Part 3

STUDY FOR MUSI RIVER BASIN

CHAPTER 7 COLLECTION AND COMPILATION OF INFORMATION AND DATA

7.1 Natural Condition of Project Area

7.1.1 Topography and Geology

(1) Topography

The Musi River is the largest river in Sumatra flowing down from west to east in South Sumatra Province which has the fourth largest catchment area of 59,942 km^2 in Indonesia, and it is approximately 640km long. The average bed slope widely varies from upstream (1/100 - 1/200) to downstream (1/10,000) around Palembang, and becomes gentler (1/20,000) toward the coastal areas.

The topography of the Musi River basin can be mainly classified into five zones as shown in Figure 7.1.1. The mountainous zone is distributed only to the west-southwest-south region of the basin under the influence of the prominent geological structure that indicates the northwest-southeast strike. The remaining 60% of the basin excluding the mountainous zone and its adjacent piedmont zone, is occupied by central plains, inland wetlands, and coastal plains.

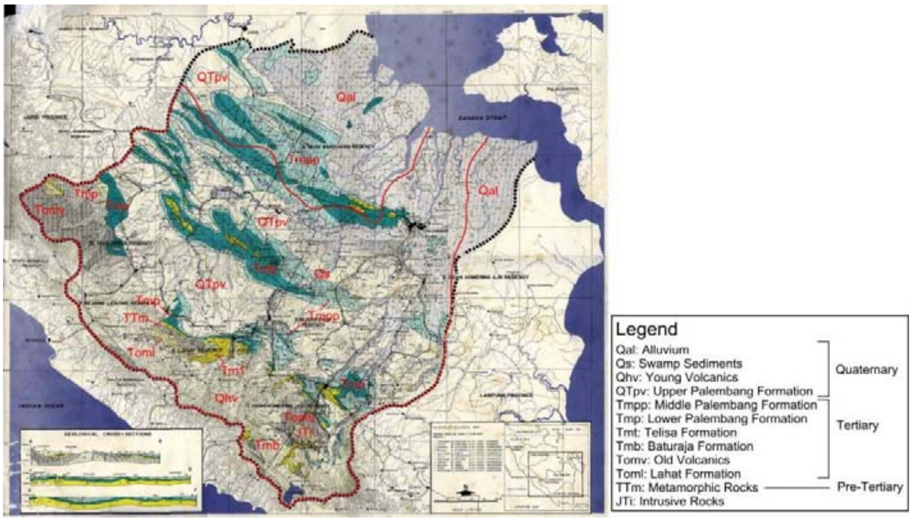
Table 7.1.1 Topographic Zones of Musi River Basin

Zone	Distribution Area	Topographical Feature
Mountainous Zone	South-southwest-west of the basin	Valley, highland, and volcano
Piedmont Zone	Between mountainous zone and central plains	Undulating hills (Distribution with a width of about 40km to the northwest-southeast direction)
Central Plains	Between piedmont zone and coastal plains	Can be classified into three: plateau, floodplain, and river levees
Inland Wetlands	Mainly along the rivers of the downstream	Natural levee and marsh
Coastal Plains	Coastal and around delta	Coastal lowlands and delta lowlands covered with peat swamp forest

Source: JICA Project Team 2

(2) Geology

A geological map of the Musi River basin is shown in Figure 7.1.1. The oldest geological formations of which distribution has been identified in the Musi River basin are pre-tertiary clastic limestone and plutonic rocks, which outcrop only in small portions of the mountains. These formations are covered by tertiary sediments and volcanic rocks with a thickness of up to about 6,000m. The tertiary formations, Lahat Formation (Toml), Old Volcanic (Tomv), Telisa Formation (Tmt), Baturaja Limestone (Tmb) and Lower-Middle Palembang Formation (Tmp-Tmpp) are lying in this order. The quaternary volcanic rocks, sediment layers consisting of tephras, marsh sediment layer, and alluvium are distributed on the top layer. The quaternary layers are composed of Upper Palembang Formation (QTpv), Young Volcanics (Qhv), Swamp Sediments (Qs), and Alluvial (Qal). As mentioned above, the pre-tertiary and tertiary formations outcrop in several belts with northwest-southeast strike, between which spaces are filled by the quaternary layers. In estimating the groundwater potential of the Musi River basin, it is assumed that these quaternary layers are functioning as productive aquifers.



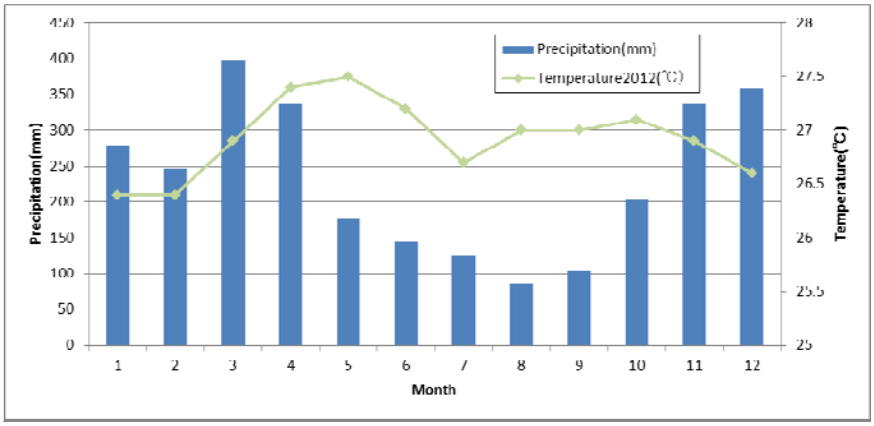
Source: Musi River Basin Stuy, PU, 1989

Figure 7.1.1 Geological Map

7.1.2 Climate, Hydrology and Rivers

(1) Climate

The climate of the Musi River basin is characterized by abundant rainfall which is moderately distributed through the year where wet and dry seasons are much less clearly defined than in Java and eastern Indonesia. Figure 7.1.2 shows the monthly rainfall and temperature observed at the Kenten Station, Palembang. The total annual rainfall is about 2,800 mm with more rainfall between October and April. The monthly average temperature has a little variation and as high as about 27°C through the year. The annual potential evapotranspiration is estimated at 1,200 to 1,500 mm/year (Musi River Basin Study, PU, 1989).

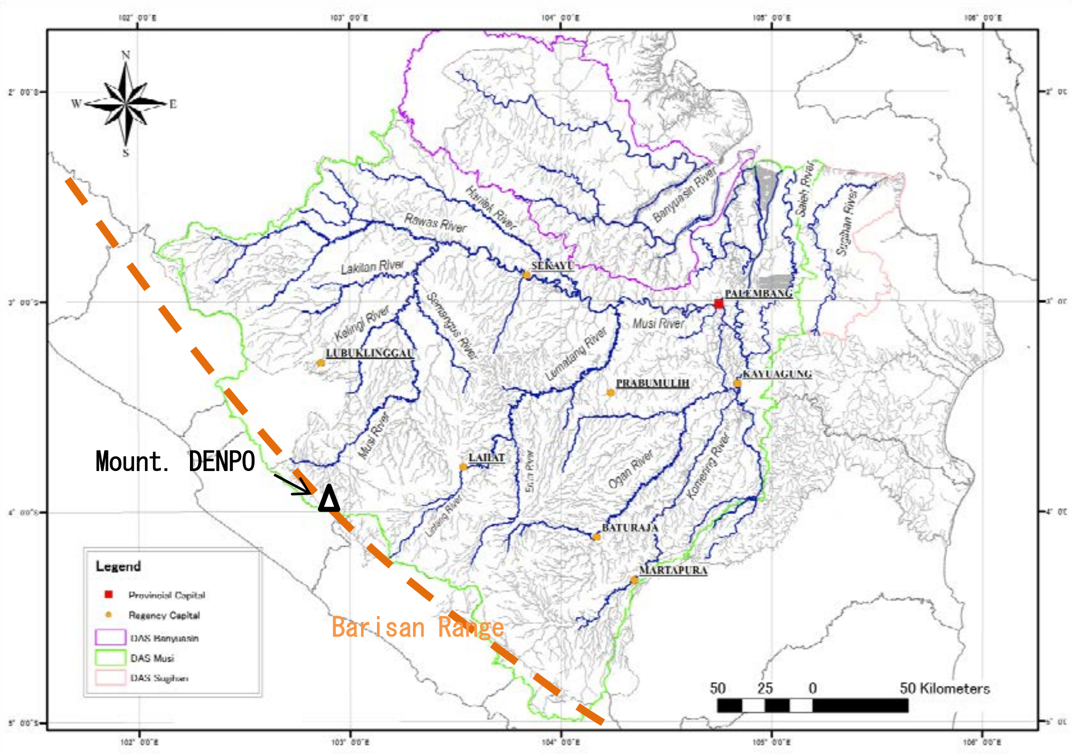


Source: JICA Project Team 2

Figure 7.1.2 Monthly Rainfall (1985-2013) and Monthly Temperature (2012) at Kenten Station, Palembang

(2) Rivers and Hydrology

The Musi River and its major tributaries originate in the Barisan Range as shown in Figure 7.1.3. The Musi River can be traced up to the foot of Mt. Dempo with an altitude of 3,159m, from where the Musi River flows northward, collecting the Kelingi, Semangus, Lakitan and Rawas Rivers. At the confluence with the Rawas River, the Musi River changes its flow direction eastward and is joined by the Harileko and Lematang Rivers before it reaches Palembang City. Two big tributaries, the Ogan and Komering Rivers, join the Musi River from the right bank in Palembang City. At the Komering Junction, the Musi River changes its flow direction to the north again, and finally empties into the Bangka Strait. The Musi River basin is sandwiches by the Banyuasin and the Sugihan River basins in the lowest area from the east and west sides respectively. Catchment areas and river lengths of these rivers and tributaries are summarized in Table 7.1.2.



Source: JICA Project Team 2

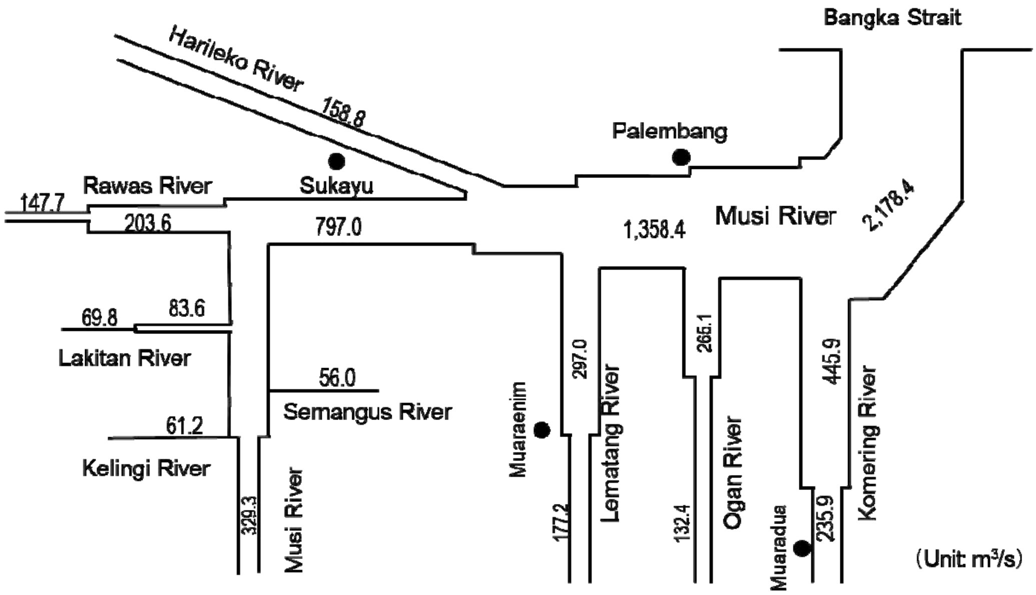
Figure 7.1.3 Musi, Banyuasin and Sugihan River Basins

According to "The Study on Comprehensive Water Management of Musi River Basin, 2003 JICA" (hereinafter referred to as the JICA Musi Study), the average discharge on the downstream stretch of the Musi River after the confluence of the Komering River is about 2,200 m^3/s with fluctuations in the dry and wet seasons between 1,400 and 4,200 m^3/s as seen in Figure 7.1.4. Normally, the Musi River and its tributaries have the highest peak discharge between February and March, and the lowest discharge between July and September. The maximum tidal range is about 3.5m, and the highest spring tide appears generally in December to January.

Table 7.1.2 Catchment Areas and River Lengths of Musi River and Main Tributaries

No.	Sub-Basin	Catchment Area (km²)	River Length (km)	Distance from Musi River Month to Confluent Point (km)
1	Komering	10,275	328	78
2	Ogan	8,358	313	88
3	Lematang	7,168	348	165
4	Semangus	1,972	183	391
5	Musi	15,226	640	-
6	Kelingi	1,898	98	421
7	Lakitan	2,563	140	374
8	Rawas	5,841	208	344
9	Harileko	4,013	334	229
10	Padang	2,040	640	-
Musi River Total		59,354	-	-
	Banyuasin	13,351	209	-
	Sugihan	3,378	129	-

Source: POLA for MBSL 2033



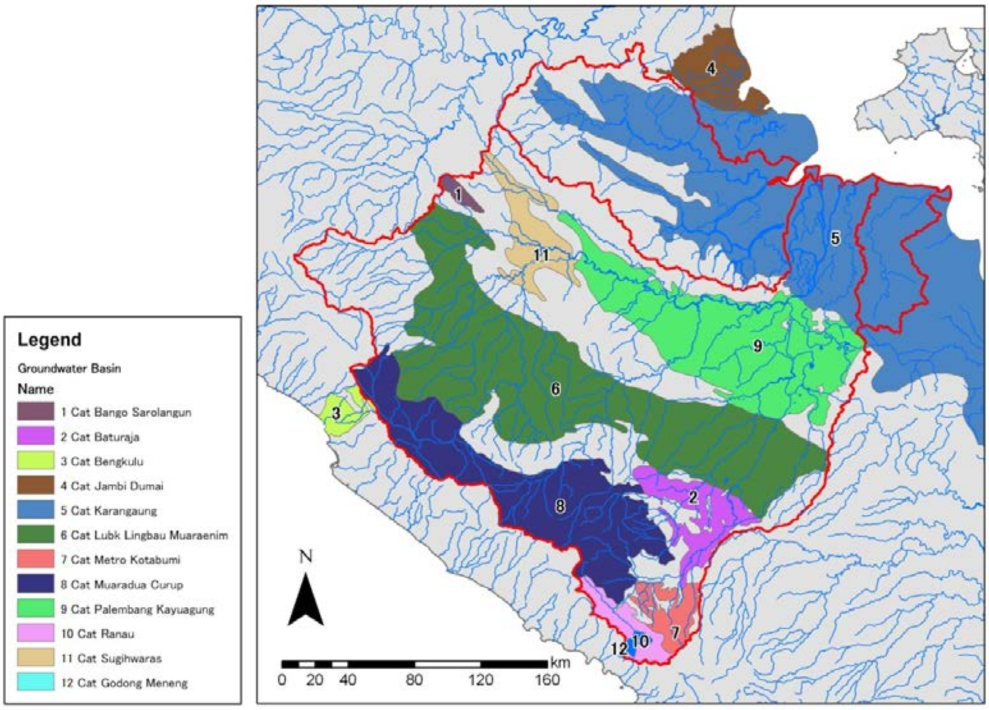
source: The Study on Comprehensive Water Management of Musi River Basin in the Republic of Indonesia (2003), JICA

Figure 7.1.4 Distribution of Annual Mean Discharges in Musi River System

7.1.3 Groundwater

Rough estimation of the groundwater development potential of the Musi River basin was made by the Ministry of Energy and Mineral Resources (ESDM) under the study report of “Groundwater in Indonesia and its Management, 2005”. Some springs identified in the mountainous zone and alluvial plains are located along the rivers. Therefore, a certain degree of groundwater development potential is expected from groundwater in fractured rocks and shallow groundwater in alluvial deposit. However, the development potential of the groundwater in the Piedmont zone, Central Plains, and inland wetlands is limited only to the shallow groundwater which exists in the quaternary deposits because of difficulty of development and water quality risk. It should be noted that the groundwater development potential of the coastal plains including the provincial capital, Palembang is low due to the possibilities of saltwater intrusion and land subsidence.

The groundwater basins in the Musi River basin, defined by ESDM, are presented in Figure 7.1.5, and the groundwater potential of each of the basins is presented in Table 7.1.3. The average groundwater development potential of 533mm/y is about 19% of 2,800mm which is the average rainfall of Palembang, and is equivalent to about 40% of 1,340mm of the annual effective rainfall which is estimated by assuming daily average evapotranspiration of 4mm. However, constraints of the water budget, environmental and economic aspects have not been taken into consideration in this rough estimation. In order to be more precise in estimating the groundwater potential, the current groundwater use, the spatial distribution characteristics of groundwater potential, the impact on the existing wells and springs, the suppression of land subsidence, the impact on the ecosystem, the groundwater level and pump capacities, etc. should be considered.



Source: JICA Project Team 2

Figure 7.1.5 Groundwater Potential for Each Groundwater Basin

Table 7.1.3 Total Groundwater Potential for Each Groundwater Basin

No.	Basin Name	Area (km^2)	Q1+Q2[*1] ($M\ m^3/y$)	Q1+Q2[*1] (%)	Ranking	(Q1+Q2)/Area (mm/y)
1	Bangko Sarolangun	6,072	4,221	5.8	5	695
2	Butruraja	2,404	1,151	1.6	10	479
3	Bengkulu	4,888	3,836	5.3	6	785
4	Jambi Dumai	69,776	20,401	28.0	1	292
5	Kurangagung	22,860	12,977	17.8	2	568
6	Lubuk Linggau Muaraenim	15,400	6,062	8.3	3	394
7	Metro Motbumi	21,640	12,331	16.9	8	570
8	Mauradua Curup	8,521	4,389	6.0	4	515
9	Palembang Kayuagung	8,652	3,759	5.2	7	434
10	Ranau	1,501	934	1.3	12	622
11	Sugihwaras	1,794	1,549	2.1	9	863
12	Gedong Meneng	1,412	1,185	1.6	11	839
Total 1(1,2,5,6,7,8,9,10,11)		88,844	47,373	65.1	-	533
Total 2(1-12)		164,920	72,795	100.0	-	441

Note: *1: Q1 is shallow aquifer and Q2 is deep aquifer
Source：JICA Project Team 2

7.1.4 Sediment

Generally, mass movement such as landslide, slope failure and debris flow is one of the factors of sediment discharge. Moreover, land development with deforestation is considered to become another factor for surface erosion. Field reconnaissance was carried out from June 2 to 7 2014 in the dry season along the Musi River and its tributaries (the Komering, the Saka, the Ogan, the Lematang and the Kelingi rivers) to supplement insufficient basic information regarding the sediment discharge of the Musi River basin (e.g. landslide and slope failure distribution maps, river longitudinal and transverse map and sediment management plan). The results of the field reconnaissance are summarized as follows:

(1) Land Use

Rice field and plantations such as rubber, oil palm and tea are located in the middle and lower part of the Musi River basin. Some of them were managed well, so soil erosion will not occur in these plantation areas as shown in Photo 7.1.1.

(2) Sediment Discharge

Disordered sand and gravel mining were observed in the downstream stretches of the Komering River (Photo 7.1.2 A and B). It is considered that this illegal activity may cause degradation of the river bed in the future.

An outcrop composed of volcanic deposits was observed at the northeastern side of Lake Ranau, located in the uppermost part of the Komering River basin (Photo 7.1.2 C and D). Since some volcanoes are located around Lake Ranau according to the topo-maps, it is presumed that those volcanic deposits, such as volcanic ash, non-welded pyroclastic flow deposit and pumice falls were widely distributed around Lake Ranau. A geological map shows that volcanic deposits are distributed widely in northeastern area of the volcanoes at the uppermost part of the Komering River basin. Alluvium deposit is distributed along the Komering River (Figure 7.1.6), that is presumed to be the sediment which had been transported in an erosion process called “dissection”.

Rice Field (021)

Rubber Plantation (028-029)

Tributary of Lematang River
Oil palm Field (030)

Tea Plantation on the Hillside of Mt.Dempo (032)

Source: JICA Project Team 2

Photo 7.1.1 Conditions of Land Use

A; Sand excavated by pump in the Komering River (005)

B; Closer View of gravel excavation(008)

C; Pumice flow and volcanic ash layer (018)

D; Closer view of Pumice flow (017)

Source: JICA Project Team 2

Photo 7.1.2 Sand and Gravel Mining and Their Sources

(3) Riverbank Erosion

Riverbank erosion is observed at some parts of the Musi River and its tributaries (Photo 7.1.3). Revetment works by gabions or masonry were provided in some parts to protect houses and roads near the river. It was observed that several revetment works have been eroded by river water flow due to insufficient foundation.

Riverbank erosion observed at the lower terrace in the Komering River(006)

Existing retaining wall destroyed by flood in the Lematang River (027)

Subsidence and deformation of revetment works by erosion in tributary of the Lematang River (022)

Insufficient foundation of revetment works in tributary of the Lematang River (024)

Source: JICA Project Team 2

Photo 7.1.3 River Bank Erosion

(4) Turbidity of River Water

One of the purposes of this filed reconnaissance was to know the difference of wash load by river based on the turbidity of river water. As a result, turbid water flow was observed in several rivers during the reconnaissance.

The clearest river water was observed at the uppermost stream of the Komering River which is located at the flow-out point of Lake Ranau (A). On the other hand, turbid river water was observed in the middle part of the Lematang River (B, C and D).

The river water around the mountain foots in the upstream of the Organ, Lematang and Musi Rivers is generally clear. The turbidity increases gradually as river water goes downward.

Figure 7.1.7 shows the condition of water color in the Musi River basin based on a field survey.


A; Clearest water; the Komering River (016)

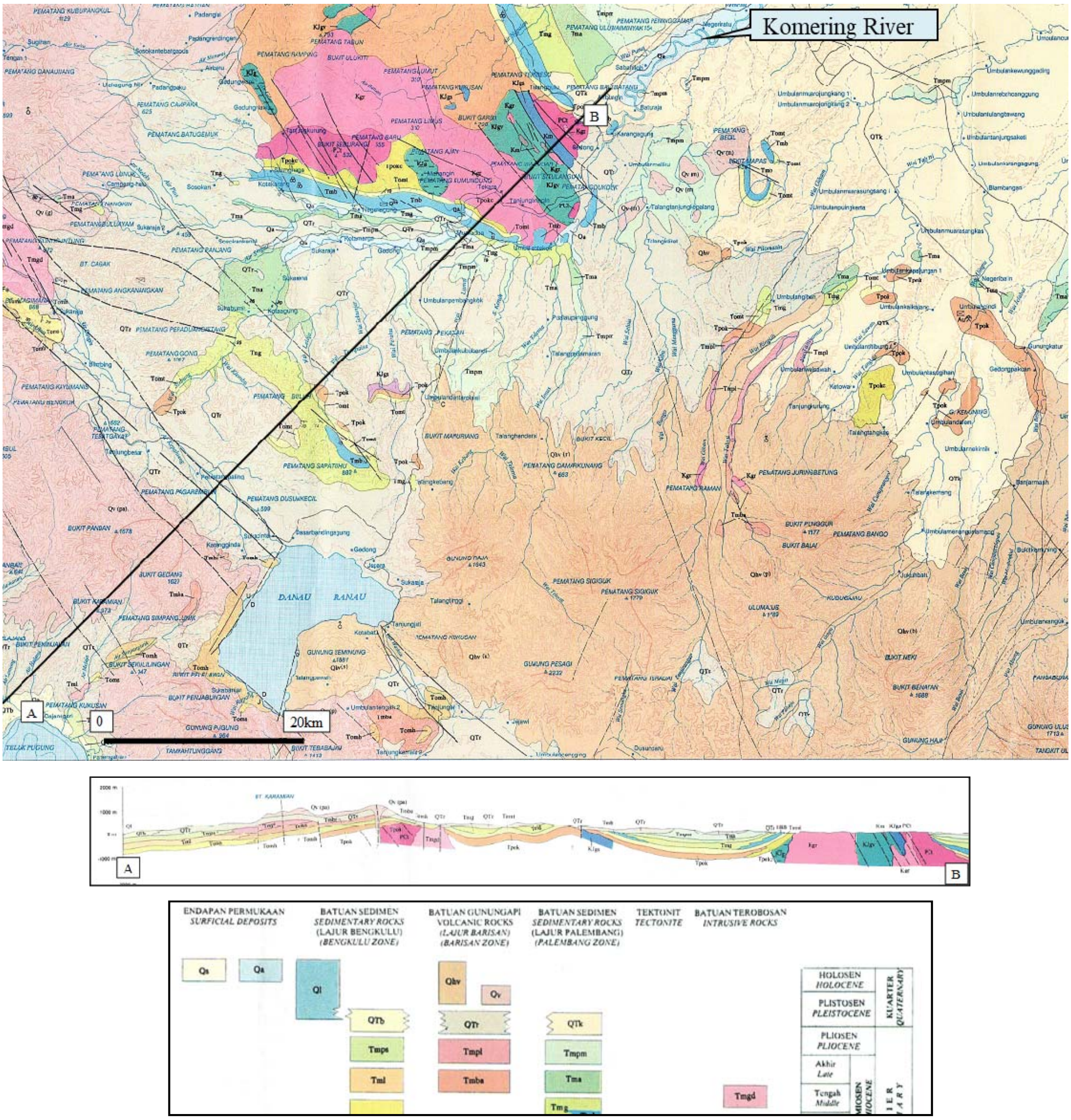

B; Condition of Confluence; the Lematang River


C; Left tributary of B (025); turbid water


D; Right tributary of B (024)

Source: JICA Project Team 2

Photo 7.1.4 Turbidity of River Water



QTb	FORMASI BINTUNAN	:	Konglomerat aneka bahan, batupasir, batulempung, tuf batuapung dengan sisipan lignit dan batulempung bermoluska
	PINTUNAN FORMATION	:	*Polymict conglomerate, sandstone, claystone, pumiceous tuff with lignite intercalations, claystone contains molusc*
QTk	FORMASI KASAI	:	Konglomerat dan batupasir kuarsa, batulempung tufan mengandung kayu terkersikan dengan sisipan tuf batuapung dan lignit
	KASAI FORMATION	:	*Conglomerate and quartz sandstone, tuffaceous claystone containing silicified wood with pumiceous tuff and lignite intercalations*
QTr	FORMASI RANAU	:	Tuf riolitan, tuf batuapung, tuf padu dengan sisipan batulempung berkarbon
	RANAU FORMATION	:	*Rhyolitic tuff, pumiceous tuff, welded tuff with carbonaceous claystone intercalations*

Source: BADAN GEOLOGI

Figure 7.1.6 Geological Map around Komering River

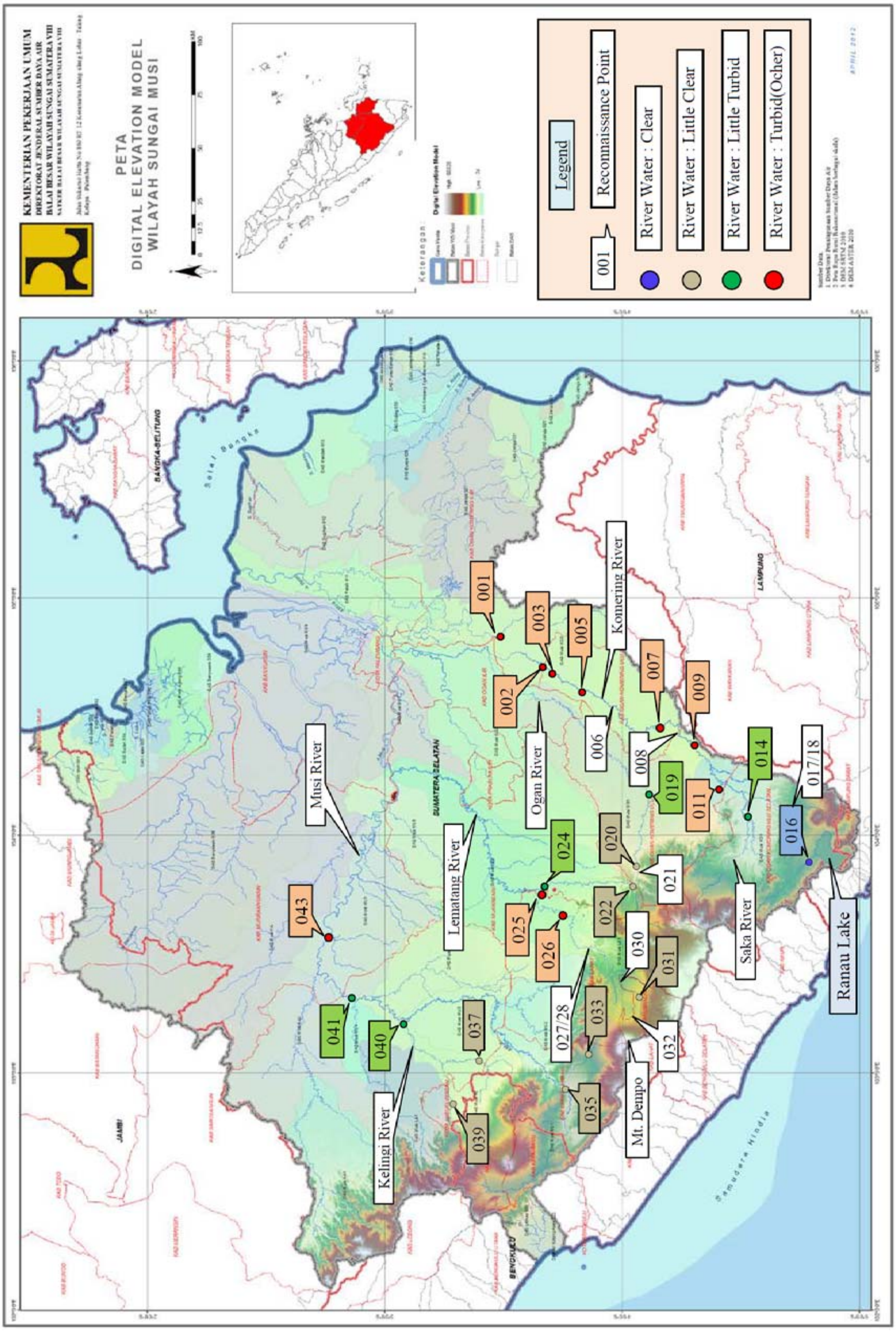


Figure 7.1.7 Condition of Water Color in Musi River Basin

Source: JICA Project Team 2

7.1.5 Natural Environment

The following information is summarized through interview survey and collection of secondary information from Balai Besar Wilayah Sungai (BBWS) Sumatera VIII, Center for Watershed Management (Balai Pengelolaan Daerah Aliran Sungai: BPDAS), Natural Resources Conservation Agency (Balai Konservasi Sumber Daya Alam: BKSDA), national park office, Sriwijaya University, provincial environmental office and non-government organizations (NGOs).

Table 7.1.4 Summary of Natural and Living Environment of Musi River Basin

Item	Summary
Forest	Forestland in South Sumatera Province is 3,458 thousand ha in 2016 and among it, protection forest is 578 thousand ha (17%), nature reserve and conservation area is 791 thousand ha (23%), limited production forest is 214 thousand ha (6%) , permanent production forest is 1,714 thousand ha (50%), convertible production forest is 161 thousand (5%). Plantation industry-driven deforestation in limited production forest and convertible production forest area has been a social issue in the basin.
Protected area	Major protected areas in the watersheds are Bukit Barisan Selatan national park, Kerinci Seblat national park (world natural heritage), and Taman National Park. Six sites of Important Bird Area (IBA) are located in the watershed.
Ecosystem	Characteristics of the watershed's ecosystem can be divided into three domains such as the mountainous upper river sheds, flat middle areas which are heavily converted to production purposes, and tidal flat in the downstream area. In the peatland and mangrove forest in the downstream, 53 species of mammals, 213 species of birds, and 106 species of trees are found.
Peatland	The total area of peatland in the province is 1.3 million ha and of which 97% is less than one meter thick. It is less than 2.5m even in the thicker deposits. There is also a report saying that most of the peat in agricultural area is already decomposed by human activities such as drying, firing, and oxidation. The comparatively deeper peat is said to be found in Musi Banyuasin Regency, Muara Enim Regency and Ogan Komering Ilir Regency. From the site survey done by Sriwijaya University, the peat dome of around six meters deep is identified, while comprehensive survey is not yet completed.
Greenhouse gas (GHG)	The GHG reduction plan of South Sumatera Province (RAD-GRK SUMSEL) expects about 94.5% of the GHG emission in 2020 (3.5 Gt CO_2) which is from the energy consumption, while 5.1% is from peatland. To achieve the emission reduction target, the forest and peatland are important (51.8% from the energy sector, 47.1% from the forest and the peatland).
Landscape	Rainforest in the mountain area, including the world natural heritage site, tea garden in Mt. Dempo, Lake Ranau, Lake Raya, and mangrove swamps are major landscapes in the watershed.
Water quality	In 2006, the survey indicates COD, TSS and Escherichia coli exceed the environmental standard in some rivers such as Musi, Lematang, and Ogan. It is also reported that water quality is worse in the dry season.

Source: JICA project Team 2

7.2 Social Condition of Project Area

7.2.1 Administration

The Musi River basin extends over four provinces, South Sumatra, Bengkulu, Jambi and Lampung. South Sumatra Province occupies 96% of the total basin area of some 60,000km^2, while Bengkulu, Jambi and Lampung occupy 3.6%, 0.4% and a negligibly little part respectively. The Banyuasin River basin stretches over South Sumatra and Jambi Provinces, and the entire Sugihan River basin is situated within South Sumatra Province.

Regencies (Kabupaten) and cities (Kota) in the three river basins are listed in Table 7.2.1.

Table 7.2.1 List of Regencies and Cities in Musi River Basin

River Basin	Province	Regency/ City
Musi	South Sumatra	Palembang City
		Prabumulih City
		Pagar Alam City
		Lubuk Linggau City
		Ogan Komering Ilir (OKI) Regency
		Ogan Ilir Regency
		Ogan Komering Ulu (OKU) Timur Regency
		Ogan Komering Ulu (OKU) Regency
		Ogan Komering Ulu (OKU) Selatan Regency
		Muara Enim Regency
		Penukal Abab Lematang Ilir (PALI) Regency
		Lahat Regency
		Empat Lawang Regency
		Musi Rawas Regency
		Musi Rwas Utara Regency
		Musi Banyuasin Regency
		Banyuasin Regency
	Jambi	Muaro Jambi Regency
		Batanghari Regency
		Sarolangun Regency
	Benkulu	Kepahiang Regency
		Rejang Lebong Regency
	Lampung	Lampung Barat Regency
Banyuasin	South Sumatra	Musi Banyuasin Regency
		Banyuasin Regency
	Jambi	Muaro Jambi Regency
		Batanghari Regency
Sugihan	South Sumatra	Banyuasin Regency
		Ogan Komering Ilir Regency

Source: JICA Project Team 2

7.2.2 Population

Population data were collected from the Bureau of Statistics and are summarized in Table 7.2.2. The total population in the Musi River basin in 2010 was approximately 7.95 million, and the annual growth rate from 2000 to 2010 was 1.06%.

Table 7.2.2 Current Total Population and Population Growth Rate in Musi River Basin

No.	Regency/City*1	Area (km²)	Population 2000	Population 2005	Population 2010	Annual Growth Rate (% /year)
1	Palembang City	381	1,451,776	1,338,793	1,455,284	0.02%
2	Prabumulih City	431	112,377	130,340	161,984	3.68%
3.	Pagar Alam City	553	105,868	114,562	126,181	1.76%
4.	Lubuk Linggau City	354	154,584	174,452	201,308	2.65%
5.	Ogan Komering Ilir (OKI) Regency	4,383 (17,215)	591,863	656,828	727,376	2.06%
6.	Ogan Ilir Regency	2,246	334,279	356,983	380,904	1.31%
7.	OKU Timur Regency	2,075 (2,634)	505,928	556,010	609,982	1.87%
8.	OKU Regency	4,281 (4,343)	198,663	255,246	324,045	4.89%
9.	OKU Selatan Regency	3,761 (4,539)	316,129	317,277	318,428	0.07%
10.	Muara Enim Regency	7,872	717,756	632,222	716,676	3.96%
11.	Lahat Regency	4,759 (7,568)	670,149	545,754	368,874	3.22%
12.	Empat Lawang Regency	2,305 (7,568)	190,591	204,639	221,176	1.41%
13.	Musi Rawas Regency	11,994 (12,202)	436,476	474,430	525,508	1.86%
14.	Musi Banyuasin Regency	13,585 (13,637)	402,422	459,175	561,458	3.35%
15.	Banyuasin Regency	8,181 (12,636)	670,470	733,828	750,110	1.12%
16	Muaro Jambi Regency	1,140 (5,509)	48,421 (233,993)	57,062 (275,752)	70,968 (342,952)	3.90%
17	Batanghari Regency	1,139 (5,782)	37,554 (190,636)	40,159 (203,862)	47,541 (241,334)	2.39%
18	Sarolangun Regency	104 (5,892)	3,144 (178,097)	3,417 (193,580)	4,346 (246,245)	3.29%
19	Kepahiang Regency	713	105,300	114,749	124,865	1.70%
20.	Rejing Lebong Regency	1,464 (1,507)	230,154 (236,914)	234,910 (241,810)	239,745 (246,787)	0.41%
21	Bengkulu Tengah Regency	502 (5,618)	6,387 (71,481)	7,441 (83,280)	8,787 (98,333)	3.01%
22	Lampung Barat Regency	219 (5,014)	N/A	N/A	N/A	N/A
Total of Musi River Basin		**72,465 (137,036)**	**7,290,290 (7,875,752)**	**7,408,278 (8,063,571)**	**7,945,546 (8,749,810)**	**1.06%**

Note: 1) The Musi River basin expands over Bebgkulu Seratan by 0.56ha, Kaur by 3ha, Seluma by 8ha and Lebong by 13ha Regencies too, but these regencies that occupy very small portions in the Musi River basin are omitted in the table.
2) Values in parentheses are the total area and population of the regency/city including those outside of the Musi River basin
3) Muara Enim Regency includes PALI Regency (separated in 2013) and Musi Rawas Regency includes Musi Rawas Utara Regency (separated in 2014).

Source: Area data; BAPPEDA, Population data; Bureau of Statistics

7.2.3 Economy

The gross Regional Domestic Product (GRDP) of South Sumatra Province in 2009 was Rp.60.4 billion, which corresponds to Rp.8 million of per capita GRDP. The GRDP of South Sumatra Province by sector is presented in Table 7.2.3. The economic structure of South Sumatra Province is dominated by three major sectors, namely mining, agriculture, and manufacture that accounted for 23%, 20% and 17% of the total GRDP respectively.

South Sumatra Province is rich in fossil fuel resources. It is reported that there are approximately 24,179.98 billions of standard cubic feet (BSCF) gas reserves in South Sumatra Province or ± 13.01 % of the total natural gas reserves in Indonesia as of 2009. The province has coal reserves of approximately ± 38.44 % of the total coal reserves of the national or 22,240.47 million tons, while oil reserves in South Sumatra Province of ± 8.78 % of the total national petroleum reserve or by 757.60 million stock tank barrels (MMSTB).

On the other hand South Sumatra Province is regarded as Food Barn. The agriculture sector is divided into subsectors of food crops and horticulture, plantation, livestock and fisheries. Rice is the most important crop in the province, and Musi Banyuasin, OKU, and OKI regencies are the biggest rice producers. Other food crops are also cultivated such as maize, cassava, sweet potato, peanuts, and soybeans. Rubber, oil palm, and coffee are major cash crops of the plantation subsector.

Major manufactural products in the province include gas-related, food, beverage and fertilizer and chemical ones.

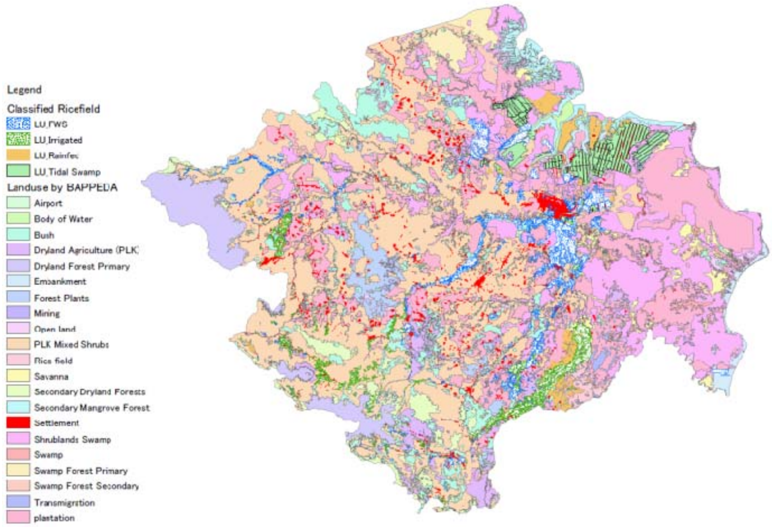
Table 7.2.3 Gross Regional Domestic Product by Sector of South Sumatra Province

Sector	Year				
	2005	2006	2007	2008	2009
Agriculture	9,805,678	10,437,334	11,113,699	11,567,788	11,927,064
Mining	13,330,108	13,377,903	13,411,653	13,616,652	13,836,934
Manufacture	8,807,199	9,273,621	9,801,805	10,136,764	10,347,071
Electricity, Gas, and Clean Water	231,369	248,673	267,073	281,069	295,377
Building	3,585,898	3,845,876	4,157,657	4,412,936	4,737,050
Trade, Hotel, and Restaurant	6,429,518	6,939,621	7,567,159	8,086,906	8,340,138
Transportation and Communication	2,005,038	2,216,756	2,534,185	2,886,983	3,284,286
Finance, Rental, and Corporate Services	1,859,817	2,013,374	2,197,304	2,386,939	2,550,333
Services	3,578,911	3,861,690	4,211,579	4,689,418	5,128,293
Total	**49,633,536**	**52,214,848**	**55,262,114**	**58,065,455**	**60,446,546**

Source: POLA 2013

7.2.4 Land Use

The JICA Project Teams 1 and 2 jointly elaborated the present land use map, based on the Land Use Map 2010 prepared by BAPPEDA of South Sumatra Province, by adding categories of paddy areas such as fresh water swamp, irrigated, rainfed and tidal swamp, as shown in Figure 7.2.1.



Source: JICA Project Teams 1 and 2

Figure 7.2.1 Present Land Use Map in Musi River Basin

The statistical data on the extent of major land use categories in South Sumatra Province as of 2015 are officially fixed by through rearrangement jointly made by Badan Pusat Statistik (BPS, Statistic Indonesia), Ministry of Agriculture and South Sumatra Bureau of Statistics as shown in Table 7.2.4. Total forest area is broken down as shown in Table 7.2.5. Detailed data of each land use category are presented in the Supporting Report E.

Table 7.2.4 Major Land Use Category Area by City/ Regency in South Sumatra for 2015

Regency (R) / City (C)		Wetland Crop Area (ha)	Dryland Crop Area (ha)	Shifting Cultivation Area (ha)	Estate Crop Area (ha)	Temporarily Unused Area (ha)	Total Forest Area (ha)
1.	Palembang C.	6,189	1,839	653	522	3,164	50
2.	Prabumulih C.	700	3,745	960	11,197	864	2,138
3.	Pagar Alam C.	3,440	2,045	438	12,546	874	52,188
4.	Lubuk Linggau C.	1,894	2,165	2,116	11,620	548	8,777
5.	OKI R.	185,998	86,021	34,442	270,742	104,785	872,210
6.	Ogan Ilir R.	67,627	15,384	3,605	42,682	25,060	100
7.	OKU Timur R.	85,620	27,279	7,681	103,359	5,399	19,486
8.	OKU R.	8,872	26,945	17,076	117,509	29,787	228,872
9.	OKU Selatan R.	18,040	35,631	21,556	82,562	22,074	339,230
10.	Muara Enim R.	27,017	30,676	23,449	224,329	34,425	346,115
11.	PALI R.	6,579	11,204	4,714	55,476	6,720	23,887
12.	Lahat R.	17,525	20,538	4,507	151,408	56,111	186,134
13.	Empat Lawang R.	14,091	9,942	13,867	69,355	3,517	81,993
14.	Musi Rawas R.	30,451	29,785	14,916	232,516	46,777	333,955
15.	Musi Rawas Utara R.	7,131	21,018	13,775	125,468	64,546	356,450
16.	Musi Banyuasin R.	66,810	29,739	29,524	395,099	95,264	689,264
17.	Banyuasin R.	226,518	23,287	9,823	248,287	30,525	545,769
South Sumatra Total		774,502	377,243	203,102	2,154,677	530,440	4,086,618

Source: Statistik Indonesia 2017, Statistik Perkebunan Indonesia 2015-2017, Sumatera Selatan Dalam Angka 2017

Table 7.2.5 Breakdown of Total Forest Area in South Sumatra for 2015

Regency (R) / City (C)		Protection Forest (ha)	Nature Reserve Forest (ha)	Limited Production Forest (ha)	Permanent Production Forest (ha)	Convertible Production Forest (ha)	Total Forest (ha)
1.	Palembang C.	0	50	0	0	0	50
2.	Prabumulih C.	0	0	1,069	0	1,069	2,138
3.	Pagar Alam C.	26,094	0	0	0	26,094	52,188
4.	Lubuk Linggau C.	1,216	4,153	1,096	0	2,312	8,777
5.	OKI R.	96,506	15,291	10,035	643,838	106,540	872,210
6.	Ogan Ilir R.	0	0	0	100	0	100
7.	OKU Timur R.	5	0	0	19,476	5	19,486
8.	OKU R.	68,309	0	18,647	54,959	86,957	228,872
9.	OKU Selatan R.	127,967	44,988	10,232	17,845	138,199	339,231
10.	Muara Enim R.	61,943	8,863	25,498	162,370	87,441	346,115
11.	PALI R.	0	0	0	23,887	0	23,887
12.	Lahat R.	48,312	52,261	4,351	28,547	52,663	186,134
13.	Empat Lawang R.	884	3,759	4,555	3,269	69,526	81,993
14.	Musi Rawas R.	64,971	75,352	7,386	177,976	8,270	333,955
15.	Musi Rawas Utara R.	189	172,779	36,753	109,786	36,942	356,449
16.	Musi Banyuasin R.	16,301	67,552	94,282	400,546	110,583	689,264
17.	Banyuasin R.	64,630	345,577	0	70,932	64,630	545,769
South Sumatra Total		577,327	790,625	213,904	1,713,531	791,231	4,086,618

Source: Sumatera Selatan Dalam Angka 2017

7.2.5 Agriculture

Strategic crops in South Sumatra Province are perennial crops such as rubber, coconut, oil palm and coffee, as well as followed by annual crop represented by rice. The current planted area and production of these four estate crops in South Sumatra Province are shown in Table 7.2.6. Majority of rubber growers are smallholders followed by government and private estates and vice versa oil palm is grown by private estates to a large extent over smallholders and government estates. On the other hand, coconut and coffee are planted by smallholders only. The detailed information is presented in the Supporting Report E.

Table 7.2.6 Planted Area and Production of Major Estate Crops in South Sumatra for 2015

Regency (R) / City (C)		Rubber		Coconut		Oil Palm		Coffee	
		Area (ha)	Product (ton)	Area (ha)	Product (ton)	Area (ha)	Product (ton)	Area (ha)	Product (ton)
1.	Palembang C.	364	496	31	15	127	211	0	0
2.	Prabumulih C.	10,267	9,684	76	36	854	2,703	0	0
3.	Pagar Alam C.	936	231	39	3	0	0	8,384	3,770
4.	Lubuk Linggau C.	9,631	2,052	221	149	235	96	1,463	277
5.	OKI R.	108,584	156,558	3,323	2,903	157,620	540,328	996	636
6.	Ogan Ilir R.	21,939	18,119	484	264	10,529	32,361	0	0
7.	OKU Timur R.	47,330	31,024	3,359	3,245	34,669	102,954	2,318	2,151
8.	OKU R.	49,207	53,402	1,119	194	44,616	148,752	21,964	15,992
9.	OKU Selatan R.	3,461	4,296	1,179	1,218	389	136	70,799	33,491
10.	Muara Enim R.	102,600	145,037	1,258	1,144	95,759	282,491	23,450	25,147
11.	PALI R.	46,269	66,643	332	301	8,875	7,785	0	0
12.	Lahat R.	38,621	39,875	554	320	55,167	187,322	51,837	21,175
13.	Empat Lawang R.	2,713	1,383	748	628	345	135	61,978	5,251
14.	Musi Rawas R.	97,378	114,433	1,936	1,933	129,597	428,686	3,477	1,889

Regency (R) / City (C)		Rubber		Coconut		Oil Palm		Coffee	
		Area (ha)	Product (ton)	Area (ha)	Product (ton)	Area (ha)	Product (ton)	Area (ha)	Product (ton)
15.	Musi Rawas Utara R.	102,654	110,223	507	360	22,041	55,212	207	182
16.	Musi Banyuasin R.	133,283	105,659	4,951	5,002	256,835	751,200	6	3
17.	Banyuasin R.	63,512	84,847	47,285	44,269	134,424	281,567	2,632	388
South Sumatra Total		838,749	943,962	67,402	61,984	952,082	2,821,939	249,511	110,352

Source: Statistik Perkebunan Indonesia 2015-2017

In South Sumatra, it is featured that almost half of wetland paddy cultivation areas are distributed in tidal and inland swamp areas and rice plants are grown under rainfed condition with limited share (15.2%) of irrigated paddy field annual harvested area, cropping intensity, annual paddy production and unit yield by regency/ city in the South Sumatera Province are tabulated in Table 7.2.7. The circumstance of the rice cultivation area in the South Sumatra Province is featured as shown in Table 7.2.8.

Table 7.2.7 Wetland Paddy Area and Production by Regency/ City in South Sumatra for 2015

Regency (R) / City (C)		Wetland Paddy Field			Annual Harvested Area (ha)	Cropping Intensity (%)	Unit Yield (ton/ha)	Annual Production (ton)
		Irrigated (ha)	Rainfed. (ha)	Total (ha)				
1.	Palembang C.	0	6,189	6,189	5,814	93.9	4.46	25,912
2.	Prabumulih C.	0	700	700	511	73.0	2.88	1,472
3.	Pagar Alam C.	3,440	0	3,440	8,694	252.7	4.95	43,040
4.	Lubuk Linggau C.	1,637	257	1,894	5,482	289.4	4.60	25,208
5.	OKI R.	650	185,348	185,998	132,641	71.3	4.62	612,706
6.	Ogan Ilir R.	0	67,627	67,627	45,253	66.9	3.83	173,244
7.	OKU Timur R.	43,506	42,114	85,620	141,729	165.5	6.08	861,235
8.	OKU R.	3,244	5,628	8,872	7,196	81.1	4.83	34,744
9.	OKU Selatan R.	16,099	1,941	18,040	39,602	219.5	5.00	197,973
10.	Muara Enim R.	6,395	20,622	27,017	26,138	96.7	4.51	117,997
11.	PALI R.	0	6,579	6,579	5,629	85.6	3.65	20,551
12.	Lahat R.	15,845	1,680	17,525	30,207	172.4	4.98	150,312
13.	Empat Lawang R.	13,105	986	14,091	28,883	205.0	4.28	123,746
14.	Musi Rawas R.	13,421	17,030	30,451	42,706	140.2	5.84	249,603
15.	Musi Rawas Utara R.	415	6,716	7,131	2,950	41.4	3.97	11,700
16.	Musi Banyuasin R.	0	66,810	66,810	45,197	67.7	4.98	225,249
17.	Banyuasin R.	0	226,518	226,518	253,034	111.7	4.87	1,231,803
South Sumatra Total		117,757	656,745	774,502	821,666	106.1	5.00	4,106,495

Source: Sumatera Selatan Dalam Angka 2017

Table 7.2.8 Features of Rice Cultivation Area

Item	Irrigated field	Rain-fed field	Tidal swamp field	Inland swamp area
Plot location	The paddy field plot is made in a fixed place.			No paddy field plot and planted area is shifted according to water level change in inland swamp.
Plot type	The water level of paddy field plot can be controlled by man-made ditches dividing the paddy filed.			No shape of paddy field plot.
Water source	The natural flow of water source river and/ or regulated flow discharged from reservoir	Rain water	Rain water and/ or pumped up fresh water from drainage canal	Stagnant fresh water in inland swamp
Share of area	13.7%	13.2%	29.9%	43.2%
Cropping period	Land preparation & transplanting times are fixed for both wet and dry season crops.	Land preparation & transplanting times of wet season crop are linked with starting of rainy season.		Seedlings grown in nurseries made in other dry land area are transplanted in dry season
Public service (Facility)	Legal status as irrigation scheme is given and O&M responsible agency is decided based on related government regulation.	No legal status is given, but if paddy field has a certain scale, the area has a passivity of taking up as the candidate for new irrigation development area.	Legal status as swamp drainage scheme is given and responsible agency for O&M is decided based on related government regulation.	Out of public services
Public service (Extension)	Cultivation of high yielding variety of rice is encouraged for triple cropping of wet and dry seasons paddy and secondary crop, double cropping of paddy, and/ or two cropping of paddy and secondary crop.	Growing of high yielding variety of rice for wet season is recommended.	Long stem and salt tolerant rice variety is advised.	Long stem variety is advised.

Source: JICA Project Team 2

7.2.6 Social Environment

The average net income of an informal employee in the province is 1,501 thousand (IDR) per month based on the 2017 statistics whereas the minimum wage in the province is 2,388 thousand. The percentage of poor people in the province is 13.1% as of September 2017, and it is higher than the national average (10.12%). The rate below poverty line is 12.36% in the urban areas whereas 13.54% in the rural areas. The most significant source of drinking water in the province in the year 2017 was the protected well (34.77%), followed by bottled water (19.75%) and piped water (16.65%). The numbers of totally or severely damaged households by disaster are 196 in 2017 and 114 in 2016 which are lower than other disaster-prone provinces.

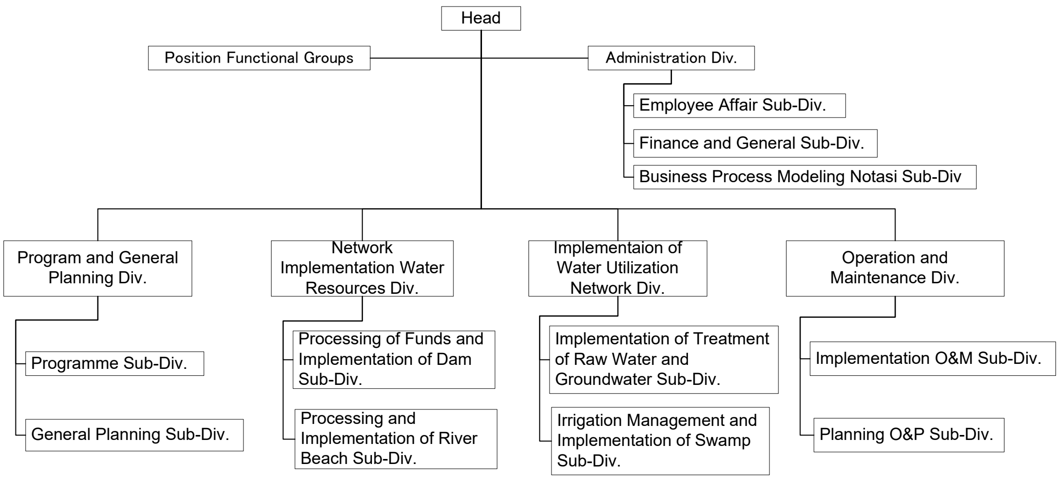
7.3 Current State of Water Sector

7.3.1 River Basin Management

(1) Management Organization

The MSBL (Musi-Sugihan-Banyuasin-Lemau) River basin, a combination of three river basins and a watershed, namely: the Musi, Sugihan, Banyuasin River basins, and the Lemau watershed, was established by the Presidential Decree No. 12 Year 2012 on the determination of river basin. The cross-province river basin is being managed by BBWS Sumatra VIII (hereinafter referred to as BBWS-S8) under the authority of the central government.

BBWS-S8 has a task to carry out the management of water resources which includes planning, construction, operation and maintenance for the purposes of water resource conservation, water resource development, water resource utilization, and control of water destructive power in the river basin. It is composed of five divisions and functional groups as shown in Figure 7.3.1, and has an approximately 500 staff.



Source: BBWS-S8

Figure 7.3.1 Organization Chart of BBWS Sumatra VIII

In April 2013 a Water Resources Management Coordinating Team (TKPSDA) was established for the MSBL River basin with a total of 88 members (44 from governmental elements including BAPPEDA, Dinas PU, Dinas Pertanian, etc., and the other 44 from non-governmental elements) to accommodate the aspirations of all stakeholders on the management of water resources. TKPSDA is based in Palembang, and responsible to the Minister of Public Works with six duties and three functions as presented in Table 7.3.1.

Table 7.3.1 Six Duties and Three Functions of TKPSDA

Duty/Function	Contents
Six Duties	1. Discussion on pattern, POLA (strategic plan) and RENCANA (implementation plan) of water resources management 2. Discussion on program design and draft action plans for natural resources management in the river basin 3. Discussion on proposed plans of allocation of water from any water source 4. Discussion on hydrological, hydro-meteorological and hydrogeological information system for integrated information management 5. Discussion on draft human resources utilization, financial, and institutional tools to optimize the performance of natural resource management in the river basin 6. Giving consideration to the Minister on the implementation of natural resources management in the river basin
Three Functions	1. Consultation with relevant parties for the integration of water resources management 2. Integration and alignment of interests among sectors and regions and stakeholders in water resources management 3. Monitoring and evaluating the of the implementation of plans and programs of water resources management activities

Source: BBWS-S8

(2) Meteorological and Hydrological Observation

1) Observation

Meteorological conditions (temperature, sunshine hours, wind speed, humidity, evaporation, etc.) are observed by Meteorological and Hydrological Agency (BMKG) under the Ministry of Transportation. BMKG has two meteorological stations (SMB II and Kenten II Stations) and manages around 120 rainfall stations in South Sumatra Province.

Two agencies, namely, BBWS-S8 and Dinas PU (PSDA Musi and PSDA Sugihan) of South Sumatra Province observe hydrological conditions (rainfall, water level and discharge) in the Musi River basin. PUSAIR does not conduct any hydrological observation by themselves but collects and arranges data from the observation agencies to publish a yearly data book.

In addition, Pelindo II (Indonesia Port Corporation II) has five tide stations along the lowest stretch of the Musi River.

Meteorological, hydrological and tide data were collected from BMKG, BBWS-S8, PSDA, the 2003 JICA Musi Study, PUSAIR and Pelindo II which are shared with the JICA Project Team 1 (the Team for the Climate Change Impact Assessment and Runoff Analysis). Table 7.3.2 and Figure 7.3.2 present an inventory and a location map of the collected rainfall data, Table 7.3.3 and Figure 7.3.3 present those of the collected water level/discharge data, and Table 7.3.4 and Figure 7.3.4 present those collected tide data, respectively.

There are remarkably many blank spaces in the tables. It is understood that the availability of water level/discharge data is especially limited. There is no water level/discharge station that has continuous data of 15 years or more.

The collected hydrological data are used for model verification of the runoff analysis by the JICA Project Team 1 and the flood inundation analysis by the JICA Project Team 2. Prior to the model verification, quality check of the collected data, particularly water level and discharge data, were conducted by the Team 2. In conclusion, it was found that the quality of the collected water level and discharge data is considerably poor. Special attention should be paid when the data are used.

Table 7.3.2 Inventory of Collected Rainfall Data

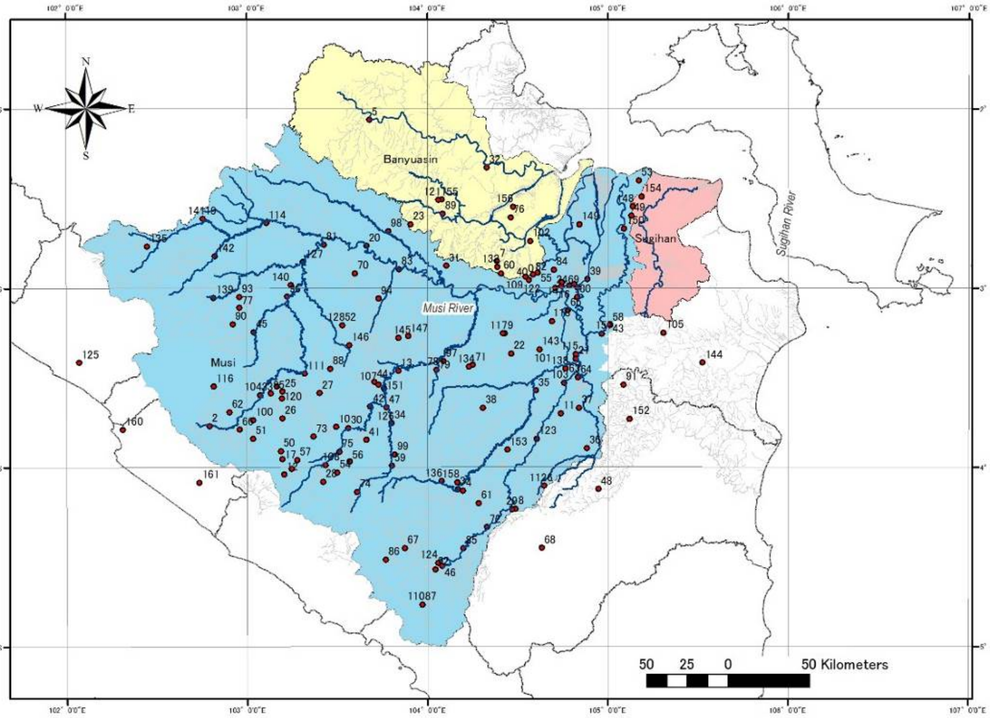
No.	Gauging Station Name	Longitude	Latitude	Source Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
001	alicia	104.54439	-2.93808	BMKG																																		
002	Batang Hari Leko	103.40859	-0.23984	BMKG																																		
003	Batu Lintang	102.7925	-3.77	BMKG																																		
001	Baturaja	104.16852	-4.12382	BMKG																																		
005	Baturajatimur	104.19772	-4.13278	BMKG																																		
006	Bayung Lincir	103.67928	-2.06281	BMKG																																		
007	Belitang	104.64828	-4.10564	BMKG																																		
008	Betung	104.38647	-2.85214	BMKG																																		
009	Cipta Muda	104.489	-4.23239	BMKG																																		
010	Gelumbang	104.42914	-3.25447	BMKG																																		
011	Gumay Talang	103.49636	-3.77578	BMKG																																		
012	Gunung Batu	104.74001	-3.70001	BMKG																																		
013	Gunung Gare	103.20681	-4.04128	BMKG																																		
014	Gunung Megang	103.8401	-3.46362	BMKG																																		
015	Ilir Barat I	104.74294	-2.98961	BMKG																																		
016	Ilir Timur I	104.74494	-2.97094	BMKG																																		
017	Ilir Timur II	104.78722	-2.98844	BMKG																																		
018	Jarai	103.19675	-3.95478	BMKG																																		
019	Kalidoni	104.81422	-2.98064	BMKG																																		
020	Karang Jaya	102.75786	-2.61475	BMKG																																		
022	Kasmaran	103.6645	-2.76542	BMKG																																		
023	Kayu Agung	104.82253	-3.39553	BMKG																																		
024	Kelekar	104.46456	-3.36758	BMKG																																		
025	Keluang	103.90789	-2.64608	BMKG																																		
026	Kenten (2)	104.71	-3	BMKG																																		
027	Kikim Barat	103.19864	-3.57784	BMKG																																		
028	Kikim Selatan	103.1979	-3.72723	BMKG																																		
029	Kikim Timur	103.40252	-3.58744	BMKG																																		
030	Kota Agung	103.42243	-4.08208	BMKG																																		
031	Kurungan Nyawa	104.46914	-4.23567	BMKG																																		
032	Lahat	103.56197	-3.78175	BMKG																																		
033	Lais	104.10533	-2.87753	BMKG																																		
034	Lalan	104.33018	-2.32846	BMKG																																		
035	Lampar Baru	103.075	-3.598	BMKG																																		
036	Lawang Kidul	103.80283	-3.75392	BMKG																																		
037	Lembak	104.60039	-3.57257	BMKG																																		
038	Lempuing Induk	104.88392	-3.89467	BMKG																																		
039	Lempuing Jaya	104.84	-3.67	BMKG																																		
041	Lubai	104.30856	-3.66919	BMKG																																		
042	Mariana 1	104.88639	-2.95269	BMKG																																		
043	Melania	104.56392	-2.95792	BMKG																																		
044	Merapi Selatan	103.66213	-3.84884	BMKG																																		
045	Merapi Timur	103.68473	-3.66282	BMKG																																		
046	Mesuji Raya	105.01244	-3.209	BMKG																																		
047	Muara Belida 1	103.70608	-3.52511	BMKG																																		
048	Muara Beliti 1	103.03822	-3.24589	BMKG																																		
049	Muara Dua	104.08036	-4.55119	BMKG																																		
050	Muara Enim 1	103.77247	-3.66725	BMKG																																		
051	Muara Kuang	104.94961	-4.12369	BMKG																																		
052	Muara Padang	105.13192	-2.59761	BMKG																																		
053	Muara Payang	103.19	-3.91	BMKG																																		
054	Muara Pinang	103.03433	-3.84	BMKG																																		
055	Muara Rupit	103.53072	-3.20836	BMKG																																		
056	Muara Sugihan	105.17132	-2.4005	BMKG																																		
057	Mulak Ulu	103.5	-4.03	BMKG																																		
058	Musi Landas	104.61339	-2.91678	BMKG																																		
060	Pagar Gunung	103.57	-3.97	BMKG																																		
061	Pajar Bulan	103.28	-3.96	BMKG																																		
062	Pampangan	105.01244	-3.209	BMKG																																		
063	Pandan Enim	103.80497	-3.9925	BMKG																																		
064	Pangkalan Balai 2	104.40811	-2.92044	BMKG																																		
065	Pasar Lama	104.28389	-4.2015	BMKG																																		
066	Pasmah Air Keruh	102.90321	-3.69297	BMKG																																		
067	Pedamaran	104.83631	-3.49606	BMKG																																		
068	Pedamaran 2	104.83492	-3.50079	BMKG																																		
069	Pemulutan	104.77939	-3.12575	BMKG																																		
070	Pendopo	102.96017	-3.79003	BMKG																																		
071	Pengandonan	103.87494	-4.45156	BMKG																																		
072	Peninjauan	104.63394	-4.45156	BMKG																																		
073	Plaju	104.83314	-2.99922	BMKG																																		
074	Plakat Tinggi	103.6	-2.92	BMKG																																		
075	Prabumulih 2	104.25075	-3.43036	BMKG																																		
076	Pracak	104.33006	-4.33528	BMKG																																		
077	Pseksu	103.37	-3.83	BMKG																																		
078	Pulau Panggung 2	103.60956	-4.13914	BMKG																																		
080	Pulau Pinang	103.51269	-3.91447	BMKG																																		
081	Pulau Rimau	104.46386	-2.60789	BMKG																																		
082	PURWODADI	102.96	-3.11	BMKG																																		
083	Rambang Dangku 1	104.05125	-3.45664	BMKG																																		
084	Rambang Dangku 2	104.05125	-3.45664	BMKG																																		
085	Rambutan	104.83178	-3.05231	BMKG																																		
086	Sanga Desa	103.42836	-2.75956	BMKG																																		
087	Sanna	104.58694	-2.92639	BMKG																																		
088	Sekayu	103.84361	-2.8963	BMKG																																		
089	SMB II	104.701	-2.9001	BMKG																																		
090	Simpang	104.20058	-4.4535	BMKG																																		
091	Simpang Campang	103.76892	-4.51575	BMKG																																		
092	Sipatuhu	103.9715	-4.76706	BMKG																																		
093	SP. Padang	103.46147	-3.45128	BMKG																																		
094	Sri Gunung	104.08603	-2.58656	BMKG																																		
095	Srikaton	102.92247	-3.20283	BMKG																																		
096	Sukajadi	105.08664	-3.53997	BMKG																																		
097	Sukaraja	104.04389	-4.57131	BMKG																																		
099	Sumber Harta	102.96044	-3.04994	BMKG																																		
100	Sungai Keruh	103.73	-3.06	BMKG																																		

No.	Gauging Station Name	Longitude	Latitude	Source Agency
101	Sungai Payang	103.13428	-3.58758	BMKG
102	Surulangun	103.22336	-3.04881	BMKG
103	Talang Padang	104.09	-3.41	BMKG
104	Tanah Abang	103.78593	-2.68415	BMKG
105	Tanjung Agung	103.82	-3.93	BMKG
106	Tanjung Aur	103.03433	-3.7375	BMKG
107	Tanjung Batu	104.62175	-3.34481	BMKG
108	Tanjung Lago	104.57	-2.74	BMKG
109	Tanjung Lubuk	104.75778	-3.53008	BMKG
110	Tebing Tinggi	103.075	-3.598	BMKG
111	Tulung Selapan	105.30948	-3.25043	BMKG
112	Tridinanti	104.74494	-2.97094	BMKG
113	Ujan Mas	103.73	-3.54	BMKG
114	002_R_Air_Dingin_Lama	103.43611	-3.98833	PU
115	003_R_Alicia	104.54417	-2.93806	PU
116	004_Banding_Agung	103.97139	-4.76694	PU
118	005_Benjarnegara	103.3225	-3.47833	PU
119	006_Belitang	104.64806	-4.10556	PU
120	007_Betung_PIR_I	104.38639	-2.85194	PU
121	008_Bingin_Teluk	103.10833	-2.63861	PU
122	009_Cilika	104.82222	-3.36944	PU
123	011_Embacang	102.81667	-3.54944	PU
124	012_Gelumbang	104.42-9999	-3.25444	PU
125	013_Indralaya	104.6925	-3.18667	PU
126	015_Kayu_Agung	104.8225	-3.39528	PU
127	017_KupangTB_Tingi	103.19472	-3.6163	PU
128	018_R_Linggasari	104.08111	-2.50833	PU
129	020_Melania	104.56389	-2.95778	PU
130	021_R_Menanga	104.60667	-3.84306	PU
131	022_Muara_Dua	104.06056	-4.53417	PU
132	023_Muara_Beliti	102.07278	-3.41611	PU
133	024_Muara_Enim	103.77222	-3.66722	PU
134	025_Muara_Lakitan	103.31306	-2.85611	PU
135	026_Muara_Lupit	103.53056	-3.20833	PU
136	027_Pagar_Alam	103.24944	-4.01083	PU
138	028_Pampangan	105.01222	-3.20889	PU
139	029_Pancaran_MusiTb_Tinggi	103.16722	-3.55056	PU
140	031_Pangkalan_Balai	104.38861	-2.88389	PU
141	032_Plaju	104.83306	-2.99917	PU
142	033_Prabumulih	104.23194	-3.44056	PU
143	034_Pulau_Kidak	102.45028	-2.76861	PU
144	035_Raksa_Jiwa	104.07806	-4.07833	PU
145	036_Sanna	104.58694	-2.92639	PU
146	037_Sirah_Pulau_Padang	104.76611	-3.45111	PU
147	038_Simpang_Mambang	102.81667	-3.055	PU
148	039_SPII_Klingi_BlokB	103.24444	-2.985	PU
149	040_Suru_Langun	102.75778	-2.61472	PU
150	042_Terawas	102.82417	-2.82306	PU
151	043_Tanjung_Batu	104.62167	-3.34472	PU
152	046_Tulung_Selapan	105.52611	-3.41778	PU
153	047_Talang_Ubi	103.84194	-3.28056	PU
154	048_Tumulyo	103.56806	-3.32028	PU
155	049_Watervang	103.895	-3.27028	PU
157	050_Timbul_Jaya	105.14-9999	-2.54667	PU
158	051_Sumber_Hidup	104.84361	-2.64583	PU
159	053_Purwodadi	105.09139	-2.66944	PU
160	054_Pinang_Belarik	103.76	-3.56167	PU
161	056_Kertamukti	105.12194	-3.73167	PU
162	057_Karya_Jaya	104.44417	-3.90333	PU
163	058_Damar_Wulan	105.18694	-2.49167	PU
164	060_Bayung_Lincir	104.06278	-2.51083	PU
165	061_Rawa_Banda	104.47611	-2.54833	PU
166	062_Sepang_Pampangan	104.96667	-3.25694	PU
167	063_Terusan	104.16778	-4.085	PU
168	Gardu Tanjak	106.10528	-6.31083	PU
169	Surabaya/Tanjung Jaya	102.31389	-3.79	PU
170	Tanjung Agung	102.7375	-4.08583	PU
171	Blang Bintang	95.364564	-5.54524	PU
172	Cibalok Gadog	106.86383	-6.65692	PU
173	Kayu Ambon	107.63306	-6.82083	PU
174	Panjalu	108.26944	-7.14381	PU
176	Bulu	111.40972	-6.86361	PU
177	Wd.Gembong	110.95	-6.70083	PU
178	Lengkong	112.485	-7.45083	PU
179	Kali Penggung	113.38	-8.16278	PU
180	Boas	124.92456	-9.44752	PU
181	Kolbano	124.53331	-10.0008	PU
182	Oeletsala	123.69483	-10.2424	PU
183	Belantak	123.41278	-0.89667	PU
184	Mayoa	120.74583	-2.3213	PU
185	Oga Bayas	120.76361	-0.5725	PU
186	Paringi	120.16667	-0.79194	PU

Source: JICA Project Team

100%-Available
90 - 99% - Available
80 - 89% - Available
70 - 79% - Available
1 - 69% - Available
0% - No Data

Source: JICA Project Team 2



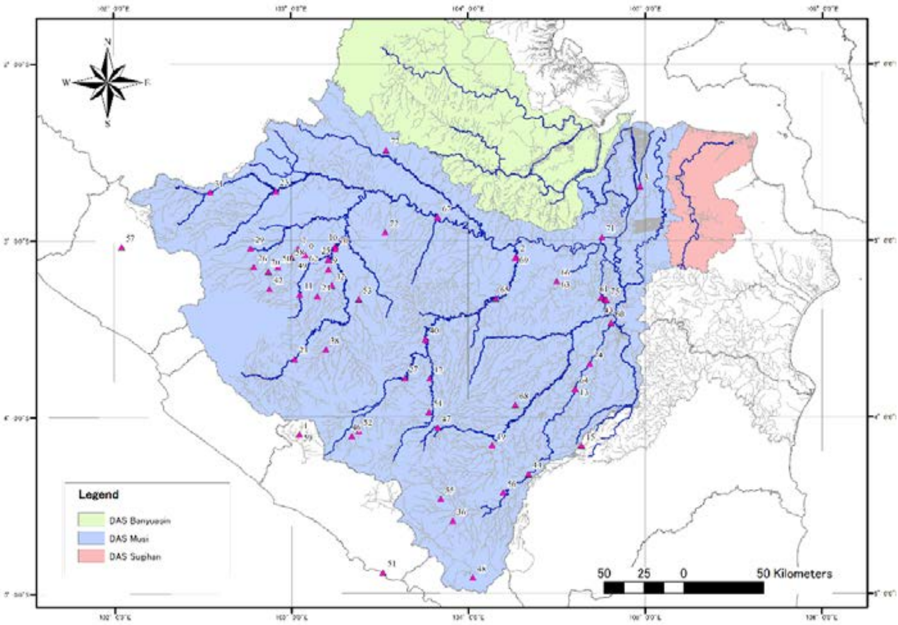
Note: The station numbers is the same as those of Table 7.3.2
Source: JICA Project Team 2

Figure 7.3.2 Rainfall Observation Staitons

Table 7.3.3 Inventory of Collected Water Level Data

No	Name of Station	Letak Lintang	Organization			year																																										
			PUSAIR	PSDA	BBWS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12
1	S. Musi Ulu - Semang / Bt. Cawang - Gunung Ayu	04 06 00 LS 103 02 40 BT	■																																3													
2	S. Lematang _ S. rotan	03 05 41 LS 104 16 21 BT	■	■												●	●										3	11	●	●	●	●		●	●				3	7	●	●	8		●			●
7	A. Megang - Megang Sakti	03 02 58 LS 103 02 18 BT	■																		5	7					●	●	●			●		●	●													
9	A. Gegas - Sukakarya	03 09 52 LS 103 12 42 BT	■														6	●	5																													
10	A. Musi - Mambang	03 02 00 LS 103 15 00 BT	■						●	5	5	11	●	▲	11	10	11	11	●	▲	8					●	11	●	●	●																		
11	A. Beliti - Rantau ringin	03 18 31 LS 103 02 58 BT	■	■						8	11					●	9	5	4		7	5					10	8	●	10		●	11		●				2	●	●	●	●	●	●	●	●	●
12	A. Enim - Sukaraja	03 47 00 LS 103 47 00 BT	■										●	●	●	●	●	●	●	●	●																											
13	A. Komering - Campaka	03 50 37 LS 104 36 21 BT	■	■																																			2	11	●	●	●	●	●	●	8	●
15	A. Belitang - Tirtonadi	04 09 52 LS 104 38 31 BT	■	■										2		3	●	●	10	10	7	5		3	●	10	●		●	●		●	●	●	●				2	●	●	●	9	7	●			●
19	A. Lengkayap - Bt. Putih	04 09 44 LS 104 08 07 BT	■	■												2	●	●	9	7		5			●	11	●	●	●	●				●	●				3	●	●	7	8	4	●			
20	A. Malus - Tj Raya	03 10 30 LS 102 52 21 BT	■	■														●	●	6	8	6						●	11	●		●		●	●				5	●	●	●	●	●	●	●	4	
23	A. Rawas - Muara Rupit	02 43 14 LS 102 54 52 BT	■														11	●	●	11	●	11	●	●	●	●	●	●																				
24	A. Temelat - Ciptodadi	03 19 03 LS 103 08 55 BT	■														5	●	●	6	9	10		6	●	●	●	●	●	●		●																
25	A. Perigi - Darmabakti	03 06 29 LS 103 12 42 BT	■														5	10	7	10	11	8	●	●	●	8	●	●	●	●		●																
27	A. Lematang - Lebakbudi	03 46 53 LS 103 38 31 BT	■	■																	4							11	●	●	●	11		●	●				5	●	●	●	●	6	●	2	9	●
29	A. Baal - Terawas	03 02 42 LS 102 46 23 BT	■	■													5	●	●	4		5					●	●	●	●		●	●		●													●
31	A. Rawas - Pulau Kidak	02 43 38 LS 102 32 44 BT	■																									●	●	●		●			●													
32	A. Kungku - Ciptodadi	03 15 16 LS 103 13 47 BT	■																										●	●		10			●													
36	W. Selabung - Kt. Agung	04 35 25 LS 103 54 44 BT	■	■																									●	●				●	●				1	10	●	●	11	●	●	●	●	●
38	A. Pangi - Ulak Badung	03 37 02 LS 103 11 49 BT	■																								●	●	●	●		●		●	●					10								
40	A. Lematang - Pinang belarik	03 33 39 LS 103 45 32 BT	■	■																						5	3	●	●	●	●	●	●	●					5	●	●	8	11		●			●
42	A. Kelingi - Ulak Surung	03 16 30 LS 102 52 42 BT	■																									●	●	●		●			●					7		●	9					
43	A. Ogan - Tj Raja	03 20 10 LS 104 46 30 BT	■	■																									●	11				●	●				5	●	1	●			●			
44	A. Komering - Martapura	04 19 30 LS 104 20 25 BT	■																															●	●													
45	A. selabung - Sanding Agung		■																										●		●																	
46	A. Pasemah - Muara Sindang	04 06 36 LS 103 20 30 BT	■																																●	●												
47	A. Ogan Kecil - Desa Blambangan	04 03 43 LS 103 49 39 BT	■																																●	●				●				●	●			
48	S. Warkuk - Desa Kota Baru	04 54 43 LS 104 01 29 BT	■																																●	●												
49	S. Kesie - Lubuk Tanjung	03 04 56 LS 103 04 42 BT	■	■																															3	●		●	3	●	●	●	●	●	●	●	●	●
50	S. Megang - Darma Bakti	03 09 08 LS 102 55 35 BT	■																																3	●												
51	S. Lim - Tanjung Siri	04 52 54 LS 103 31 03 BT	■																																3	●												
52	S. Payang - Ds. Kebon Jati	04 04 55 LS 103 22 56 BT	■																																3	●												
53	S. Siku - Ds. Kertadewa	03 20 03 LS 103 22 56 BT	■																																3	●												
54	S. Lemutu - Embawang	03 58 27 LS 103 46 44 BT	■																																3	●												
55	S. Keni - Desa Paninjauan	04 27 59 LS 103 50 41 BT	■																																3	●												
56	S. Bungin - Ds. Baturaja Bungin	04 25 49 LS 104 11 50 BT	■																																3	●												
57	S. dulu - Bukit Ulu	03 02 10 LS 102 02 40 BT	■																																●	●												
58	S. Tupak - Dwijaya	03 05 35 LS 103 00 00 BT	■																																●	●												
59	S. Cawang - Ds. Gunung Ayu	04 06 00 LS 103 02 40 BT	■																																●	●												
60	Desa Sukaraja	03 28 05 LS 104 48 31 BT	■																																	2												
61	S. Arisan - Jenang	03 19 34 LS 104 45 09 BT	■																																	3												
62	Lubuk Rumbai	03 04 56 LS 103 04 42 BT	■	■																																				●								
63	S.Komering-Mangunjaya	03 13 54 LS 104 30 02 BT	■	■																																				●								
64	S.Komering-Menanga	03 50 37 LS 104 36 21 BT	■																																					●								
65	Rambang-Tj.Rambang	03 19 48 LS 104 09 24 BT	■																																					●								
66	Kayu Agung	03 13 54 LS 104 30 02 BT		■																																			3	●	●	10	9	●	●	●	10	11
67	Sekayu	02 40 16 LS 103 38 09 BT		■																																				●	●	●	●	●	●	●	10	●
68	AWLR Pinang Belarik	03 56 17 LS 103 76 567BT			■																		11	●		4	●	●	●	●	●	●	●	●	●	●	2											6
69	AWLR Sungai Rotan	03 06 198LS 104 16 649BT			■																															●	6											
70	AWLR Mambang	03 03 569LS 103 15 18 BT			■																																										2	3
71	AWLR SKANAK	02 59 01LS 104 45 22BT			■																																											7
72	AWLR SEMANGUS	02 57 20LS 103 32 00BT			■																																										2	9
73	AWLR ULAK MENGKUDU	03 40 21LS 103 01 12BT			■																																											3
74	AWLR SUKABUMI	03 42 05LS 104 41 14BT			■																																										4	7
75	AWLR SRIJABO	03 20 23LS 104 46 53BT			■																																										4	7
76	AWLR SELANGIT	03 09 06LS 102 47 20BT			■																																										4	7
77	AWLR MUARATELADAN	02 29 25LS 103 32 19BT			■																																											2

Note: Data Availability: Number in grid is number of months when data is available. "●" means "fully available for 12 months".
Source: JICA Project Team 2



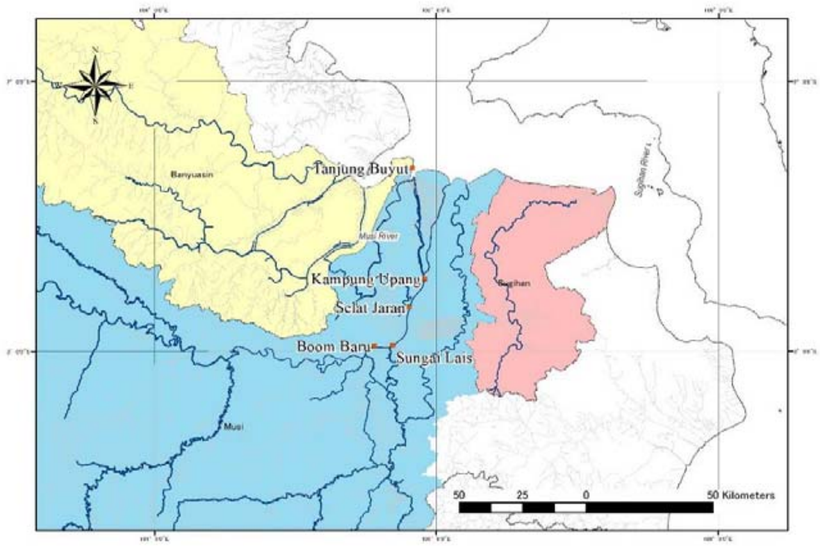
Note: The number, which is shown in above figure, is related to the station number of Table 7.3.3
Source: JICA Project Team 2

Figure 7.3.3 Water Level Observation Stations

Table 7.3.4 Inventory of Collected Water Level Data

No	Station name	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13
1	Boom Baru	2	11	5	6	9	9	9	10	●	10	●	8	7		7	6	
2	Sungai Lais	8	9	10	10	●	11	●	11	●		●	10	0				
3	Selat Jaran	6	7			9	11	10	11	10		●	11	10		10	10	5
4	Kampung Upang	4	7	9	7	11	10	●	11	●	●	●	11	●		6	1	2
5	Tanjung Buyut	6	6	10	8	●	9	●	11	●		●	10	10		10	8	2

Note: Data Availability: Number in grid is number of months when data is available. "●" means "fully available for 12 months".
Source: JICA Project Team 2

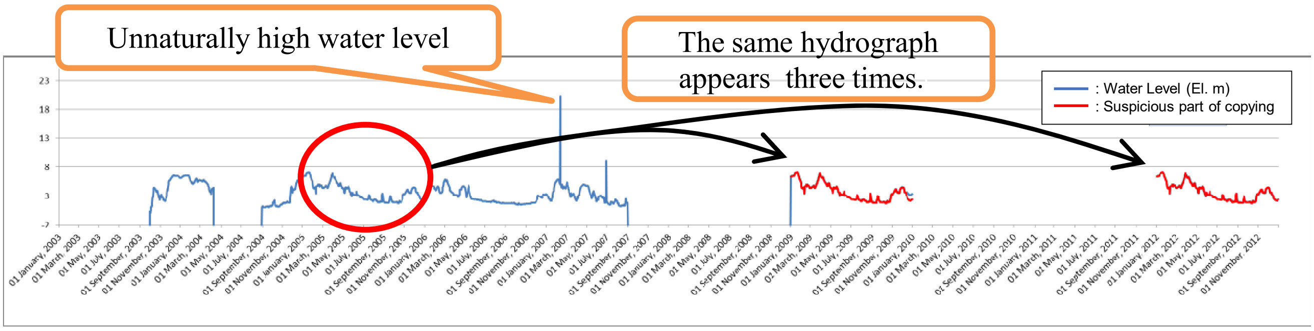


Source: JICA Project Team 2

Figure 7.3.4 Location of Tide Observation Stations

2) Data Quality

Figure 7.3.5 shows a water level hydrograph at No.2 S. Lematang_S. Rotan Station as an example. The same shape of water level hydrograph appears three times in 2005, 2009 and 2012. The data of 2005 was probably copied to those of 2009 and 2012. Moreover, an unnaturally high water level is also seen in the hydrograph. Such coping is not limited to this station, but was identified in almost all the stations.



Source: JICA Project Team 2

Figure 7.3.5 Example of Abnormal Water Level Data (No.2 S. Lematang S. Rotan Station)

The collected discharge data were also checked by examining a runoff ratio (ratio of runoff volume to rainfall volume), which are normally in the range from 0.4 to 0.7 but never exceeds 1.0 theoretically. Gridded rainfall data developed by the JICA Project Team 1 were used to estimate the rainfall volume. Table 7.3.5 shows results of the runoff ratio estimation for selected discharge stations that have more available data than the other stations. There are five stations of which the runoff ratios exceed 1.0. However, it is very difficult to trace the causes of these high runoff ratios, because the raw data of the discharge measurement that were used for the preparation of the rating curves were already lost and the curves are alone left available.

Table 7.3.5 Runoff Ratio of Selected Discharge Stations

Station	Average Annual Runoff 1985-2012 (mm)	Average Annual Rainfall 1985-2012 (mm)	Average Runoff Ratio 1985-2012	Average Annual Runoff 2005-2012 (mm)	Average Annual Rainfall 2005-2012 (mm)	Average Runoff Ratio 2005-2012
02_Lematang_Rotan	1,715	2,606	**0.69**	1,350	3,003	**0.44**
11_Beliti_Rantau_Ringin	1,985	2,424	**0.96**	2,091	1,996	**1.08**
13_Komering_Campaka	1,328	2,047	**0.62**	1,328	2,125	**0.62**
15_Belitang_Tirtonadi	3,203	2,131	**1.56**	4,298	2,441	**1.99**
19_Lengkayap_Bt_Putih	4,800	1,730	**2.54**	4,800	2,145	**2.54**
27_Lematang_Lebakbudi	1,469	2,600	**0.49**	1,840	2,529	**0.55**
36_Selabung_Kt_Agung	675	2,156	**0.35**	526	2,010	**0.27**
40_Lematang_Pinang_Belarik	1,814	1,910	**1.01**	1,749	2,133	**0.56**
43_Ogan_Raja	1,481	2,020	**0.91**	No Data	2,412	**N/a**
66_Kayu_Agung	2,467	2,411	**1.03**	2,467	2,625	**1.03**
67_Sekayu	448	2,401	**0.22**	No Data	2,162	**N/a**
10_Musi_Mambang	1,761	2,526	**0.65**	No Data	2,068	N/a
23_Rawas_Muara Rupit	2,337	2,166	**1.04**	No Data	1,938	N/a
Average	1,960	2,241	**0.93**	2,272	2,276	**1.01**

Source: JICA Project Team 2

Through the above data examination, discharge data of only five stations listed in Table 7.3.6 are judged to be narrowly acceptable in quantity and quality as data for the model verification, although they should still be used with care.

Table 7.3.6 Narrowly Acceptable Discharge Data

Station	Data Source	Data Period	Matters that require attention for data use
02_Lematang Rotan	PSDA	2003~2007/2009/2012	There are the same data repeated in 2005, 2009 and 2012. The copied data should be avoided.
13_Komering_Campaka	PUSAIR	2004/2008~2009	There are the same data repeated in 2005 and 2009. The copied data should be avoided.
27_Lematang_Lebakbudi	PUSAIR	1985/1992~1996/1998~1999/2004/2006~2009	There are the same data repeated in 2009 and 2012. The copied data should be avoided.
36_Selabung_Kt_Agung	PSDA	2003~2012	
10_Musi_Mambang	PUSAIR	1973~1985/1990~1994/1999	Examination of runoff ratio has not been conducted yet for old data from 1973 to 1984.

Source: JICA Project Team 2

(3) Existing River Facilities

1) Barrage, Dam and Hydropower Plant

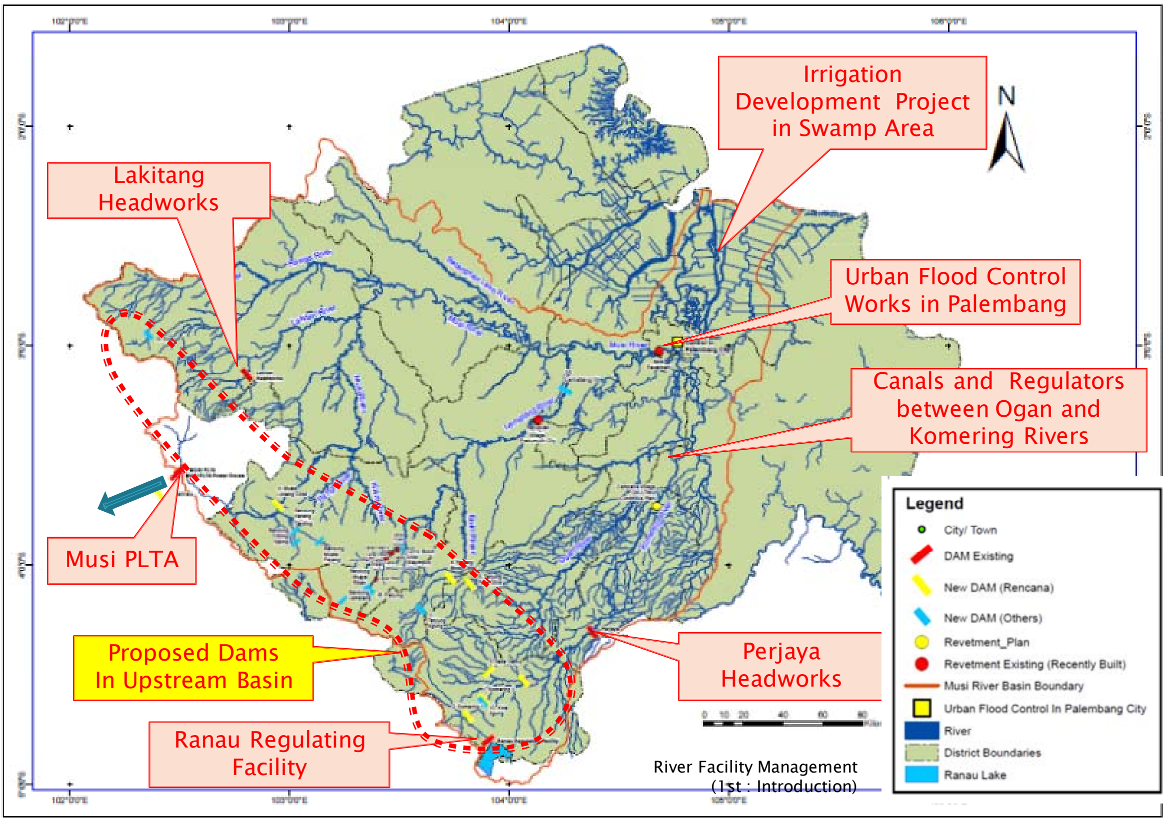
Data collection of the river facilities in the Musi River basin was conducted through site inspection and interview survey to relevant staff of BBWS-S8. Basic information and operation and maintenance of these facilities were examined. Basic dimension of the major existing dams, headworks and hydropower plants are summarized in Table 7.3.7 and Figure 7.3.6.

Table 7.3.7 Major Headworks, Dam and Hydropower Plant in Musi River Basin

River Facility	Technical Feature	Construction Year
(1) Headworks		
Perjaya Headworks	End sill height=2-3m, L=215.5m, gated weir, with 7 nos. spillway gates, 3nos. sluiceway gates, 59,148ha	1996
Lakitang Headworks	H=7.66m, L=80m, fixed weir with 4 nos. sluiceway gates, 9,667ha	1997
Lintang Kiri Headworks	H=4.0m, L=40.0m, fixed weir with 3 nos. sluiceway gates, 3,037ha	2011
Lintang Kanan Headworks (Siring Agung) (Karang Tanding)	H=1.0m, L=31.0m, fixed weir with sluiceway gates,1,293ha H=1.5m, L=24.0m, fixed weir with sluiceway gates1,761ha	1997
Lematang Headworks	H=2.0m, L=30.0m, fixed weir with 2 nos. sluiceway gates, 3,000ha	On-going construction
(2) Dam/Reservoir		
Ranau Lake	Reservoir area: 125 km^2, Storage volume: 190 MCM for irrigation water supply.	-
Ranau Regulating Facility	H=7.0m, L=144.0m, gated weir with 6 nos. regulating gates and emergency spillway	1996
(3) Hydro Power Plant		
Musi PLTA	Installed Capacity: 21.0MW, Power Generation 1,834GWh/year	2006
Ranau Niagla PLTMH	Installed Capacity: 2 x 850 kW,	2015

Source: JICA Project Team 2

From the view point of the existing river facility management, the main points that should be considered in the water balance analysis are; i) Inter-basin transfer scheme from Musi HP, ii) Water supply system from the Ranau Lake to Komering Irrigation System, and iii) Operation of regulators and their canals between the Komering River and the Ogan River.



Source: Prepared by JICA Project Team 2 referring to RENCANA(2016) and others

Figure 7.3.6 Location Map of Major Headworks, Dam and Hydropower Plant in Musi River Basin

2) Existing River Bank Protection Works

River bank erosion is one of most serious flood problems in the Musi River basin. How to protect the residential houses and infrastructures along erodible riverbank in the middle and upstream basin becomes the main issue on flood risk management.

As per information from BBWS-S8, it is pointed out that the serious bank erosion occurred in Sekayu in Banuasin Regency. The national road along the Musi River is suffering from the active bank erosion which have already reached to the side of the road by around 2-3 meters. At present, rehabilitation on the damaged river bank protection works in two sections in Selayu are being conducted by BBWS-S8 and Binamarga, respectively. The reasons for the damaged are i) progressing local scouring due to water colliding front located at an outer curve of meandering river and ii) massive sand mining activities nearby river channel.

Source: JICA Project Team 2

Figure 7.3.7 Photograph and Mechanism of River Bank Erosion in Sekayu

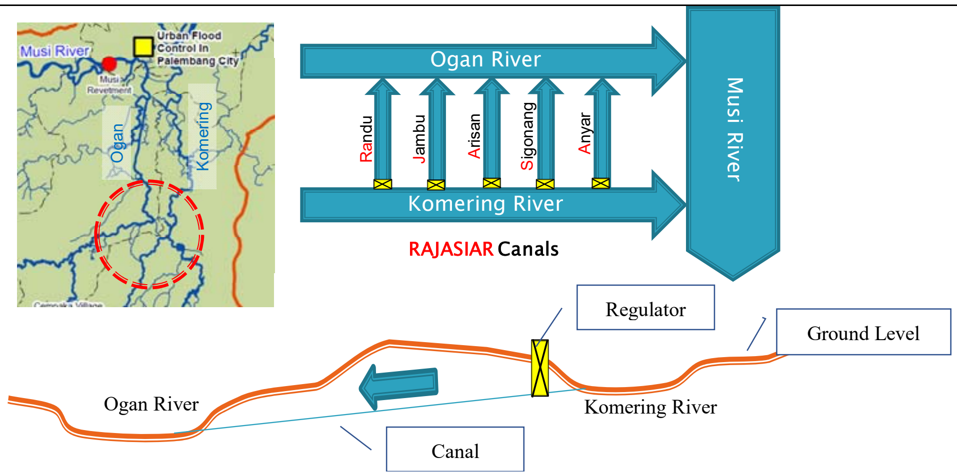
3) Existing Regulators

Between the Komering and Ogan Rivers, there are five (5) connecting canals (RAJASIAR Canals) and regulators. The canals were constructed in the Dutch Era aiming at a flood diversion from Komering to Ogan so as to mitigate flood damage in the lower Komering River. However, the riverbed degradation and bank erosion in the canals became worse due to straight and steep alignment of the canals. Thereby drought in lower Komering River became a problem because water had been diverted from Komering to Ogan even in the dry season. To cope with this, regulators were constructed at the inlet of each canal. The main functions of the regulators are shown below;

- In rainy season: Flood diversion from Komering River to Ogan River
- In dry season: Discharge control to secure water supply in downstream of Komering

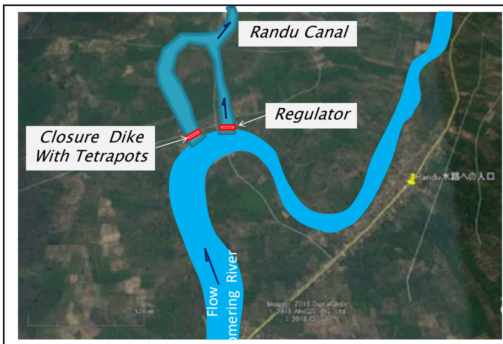
For the Randu Canal, the regulator had been repeatedly damaged by floods. In 2014, the regulator with closure dike the Randu Canal have just rehabilitated.

In addition, there is one more canal connecting the Ogan and Komering Rivers. It is the Haji Canal which is likely to cause floods over urban areas nearby.



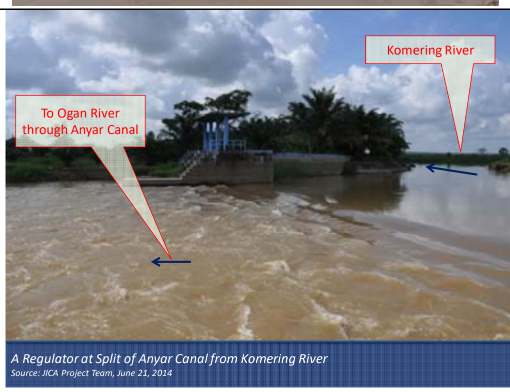
Source: JICA Project Team-2

Figure 7.3.8 Schematic Image of RAJASIAR Canals



Source: JICA Project Team 2

Figure 7.3.9 Regulator in Randu Canal in Komering River



Source: JICA Project Team 2

Figure 7.3.10 Regulator in Anyar and Segonang Canals in Komering River

7.3.2 Water Use

(1) Irrigation

In the attached tables of the Ministerial Ordinance No.14/PRT/M/2015 on "Criteria and Status of Irrigation Schemes", all the public irrigation and drainage schemes are listed up with data of location based on the regency/city and design area of each scheme. These registered schemes are also classified into five categories such as surface water irrigation, groundwater irrigation, pump irrigation/polder, swamp drainage, and fish culture pond. Furthermore, the management authority of these schemes is designated on scheme size and location basis like the River Basin Organization of DGWR for schemes over 3,000 ha and/or overriding two provinces, provincial governments for ones of 1,000 ha to 3,000 ha and/or overriding two regencies/ cities, and local governments (Regency/ City) for ones below 1,000 ha.

In South Sumatra Province, there exist 899 registered schemes consisting of 731 surface water irrigation schemes and 168 swamp irrigation schemes as shown in Table 7.3.8. The schemes under the management authority of BBWS-S8 are listed up in Table 7.3.9.

The largest surface water irrigation scheme in South Sumatra is Komering Irrigation Scheme by which 54,148 ha was developed and another 5,000 ha has been recently completed. Further extension plan of 8,500 ha is ready for commencement of implementation works. The actual monthly diversion record of irrigation water from the Komering River through the Perjaya Barrage to the command area of Komering Irrigation Scheme is shown in Table 7.3.10.

(2) Domestic, Municipal and Industrial Water Supply

Drinking water companies (PDAM) are providing domestic, non-domestic (commercial and public) and industrial water at urban areas of regency and city levels. Most of the water sources are surface water. In the other areas (Non-PDAM areas) people get drinking water from household-owned or community-owned wells.

Water demand by regency/city based on the population of 2010 is estimated as presented in Table 7.3.11 under the following assumptions:

- The criteria of the basic unit for water demand estimation of the Directorate General of Human Settlement, Ministry of Public Works 1996 is applied.
- The non-domestic water demand is assumed to be 20% of that of the domestic water demand.
- Estimated NRW (Non-Revenue Water) rates in 2010, which range from 15 to 50% are applied.
- The surface water-vs.-groundwater proportion in 2010 is applied.

Table 7.3.8 Number and Area of Registered Irrigation and Swamp Drainage Scheme

Regency (R) / City (C)	BBWS Sumatra 8		Province*		Regency/ City**				Total	
	Over 3,000 ha		3,000 – 1,000 ha		1,000 – 100 ha		Below 100 ha			
	(nos.)	(ha)	(nos.)	(ha)	(nos.)	(ha)	(nos.)	(ha)	(nos.)	(ha)
Surface Water Irrigation Scheme										
Pagar Alam C.	1	3,050	4	4,979	7	891	92	4,134	99	13,054
Lubuk Linggau C.	(1)	1,322	0	0	5	1,529	0	0	5 (1)	2,851
OKI R.	(1)	9,500	0	0	0	0	0	0	(1)	9,500
OKU Timur R.	1	47,988	3	4,920	1	650	0	0	5	53,558
OKU R.	0	0	0	0	16	2.844	18	980	34	3,824
OKU Selatan R.	0	0	3	4,801	20	4,007	21	1.172	44	9,980
Muara Enim R.	0	0	5	8,885	82	17,855	159	6.472	246	33,212
Lahat R.	0	0	8	10,443	31	6,059	183	7,289	222	23,791
Empat Lawang R.	3	9,244	1	1,500	16	5,464	2	150	22	16,358
Musi Rawas R.	2	18,341	4	6,013	20	5,513	22	1,050	49	30,917
Musi Rawas Utara R.	0	0	0	0	1	640	0	0	1	640
Sub-total	7	89,445	28	41,541	199	45,452	497	21,247	731	197,685
Lampung Province	(1)	5,048	0	0	0	0	0	0	0	5,048
Total	7	94,493	28	41,541	199	45,452	497	21,247	731	202,733
Tidal and Inland Swamp Irrigation Scheme										
Palembang C.	0	0	0	0	1	288	1	53	2	341
OKI R.	3	30,335	8	14,126	3	1,019	0	0	14	45,480
Ogan Ilir R.	2	13,536	7	14,992	46	14,425	4	279	59	43,232
OKU Timur R.	0	0	4	7,550	1	700	0	0	5	8,250
Muara Enim R.	0	0	1	1,200	4	2,757	0	0	5	3,957
Musi Banyuasin R.	3	29,065	7	11,641	55	17,722	1	90	66	58,518
Banyuasin R.	14	164,197	0	0	3	2,066	0	0	17	166,263
Total	22	237,133	27	49,509	113	38,977	6	422	168	326,041

Note: *; Dinas PU Pengairan dan Bina Marga Sumatera Selatan, **; PU Local Government
Source: DGWR

Table 7.3.9 List of Registered Irrigation and Swamp Drainage Schemes under BBWS-S8

Scheme	(ha)	Location	Scheme	(ha)	Location
Surface Water Irrigation Scheme			Swamp Irrigation Scheme		
1. Komering Selatan/ Way Komering	62,536		5. Delta Upang	5,896	Banyuasin R.
	(9,500)	OKI R.	6. Gasing Puntian	4,830	Banyuasin R.
	(47,988)	OKU Timur R.	7. Karang Agung Hilir	9,777	Banyuasin R.
	(5,048)	Lampung Province	8. Karang Agung I	6,300	Banyuasin R.
2. Kelingi Tugu Mulyo	10,163		9. Katang Agung Tengah	4,001	Banyuasin R.
	(8,841)	Musi Rawas R.	10. Kumbang Padang	4,268	Banyuasin R.
	(1,322)	Lubuk Linggau C.	11. Padang Sugihan	10,200	Banyuasin R.
3. Air Keruh	3,152	Empat Lawang R.	12. Pulau Rimau	23,184	Banyuasin R.
4. Lintang Kanan	3,054	Empat Lawang R.	13. Telang I	18,676	Banyuasin R.
5. Lintang Kiri	3,038	Empat Lawang R.	14. Telang II	9,660	Banyuasin R.
6. Air Lakitan	9,500	Musi Rawas	15. Air Tenggulang	6,156	Musi Banyuasin R.
7. Muara Riben	3,050	Pagar Alam C.	16. Karang Agung Hulu	6,350	Musi Banyuasin R.
Irrigation Scheme Total	94,493		17. Karang Agung II	17,000	Musi Banyuasin R.
(South Sumatra Total)	(89,445)		18. Lubuk Tnjung Seteko	3,876	Ogan Ilir R.
Swamp Drainage Scheme			19. Ogan Keramasan I + II	9,660	Ogan Ilir R.
1. Air Saleh	17,011	Banyuasin R.	20. M. Gajah Mati	5,950	OKI R.
2. Air Senda	4,711	Banyuasin R.	21. Sugihan Kanan	20,885	OKI R.
3. Delta Air Sugihan Kiri	34,690	Banyuasin R.	22. Sungai Lumpur	3,500	OKI R.
4. Delta Cinta Manis	5,554	Banyuasin R.	Drainage Scheme Total	237,133	

Source: DGWR

Table 7.3.10 Monthly Diversion Record of Perjaya Barrage

(Unit: m^3/s)

Month	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan.	-	27.99	28.58	24.94	40.49	26.46	35.27	35.85	9.86	21.06	37.44	28.40
Feb.	-	20.82	25.33	30.03	30.18	42.69	34.31	37.48	17.94	29.39	24.79	28.06
Mar.	-	13.85	34.55	30.24	33.59	39.62	37.52	30.14	14.67	9.26	25.79	22.19
Apr.	31.34	35.95	40.70	31.50	37.27	39.61	37.09	35.67	23.27	8.38	34.39	19.07
May	34.66	39.93	40.31	44.01	40.67	36.63	41.39	38.88	29.94	25.62	33.88	39.25
June	40.78	47.32	39.29	42.39	42.13	24.38	43.09	44.85	19.90	42.50	35.55	40.44
July	32.58	45.30	31.04	39.00	17.79	40.80	37.67	41.30	16.74	21.15	33.07	33.90
Aug.	27.97	25.61	29.33	33.12	24.22	21.91	37.30	35.35	27.81	29.05	21.05	-
Sept.	28.80	26.49	32.36	34.63	10.99	31.09	15.07	11.43	26.75	27.27	2.44	-
Oct.	30.35	44.81	31.45	29.46	18.82	33.07	32.68	37.35	41.84	26.87	6.75	-
Nov.	33.96	23.84	24.34	34.78	19.46	35.67	47.00	19.79	12.03	39.32	13.27	-
Dec.	33.27	20.92	31.19	40.20	35.81	38.36	21.43	14.53	15.47	35.36	24.94	-

Source: Komering Irrigation Operation and Management Office

Table 7.3.11 Current Water Demand in Musi River Basin (As of 2010)

No	Regency/City	Surface Water (m^3/s)			Groundwater (m^3/s)	
		Domestic + Non-domestic	Industry	Total	Domestic + Non-domestic	Industry
1	Palembang City	3.18	0.40	3.58	0.15	To be estimated.
2	Prabumulih City	0.04	0.01	0.05	0.15	To be estimated.
3.	Pagar Alam City	0.04	0.03	0.07	0.10	To be estimated.
4.	Lubuk Linggau City	0.11	0.08	0.19	0.24	To be estimated.
5.	Ogan Komering Ilir Regency	0.01	0.03	0.04	0.29	To be estimated.
6.	Ogan Ilir Regency	0.04	0.12	0.16	0.31	To be estimated.
7.	OKU Timur Regency	0.03	0.61	0.64	0.25	To be estimated.
8.	OKU Regency	0.24	0.00*	0.24	0.15	To be estimated.
9.	Oku Selatan Regency	0.01	0.03	0.04	0.23	To be estimated.
10.	Muara Enim Regency	0.17	0.12	0.29	0.50	To be estimated.
11.	Lahat Regency	0.05	0.04	0.09	0.20	To be estimated.
12.	Empat Lawang Regency	0.02	0.02	0.04	0.16	To be estimated.
13.	Musi Rawas Regency	0.11	0.00*	0.11	0.46	To be estimated.
14.	Musi Banyuasin Regency	0.21	0.33	0.54	0.52	To be estimated.
15.	Banyuasin Regency	0.08	0.12	0.20	0.86	To be estimated.
16	Muaro Jambi Regency	0.01	0.10	0.11	0.06	To be estimated.
17	Batanghari Regency	0.01	0.09	0.10	0.04	To be estimated.
18	Sarolangun Regency	0.00*	0.00*	0.00*	0.00*	To be estimated.
19.	Kepahiang Regency	0.00*	0.17	0.17	0.08	To be estimated.
20.	Rejing Lebong Regency	0.04	0.01	0.05	0.30	To be estimated.
21	Bengkulu Tengah Regency	0.00*	0.00*	0.00*	0.01	To be estimated.
22	Lampung Barat Regency*	0	0.09	0.09	0	To be estimated.
	Total (NRW is considered)	4.40	2.40	6.80	5.07	To be estimated.

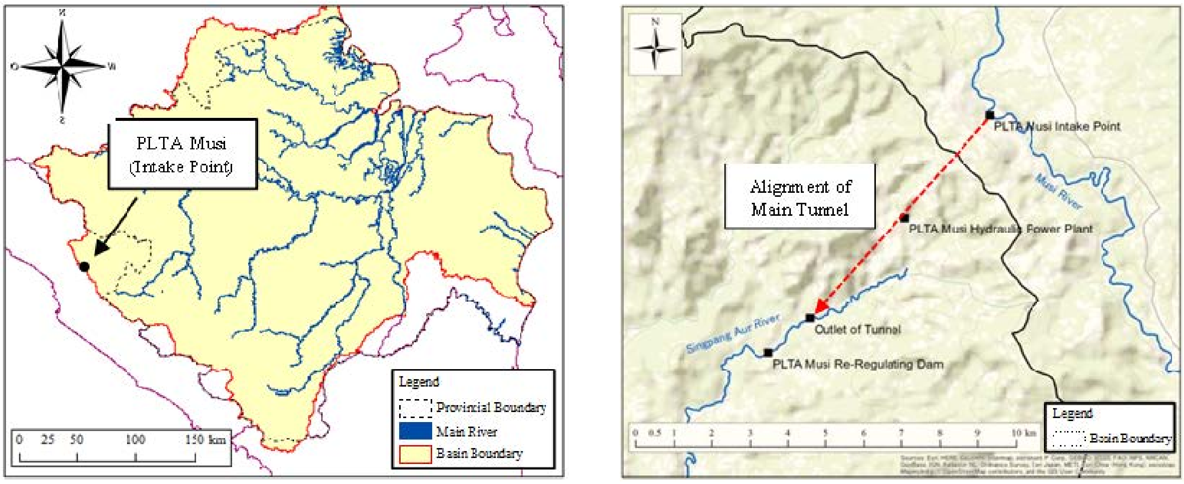
Note: Muara Enim Regency includes PALI Regency (separated in 2013) and Musi Rawas Regency includes Musi Rawas Utara Regency (separated in 2014).
*: 0.00 means between 0 to 0.004 m^3/s

Source: JICA Project Team 2

(3) Hydropower

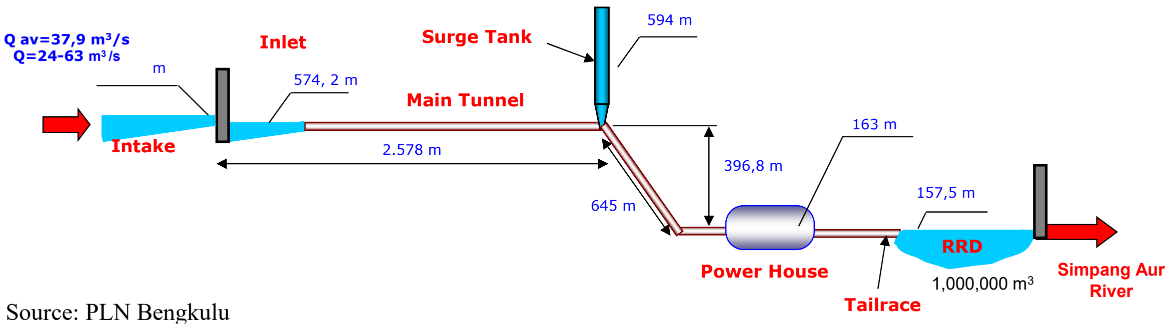
There is the Musi Hydropower Station (PLTA Musi) in Rejang Lebong Regency of Bengkulu Province, near the basin boundary of the Musi River. It takes 37.9 m^3/s of average discharge water (24-63 m^3/s) of the Musi River to generate 210 MW (70 MW x 3 units) of hydropower which is supplied to Bengkulu Province by PLN Bengkulu. The hydropower water is finally drained to the Indian Sea through the Simpang Aur River. The catchment area of the intake facility is 587km^2.

With abundant potential of water resource in the Musi River basin, it is planned that a part of the future electricity demand that is estimated to increase due to the population growth and the watershed development is covered by hydropower. According to the draft RENCANA, a total of 9,386 kW is supposed to be generated in 30 years by Mini Hydro Power (MHP) plants which will be constructed in four regencies of Lahat, Muara Enim, Musi Rawas and Ogan Komering Ulu.



Source: JICA Project Team

Figure 7.3.11 Location and Alignment of PLTA Musi



Source: PLN Bengkulu

Figure 7.3.12 Layout of PLTA Musi

Intake weir

Spillway

*Source: PLN Bengkulu

Photo 7.3.1 Facilities of PLTA Musi

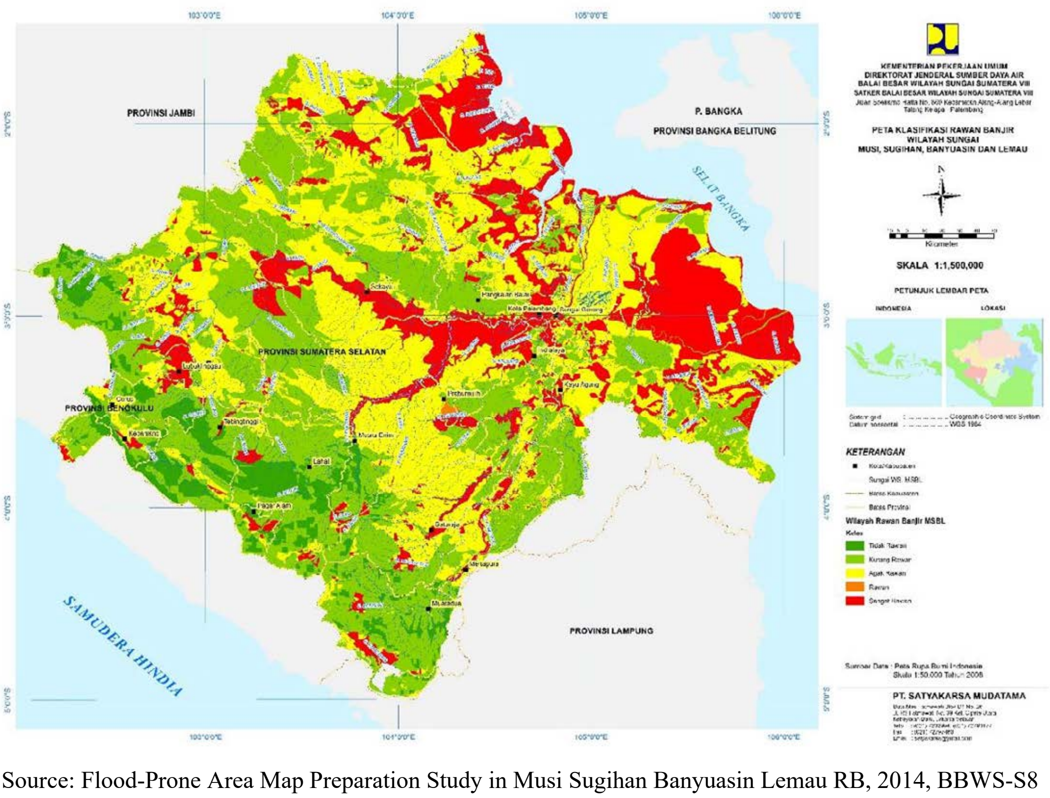
7.3.3 Flood and Sediment Discharge

(1) Flood

1) Flood Inundation Area

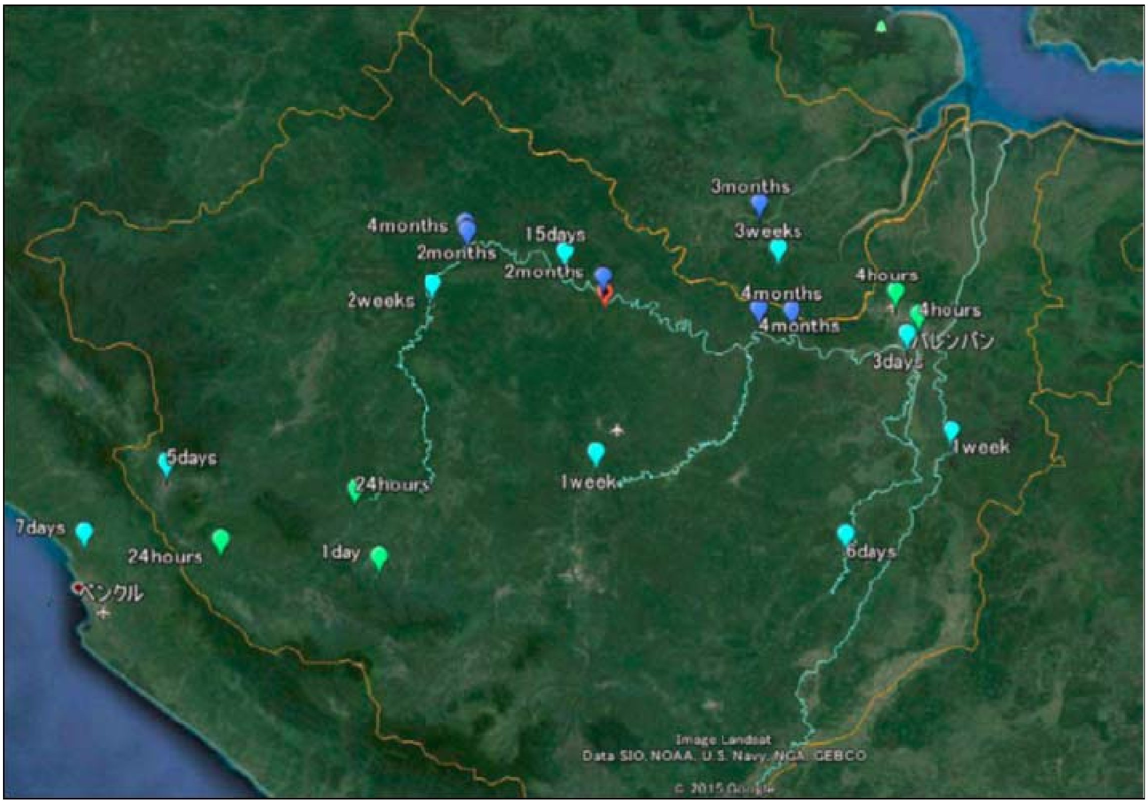
Flood is one of the most important natural disaster in the Musi River basin. At the low-lying areas near the confluences such as the Musi and Kelingi Rivers, the Musi and Lakitan Rivers, the Musi and Rawas Rivers in the middle stretches of the Musi River, extensive inundations occur every year. The floods often damage nearby roads. In Palembang City, damages due to flood inundation were not so serious before. However, due to rapid urbanization of the city keeping pace with the recent economic development, urban areas of Palembang City have been expanded even to the lower flood prone areas. Sekayu is also located in the low-lying area along the Musi River, and suffers from inundation caused by the backwater of the Musi River through drainage channels.

A flood map was prepared for the Musi, Banyuasin and Sugihan River basins in 2014 by a local consultant under the Flood-Prone Area Map Preparation Study in Musi, Sugihan, Banyuasin, and Lemau River basin, based on interview survey and GIS analysis as shown in Figure 7.3.13. Figure 7.3.14 also shows the flood inundation duration based upon the interview survey conducted in the 2014 study. According to the figure, the flood inundation varies very much according to the location. It was as long as 2 to 4 months along the middle stretches of the Musi River above Palembang, while it was as short as 24 hours or 1 day in hilly areas.



Source: Flood-Prone Area Map Preparation Study in Musi Sugihan Banyuasin Lemau RB, 2014, BBWS-S8

Figure 7.3.13 Flood Prone Area Map



Source: Prepared by JICA Project Team 2 based on interview survey data under Flood-Prone Area Map Preparation Study in Musi Sugihan Banyuasin Lemau RB, 2014, BBWS-S8

Figure 7.3.14 Duration of Inundation during 2014 Flood

2) Flood Control Works

In order to cope with the flood problems, river training works have been carried out so far. The river training works have been executed aiming to protect and stabilize the banks where riverbank erosion has caused damages to the major road network. In Palembang a JICA loan project, “Urban Flood Control System Improvement in Selected Cities” has been implemented since 2011. Main features of the project are summarized in Table 7.3.12. Beside the above works, there has been no significant flood control measure implemented in the Musi River basin.

Table 7.3.12 Outline of Urban Flood Control System Improvement in Selected Cities (Palembang)

Item	Outline
Target Area	Bendung River, 5.5 km from the confluence with the Musi River to Talang Aman Pond
Channel Dimensions	- Channel width: 10 to 15 m (existing channel width) - Channel excavation: 1.0 m in average - 45.5 m^3/s at the mouth to 14.2 m^3/s at the outlet of Talang Aman Pond with 15-year return period
Project Contents	Channel excavation of 110,000m^3 within existing channel Protection of existing revetment: 32,400 m^3 Inspection Road 2,100 m Non-structure Measures for adaptation of climate change
Project Budget	Construction Cost = Rp. 41.7 billion in August 2008 price level Budget for land/house in 2009: Rp.1.5 billion (15 ha)

Source: JICA Project Team 2

(2) Current Situation of Sediment Discharge and Future Issue

From the results of reconnaissance in the Musi River basin, the process of the sediment production is summarized as follows;

1) Geological and Topographical Factor

- A mountain range with active volcanoes is located along the coastline on the south-western side in the Musi River basin. The volcanic deposits are thickly distributed around the volcanoes and a vast plain is spread in the north-eastern area of the mountain range.
- Non-welded volcanic deposits are distributed at the northeastern part of the Lake Ranau, while alluviums are distributed along the Komering River. In the Pleistocene age, these alluviums are presumed to be the sediments which had been transported by erosion, called "dissection", In other words, mass movements such as landslide, slope failure, and debris flow are presumed to have been terminated basically in this period. While, the recent time would be a "stable" period that no remarkable erosion is found. In fact, obvious traces of landslide, slope failure and debris flow were not observed in the reconnaissance area. The distribution of mass movement should be identified by satellite image.

2) Factor by Human Activity

- Rice fields and plantations (tea, rubber, palm, etc.) are developed in the hillsides and the vast plain. These fields were basically managed properly.
- Deforestation would be a factor of surface erosion; it will be prevented if proper management of deforested field is done.

3) Current Situation of Sediment Discharge

- The sediment distributed in the vast plain is thought to be transported gradually with every flood.
- A lot of riverbed deposits were observed in the middle reaches of the Komering River. Probably, these deposits are presumed to be the volcanic sediments which had been transported by erosion in Pleistocene.
- Riverbank erosion which is assumed to be the source of the sediment discharge was observed at several parts of the rivers.
- The sediment discharge is presumed to vary according to the tributaries, because turbidity of river water varies depending on the situation. This difference is assumed to be due to the difference of development types such as deforestation and plantation.

4) Issues about Sediment Management

The Musi River basin is vast and has a lot of tributaries. The current issues about the sediment management are as follows.

- Deforestation and disorderly land development are thought to be a factor of the sediment discharge. Hence, proper management of sediment discharge for those lands is highly recommended.

- Disorderly sand and gravel excavation in the river may cause riverbed degradation.
- Construction plan and management of revetment works based on the proper design criteria are required; Subsidence and deformation of revetment works are observed at several parts of the river.
- As mentioned above, there is no basic information (e.g. landslide and slope failure distribution maps, river longitudinal and transverse map and sediment management plan) regarding the sediment discharge of the Musi River basin. This means that there is no measure to manage the whole basin in a bird's eye view. In the future, the sediment management is required to be conducted based on a plan using remote sensing (satellite image analysis) with other management (forest, land use, water resource and etc.). Furthermore, periodical revision is needed by proper monitoring.

7.3.4 Peat Land Management

(1) Action by the Indonesian Government on Climate Change

Under the Paris Agreement, Indonesia has committed to reducing its greenhouse gas emissions unconditionally by 29 % and conditionally by % by 2030.

A research result[1] shows that among the total CO_2 emissions in Indonesia (464.18 MT[2]), those from peatland fires occupy 90% or more. Thus, fire management in the peatland fire is one of the essential activities for the central government. In January 2016, the Peatland Reconstruction Agency (BRG) was established and placed directly under the President Office, and the office in South Sumatra Province (TRGD) was founded and given authority to plan and manage all peatland reconstruction-related activities in the province.

Looking at the current status of CO_2 emissions in South Sumatra, large-scale peatland fires are anthropogenic incineration of forest cover and uncontrollable ground peat fire in the process of plantation creation, and climate change is not being the direct cause. The general stages of CO_2 generation are as follows. 1) The government grants the plantation company a forest development permit (concession)→ 2) excavation of the water channel → 3) dry the target land artificially by lowering groundwater level by draining the groundwater through the excavated channels → 4) set fire and incinerate the forest in the target area (fire may spread outside of the concession area accidentally) → 5) land preparation for plantation → 6) Organic matter continues to drain from the waterways. Among them, the stage where a large amount of CO_2 is generated is forest (and peat) incineration (4), but the generation of CO_2 by organic decomposition process takes place in other steps also. Figure 7.3.15 shows fires are concentrated in the concession land where private business entities are planning to establish palm tree plantations in the forest area near the coast.

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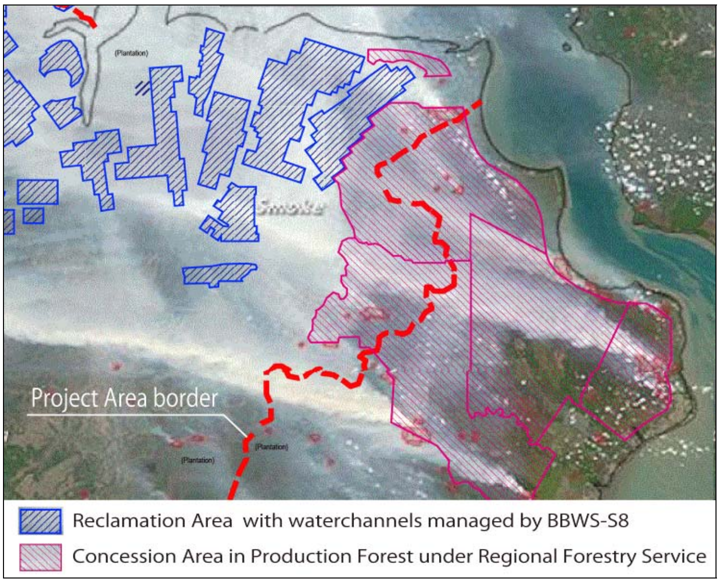
1 Levine et al., 1999, Geophys. Res. Lett.; Page et al., 2002, Nature
2 World Bank Data Indicators (2014)



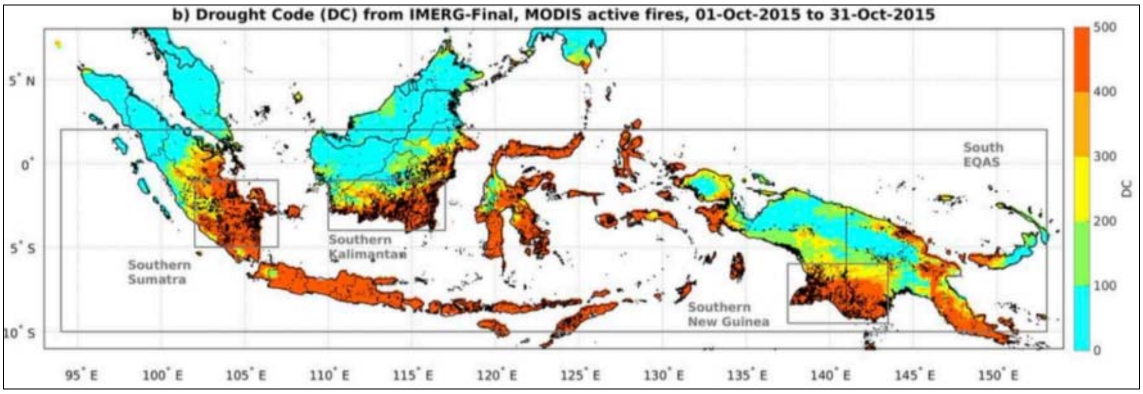
Haze spreading from forest fire of South Sumatra in 2015. The forest is burning in the concession area where peat is distributed. Not much land cover is left in the area, developed for irrigated area (shaded blue) by BBWS-S8.

Source: JICA Project Team 2

Figure 7.3.15 Spreading Haze in 2015 Forest Fire

(2) Relationship between Climate Change and Greenhouse Gases from Peatland

The southern oscillation of the seawater temperature (El Niño / ENSO) occurs periodically. When El Niño occurs, most of Indonesia including South Sumatra becomes extremely dry (Figure 7.3.16). The years in 1982-1983, 1997-1998, 2006 and 2015 when El Niño occurred, there was almost no rain in the dry season, and broad areas were so dry that many forest fires went uncontrollable. In 2015, from July to October 6,233 km^2 (623,304 ha) of forests in Indonesia were burnt, and the smoke was spread to neighboring countries such as Singapore and Malaysia, causing severe haze pollution. Among them, the peatland burning area in South Sumatra Province was 1,460 km^2 (146,986 ha), which is 23.4% of the whole nation's burnt area[3].



Source: Long-lead prediction of the 2015 fire and haze episode in Indonesia, Robert Field et al., (2018) NASA, Indonesian Ministry of Environment and Forestry

Figure 7.3.16 Locations of Hotspots in Indonesia in 2015

3 Carbon Emission from Peat Fire in 2015 (Indonesian National Institute of Aeronautics and Space)

(3) Present Situation of Peatland in South Sumatra Province

The peatland which spreads to the broad area of the coast of South Sumatra province, including the lower stream of the Musi River, used to be a large tidal flat with dense mangrove forests until the 1970s. Therefore, the topography is low and flat, and the soil is a sedimentary layer of accumulated organic matter, which forms peat underground. However, accurate information on the peat distribution and depth has not been obtained by any governmental agencies so far, and there is no definite peat distribution map yet (Mr. Adong, TRGD), In addition to that making it is difficult to formulate effective countermeasures for peatland fire.

At present, BBWS-S8 has constructed waterways for large-scaled agriculture area which is being used for paddy fields in areas lower than the high tide level after removal of mangrove forest. The higher water level than the ground level makes tidal irrigation possible in this area which is more profitable than palm oil tree plantation. According to Dr. Momon S. Imanudin at Lowland -Wetland - Coastal Area Data Information Center, the peat beneath the irrigation area is so thin that it has already been decomposed and diminished by 30 years of agricultural activities. On the other hand, the peatland is slightly higher than the high tide level which is developed as a plantation site because of the lack of irrigation water. The amount of CO_2 generated from the paddy fields and plantations is much smaller compared to the amount of CO_2 emitted from the peatland during the plantation development.

The poverty of the inhabitants in the Musi Delta area is another cause of forest fire. According to Lowland-Wetland Coastal Area Delta Information Center, more than half of agriculture lands in the delta is still relying on rain-fed agriculture. Many farmers have nothing to cultivate during the dry season but to dig a channel, burn the forest, and cut the trees illegally and smuggle them to Java Island under a private enterprise.

7.4 Existing Future Plans on Land and Water Resources Management

7.4.1 Spatial Plan

The study on Sumatra State Spatial Plan began in 2011, and the spatial plan was approved by PUPR in 2016 which was issued in the Regulation No. 11, 2016 of South Sumatra Province as the South Province Spatial Plan for 2016-2036.

(1) Purposes, Policies and Strategies

Considering strategic issues and the vision of the development of the province in 2025, purpose of the spatial planning is set as follows:

"Creating a Productive, Efficient, and Qualified Provincial Territorial Space by Utilizing the Potential of Sustainable Food Resources and Energy Towards an Excellent and Leading Province"

(2) Spatial Plans

Based on the above policies and strategies, a spatial structure plan and a spatial pattern plan are prepared as follows:

1) Spatial Structure Plan

The spatial structure plan is composed of urban development plan and infrastructure network system development plan. The infrastructure network system development plan is further composed of network development plans of land transport, energy/electrical infrastructure, telecommunication, water resources and socioeconomic facilities.

In the water resources network system development plan the development of water resources infrastructure system is directed to the following:

- Increase the availability of raw water;
- Develop reservoirs for ecological functions, ecosystem, conversion of water resources, flood control and supply water to strategic areas;
- Utilize water resources to support the program for the sustainable food agricultural land protection; and
- Safeguard the central plain area that is an area of potential groundwater and major river basins.

Regarding the development and construction of reservoirs or dams in South Sumatra Province, the following dams, barrages, and reservoirs are listed to support food and energy security to control floods:

i) Perjaya Headwork in Ogan Komering Ulu Timur Regency
ii) Watervang Dam in Lubuklinggau City
iii) Lakitan Dam in Musi Rawas Regency
iv) Basemah Dam, Sulah Dam in Pagar Alam City
v) Air keruh Dam in Empat Lawang Regency
vi) Lintang Kiri Dam, Tanjung Agung, Embung Sejumput in Lahat Regency
vii) Tunggul Bute Dam, Padang Bindu (Indramayu) in Muara Enim Regency
viii) Tigadihaji / Komering II Dam, Saka, Komering I in Ogan Komering Ulu Selatan Regency
ix) Gasing Dam, Muara Tanjung Api-Api Dam, Tanjung Embung, Talang Buluh Dam in Banyuasin Regency
x) Tanjung Barangan Dam in Palembang City
xi) Kemala Dam (Tanjung Pura) in Ogan Komering Ulu Regency

2) Spatial Pattern Plan

The spatial pattern plan of the province is a distribution plan for the allocation of space within the province for both the protection and cultivation functions. Determination of the spatial pattern of the South Sumatra Province was carried out by referring to the nationally protected and cultivated areas and paying attention to the protected and cultivated areas proposed by the regency/city.

The spatial pattern plan is expected to function the following:

- Allocation of space for cultivation areas for various socioeconomic activities and protected areas for environmental conservation in the province;
- Regulating the balance and harmony of the space allocation;
- As a basis for preparing indications of the five-year medium-term main program for twenty years; and
- As a basis for granting permits for large-scale use of space in the province.

The spatial pattern plan is presented in the spatial pattern map as shown in Figure 7.4.1.

7.4.2 POLA and RENCANA for Water Resources Management of MBSL River Basin

(1) Outline

The POLA (Strategy) and RENCANA (Plan) for water resources management for the Musi-Banyuasin-Sugihan-Lemau (MBSL) River basin were promulgated in 2014 as the decree of the Minister of the MPW (Ministry of Public Works) No. 196/KPTS/M/2014 and in 2017 as the decree of the Minister of the MPWPH (Ministry of Public Works and Public Housing) No. 317/KPTS/M/2017 respectively.

The MBSL River basin that covers 86,100 km^2 including the Lemau River basin and coastal areas near the Banyuasin and Sugihan River basins is slightly larger than the 76,000 km^2 target area of this Project that focuses on the Musi, Banyuasin and Sugihn River basins, as shown in Figure 7.4.2.

(2) POLA

1) Purpose, Objectives and Vision

The purpose of the POLA for Water Resources Management is to establish the basic framework of water resources management in the MSBL River basin, which will serve as a reference in planning and implementation, utilization, and conservation of water resource management.

The objectives of the POLA formulation for the water resources management in WS MSBL are as a binding reference for the Government, Provincial Government, Regency/Municipal Government, and the community in the implementation of development in WS MSBL by providing guidance on the following:

i) Conservation of integrated water resources in WS MSBL,

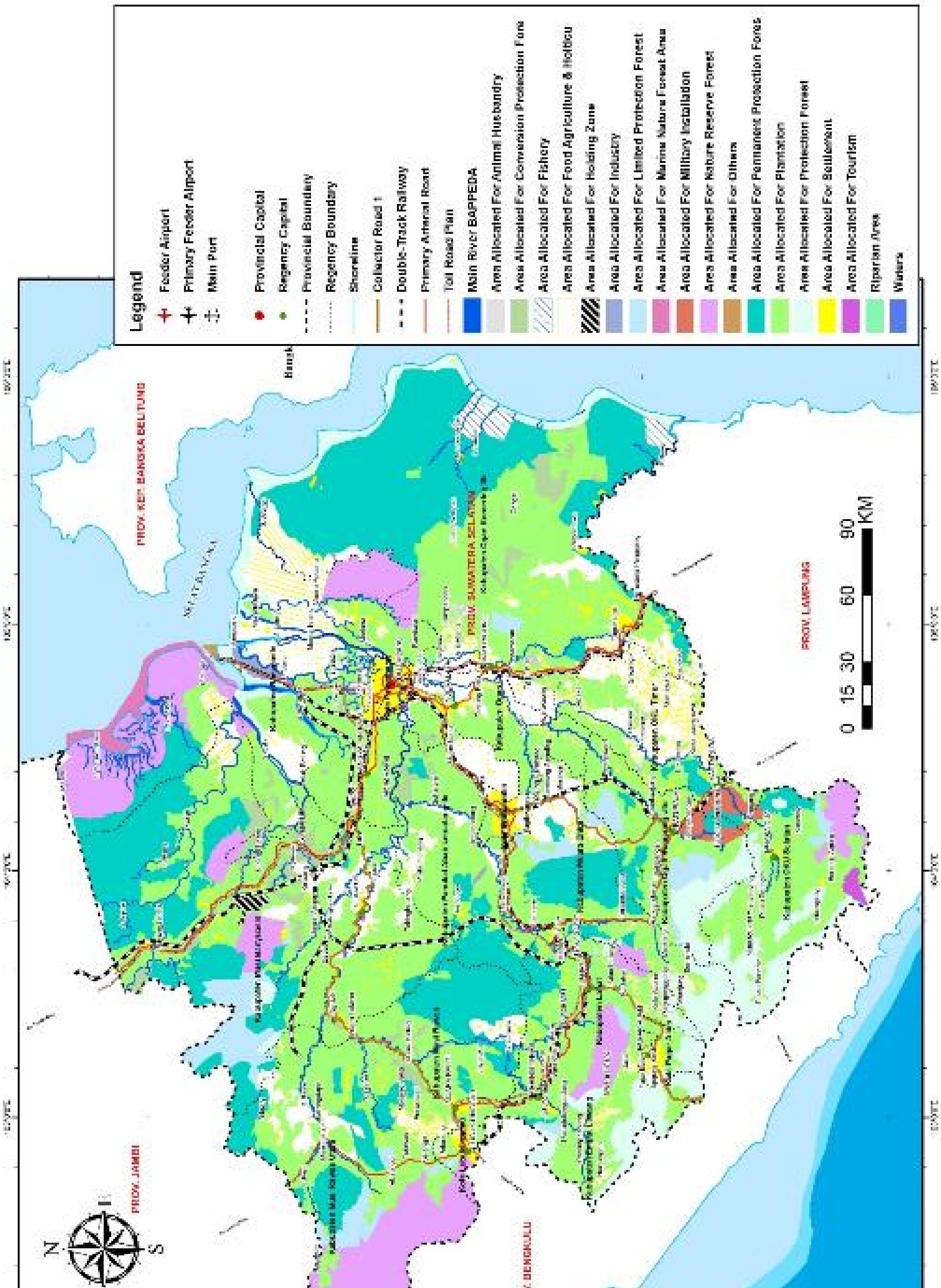
ii) Utilization of water resources in WS MSBL,

iii) Water damage control in WS MSBL,

iv) Water resources information system in WS MSBL and,

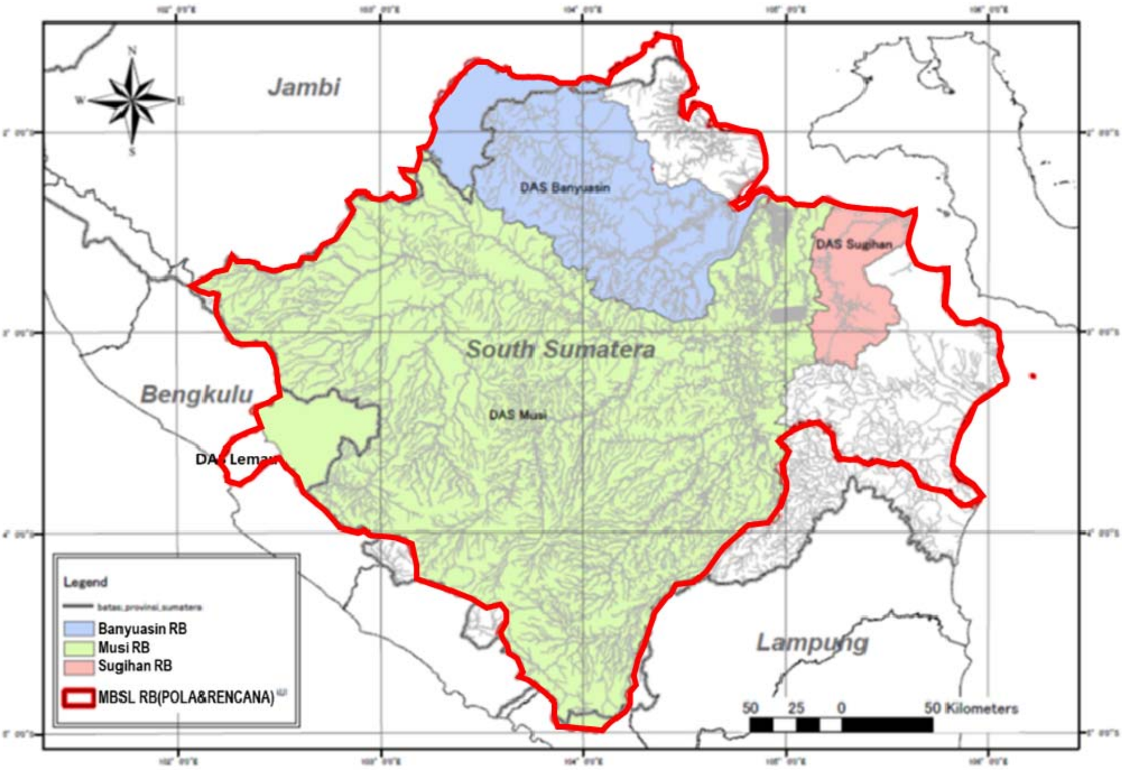
v) Empowerment and enhancement of the role of the community and business community in the management of water resources in WS MSBL.

The vision of the POLA is the realization of water resources management in a fair, comprehensive, integrated, and environmentally friendly way, to realize the sustainable use of water resources by encouraging the participation of the community and the business world.



Source: Spatial Plan 2016-2036, South Sumatra Province

Figure 7.4.1 Spatial Pattern Map of South Sumatra Province



Source: BBWS-S8

Figure 7.4.2 Musi-Banyuasin-Sugihan-Lemau (MBSL) River Basin

2) Strategic Issues

In addition to national strategic issues including Millennium Development Goal (MDG's), food security, global climate changes and energy availability, and the following local strategic issues are taken into consideration in the preparation of the POLA:

i) Water availability potential
ii) Potential of water transportation
iii) Potential of hydropower development
iv) Potential of raw water development
v) Potential of irrigation area development and upgrading of swamp area
vi) Watershed degradation
vii) Lack of forest for the water management
viii) Lack of facilities for the utilization of water resources
ix) Increased mining of materials
x) Increased frequency of flood

3) Operational Policy

In the POLA operational policies that are fundamental directives for each of the five aspects for the water resources management are also proposed, based on the following conditions:

- High economic growth is expected;

- No significant political change is expected; and
- Two climate change scenarios (no significant climate change and significant climate change impact) are considered.

It is noted, that there is no description about how these climate change scenarios were incorporated in the operational policies.

(3) RENCANA

1) Objectives

The water resources management plan (RENCANA) is a basic framework in planning, implementing, monitoring, and evaluating the conservation of water resources, efficient use of water resources, and control of water damage, with the principle of integration between surface water and groundwater and involves community and the business world. The objectives to be achieved in this Water Resources Management Plan are:

i) This document is a comprehensive and integrated water resource management planning document for the period of the next 20 years (2017-2037);

ii) This document is used as a guide and guidance which is used as the basis for the preparation of program and activity plan in the implementation of conservation of water resources, utilization of water resources, control of water damage, availability of data and information of water resources, and empowerment and improvement of society's, private's, and government's roles;

iii) This document is used as a guideline and direction as the basis for the preparation of programs and activity plans of each sector related to water resources in the implementation carried out by the authorized technical institution in accordance with their field of duty;

iv) This document provides input and direction for the development of areas appropriate to the hydrological, hydrometeorological, hydrogeological, and potentials of water resources available in the river basin so as to ensure the sustainable use of water resources for the greatest prosperity of the people; and

v) This document increases the active role of communities in the implementation of water resources management of river basins.

2) Efforts

All structural and non-structural efforts to be implemented in the 20 years from 2017 to 2037 are summarized in Table 7.4.1. The total cost was estimated to be 152 trillion rupiah.

Table 7.4.1 Summary of Efforts for Water Resources Management Proposed in RENCANA

1) Water Resources Conservation

Sub-aspect	Sub-sub-aspect	Selected Strategy
1.1 Water Resource Protection and preservation	a. Maintenance of community of water recharge and water catchment function	Determination of areas that serve as Water recharge Areas (DRA) and Water Catchment Areas (SECONDA)
		Establishment of regulations to preserve the function of water recharge and water catchment areas
		Management of areas that serve as water recharge areas and catchment areas
		Organization of conservation programs for water recharge and water catchment function
		Implementation of community empowerment in preservation of water catchment function and water catchment area
		Monitoring and supervision of the implementation of activities maintenance of continuity of water recharge function and catchment area (SECONDA)
	b. Control of utilization of water source	The control of utilization of water resource shall be carried out in accordance with the provisions of zone utilization in the relevant water source.
		Monitoring, supervision and law enforcement of utilization zone at water resource.
	c. Water filling on water resource	Adding water to the groundwater layer.
		Increased rainwater occupancy capacity in watersheds through land use.
		Utilization of weather modification technology to increase rainfall within a certain time.
		Implementation of monitoring and supervising the implementation of water filling at water source.
	d. Regulation of sanitary facilities and infrastructure.	Establishment of guidelines for construction of sanitation infrastructure and facilities.
		Separation between drainage networks and wastewater collection networks in urban areas
		Disposal of wastewater through wastewater collection networks in urban areas into a centralized wastewater system.
		Construction of a centralized wastewater treatment system in every neighborhood (communal).
		Application of environmentally friendly wastewater treatment technology.
		Establishment of licensing mechanism related to sanitary facility infrastructure arrangement.
		Organizing the monitoring and supervising the implementation of the sanitary facilities infrastructure arrangement.
	e. Protection of water resources from development and land use activities at water source.	Arrangement of development and/or land use activities at water source in accordance with the provision of utilization zone in water source.
	f. Upstream processing controls	Prevention of landslides, reduction of erosion rates, and reduction of sedimentation levels in the source water and water resources infrastructure as well as increasing the infiltration of water into the soil.
		Conduction monitoring and supervision of the implementation of soil processing control in the upstream area.
	g. Setting border area of source water	Stipulation of bank boundary water source and utilization of border area of water source (river, reservoir, embung, situ, springs and other)
	h. Forest and land rehabilitation	Rehabilitation of degraded forests (dry land forests, wetlands, coastal/ mangrove forests within and outside state-designated forest areas (forests), through vegetative and/or forest management and social, economic and cultural community.
		Critical land rehabilitation through vegetative, civil and technical or agronomic efforts as well as social, economic and cultural approaches of the community.
		Implementation of monitoring of forest and land rehabilitation.
	i. Conservation of protection forest, nature reserve area and nature conservation area.	Maintenance covers protection forest, nature reserve area (Nature reserve forest and national park) and conservation areas according to the size set by the government.
		Seeking the addition of the protection forest area, nature reserve area (Nature reserve forest and national park) and nature conservation areas reach the percentage amount equal to or greater than 30% of watershed size in the river area.
		Ensuring the empowerment of the community in preserving the protection forest, nature reserve area (Nature reserve forest and national park) and nature conservation area.
1.2 Water Preservation	a. Storing excessive water to be utilized by construction water reservoirs and by revitalizing natural water reservoirs.	Organize the conservation program of water recharge function and catchment area
	b. Saving water with efficient and effective use.	Saving of clean water /raw water (Target: 30% leakage decrease)
	c. Controlling groundwater use by prioritizing the use of surface water.	Preparation of regional regulation on land use utilization. Socialization of PERDA concerning regulation of groundwater utilization
1.3 Management of Water Quality and Control of Water Pollution.	a. Improvement of water quality on source water and infrastructure source of water	Monitoring and evaluating of water quality at water source. Target: The standard of water quality in all rivers becomes Class B
	b. Prevention of the entry of water pollution on water source and infrastructure of water source	Prevention of pollution on water sources. Target: river-main river (S. Musi, Sungai Banyuasin, Sungai Lalang, S. Sugihan, and other small rivers)
1.4 Routine Activities		Operational management of hydrological system and water quality facilitation of development and empowerment of water resource institution

2) Water Resources Utilization

Sub-aspect	Selected Strategy
2.1 Stewardship of Water Resources	Stipulation of utilization zones of water source and water reservoirs in water source in spatial plan maps regency/ city in MSBL RB
	Determination of the designation of water on water source
2.2 Provision of Water Resources	Establishment of compliance with water allocation and water use rights plans
	For irrigation: fulfillment of irrigation water demands for new irrigation area.
	Achievement of the fulfillment of principle water supply demand and construction of irrigation networks.
	Development of alternative sea water utilization for the purpose of fulfilling the water demand for people in swamp area and coastal area.
	Development of reclamation network of swamp/new brackish water pond.
	Provision of raw water for industry area.
	Construction of PDAM installation in some areas (target: The area, household, urban and industrial needs can be fulfilled at 100%).
2.3 Utilization of Water Resources	Development of an institutional tool for controlling natural resource use.
	Improvement of law enforcement on excessive use of natural resources.
	Increase of the efficiency of water use with OM, rehabilitation, and OM on raw water supply, new irrigation & swamp / Brackish water pond networks.
2.4 Development of Water Resources.	Enhancement of the development of swamp network.
2.5 Water Resources	Optimization of Ranau Lake water utilization in sub watershed Komering Kab South OKU for 60 MW hydroelectric/micro hydro power and additional water supply for Komering irrigation
	Construction of the dam and reservoir to meet the demand of irrigation water, of raw water and hydropower development

3) Water Damage Control

Sub-aspect	Selected Strategy
3.1 Prevention	Mapping and determining of disaster-prone areas due to water damage (including frequency, intensity, impact and return period.
	Integration of planning, construction and management of productive area drainage, urban drainage, road drainage, and river into flood control system.
	Enhancement of the adaptability of people living in flood-prone areas and drought area.
	Socialization on the prevention of water damaged power.
	Establishment effective cooperation pattern between upstream and downstream areas in controlling damaged water power.
	Upstream-downstream balancing is done by spatial planning mechanism and operation of river infrastructure in accordance with agreements of stakeholders.
	Enhancement and maintenance of forest function.
	Prevention and release of riverbanks from illegal settlements and buildings and regulating the use of river banks.
	Control of the riverbank usage in accordance with the plan set.
	Control of land use in disaster prone areas in accordance with the level of vulnerability of the areas concerned.
	Enhancement of dissemination information on flood retention areas and water-related disaster prone areas.
	Enhancement of public preparedness in facing the impacts of global climate change and water damage.
	Enhancement of water recharge into the soil to reduce surface flow.
	Enhancement of dissemination information on flood retention areas and water-related disaster prone areas.
	Enhancement of public preparedness in facing the impacts of global climate change and water damage.
	Enhancement of water recharge into the soil to reduce surface flow.
	Increase of drainage capacity of rivers and channel.
	Establishment of areas with flood retention functions as flood control infrastructure.
	Maintenance of an area with flood retention functions as a flood control infrastructure.
	Provision of flood control infrastructure to protect public infrastructure, housing area, and productive area.
	Beach security.
	Maintenance of facilities and infrastructure intended to prevent damage and / or disaster caused by water damage.
3.2 Countermeasures	Determination of damage and / or disaster management mechanisms due to water damage.
	Implementation of the socialization mechanism for the prevention of damage and / or disaster caused by water damage.
	Improve the quality of forecasting and warning systems in relation to hazards associated with water damage (such as: weather information, rainfall, flood discharge etc.).
	Monitoring of forecasting and warning systems in disaster prevention due to water damage.
	Enhancement of knowledge, preparedness, and community's ability to cope with disasters caused by water damage.
	Improved system and enhancement of disaster management performance due to water damage.
	Preparation of budgeting system in accordance with emergency conditions for the control of damaged water resources from the State Budget (APBN) and/or Regional Revenue Budget (APBD) and other source of funds.
	Socialization procedure operation correction of damage and/or disaster damage caused by water damage.
3.3 Recovery	Preparation of budgeting system in accordance with emergency conditions for the control of damaged water resources from the State Budget (APBN) and / or Regional Revenue Budget (APBD) and other source of funds through socialization procedure operation correction of damage and / or disaster damage caused by water damage.
	Development of the participation of communities and businesses in coordinated activities for the recovery of water-damaged disasters
	Recovery of social and psychological impacts of water-related disasters by stakeholders

4) Water Resources Information System

Sub-aspect	Selected Strategy
4.1 Information on Water Resources	Construction and procurement of hydro-climatological station. Construction and procurement of discharge measuring station and water quality monitoring station. Improvement of water resources information system infrastructure and facilities (Target: 100%)
	Preparation, implementation, operation, maintenance, and water source information system for water resources.
4.2 Management of Information System	Coordinating the management of water resources information system.

5) Empowerment and Monitoring

Sub-aspect	Selected Strategy
5.1 Involving Role of Community in Water Resources Management	Activation of community participation in water resources management.
	Excavation of local wisdom towards water resources management.

Source: BBWS-S8

(4) Proposed River Facilities

1) Proposed Dams in RENCANA

In RENCANA (Year 2017), the proposed plan for construction of eight (8) dams is presented to meet the needs of both domestic or irrigation water. The investment schedule of these dams is divided into four periods (5 years) as shown in Table 7.4.2.

Table 7.4.2 Proposed Plan of Construction of Dam in POLA/RENCANA in Musi River Basin

2016-2021	2022-2026	2027-2031	2032-2036
1. Komering 2 (2021) 2. Komering 1 (2021)	3. Muara Lingtang (2026) 4. Saka (2026) 5. Tanjung Pura (2026)	6. Muara Dua (2031)	7. Padan Bindu (2036)

No.	Name of Dam	River	Completion Year	Potential Discharge (m^3/s)	Total Storage (MCM)/ Dam Height	Present Status
1	Komering II (Tiga Dihaji Dam)	Komering	By 2022	+5.5	105.8 (H=121.5m)	Pre F/S in 1982. DD,LARAP, AMDAL were completed. Construction work was started since 2019.
2	Komering I	Komering	By 2021	+5.0	938 (H=50-70m)	Pre F/S in 1982.
3	Saka	Komering/ Saka	By 2026	+5.5	43.2 (H=74.8m)	F/S in 2015, D/D in 2016
4	Muara Lintang	Musi	By 2026	+5.0	21,633 (H=150m)	RENCANA. No study
5	Tanjung Pura	Enim	By 2026 By 2031	+3.0 +5.0	766 (H=160m)	Pre FS2015
6	Muara Dua	Komering	By 2031	+9.0	139 (H=40-50m)	Pre F/S in 1982. At present, BBWS-S8 decided to cancel the dam construction due to social issue.
7	Padang Bendu	Enim	By 2036	+10.0	938 (H=50-70m)	Pre FS2015

Source: Water Resources Management Plan Musi-Sugihan-Banyuasin, Lemau River Basins (Year 2017), Figure 3-2 Water Balance of High Economic Scenario p.32, Figure 5-2 Balance of Water Fulfillment in MSBL RB

The following information are provided for the proposed dams by BBWS-S8;

- For the Muara Lintang Dam, only data/information on the POLA/RENCANA is available, but no study/investigation is conducted yet.

- For the Padang Bindu Dam and the Tanjung Pura Dam, the study was conducted in 2015. The study report was provided to JICA Project Team 2.
- For the Muara Dua Dam, it is included as one of potential dam sites in the POLA/RENCANA. However, based on the result of protest movement by local residents, the Balai VIII decided to cancel the dam construction. It is confirmed between Balai VIII and JICA Project Team 2. that the Muara Dua Dam is not considered for the future water balance study to be carried out in this Project.

2) Proposed Dams in Other Sources

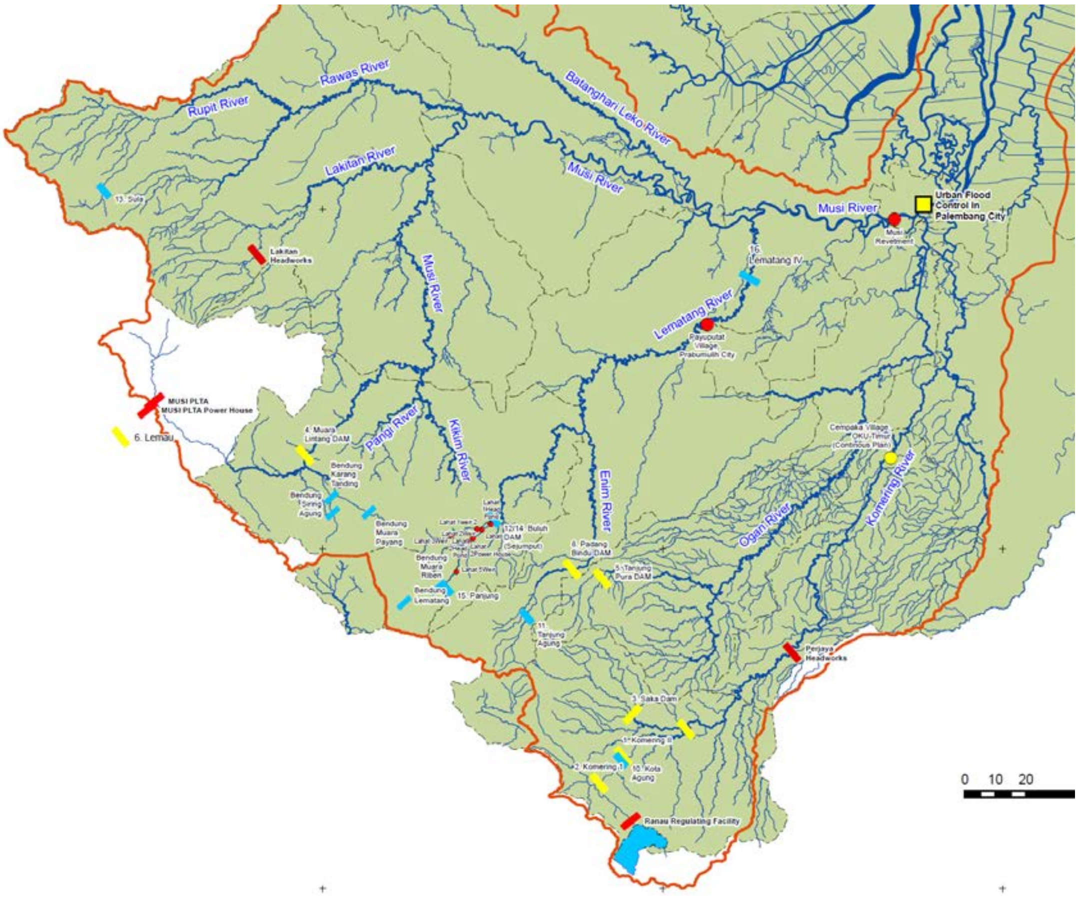
In addition to the RENCANA, data and information of the proposed river facilities in the Musi River basin were collected from following three (3) sources. The name, location, dimension and function are summarized in Table 7.4.3 and .

01: Blue Book: Documen Rancangan Rencana Pengelolaarn Sumber Daya Air Wilayah Sungai MSBL (27 March 2013), p.137-143

02: A List of "Potential of Dam and Hydropower" source BBWS-S8 (2011)

03: A list of Economic Feasibility of Reservoir SDA

As per collected data and documents from the interview survey to BBWS-S8, HV-curves for some proposed dams are prepared using the GIS.



Source: Prepared by JICA Project Team 2 referring to RENCANA(2016) and others

Figure 7.4.3 Location Map of Proposed Dams in Musi River Basin

Table 7.4.3 List of Proposed Dams in Musi River Basin

No.	Name	Main Function				Location	River	Source[3]						Proposed Development Stage in RENCANA	Present Status	Remarks
		Flood Control	Irrigation	Hydropower Generation	Domestic and Industrial Water			00	01	02	03	04	05		Stage	
1	Komering 2（Tiga Dihaji)		o	o	o	Ds. Sekabumi Pauh Kec. Tiga Dihaji Kab. OKU Selatan	Komering WS /Komering River	o	o	x	o	o	o	2021	D/D: completed F/S: completed in Apr. 2013	Renamed from Komering 2 to Tigadihaji
2	Komering 1		o	o		Ds. Sekabumi Pauh Kec. Tiga Dihaji Kab. OKU Selatan	Komering WS /Komering River	o	o	x	o	o	o	2023	FS1982	
3	Saka		o			Ds. Sekabumi Pauh Kec. Tiga Dihaji Kab. OKU Selatan	Komering WS /Saka River?	o	x	x	x	x	x	2025	F/S: completed in Apr. 2013	
4	Muara Lintang		o	o		Ds. Sekabumi Pauh Kec. Tiga Dihaji Kab. OKU Selatan	Musi WS /Musi River	o	o	o	o	o	x	2027	no study/investigation is conducted yet.	
5	Tajung Pura		o	o	o	OKU /Muara Jaya	Ogan WS /Ogan River	o	o	o	o	o	x	2028	Pre-F/S: completed in 2015	
6	Lemau		o			Ds. Sekabumi Pauh Kec. Tiga Dihaji Kab. OKU Selatan	Lamau River	o	x	x	x	o	x	2030	no information	Out of Musi River Basin
7	Muara Dua		o	o		Ds. Sekabumi Pauh Kec. Tiga Dihaji Kab. OKU Selatan	Komering WS /Selabung River	o	o	o	o	o	o	2032	no information	BBWS already decided to cannel the dam construction. It is assessed as "not feasible" due to high risk of backwater. Proposed Dam Site is already occupied with houses, so it would be very difficult to implement
8	Padang Bindu		o	o	o	Muara Enim /Tanjung Agung	Enim WS /Enim River	o	o	o	o	o	x	2033	Pre-F/S: completed in 2015	
Proposed Dams in Other Source																
9	Baru		o	o		OKU Selatan	Komering River	x	o	o	o	x	x	no information		(same as Komering 1 in Pre FS 1982 & FS2013)
10	Kota Agung		o	o		OKU Selatan	Komering WS /Selabung River	x	o	o	o	x	x	no information		(same as Komering 2 Pre FS 1982 & FS2013)
11	Tanjung Agung		no info	o			Enim WS /Musi River?	x	o	o	x	x	x	no information		
12	Sejumput		o	o		Lahat /Pulau Pinang	Lematang WS /Lematang River	x	o	o	o	x	x	no information		(same as 14 Buluh Dam)
13	Sula		o	o		Musi Rawas /Rawas Ulu	Rawas WS /Rupit River	x	o	o	o	o	x	(2013-2032)		
14	Buluh		o	o	o	Lahat /Pagar Gunung	Enim WS /Musi River?	x	x	o	x	o	x	(2013-2032)	Pre-F/S: completed in 2015	
15	Panjung		no info	o		Lahat /Kota Agung	Lematang WS /Lahat River	x	x	o	x	x	x	no information		
16	Lematang IV		o	o		Lahat /Kota Agung	Lematang WS /Lematang River	x	x	o	x	o	x	(2013-2027)		(Lematan Headworks is on-going construction)
Existings Dams																
17	Musi 1 HEPP		-	o		Rejang Lebong /Padang U Tanding	Musi WS /Musi River	x	x	o	x	x	x	already constructed		
18	Ranau (pre-F/S 1982)		o	o		OKU Selatan	Komering WS /Komering River	-	-	-	-	-	o	-	Pre-Fs: completed in 1982	

Note: 1) Proposed location of Baru Dam in RENCANA is same as that of Komering 1 Dam in Pre-FS 1982 and FS2013
2) Proposed location of Kota Agung Dam in RENCANA is same as that of Komering 2 Dam in Pre-FS 1982 and FS2013
3) o: available, x: not available

Source:
00: RENCANA 2016
01: Blue Book (confirmed by Mr.Katayama). Documen Rancangan Rencana Pengelolaarn Sumber Daya Air Wilayah Sungai MSBL (27 March 2013), p.137-143
02: A List o f"Potential of Dam and Hydropower" source BBWS Sumatera VIII (2011) (collected by Mr.Katayama)
03: A list of Economic Feasibility of Reservoir SDA (collected by Mr.Katayama)
04: Documen Rancangan Rencana Pengelolaarn Sumber Daya Air Wilayah Sungai MSBL (27 March 2013), Figure 4.3 - 4.7, p.134-136
05:_Komering PreFS1982

(5) Proposed Irrigation and Swamp Drainage Development

In RENCANA (Year 2017), the proposed plan for new development of surface water irrigation and swamp drainage schemes for the next 20-year period is presented with the implementation schedule on a five-year term basis as shown in Table 7.4.4.

Table 7.4.4 Proposed Plan for Irrigation Development in South Sumatra

(Unit: ha)

Name of Scheme	Regency /City	2016 - 2021	2021- 2026	2026 - 2031	2031 - 2036	Total
Surface Water Irrigation Scheme (ha)						
1. Komering Selatan	OKU Timur R. & OKI R.	0	5,000	5,000	3,500	13,500
2. Lematang	Pagar Alam C.	2,000	0	0	0	2,000
3. Air Rawas	Musi Rawas R.	0	2,000	3,000	4,000	9,000
4. Kembahang	Musi Rawas Utara R.	0	0	0	3,000	3,000
5. Muara Beliti	Musi rawas R.	0	0	0	3,000	3,000
6. Air Gegas	Musi Rawas R.	0	2,000	0	0	2,000
7. Merapi	Pagar Alam C.	0	0	0	5,000	5,000
8. Donku Kanan / Kiri	Lahat R.	0	0	0	10,000	10,000
9. Komering Tulang Bawang	Lampung Province	0	0	0	10,000	10,000
Surface Water Irrigation Scheme Development Total		2,000	9,000	8,000	38,500	57,500
Swamp Irrigation Scheme (ha)						
1. Batangharileko	Musi Banyuasin R.	3,000	0	0	0	3,000
2. Lebak Jejawi	OKI R.	0	2,000	2,000	2,000	6,000
3. Lebak Pangkalan Lampam	Musi Rawas Utara R.	0	2,000	2,000	2,000	6,000
4. Lebung Hitam	OKI R.	0	1,000	2,000	0	3,000
5. Burai	Ogan Ilir R.	0	1,000	2,000	0	3,000
Swamp Drainage Scheme Development Total		3,000	6,000	8,000	4,000	21,000

Source: Water Resources Management Plan Musi-Sugihan-Banyuasin, Lemau River Basins (Year 2017)

CHAPTER 8 FIELD SURVEY AND OBSERVATION

8.1 River Survey

8.1.1 River Cross Section Survey

Regarding topographical information on the rivers, there were only available bathymetry survey data for the lowest Musi River stretch below Palembang. For the flood inundation analysis, river cross section data covering river banks as well as river channel are indispensable for river stretches in flood inundation areas. Under the Project, cross section survey was conducted for the Musi River and its major tributaries as shown in Table 8.1.1 and Figure 8.1.1.

All elevation data of the survey products have been reduced to the BAKOSURTANAL datum (referred to as "mean sea level or msl" hereinafter) that is equivalent to the average of mean sea levels at seven tide stations around Sumatra Island, namely Malahayati, Sibolga, Telukbayur Padang, Bengkulu, Long-Lampung and Dumai Stations.

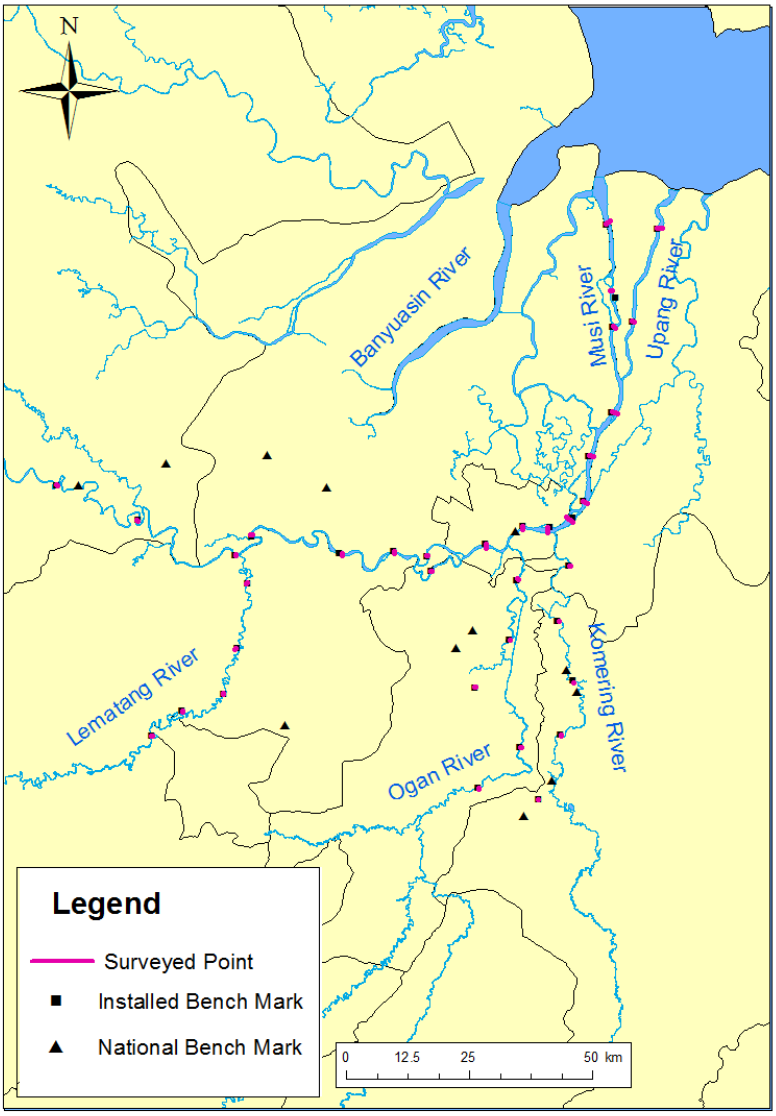
Table 8.1.1 Summary of Cross Section Survey

No	River	Number of Cross Section	Stretch and Interval
1	Musi River (Mid-Lower reaches)	20	Stretch: River mouth to 250km Interval: Approx. 10km
2	Komering River	5	Stretch: 50km upstream from conjunction point to Musi River (Kayu Agung) Interval: Approx. 10km
3	Ogan River	5	Stretch: 50km upstream from conjunction point to Musi River (Tanjung Raja) Interval: Approx. 10km
4	Lematang River	5	Stretch: 50km upstream from conjunction point to Musi River (Muara Enim) Interval: Approx. 10km
	Total	35	

Source: JICA Project Team 2

8.1.2 Tide and Water Level Gauge Survey

In the Musi River basin there are several tide and water level gauges that are managed by PELINDO II, BBWS-S8 and Dinas PU. However, the zero datum levels of the tide gauges have been set at the low water levels at the gauge sites, and those of the water level staff and automatic gauges of BBWS-S8 and Dinas PU have been locally and arbitrarily determined. Therefore, the collected tide and water level data cannot be used directly as they are when they are used together with the cross section survey data, and the tide and water level data should be adjusted to the mean sea level of BAKOSURTANAL. In order to estimate the adjustment values for the tide and water level gauges, elevation survey was conducted.



Source: JICA Project Team 2

Figure 8.1.1 Location of Cross Section Survey

8.2 Groundwater Level Observation

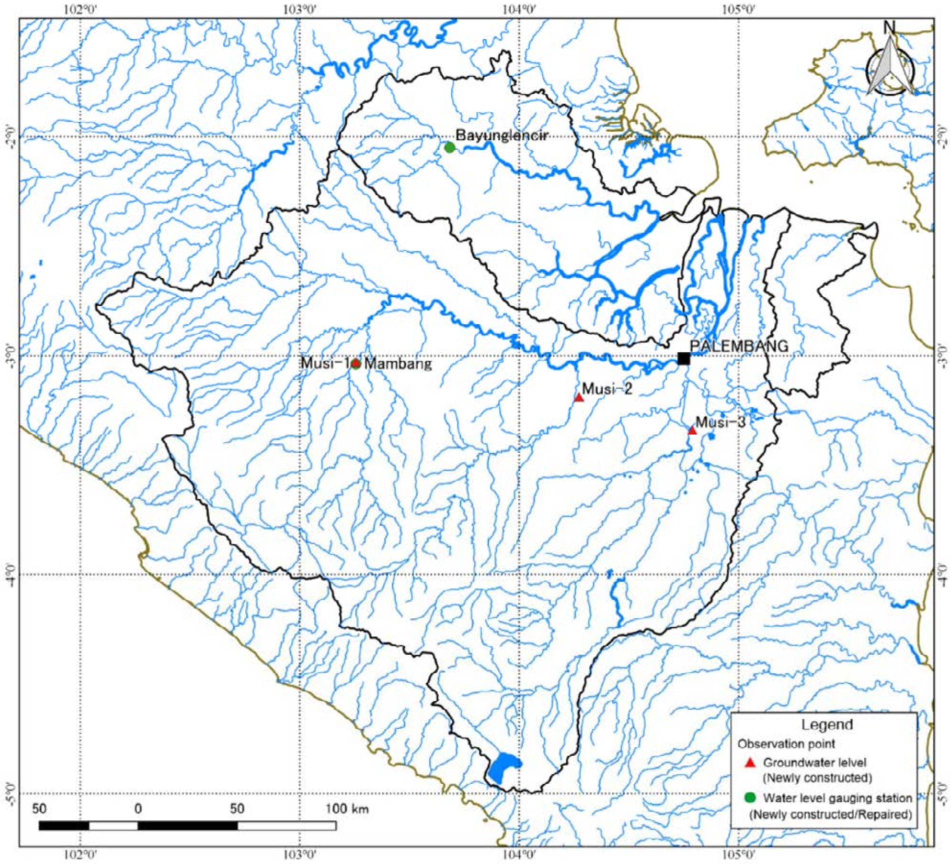
8.2.1 Construction of Groundwater Level Observation Wells

Since there were no groundwater level data for the Musi River basin, three observation wells were constructed near the existing water level stations of the Musi River (Mambang), Lematang River (Sungai Rotan) and Komering River (Tanjung Raja). Immediately after the completion of the well construction, groundwater level monitoring was commenced. Table 8.2.1 shows information on the three observation wells which were constructed under the Project. The location of the three wells is also presented in Figure 8.2.1.

Table 8.2.1 Information on Observation Wells in Musi River Basin

Well Name	District	Village	Coordinate (WGS84)	Elevation (m msl)*	Depth (GL-m)	Casing (mm)	Screen Depth (GL-m)	Drilling Period
Mambang (Musi-1)	Musi Rawas	Mambang	S 03 02'02.8" E 103 15' 17.7"	31.164	40.0	100	6–12, 32–38	29-30 Aug. 2013
Sungai Rotan (Musi-2)	Muara Enim	Sukarami	S 03 11'36.9" E 104 16'20.6"	9.209	46.0	100	18-21, 31-34, 36-42	6-10 Sep. 2013
Tanjung Raja (Musi-3)	Ogan Ilir	Sungai Pinang	S 03 20'46.5" E 104 47'20.3"	7.097	49.0	100	12-18, 30-33, 43-46	17-19 Sep. 2013

Note: * at the top of concrete base of each well
Source: JICA Project Team 2

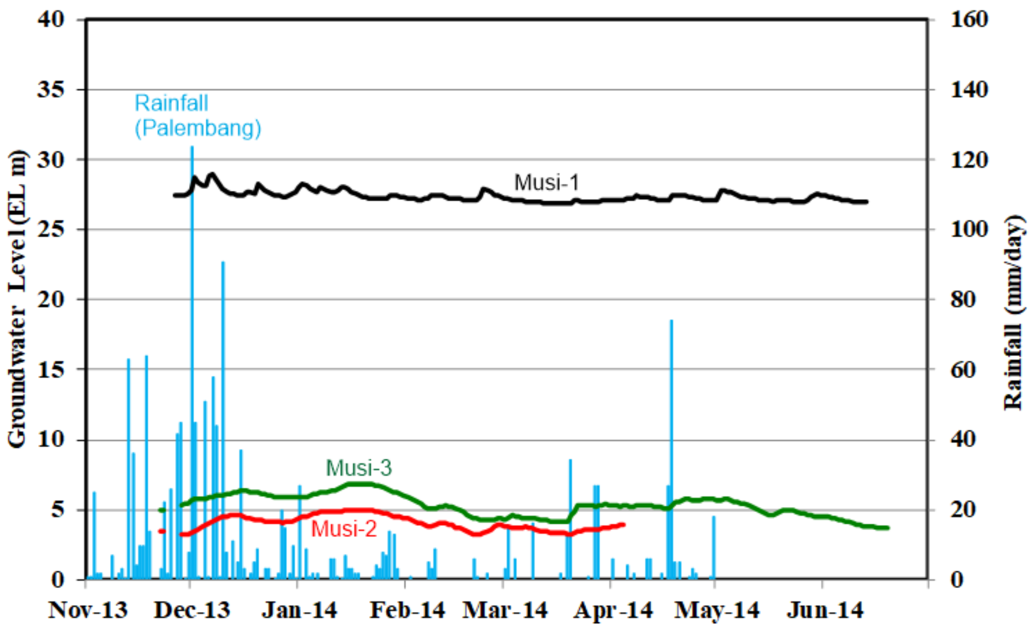


Source: JICA Project Team 2

Figure 8.2.1 Location of Newly Constructed Observation Wells

8.2.2 Groundwater Level Observation

Hourly groundwater level monitoring has been carried out since November 2013 by an automatic piezometric data logger for the above three observation wells. Figure 8.2.2 shows the result of the groundwater level monitoring from November 2013 to June 2014. For groundwater level data, please refer to Data C in the Data Book.



Source: JICA Project Team 2

Figure 8.2.2 Groundwater Level Data in Observation Wells

(1) Musi-1 Observation Well

Musi-1 is located in the middle of the Musi River basin, about 120m far from the Musi River. The aquifer is unconfined. The groundwater level shows good response to rainfall events, but it has no seasonal change (around EL 27m).

(2) Musi-2 Observation Well

Musi-2 is located at the lower part of the Musi River basin, about 1,200m far from the Lematang River. The observed ground water level is above the aquifer, therefore the aquifer is confined. The groundwater level shows gentle changes without response to the rainfall. It may fluctuate mainly and may vary according to the river water level.

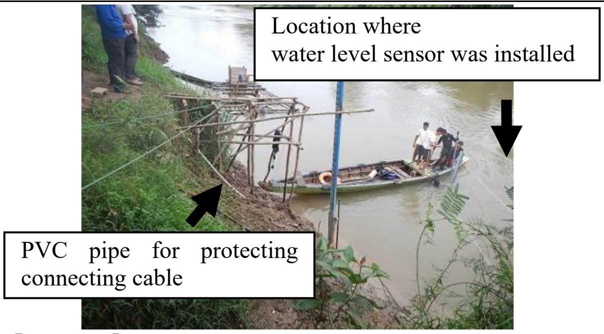
(3) Musi-3 Observation Well

Musi-3 is located at the lower part of the Musi River basin, about 400m far from the Komering River. Since the observed water levels are above the aquifer, the aquifer is confined. The fluctuation of the groundwater level is concordant with that of Musi-2. The groundwater level may vary according to the river water level.

8.3 Discharge Measurement

8.3.1 Construction and Restoration of Water Level Gauges

Based on the agreement with BBWS-S8 and the JICA Project Team, a new water gauging station was constructed at Bayunglencir in the Banyuasin River basin, and the broken pressure-type water level gauge of the Mambang Station was replaced with new one under the Project as shown in Photo 8.3.1.



【Mambang】Replaced Water Level Sensor (as of June 2014)

【Mambang】Repaired Water Level Gauging Station and Constructed Benchmark

【Bayunglencir】Established Water Level Sensor

【Bayunglencir】Constructed Water Level Gauging Station and Benchmark

Source: JICA Project Team 2

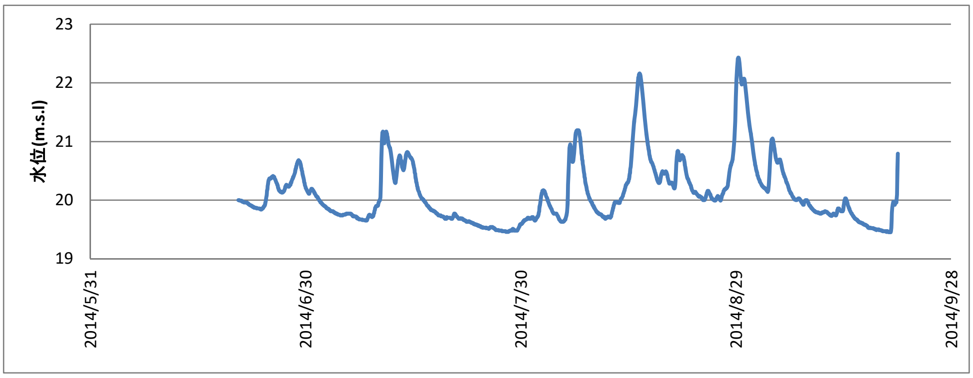
Photo 8.3.1 Construction and Rehabilitation of Water Level Gauging Stations

Table 8.3.1 shows site information of the newly-constructed and rehabilitated stations, and the location of the two stations are presented in Figure 8.2.1 together with the newly constructed wells. Figure 8.3.1 and Figure 8.3.2 present observed water levels.

Table 8.3.1 Site Information of New and Rehabilitated Water Level Stations

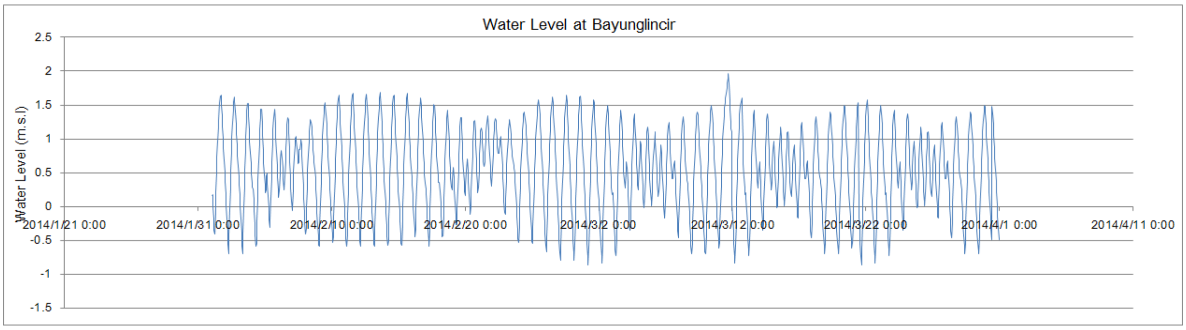
No.	Site name	Kabupaten (Regency)	Desa (Village)	Coordinates (WGS-84)	
				Latitude	Longitude
1	Mambang	Musi Rawas	Mambang	3° 2'8.68"S	103°15'21.11"E
2	Bayunglencir	Musi Banyuasin	Bayunglencir	2° 3'2.83"S	103°41'1.10"E

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 8.3.1 Observed Water Levels at Mambang Station



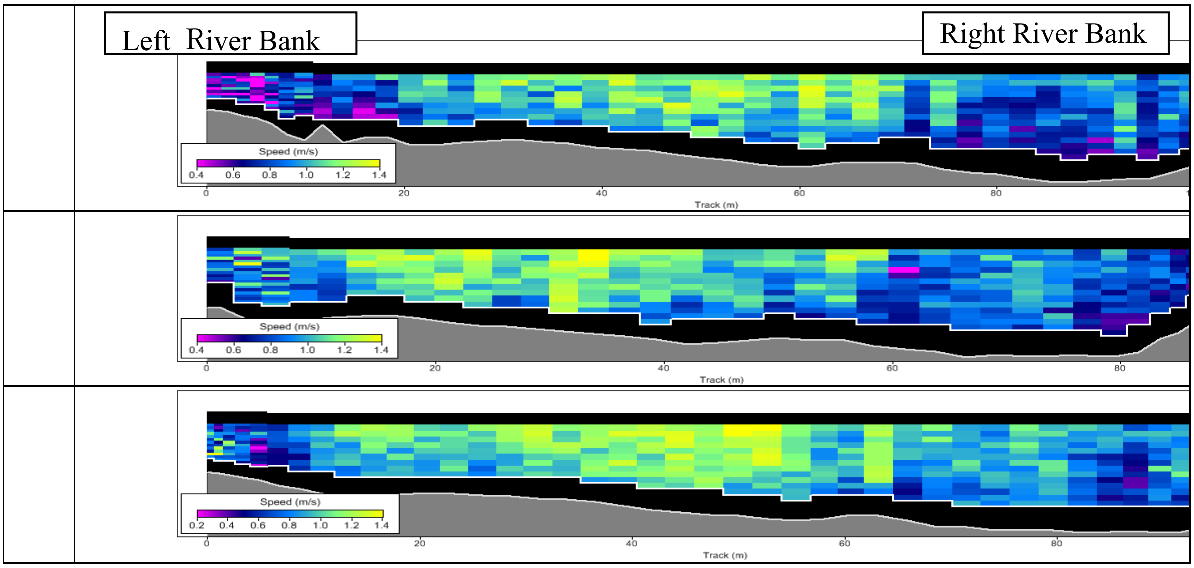
Source: JICA Project Team 2

Figure 8.3.2 Observed Water Level at Bayunglencir Station

8.3.2 Discharge Measurement

Discharge measurement was carried out at the restored water level station, the Mambang Station, on an OJT (on-the-job-training) basis, by using an Acoustic Doppler Current Profiler (ADCP), named "River Surveyor" developed by an American company, Xylem Inc. and owned by BBWS-S8, as shown in Photo 8.3.2. In order to construct a water level-discharge rating curve that covers a certain discharge range, the discharge measurement was conducted three times, namely in October (before the wet season) and November (at the beginning of the wet season) 2013 and in May 2014 (at the end of the wet season). The results of the discharge measurement are presented in Figure 8.3.3 and Figure 8.3.4.

According to the Inception Report, it was supposed to conduct discharge measurement at somewhere in the Banyuasin and Sugihan River basins. However, the both the river basins are so low-lying that almost all the river stretches are under the tidal influence. Based upon discussions with the JICA Project Team 1 , therefore, discharge measurement in both the river basins was canceled.



Source: JICA Project Team 2

Figure 8.3.3 Distribution of Velocity

ADCP sensor attached to boat

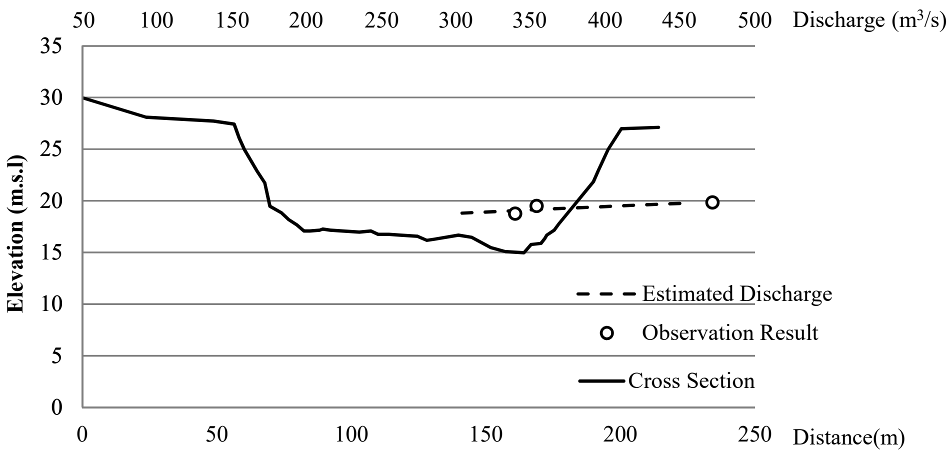
Receiver and laptop PC for monitoring

Base Station

Observation by ADCP

Source: JICA Project Team 2

Photo 8.3.2 Field Work for Discharge Measurement



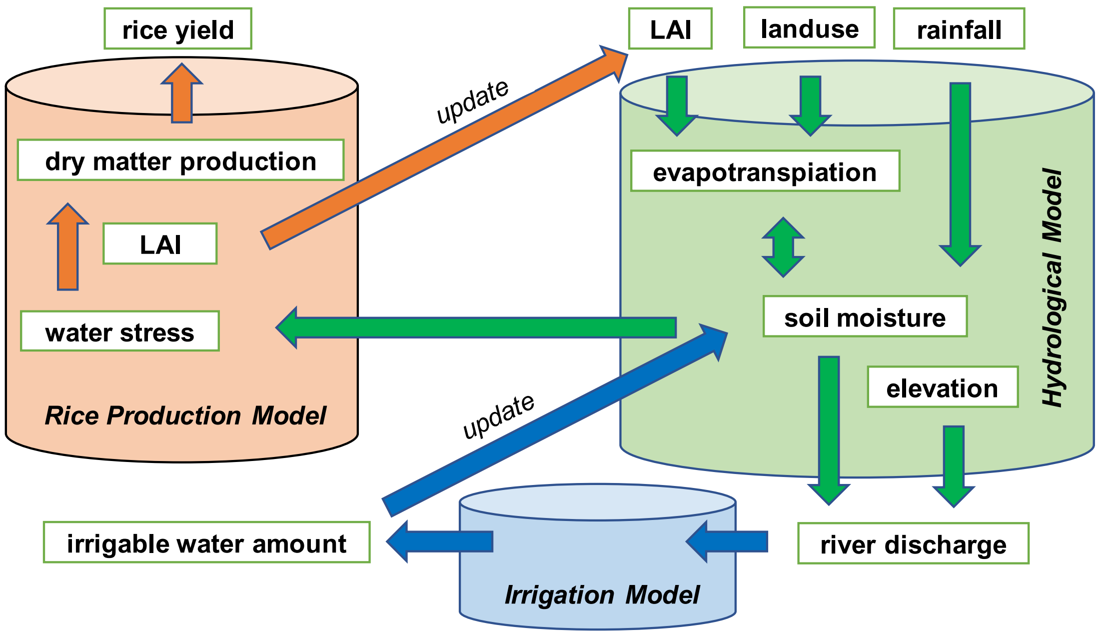
Source: JICA Project Team 2

Figure 8.3.4 Surveyed Cross Section and Discharge Curve

8.4 Survey on Crop Modeling Data

8.4.1 Simulation Model for Rice-Weather Relation

Aiming to evaluate future impacts of the future climate change on rice yield in a quantitative manner, a simulation model which is called Simulation Model for Rice-Weather Relation (SIMRIW)-rainfed has been developed by the JICA Project Team 1 based on the Water and Energy Budget-based Distributed Hydrological Model (WEB-DHM. The model has five components such as WEB-DHM, SIMRIW-Rainfed, Paddy Model, Coupling System and Irrigation Model. Figure 8.4.1 shows linkage between hydrologic, irrigation and crop models.



Source: JICA Project Team 1

Figure 8.4.1 Linkage between Hydrological, Irrigation and Rice Production Models

8.4.2 Survey Items and Method

Aiming to collect on-farm level observation data to put into the above crop model, the following items of field survey and laboratory analysis were selected, considering wet paddy field types in South Sumatra Province. Implementation of on-farm level data collection and laboratory works were contracted out to Sri Wijaya University.

Table 8.4.1 Survey Items and Methods

<table>
<tr><th>Survey Method</th><th colspan="3">Survey Item</th></tr>
<tr><td rowspan="9">Field observation & interview</td><td rowspan="2">Cultivation practices</td><td>Work period</td><td>Land preparation, puddling, transplanting (nursery, planting), direct sowing, prevention & harvesting</td></tr>
<tr><td>Work method</td><td>Manual, animal power (own-breeding, contract) & farm machine (own, contract)</td></tr>
<tr><td rowspan="3">Farm input</td><td>Seed</td><td>Variety, sowing amount & supply source (purchase, own-stock)</td></tr>
<tr><td>Fertilizer</td><td>Type of chemical fertilizers, application time, amount (material, weight, nitrogen content, phosphate content, potassium content) & organic fertilizer (compost, manure)</td></tr>
<tr><td>Agro-chemical</td><td>Kind of pest and disease, agro-chemicals used (type, amount) & spraying time and frequency</td></tr>
<tr><td colspan="2">Paddy field condition</td><td>Surface water depth for rainy season & surface water drain condition</td></tr>
<tr><td rowspan="2">Irrigation</td><td>Period</td><td>Supplemental irrigation for rainy season & full irrigation for dry season</td></tr>
<tr><td>Method</td><td>Plot-to-plot irrigation, direct intake from on-farm level canal & irrigation water depth</td></tr>
<tr style="display:none"></tr>
<tr><td rowspan="5">Laboratory analysis</td><td rowspan="2">Soil sample</td><td>Physical</td><td>Soil moisture content, percolation rate, pF & soil texture</td></tr>
<tr><td>Chemical</td><td>Total carbon content (T-C), total nitrogen content (T-N) & C/N ratio</td></tr>
<tr><td rowspan="3">Plant sample</td><td>Sampling time</td><td>2-week after transplanting, 6-week transplanting, heading & maturity (grain, straw)</td></tr>
<tr><td>Physical</td><td>Dried matter weight, leaf area & yield</td></tr>
<tr><td>Chemical</td><td>Total nitrogen content</td></tr>
</table>

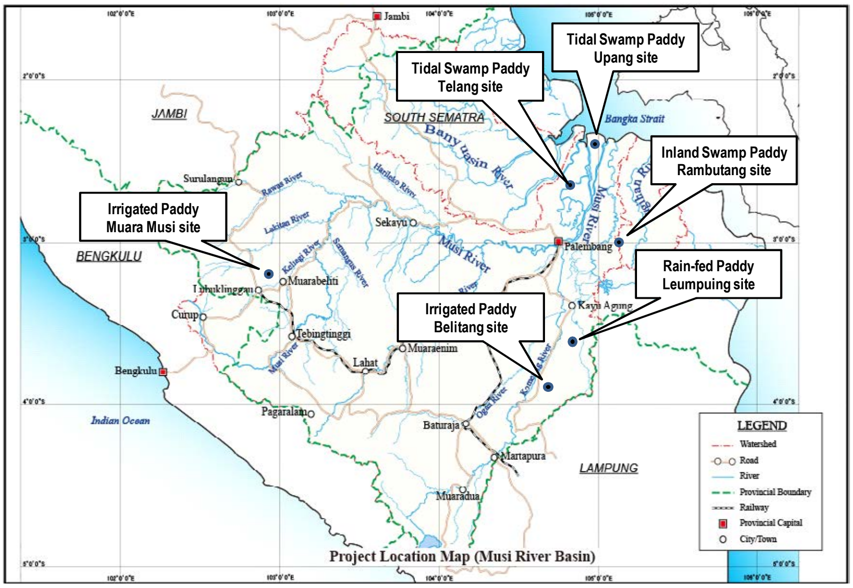
Source: JICA Project Team 2

8.4.3 Survey Area

Field observation and sampling places were set up at two sites each in paddy field of irrigation scheme and tidal swamp reclamation schemes as well as one site each in rain-fed paddy and inland freshwater swamp areas. In the respective sites, 25 sample farm households were selected for gathering information on their paddy cultivation practices through face-to-face interview survey to individual sample farmers by enumerators of Sri Wijaya University. Plant samples were collected at the abovementioned four sampling times from the field observation sites in the rain-fed paddy area during the rainy season, the inland freshwater swamp area during the dry season, and the irrigation schemes and tidal swamp reclamation schemes during both seasons. Dried soil and plant samples were used for physical and chemical analysis in the laboratory of Sri Wijaya University. The location of field observation sites is illustrated in Figure 8.4.2.

8.4.4 Survey Results

Out of the field observation and laboratory analysis results, focal points are summarized in the form of average data as shown in Table 8.4.2.



Source: JICA Project Team 2

Figure 8.4.2 Location of Survey Areas

Table 8.4.2 Focal Points of Survey Results

Item		**Unit**	**Field Condition of Observation Site**					
			Irrigated		**Rain-fed**	**Tidal Swamp**		**Inland**
Field observation site			Belitang	Muara Musi	Leumpuing	Telang	Upang	Rambutan
Average data of interview results on rainy season field observation								
Yield	Dry paddy	(ton ha-1)	4.08	3.89	3.96	5.01	2.94	-
Fertilizer	Urea	(kg ha-1)	50	112	56	111	75	-
Applied	TSP	(kg ha-1)	41	77	58	92	69	-
Amount	NPK	(kg ha-1)	61	108	53	76	82	-
Average data of interview results on dry season field observation								
Yield	Dry paddy	(ton ha-1)	4.28	4.58	-	-	-	2.72
Fertilizer	Urea	(kg ha-1)	75	114	-	-	-	92
Applied	TSP	(kg ha-1)	46	88	-	-	-	66
Amount	NPK	(kg ha-1)	71	105	-	-	-	137
Laboratory analysis data on soil samples								
Texture	Sand	(g g-1)	0.318	0.579	0.403	0.443	0.195	-
	Silt	(g g-1)	0.414	0.301	0.379	0.447	0.403	-
	Clay	(g g-1)	0.268	0.120	0.218	0.110	0.402	-
Element	T-N	(mg g-1)	15.204	15.316	47.448	10.262	45.954	-
	T-C	(mg g-1)	1.096	2.596	1.552	1.000	2.400	-
	C/N ratio		13.9	5.9	30.6	10.3	19.1-	-
Laboratory analysis data on rainy season plant samples								
Dry matter weight	2-week	(g m-2)	10.4	22.8	15.0	2.2	3.2	-
	6-week	(g m-2)	63.4	45.2	92.0	30.0	36.3	-
	Heading	(g m-2)	303.0	659.0	361.0	349.0	437.0	-
	Grain	(g m-2)	302.0	670.0	375.0	470.0	281.0	-
	Straw	(g m-2)	582.0	754.0	685.0	652.0	389.0	-
T-N content	2-week	(g g-1)	0.011	0.014	0.016	0.012	-	-
	6-week	(g g-1)	0.012	0.019	0.021	0.013	-	-
	Heading	(g g-1)	0.026	0.013	0.032	0.011	0.048	-
	Grain	(g g-1)	0.090	0.017	0.017	0.012	0.037	-
	Straw	(g g-1)	0.024	0.025	0.025	0.009	0.051	-
Laboratory analysis data on dry season plant samples								
Dry matter weight	2-week	(g m-2)	-	-	-	-	-	-
	6-week	(g m-2)	-	-	-	-	-	-
	Heading	(g m-2)	-	-	-	-	-	-
	Grain	(g m-2)	-	-	-	-	-	-
	Straw	(g m-2)	-	-	-	-	-	-
T-N content	2-week	(g g-1)	0.012	-	-	-	-	-
	6-week	(g g-1)	0.022	-	-	-	-	-
	Heading	(g g-1)	0.027	-	-	-	-	-
	Grain	(g g-1)	0.047	-	-	-	-	-
	Straw	(g g-1)	0.026	-	-	-	-	-

Source: JICA Project Team 2

8.4.5 Findings

To practice the model for estimating rice yield precisely under the present climate, it is required to set up initial condition as follows:

- In the hydrological model, input data required are solar radiation, day length, and temperature, to be observed, and soil moisture, to be measured;
- In the rice production model, input date required are information on farm management aspects at field level in terms of rice variety, transplanting date as well as fertilizer application rates and date. Also, laboratory analysis works are needed for grasping dry matter and nitrogen content of rice plant samples to be taken during crop growing period;
- In this model, leaf area index (LAI) should be calculated; and
- In the irrigation model, input data are river discharge to be obtained from the hydrological model.

For simulating the impact of future climate changes on rice yield, it is indispensable to clarify an eco-system of paddy field. In case of the MBSL River basin, the eco-system is classified into irrigated, rainfed, tidal swamp and inland fresh water swamp. Not only natural features but also farmers' paddy cultivation practices are different among these eco-systems so that it is needed to make adjustment of the effect of water stress on crop yield. For this purpose, the technological coefficient that is theoretically simulated crop yield against the observed yield is set up. For example, the coefficient set up for each ecosystem of MBSL River basin is 1.065 for irrigated, 1.183 for rainfed, 1.130 for tidal swamp and 0.821 for inland fresh water swamp.

As the eastern part of Sumatra Island including the MBSL River basin is directly affected by drought condition caused by the El Nino Southern Oscillation Signal, it is desirable to establish fixed observation sites of paddy field in each ecosystem for collecting field data of at least five years as reliable basic inputs to the rice production model. From such point of view, it has been decided under the present study to examine the sufficiency of supplemental irrigation water diversion requirement in the irrigation ecosystem and thereby to estimate the impacts of future climate change focusing on the area basis instead of the crop yield basis.