also water level control weir (or regulator gate), drop structure, syphon, spillway, and further water gages for the purpose of proper operation, etc. Examples of main structures in Kelara Karalloe and Lamasi are shown in the following figures, and also Table 5.3.7 summarizes those major structures and facilities by scheme:



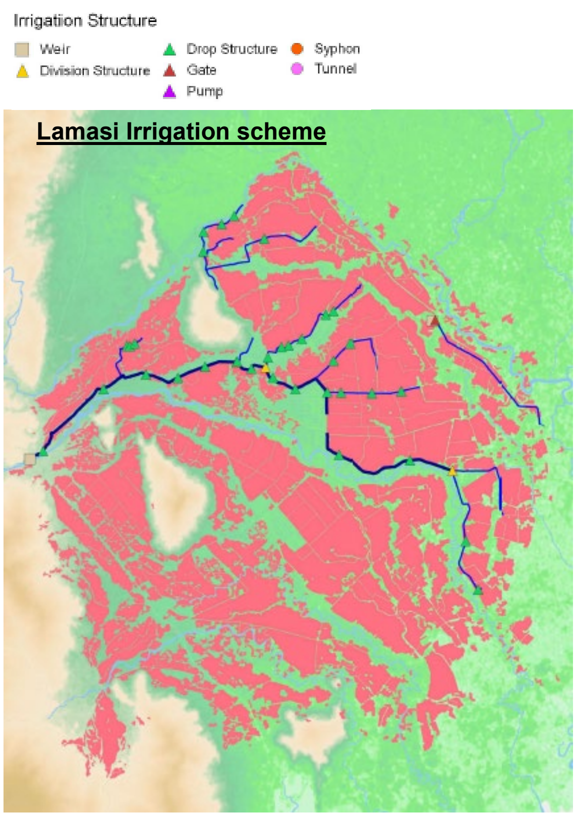


Figure 5.3.1 Main structures in Kelara Karalloe and Lamasi Irrigation schemes

Source: PUPR ePAKSI database*

*ePAKSI is a geo-spatial database for irrigation service areas and those facilities operated by PUPR (URL: http://103.211.51.198/). With the registration by PUPR to access the URL site, Point (Facilities), Line (Canal), and Polygon (Service Area) data are available by each irrigation scheme in the country. Some of the data are now under preparation, so it should be noted that the data was obtained on 28th January 2022.

Box. Karalloe Dam

Karalloe Dam

It should be noted that the Karalloe dam was newly constructed in 2021 at just upstream of the Karalloe weir. It is a concrete-face rockfill dam with 85m height and 396m in top length. The effective storage is 29.5 million m^3, serving 7,000 ha of irrigated farmland. BBWS Pompengan Jeneberang considers DI Kelara-Karalloe is one of the most prioritized irrigation schemes for development or/and rehabilitation due to its severe water availability. The water condition is expected to be greatly improved once a conduit tunnel to the existing primary canal is constructed. Therefore, the BBWS is currently requesting budget for the tunnel construction.

Table 5.3.7 Major Irrigation Facilities in Each of the 5 Target Schemes

Item	Unit	Kelara-Karalloe	Leko Pancing	Bantimurung	Lamasi	Kalaena
Dam	Nos	1	0	0	0	0
Weir	Nos	2	0	1	2	1
Division Structure	Nos	1	0	0	3	0
Drop Structure	Nos	84	22	0	33	4
Gate	Nos	6	0	0	1	0
Intake	Nos	148	33	5	60	80
Pump	Nos	0	0	0	0	0
Aqueduct	Nos	11	0	0	7	3
Culvert	Nos	73	43	0	21	23
Slope Channel	Nos	14	0	1	1	0
Spillway	Nos	211	0	0	9	0
Syphon	Nos	0	0	0	0	2
Tunnel	Nos	5	0	0	0	0
Water Gauge	Nos	2	0	1	7	4
Primary Canal	km	10.5	5.5	3.0	15.7	19.3
Secondary Canal	km	49.8	29.8	2.5	32.0	27.8
Tertiary & Quarter Canal	km	121.1	1.6	0.0	0.6	2.4
Supply Canal	km	0.6	0.0	0.0	0.0	0.0
Drainage Canal	km	0.0	0.0	0.0	0.0	0.0

Note: The above table does not reflect all the categories of structures.
Source: PUPR ePAKSI database (as of 27.1.2022)

2) Target Structures and Facilities to be Rehabilitated

In the 5 target irrigation schemes, surveys were conducted on the structural and functional soundness of the existing irrigation structures and facilities with the help of BBWS offices, identifying the necessity of rehabilitation. The following table shows the number of surveyed facilities: primary canals, secondary canals, irrigation facilities including weirs, diversion works, and inspection roads, and also mechanical structures including gates and operation equipment.

Table 5.3.8 Facilities Surveyed in Each of the Target Schemes

Items		ID	Kalara-Karalloe	Leko-pancing	Banti-murung	Lamasi		Karaena		
						Kanan	Kiri	UPT Kalaena	UPT Kalaena Kanan	Kalaena Kiri
Canal & Road	Primary Canal	Nos	1	1	2	2	2	1	2	1
		Length (m)	10,815	5,756	13,825	14,074	22,147	16,137	19,679	19,257
	Secondary Canal	Nos	13	6	11	9	9	6	12	9
		Length (m)	64,438	29,852	40,777	52,715	29,402	27,662	39,632	27,658
	Inspection Road	Length (m)	64,500	23,791	45,418	56,756	45,581	42,871	51,289	44,768

Items		ID	Kalara-Karalloe	Leko-pancing	Banti-murung	Lamasi		Karaena		
						Kanan	Kiri	UPT Kalaena	UPT Kalaena Kanan	Kalaena Kiri
Civil Structure & Mechanical	Weir	Nos	1	1	1	2	2	1	1	1
	Off-take Structure	Nos	79	32	48	58	60	44	57	35
	Drop Structure	Nos	8	-	-	36	21	21	53	5
	Bridge	Nos	32	-	98	32	27	39	31	14
	Others (Culvert, Syphon, etc.)	Nos	123	6	23	8	38	51	35	31
	Mechanical Structure	Nos	84	33	46	57	62	56	29	36

Source: BBWS Jeneberang and BBWS Pompengan Larona, and JICA Project Team

3) Evaluation Indicator for Facility Soundness

For the survey of existing irrigation facilities, the JICA team has introduced an evaluation indicator to identify the soundness of the structures and facilities in order to determine the necessity of rehabilitation and the level of measures toward extending the service period of those ones. The evaluation indicator presents 5 levels of ranking, as shown in the table below, based on Japanese guidelines and corresponding to the 5 ranks used in the major irrigation facility survey conducted in Lecopancing (DAFTAR INVENTARISASI ASET IRRIGASI, 2014). The replacement rates of canal length linked to ranks are set by the JICA team to estimate the degree of rehabilitation.

Table 5.3.9 Evaluation Indicators for Structure and Facility Conditions

Soundness (Rank)	Facility Condition		Estimated Measures (Proposed Works)
	Canal & Civil Facilities (Turnout, Syphon, Culvert, Drop, Bridge, etc.)	Machinery Equipment (Gates, Motors, O/M equipment, etc.)	
S-5 (PR)	Almost no deformation Status	No abnormality is found	No measures required
S-4 (PB)	A state in which minor deformation is observed	Minor deformation is observed, but the machine No hindrance to	Observation required (Continuous monitoring)
S-3 (PS)	Deformation is noticeable	If left unattended, the function will be hindered. A state that requires countermeasures when it comes out.	Repair・reinforcement (Countermeasures against deterioration)
S-2 (RB)	Conditions with deformations that affect the structural stability of the facility	A state in which the function is impaired. A state that requires urgent measures due to significant performance degradation	Required Reinforcement・repair (Urgent deterioration measures)
S-1 (PA)	A condition in which there are multiple alterations that significantly affect the structural stability of the facility. There is a high risk that facility functions will be lost or significantly reduced in the near future. Reinforcement is difficult to deal with economically and the facility needs to be renewed	The reliability of equipment, etc. have declined significantly, making it difficult to provide financial support for repairs. There is a high risk that equipment will lose its function in the near future. A state in which the performance of the original function and the social function is significantly reduced overall.	Update (Renew)

Note: Soundness Ranking Explanation in Indonesian (The replacement rates of canal length are set by project team)

PA : = Asset Renewal (Pembaruan Aset): 100% replace for canal rehabilitation
RB : = Heavy Rehabilitation (Rehab Berat): Approximately 70% replace
PS : = Medium Repair (Perbaikan Sedang): Approximately 30% replace
PB : = Periodic Maintenance (Pemeliharaan Berkala): Approximately 10% replace
PR : = Routine Maintenance (Pemeliharaan Rutin): No replace

Source: BBWS Jeneberang and BBWS Pompengan Larona, and JICA Project Team

4) Result of the Evaluation

The results of the evaluation for facility soundness in each scheme are summarized in the table below (for detail, refer to the Appendix). For reference, IKSI scores for 2017 are also shown. It should be noted that these scores are for assessing the current status, and not for the purpose of ranking the implementation.

Table 5.3.10 Evaluation Results of the Facility Soundness in Each Scheme

No.	Scheme Name	DI Name	Beneficial Area (ha)		Soundness Ranking			Inspection Road Length to be Asphalt Pavement (m)	IKSI score (2017)	
					Canal	Civil & Mech	Over All		Facility	Total
1	Kelara-Karalloe	Kelara Karalloe	10,000		2.90	3.79	3.20	54,371	28.75	3.51
2	Lekopancing	Lekopancing	3,626		2.80	3.04	2.88	25,524	29.68	3.58
3	Bantimurung	Bantimurung	6,513		3.10	3.97	3.39	19,748	29.21	3.47
4	Lamasi	Lamasi Kanan	(6,617)	11,506	2.61	3.29	2.87	66,789	29.35	3.27
		Lamasi Kiri	(4,665)		2.60	3.57		41,395		
5	Kalaena	UPT Kalaena	(7,413)	18,184	2.70	3.30	2.91	21,283	29.35	3.45
		UPT Kalaena Kanan	(6,222)		2.70	2.95		52,931		
		Kalaena Kiri	(4,618)		2.60	4.09		46,915		
Total			**49,829**		**-**	**-**	**3.02**	**328,956**		

Note : Beneficial Areas shown in ( ) are potential areas provided by the relevant BBWS offices.
"Total" of IKSI score includes evaluations of social issues.
Source: BBWS Jeneberang and BBWS Pompengan Larona, and JICA Project Team

The soundness ranking of "Canal" has been calculated as the average considering the evaluation and the length for each canal. The soundness ranking of "Civil & Mech" is the simple average calculated on basis of each facility's evaluation result. Furthermore, "Over All" soundness ranking has been calculated by giving a weight of 2/3 on the "Canal" and 1/3 on the "Civil & Mech", taking into account the ratio of construction cost in general. In the cases where an irrigation scheme is sub-divided into areas, "Over All" ranking was calculated by the ranking of each area with the weight of the beneficial area (ha), and the "Total", i.e., the overall ranking for the 5 irrigation schemes, is now calculated in the same way, taking into account each size of the beneficial areas (ha).

According to the average rank of facility soundness for each irrigation scheme, it is assessed that the deterioration of irrigation facilities is moderately progressing over the entire schemes, with Lamasi area being the most deteriorated (2.87 for the overall ranking) while Bantimurung being the least (3.39 for the overall ranking). In addition, the evaluation of "Over All" came to 3.02 for those 5 irrigation schemes corresponding to 3.62 in Central Java (refer to 3.3.3), thus it can be clearly said that the facilities in this province are relatively deteriorated and basic rehabilitation is more necessary rather than modernization.

5) Rehabilitation Length of Inspection Roads

As with the irrigation facilities, the canal inspection roads were also assessed for their soundness. In the irrigation facility rehabilitation plan, it is considered necessary to rehabilitate and/or upgrade the inspection roads as well as the irrigation facilities, and the above table also shows the road length, which is calculated for the need of rehabilitation and/or upgrading based on the evaluation results (see the most right column of the table).

The length of the pavement of the inspection road is basically considered the same as the canal length. Based on the soundness of the road, if the existing road is paved with concrete or asphalt and is ranked "S-5", rehabilitation is not required. In the case of other rankings, it is assumed that 10-100% of the road length should be rehabilitated or upgraded depending on the soundness ranking.

6) Canal Rehabilitation Plans

In terms of investment scale for the rehabilitation, canals will require the biggest part of it than the structures and facilities in most cases according to the past rehabilitation works implemented by DGWR.

Therefore, this section discusses the planning for the rehabilitation of existing canals, and the following shall be considered first in the planning:

a) Follow the existing canal size, cross-sectional shape, and lining (structure and material),

b) Estimate the causes of deterioration, malfunctions, and accidents in the facility, and plan the corresponding rehabilitation,

c) Rehabilitation will be within the existing site,

d) The canal inclines should be designed to ensure appropriate flow velocities and bottom width-depth ratios for lining and sediment in the rehabilitated canals, and structures such as water level regulators shall be installed as necessary,

e) At the primary (main) canals and secondary canals, the lining should be applied to the sides and also the bottom of the canals,

f) The type of the canal lining should be selected taking into account the present type and the recommendations in the design standard Kp-03 Channel-eng, 4.2. For the primary canals, though the standard recommends stone pair (wet masonry) lining, the concrete lining is preferable when the flow volume is large and the water depth is deep as the collapse is often found in many places. On the other hand, in the secondary canals, if stones can be easily procured around the site, it seems appropriate to rehabilitate the canal by stone pair (plastering wet masonry), which is commonly found at present. In addition, construction works should be implemented during the period when there is no/lean water in the canals to avoid interrupting the farming. The preparation of precast concrete panels in advance is one way to shorten the construction period, and

g) Along with primary canals and secondary canals, the inspection road should be rehabilitated and/or upgraded. The width of those roads should be designed according to the design standard Kp-03 Channel-eng, 3.3.5, although depending on the flow discharge, it will be basically 5.0m for the primary canals and 3.0m for the secondary canals. In addition, the pavement shall be made of asphalt and the width should be 3.0m.

The proposed typical cross-sections of canal rehabilitation, concrete lining, and wet masonry lining are shown below:

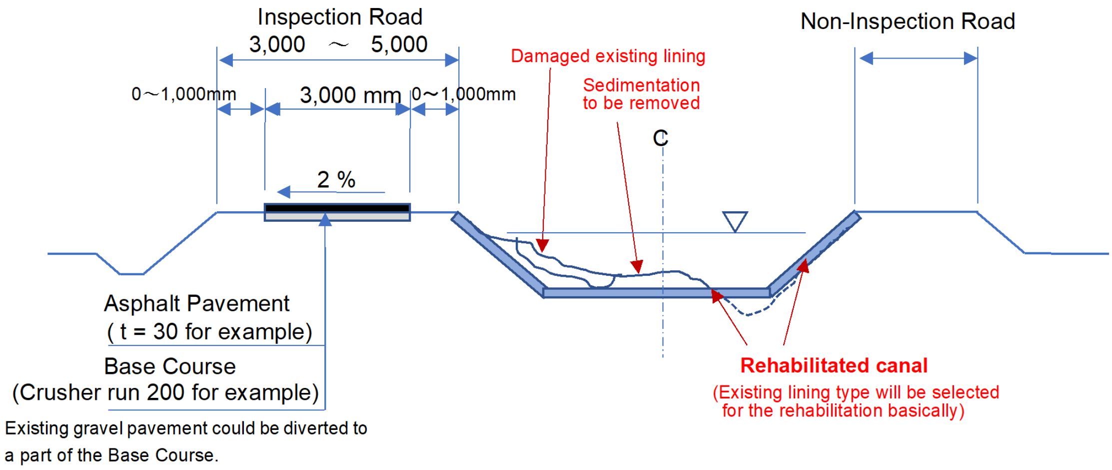


Figure 5.3.2 Conceptual Design of Canal Rehabilitation and Upgrading

Source: JICA Project Team

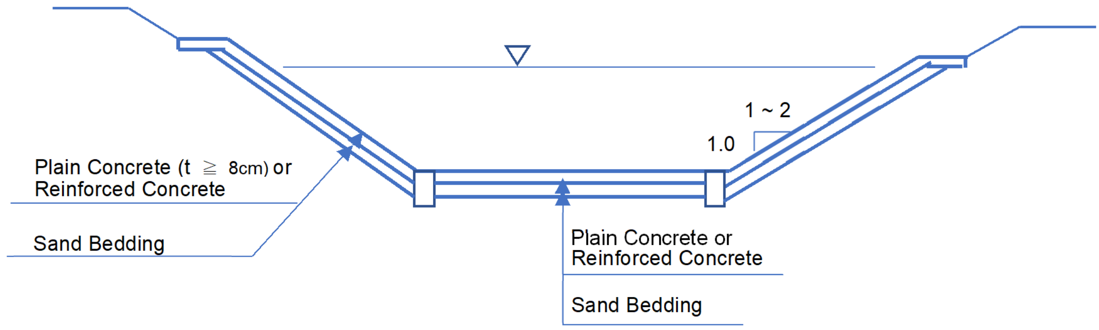


Figure 5.3.3 Typical Cross-Section of Concrete Lining Canal
Source: JICA Project Team

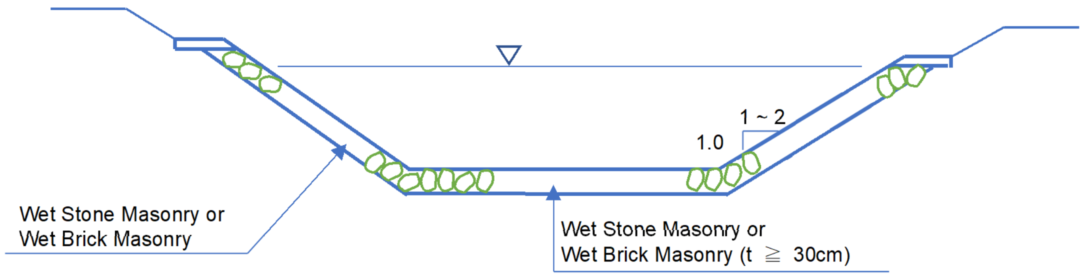


Figure 5.3.4 Typical Cross-Section of Wet Masonry Lining Canal
Source: JICA Project Team

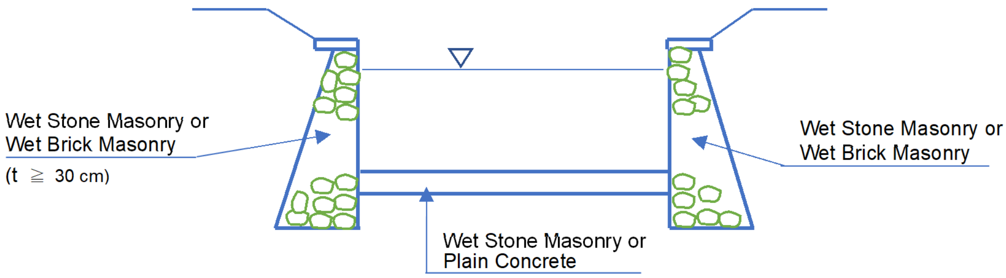


Figure 5.3.5 Typical Cross-Section of Wet Masonry Lining Canal Retaining Wall Type
Source: JICA Project Team

As mentioned above, the present surface of the canal is earth or wet masonry which coefficient of roughness is relatively bigger, and for the rehabilitation, the canal surface should be covered by highly watertight materials in order to prevent leakages. When the lining is made of materials with a small coefficient of roughness, such as concrete, the flow velocity would increase and the water level may become lower and not reach enough height for distribution.

Here, assuming an earthen canal with a depth of 2.5 m and a bottom width of 10.0 m as a typical cross section of the present canal, the water depths corresponding to the following rehabilitation measures and different bottom widths (10.0 m, 8.6 m, 7.0 m, 6.0 m, 5.8 m) are estimated and shown in the table below:

Rehab-1: Lining the entire surface with concrete,
Rehab-2: Lining the entire surface with wet masonry,
Rehab-3: Lining the side walls with concrete and the bottom with wet masonry,
Rehab-4: Lining the side walls with wet masonry and the bottom with concrete,
Rehab-5: Lining the side walls with concrete and the bottom remains earth, and
Rehab-6: Lining the side walls with wet masonry and the bottom remains earth.

Table 3.3.11 Water Depth for Each Rehabilitation Condition

Lining Type	Concrete Lining	Wet Masonry	Earth w/certain grass
Coefficient of roughness n	0.015	0.025	0.030

(Source: Japanese design guideline for Canal, 2014)

Case	Side Wall	Base	Water Depth H (m, % for Original 2.5m)				
			B=10.0m	B=8.6m	B=7.0m	B=6.0m	B=5.8m
Original	Earth w/certain grass	Earth w/certain grass	2.50	2.84	3.47	4.07	4.22
			100%	114%	139%	163%	169%
Rehab-1	Concrete Lining	Concrete Lining	1.56	1.76	2.10	2.41	2.49
			63%	70%	84%	97%	**100%**
Rehab-2	Wet Masonry	Wet Masonry	2.21	2.50	3.03	3.53	3.66
			88%	**100%**	121%	141%	147%
Rehab-3	Concrete Lining	Wet Masonry	2.02	2.26	2.68	3.07	3.17
			81%	90%	107%	123%	127%
Rehab-4	Wet Masonry	Concrete Lining	1.81	2.06	2.52	2.97	3.08
			72%	83%	101%	119%	123%
Rehab-5	Concrete Lining	Earth w/certain grass	2.24	2.50	2.97	3.40	3.51
			89%	100%	119%	136%	140%
Rehab-6	Wet Masonry	Earth w/certain grass	2.41	2.72	3.29	3.83	3.97
			96%	109%	132%	153%	159%

Source: JICA Project Team

When the water level in the present canal to be 100% as designed, that of the entire concrete lining would be lower to 63% (Rehab-1, B=10.0m) and that of the entire wet masonry lining would be lower to 88% (Rehab-2, B=10.0m), namely in both cases, the water level will be lower due to the rehabilitation. It is necessary to carefully evaluate in the detail design of the rehabilitation how the hydraulic conditions such as flow velocity and water depth would change and how these changes would affect water management and facility maintenance. In general, following measures against lowering of the water level with the introduction of canal lining are proposed as;

a) In the case of entire rehabilitation by lining, design the canal cross section and gradient to ensure the appropriate flow velocity and water depth. If necessary, to ensure enough water level for distribution, new canal structures, e.g., weirs or gates to raise the water level, should be installed (see the lower inset of Figure 5.3.6) or otherwise there may a need of making the canal longitudinal gradient to be gentler in combination of introduction of drop structures (see the upper inset of Figure 3.3.6).

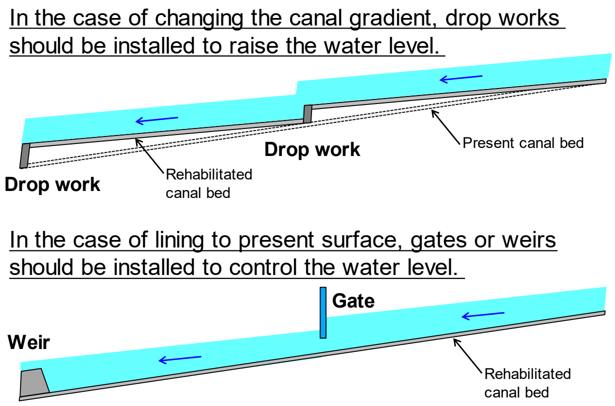


Figure 5.3.6 Images of Raising the Water Level

source: JICA Project Team

b) In case of partial rehabilitation with canal lining, if the flow velocity increases and the water level becomes lower, the following measures should be considered;
- Select the lining materials with high coefficient of roughness such as the wet masonry,
- Use the existing structures e.g. division works or gates, etc. to adjust the flow velocity and the water level,
- Install new canal structures e.g. weirs or gates, etc. and,
- Make narrower the canal section to raise the water level, and in this case, it is necessary to evaluate carefully the effect of the lining by simulating the flow condition at the upstream and downstream sides of the rehabilitated reaches of canals.

The table above also shows the water level and degree of its changes when the present canal bed (B=10.0m) is to be narrowed to 8.6m - 5.8m, with the conditions of discharge and gradient being the same as the original one. In the case of concrete lining, the water level would be the same as the original one under the canal bed narrowed to 5.8m, and for wet masonry, it comes to 8.6m to ensure the same water level as the original.

Narrowing of the canal bed should be implemented for a certain length, and thus there will be newly created spaces which can be available for other roles such as construction of inspection road. However, compared to partial rehabilitation, the amount of filling soil into the space would be larger and the construction cost would increase. Since the degree of canal bed narrowing varies depending on the lining method and the length of rehabilitation of canal, it is necessary to examine the design plan with hydraulic simulation also taking into account construction cost.

In this rehabilitation plan, although basically the same approach would be applied where a lining exists, the concrete lining would be installed to the relatively large canal (e.g., design discharge over $5m^3/s$), and the wet masonry lining would be installed to the others. If the water level is likely to be lowered as a result of the lining, the changing of lining material, using the existing structures, narrowing the canal bed, and installing new canal structures should be considered as counter-measures.

7) Civil Structures and Associated Mechanical Equipment Rehabilitation Plan

Planning for the rehabilitation of existing civil structures and also associated mechanical equipment, e.g. gates, should be based on the following considerations and procedures;

a) Follow the existing facility size, shape, materials, and functions,
b) Estimate the causes of deterioration, malfunctions, and accidental collapses if any for the structures, and plan the corresponding rehabilitation as required (e.g. installing trash-racks to cope with garbage accumulation in the canals and in front of structures),
c) Rehabilitation should be planned and implemented within the existing site,
d) Survey the conditions of the ground around the structures to be rehabilitated and plan the necessary measures for temporary facilities required for the construction, and environmental consideration,
e) Survey the occurrence of unusual hydraulic events around the structures and plan the necessary measure, and
f) Inspect the wear, corrosion, vibration, noise, operation failure, malfunctions, etc., and plan the necessary measures.

5.4 Preliminary Cost Estimation, Implementation Schedule, and Project Evaluation

5.4.1 Preliminary Cost Estimation

In South Sulawesi province, there are 5 irrigation schemes identified for rehabilitation. The current land use is of course whole cultivated, in which wet paddy is planted during rainy season while paddy with irrigation water or Palawija in case of irrigation water not available are planted during dry season. Sometimes, parts of lands may be left uncultivated during dry season dur to non-availability of water.

The DGWR has implemented large scale rehabilitation works nationwide during the last 5-year mid-term development period from 2015 – 2019, covering about 3 million ha. The unit rehabilitation cost for those large-scale rehabilitation projects ranged from very minimal cost to very high rehabilitation cost. Excluding extremely low rehabilitation unit cost of less than 7 million Rp/ha (about 500 $/ha) and also extremely high rehabilitation cost higher than 140 million Rp/ha (about 10,000 $/ha), the screened rehabilitation unit cost arrived at 22,142 thousand Rp per hectare as the average.

The Team takes the average unit rehabilitation cost of 22,142 thousand Rp per hectare as the base rehabilitation cost required. In addition to the unit rehabilitation cost above-mentioned, such associated costs as survey and design, administration and also contingencies composed of both physical and cost inflation must be counted in order to implement rehabilitation projects. Referring to general practices, those associated costs are counted by additional percentage ratio indicated below and calculated in Table 5.4.1.

1) Rehabilitation cost: 22,142 thousand Rp/ha
2) Survey and Design: 10% of the rehabilitation cost
3) Administration: 5% of rehabilitation cost, plus survey & design
4) Contingency (physical): 5% of rehabilitation cost, plus survey & design
5) Contingency (price inflation): 5% of rehabilitation cost, plus survey & design

The unit rehabilitation cost for the total 5 irrigation schemes in South Sulawesi Java province arrives at 28 million Rp/ha (2,000 US$/ha). With the total net rehabilitation target area of 49,829 ha, the total investment cost for rehabilitation comes to 1,395 billion Rp, equivalent to about 100 million US$.

Table 5.4.1 Estimation of Unit Rehabilitation Cost for South Sulawesi Province

No.	Particulars	Cost, thousand Rp/ha	Multiplier	Remarks
1	Unit Rehabilitation Cost (original)	22,142	-	Refer to Figure 3.4.1
2	Survey and Design	2,214	10%	Against above No.1
3	Administration, etc.	1,218	5%	Against above sum No.1-2
4	Contingency (Physical)	1,218	5%	Against above sum No.1-2
5	Contingency (Price Inflation)	1,218	5%	Against above sum No.1-2
6	Total of above	28,018	126%	Sum of No.1-5
7	Say (thousand Rp/ha)	**28,000**	126%	Rounded up
8	@14000	**2,000**	$/ha	
9	Total Net Irrigation Area (ha)	**49,829**	ha	Net irrigable area
10	Total Cost in Rp	**1,395 billion Rp**		Whole project cost for 134,362 ha
11	Total Cost in US$	**100 million US$**		Whole project cost for 134,362 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

5.4.2 Implementation Schedule

For the implementation schedule, the Team sets 5 years according to general practices for the rehabilitation project in the South Sulawesi province, composed of first 1 year for the survey and design required while the rest 4 years for the implementation of the rehabilitation works. The rehabilitation works are therefore to start from the 2nd year and partial benefit is planned to accrue from the 3rd year gradually according to the area where rehabilitation works had been completed in the preceding year. The rehabilitation works are scheduled to complete by the end of 5th year and the whole area could be benefitted from the 6th year (see Table 5.4.2).

Table 5.4.2 Overall Implementation Schedule (5 years for implementation)

Rehabilitation Year	1	2	3	4	5	-	-	-	-	-	Remarks
Benefit Year	-	-	1	2	3	4	5	6	7	8	
Survey & Design											
Rehabilitation Works											
Benefit on the 1st one-quarter area											
Benefit on the 2nd one-quarter area											
Benefit on the 3rd one-quarter area											
Benefit on the 4th one-quarter area											

Source: JICA Project Team

5.4.3 Project Economic Evaluation

The economic analysis is carried out to assess the economic feasibility of the project. The analysis compares the project benefit accrued by implementing the project and the cost that are necessary for the project implementation. Following are the preconditions of the economic evaluation, benefits that will show up by implementing the project as well as the economic returns as expressed by EIRR:

1) Preconditions of the Evaluation

Preconditions to conduct the economic evaluation are elaborated as follows:

- ✓ Referring to other similar projects in the irrigation/agriculture sector, the economic life of the project is designed as 35 years (5 years construction and 30 years operation). Namely, economic evaluations are examined over this period considering the initial investments costs, operation and maintenance costs, and expected benefits to accrue.
- ✓ EIRR (Economic Internal Rate of Return) is applied for the evaluation criteria. For the opportunity cost of capital, which is the cut-off rate to judge economic feasibility, 10% is applied referring to the practices of international donner organizations such as the World Bank, ADB, and JICA[6]. Also, B/C ratio (Benefit Cost Ratio) and NPV (Net Present Value) are calculated for the references.
- ✓ For the conversion from financial prices to economic ones, standard conversion factor (0.9) is applied for all types of prices except for farm labor (0.6) considering the imperfect competitive labor market in the rural economy.
- ✓ All project costs and benefits are calculated in Indonesian Rupees (IDR), and the foreign exchange rate of 1 USD = 14,000 IDR is applied as of January 2022. All prices are standardized into the price level as of 2019 fiscal year.
- ✓ For the rehabilitation project, there is no incremental operation and maintenance fee.
- ✓ Transfer costs such as taxes and debts are not considered in the economic evaluation as they are "zero-sum" when aggregating all the costs and benefits among stakeholders in the economy.

2) Expected Benefit and its Evaluation Cases

The economic analysis is carried out to assess the economic feasibility of the project. The analysis compares the project benefit accrued by implementing the project and the cost that are necessary for the project implementation. Following are the preconditions of the economic evaluation, benefits that will show up by implementing the project as well as the economic return as expressed by EIRR:

- ✓ **The Effect on the Increase of Irrigable Areas:** with the project, thanks to the incremental irrigation water coming after the rehabilitation of the existing irrigation systems, the irrigable areas in which the beneficiary farmers can cultivate paddy rice and Palawija crops are expected to increase.
- ✓ **The Effect on the Yields Increase:** with the project, the organization of water user's associations (WUA) and agriculture extension activities enable timely planting and proper water management, which leads to yield increase.

In the base scenario (the Case 0), the evaluation takes into account both the effect on the increase in irrigable areas and the effects on yield increase up to the good agriculture practice level by the promotion of high-yielding superior seeds and fertilizer inputs.

In the alternative scenario (the Case 1), the scenario assumes that the yield does not increase as expected due to external factors such as the stagnation of research & development and extension services. In this scenario, it is assumed that the increment of the target yield is reduced by 20%.

---

[6] JICA (2012) "Survey for Maximum Utilization of Irrigation Water Indonesia: Final Report" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 28 years of economic life of the project (3 years for the construction and 25 years for the operation). Also, JICA (2004) "The Study on Comprehensive Recovery Program of Irrigation Agriculture in the Republic of Indonesia" applies 10% as opportunity cost of capital, 0.9 of standard conversion factor, 30 years of economic life of the project.

Table 5.4.3 Two Evaluation Cases in the Analysis (South Sulawesi)

Case	Name of the Scenario	The Effects to be considered
Case 0	Base Scenario (Suggested Scenario)	Considering the effect on the increase of irrigable areas by irrigation efficiency increase, with the effect on the yield increase (up to Good Agriculture Practice level).
Case 1	Alternative Scenario	Considering the effect on the increase of irrigable areas by irrigation efficiency increase, and the effect on the yield increase which is reduced by 20% compared to the base scenario.

Source: JICA Project Team

3) Calculation and Economic Conversion of the Project Benefits

For the purpose of economic analysis, information of calculation basis have been collected and estimated from different sources as; 1) the base and target yields have been set by referring to BPS-Statistics of South Sulawesi Province, 2015-2018, and 2) the prices of paddy and maize, as the representative crop of Palawija, have been set by referring to the results of price monitoring conducted by BPS South Sulawesi Province (2018-2020) as summarized in Table 5.4.4 and Table 5.4.5:

Table 5.4.4 Base and The Target Paddy Yields (South Sulawesi)

Irrigation Scheme	Type	Service Area (Ha)	Paddy Rice						Maize
			Base Yield (t/ha)	Years after project has been started (till 30 years)					Base Yield (t/ha)
				1st	2nd	3rd	4th	5th	
DI Kelara Karalloe	Rehabilitation	10,000	5.11	5.11	5.11	5.15	5.18	5.22	5.49
DI Lekopancing		3,626	5.73	5.73	5.73	5.77	5.81	5.85	4.67
DI Bantimurung		6,513	5.73	5.73	5.73	5.77	5.81	5.85	4.67
DI Lamasi		11,506	4.95	4.95	4.95	4.98	5.02	5.05	5.04
DI Kalaena		18,184	5.44	5.44	5.44	5.48	5.52	5.56	6.23
All South Sulawesi		49,829	5.32	5.32	5.32	5.36	5.40	5.43	5.49

Source: JICA Project Team
Note: The base and target yields of all South Sulawesi are calculated as the weighted averages of the service areas.

Table 5.4.5 Applied Paddy and Maize Prices in the Evaluation (South Sulawesi)

Months and Average	Paddy Rice				Maize (Palawija)			
	2018	2019	2020	Average	2018	2019	2020	Average
January	-	-	-	-	3,004	5,071	-	4,348
February	-	-	-	-	2,945	5,109	-	4,204
March	-	-	-	-	2,891	5,073	-	4,157
April	-	-	-	-	2,992	5,075	-	4,189
May	4,600	-	-	4,600	2,971	5,120	-	4,255
June	-	-	-	-	3,039	5,039	-	4,234
July	-	-	-	-	3,047	5,049	-	4,245
August	-	-	-	-	3,152	5,140	-	4,329
September	-	-	-	-	3,234	5,204	-	4,471
October	-	-	-	-	3,297	5,185	-	4,501
November	-	4,925	-	4,925	3,413	5,155	-	4,546
December	-	4,900	-	4,900	3,543	5,206	-	4,645
Average	4,600	**4,913**	-	4,756	3,127	**5,119**		4,344
In Economic Price (x 0.9)				4,421	In Economic Price (x 0.9)			4,607
Rounded				**4,420**	Rounded			**4,610**

Source: The results of price monitoring by BPS Central Java Province (2018-2020)
Note: The average price as of 2019 is applied to standardize into 2019 price level.

The per hector farming cost is estimated by referring to the standard cost ratio against the cropping revenue per hector. The applied standard cost ratios are estimated based on the BPS "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy and Maize 2017" (national level statistics) with some necessary modifications considering the farming practices in the project area. It implies that the farming cost is assumed to proportionally increase depending on the yield level. Table 5.4.6 shows the farming cost under the base yield:

Table 5.4.6 Estimation of Unit Farming Cost for Per-ha Cultivation of Paddy and Maize (South Sulawesi)

Item	(Wetland) Paddy		Palawija (Maize)	
	Financial	Economic	Financial	Economic
Standard Profit Ratio per Revenue	0.31	0.71	0.35	0.64
Standard Cost Ratio per Revenue	0.69	0.29	0.65	0.36
Base Yield per Ha (ton per ha)	5.32	5.32	5.49	5.49
The Local Prices of Paddy and Maize (IDR per kg)	4,913	4,420	5,119	4,610
Estimated Revenue per ha (000' IDR per ha)	26,137	23,514	28,103	25,309
Estimated Cost per ha (000' IDR per ha)	18,035	6,819	18,267	9,111
Estimated Profit per ha (000' IDR per ha)	8,102	16,695	9,836	16,198

Source: JICA Project Team based on BPS, "Value of Production and Cost of Production per Planting Season per Hector of Wetland Paddy and Maize 2017"

The target cultivated areas by crop are set in line with the land use plan for the target service area and also the cropping pattern with the project implemented (See Chapter 5.2 for more detail). With the cultivated areas to be realized with the project, the benefits are to accrue through paddy rice and Palawija production from the base year till 35th year.

Table 5.4.7 Base and Target Cultivated Areas by Crop (South Sulawesi)

Province	Service Area, ha	Paddy				Palawija			
		Without	With	Increment		Without	With	Increment	
		ha	ha	ha	%	ha	ha	ha	%
South Sulawesi	49,829	90,645	93,425	2,780	3.1	1,582	1,687	105	6.6

Source: JICA Project Team

4) Economic Conversion of Project Cost

For the economic analysis, the project cost should be converted to economic price by applying standard conversion factor (0.9). The economic analysis does not take into account any price escalation because there is large uncertainty in the price escalation in the future. Table 5.4.8 shows the converted economic costs to be entered in the economic evaluation:

Table 5.4.8 Economic Conversion of Development Cost and O&M Cost for South Sulawesi Province

No.	Particulars	Cost, thousand Rp/ha	Multiplier	Remarks
1	Unit Rehabilitation Cost (original)	22,142	-	Refer to Figure 3.4.1
2	Survey and Design	2,214	10%	Against above No.1
3	Administration, etc.	1,218	5%	Against above sum No.1-2
4	Contingency (Physical)	1,218	5%	Against above sum No.1-2
5	Contingency (Price Inflation)	1,218	5%	Against above sum No.1-2
6	Total of above	28,018	126%	Sum of No.1-5
7	Total without Price Contingency	26,800	121%	Deduction of No.5 from No.6
8	Unit Economic Development Cost	24,120	109%	No. 7 x 0.9
9	Total Net Irrigation Area (ha)	49,829	ha	Net irrigable area
10	Total Financial Cost in Rp	1,335 billion Rp	-	Whole project cost for 49,829 ha
11	Total Economic Cost in Rp (x 0.9)	**1,202 billion Rp**	-	Whole project cost for 49,829 ha

Source: Unit Development cost by DGWR, and others by JICA Project Team

5) Evaluation Results

In order to examine the economic validity of the Project, EIRR, B/C, and NPV have been calculated. The calculated EIRR is 11.68%; B/C ratio is 1.19 and the NPV is 187 billion IDR for the base scenario (Case 0). As an alternative scenario (Case 1), the evaluation does not consider any yield increase which results are 10.25 %, 1.03, and 27 billion IDR for the EIRR, B/C ratio, and NPV respectively (see Table 5.4.9). According to the evaluation result, the Project is judged to be economically feasible under the base scenario since the EIRR (11.68%) exceeds the opportunity cost of capital (10.0%), and also the Project is still economically feasible even under the alternative scenario (EIRR: 10.25%).

Table 5.4.9 Results of the Project Economic Analysis for South Sulawesi Province (South Sulawesi)

Particulars	Case 0	Case 1 (80% Yield Increase)
EIRR, %	11.68	10.25
B/C Ratio	1.19	1.03
NPV, million IDR	187,051	26,718

Source: JICA Project Team

CHAPTER 6 SYSTEM O&M, AND WATER USERS ASSOCIATION (WUA)

This chapter discusses system operation and management of irrigation schemes in Indonesia and also water users' associations organized by the beneficiary farmers. It starts with the review of the current set-up of the system operation and management of national irrigation systems, whose command area is basically more than 3,000 ha, and examines the status and structure, roles, responsibilities, etc. of existing WUAs that the JICA team had actually visited. Then, this chapter tries to provide improvement measures in the area of O&M specifically in the context of joint management by both the government (DGWR) and the farmers.

6.1 System Operation and Management of Irrigation Schemes in Indonesia

A typical irrigation system consists of headworks (intake-facilities), main canal, secondary canals, and tertiary canals, which altogether deliver and distribute irrigation water to the beneficiaries' farmlands. Some systems may have storage facilities, i.e. dam reservoir, which accordingly enhances year-round irrigation realizing even 3-time cultivation in a year. This system arrangement is briefly illustrated in Figure 6.1.1 together with the responsible entities.

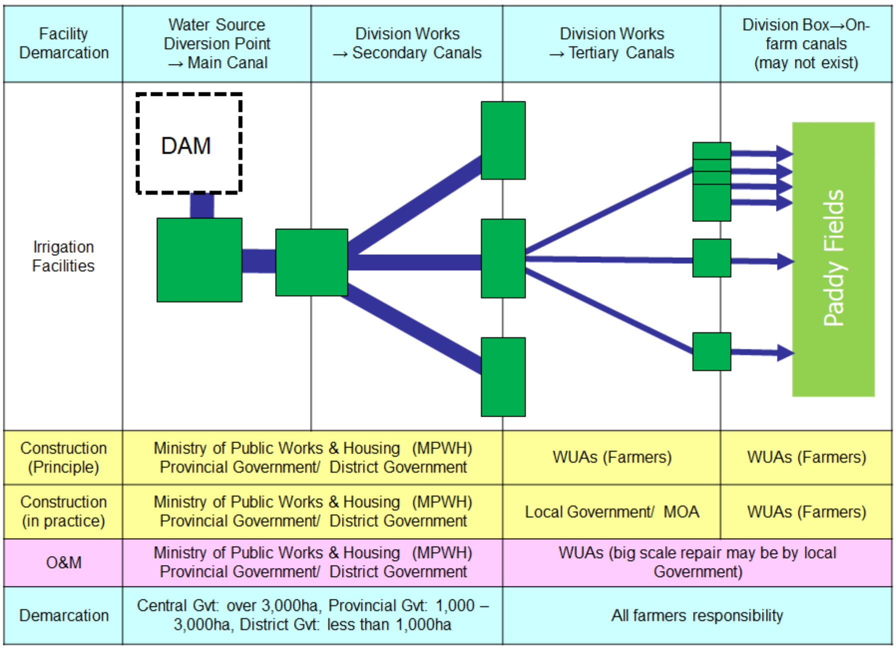


Figure 6.1.1 Current Set-up of Irrigation System Construction and O&M
Source: JICA Team based on Information from Directorate General of Water Resources

As is briefed in above figure, construction as well as the operation and maintenance (O&M) for the established irrigation systems are in principal undertaken by the 2 major stakeholders, that are the government and beneficiary farmers. In this arrangement, the government is responsible from the top-upstream side, e.g., water source development and head-intake facilities, to the secondary canal level while the beneficiary farmers are responsible for the lower level (or terminal level) facilities, which are the tertiary canals and below thereof.

On the government side, construction of the irrigation systems and those O&M are administratively undertaken by different levels of the government according the scale of the beneficiary area. The Law No.20 (2006) specifies that;

1) The central government (MPWH) should be responsible for the irrigation systems over 3,000 ha of beneficial area (Article 16, of Law No.20),
2) Provincial government be responsible for those systems with beneficiary area of 1,000 ha to 3,000 ha (Article 17, of Law No.20),
3) The rest, smaller than 1,000 ha area, should be undertaken by Kabupaten (district) government (Article 18, of Law No.20).

Note: Above responsibility demarcation by area size applies to both construction and O&M, though the lower *governments can request their higher-ups if they can hardly develop/manage at their level.*

In terms of O&M for the facilities placed under the government responsibility, the principal arrangement follows the area size demarcation mentioned above; however, in nowadays context, there are many national irrigation systems whose facilities are partly or mostly operated and maintained by local governments. For example, the JICA team visited the beneficiary areas of Sidorejo, Sedadi and Klambu irrigation systems located in Java Central Province and covered by Kedung Ombo dam, in which only the headworks (intake-weirs) are managed by BBWS Pemali Juana while the rests including main canals are by provincial government.

As aforementioned, tertiary canals and below thereof should always be managed by the farmers. In Indonesia, a standard design[1] of tertiary canals instructs the project implementor to align the canal basically covering each 100 ha of the beneficiary farmland. Below the tertiary canals, further, there may be quarterly level canals, so-called on-farm canals. This quarterly level canal should always be established in dryland (upland) irrigation areas, yet, lowland irrigation areas, i.e. paddy irrigation areas, may not have such terminal canals as plot-to-plot irrigation may function well in distributing the irrigation water over the command area of a tertiary canal.

One thing noted is that though the tertiary canals should be constructed by the beneficiary farmers in principle, at the same time, the farmers are entitled to request their respective local government to construct the tertiary canals and associated facilities on behalf of them including fund arrangement. Local government here means Kabupaten (district) government, which usually has a division to undertake agriculture infrastructure. If the Kabupaten government can hardly implement the tertiary canal establishment, they can also request the higher-ups, e.g., the Provincial government.

In sum, the current set-up of O&M is a joint management undertaken by both the government(s) and beneficiary farmers. Though the actual implementor of construction works may differ according to such conditions as financial capability, technical capability, organizational capability, etc. of the entities originally decided in the Law, O&M of the tertiary canals and below thereof are always farmers' responsibility. There may be a possibility for the farmers organization, that is WUA, to undertake higher level's O&M, i.e. O&M of secondary canals. Including this idea, following sub-chapters explore capacities of existing WUAs that the Team had visited in February 2020.

6.2 Water Users Association (WUA) and Related Organizations

6.2.1 Current Structural Set-up of Water Users Association

Water Users Associations in Indonesia are established at such three levels as tertiary canal level, secondary canal level, and whole system level or, instead, in some case divided whole system levels. These water users associations are named by its level P3A[2] at the tertiary level, GP3A[3] at the secondary level and IP3A[4] at the system level. P3A literally means water user farmer group, and GP3A means the association of the water user group, and then IP3A does the main association of them.

It means that P3A is formed basically corresponding to each and every tertiary canal, GP3A is organized corresponding to each secondary canal with some exceptional cases in that a GP3A covers several number of secondary canals. IP3A is the highest-level organ for the Water User's Association usually established at the whole system level, or in some cases, for example, one IP3A may cover whole right

[1] Based on the Technical Manual 'KP.05 Tertiary Plot' in page 29 Chapter 4.3
[2] Perkumpulan Petani Pemakai Air (P3A):Literally translated as Water User Farmer group
[3] Gabungan Perkumpulan Petani Pemakai Air (GP3A): Literally translated as Association of Water User Farmer group
[4] Induk Perkumpulan Petani Pemakai Air (IP3A): Literally translated as Main Association of Water User Farmer group.

main canal command area while the other one may cover the rest area, i.e., whole left main canal command area.

As aforementioned, in Indonesia, regardless of its command area size, tertiary canal and below thereof are all managed by the members of Water Users Association, here called P3A. Then, the management of secondary canal level and also system level is dependent on the agreement between the GP3A and the government organization responsible for the irrigation system, namely, B/BWS or PSDA[5]. In most cases, maintenance works for secondary and system levels are conducted by the government organizations while GP3A and IP3A request and negotiate on the distribution of water from the dam if any, primary and secondary canals to their farmlands.

1) Structure of P3A

As shown in Figure 6.2.1, P3A is formed by farmers who use same tertiary canal. Though one P3A basically covers only one tertiary canal, there may be some exceptions in which a P3A may cover a couple number of tertiary canals in order to take a balance of coverage area size, or membership population size, among P3As.

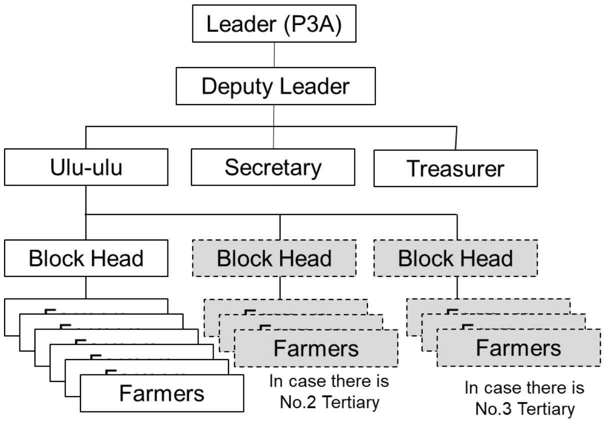


Figure 6.2,1 Structure of P3A (Sidorejo Scheme)
Source: JICA Team based on Interview to the P3A

Each tertiary canal assigns a Block Head, a farmer nominated by P3A, who controls water distribution from the secondary canal into their tertiary canal. There is also Ulu-ulu[6] who is a nominated farmer or village official by the P3A leaders and/or village leader, or otherwise by the beneficially farmer members, who coordinates Block Heads and oversees the control of irrigation water at intake gates installed along the secondary canal.

The board members of P3A are usually composed of Leader, Deputy leader, Secretary, Treasurer and Ulu-ulu. The board members organize general meetings for the P3A member farmers. In the general meeting, farmers discuss water demands based on their cropping pattern and crop schedule, schedule of canal cleaning, needs of repair to prevent seepage, rehabilitation works for broken parts of the tertiary canal. Then, the important matters for the discussion in P3A become the agenda in the GP3A meeting, at which all the P3A representatives under the GP3A gather and discuss.

2) Structure of GP3A

According to the relevant by-laws and regulations for WUAs, it is defined that a GP3A should be organized by all the relevant beneficiary farmers within the command area of its secondary canal(s). However, as the membership becomes very huge if all the beneficiary farmers have to get together, usually only the representatives of P3As under the said secondary canal(s) are convened in order to form the GP3A. In practice, therefore, a simple structure as

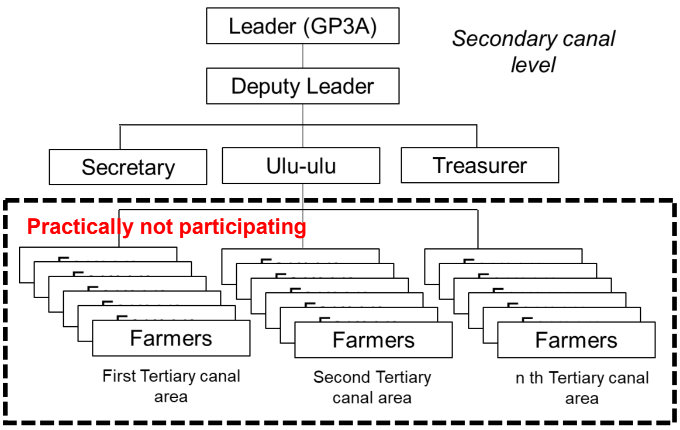


Figure 6.2,2 Structure of GP3A (Sidorejo Scheme)
Source: JICA Team based on Interview to the GP3A

[5] Pengelolaan Sumber Daya Air (PSDA): Water Resource Management Agency in charge of water resources development and management including irrigation established under provincial government
[6] Farmers or village officials who oversee controlling of water at intake gates to the tertiary canals.

shown in Figure 6.2.2 is applied for the GP3A. The board members are composed of Leader, Deputy leader, Secretary, Treasurer and Ulu-ulu, who are all selected from the leaders of relevant P3As. P3A representatives bring up such issues, which have not been solved at the level of their P3As, to the GP3A and discuss at the level of GP3A to find a solution.

3) Structure of IP3A

Relevant by-laws and regulations for WUAs defines again that an IP3A should be established by all the relevant beneficiary farmers within the command area of its system level. However, as the size of the WUA becomes too huge at the level of IP3A, a simplified practice is applied same as that of GP3A, namely, only the representatives of GP3As under the irrigation system are usually convened in order to organize the IP3A. In practice, therefore, a simple structure is applied for the IP3A as exampled in Figure 6.2.3.

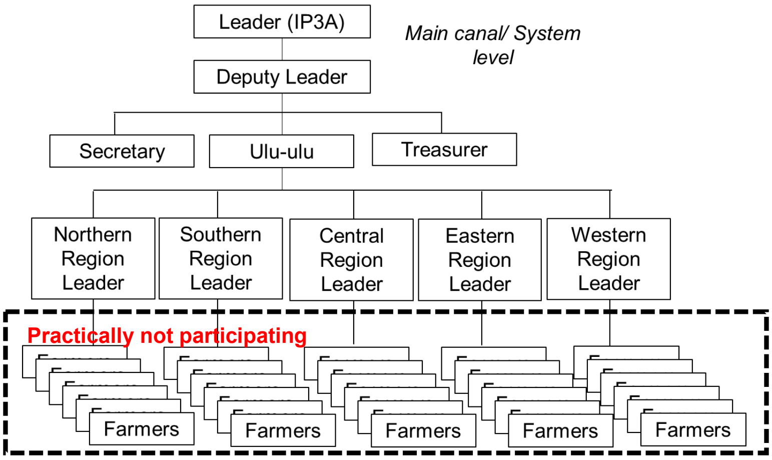


Figure 6.2.3 Structure of IP3A (Sidorejo Irrigation Scheme)
Source: JICA Team based on Interview to the GP3A

The board members are the same as those of GP3A as afore-mentioned e.g. who are composed of Leader, Deputy leader, Secretary, Treasurer and Ulu-ulu. They are all selected from the leaders of relevant GP3As. In addition to the board members, there may be leaders assigned to specific command areas. The example shows a practice of Sidorejo irrigation scheme in Java Central province where there are 5 leaders in charge of each regional block command area, e.g. norther region, southern region, central region, so forth. This practice has been introduced due to its large scale of the command area of 7,900 ha with as many as 45,000 farmers.

At the IP3A meeting, issues which had not been solved at the level of GP3As are brought up and the IP3A members discuss and try to solve the issues based on the consensus among the concerned members. Likewise, based on the agreed cropping pattern and cultivation schedule by the IP3A members, the IP3A board members will discuss and negotiate with officers of B/BWS and PSDA, especially on the water requirement from the water source.

6.2.2 Other Related Organizations in Irrigation Management

Though the main actors for irrigation management are B/BWS, PSDA and the water users associations such as P3A, GP3A and IP3A, irrigation related issues are also discussed and coordinated in an irrigation commission, called Komir, and in a development planning conference (MUSRENBANG) organized at the district level (Kabupaten level).

Irrigation Commission (Komir) has the task of assisting the governor of Kabupaten or mayor of Kota in making policies related to irrigation in accordance with their authority. The commission is aimed at the improvement of irrigation networks, irrigation network management, irrigation asset management, irrigation water management, and also sustainability of irrigation systems, and reporting to higher-ups, e.g., provincial government.

Here is the case of Grobogan district in Java Central province, which includes Sidorejo irrigation scheme and Sedadi irrigation scheme surveyed by JICA team in February 2020. The Irrigation Commission in this area is established at the level of this Grobogan district[7], and the current board members/ members of the commission (2016-2021) are listed below:

Board Member of Irrigation Commission:

- ✓ Chairperson: Head of Grobogan Regional Development Planning Agency
- ✓ Deputy Chairperson: Head of the Public Works Office of Grobogan District
- ✓ Secretary: Head of Irrigation Operation and Maintenance Division of the Public Works Office of Grobogan District

Members of Irrigation Commission:

- ✓ Head of the Department of Agriculture, Food Crops and Horticulture, Grobogan District
- ✓ Head of Maritime Affairs and Fisheries Office of Grobogan District
- ✓ Head of the Food Security Agency of Grobogan District
- ✓ Head of Water Resources Regional Infrastructure Division at the Grobogan District Regional Development Planning Agency
- ✓ Head of Legal Division of the Grobogan District Secretariat
- ✓ Head of Section of Village Resources and Settlements on Community Empowerment Agency and Local Government (BPMPD) at Grobogan District
- ✓ Head of the Forestry and Plantation Office of Grobogan District
- ✓ IP3A Leader of Sidorejo scheme
- ✓ IP3A Leader of Sedadi scheme
- ✓ IP3A Leader of Glapan scheme
- ✓ IP3A Leader of Dumpil scheme
- ✓ IP3A Leader of Kedungwaru scheme
- ✓ WUA representatives who represent total 182 Irrigation schemes under the jurisdiction of Grobogan District

The commission members are appointed in every 5 years by the district government head initiative. Irrigation related issues at the district level are discussed among the participants of the commission coming from multi-sectors. Periodical meeting should be held in every 3 months, at which the members discuss preparation of cropping before every planting season, problems on existing facilities including diversion weirs and main and secondary canals within the district area together with measures.

Irrigation commission above-mentioned centers on irriation related matters only as is called and as leaders of IP3As are included in the commission while Development Planning Conference deals with not only irrigation related issues but also any other important issues within the district. Therefore, the chairperson of the Conference is the district head and supported by BAPPEDA technically and administratively. Thus, issues forwarded to this Conference should be those ones, which have not been solved at the level of Irrigation Commission or which need coordination with other sectors than agriculture and irrigation.

6.2.3 Water Users Associations in Java Central Province

Java Central province has a long history of rice cultivation. Existing irrigation systems under BBWS Pemali Juana had been mostly constructed in the late 19th century during the colonization era. Farmers in this area are mostly Javanese people, inherited farmland from their ancestors. Under BBWS Pemali Juana, there are 22 irrigation schemes, of which three irrigation schemes were covered by the interview surveys conducted in February 2020, namely, Sidorejo, Sedadi and Klambu-Kiri.

[7] From year 2020, irrigation commission will be organized based on river territory and the coverage area of irrigation scheme (Daerah Irigasi), instead of the current district administration basis, with reference to a new president degree issued in 2019 (No.17 concerning water resource).

1) Water Users Associations and Coverage Areas for the 3 Irrigation Schemes

Table 6.2.1 shows typical characters of the 3 irrigation schemes that the Team visited, e.g. total number of members, farmland area, average farmland area per member, average area covered by one P3A, etc. It can be noted that the number of members is in fact quite large in each irrigation scheme, namely 45,000 in Sidorejo, 32,000 in Sedadi and 33,851 in Klambu-Kiri. With this big number of farmers, though the farmland area (beneficial area) extends over from about 8,000 to more than 20,000 ha per irrigation system, the average farmland area per member becomes very small, namely, 0.2 ha in Sidorejo, 0.5 ha in Sedadi and 0.6 ha in Klambu-Kiri.

Table 6.2.1 Water Users Association and Irrigated Area in Java Central Province

Irrigation Scheme	Sidorejo	Sedadi	Klambu-Kiri
Total No. of Members	45,000	32,000	33,851
Farmland Area, ha	7,938	16,055	20,709
Average Farmland Area (ha) per member	0.2	0.5	0.6
No. of IP3A	1	1	1
No of GP3A	8	8	4
No. of P3A	63	63	110
Average Area (ha) covered by One P3A	126	254.8	188.3
Average No. of Members in One P3A	714	507	308
Average No. of P3A under One GP3A	7.9	7.9	27.5

Source: JICA project team (based on the interview results to WUA representatives, and relevant data from BBWS and PSDA

In terms of number of WUAs, one IP3A is established in each of the 3 irrigation systems. Note that there are 2 main canals under Klambu irrigation scheme covering Klambu-Kiri (left) area and Klambu-Kanan (right) are, so that there are two IP3As under the Klambu irrigation scheme. Number of GP3As ranges from 4 in case of Klambu to 8 in Sidorejo and Sedadi, while that of P3A ranges from 63 to as many as 110. As average, therefore, one P3A should cover an area of 126 ha to 255 ha with the number of farmer beneficiaries of 308 (Kulambu-Kiri) to as many as 714 (Sidorejo).

From above, it is known that even the P3A which is the smallest WUA in the irrigation schemes has very big number of members ranging from about 300 members to over 700 members. Issues concerning their tertiary canal command area, at which the P3A is basically established, should be discussed and tried to solve among the members first, yet it seems difficult to organize a general meeting convening all the members.

Same situation does take place at the higher-ups, i.e. at the levels of GP3A and IP3A. It is in fact more difficult to convene all the beneficiary farmer members at these higher-ups level, and therefore only the representatives are usually convened and discus matters to solve (refer to the discussions in 6.2.1 Current Structural Set-up of Water Users Association).

2) Written Regulation

As a result of the interview survey, it was found that all irrigation schemes keep written regulations at each of the 3 levels, i.e. at the levels of P3A, GP3A and IP3A. There is a standard format of regulation provided by PSDA, and each association modifies it according to their situation. The regulation is composed of the Articles of Association, and its By-laws which is construed as an extended part of the Articles of Association.

An example of the Articles of Association applied in GP3A Dharma Tirta of Sidorejo Irrigation Scheme is shown below, composed of total 10 chapters, under which there are 25 provisions and by-laws:

Chapter 1. NAME, TIME AND ADDRESS OF THE ORGANIZATION
Chapter 2. PRINCIPLES, PROPERTIES AND GOALS
Chapter 3. DUTIES, TARGETS, SCOPE AND LIMITATIONS OF THEIR WORK

Chapter 4. ORGANIZATION
Chapter 5. PROPERTY AND INCOME
Chapter 6. WORKING PROCEDURE
Chapter 7. DEVELOPMENT / STREAMLINING IN ORGANIZATIONS
Chapter 8. AMENDMENT TO ARTICLE OF ASSOCIATION
Chapter 9. DISSOLUTION
Chapter 10. CLOSING

It can be said that the regulation is well structured with necessary provisions. However, some parts of the main chapters of Articles of Association and By-laws are often overlapped. Main chapters in the Articles of Association can be more simplified and details in the main chapters should be transferred to the respective provisions of the By-laws. Some specific features were confirmed from this written regulation as below:

2.1) Approval from the District Head for the WUA's Set-up

Matters and issues in irrigation water management are handled by B/BWS in Indonesia in general. However, the establishment of WUA needs approval from the district (Kabupaten) head where the WUA is to be established. WUA members communicate BBWS field staff and also PSDA officers for technical matters while matters associated with WUA such as approval of its establishment need to obtain approval from the district head as it is concerned to a district development[8].

2.2) Regulation on the Secondary Canal

The GP3A Dharma Tirta is expected to have a role in the management on the secondary canal of Godongan & Genuksuran. However, the demarcation on the responsibility between the GP3A and the BBWS/PSDA in terms of operation and maintenance of the secondary canal is not clearly mentioned in the Articles of Association, neither in the By-laws. According to the relevant regulation as quoted below, it seems that whole responsibility on the irrigation management within the secondary canal command area be on the GP3A, yet it is in fact difficult for the GP3A to undertake whole responsibility, and farmers due think that the responsibility be with BBWS/PSDA.

> *CHAPTER III: DUTIES, TARGETS, SCOPE AND LIMITATIONS OF THEIR WORK, Article 5: The tasks of GP3A "TIRTO LANGGENG" are as follows: 1) Manage water and irrigation networks in the Godongan & Genuksuran Secondary canal, 2) Participate in maintaining irrigation networks along the irrigation system of Godongan & Genuksuran Secondary canal, and 3) Determine and regulate the contributions from the member farmers in the form of money out of the harvest to finance the operations and maintenance of the Godongan & Genuksuran Secondary canal irrigation network,*

2.3) Difficult Decision Making Among Large Number of Members

In GP3A Dharma Tirtra, member meeting should be implemented once or twice a year with the participation of more than two-third of its members as quorum. Here, the issue is who should be the members. According to the relevant provision of Articles of Association (Article 17), the term of 'Member' is defined as ALL the farmers who benefit directly from the irrigation water. The command area of the GP3A is 686 ha, relatively small as a GP3A assigned to a secondary canal. However, in this beneficial area under the GP3A Dharma Tirta, there are more than 1000 farmer members. With this huge member farmers, it is practically not possible to organize the meeting at once at a place

[8] As explained in the Chapter 6.2 of Articles of Association, the set-up of Irrigation Commission and Development Planning Conference specifies that the matter of WUA should be the part of integrated development.

3) Water Users Fee and its Use

Water users fee paid by the farmer members is basically used for its internal activities in Indonesia, not to be paid to the government as the service fee for delivering the water. The P3A leader collects the fee from his/her general members. Each P3A sets its own amount for the fee, which may differ from that of other P3As. The amounts of the fee indicated in Table 6.2.2 are examples from some P3A leaders in each irrigation schemes. Some P3As collect the water users fee by cash while others collect it by in-kind, e.g. in a form of harvested paddy. An interviewee told the Team that it is easier to collect the fee by paddy since the members can hardly excuse them by scarcity of cash in hand.

The amount of the fee per hectare for year-round is Rp.210,000 in a P3A interviewed under Sidorejo irrigation scheme, 100 kg paddy in a P3A interviewed under Sedadi scheme, and Rp.150,000 in a P3A located in upper stream of Klambu-Kiriand, and Rp.180,000 in the downstream area. These amounts are all for year-round due, and with an assumption that there is a 2 times harvest of 6 tons/ha of paddy in a year, the fee accounts for 0.4%, 0.8%. 0.3% and 0.3% of the gross production value[9]. This range of water users fee may not be a burden for the payers, the beneficiary famers.

The major expense out of the collected water fees goes to maintenance and rehabilitation works for the tertiary canals. Aside from this, parts of the collected money are used for board member's honorarium and for administration cost for the GP3A and IP3A, to which the P3A belongs. In addition, remaining amounts, if any, may be used for some social responsibility activities such as recovery works from damages of flooding. The use of the remaining money is decided by the P3A members during their P3A meeting.

According to the interviewees, most of the members pay water users fee. However, still there are some members who do not pay the fee. Therefore, there is a penalty provision in their regulations for such nonpayment. For example, leaders of the P3A do not allow the non-payment members to use tractor, which was provided/ subsidized by the government and managed by the P3A leaders. In such case, the non-payment members should rent the tractor from neighbors, whose rental fee is higher than the one managed by the P3A.

Table 6.2.2 Water Users fee and its Use in 3 Irrigation Schemes in Java Central Province

Scheme	Sidorejo	Sedadi	Klambu Kiri
Fee	Rp 210,000	Paddy 100kg	Upper stream: Rp. 150,000 Downstream: Rp. 180,000
Ratio of the use	50 % for rehabilitation of tertiary canal	40 % for rehabilitation of tertial canal	60% for maintenance of tertiary canal
	25 % for administration and board member's fee.	30 % for board members	30 % for board members
	15 % for GP3A's activity	10 % for saving	10% for social responsibility (e.g. funeral, meeting, accident and damage of flood)
	5 % for IP3A's activity	5 % for administration cost	
	5 % for saving	15 % for other (e.g. meeting expense)	
Penalty	Tractors are not allowed to lend out (Note: the tractor was subsidized by the government and belongs to the P3A).		

Source: JICA Project Team, based on the interview survey results to WUA members and the data from BBWS and PSDA

4) Operation and Maintenance

Regarding O&M, general members of the P3A have a responsibility of checking their tertiary canal daily during the cropping season, e.g. checking the water flow and also the physical conditions of the canal.

[9] Farm-gate price of 100kg of paddy is about Rs. 450,000 as of February 2021 in the irrigation scheme areas, and with this price, 12 tons of paddy harvested in a year is valued at Rs. 54 million. With this value of Rs.54 million representing the farm-gate price of 12 tons of paddy, the water users fee paid by the farmers accounts for only around 0.3% to 0.8%.

BBWS/PSDA have provided trainings for operation and maintenance, which targeted leaders only and only those who attended had received relevant manuals for O&M. General members are supposed to receive the trainings from the leaders trained by BBWS/PSDA, and they rarely have O&M manuals according to an interview to the members.

According to the interviews, P3A members usually clean their tertial canal monthly during the cropping season. Individual farmer cleans the section of the tertiary canal passing beside his/her paddy field. Farmers remove sediment and trash such as plastics. Regarding cleaning of secondary canal, PSDA takes responsibility for removing the sediment with their own budget. Members addressed that sediment and domestic rubbish in the secondary canal sometimes disturb water flow and accordingly they can hardly obtain proper amount of irrigation water (see Photo right as an example).

Example of domestic garbage dumped at the intake from a secondary canal to their tertiary canal

6.2.4 Water Users Associations in Sulawesi South Province

There are 35 irrigation schemes under the BBWS Pompengan Jeneberang in Sulawesi South province. The JICA team surveyed such 4 irrigation schemes as Kelara Karalloe, Bantimurung, Lamasi and Kalaena. Unlike the case of WUAs in Java Central province, farmers of the schemes were from different ethnic groups, i.e., there are Toraja people, Javanese people and Bugis people in the Lamasi scheme while, in Kalaena scheme, there are more than three ethnic groups represented by Javanese, Luwu and Bali. According to a farmer who has a root in Bali, his ancestor moved from Bali island under an immigrant policy enforced during the colonial era.

1) Water Users Association and Coverage Area for the 4 Irrigation Schemes

As shown in Table 6.2.3, the total number of famers by scheme ranges from 7,000 to as large as 20,000 with an extensive farmland area of 6,500 ha to 17,000 ha. Thus, the average farmland area per famer member comes to 0.6 ha only to 0.9 ha at maximum. As afore-mentioned, P3A is the most basic WUA established at a tertiary canal level, and in those 4 irrigation schemes the P3A covers an area ranging from 49 ha (Lamasi) to 166 ha (Kalaena). The average number of members in those P3As is 216 in Kelara Karraloe, 121 in Bantimurung, 85 in Lamasi and 196 in Kalaena.

WUAs in Indonesia are established at such 3 levels as tertiary level, secondary level and system level, corresponding to P3A, GP3A, and IP3A. There are these 3 levels of WUAs in those 2 irrigation schemes of Bantimurang and Lamasi, while Kelara Karraloe and Kalaena have yet to establish the IP3A, the system level WUA. Number of GP3As by scheme ranges from 3 only (Kelara Karraloe, Kalaena) to 11 (Lamasi) while that of P3A is from 51 (Kelara Karraloe) to as many as 235 (Lamasi). Therefore, a typical GP3A has 9 to 34 P3As by scheme under their beneficiary area, quite different among the schemes.

Table 6.2.3 Water Users Association and Irrigated Area in Sulawesi South Province

Irrigation Scheme	Kelara Karraloe	Bantimurung	Lamasi	Kalaena
Total number of Members	11,000	7,000	20,000	20,000
Farmland Area(ha)	7,815	6,513	11,456	16,946
Average Farmland Area(ha) per member	0.7	0.9	0.6	0.9
Average Area (ha) covered by One P3A	153	112	49	166
No. of IP3A	0	1	1	0
No. of GP3A	3	6	11	3
No. of P3A	51	58	235	102
Average No. of Members in One P3A	216	121	85	196

Irrigation Scheme	Kelara Karraloe	Bantimurung	Lamasi	Kalaena
Average No. of P3A under One GP3A	17	9.7	21	34

Source: JICA project team (based on the interview results to WUA representatives, and relevant data from BBWS and PSDA

2) Water Users Fee and its Use

Regarding water users fee, P3A leaders collect the fee from the member famers except Lamasi scheme and Kalaena scheme. In Lamasi irrigation scheme, a member told JICA team that they used to collect the fee before the time of Megawati's political era (2001-2004) but a policy during Megawati's era gave a negative impact on their fee collection and the P3A leaders stopped collecting the fee[10]. Nowadays members started to think about the importance of collecting the fee for the purpose of maintaining their tertiary canal.

Regarding the amount of the fee, as shown in table below, in Kelara Karraloe, they collect 50kg paddy per hectare which can be converted to Rp.225,000 in each season (Assuming that the yield is 6 ton/ha, 50 kg paddy accounts at 0.8 % of the gross production value). In Bantimurung, the fee is Rp.100,000 per year (0.4% of the gross farm gate price of paddy) or 40kg paddy (about Rp.180,000). In some downstream areas in Bantimurung, the fee is set at Rp.250,000, accounting for 1% of the of the gross farm gate price. In Kalaena scheme, there is only one P3A which collects the fee, that is only Rp.50,000 per year, equivalent to 0.2 % of the gross farm gate price.

Collection ratio for the users fee is quite high among the schemes. According to GP3A leaders, almost 100% members pay the fee in Kelara Karraloe, 95% in Bantimurung and 80% in Kalaena. P3A leaders collect the fee in cash or in-kind, i.e. by paddy, per season or by year-round based on cultivated area. P3A leaders told the Team that it was easier for them to collect the fee in-kind (by paddy) because the members can hardly excuse them from the scarcity of cash. In Kelara Karraloe scheme, 50kg of paddy/ha is collected seasonally, and in such cases that a downstream area could not have enough amount of water, the farmers are allowed to pay the fee only once a year.

Table 6.2.4 Water Users Fee and its Use in 4 Irrigation Schemes in Sulawesi South Province

Scheme	Kelara Karraloe	Bantimurung	Lamasi	Kalaena
Fee	50kg of paddy per ha per season (only once a year in downstream)	Rp. 100,000 per ha per year. (In some area, 40kg per ha per year.) In downstream area Rp.250,000/ha per year or 50kg of paddy/ha per year.	Not collected as of now	Except for one P3A, no fee is collected. (Rp.25,000 per season x 2 times per year)
Use of the fee	50% for *Mandor*	10% for *Ulu-ulu*	N/A	25% for administration
	10% for GP3A and P3A board member	50% for maintenance of tertiary canal	N/A	25% for board members
	15% for maintenance of tertial canal	20% for meeting, accident recovery, and social responsibility	N/A	50% for rehabilitation and maintenance
	15% for saving	20% for saving	N/A	-
	10% for meeting, and social responsibility	(in downstream area, 20% for Ulu-ulu, 40% for maintenance, 40% for social responsibility.	N/A	-
Rate of collection	Almost 100%	95% (approx. 75% in downstream)	N/A	Approx. 80%
Penalty	Stop water	No penalty (many complaints about scarcity of water in downstream)	N/A	Stop giving subsidized fertilizer

Source: JICA Project Team, based on the interview survey results to WUA members and the data from BBWS and PSDA

The use of collected fee is also indicated in the table above. The fee collected is used on the payments

[10] As far as it is from the interviews, at that time when Megawati became president, she was considered by many people to be a representative of the little and poor people. So, the impact is that many farmers felt that Megawati would defend a lot of the lower classes of society, and accordingly many farmers started thinking that the state/government must provide the needs of public facilities including irrigation water, and not impose fees from farmers related to the water.

for Mandor[11]/ Ulu-ulu, maintenance of tertiary canal, and expenses/honorarium for board members, which are the most common expenses in the 3 irrigation schemes (Mandor and Ulu-ulu are the person in charge who oversee daily water distribution).

There is a penalty for the member farmers who do not pay the water fee in 2 schemes. In Kelara Karraloe scheme, P3A leader does not allow the farmer who has not paid the fee to use water. In Kalaena scheme, P3A leader controls Kelompok-tani, which is the window to provide subsidized fertilizer, not to provide subsidized fertilizer to the farmer who has not paid the fee. In some of the P3As under Kalaena scheme, P3A members also work as members of Kelompok-tani, and thus the P3A members can control who should not receive the subsidized fertilizer.

3) Operation and Maintenance

Regarding O&M, the leaders in all the 4 schemes have received a training of operation and maintenance from BBWS, yet such training was once conducted quite a long time ago. The training was implemented back in 2009 in Kelara Karraloe scheme, 2013 in Bantimurung scheme, 2011-2012 in Lamasi, and before 2014 in Kalaena scheme. As of now, only a few members who attended the training keep the O&M manual, e.g., only Mandor keeping the manual in Kelara Karraloe, only some of the IP3A and GP3A leaders in Bantimurung scheme, no member keeping the manual in Lamasi scheme, so on.

Mandor and Ulu-ulu are the person in charge, who oversee daily water operation and maintenance in Kelara Karraloe, Bantimurung and Lamasi schemes while no Mandor and Ulu-ulu are assigned in Kalaena scheme. Mandor or Ulu-ulu controls irrigation water to distribute from the secondary canal to their tertiary canal. Concerning the cleaning of canals, it is a common practice for the 4 schemes to clean tertiary canals before the planting season. On a specific date decided, the P3A members gather and start removing sediment from their tertiary canals.

There are problems the farmers are facing in terms of operation and maintenance in the 4 schemes. First, it is the scarcity of irrigation water in many parts of Kelara Karraloe scheme and Bantimurung scheme where sediment and rubbish accumulated in the secondary canals prevent smooth water flow. In Lamasi and Kalaena schemes, the scarcity of irrigation water takes place during dry season, especially in October. In the Lamasi irrigation scheme area, due to the scarcity of water, the farmers need to raise water level in the secondary canal high enough to withdraw the water into their tertiary canals.

Second, many illegal water uses are confirmed. It is reported by members that some farmers dug holes on the embankment of the secondary canals to directly withdraw the water to his/her field and also drain the excess water from their field during flooding especially in Bantimurung scheme. Conflict on water use among users was also confirmed in Kelara Karraloe scheme, Lamasi scheme and Kalaena scheme. In Kalaena scheme, water scarcity has led to a conflict in the downstream area.

6.3 Challenges and Recommendations

Though the discussions above, there are issues that have to be undertaken and improved in order to maintain the irrigation schemes well operational and thus sustainable. Such issues are listed below, and following discussions center on the improvement/ measures to over the issues:

- ✓ Difficulties in Reflecting a Member’s Opinion in a P3A Meeting, i.e. General Assembly Meeting,
- ✓ Lack of Planning Section, and Not-clear Organizational Structure,
- ✓ Difficulty of Delivering the Water till the Tail End, and
- ✓ Large Command Area at Tertiary Level.

[11] Mondor’s role is same as that of Ulu-ulu. It is only the calling title different from their local language.

6.3.1 Difficulties in Reflecting a Member's Opinion in General Assembly Meeting

As afore-mentioned, there are stratified water users associations in accordance with the level of command area coverage in Indonesian national irrigation schemes; e.g. P3A at the level of tertiary canal, GP3A at the level of secondary canal and IP3A at the system level. A very typical character in Indonesian irrigation schemes is the seize of the minimum command area, i.e. at the level of tertiary canal. In Indonesia, typical design of a tertiary canal is set to cover 100 ha each, which is in fact quite big coverage area as compared to those of other Asian countries[12].

Worsened with the small fraction of the beneficial farmland, say as small as 0.2 ha to less than 1.0ha per farmer member, a typical P3A can do nothing but to have large number of membership as indicated in Figure 6.3.1, e.g. average 85 membership per P3A under Lamasi to as many as 507 membership per P3A under Sedadi. With this condition wherein there are so many members, it is practically impossible to hold general assembly meeting attended by all the members.

Table 6.3.1 Summary of Membership Sizes for the Surveyed Water Users Associations

Particulars	Sidorejo	Sedadi	Klambu-K	K. Karraloe	Bantimurung	Lamasi	Kalaena
Total No. of Members	45,000	32,000	33,851	11,000	7,000	20,000	20,000
Av Area per Farmer, ha	0.2	0.5	0.6	0.7	0.9	0.6	0.9
Av Area per P3A, ha	126	254.8	188.3	153	112	49	166
No. of IP3A	1	1	1	0	1	1	0
No of GP3A	8	8	4	3	6	11	3
No. of P3A	63	63	110	51	58	235	102
Av. Membership per P3A	714	507	308	216	121	85	196
Av. Membership per GP3A	5,625	4,000	5,177	3,667	1,167	1,818	6,667
Av No. of P3A per GP3A	7.9	7.9	27.5	17	9.7	21	34

Note: Av. stand for Average.
Source: Interview results to the relevant P3As by JICA Project Team

General Assembly meeting is the supreme decision-making body in the water users association, under which important issues should be raised, discussed, and agreed upon or voted for/against. By-laws also specifies that issues shall be discussed and agreed upon in the General Assembly meeting, and this provision applies not only to the P3A but also to GP3A and IP3A as well. With the huge membership, how this general assembly meeting can be held becomes a critical issue.

One solution is to set up Representatives General Assembly (GA), or can be called Board of Directors (BD) Meeting in other word, to which only representatives who lead his/her coverage irrigation area should be convened. It means there should be this Representative GA placed in between the General Assembly Meeting and General Membership, and most of the issues should be raised, discussed and voted for/against at the level of this Representative GA, while such critical issues, e.g. desolation, merge with other organizations, etc. should still be forwarded to the GA meeting. Issues forwarded to the GA and to Representative GA should first be decided at a GA meeting.

In general, under a tertiary canal, there are number of on-farm ditches, which feed each farm plot with irrigation water. Though the number of on-farm ditches depends very much on the local condition together with the maintenance level, there could be more than 10 number of on-farm ditches per tertiary canal. Therefore, first all the concerned members under each on-farm ditch shall be convened and they should select their leader who is to represent the on-farm ditch members at the level of Representative GA.

Likewise, it is obviously difficult, or rather impossible, to convene all the membership at the level of GP3A and IP3A. In the former case (GP3A), therefore, representatives of P3A should represent his/her

[12] For example, a standard design of tertiary canal in Philippines is to cover only 50 ha, and that of Myanmar is to cover 50 acre (20ha) to 100 acres (40 ha) at the maximum.

all the P3A membership at the level of GP3A GA meeting while in the latter case (IP3A), representatives of GP3A should do his/her all the GP3A membership at the level of IP3A GA meeting. Or, instead, all the representatives selected as per each tertiary canal could also represent his/her all the members under the tertiary canal at the level of GP3A GA meeting, and likewise, all the representatives selected as per each secondary canal could also represent his/her all the members under the secondary canal at the level of IP3A GA meeting (see Table 6.3.2 and Figure 6.3.1).

Table 6.3.2 Proposed Representative General Assemblies

Level of Water Users Association	General Assembly (GA)	Representatives GA
IP3A (system level)	All the members under the IP3A	Reps of GP3A, or Reps of Each Secondary Canal
GP3A (basically secondary canal level)	All the members under the GP3A	Reps of P3A, or Reps of Each Tertiary Canal
P3A (basically tertiary canal level)	All the members under the P3A	Reps of Each On-farm Canal
On-farm Ditch Group (Newly proposed)	All the members under the On-farm Ditch	No need

Source: JICA Project Team

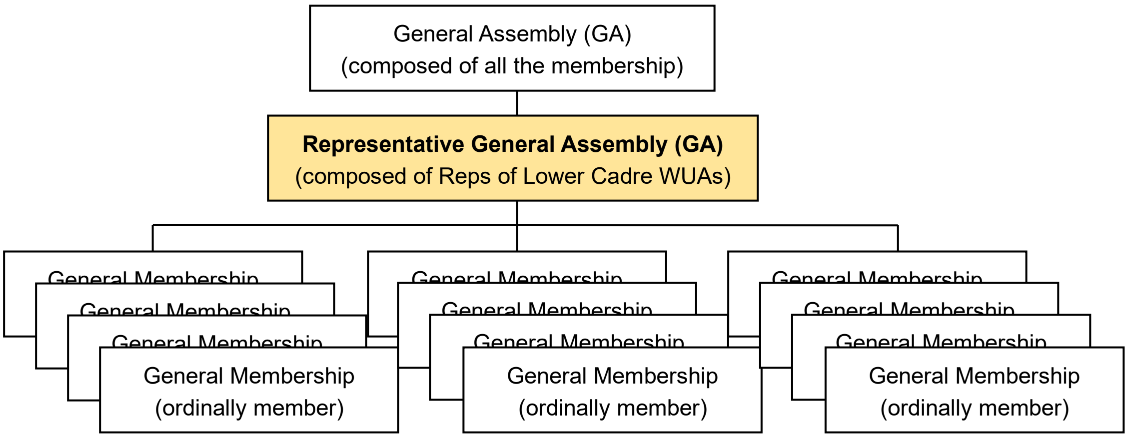


Figure 6.3.1 Proposed Representatives General Assembly in Huge WUA's Organizational Structure

Source: JICA Project Team

6.3.2 Lack of Planning Section and Not-clear Organizational Structure

In an organization, there should be three decentralized dimensions, i.e., planning, decision making, and implementation. It means that at first a plan is made in section/sub-group, and the plan is forwarded to the decision making body that is General Assembly (GA) or Representatives GA, and now the plan should be put into implementation, under supervision of a management body, by the general members who have agreed upon it in the GA (or Representative GA).

Namely, above-mentioned Planning, Decision-making and Implementation should be decentralized in an organization. This set-up is very simply understood when referring to a private company, in which a plan is usually made in a planning section, and the plan, if very important, is forwarded to the shareholders meeting, in which decision shall be made, and the agreed plan should now be implemented by the company's staff under supervision represented by the Chief Executive Officer/ Directors and managers thereunder.

However, there is a big difference in between private company and member associated organization like Water Users Association. In a private company, implementors and decision-makers are completely different, i.e., a plan is implemented by the staff under the company's directors/managers while the decision, if very important, is made by shareholders equivalent to general assembly meeting in case of WUA. In WUA, however, the decision is made by the general assembly members who at the same time are the implementors. Also, the chairperson and his/her director/management members are also a part of decision makers at the level of general assembly and also the part of implementors, though as in the position of supervision/management.

Taking into account the need of decentralizing the three aspects of organizational powers, following organizational structure is now proposed to cope with afore-mentioned issues as:

In case of P3A, our recommendation for establishing WUA is to at first organize farmers by on-farm ditch level as WUG (water users group), and several neighboring WUGs will together form a WUA, that is P3A in Indonesia, which is in conformity with a tertiary canal.

Then, we think that the most important point in terms of managing an organization is to de-centralize such functions as planning, decision making, and implementation, and therefore we should propose the structure of WUA as illustrated in Figure 6.3.1 with the following basics:

1) The base structure should be the on-farm ditch groups (called WUGs, water users groups), which are organized by each on-farm ditch water users. Each WUG should have a leader and co-leader.

2) On the other hand, the top structure in the P3A is the General Assembly (GA) composed of all the water users under the tertiary canal. This GA functions as a venue to decide most crucial issues for the organization such as budget, rules and regulations, registration/dissolution of the organization, and the level of irrigation service fee and its collection method, etc.

3) Under the GA, there should be Representative GA[13] (or may be called Board of Directors, BOD) as afore-mentioned in 6.4.1 'Difficulties in Reflecting a Member's Opinion in General Assembly Meeting'. The Representative GA should be composed of all the WUG leaders and therefore the Representative GA can represent each and every WUGs. Thus, this arrangement enables all the concerned WUGs to convey its problem/opinion to the Representative GA, which can make decisions instead of the General Assembly.

4) Under the Representative GA, 5-8 executive officials should be nominated and organized as Management Board (MB). The responsibility of the MB is the day-to-day implementation management according to the decision made by the GA or by the Representative GA. Each of the MB officials has their own duty as chairperson, vice-chairperson, secretary, treasurer, auditor, and the MB members including *Ulu-ulu*, who is responsible for O&M within the organization's jurisdictional area.

5) All planning of each specific concern should be made in the Planning Committees (PCs) placed under the MB. The committee may include financial committee, water distribution committee, and agricultural development committee, depending on their necessity. The MB officials can lead each committee as a leader: for instance, financial committee by the treasurer, water distribution committee by the Ulu-ulu, agriculture development committee by the vice chairperson, etc., and then the committee members are selected from water users who are willing to participate in each committee activities.

As mentioned above, it is proposed to introduce de-centralized power structure into the P3A; namely, planning by the PC, decision making by the GA or Representative GA depending upon the level of importance of issues, and implementation supervised by the MB. Any plan is drafted in the PC and forwarded to the GA/Representative GA for the decision, and according to the decision made by the GA/Representative GA, the implementation starts under the supervision of MB. In this arrangement, even the chairperson has only one vote in terms of decision making as a member of the General

[13] According to the current set-up of the By-laws adopted, there is Inspectors Board composed of leader and members, which is in charge of inspection of the Management Board. The Representative GA here proposed can supersede the current Inspectors Board.

Assembly, and when the implementation comes, the chairperson becomes the Chief Executive Officer (CEO) as authorized in the GA.

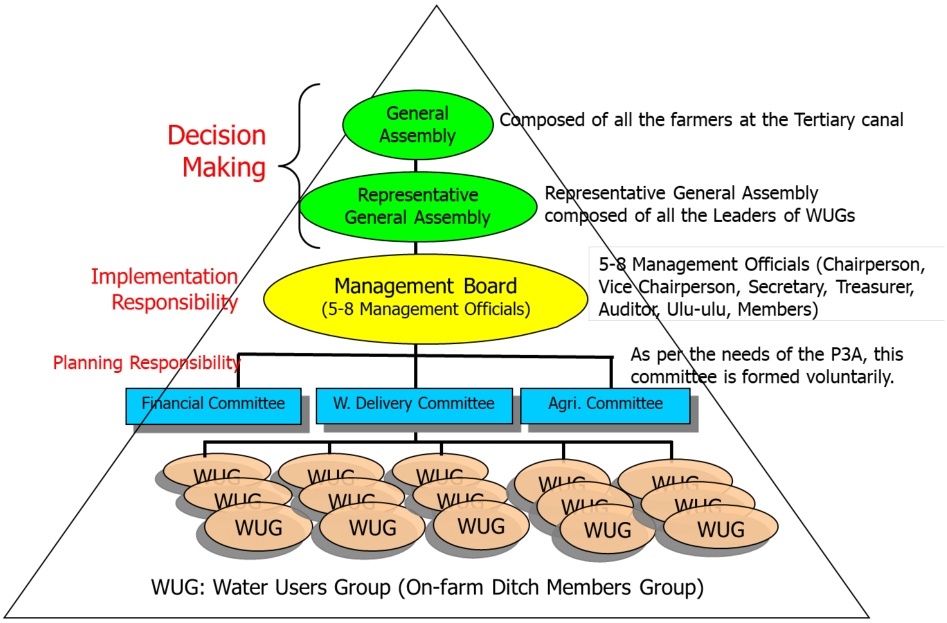


Figure 6.3.2 Proposed Structure of P3A (Water Users Association)

Source: JICA Project Team

One upper cadre of WUA from the above-discussed P3A is GP3A, which is basically established at the level of secondary canal. Membership of a GP3A surveyed by JICA team in Central Java and Sulawesi Selatan provinces reaches as many as 1,200 to over 6,000 (while, membership of a P3A ranges from 90 – 700 as discussed in 6.4.1 Difficulties in Reflecting a Member's Opinion in General Assembly Meeting). Given so many membership, same concept of P3A recommended should also be introduced in the organizational structure of GP3A, e.g.,

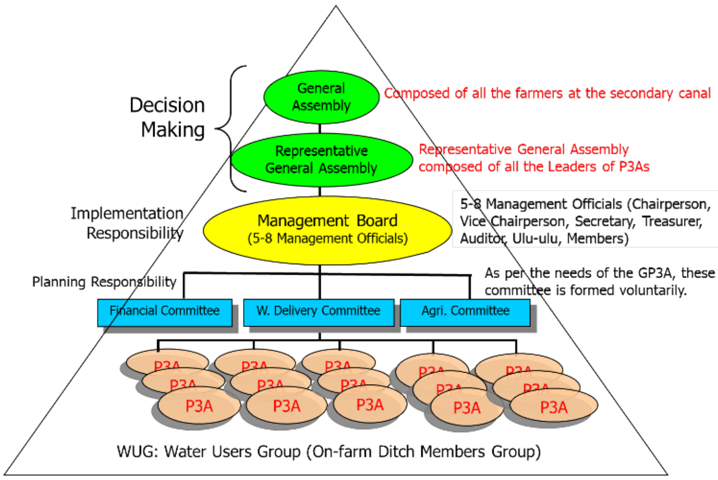


Figure 6.3.3 Proposed Structure of GP3A (Secondary C Level)

Source: JICA Project Team

- ✓ WUG in the proposed P3A (see Figure 6.3.2) should be P3A under GP3A as in Figure 6.3.3,
- ✓ Representative General Assembly should be composed of the leaders of P3A, while the General Assembly is composed of all the members under the said secondary canal (instead of tertiary canal in case of P3A), and
- ✓ Other organs within the GP3A structure can remain same as those of P3A with the same responsivity and authority of P3A.

Further one upper cadre of WUA from the above-discussed GP3A is IP3A, which is basically established at the main canal level or system level. Membership of an IP3A is in fact too huge, ranging from 7,000 to 45,000 in case of IP3As surveyed in Central Java and Sulawesi Selatan provinces (while, membership of a GP3A ranges from 1,200 – 6,000). With so huge membership, it seems not possible not only to call upon General Assembly meeting but also just to administer day-to-day O&M activities.

Therefore, it is recommended for the IP3A to organize only for the purpose of making coordination among GP3As and also with the B/BWS. Thus, the members of the IP3A can merely be the leaders of GP3As, and the chairperson of IP3A can be selected amongst GP3A leaders. It means for the IP3A that no general assembly, no representative GA, no management board as well as no planning committees are required as day-to-day operation and management are administered at the levels of GP3A and P3A.

6.3.3 Difficulty of Delivering the Water till the Tail End

Disparities in supplying water to the farmers along a canal are not only due to the physical problems of reaching the tail of long canals but also may be caused by a farmers' relentless behavior. Upstream farmers have no incentive to use less water in the absence of strong organizational norm for the management of the system under their jurisdiction. Thus, they leave turnout gates fully open to withdraw as much water as possible at all times.

Organizational norm or operational principle within the P3As and GP3As should be strengthened in order to rectify the situation illustrated right. Then, to strengthen the norm and make the operation principle function, the first step is to establish or re-organize a WUA according to the discussion under '6.3.2 Lack of Planning Section and Not-clear Organizational Structure', in order to respond above situation.

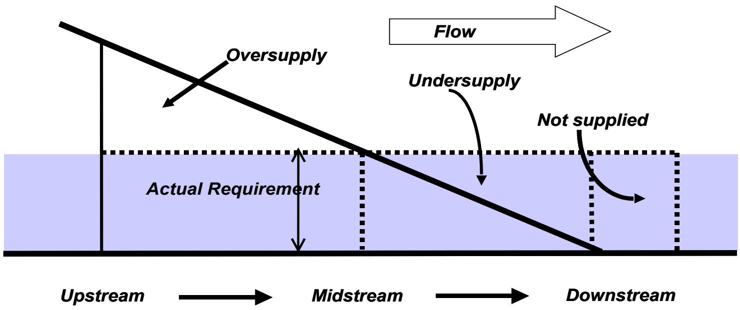


Figure 6.3.4 Typical Inequitable Water Supply along a Canal
Source: JICA Project Team

When the farmers are well responsible of operating the system under their jurisdiction, above situation would improve, because under user own management responsibility, tampering with water distribution becomes very difficult. While other farmers might tolerate thefts of 'government' water, when the water supply is allocated to the collectivity of the farmers, any theft of water implies stealing from fellow farmers. Clear responsibility of system O&M within their responsible area would make overuse by the fellow farmers very difficult.

If the water availability is inadequate, simply because there is inadequate supply, then there is clear limit to satisfy the farmers. However, even if the quantity is not enough, the farmers would have no way, but agree and share as far as the scarce water is equitably distributed. The responsibility of O&M of the system within their responsible area can create good will to realize equitable distribution. With this, an idea of starting plantation from the tail end of a canal, then going upstream of the canal, can be agreed by the member farmers, which definitely contributes to equitable water distribution, thus equitable benefit.

6.3.4 Large Command Area at Tertiary Level

Typical tertiary canals are exampled in the following photos. One of the typical characters in Indonesian national irrigation schemes is, as afore-said, its large commend area of a tertiary canal, e.g. from 49 ha in case of Lamasi irrigation system (Sulawesi Selatan province) to as large as 255 ha in case of Sedadi irrigation system (Central Java province) amongst the irrigation systems surveyed by the JICA team. There is obviously a difficulty in managing such big area from the both viewpoints of organizational aspect (refer to the discussions in Sub-chapter 6.4.1) and water equitable distribution aspect.


Photo Left: A Typical Lined Tertiary Canal (Central Java), Photo Right: A Typical Earthen Tertial Cana (West Java)

Worse further, there are farmers who directly pump up irrigation water from the secondary canal located beside his/her farm plots or even from the primary canal. Such direct water-take from others than tertiary canal is not principally allowed in the national irrigation systems, but there are in fact certain number of such cases. This case is found and often aggravated with scarce network of tertiary canal that has to deliver water over 100 ha area or even more wider areas in many cases. To rectify this situation, there may be two measures as;

1) Establishment of additional tertiary canal(s), and
2) Establishment of well-networked on-farm ditches, and probably the combination of 1) and 2).

Standard design of tertiary canal in Indonesia has long practiced 100 ha of command coverage area per tertiary canal, and therefore it may be difficult to reduce this standard 100 ha coverage per tertiary canal by dividing into 2 to 3 smaller block areas. However, as a matter of fact, there are many tertiary command areas whose coverages are more than the standard of 100 ha, i.e., 5 irrigation schemes among total 6 systems surveyed by the JICA team have an average area of more than 100 ha at the tertiary level (see Table 6.4.1). Therefore, it is recommended that:

1) At least a tertiary command area more than 200 ha should be divided into two blocks by additionally constructing one more tertiary canal, and
2) It could be better to do it above 1) in case of more than 150 ha command area.

There is one issue in constructing additional tertiary canals. The tertiary canal is basically the beneficiary farmers' property, and therefore the Government, B/BWS in this case, is in the position of assisting and helping the farmers in improving their property. It means that the B/BWS does NOT principally provide fund for the purpose of constructing additional tertiary canals, nor does land acquisition.

Then, in fact, there may be funds provided to the beneficiary farmers from the Ministry of Agriculture, who is basically in charge of on-farm development, and/or local government. Further, the Ministry of Agriculture's regional office or local government office may construct the additional tertiary canals on behalf of the beneficiaries. However, even in such case, no land acquisition is compensated by the government offices, and therefore land acquisition shall be arranged by the beneficiary farmers.

Land to be occupied by a tertiary canal is not so big, say about 1.0-2.0 m width enough to lay down the tertiary canal. Yet, as the farmers holding areas are very small, very often less than 0.5 ha per farmer (see Table 6.3.1 above), no farmers want to surrender a part of his/her farm plot voluntarily. Therefore, local government office or Ministry of Agriculture's regional officer should facilitate the relevant farmers to make some financial contributions to the farmers whose land will partly be occupied by the new additional tertiary canal.

Such arrangement should also be made in constructing on-farm ditches. On-farm ditches are basically earthen made ditches, and can be constructed by farming tools, e.g. hoe. A typical on-farm ditch is to occupy only about half a meter to max. 1.0 m width. Therefore, fund arrangement for the construction may not be required but still there should be a need of making financial contribution for the land acquisition to the farmers whose lands are to be partly occupied by the on-farm ditches.

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

This Project has formulated Irrigation Development and Management Strategy with the target year of 2044 as elaborated in Part I of this report, and further undertook preliminary feasibility study on the prioritized 4 areas such as Lampung province (BBWS Mesuji Sekampung), Kalimantan East province (BWS Kalimantan I), Central Java province (BBWS Pemali Juana) and South Sulawesi province (BBWS Pompengan Jeneberang). The former 2 areas envisage new irrigation development while the later 2 areas are to undertake rehabilitation and also modernization of existing irrigation schemes.

All the 4 prioritized areas have been studied from technical and economic points of view, and concluded to be feasible to implement based on the results of the preliminary feasibility study. The Government of Indonesia should, with reference to the points summarized below, start internal discussions as well as consultations with potential donors engaged in irrigation development sector on which ones out of the 4 priority areas should be put into implementation first, and then which area be the next, so on. Upon the discussions and decision made, the Government should embark on the next step, which is the Feasibility Study for the top priority area(s), possibly in collaboration with donor(s).

1) The government of Indonesian has implemented irrigation development since long time ago. However, even with the large irrigated area so far developed, self-sufficiency of rice has not been achieved yet, and food security is one of the government national top priority issues. With this as background, there is due need of developing new irrigated areas for paddy production, and identified 2 areas, i.e., Lampung province and Kalimantan East province, present huge new development potential. In the former province, a huge area of as much as about 57,000 ha (net) can be secured in one place to develop, that is an extension area of Komering irrigation scheme, and the latter province provides approximately total 54,000 ha (net) of new development potential composed of 3 sub-areas (KT2, KT31&KT32, and KT4).

2) Irrigation development has, as afore-mentioned, long been implemented in Indonesia firstly focusing on Java island and then Sulawesi island. In these islands, areas where irrigation development has more been implemented can be found, for example, in the central part of Java island and southern part of Sulawesi island. In there, many irrigation facilities have been aged and need rehabilitation. In the Central Java province, total 11 irrigation schemes (total 134,000 ha) have been identified while total 5 schemes (total 49,800 ha) identified in South Sulawesi for the rehabilitation purpose, including modernization in Central Java. These identified irrigation schemes will improve their performance with the rehabilitation works completed.

3) According to the preliminary economic evaluation analysis, such base EIRRs have been obtained as; 10.68% for the new irrigation development project in Lampung province, 13.62% for the new irrigation development project in Kalimantan East province, 16.14% for the rehabilitation/ modernization project in Central Java province and 11.68% for the rehabilitation project in South Sulawesi province. Although these economic evaluation results are preliminary ones, still there is a justification in investing the project cost to realize the project benefit from the view point of economic return as the EIRRs are more than 10%, the commonly applied opportunity cost of investment.

7.2 Recommendations

1) **Need for Feasibility Study;** The Part II of this report presented preliminary feasibility study results on the priority 4 areas, 2 areas for new irrigation development and 2 areas for rehabilitation including modernization. Though the planned development and rehabilitation projects were all judged feasible in economic term through economic evaluation based on EIRR, prior to putting the

program(s) into implementation, a feasibility level study and detail plan formulation, including disbursement arrangement in case of the project to be loan-assisted, should be carried out taking into all the aspects such as technical soundness, financial viability, economic viability, environmental and social consideration, and institutional set-up, etc.

2) **Environmental and Social Consideration;** Land opening and reclamation are required for the new irrigation development areas of Lampung province and Kalimantan East province. In fact, most of the current land use for these areas are bush and shrub, forest, individual basis plantation, marsh land, etc. Opening up of the lands and conversion into irrigated paddy fields entail big changes of natural environment, and thus environmental assessment should be fully carried out, i.e., according to JICA guideline, the project will be categorized as 'A' which is likely to have significant adverse impacts. Further, the project will require resettlement program, in which beneficiaries are to be invited as settler. Social consideration should also be taken into account, and Resettlement Action Plan (RAP) should be prepared.

3) **Concession Area of Plantation for Kalimantan East Province:** The potential new development area for Kalimantan East is 54,000 ha (net), and to obtain this large area, the plantation concession area not yet planted are considered to be able to develop for the irrigation purpose (note that already planted concession areas were excluded in the beneficial area). Therefore, the plantation concession areas not yet planted should be changed to develop-able area through negotiations with the private companies granted with the concessions. In fact, of the area of 54,000 ha, the concession area not yet planted occupies as much as 31,500 ha, and hence without changing the land use regulation, no such large area of 54,000 ha can be secured.

4) **Plantation Area for Lampung Province:** For the new development of Lampung province, the GIS analysis found that the Komering Extension Area No.4-1 may extend over 70,000 ha, and could be enough to secure the net area of 57,000 ha. However, there should be a need of knowing the extents/existence of plantation of sugarcane and palm as much exactly as possible (ATR/BPN data does not show any plantation area, but in fact there are many sugarcane and palm areas as detected by Google Earth). The Team has delineated the sugarcane and palm plantation areas using Google Earth images, which would include some errors. Therefore, the feasibility study for the Lampung province, identification of plantation areas should be included.

5) **Rehabilitation and Modernization Project with Higher Priority:** Rehabilitation projects planned in South Sulawesi province and Central Java should be given higher priority than those of new development. This is because rehabilitation projects entail less negative environmental impacts, nor social negative impact. Also, benefit will accrue in much faster speed as compared to the new development of irrigation project. Modernization does the same, and as a matter of fact, the modernization project planned for the 3 irrigation systems in the Central Java province could be a model, which can be referred to in many existing projects upon rehabilitation completed.

PART III

Irrigation and Drainage Technology Exchange

CHAPTER 1 1ST EXCHANGE PROGRAM (FEBRUARY 19-22, 2019)

In this Project, in addition to the formulation of med-term and long-term strategies for irrigation development and management, technical exchanges between irrigation officials from Japan and Indonesia were conducted. The technical exchange was aimed at deepening understanding of irrigation management in both countries through direct dialogue among Japanese Land Improvement District officials, Indonesian government officers, and water users' association members under the theme of "Efficient Water Distribution and Water Use Coordination".

This chapter outlines the 1st irrigation and drainage technical exchange program between Japan and Indonesia. This exchange is carried out in cooperation with Directorate General of Water Resources (DGWR), Ministry of Public Works and Housing, Indonesia and Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan, with the theme of "efficient water distribution and water use". The 1st technical exchange program composed of a seminar in Jakarta and field visit in Sidorejo, Central Java, and Japanese delegates exchanged opinions with DGWR, Central Java Irrigation Committee and Water Users Association (P3A).

1.1 Objective

Under the program, experiences in Japan and Indonesia in the field of irrigation and drainage management can be exchanged, and therefore both sides can share and learn each other their experiences. Hence, the objective of the program is to enrich their future activities, especially in term of effective irrigation water distribution/ utilization and water use allocation among stakeholders in both countries.

1.2 Overall Schedule and Activities for Japanese Delegates

The composition of delegates dispatched from Japan is as shown in Table 1.2.1. In addition, 4 officers from MAFF (including Director, Overseas Land Improvement Office, Rural Development Bureau), 1 officer from Ishikawa Prefecture, 2 officers from Iwate and Nagano Prefectural Federation of Land Improvement Associations had joined this mission.

Table 1.2.1 List of Japanese Delegates for 1st Technical Exchange

Name	Mr./Ms.	Title	Organization/Division, Directorate
Takuji Tanaka	Mr	Executive Technical Advisor to the Director General, Rural Development Department, Japan International Cooperation Agency (JICA)	JICA
Yaichi Kobayashi	Mr	Director-General, National Federation of Land Improvement Associations	National Federation of Land Improvement Association
Yukio Kobayashi	Mr	Director-General, Technique Department, Niigata Prefectural Federation of Land Improvement Associations	Niigata Pref. Federation of Land Improvement Association
Tadashi Ibayashi	Mr	President, Taisetsu Land Improvement District (LID)	Taisetsu LID
Noboru Shimoyama	Mr	Director-General, District's Secretariat, Ogata Land Improvement District (LID)	Ogata LID
Nobuyuki Fukuda	Mr	Managing Director, Toban Yosui Land Improvement District (LID)	Toban-yosui LID

Source: JICA Study Team (2019)

The program was carried out during the five days from February 18 to 22, 2019. Table 1.2.2 shows the overall schedule for the program of 1st technical exchange. On February 19, a technical exchange seminar was held at the DGWR in Jakarta. From February 20 to 21, the field visit at the Sidorejo irrigation scheme, Central Java, and opinion exchange had been conducted with concerned personnel such as local officers from BBWS (Pemali Juana Ricer Basin Organization) and Central Java Irrigation Committee and also P3A members of Sidorejo irrigation scheme.

Table 1.2.2 Overall Schedule for the Mission of 1st Technical Exchange

Date	Schedule	Stay
18 Feb (Mon)	Tokyo Haneda (10:20) → Jakarta (16:15)（NH855） Arrival in Indonesia	Jakarta
19 Feb (Tue)	a.m. Technical Exchange Seminar at DGWR, PU p.m. Move to Semarang Jakarta (17 :20) →Semarang (18:35) (GA244)	Semarang
20 Feb (Wed)	Field visit (Sedadi weir, Sidrejo Irrigation Scheme etc.) Discussion with P3A	Semarang
21 Feb (Thu)	a.m. Workshop with Irrigation Commission at Hotel Santika Premiere p.m. Move to Jakarta Semarang (17:45) → Jakarta (18:55) (GA245) p.m. Move to Tokyo Jakarta (21:45) → Tokyo Haneda (6:50) (NH856)	
22/2/2019 (Fri)	Arrival at Tokyo	

Source: JICA Study Team (2019)

1.3 Technical Exchange Seminar

Technical exchange seminar was held on February 19, 2019 at DGWR HQs. Table 1.3.1 shows the agenda of technical exchange seminar. This seminar consisted of two sessions. Session 1 had two presentations from Indonesian side; "Rehabilitation and Development of Irrigation to Support Food Security" by the Director of Irrigation and Lowland (DIL), DGWR and "Operation and Maintenance of Irrigation" by the Director of Operation and Maintenance, DGWR.

Session 2 had two presentations from Japanese side: "Efficient Operation for Water Distribution and Water Use Adjustment in LID" by the president of Taisetsu LID and "Role and Action for Appropriate Irrigation Management in Local Government in Japan" by an expert of Agricultural Infrastructure from Ishikawa Prefecture.

Technical exchange seminar

There was a fruitful exchange of opinions during the seminar, and in particular, the Indonesian side requested to share the experiences of Japan's efforts regarding regulations on agricultural land conversion, which is currently a priority issue arising in Indonesia.

Table 1.3.1 Agenda for Technical Exchange Seminar on February 19, 2019

Time	Agenda	Meeting Room
9:30-9:35	Opening remarks and Greetings by a) Mr. Hari Suprayogi, Director General of Water Resource, Ministry of Public Works and Housing, Indonesia b) Mr. Mitsuo Ishijima, Director Overseas Land Improvement Office, Rural Development Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan c) Mr. Takuji Tanaka, Executive Technical Advisor to the Director General, Rural Development Department, Japan International Cooperation Agency	DGWR Meeting Room (2nd floor)
9:35-9:55	Rehabilitation and Development of Irrigation to Support Food Security by Director of Irrigation and Lowland	
9:55-10:15	Operation and Maintenance of Irrigation by Director of Operation and Maintenance	
10:15-10:30	Q&A Discussion	
10:30-10:50	Efficient Operation for Water Distribution and Water Use Adjustment in LID by President of Taisetsu Land Improvement District	
10:50-11:10	Role and Action for Appropriate Irrigation Management in Local Government in Japan by Expert of Agricultural Infrastructure Division, Ishikawa Prefecture	
11:10-11:30	Q&A Discussion	
11:30-12:00	Closing Remarks and Photo Session	

Source: JICA Study Team (2019)

1.4 Field Visit

The field visit was conducted in Semarang, Central Java on a two-day trip from February 20 to 21, 2019. Table 1.4.1 shows the agenda for the field visit. On the first day, an on-site visit was conducted at Sedadi and Sidorejo irrigation schemes and discussions about the activity of irrigation water management were done among the participants including local farmers, P3A, and officers from the province and BBWS.

On the second day, a workshop-style meeting was held in Semarang city. The Indonesian side presented “Role of Irrigation Commission of Central Java Province” by Kepala Dinas PU SDA TaRu Central Java Province and “Role of BBWS Pemali Juana for Irrigation Operation and Maintenance” by O&M Division, BBWS Pemali Juana, and the Japanese side presented “Role of the Prefectural Land Improvement Associations in Irrigation and Drainage Facility Management” by the DG of Technique Department, Niigata Prefectural Federation of Land Improvement Associations.

Table 1.4.1 Agenda for Field Visit in Semarang, Central Java from February 20 to 21, 2019

Date	Time	Agenda	Location
19 Feb	18:35	Arrived at Semarang Airport	Hotel Santika
20 Feb	8:00-10:00	Going to Sedadi Irrigation Area	Sedadi and Sidorejo Irrigation Area
	10:00-10:25	Sedadi Irrigation Infrastructure field visit	
	10:25-11:25	Going to Sidorejo Irrigation Area	
	11:25-12:00	Sidorejo Irrigation Infrastructure field visit	
	12:00-13:00	Lunch Break	
	13:00-13:30	Presentation of Sidorejo Irrigation area by BBWS Pemali Juana and P3A a) Role of Sidorejo IP3A b) Water distribution at Sidorejo and Sedadi Irrigation areas c) Outline of Sidorejo Irrigation Area	
	13:30-14:30	Q&A Discussion with Sidorejo WUA & IP3A	
	14:30-17:30	Going back to Semarang City	
21 Feb	9:00-9:45	Opening remarks and Greetings by a) Head of BBWS Pemali Juana b) Kepala Dinas PU SDA TaRu Central Java Province c) Mr. Yuichi Kobayachi, DG National Federation of Land Improvement Associations	Hotel Santica
	9:45-10:05	Role of Irrigation Commission of Central Java Province by Kepala Dinas PU SDA TaRu Central Java Province	
	10:05-10:25	Role of BBWS Pemali Juana for Irrigation Operation and Maintenance by O&M Division, BBWS Pemali Juana	
	10:25-10:45	Role of the Prefectural Land Improvement Associations in Irrigation and Drainage Facility Management by Mr. Yukio Kobayashi DG Technique Department, Niigata Prefectural Federation of Land Improvement Associations	
	10:45-11:15	Q&A Discussion	
	11:15-12:15	Lunch	
	12:15-13:00	Wrap-up meeting	
	13:00-14:00	Going back to Semarang Airtport	

Source: JICA Study Team (2019)

1) Sidorejo Irrigation Scheme

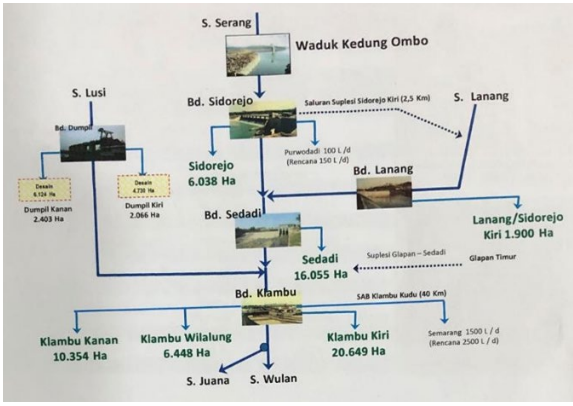
Table 1.4.2 shows the outline of the irrigation scheme for the Kedung Ombo Dam. The Sidorejo Irrigation Scheme is with a beneficiary area of 7,938 ha and irrigation water is taken from the Serang River via Siderejo weir. The Sedadi Irrigation Scheme is with a beneficiary area of 16,055 ha, and irrigation water is taken from both Serang and Lanang Rivers via Sedadi weir (see photo right).

Sedadi weir

The current cropping pattern in Sidorejo Irrigation Scheme is paddy - paddy or parawija - palawija, which means planting three times a year. Currently, rehabilitation of canals is on-going, and the cropping intensity is now 220%, but it will be increased up to 275% upon the rehabilitation completed according to the plan.

Table 1.4.2 Outline of Irrigation Schemes for Kedung Ombo Dam

Sidorejo Irrigation Scheme	Cropping pattern	Paddy – Paddy / Palawija – Palawija
	Area	6,038 hectare
	IP	220 %
	Number of farmers	65.000 household
Sedadi Irrigation Scheme	Cropping pattern	Paddy – Paddy / Palawija – Palawija
	Area	16.055 hectare
	IP	230 %
	Number of farmers	33.785 household
Klambu Irrigation Scheme	Cropping pattern	Paddy – Paddy / Palawija – Palawija
	Area	38.745 hectare
	IP	230 %
	Number of farmers	65.000 household
Total Service Area		**62.738 hectare**



Source: BBWS Pemali Juana (2019)

2) P3A of Sidorejo Irrigation Scheme

Under Sidorejo Irrigation Scheme, there are 70 P3A, which are further grouped into 7 GP3A. Sidorejo Integrated Water Use Association (IP3A) supervises these 7 GP3As. The main roles of P3A are to determine cropping systems and cropping plans, gatekeeping, and farm management. It has a management area of 18,000 farmers and 0.25-0.3 ha per farmer.

The collection levy for irrigation water is 24,000 rupiah/year/farmer, and the collection is utilized for the construction and development (70%), wages (10%), compensation (12.5%) for executives, and training (7.5%). P3A's major issues regarding irrigation water include water stealing, illegal water intake (pump-up), unequal distribution of irrigation water to the downstream, and the number of people who maintain and manage canals is decreasing. In addition, farming issues include pests and diseases, high fluctuation of crop prices, and difficulty in capital investment.

3) Irrigation Commission of Central Java Province

The Irrigation Commission, established by a governor's decision, is a commission composed of government officials and also P3A members, etc., under the head of the Provincial Regional Development Planning Agency. Irrigation Commission of Central Java Province has 40 members. The Provincial Irrigation Commission plays a role as a coordinating body for water use and performs various tasks such as formulation of a policy to maintain and improve irrigation conditions and functions; formulation of an annual plan for the supply and distribution of water for irrigated agriculture.

In Central Java, many disasters have occurred and are a threat to irrigation facilities. Urban infrastructure such as highways also adversely affects agricultural activities. Industrial development is progressing in the western part of the province, and securing industrial water is an issue, while meager rainfall on the eastern part of the province, and securing of the entire water resource are also an issue.

Presentation of IP3A

4) Observation of Japanese Delegates

Through field visits, the delegation from Japan was impressed by the high-quality level of construction (such as the lining of tertiary canals) and the high motivation of concerned stakeholders in irrigation water management in Indonesia. In-depth discussions were also held as the actual condition of farm management was confirmed with farmers, P3A, and Province and BBWS officers. Recommendations for "Efficient water distribution operation and water use adjustment" set as the theme this time are as follows:

- ✓ In order to improve the efficiency of water distribution in major hydraulic facilities such as dams and weirs, systematic data collection and analysis should be performed, and each data should be collected at one place. It is desirable to introduce a modernized water management system.
- ✓ In order to improve the efficiency of water distribution in the tertiary canals, for design and construction, it may be necessary to take measures such as out-sourcing to province and/or training for farmers.
- ✓ In order to improve the efficiency of water distribution at on-farm level, it is espected to investigate the water supply and demand in accordance with the farming system and to build an ideal water distribution model with the cooperation of the Ministry of Agriculture.

CHAPTER 2 2ND EXCHANGE PROGRAM (AUGUST 5-9, 2019)

This chapter outlines the 2nd irrigation and drainage technical exchange between Japan and Indonesia. This exchange is carried out in cooperation with DGWR, Indonesia and MAFF, Japan, with the theme of "efficient water distribution and water use". The 2nd technical exchange program composed of a seminar and a field visit in Hokkaido, and Indonesian delegates exchanged opinions with MAFF and Taisetsu LID, etc.

2.1 Objective

Under the program, experiences in Japan and Indonesia in the field of irrigation and drainage management can be exchanged, and therefore both sides can share and learn each other their experiences. Hence, the objective of the program is to enrich their future activities, especially in term of effective irrigation water distribution/ utilization and water use allocation among stakeholders in the both countries.

2.2 Overall Schedule and Activities for Japanese Delegates

The composition of delegates dispatched from Indonesia is as shown in Table 2.2.1:

Table 2.2.1 List of Indonesian Delegates for 2nd Technical Exchange

Name	Mr./Ms.	Title	Organization/Division, Directorate
MOHAMAD KOTRA NIZAM LEMBAH (Mission Leader)	Mr.	Head of Sub-directorate of Operation and Maintenance of Irrigation and Lowland,	Directorate of Operation and Maintenance, DGWR (Directorate general of water resources)– MPWH (Ministry of Public Works and Housing)
ARIFA NALENDRA	Mr	Head of Sub-division of Organization	Secretariat General of Ministry of Public Works and Housing
ZALDI RONALD DIMYADI	Mr	Head of Section of Reservoir, Pond, and Coastal Maintenance	Department of CKPSDA (Infrastructures and Water Resources Management), Lampung Provincial Government
DIAH ASRI SAWITRI	Ms	Head of Section of Irrigation System Operation	Agency of PUSDA (Public Works and Water Resources) East Java Provincial Government
IRAWAN INSAN WIDODO	Mr	Head of Section of Irrigation and Raw Water O&M	Agency of PUSDATARU (Public Works and Water Resources and Spatial Planning), Central Java Provincial Government
LESTY ARLENSIETAMI	Ms	Junior Irrigation Technician	BBWS (River Basin/Territory Organization) Pemali Juana
MUHAMMAD ARDIANSYAH	Mr	Water Resources Management Assessor	Directorate of Operation and Maintenance, DGWR, MPWH
BUDI MUHAMMAD HABIBI	Mr	Water Resources Management Assessor	Directorate of Irrigation and Lowland, DGWR, MPWH
WARDI	Mr	Chairman	Tirta Aji Water User Association (P3A)
SURATMIN	Mr	Secretary	Tirta Aji Water User Association (P3A)

Source: JICA Study Team (2019)

The program was carried out during the five days from August 5 to 9, 2019. Table 2.2.2 shows the overall schedule for the program of 2nd technical exchange. On August 6, a technical exchange seminar was held at the JICA Headquarters in Tokyo. From August 7 to 8, a field visit at the Taisetsu LID, Hokkaido, and opinion exchanges had been conducted with concerned personnel including Taisetsu LID representatives and MAFF officials.

Table 2.2.2 Overall Schedule for the Mission of 2nd Technical Exchange

Date	Schedule	Stay
5 Aug (Mon)	・Departure from Jakarta ・Arrive in Tokyo	Tokyo
6 Aug (Tue)	a.m ・Courtesy call to MAFF ・Policy Dialogue (Luncheon style) at MAFF, Tokyo p.m. ・Technical exchange seminar at JICA Head Quarter, Tokyo	Tokyo
7 Aug (Wed)	a.m. ・Move to Hokkaido by Air p.m. ・Arrive in Hokkaido ・Site visit to Kamikawa Rice Processing Center	Hokkaido

Date	Schedule	Stay
	・Visit to Taisetsu LID	
8 Aug (Thu)	a.m. ・Field visit p.m. ・Field visit (cont.) ・Departure from Hokkaido ・Arrive in Tokyo	
9 Aug (Fri)	・Arrive in Jakarta	

Source: JICA Study Team (2019)

2.3 Technical Exchange Seminar

Technical exchange seminar was held on August 6, 2019 at JICA Headquaters. Table 2.3.1 shows the agenda of technical exchange seminar. This seminar consisted of two sessions. Session 1 had two presentations from Japanese side; "Study on the efficient water use management using telemetering system" by the Director of Agriculture Development Consultants Association and "Efficient water distribution and water use" by the Director General of O-gata LID.

Technical exchange seminar

Session 2 shared two presentations from Indonesian side; "Irrigation management in Indonesia" by the Head of Sub-directorate of Operation and Maintenance of Irrigation and Lowland, Directorate of Operation and Maintenance, DGWR, and "Role of BBWS Pemali Juana for irrigation operation and maintenance" by a Junior Irrigation Technician of BBWS Pemali Juana.

Table 2.3.1 Agenda for Technical Exchange Seminar on August 6, 2019

Time	Agenda	Meeting Room
14:00-14:15	Opening remarks and Greetings by a) Mr. Mitsuo Ishijima, Executive Technical Advisor to the Director General, Rural Development Department, JICA b) Mr. MOHAMAD KOTRA NIZAM LEMBAH, Head of Sub-directorate of Operation and Maintenance of Irrigation and Lowland, Directorate of Operation and Maintenance (DOM), DGWR, PUPR	JICA HQ Meeting Room
14:15-14:45	Study on the efficient water use management using telemetering system by Director of Agriculture Development Consultants Association (ADCA)	
14:45-15:15	Efficient water distribution and water use by Director General of O-gata LID	
15:15-15:45	Coffee Break	
15:45-16:15	Irrigation management in Indonesia by Head of Sub-directorate of Operation and Maintenance of Irrigation and Lowland, DOM, DGWR, PUPR	
16:15-16:45	Role of BBWS Pemali Juana for irrigation operation and maintenance by BBWS Pemali Juana	
16:45-17:00	Q&A Discussion	
17:00-17:10	Reviews by; a) Mr. MOHAMAD KOTRA NIZAM LEMBAH, Head of Sub-directorate of Operation and Maintenance of Irrigation and Lowland, DOM, DGWR, PUPR b) Mr. Yuichi Kobayachi, DG National Federation of Land Improvement Associations	
17:10	Closing remark by Mr. Kenji Miyakawa, Director Overseas Land Improvement Office, Rural Development Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan	

Source: JICA Study Team (2019)

2.4 Field Visit

A field visit was conducted in Asahikawa, Hokkaido on a two-day trip from August 7 to 8, 2019. Table 2.4.1 shows the agenda for the field visit. On the first day, a site visit was conducted at Kamikawa Rice Processing Center and Taisetsu LID (LID irrigation management office) and discussions among the participants had been done. On the second day, a field visit to irrigation facilities including Chikabumi head works, main canals, etc. had been conducted.

Table 2.4.1 Agenda for Field Visit in Asahikawa, Hokkaido from August 7 to 8, 2019

Date	Time	Agenda	Location
Aug 7	12:10	Arrived at Asahikawa Airport	Asahikawa, Hokkaido
	12:50-13:30	Lunch Break	
	13:30-14:10	Going to Kamikawa Rice Processing Center	
	14:10-14:40	Kamikawa Rice Processing Center	
	14:40-14:55	Going to Taisetsu LID	
	14:55-16:55	Taisetsu LID site visit a) Outline of Taisetsu LID b) Outline of Water Management System (Agricultural irrigation system and facility overview, functions of each facility, maintenance and operation methods, etc.) c) Site visit for monitoring system in the office (status of images and water level data transmitted from the facility, effects of monitoring system, etc.)	
	16:55	Going back to Hotel	
Aug 8	8:40-9:30	Going to the Pippu irrigation scheme	
	9:30-10:10	Pippu main canal (Overview of float type water level adjustment gate and water level monitoring system) field visit	
	10:10-11:00	Chikabumi Head Works field visit	
	11:00-11:30	Chikabumi main canal and Paddy field art field visit	
	11:30-12-15	Lunch Break	
	12:15-13:15	Maruyama regulating reservoir field visit	
	13:15-13:55	Kitano irrigation scheme (land consolidation, pipeline system) field visit	
	13:55-14:15	Chikabumi tertiary canals field visit	
	14:15-15:15	Going to the Airport	
	16:25	Going back to Tokyo	

Source: JICA Study Team (2019)

During the field visit, Indonesian delegation and Japanese side actively exchanged opinions. For “Efficient water distribution and water use”, which is the theme of this technical exchange, there was a strong interest on the remote monitoring system (monitoring system for images and water level data transmitted from irrigation facilities) equipped in LID offices, and on the floating water level adjustment gates in canals. It seemed to be recognized that it is reasonable to introduce such kind of technology into Indonesian irrigation systems as a technology for delivering irrigation water properly.


Rice Processing Center

It was also impressive that the delegates from P3A, who are also farmers, were strongly interested in the rice processing center's efforts applying new technologies of rice selection and distribution systems to add value of rice to respond consumer needs.

CHAPTER 3 3RD EXCHANGE PROGRAM (NOVEMBER 25-29, 2019)

This chapter outlines the 3rd irrigation and drainage technical exchange between Japan and Indonesia. This exchange is carried out in cooperation with DGWR, Indonesia and MAFF, Japan, with the theme of "efficient water distribution and water use". The 3rd technical exchange program composed of a seminar in Jakarta and field visit in Surakarta, Central Java, and Japanese delegates exchanged opinions with DGWR, Central Java Irrigation Committee and Water Users Association (P3A).

3.1 Objective

Under the program, experiences in Japan and Indonesia in the field of irrigation and drainage management can be exchanged, and therefore both sides can share and learn each other their experiences. Hence, the objective of the program is to enrich their future activities, especially in term of effective irrigation water distribution/ utilization and water use allocation among stakeholders in the both countries.

3.2 Overall Schedule and Activities for Japanese Delegates

The composition of delegates dispatched from Japan consisted of four from the National and Prefectural LID associations and two from JICA, a total of six team members, and two officers from the MAFF accompanied the team including deputy director of Overseas Land Improvement Office, Rural Development Bureau (see Table 3.2.1).

Table 3.2.1 List of Japanese Delegates for for 3rd Technical Exchange

Name	Mr./Ms.	Title	Organization/Division, Directorate
MORII HIDEYUKI	Mr.	Director of Planning Research Division and Director of LID PR Center	National Federation of Land Improvement Associations
KOBAYASHI YUKIO	Mr.	Director-General	Technique Department, Niigata Prefectural Federation of Land Improvement Associations
SHIMOYAMA NOBORU	Mr.	Director-General	District's Secretariat, O-gata Land Improvement District
FUKUDA NOBUYUKI	Mr.	Director-General	Toban Yosui Land Improvement District
ISHIJIMA MITSUO	Mr.	Executive Technical Advisor to the Director General	Rural Development Department, JICA
TOGO CHISA	Ms.	Staff Officer	Rural Development Department, JICA

Source: JICA Study Team (2019)

The program was carried out during the five days from November 25 to 29, 2019. Table 3.2.2 shows the overall schedule for the program of 3rd technical exchange. On November 26, a technical exchange seminar was held at the DGWR HQs in Jakarta. From November 27 to 28, the field visit at the Colo irrigation scheme, Central Java, and opinion exchange had been conducted with concerned personnel such as local officers from BBWS (Bengawan Solo), Provincial officers and also P3A members of Colo irrigation scheme.

Table 3.2.2 Overall Schedule for the Mission of 3rd Technical Exchange

Date	Schedule	Stay
25 Nov (Mon)	JICA Team: Tokyo Narita (10:55) → Jakarta (16:55) （JL725） MAFF: Tokyo Haneda (10:20) → Jakarta (16:15) （NH855） Arrival in Indonesia	Jakarta
26 Nov (Tue)	a.m. Technical Exchange Seminar at DGWR, PU p.m. Move to Surakarta Jakarta (16 :35) →Surakarta (18:05) (GA226)	Surakarta
27 Nov (Wed)	Field visit (Colo Irrigation Scheme, Wonogiri Dam etc.) Discussion with P3A at Hapsari Hotel	Surakarta
28 Nov (Thu)	a.m. Workshop at Hotel Alana p.m. Move to Jakarta Surakarta (16:05) →Jakarta (17:25) (GA221)	

Date	Schedule	Stay
	p.m. Move to Tokyo Jakarta (21:45)	
29 Nov (Fri)	→Tokyo Haneda (6:50) (NH856)	

Source: JICA Study Team (2019)

3.3 Technical Exchange Seminar


Technical exchange seminar

Technical exchange seminar was held on November 26, 2019 at the DGWR HQs in Jakarta. Table 3.3.1 shows the agenda of technical exchange seminar. This seminar consists of two sessions. Session 1 has two presentations from the Indonesian side; "Policy of Irrigation Development and Rehabilitation in Indonesia" by the Director of Irrigation and Lowland (DILL), DGWR and "Efficiency of Irrigation Operation and Maintenance in Indonesia" by the Director of Operation and Maintenance, DGWR.

Session 2 has three presentations from Japanese side: "Effective Irrigation Water Distribution/Utilization and Water Use Allocation among Stakeholders in Japan" by the Director General of Toban LID, "Modernization and Challenges in Nowadays Irrigation and Agriculture in Japan" by the Deputy Director of Overseas Land Improvement Office, Rural Development Bureau, MAFF and "Introduction of F-IDAMS towards Food Sovereignty in Indonesia" bythe team leader of JICA Study Team. There was a fruitful exchange of opinions during the seminar.

Table 3.3.1 Agenda for Technical Exchange Seminar on November 26, 2019

Time	Agenda	Meeting Room
09:00-09:20	a) Opening Remarks and Greetings by DG of WR b) Greetings from JICA HQs (Mr. Ishijima, Executive Technical Advisor to the DG, Rural Development Department, JICA) c) Greetings from MAFF, Japan (Mr. Matsuo, Deputy Director of Overseas Land Improvement Office, Rural Development Bureau)	2nd Floor of PU
09:20-10:15	a) Policy of Irrigation Development and Rehabilitation in Indonesia by Director of DILL b) Efficiency of Irrigation Operation and Maintenance in Indonesia by Director of O&M	
10:15-10:30	Q & A Discussions	
10:30-11:30	a) Effective Irrigation Water Distribution/Utilization and Water Use Allocation among Stakeholders in Japan (Mr. Fukuda, Director General of Toban LID) b) Modernization and Challenges in Nowadays Irrigation and Agriculture in Japan (Mr. Matsuo, Deputy Director of Overseas Land Improvement Office, Rural Development Bureau, MAFF) c) Introduction of F-IDAMS towards Food Sovereignty in Indonesia (Mr. Hashiguchi, Team leader, JICA team)	
11:30-11:45	Q & A Discussions	
11:45-12:00	a) Vote of Thanks from JICA HQs (Mr. Ishijima, Executive Technical Advisor to the DG, Rural Development Department, JICA) b) Closing Remark (DG of WR) c) Photo Session	

Source: JICA Study Team (2019)

3.4 Field Visit

The field visit was conducted in Surakarta, Central Java, during a two-day schedule from November 27 to 28, 2019. Table 3.4.1 shows the agenda for the field visit. On the first day, a site visit was conducted to Wonogiri Dam, Colo headworks, and Colo irrigation scheme, and the Japanese delegates had discussions with farmers, irrigation associations (P3A), and prefecture / BBWS staff. On the second day, a workshop-style meeting was held in Surakarta City, with BBWS staff giving an overview of the Colo irrigation scheme and provincial officials giving an overview of the role of the irrigation committion. From the Japanese side, National Federation of LID made a presentation about Effective Irrigation Water Distribution/Utilization and Water Use Allocation among Stakeholders in Japan, and then MAFF gave a presentation about Modernization and Challenges in Nowadays Irrigation and Agriculture in Japan.

Table 3.4.1 Agenda for Field Visit in Surakarta, Central Java from November 27 to 28, 2019

Date	Time	Agenda	Location
Nov. 27	08:00-9:30	Going to Colo Irrigation Area (Ready by 7:45 at hotel lobby)	Colo Irrigation Area
	09:30-10:00	Wonogiri Dam Observation, including explanation	
	10:30-11:00	Colo Headworks of Colo Irrigation Scheme	
	11:30-2:00	Colo East Irrigation Area Observation	
	12:30-3:30	Lunch (at Hapsari Hotel)	
	13:30-5:00	Discussions with P3A (including P3A presentation)	
	15:00-7:00	Going back to Alana Hotel, Solo City (Surakarta City)	
Nov. 28	8:30-	Registration at Hotel Alana	Hotel Alana
	9:00-9:15	a) Greetings by BBWS Head b) Greetings by Head of Dinas PUSDATARU, Provinsi Jawa Tengah c) Greetings by JICA (Mr. Ishijima, Executive Technical Advisor to the DG, Rural Development Department, JICA) d) Greetings by MAFF, Japan (Mr. Matsuo, Deputy Director of Overseas Land Improvement Office, Rural Development Bureau, MAFF)	
	9:15-9:45	Presentation by BBWS (Effective Irrigation Water Distribution/Utilization and Water Use Allocation among Stakeholders in Case of Colo Irrigation Scheme)	
	9:45-10:00	Q & A Discussions	
	10:00-0:30	Presentation by Dinas of Provinsi (Role of Irrigation Commission in line with Effective Irrigation Water Distribution/Utilization and Water Use Allocation among Stakeholders)	
	10:30-0:45	Q & A Discussions	
	10:45-1:15	Effective Irrigation Water Distribution/Utilization and Water Use Allocation among Stakeholders in Japan (Mr. Morii, Director of Planning Research Division and Director of LID PR Center, National Federation of LID)	
	11:15-1:30	Q & A Discussions	
	11:30-2:00	Modernization and Challenges in Nowadays Irrigation and Agriculture in Japan (Mr. Matsuo, Deputy Director of Overseas Land Improvement Office, Rural Development Bureau, MAFF)	
	12:00-2:15	Q & A discussions	
	12:15-2:30	a) Vote of Thanks by Federation of LID, Japan (Mr. Morii, Director of Planning Research Division and Director of LID PR Center, National Federation of LID) b) Closing Remarks by Indonesian representative c) Photo Session	

Source: JICA Study Team (2019)

Through all three technical exchanges, the Indonesian delegation and the Japanese participants actively exchanged opinions on their respective issues and efforts to address them. In the technical exchange, the theme was "Efficient water distribution and water use", and the efforts of Japan's LID, local governments, and MAFF were shared, and the Indonesian side also shared the efforts of irrigation projects in Indonesia.

In particular, in the second technical exchange held in Japan, a field visit was made to an irrigation project in Japan, and the effectiveness and usefulness of introducing the technology related to irrigation modernization such as the remote monitoring system into the irrigation systems in Indonesia was confirmed. It is summarized that it was a useful technical exchange as it was a great opportunity for both the Indonesian side and the Japanese side to share their lessons learned. Based on the results from the technology exchanges, regarding the rehabilitation project for the existing irrigation schemes in Indonesa, it has been proposed to introduce "Irrigation Modernization".

Wrap-up of field visit