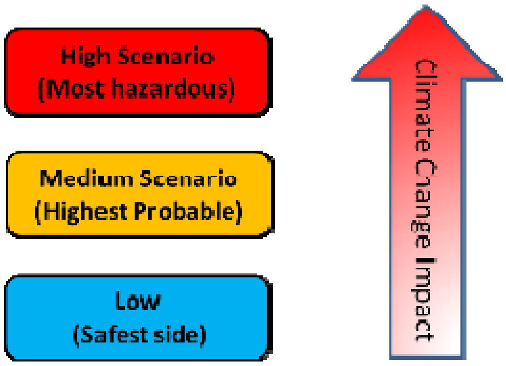
CHAPTER 9 ASSESSMENT OF CLIMATE CHANGE IMPACTS IN 2050

9.1 General

This chapter discusses the assessment of climate change impacts in 2050, focusing on drought and flood hazards in particular. For these purposes, water balance and flood inundation analyses are conducted by using climate and runoff discharge data provided by the JICA Project Team 1 for the Component-1: Climate Change Impact Assessment and Runoff Analysis. Based on results of the analyses, impacts and risks on drought and flood are assessed, and then resilience measures within the existing capacities of the related sectors are also discussed.

In order to cover the uncertainty of climate change as much as possible, this project deals with three scenarios as presented in Figure 3.1.1. The three scenarios are High Scenario (Most hazardous), Medium Scenario (Highest probable) and Low Scenario (Safest side). In the water balance and flood inundation analyses three representative General Circulation Models (GCMs) are selected corresponding to the three scenarios respectively, and the analyses are conducted by using the runoff discharge data of the representative GCMs provided by the JICA Project Team 1.



Source: JICA Project Team 1

Figure 9.1.1 Three Climate Change Scenarios

9.2 Ground Elevation and Land Use in 2050

9.2.1 Mesh Data of Ground Elevation

(1) Available DEMs

Flood simulation model requires accurate digital elevation model (DEM) to express actual flood movement in floodplain. To select more suitable DEM for the Musi River basin, the available free DEM data were collected as shown in Table 9.2.1. The JICA Project Team 2 also tried to collect available DEM from Indonesian counterpart, but there was no available DEM in the target area.

Table 9.2.1 List of Available Free DEM Data

Name	DSM/ DTM*	Reference Ellipsoid	Reference Geoid	Resolution	Source
SRTM (version 4.1)	DSM	WGS84	EGM96	3 arc-second (about 90m)	https://cgiarcsi.community/data/srtm-90m-digital-elevation-database-v4-1/
SRTM (version 3.0)	DSM	WGS84	EGM96	1 arc-second (about 30m)	https://earthexplorer.usgs.gov/
Aster GDEM (version 2.0)	DSM	WGS84	EGM96	1 arc-second (about 30m)	https://lpdaac.usgs.gov/dataset_discovery/aster/aster_products_table/astgtm
ALOS World 3D (version 2.1)	DSM	GRS80	EGM96	1 arc-second (about 30m)	https://www.eorc.jaxa.jp/ALOS/aw3d30/index_j.htm
DEMNAS	DSM	WGS84	EGM2008	0.27 arc-second (about 8m)	http://tides.big.go.id/DEMNAS/
MERIT DEM	DTM	WGS84	EGM96	3 arc-second (about 90m)	http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/index.html

Note: *DSM: Digital Surface Model, DTM: Digital Terrain Model
Source: JICA Project Team 2

(2) DEM selection

To select most appropriate DEM for flood simulation modeling of the Musi River basin, DEM data shown in Table 9.2.1 were compared with geodetic control points (GCPs) and bench marks (BMs). The geodetic control points were downloaded from the website of BIG (Badan Informasi Geospasial) which was established by granting more responsibility to the National Coordinating Agency for Surveys and Mapping (Bakosurtanal) with Law No. 4/2011 on Geospatial Information and Presidential Regulation No. 94/2011 on the Geospatial Information Agency. The compatibility with the GCPs validates the accuracy of DEMs.

As a result, ALOS, DEMNAS and MERIT showed relatively good fitting in comparison of GCPs for the target area of flood simulation. In addition to that, digital terrain model (DTM), whose grids' elevations are modified from digital surface model (DSM) by removing the height of buildings and vegetation, should be applied to flood simulation model because flooded water flow through buildings and vegetation. Therefore, MERIT DEM was selected to build a terrain model for the flood simulation model.

9.2.2 Future Land Use

(1) Focal Points for Prediction of Future Land Use

In predicting the future land use in the MSBL River basin for the year of 2050, the basic concept is to refer to POLA 2014 and RENCANA 2017 of the MSBL River basin as well as the Spatial Plan of South Sumatra Province (RTRW Sumatera Selatan). The planning target year made in these references is 2031 by POLA/RENCANA and 2036 by RTRW. For the purpose of providing input data required for undertaking run-off analysis by the JICA Project Team 1, the future land use condition is set up as follows:

- Protection zone demarcated in RTRW South Sumatra, covering 15.5% of the province is to be fully maintained;
- As for the existing irrigated paddy field areas of surface water irrigation schemes under the authority of BBWS-S8 and South Sumatra Provincial Government, each scheme will be fully utilized through execution of remaining construction and/or rehabilitation works

by 2050, while those under the authority of local governments will be partly integrated into newly planned surface water irrigation schemes in RENCANA 2017 as listed up in Table 7.4.4 or remained by means of renovation activities;

- The existing rainfed paddy field areas will be partly covered by extension plan of the existing surface water irrigation schemes and the rest will be converted to other crop cultivation areas;
- Regarding tidal swamp drainage schemes under the authority of BBWS-S8 and South Sumatra Provincial Government, the existing paddy field areas will be fully maintained, while small scale inland swamp drainage schemes under the authority of local governments will be converted to permanent tree crop, especially oil palm, planting areas;
- New development schemes planned in RENCANA 2017 will be fully functioned by 2050 and used for rice cultivation purpose;
- Estate crop growing area will be expanded up to 3.18 million ha or the maximum area of plantation zone set up in RTRW up to 2050, considering that estate crops are the main source of financial income in agricultural sector of the province. To meet land resource requirement for the expansion of about one million ha, temporally unused land, shifting cultivation area, convertible production forest, and permanent production forest will be converted in order; and
- The whole area of Palembang and Prabmulih Cities will be fully utilized for residential, industrial and public purposes in 2050. In other regencies and cities, residential area will be extended due to population increase so that dry farm land area will partly be converted to residential area as required.

(2) Predicted Areas of Future Wetland Paddy Field, Estate Crop Field and Forest Areas

Taking the above assumptions into account, the predicted future areas of surface water irrigation and swamp drainage schemes, permanent tree crops, and forest in the MSBL River basin for 2050 are tabulated in Table 9.2.2, Table 9.2.3 and Table 9.2.4, respectively.

The abovementioned future land use condition is illustrated as shown in Figure 9.2.1 and the area extent of major land use categories by regency/ city is tabulated in Table 9.2.5.

Table 9.2.2 Predicted Future Irrigation Area in South Sumatra for 2050

Regency (R) / City (C)		Surface Water Irrigation Scheme (ha)				Swamp Irrigation Scheme (ha)		
		BBWS-S8	Province	Regency	Total	BBWS-S8	Province	Total
1.	Palembang C.	0	0	0	0	0	0	341
2.	Prabumulih C.	0	0	0	0	0	0	0
3.	Pagar Alam C.	10,050	1,479	1,525	13,054	0	0	0
4.	Lubuk Linggau C.	1,322	0	1,529	2,851	0	0	0
5.	OKI R.	13,000	0	0	13,000	39,335	14,126	46,480
6.	Ogan Ilir R.	0	0	0	0	16,536	14,992	43,232
7.	OKU Timur R.	57,988	4,920	650	63,558	0	7,550	8,250
8.	OKU R.	0	0	3,824	3,824	0	0	45,480
9.	OKU Selatan	0	4,801	5,179	9,980	0	0	0
10.	Muara Enim R.	0	8,885	24,327	33,212	0	1,200	3,957
11.	PALI R.	0	0	0	0	0	0	0
12.	Lahat R.	10,000	5,443	8,348	23,791	0	0	0
13.	Empat Lawang R.	9,244	1,500	5,614	16,358	0	0	0
14.	Musi Rawas R.	32,341	4,013	6,563	42,917	6,000	0	0
15.	Musi Rawas Utara R.	3,000	0	640	3,640	0	0	0
16.	Musi Banyuasin R.	0	0	0	0	32,065	11,641	58,518
17.	Banyuasin R.	0	0	0	0	164,197	0	166,263
South Sumatra Total		136,945	31,041	58,199	226,185	258,133	49,509	326,041
Lampung Total		15,048	0	0	15,048	0	0	0
Total		151,993	31,041	58,199	241,233	258,133	49,509	326,041

Source: JICA Project Team 2

Table 9.2.3 Predicted Future Permanent Tree Crop Planting Area in South Sumatra for 2050

Regency (R) / City (C)	Rubber (ha)	Coconut (ha)	Oil Palm (ha)	Coffee (ha)	Others (ha)	Total (ha)	Change* (ha)
Palembang C.	0	0	0	0	0	0	▲ 522
Prabumulih C.	0	0	0	0	0	0	▲ 11,197
Pagar Alam C.	1,180	40	0	12,440	1,800	15,460	4,301
Lubuk Linggau C.	12,210	220	0	2,910	630	15,970	3,790
OKI R.	198,390	3,320	265,040	2,030	17,370	486,150	198,257
OKU Timur R.	28,350	3,360	14,560	0	8,800	55,070	13,318
Ogan Ilir R.	49,580	480	45,690	3,910	9,970	109,630	11,984
OKU R.	99370	1,120	51,630	33,320	7,410	192,850	68,534
OKU Selatan R.	5,840	1,180	60	96,360	10,760	114,200	27,612
Muara Enim R.	136,350	1,260	123,050	31,810	36,480	328,950	69,403
PALI R.	58,430	330	11,400	0	12,080	82,240	14,684
Lahat R.	55,080	550	77,930	95,080	33,040	261,680	82,461
Empat Lawang R.	5,440	750	0	85,700	20,450	112,340	26,106
Musi Rawas R.	132,960	1,550	172,800	4,450	11,010	322,770	79,372
Musi Rawas Utara R.	138,390	390	30,500	230	9,350	178,860	44,101
Musi Banyuasin R.	193,720	4,950	337,490	0	19,630	555,790	141,085
Banyuasin R.	91,510	47,300	201,050	4,160	13,020	357,040	96,167
South Sumatra	1,206,800	66,800	1,331,200	372,400	211,800	3,189,000	869,456

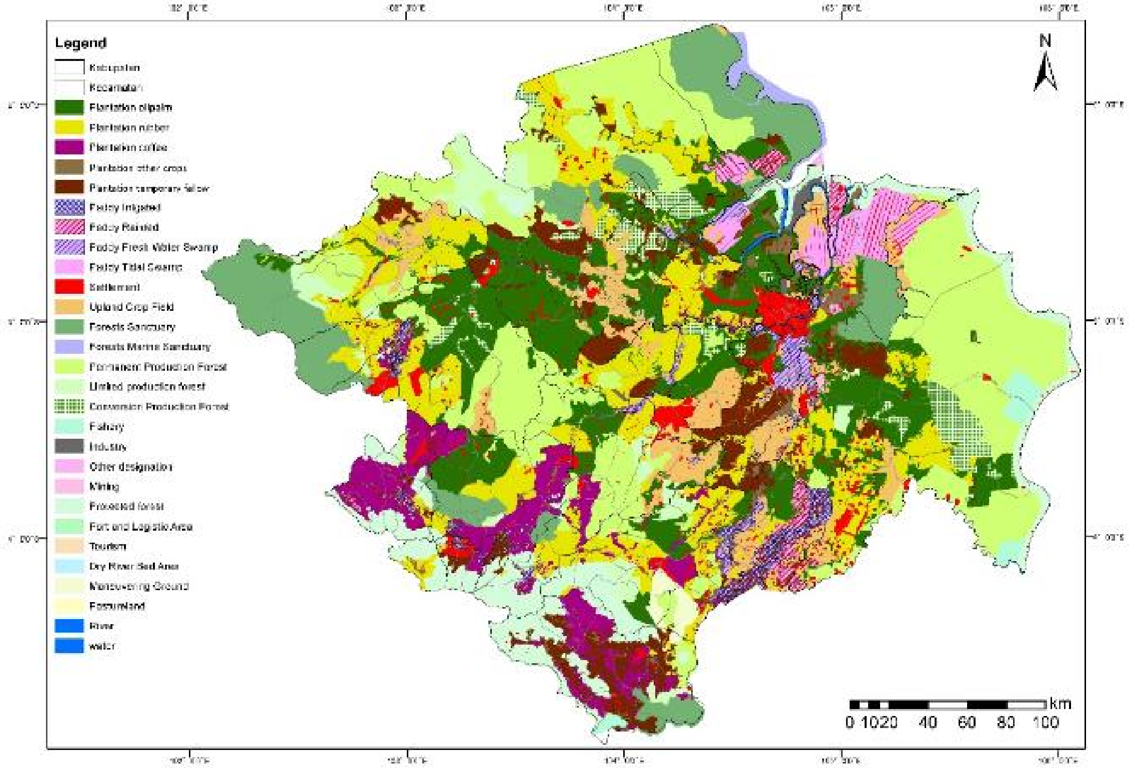
Note: *; Change in the total area of four major estate crops between 2015 and 2050

Source: JICA Project Team 2

Table 9.2.4 Predicted Future Forest Area in South Sumatra for 2050

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	1,070	0	1,060	2,130
3.	Pagar Alam C.	26,090	0	0	0	24,490	50,580
4.	Lubuk Linggau C.	1,220	4,150	1,100	0	620	7,090
5.	OKI R.	96,510	15,290	10,030	643,840	30,350	796,020
6.	Ogan Ilir R.	0	0	0	100	0	100
7.	OKU Timur R.	10	0	0	19,480	0	19,490
8.	OKU R.	68,310	0	18,650	54,960	58,470	200,390
9.	OKU Selatan R.	127,970	44,990	10,230	17,840	138,130	339,160
10.	Muara Enim R.	61,940	8,860	25,500	162,370	40,690	299,360
11.	PALI R.	0	0	0	8,550	0	8,550
12.	Lahat R.	48,310	52,260	4,350	28,550	3,010	136,480
13.	Empat Lawang R.	880	3,760	4,550	3,270	43,920	56,380
14.	Musi Rawas R.	64,970	75,350	7,390	157,680	0	305,390
15.	Musi Rawas Utara R.	190	172,780	36,750	109,780	36,910	356,410
16.	Musi Banyuasin R.	16,300	67,550	94,280	400,520	74,650	653,300
17.	Banyuasin R.	64,600	345,560	0	67,160	0	477,320
South Sumatra Total		577,300	790,600	213,900	1,674,100	452,300	3,708,200

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.2.1 Land Use Condition of MSBL in 2050

Table 9.2.5 Major Land Use Category Area by City/ Regency in South Sumatra for 2050

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.	0	0	0	0	0	0
2.	Prabumulih C.	0	0	0	0	0	0
3.	Pagar Alam C.	3,440	1,600	0	15,460	0	50,580
4.	Lubuk Linggau C.	1,894	1,690	0	15,970	0	7,090
5.	OKI R.	185,998	68,810	0	486,150	0	796,020
6.	Ogan Ilir R.	67,627	12,300	0	55,070	16,240	100
7.	OKU Timur R.	85,620	21,820	1,400	109,630	5,390	19,490
8.	OKU R.	8,872	21,550	0	192,850	0	200,390
9.	OKU Selatan R.	18,040	28,500	0	114,200	0	339,160
10.	Muara Enim R.	27,017	24,540	0	328,950	0	299,360
11.	PALI R.	6,579	8,960	0	82,240	0	8,550
12.	Lahat R.	17,525	16,430	0	261,680	0	136,480
13.	Empat Lawang R.	14,091	7,950	0	112,340	0	56,380
14.	Musi Rawas R.	30,451	23,820	0	322,770	0	305,390
15.	Musi Rawas Utara R.	7,131	16,810	0	178,860	24,870	356,410
16.	Musi Banyuasin R.	66,810	23,790	0	555,790	0	653,300
17.	Banyuasin R.	226,518	18,630	0	357,040	0	477,320
South Sumatra Total		774,502	297,200	1,400	3,189,000	46,500	3,708,200

Source: JICA Project Team 2

9.3 Water Use

9.3.1 Projection of Water Use

(1) Projection of Water Use for Agriculture

1) Purpose

In this Project, the main purpose of water use projection for agriculture is to assess impacts of the future climate change on irrigation water demand in surface water irrigation scheme command areas. In the MSBL River basin. however, selection of representative climate change models is to be carried out prior to the impact assessment. In this regard, water balance examination method is applied to the selection of three representative GCMs among nine GCMs. Aiming to prepare input data concerning irrigation water diversion requirement for the said assessment, therefore, the following cases have been set up and unit irrigation water requirement of each case has been estimated for the respective nine GCMs by referring to climate data of nine areas where surface water irrigation schemes are located;

Case 1 Historical (Observed) climate observation data and irrigated area of existing schemes;

Case 2: Present climate model data and irrigation area of existing schemes;

Case 3: Future climate model data and irrigation area of existing schemes; and

Case 4: Future climate model data and irrigation area of future schemes.

Thus, 324 outputs of unit irrigation water requirement in total (4 cases x 9 GCMs x 9 areas) have been made and used for calculating irrigation water diversion requirements of surface water irrigation schemes.

2) Methodology of Irrigation Water Demand Calculation in POLA

In POLA, Indonesian National Standard (SNI 19-6728.1-2002) is applied to calculate irrigation water demand. Unit irrigation water consumption is commonly set up at 1.0 l/s/ha for all irrigation water intake types such as technical, semi-technical and simple irrigation systems. In calculating annual irrigation water diversion requirement, two factors such as irrigation command area and cropping intensity are used. Therefore, no climatic factor is included in this SNI formula which is specified as follows;

IWR = A x CI x a

Where,

IWR: Annual irrigation water diversion requirement (l/s)

A: irrigation command area (ha)

CPI: cropping intensity (%)

a: unit water requirement (l/s/ha)

From this formula, however, it is impossible to clarify the effect or impact of climate change on irrigation water needs.

3) Methodology of Irrigation Water Demand Calculation in the Project

Aiming to quantify the effect of several alternative formulas have been compared from the viewpoint of monsoon climate features in Indonesia. As a result, the formula selected in “Irrigation Planning Standard, Design Criteria for Irrigation Networks (KP-1)” of DGWR is taken up instead of the above SNI formula. In KP-1, irrigation water demand is calculated based on the following formula:

KAI=(Etc+IR+WLR+P-Re)/IE ×A

Where

KAI:irrigation water needs (l/s)

Etc: consumptive water needs (mm/day)

IR: irrigation water needs at paddy field level (mm/day)

WLR: water needs to replace the water layer (mm/day)

P: percolation (mm/day)

Re: effective rainfall (mm/day)

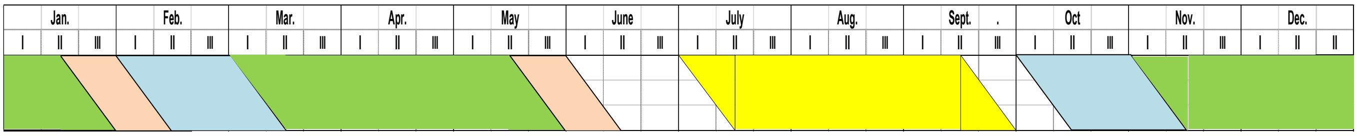
IE: irrigation efficiency (%)

A: irrigation area (ha)

Among these factors, the consumptive water needs are calculated by multiplying plant coefficient with evapotranspiration, and the irrigation water needs at paddy field level are calculated by using data on water needs to replace water loss due to evaporation and percolation in fields that had been saturated, percolation, open water evaporation during land preparation, and crop coefficient. In this formula, two climate factors such as rainfall and evapotranspiration are included so that the impact of climate change on irrigation water needs can be grasped in quantitative manner.

4) Cropping Calendar

For calculating irrigation water needs for crop cultivation on irrigated paddy field, it is required to set up a cropping calendar for each cropping season of paddy and secondary crops. Also, it is a prerequisite to use the sole cropping calendar in clarifying the impact of climate change on irrigation water needs in the MSBL basin aiming to simplify a comparative examination procedure for alternative climate change cases. To cope with such pre-condition, the sole cropping calendar is set up by basically referring to RENCANA 2017 as well as data on planting and harvesting times of paddy and secondary crops on monthly basis collected from Food Crops and Horticulture Office of South Sumatra Province. With some modifications based on the above data, the cropping calendar 15-day land preparation period before transplanting seedlings of both the wet and dry season paddy and 10-day water supply cutting period before harvesting time of the both seasons, the sole cropping calendar is set up as illustrated in Figure 9.3.1.



Note: Blue-colored part; Land preparation period, Green-colored part; Rice growing period under irrigated condition,Pink-colored part; Rice growing period under dried-up condition, Yellow-colored period; Secondary crop growing Period under irrigated condition
Source: JICA Project Team 2

Figure 9.3.1 Common Cropping Calendar for Surface Water Irrigation Scheme in MSBL Basin

5) Unit Irrigation Water Requirement

For quantifying the effect of different climate change models on irrigation water demand, unit irrigation water requirement is calculated by substituting evapotranspiration and rainfall data of nine GCMs as well as historical rainfall observation data in the KP-1 formula for the respective irrigation schemes and each regency. The calculation works are carried out on a 10-day period basis for a period of 15 years from 1985/86 wet season to 2000 dry season for the present pattern and 2050/51 wet season to 2065 dry season for the future scenario patterns. An example of the calculation results for Musi Rawas Regency is shown in the form of average value for each crop season in Table 9.3.1, while the full results are presented in the Supporting Report E.

Table 9.3.1 Example of Average Unit Irrigation Water Demand by GCM for Each Case

Case / Season / Crop		Seasonal Average Unit Irrigation Water Requirement for Musi Rawas Regency (l/s/ha)								
		GCM-1	GCM-2	GCM-3	GCM-4	GCM-5	GCM-6	GCM-7	GCM-8	GCM-9
Case 1* Historical (Observed) climate data & Existing surface water irrigation area										
W/S	paddy	0.89*	***(* based not on the data of each GCM but on actually observed data)***							
D/S	paddy	0.97*								
D/S	secondary	0.49*								
Case 2 Present climate model data & Existing surface water irrigation area										
W/S	paddy	0.46	0.82	0.62	0.76	0.76	0.64	0.64	1.04	0.65
D/S	paddy	0.99	0.70	0.75	0.69	0.69	0.76	0.80	1.11	0.75
D/S	secondary	0.43	0.40	0.45	0.63	0.63	0.28	0.37	0.47	0.37
Case 3 / Case 4 Future climate model data & Existing / Future surface water irrigation area										
W/S	paddy	1.01	0.77	0.68	0.83	0.82	0.68	0.75	1.02	0.86
D/S	paddy	0.47	0.97	0.68	0.88	0.74	0.76	0.79	1.08	0.85
D/S	secondary	0.59	0.23	0.39	0.42	0.65	0.29	0.35	0.46	0.46

Note: W/S; Wet Season, D/S; Dry Season
Source: JICA Project Team 2 (Data Book E2)

6) Irrigation Water Diversion Requirement

Irrigation water diversion requirement is predicted based on the above unit irrigationan water demand. In addition, cropping pattern is to be set up at 300% aiming to make more clearly differenciated features on rainfall patterns throughout the year of the respective GCMs. The irrigation water diversion requirement is to be estimated for the existing and planned surface water irrigation schemes under the authority of BBWS-S8 as well as the regency-based sum of command areas of planned surface water irrigation schemes under the authority of South Sumatra Province and local governments. Table 9.3.2 shows an example case represented by Regency Musi Rawas with 8,000-ha increase in surface water irrrigation area in the future. Data indicate the average of irrigation water demand of every 10-day period during esch crop season. Detailed results are compiled in the Supporting Report E.

Table 9.3.2 Example of Irrigation Water Demand Calculation by GCM for Musi Rawas Regency

Case / Season / Crop		Seasonal Average of Irrigation Water Demand for Musi Rawas Regency (m^3/s)								
		GCM-1	GCM-2	GCM-3	GCM-4	GCM-5	GCM-6	GCM-7	GCM-8	GCM-9
Case 1* Historical (Observed) climate data & Existing surface water irrigation area										
W/S	paddy	28.1*	***(* based not on the data of each GCM but on actually observed data)***							
D/S	paddy	30.5*								
D/S	secondary	15.4*								
Case 2 Present climate model data & Existing surface water irrigation area										
W/S	paddy	14.4	19.7	19.6	20.4	23.5	20.3	19.9	32.9	20.0
D/S	paddy	31.7	22.2	24.9	24.2	22.1	24.2	25.7	35.6	7.6
D/S	secondary	13.3	12.5	11.3	14.7	19.7	8.7	11.6	13.7	11.9
Case 3 Future climate model data & Existing surface water irrigation area										
W/S	paddy	31.6	24.9	21.2	26.2	25.7	20.9	22.9	31.3	27.2
D/S	paddy	14.9	30.2	21.3	28.1	23.9	24.3	25.3	34.0	27.4
D/S	secondary	18.8	16.1	12.0	13.6	20.2	9.7	10.8	15.5	13.9
Case 4 Future climate model data & Future surface water irrigation area										
W/S	paddy	39.6	31.3	26.6	32.8	32.2	26.2	28.8	39.3	34.1
D/S	paddy	18.7	37.9	26.7	35.2	30.0	30.5	31.8	42.7	34.3
D/S	secondary	23.6	20.2	15.1	17.0	25.4	12.2	13.5	17.4	17.4

Note: W/S; Wet Season, D/S; Dry Season
Source: JICA Project Team 2 (Data Book E2)

(2) Projection of Water Use for Domestic, Muncipal and Industrial Purposes

1) General

Municipal and industrial water demand in this Project covers the water demand of the human life and urban activities; activities in houses, offices, commercial facilities, governmental facilities, public facilities and industrial facilities. This section does not cover the water demands of the irrigation, fishery, forestry and maintenance of river.

The statistical information of water supply as the basis of the water - demand projection is basically compiled in accordance with the administrative area. Data of each area of river basin in city or regency is presented in the Supporting Report F.

2) Current Water Supply Situation

Generally, public water supply systems in Indonesia are managed by Indonesian Regional Water Utility Company (hereafter; PDAM) of each regency or city under the Ministry of Public Works.

(a) PDAM and Non-PDAM

PDAMs are supplying water to several fields of residence, commercial, public area and industrial zones. Those customers are receiving water supply service from PDAM based on the contract. while Non-PDAM means the area where PDAM does not supply water. Water users in the area take raw water directly from water sources such as surface water body or ground, but not taking the water from PDAM's water supply pipes, and use it for drinking, shower, kitchen or bottled water depending on their use and application. Therefore, coverage ratio means the total PDAM's customers ratio in each city and regency.

As of 2016, the coverage ratio of PDAM had been around/under 30% in regencies of the project area except Palembang City with 77% in 2015.

(b) Purposesof Water Usage

In PDAM and Non-PDAM area, purposes of water usages are classified into domestic water, non-domestic water, and industrial water as summarized below:

- Domestic water : Water consumption of life activities; bath, kitchen, cleaning and restroom in residential areas
- Non-domestic water (Urban Water):

  Water consumption for commercial, governmental and public activities; shopping malls, restaurants, hotels, sports centers, theaters, governmental offices, police and fireguard posts etc.
- Industrial water : Water consumption of industrial estates, private factories etc.

(c) Source of Water

The water source consists of surface water and groundwater in the Musi, Banyasin and Sugihan River basin based on the statistical information of water (ref: Directori Perpamusi 2016). Although the statistical data of the water resources in Non-PDAM area has not been available, the bottled water for the potable water and the raw water taken from surface water and/or collector of rainfall for cleaning are main resources in the area. Actual water demand in 2015 is shown in the Supporting Report F.

3) POLA 2014 and RENCANA 2017

The POLA 2014 is the latest water resources management plan for the Musi, Sugihan, Banyasin and Lemau River basin. The project area is one portion of the areas covered by the POLA 2014. RENCANA 2017 explained also the future demand projection of domestic, industry and public However, it was clarified through the JICA Project that some areas which are located outside of the Musi, Banyasin and Sugihan River basins were included in the target area for the demand projection in RENCANA 2017, and that the population projection method in RENCANA 2017 was not necessarily conforming to the population data of BPS. Therefore, the demand projection in the JICA Project was based on the available statistic data required for the demand projection as much as possible as shown in the following sections.

4) Condition for Water Demand Projection

(a) Basic Condition

Basis for the demand forecast is set at a condition in 2015 as a current water supply demand in the Musi, Banyasin and Sugihan River basin as shown in Table 9.3.3.

Table 9.3.3 Basic Condition for Demand Forecast in 2015

Organization		PDAM		Non-PDAM	
Water Source[*1]		**Surface**	**Ground**	**Surface**	**Ground or Collecting Rain Water**
Purpose to Use	Domestic	- Population (Census Data) - Unit Water Consumption[*2] - Coverage[*3] - NRW[*3]		- Lpcd =(Lpcd(PDAM)+30[*5])/2 - Area which is not supplied by PDAM. (100%-PDAM area) - NRW=0%	
	Non-Domestic[*4]	20% of Domestic		20% of Domestic	
	Industrial	26 l/capita/day based on the criteria of Cipta Karya 1998 Provincial statistical data of workers (Dalam Angka 2017)		26 l/capita/day based on the criteria of Cipta Karya 1998 Provincial statistical data of workers (Dalam Angka 2017)	

Note:
*1: Ratio of surface/ground is referred to the actual consumption (ref: DirektoriPerpamsi).
*2: Calculated from actual supplied water volume (sell volume) and no. of user (ref: DirektoriPerpamsi) until 2016.
*3: All numbers are referred from DirektoriPerpamsi. Coverage is calculated at population ratio which is supplied by PDAM.
*4: Water for public facility is calculated by 10-15% of domestic water demand according to the criteria of Directorate General of Human Settlement. Ministry of Public Works 1996. 20% of domestic water is estimated taking into consideration commercial use about 5-10%.
*5: 30 litter is the average unit consumption for residents in agricultural area which is stipulated as the public tap in the criteria of Directorate General of Human Settlement. Ministry of Public Works 1996.

Source: JICA Project Team 2

(a) Coverage Ratio of Water Supply Services

JICA Project Team 2 set the coverage ratio at 100% in 2050 taking into consideration the 100% coverage ratio of POLA. Each coverage ratio in the city or regency will be gradually increased to the target level until 2050. The coverage ratio of each city or regency where PDAM provides water supply service is shown in the Supporting Report F.

(b) Unit Water Consumption

According to the criteria issued by Cipta Karya, unit water consumption was defined based on the scale of the city which expresses as the number of population. Unit water consumptions for each city and regency, where PDAM provides water supply service were defined at 120 or 150 liter per capita per day (lpcd). As for the Palembang City, it is necessary to pay special attention since it is the second largest city in Sumatra Island. Unit water consumption of Palembang City was defined to apply for 200 lpcd in 2050 which is gradually increased from the current unit water consumption of 199 lpcd in 2015.

(c) Non-revenue Water (NRW) Ratio

Reduction of non-revenue water (NRW) has four target grades of 30%, 25%, 20% and the current ratio under 20% which depend on the current NRW ratio of each city or regency in 2015. It is generally known that the NRW ratio can be reduced easily until 30% by means of the systematic way of replacing pipes based on the leakage survey, and control and monitoring water consumption volume by water meter. In the river basins, certain coverage ratios of the water supply have been under 30% as of 2015. The development of the water supply services, especially the development of the pipeline network, is under the risk of increasing the NRW. The NRW of each city or regency where PDAM provides water supply service until 2050 is presented in the Supporting Report F.

(d) Groundwater

Groundwater is projected by the ratio of water resource where PDAM provides water supply service on the basis of the data mentioned in Direktori Perpamsi 2016 throughout the period of the projection (2010-2050). For this demand forecast, the ratio of actual water usage from river, spring, lake and deep well in 2015 was utilized.

5) Projected Population

(a) Population Projection in POLA 2014

Population is simply projected in POLA 2014 by the formula which can be calculated by the factors such as growth ratio and years with the basis of the population in 2012. This projection therefore does not reflect the long term population growth in South Sumatra, Jambi and Bengkulu Provinces formulated by BPS and urbanization factor for each city and regency was not taken into consideration.

On the other hand. JICA Project Team 2 estimated taking into consideration urbanization factor which BPS estimated the urbanization ratio of South Sumatra, Jambi and Bengkulu provinces in 2035 at 40.1%, 38.2% and 35.6% in Census 2010 of Indonesia, respectively. From the viewpoint to express the different growth ratio for urban and rural area in each city or regency, it can be evaluated that the method of JICA Project Team 2 will be more realistic. The growth ratio of population and urbanization ratio for each province is presented in the Supporting Report F.

(b) Population Projection in the Project

There is no projected population data until 2050. BPS has projected to each province from 2010 to 2035. Projection of population growth until 2050 is prepared with the following basis;

- Basis of the data for the projection is Census 2010 of Indonesia by BPS and is complemented by the data of Provinsi Dalam Angka 2017 issued by the branch office of BPS in each province.
- The projection of population is carried out for each city/regency. Until 2035, the population of the regency and city is calculated with utilization of growth ratio in each province based on Census 2010.
- After 2035, the JICA Project Team 2 expands the growth ratios with the linear formula of the increment ratio about the growth ratio. In this case, the growth ratio is projected under zero between 2035 and 2050, while the growth ratio for the projection is zero.
- As the projection is for the water demand projection and is separately carried out in accordance with the urban/rural areas. The urban and rural population for each city/regency are projected by the data of urban/rural population of Census 2010 until 2035 and the expanded data by the urbanized ratio projected by JICA Project Team 2 in accordance with the same method of the growth ratio.
- All datum of the population are adjusted by the ratio with the area of the basin divided by the administrative area of each city/regency.
- The population projection in each city and regency until 2050 estimated by JICA Project Team 2 is shown in the Supporting Report F.

6) Water Demand Projection

Demand projection until 2050 by means of applying factors as described above is summarized in Table 9.3.4 to Table 9.3.6. Demand projection for each city and regency in 2015 and 2050 are shown in the Supporting Report F. The difference of water demand projection between RENCANA 2017 and the Project is also shown in Figure 9.3.2. This difference in the projected water demand is mainly due to differences in the target areas and projection methods of target population applied for RENCANA 2017 and the JICA Project, respectively.

Table 9.3.4 Summary for Water Demand Projection of Musi River Basin until 2050

Year	**2015**		**2025**		**2035**		**2050**	
Purpose	Surface	Ground	Surface	Ground	Surface	Ground	Surface	Ground
Domestic	9.071	0.205	12.895	0.292	15.152	0.371	18.158	0.480
Non-domestic	1.816	0.041	2.581	0.058	3.033	0.074	3.634	0.096
Industry	0.048	0.000	0.054	0.000	0.058	0.000	0.059	0.000
Total	10.935	0.246	15.530	0.350	18.243	0.445	21.851	0.576
	11.181		15.880		18.688		22.427	

Source: JICA Project Team 2

Table 9.3.5 Summary for Water Demand Projection of Banyuasin River Basin until 2050

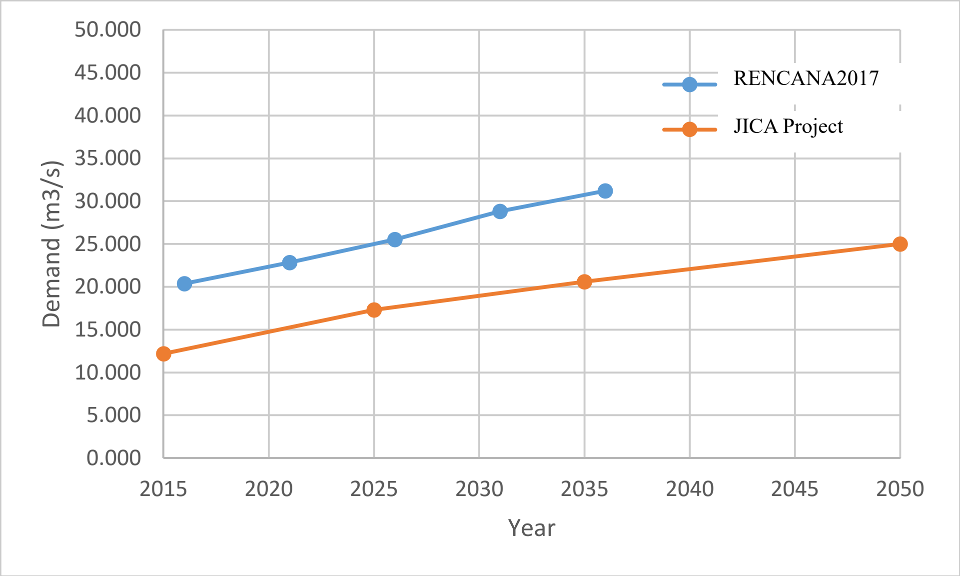
Year	2015		2025		2035		2050	
Purpose	Surface	Ground	Surface	Ground	Surface	Ground	Surface	Ground
Domestic	0.671	0.001	0.968	0.002	1.276	0.002	1.732	0.003
Non-domestic	0.134	0.000	0.194	0.000	0.255	0.000	0.346	0.001
Industry	0.011	0.000	0.012	0.000	0.013	0.000	0.014	0.000
Total	0.816	0.001	1.174	0.002	1.544	0.002	2.092	0.004
	0.817		1.176		1.546		2.096	

Source: JICA Project Team 2

Table 9.3.6 Summary for Water Demand Projection of Sugihan River Basin until 2050

Year	2015		2025		2035		2050	
Purpose	Surface	Ground	Surface	Ground	Surface	Ground	Surface	Ground
Domestic	0.155	0	0.220	0	0.289	0	0.392	0
Non-domestic	0.031	0	0.044	0	0.058	0	0.078	0
Industry	0.002	0	0.002	0	0.003	0	0.003	0
Total	0.188	0	0.266	0	0.350	0	0.473	0
	0.188		0.266		0.350		0.473	

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.3.2 Difference of Water Demand Projection between RECANA 2017 and JICA Project

As mentioned in the previous section 3) POLA 2014 and RENCANA 2017, in the JICA Project the areas of cities/regencies located inside the three river basins including Musi, Banyasin and Sugihan basins are considered, and the population projection is made based on the long term population data (2011 to 2035) of BPS. The demand projection in the JICA Project is therefore considered more realistic, while demand projection of RENCANA 2017 based on simple average of short term population growth rates (2006 to 2010) is seemed overestimate.

9.3.2 Water Balance Analysis

Water balance analysis was conducted for the entire Musi River basin. The details of the water balance analysis are provided in the Surporting Report B.

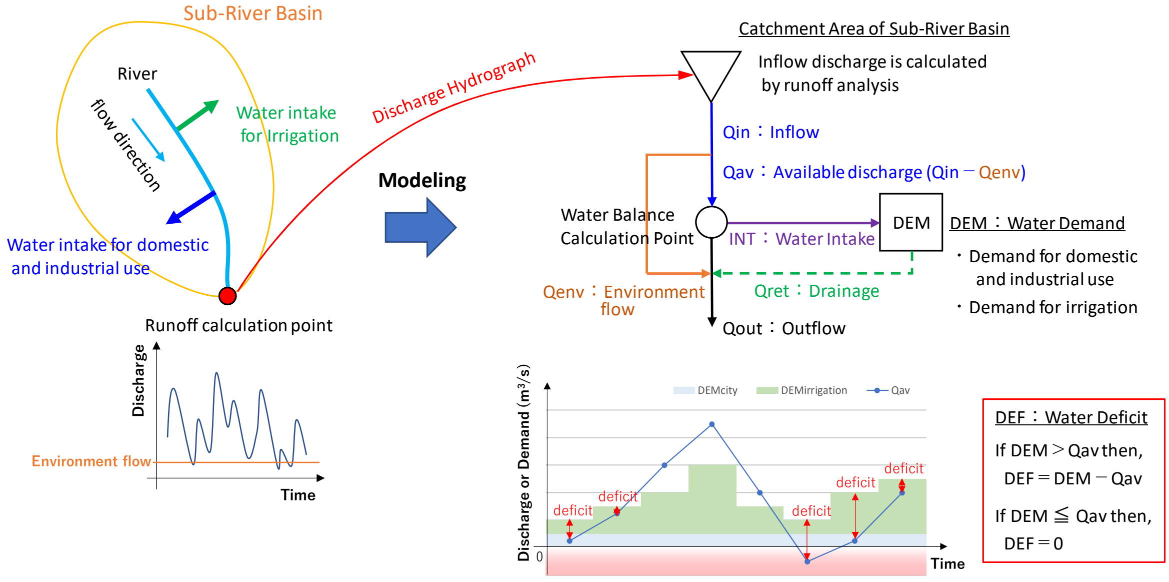
(1) Conditions of Analysis

The conditions of the water balance analysis are summarized in Table 9.3.7 and concepts of the analysis model are summarized in Figure 9.3.3.

Table 9.3.7 Computational Conditions of Water Balance Analysis

Item	Computation Condition
Target Area	Entire Musi River basin
Computation Unit	Sub river basin
Computation Time Step	10 days
Computation Period	-Case for Present: Sep. 1 1985 - Aug. 31 2000 (15 years) -Case for Future: Sep. 1 2050 - Aug. 31 2065 (15 years)
Modeled River Facility	Ranau Regulating Facility and Musi Hydroelectric Power Plant
Priority in Water intake	(1) Environmental flow (River maintenance flow) (2) Water demand for city and industry (3) Water demand for irrigation
Return Flow Back to River by Drainage	-Assume 80% from water use in city and industry -Assume 30% from irrigation in agricultural field

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.3.3 Basic Concept of Water Balance Modeling

(2) Selection of 3 Representative GCMs (Scenarios)

1) Purpose of Selection of 3 Representative GCMs

GCMs (General Circulation Models) has uncertainty and variety in principal. At first, 9 GCMs were selected to explain the climatic characteristics of the Musi River basin relatively well by screening more than 30 GCMs by the JICA Project Team 1. Subsequently, the JICA Project Team 2 selects 3 GCMs as high risk scenario, medium risk scenario and low risk scenario considering both GCM's characteristics and work load.

Table 9.3.8 First Selection of 9 GCMs

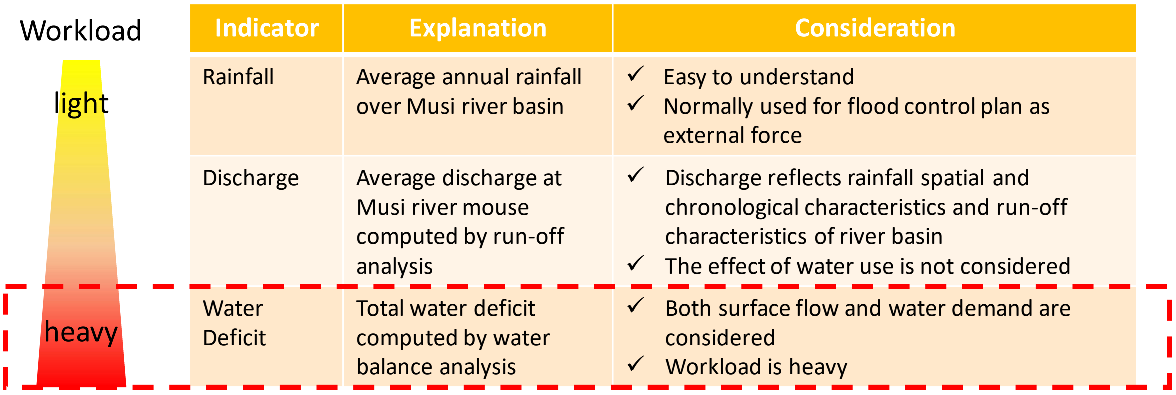
No.	GCM
1	CCCMA_CGCM
2	CSIRO_MK35
3	GFDL_2_0
4	GFDL_2_1
5	GISS_AOM
6	INGV_ECHAM4
7	MIUB_ECHO
8	MIUB_MPI_ECHAM5
9	MIUB_MRI_CGCM232A

Source: JICA Project Team 1

The purpose in selecting 3 GCMs is to grasp the uncertainty of GCMs and to study future water resource management considering future drought risk quantitatively.

Table 9.3.9 shows indices for selecting 3 GCMs. Rainfall and discharge can express drought risk from water supply point of view, while water deficit can express drought risk from both water supply and water demand point of view. As a result, “Water Deficit” was selected as indicator for selecting 3 GCMs.

Table 9.3.9 Indices for Selecting 3 GCMs



Indicator	Explanation	Consideration
Rainfall	Average annual rainfall over Musi river basin	✓ Easy to understand ✓ Normally used for flood control plan as external force
Discharge	Average discharge at Musi river mouse computed by run-off analysis	✓ Discharge reflects rainfall spatial and chronological characteristics and run-off characteristics of river basin ✓ The effect of water use is not considered
Water Deficit	Total water deficit computed by water balance analysis	✓ Both surface flow and water demand are considered ✓ Workload is heavy

Source: JICA Project Team 2

Therefore, water deficit was computed for a total of 28 cases as shown in Table 9.3.10.

Table 9.3.10 Study Cases for Water Balance Analysis

Case	Climate	Land Use	Number of Cases
Case 1	Historical (Observed)	Present	1 Cases
Case 2	9 GCMs (Present)	Present	9 Cases
Case 3	9 GCMs (Future)	Present	9 Cases
Case 4	9 GCMs (Future)	Future	9 Cases

Source: JICA Project Team 2

2) Water Balance Analysis

By using the runoff discharge data provided by the JICA Project Team 1 and the water demand projection data as described in the above, the water balance analysis was made for the 28 cases in Table 9.3.10. The Results are summarized below .

Table 9.3.11 Result of Water Balance Analysis

(Unit: MCM / Year)

Case		Water Balance (10 days Base)											
		Qin	Qenv	Demand		Intake		Deficit				Qret	Qout
				City	Irrigation	City	Irrigation	Qenv	City	Irrigation	total		
Case 1	Observed Rainfall	87,453	31,758	345	4,037	302	3,264	4,669	43	773	816	1,144	85,030
Case 2	GCM1 CCCMA_CGCM	79,910	31,758	345	3,685	265	2,219	7,114	80	1,466	1,546	679	78,105
	GCM2 CSIRO_MK35	81,724	31,758	345	3,900	286	2,575	6,320	59	1,325	1,384	768	79,631
	GCM3 GFDL_2_0	78,241	31,758	345	4,054	303	3,253	4,078	42	801	843	1,207	75,892
	GCM4 GFDL_2_1	80,555	31,758	345	3,724	286	2,709	6,369	59	1,015	1,074	988	78,548
	GCM5 GISS_AOM	77,423	31,758	345	3,879	253	2,400	8,640	92	1,479	1,571	925	75,695
	GCM6 INGV_ECHAM4	77,611	31,758	345	3,833	317	3,249	2,301	27	584	611	1,266	75,310
	GCM7 MIUB_ECHO	78,036	31,758	345	4,121	315	3,260	1,978	30	860	891	1,152	75,613
	GCM8 MIUB_MPI_ECHAM5	83,719	31,758	345	3,633	306	2,679	3,051	38	954	992	917	81,650
	GCM9 MIUB_MRI_CGCM232A	80,408	31,758	345	3,716	305	2,910	3,278	40	806	846	1,068	78,260
Case 3	GCM1 CCCMA_CGCM	85,804	31,758	689	3,753	572	2,372	4,452	117	1,381	1,499	858	83,718
	GCM2 CSIRO_MK35	60,706	31,758	689	4,625	475	2,396	11,021	214	2,229	2,443	1,023	58,858
	GCM3 GFDL_2_0	85,987	31,758	689	3,838	610	3,050	3,063	79	788	867	1,320	83,647
	GCM4 GFDL_2_1	75,017	31,758	689	4,288	546	3,183	6,689	143	1,105	1,247	1,356	72,644
	GCM5 GISS_AOM	86,423	31,758	689	3,815	511	2,399	7,992	178	1,416	1,594	1,126	84,639
	GCM6 INGV_ECHAM4	77,474	31,758	689	3,954	603	3,104	3,383	86	850	936	1,376	75,143
	GCM7 MIUB_ECHO	81,687	31,758	689	4,369	617	3,342	2,333	72	1,027	1,099	1,399	79,128
	GCM8 MIUB_MPI_ECHAM5	89,621	31,758	689	3,653	601	2,536	3,606	88	1,117	1,206	1,066	87,551
	GCM9 MIUB_MRI_CGCM232A	75,213	31,758	689	4,367	552	2,870	5,948	137	1,497	1,635	1,301	73,093
Case 4	GCM1 CCCMA_CGCM	86,938	31,758	689	4,196	556	2,633	5,682	133	1,563	1,696	953	84,702
	GCM2 CSIRO_MK35	62,053	31,758	689	5,174	476	2,706	12,427	214	2,468	2,682	1,180	60,051
	GCM3 GFDL_2_0	87,071	31,758	689	4,300	595	3,398	4,179	94	902	996	1,521	84,599
	GCM4 GFDL_2_1	75,886	31,758	689	4,748	536	3,486	8,703	153	1,263	1,415	1,514	73,378
	GCM5 GISS_AOM	87,045	31,758	689	4,329	495	2,838	10,899	195	1,491	1,686	1,313	85,025
	GCM6 INGV_ECHAM4	78,545	31,758	689	4,385	593	3,417	4,195	96	968	1,064	1,541	76,076
	GCM7 MIUB_ECHO	82,629	31,758	689	4,808	603	3,613	3,311	86	1,195	1,281	1,553	79,966
	GCM8 MIUB_MPI_ECHAM5	90,660	31,758	689	4,150	593	2,899	4,714	96	1,251	1,347	1,282	88,450
	GCM9 MIUB_MRI_CGCM232A	76,052	31,758	689	4,830	536	3,240	7,766	153	1,590	1,743	1,472	73,747

Source: JICAProject Team 2

3) Selection of 3 Representative GCMs

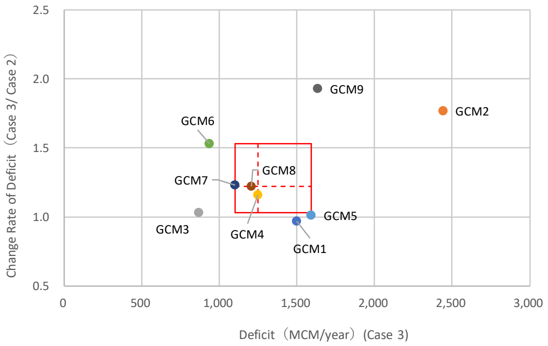
The deficits data obtained from the water balance analysis are rearranged as presented in Table 9.3.12, Figure 9.3.4 and Figure 9.3.5 by especially focusing on the increase rates of deficits from Case 2 to Case 3 and Case 2 to Case 4. Namely the 3 representative GCMs corresponding to High, Medium or Low Scenarios are selected as shown in Table 9.3.13.

Table 9.3.12 Selecting 3 Representative GCMs by Deficit

(Unit: MCM / Year)

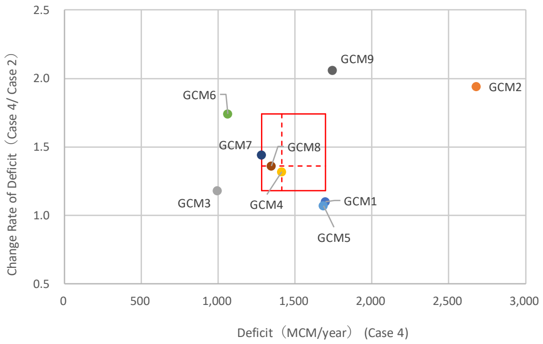
GCM		Case 2		Case 3		Case 4		Case 3/Case 2		Case 4/Case 2	
		Deficit	RANK	Deficit	RANK	Deficit	RANK	Deficit	RANK	Deficit	RANK
GCM1	CCCMA_CGCM	1546.2	2	1498.6	4	1696.4	3	0.97	9	1.10	8
GCM2	CSIRO_MK35	1384.0	3	2442.9	1	2681.5	1	1.77	2	1.94	2
GCM3	GFDL_2_0	842.9	8	866.7	9	996.0	9	1.03	7	1.18	7
GCM4	GFDL_2_1	1074.1	4	1247.2	5	1415.3	5	1.16	6	1.32	6
GCM5	GISS_AOM	1570.9	1	1593.7	3	1685.6	4	1.01	8	1.07	9
GCM6	INGV_ECHAM4	611.2	9	935.7	8	1063.9	8	1.53	3	1.74	3
GCM7	MIUB_ECHO	890.6	6	1099.0	7	1281.1	7	1.23	4	1.44	4
GCM8	MIUB_MPI_ECHAM5	992.1	5	1205.7	6	1347.0	6	1.22	5	1.36	5
GCM9	MIUB_MRI_CGCM232A	845.7	7	1634.7	2	1743.3	2	1.93	1	2.06	1
Max		1570.9	-	2442.9	-	2681.5	-	1.93	-	2.06	-
75%		1384.0	-	1593.7	-	1696.4	-	1.53	-	1.74	-
50%		992.1	-	1247.2	-	1415.3	-	1.22	-	1.36	-
25%		845.7	-	1099.0	-	1281.1	-	1.03	-	1.18	-
Min		611.2	-	866.7	-	996.0	-	0.97	-	1.07	-

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.3.4 Scatter Plot of Comparing Cases 2 & 3



Source: JICA Project Team 2

Figure 9.3.5 Scatter Plot of Comparing Cases 2 & 4

Table 9.3.13 Result of Selecting Representative 3 GCMs

Scenario	Selected GCM	Selection Reason
High	(GCM6) INGV_ECHAM4	Change rate of deficit (Case 3/ Case 2) equals the third quartile.
Medium	(GCM8) MIUB_MPI_ECHAM5	Change rate of deficit (Case 3/ Case 2) equals the second quartile.
Low	(GCM3) GFDL_2_0	Change rate of deficit (Case 3/ Case 2) equals the first quartile.

Source: JICA Project Team 2

4) Deficit Volume

The total deficit of the present case is assumed to be the one of Case 1. The total deficit of each scenario is estimated by multiplying the present deficit volume by the corresponding increase rate of Cases 3 or 4 from Case 2 as shown in Table 9.3.14. In conclusion, the deficit volume is projected to increase by 18% to 74%, from 816 to 963 to 1,420 MCM/year in future as impacts of climate and landuse changes.

Table 9.3.14 Total Deficits of Selected Representative 3 GCMs

Scenario	Present Total Deficit (MCM/year)	Future Climate + Present Land Use		Future Climate + Future Land Use	
		Increase rate from Case 2 to Case 3	Total deficit (MCM/year)	Increase rate from Case 2 to Case 4	Total deficit (MCM/year)
High	816 (168)	1.53	1,248 (298)	1.74	1,420 (433)
Medium		1.22	996 (207)	1.36	1,110 (275)
Low		1.03	840 (194)	1.18	963 (260)

Note: Values in the parentheses means total deficit volumes that are estimated without consideration of river maintenance flow.
Source: JICA Project Team 2

(3) Preliminary Water Balance Analysis for Tidal Swamp Areas

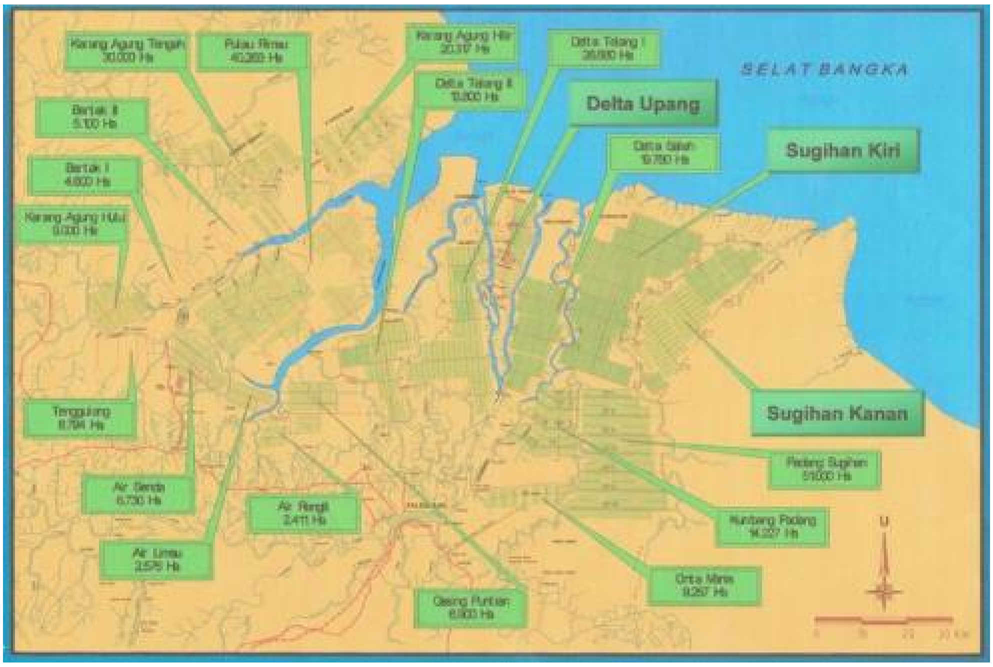
1) Development of Tidal Irrigation Area

There are extensive tidal swamp irrigation areas in the low-lying areas of the Musi, Banyuasin and Sugihan River basins as shown in Figure 9.3.6. The Indonesian Government is making efforts to expand the tidal swamp irrigation in line with a policy to support South Province as foodshed. Especially the tidal swamp irrigation area of the Sugihan River basin is projected to increase in double.

Table 9.3.15 Projection of Tidal Swamp Irrigation Area

Present/Future	Lower Musi	Banyuasin	Sugihan	Total
Present	51,722	142,667	15,688	210,077
Future (2050)	53,705	154,230	31,978	239,913

Source: BBWS-S8



Source: BBWS-S8

Figure 9.3.6 Tidal Swamp Irrigation Areas

2) On-farm Level Water Consumption in Tidal Swamp Irrigation Aeas

The irrigation method of the tidal swamp areas is very much dependent on the tidal fluctuation. Generally during the high tide river water is drawn to and stored in the tertiary canals, from where the stored water is further pumped up to the paddy fields. During the low tide, the water in the paddy field is drained to the canals and then to the river. Because of the totally different irrigation method from the other areas, the tidal swamp irrigation areas were excluded from the water balance analysis for the Musi River basin described in the previous section.

Alternatively, a preliminary water balance analysis is conducted for the lowest areas of the Musi River basin, the Banyuasin River basin and the Sugihan River basin through following assumptions that are made for estimating on-farm level freshwater consumption volume:

- Single cropping of rice with 90-day growing variety for the wet season is the basic condition, which is commonly practiced by immigrant farmers;
- Land preparation work is to be commenced after accumulated precipitation at the beginning of the wet season is over 20 mm and then contimued until on-farm water depth becomes 250 mm;
- After transplanting rice seedlings, pumping-up of water from drainage canal is done by farmers themselves upon their own decision and expense aiming to

maintain water depth at the level of 250 mm to protect sea water rising from deep soil layer;

- Accordingly, rice cultivation period changes year by year reflecting rainfall condition in the initial stage of wet season; and
- Main gates of drainage system is controlled by BBWS-S8, while on-farm level drainage facilities are managed by farmers.

Based on the above assumptions, the on-farm level water balance under rainfed rice growing condition has been assessed for the respective drainage scheme groups along the Banyuasin, Musi and Sugihan Rivers under the selected three GCM climate condition. An example of calculation results of on-farm level supplemental water requirement by pumping up from drainage canals in tidal swamp drainage scheme areas is as shown in Table 9.3.16.

Table 9.3.16 Example of On-farm Level Supplement Water Requirement in Tidal Swamp Area

Year	Present Climate Model (m^3/s)			Year	Future Climate Model (m^3/s)					
	Existing Scheme Area				Existing Scheme Area			Future Scheme Area		
	GCM-3	GCM-6	GCM-8		GCM-3	GCM-6	GCM-8	GCM-3	GCM-6	GCM-8
1985/86	264.5	447.0	61.0	2050/51	437.6	138.7	127.9	473.0	149.9	138.2
1986/87	620.7	174.1	448.5	2051/52	245.9	174.4	39.1	265.9	188.5	42.2
1977/88	620.7	118.7	96.5	2052/53	78.5	138.8	31.6	84.8	160.9	34.2
1988/89	254.8	30.3	99.8	2053/54	252.0	179.7	32.3	272.4	194.3	34.9
1989/90	173.1	287.4	72.5	2054/55	395.7	289.2	210.6	427.7	312.6	227.7
1990/91	196.7	177.8	395.3	2055/56	78.5	145.0	113.9	84.8	156.8	123.1
1991/92	310.5	186.9	203.2	2056/57	190.0	131.1	0	205.4	141.7	0
1992/93	334.4	105.2	276.6	2057/58	198.3	101.9	134.3	214.3	110.1	145.2
1993/94	245.4	220.2	174.1	2058/59	124.9	281.7	166.3	135.0	304.5	179.8
1994/95	300.1	246.5	239.7	2059/60	101.5	165.2	53.8	109.7	178.6	58.1
1995/96	187.8	192.0	83.0	2060/61	279.3	389.0	279.0	301.9	420.5	301.7
1996/97	671.3	311.6	291.0	2061/62	148.1	245.4	372.7	160.1	265.3	402.9
1997/98	205.5	332.4	128.4	2062/63	535.9	389.0	122.4	579.3	420.5	132.3
1998/99	203.8	292.2	255.8	2063/64	619.6	254.8	229.4	669.9	275.4	248.0
1999/00	302.2	170.9	209.9	2064/65	160.9	152.3	361.0	173.9	164.6	390.3

Source: JICA Project Team 2

3) Water Balance Analysis

Table 9.3.17 compares the river runoff discharges and the water demands under the climate and landuse changes. Regarding the Lower Musi River basin below Palembang, the river discharge is overwhelming the water demand for all the scenarios. Therefore, it could be said that the probability of water shortage is negligible small for the Lower Musi River basin.

As for the Banyuasin and Sugihan River basins, there are cases, depending upon the climate change scenario, that the maximum irrigation demand is greater than the minimum river runoff discharge. As seen in Figure 9.3.7, however, the maximum water demand occurs only during flood seasons, and no water shortage takes place in the 15 years of the analysis period. Therefore, it is deemed that the probability of water shortage is negligible small also for the Banyuasin and Sugihan River basins.

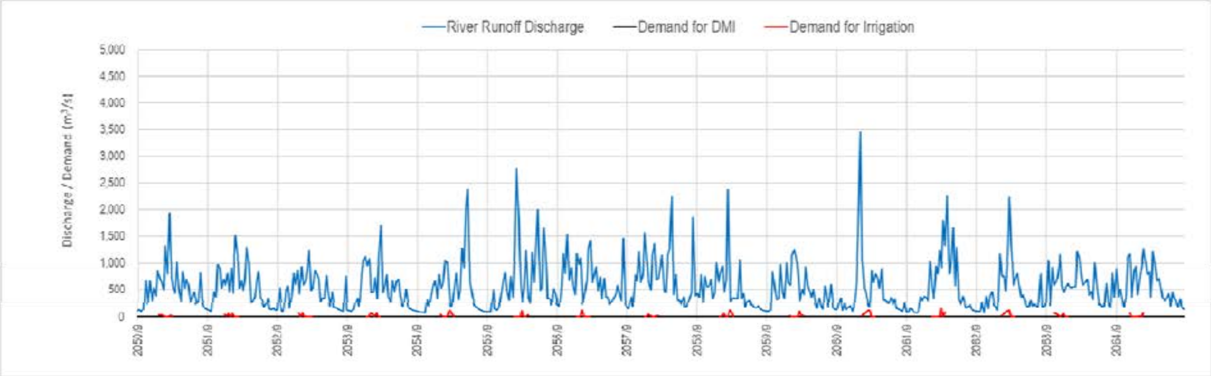
Table 9.3.17 Comparison between Runoff Discharge and Water Demands

Unit: m^3/s

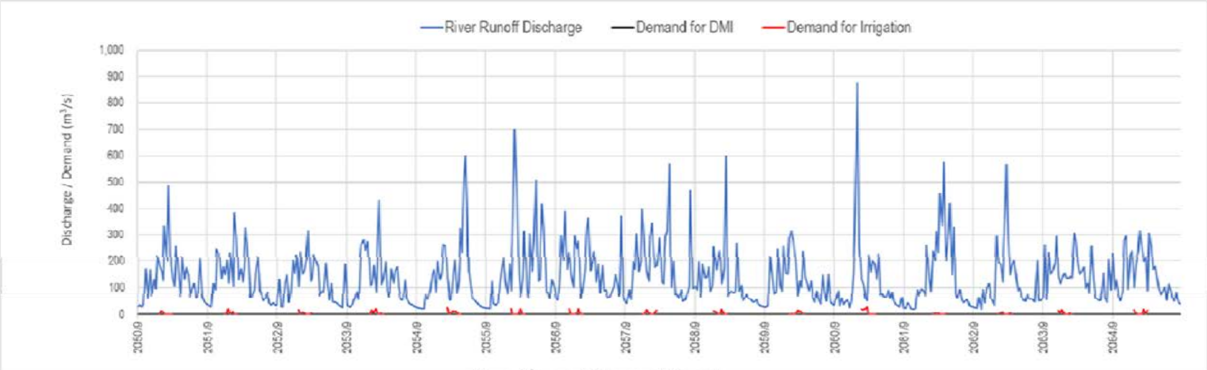
Scenario	Item	Lower Musi	Banyuasin	Sugihan
High (INGV_ECHAMA4)	Min. River Runoff Discharge in 15 years (2050-2065)	514.4	79.4	20.1
	Max. Water Demand for Irrigation in 15 years (2050-2065)	121.2	173.3	27.4
	Max. Water Demand for Domestic, Municipal and Industrial purposes in 15 years (2050-2065)	0.1	2.1	0.5
Medium (MIUB_MOI_ECHAM5)	Min. River Runoff Discharge in 15 years (2050-2065)	729.3	119.0	30.1
	Max. Water Demand for Irrigation in 15 years (2050-2065)	109,3	132.1	28.5
	Max. Water Demand for Domestic, Municipal and Industrial purposes in 15 years (2050-2065)	0.1	2.1	0.5
Low (GFDL_2_0)	Min. River Runoff Discharge in 15 years (2050-2065)	450.3	77.1	19.5
	Max. Water Demand for Irrigation in 15 years (2050-2065)	74.3	116.0	34.4
	Max. Water Demand for Domestic, Municipal and Industrial purposes in 15 years (2050-2065)	0.1	2.1	0.5

Note: Outputs of the runoff analysis of the JICA Project Team 1 for the case of future climate and future land use are used as the river runoff discharges.

Source: JICA Project Team 2



Banyuasin River Basin



Sugihan River Basin

Source: JICA Project Team 2

Figure 9.3.7 Runoff Discharge and Demand Hydrograph (High Scenario)

9.4 Flood

Flood inundation analysis was conducted to assess impacts of climate change on flood hazard. Details of the analysis are described in Supprting Report B, and the outlines of the analysis are discussed as below:

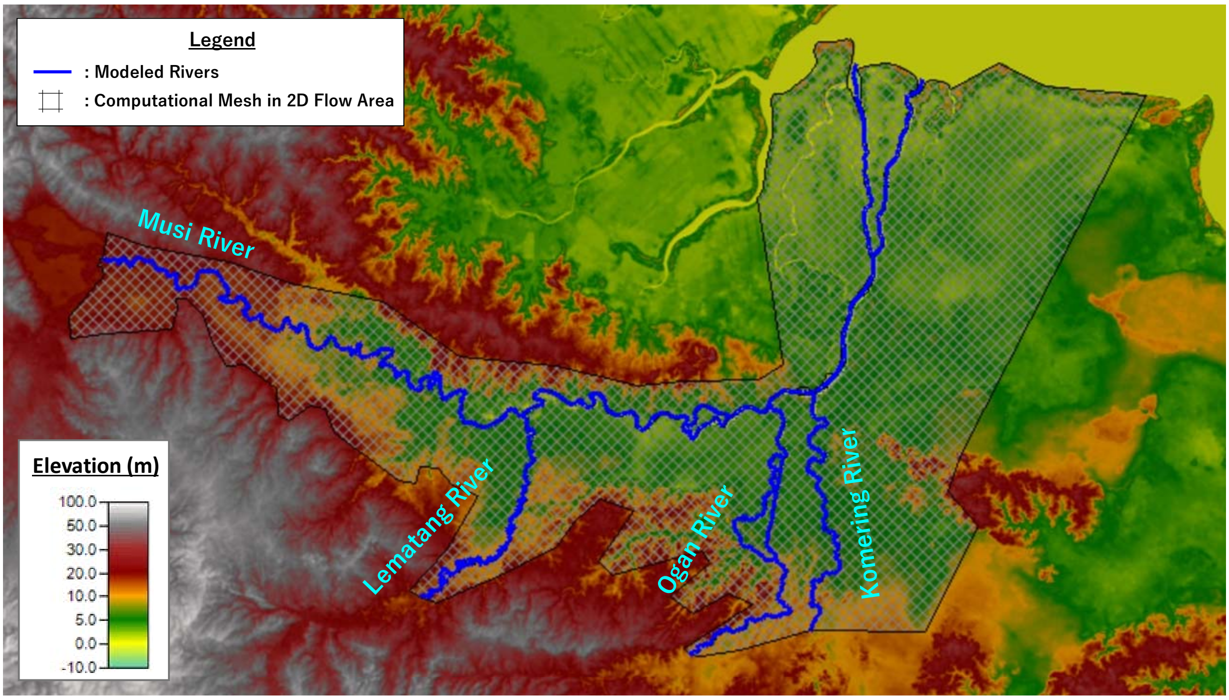
9.4.1 Set up of Flood Inundation Model

By using HEC-RAS software which is freely available and enables two-dimensional flood inundation analysis, a flood simulation model for the Musi River basin was developed by the JICA Project Team 2. Basic Conditions of the simulation model are summarized as follows:

Table 9.4.1 Basic Conditions of Flood Inundation Model

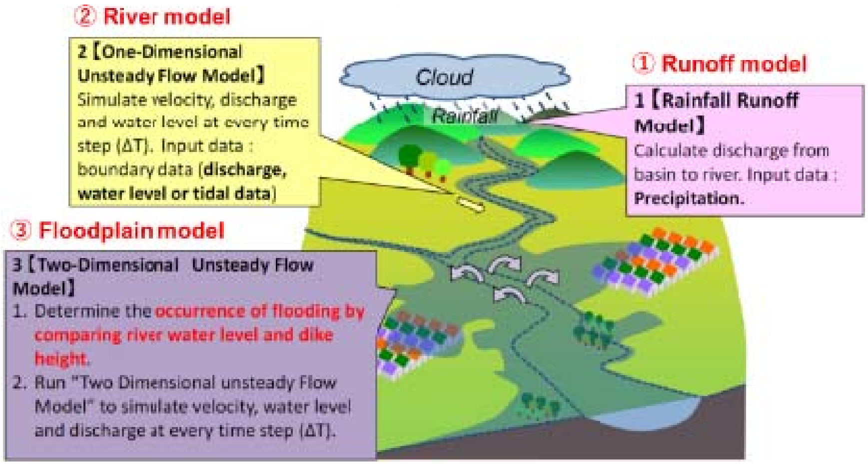
Item	Contents	Remarks
Software	HECRAS	
Target inundation analysis area (2D flow Area)	Total Area:12,000 km^2 DEM: MERIT DEM Mesh size: 1km	Refer to Figure 9.4.1.
Computation	Timestep: 2 minutes Equation: the full Saint-Venant Equations	Refer to Figure 9.4.2.
Boundary condition	Upstream and lateral inflow: Discharge provided by JICA Project Team 1 Downstream: Tanjun Buyut Tide data	
Target calibration flood	2005 Flood	

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.4.1 Target Area of Flood Inundation Analysis



2【One-Dimensional Unsteady Flow Model】
Simulate velocity, discharge and water level at every time step (ΔT). Input data : boundary data (**discharge, water level or tidal data**)

1【Rainfall Runoff Model】
Calculate discharge from basin to river. Input data : **Precipitation.**

3【Two-Dimensional Unsteady Flow Model】
1. Determine the occurrence of flooding by comparing river water level and dike height.
2. Run "Two Dimensional unsteady Flow Model" to simulate velocity, water level and discharge at every time step (ΔT).

Source: JICA Project Team 2

Figure 9.4.2 Conceptual Illustration of Flood Inundation Model

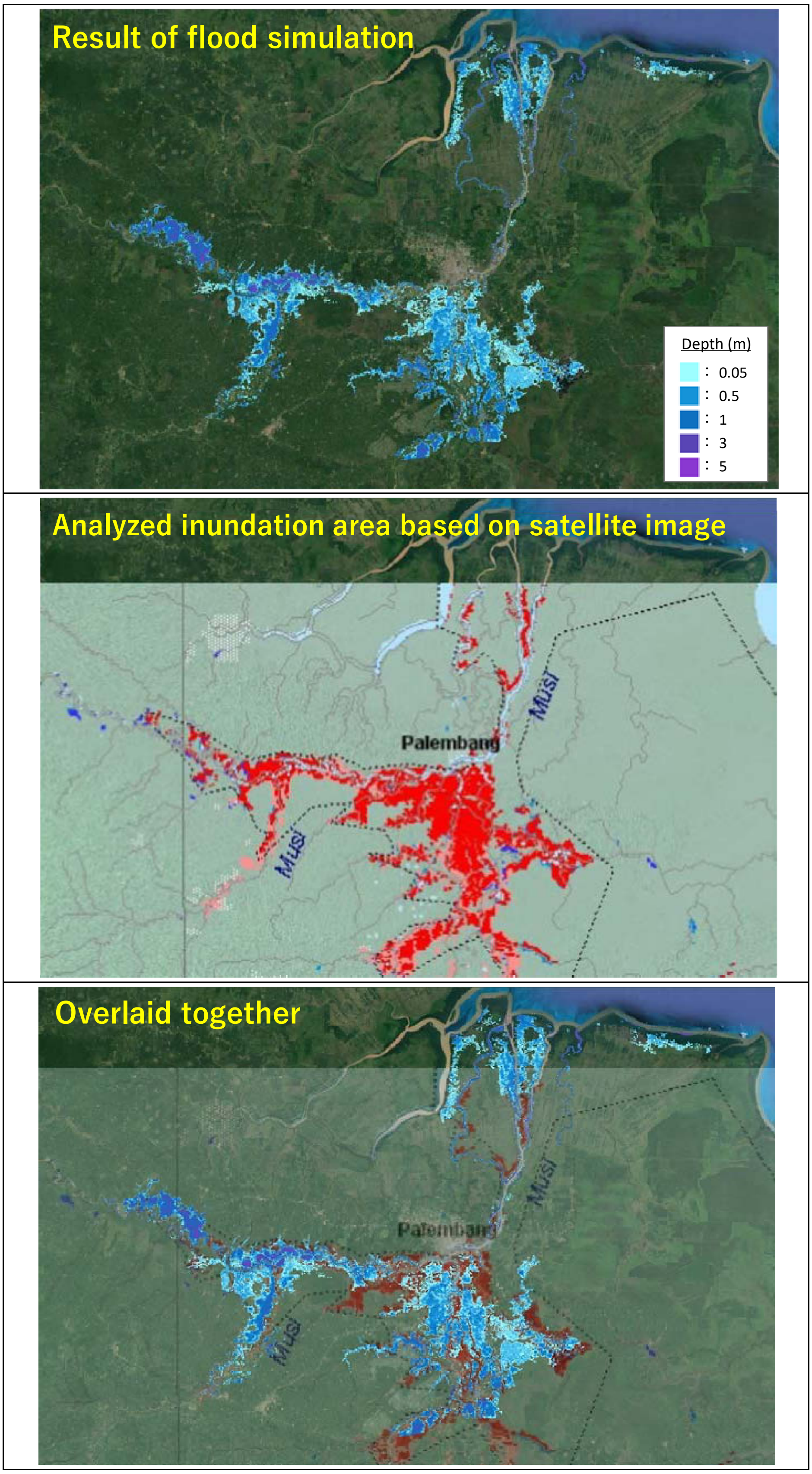
9.4.2 Model Calibration

Calibration of the flood simulation model was conducted for the 2005 Flood of which flood map (satellite image map) published by Dortmouth College, USA is the only one available flood record map for the Musi River basin. The simulation results are presented in Figure 9.4.3 and Figure 9.4.4.

Figure 9.4.3 compares simulated flood inundation areas with the satellite map by Dortmouth College. The simulated inundation area is larger than that of the satellite image inundation area in the downstream lowland delta but they match well in the most part of the inundation area. Figure 9.4.4 compares the simulated and observed water levels at Boon Baru Tide Station in Palembang. Calculated water level is higher about 30 cm at peak than the observed value, but this gap can be considered as small enough taking into acount the available data limitation such as rough interval of river cross section (the details are reported in the Supporting Report B).

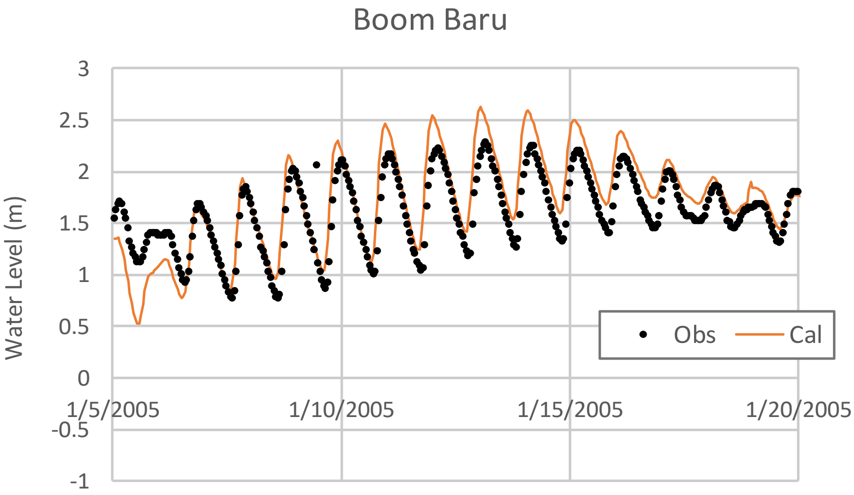
The JICA Project Team 2 considers that the developed simulation model is acceptable, and that further improvement is very difficult due to the scarcity of data/information, especially precise DEM as well as the limited accuracy of the input discharge data. The limitation of the flood inundation simulation is summarized as follows:

- The reliability of the model depends mostly on the accuracy of geometry data such as river cross section, and digital elevation map. In addition, input boundary condition such as discharge hydrograph and stage (water level) hydrograph also govern the result. If these basic geometry data and boundary data don't have enough accuracy in the context of the purpose, the model cannot give a good result.
- Model calibration is important to improve the reliability of the model. Model calibration requires discharge, water level, inundation area data and so on.
- The smaller the computation mesh size is, the better result will be generally achived. However, the smaller computation mesh size is, the longer time is taken. The balance between the accuracy and the workability is important in the context of the simulation purpose.



Source: JICA Project Team 2

Figure 9.4.3 Comparison of Inundation Area



Note: Obs: Observed values at Boom Baru Tidal Gauge Station, Cal: Calculated water level by flood simulation model

Source: JICA Project Team 2

Figure 9.4.4 Comparison of Water Level at Boom Baru Tidal Station

9.4.3 Simulation Results of Impact of Land Use and Climate Changes

The Impacts of landuse and climate changes are evaluated by using the calibrated simulation model. Since there are important low-lying tidal areas in the lower Musi River, sea level rise as well as increase of rainfall are considered as significant climate change impacts in the evaluation.

(1) Landuse Change

According to the results of the runoff analysis by the JICA Project Team 1, the future land use change discussed in Subsecton 9.2.2 hardly influence the flood runoff discharges. Therefore, the JICA Project Team 2 considers that the land use change will not significantly impact the flood inundation phenomena in the river basin scale, although the impact of land use change should be carefully examined when planning rainstorm drainage improvement for urban areas.

(2) Sea Level Rise

Sea level rise due to climate change has been already observed in a lot of places in the world. It is necessary to assume future sea rise at the Musi River mouth for the assessment of climate change impact on the flood condition of the Musi River basin.

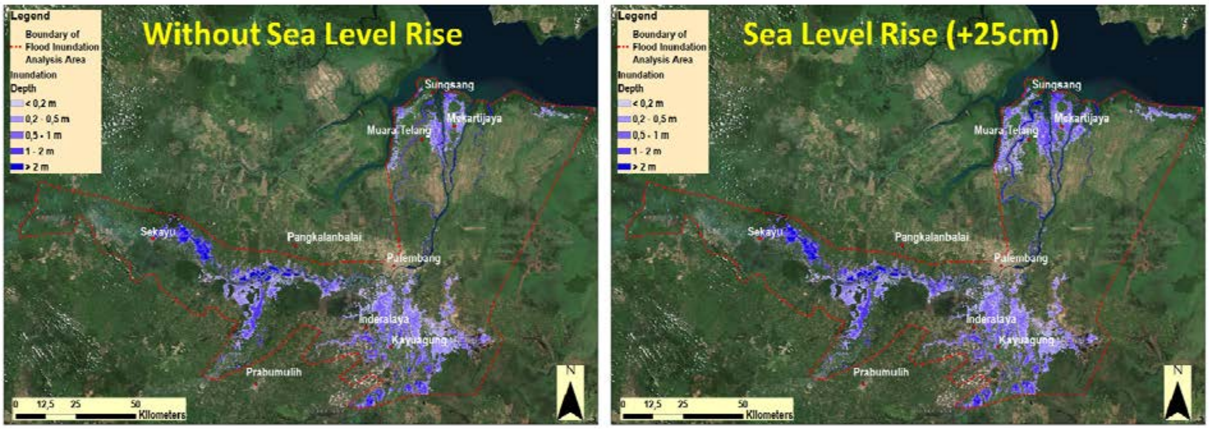
Several study reports on the sea level rise were collected and summarized in Table 9.4.2. According to the table, the rise rate ranges from 0.1 to 1.3 cm/year. In conclusion, it is proposed that the sea level rise rate of 0.5 cm/year that has been estimated in the latest study focusing South Sumatra will be employed for the flood inundation analysis.

To evaluate the impact of the sea level rise in terms of flood inundation area, flood inundation simulation was conducted for the 2005 Flood for two cases without and with sea level rise of 25cm as shown in Figure 9.4.5. It is understood from this figure that the inundation area expands in the lowest stretches of the Musi River near the river mouths.

Table 9.4.2 Sea Level Rise by Previous Study Reports

No.	Existing Report	Target Area	Target Year	Sea Level Rise (cm)	Rise Rate (cm/Year)	Evidence	Adoption
1	**”Climate Change Risk and Adaptation Assessment, South Sumatera" sector report ”Sea Level Rise and Extreme Event Projections” by MOE（GIZ & Aus AID)** **Climate Change Risk and Adaptation Assessment, South Sumatera, Sea Level Rise and Extreme Event Projections FINAL DRAFT** **p73. June 2012 Ministry of Environment（GIZ & Aus AID)**	**South Sumatra**	**2000–2050**	**25.2cm** **±11.7cm**	**0.5cm/year**	**Focusing on the SRCC (Special Report on Emission Scenario) A1B scenario by IPCC, analyzed using HYCOM (HYbrid Coordinate Ocean Model) and FVCOM (Finite Volume Coastal and Ocean Model)**	✔
2	World Bank Water Management Report (2012) Water Management for Climate Change Mitigation and Adaptive Development in Lowlands – WACLIMAD. Government of Indonesia (World Bank). P16.February 2012	All Indonesia	Present (2012?-2050)	50cm	1.3cm/year	Configuration based on estimates of sea level rise in the 21st century of the IPCC AR4 (18-59 cm / all scenarios) and estimates of sea level rise by analyzing Sofian, 2010 papers (35-40 cm in 2050, 75 cm in 2100)	
3	IPCC AR4 Report(2007) Climate change 2007: Summary for policy makers Ministry of the Environment	All World	1990-2090	21cm-48cm (2090-2099 year /A1B scenario)	0.4cm/ year	Analysis result by Atmosphere-Ocean General Circulation Model (AOGCM)	
4	Paper on Sea Level Rise (1994) TETSUO YANAGI and TATSUYA AKAKI. 1994. Sea Level Variation in the Eastern Asia, Journal of Oceanography Vol. 50, pp. 643 to 651.	East Asia	1985-2030	13cm	0.29cm/ year	Estimated from tide level data at 16 stations from 1951 to 1991	
5	Report on climate change by WWF (2007) Michael Case, Fitrian Ardiansyah, Emily Spector. 2007. Climate Change in Indonesia Implications for Humans and Nature. WWF report.	All Indonesia	21st Century	13cm (0.3cm/ year×43year)	0.1-0.3cm/ year	Cruz, et al., 2007 paper cited	

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.4.5 Simulated Inundation Areas without and with Sea Level (2005 Flood)

(3) Rainfall Increase

1) Selection of 3 Representative GCMs

Like the water balance analysis, three representative GCMs that correspond to High, Medium and Low Scenarios were selected by taking into consideration the increase rate of 5-month rainfall in the rainy season (October to March). They are GISS_AOM(High), CCCMA_CGCM(Medium) and GFDL_2.1(Low).

2) Preparation of Model Hyetographs and Runoff Analysis

Model hyetographs for different return periods and different scenarios are prepared by using and enlarging the 1993/1994 rainfall that recorded the maximum 5-month rainfall in the past. The enlargement ratios are summarized as presented in Table 9.4.3, and the basin mean 5-month rainfall for several return periods were estimated as presented in Table 9.4.4. Differences of the enlargement rates among the scenarios are 14% at the maximum.

The JICA Project Team 1 conducted runoff analysis by applying these enlarged rainfall data to provide corresponding runoff discharge data to the JICA Project Team 2.

Table 9.4.3 Enlargement Ratio of 5-month Rainfall (1993/1994 Rainfall Type)

Return Period	Without Climate Change (Historical)	With Climate Change		
		High (GISS_AOM)	Medium (CCCMA_CGCM)	Low (GFDL_2.1)
2	0.71	0.79	0.73	0.68
5	0.82	0.91	0.84	0.78
10	0.88	0.97	0.89	0.84
25	0.94	1.03	0.95	0.89
50	0.98	1.06	0.98	0.93
100	1.01	1.10	1.01.	0.96

Source: JICA Project Team 1

Table 9.4.4 Basin Mean 5-month Rainfall by Return Period and Climate Scenario

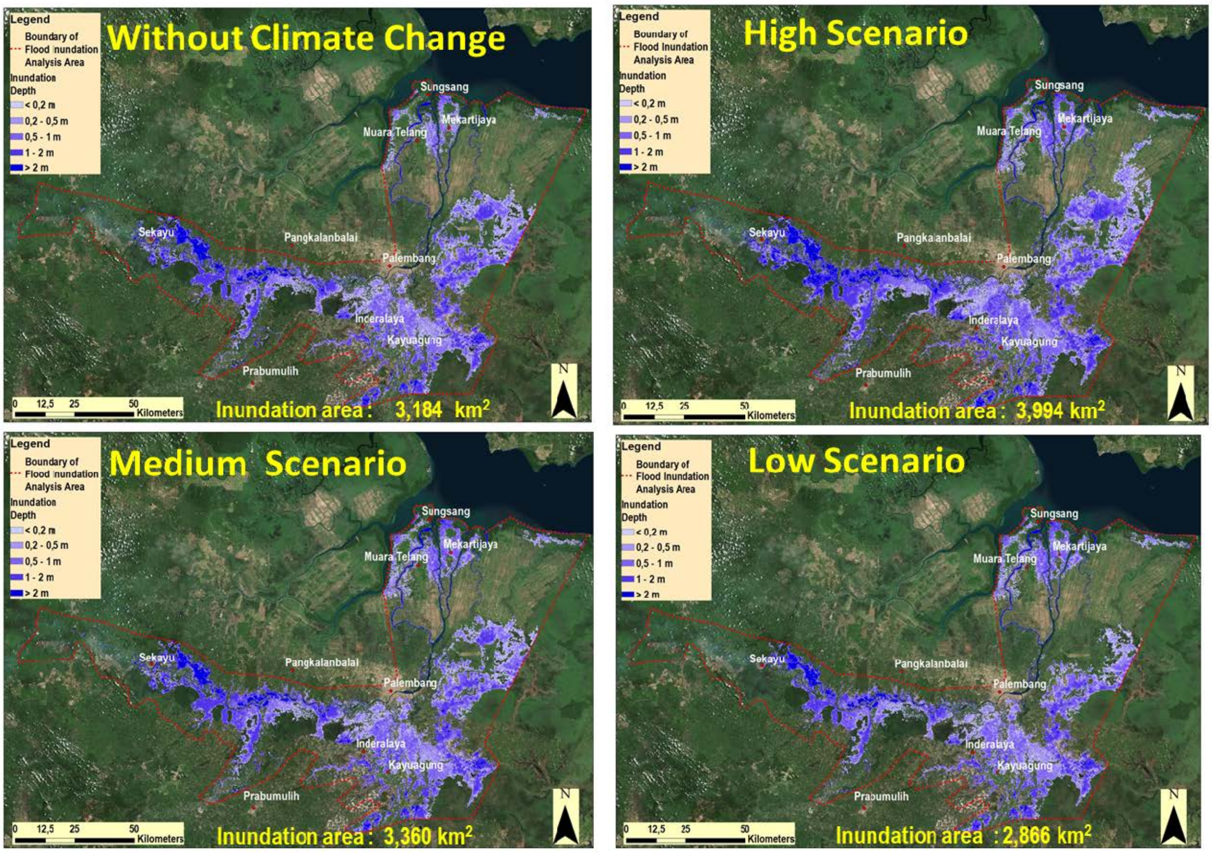
Unit: mm

Return Period	2yr	5-yr	10-yr	25-yr	50-yr	100-yr
Present Condition	1,349	1,558	1,672	1,786	1,862	1,919
High Scenario in 2050	1,501	1,729	1,843	1,957	2,014	2,090
Medium Scenario in 2050	1,387	1,596	1,691	1,805	1,862	1,919
Low Scenario in 2050	1,292	1,482	1,596	1,691	1,767	1,824

Source: JICA Project Team 2

3) Flood Inundation Analysis

Using the runoff discharge data provided by the JICA Project Team 1, the flood inundation analysis was conducted for several cases of the different return periods and scenarios. Figure 9.4.6 shows simulated flood inundation areas of the 100-year return period.



Source: JICA Project Team 2

Figure 9.4.6 Simulated Inundation Areas (100-year Return Period)

9.4.4 Increase of Heavy Rainfall

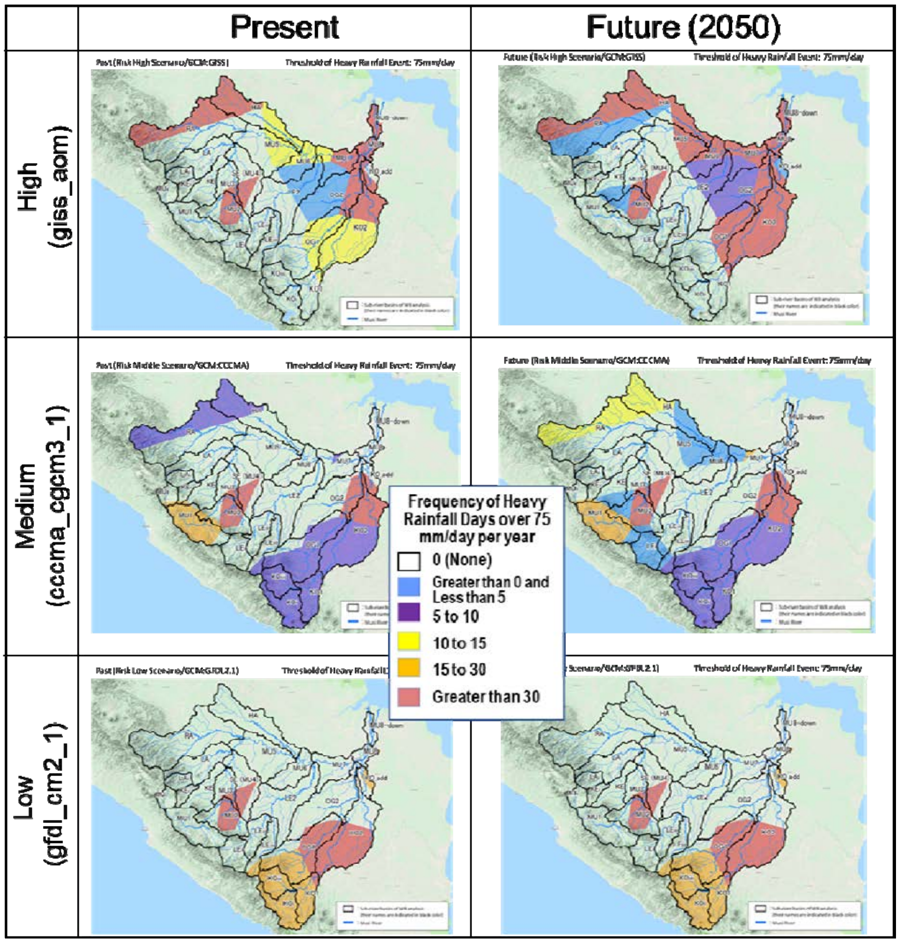
It is also concerned that climate change might worsen inland flood in the urban areas. In order to grasp how much heavy rainfall events will increase as an impact of climate change, a frequency analysis was conducted by using bias-corrected daily rainfall data of 500m x 500m mesh areas provided by the JICA Project Team 1.Table 9.4.5 presents the total numbers of days of heavy daily rainfall over the Musi River basin for different threshold rainfall intensities and the three climate scenarios. This table also provides the increase rates from the present to the future. Figure 9.4.7 shows the case of the threshold of 75mm/day, namely the numbers of the rainfall days over 75mm/day.

From the table and the figure it is understood that the frequency of heavy rainfall will generally increase in the future, and that the increase rates for the High Scenario are especially high, ranging from 1.5 to 7.0.

Table 9.4.5 Average Number of Days of Heavy Rainfall per Year before and after Climate Change

Threshold	High (giss_aom)			Medium (cccma_cgcm3_1)			Low (gfdl_cm2_1)		
(>=mm/day)	Present	Future	Increase rate	Present	Future	Increase rate	Present	Future	Increase rate
50	37.5	57.7	1.5	39.3	38.8	1.0	14.7	13.7	0.9
75	18.8	31.1	1.7	7.1	8.6	1.2	8.5	8.8	1.0
100	10.8	17.5	1.6	3.8	4.1	1.1	1.3	2.6	2.0
125	3.7	9.0	2.4	2.5	2.7	1.1	0.0	0.9	-
150	0.8	3.5	4.4	1.5	1.1	0.7	0.0	0.2	-
175	0.1	0.7	7.0	0.3	0.3	1.0	0.0	0.1	-
200	0.0	0.0	-	0.2	0.1	0.5	0.0	0.0	-

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 9.4.7 Frequency of Daily Rainfall over 75mm/day

9.5 Assessment of Climate Change Impact in 2050

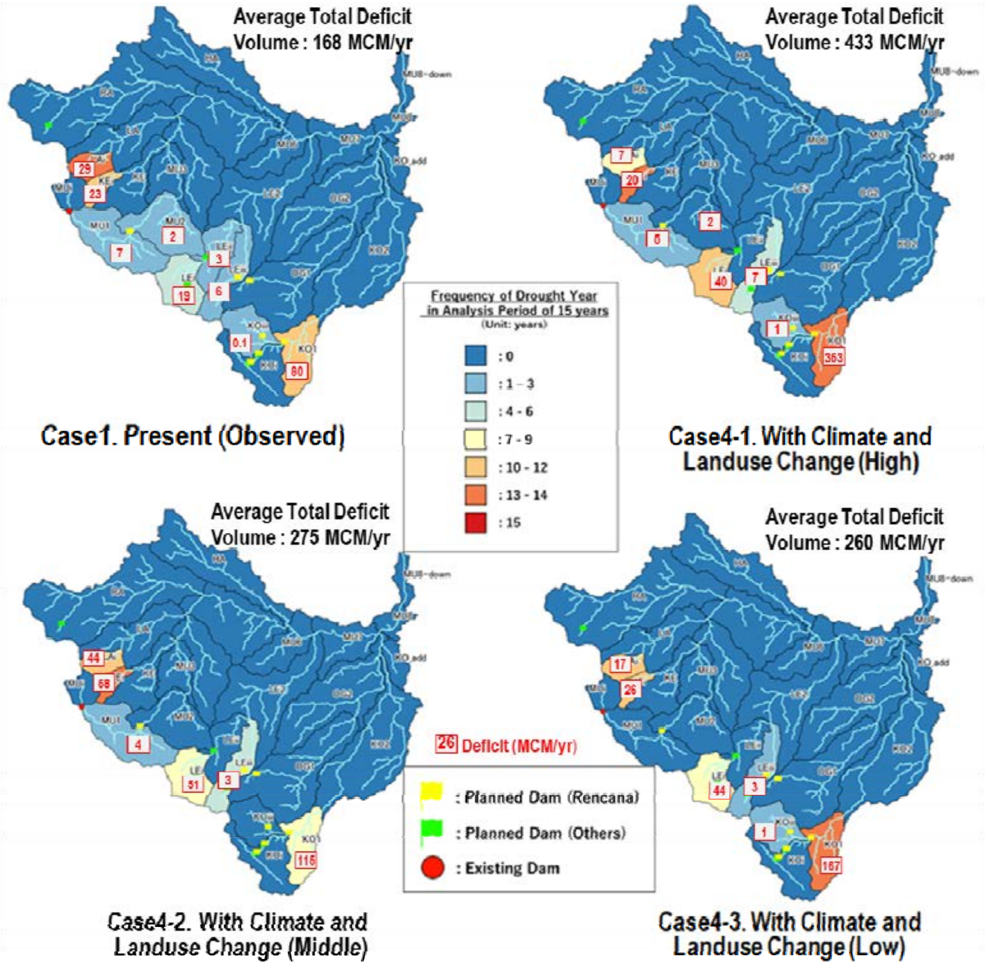
9.5.1 Drought

In order to assess the impact of climate change on water use, the frequency of drought year, as an indicator of water security level, when water deficit for irrigation and/or DMI uses occurs was estimated by using the results of the water balance analysis in Subsection 9.3.3. The frequency means the number of drought years in the balance analysis period of 15 years, and was estimated for each sub-basin. The average annual total deficit volumes are also indicated in the figures. From these figures, considerations were made as follows:

- As shown in Figure 9.5.1, in all the scenarios drought occurs only in upstream sub-basins, but there is no drought in the middle and lower river basins. These water-short sub-basins include those of the Komering, Lematang, Kelingi and Lakitan Rivers where existing and proposed large-scaled irrigation intake facilities are concentrated.
- A few dam reservoirs have been planned/proposed for the water-short sub-basins of the Komering and Lematang Rivers. However, those of the Kelingi and Lakitan Rivers have no planned/proposed dam site.

- DMI water which is prioritized more than irrigation water in terms of water security will be secured almost 100% in all the climate change scenario. However, almost all the deficit volume is for irrigation water.

In preparing Figure 9.5.1, river maintenance flow was not taken into account. In Subsection 10.3.2, however, the river maintenance flow it will be taken into account in examining the feasibility of dam reservoirs as adaptation measures.



Source: JICA Project Team 2

Figure 9.5.1 Frequency of Drought Occurrence and Volume of Deficit (Case 4)

9.5.2 Flood

There are extensive swamp areas in the midstream areas of the Musi River basin. In the downstream area there are extensive agricultural areas that used to be tidal swamp areas. These areas are vulnerable to habitual inundation.

Using the runoff discharge data provided by the JICA Project Team 1 and the assumed sea level rise of 25 cm in 2050, a flood inundation analysis was conducted for several cases of the different return periods and climate change scenarios, of which results are summarized in Figure 9.4.6 and Table 9.5.1.

It could be understood that the flood inundation area definitely increases as the return period increases. Under the present condition the estimated inundation area of 100-yr return period is about 3,200 km^2. It is anticipated to increase or decrease to 4,000 to 2,900 km^2 in the future by 2050, depending on the future climate scenario. It is also seen that flood inundation will expand especially in the lower coastal areas due to the sea level rise. According to the simulation results, some 260,000 to 300,000 houses will be situated in the flood inundation areas. However, it is noted that not all the houses will be affected by the flood inundation practically. Most of the population in the flood plains are living in pillar houses as seen in Photo 9.5.1, and are very familiar on how to live with flood, according to BBWS-S8. In addition, most of major settlement areas, which are located higher in elevation, narrowly escape from flood inundation as discussed in Subsection 10.3.1(3) 1). The houses in the inundation areas are generally scattered along roads and river banks in the flood plains.

Table 9.5.1 Results of Flood Inundation Analysis

Scenario	Return Period	Inundation Area (km^2)	Inundation Vol. (MCM)	No. of Affected Houses	Affected Paddy Field (ha)
Historical (Without Climate Change)	2 years	646	368	0	46,356
	5 years	1,249	820	174,259	47,194
	10 years	1,862	1,267	201,415	47,894
	25 years	2,434	1,761	227,614	50,476
	50 years	2,856	2,124	257,135	51,694
	100 years	3,184	2,462	271,931	53,794
High	2 years	1,313	849	189,545	58,843
	5 years	2,371	1,696	233,904	60,643
	10 years	2,981	2,229	246,857	62,743
	25 years	3,548	2,814	264,688	65,643
	50 years	3,749	3,067	285,178	68,943
	100 years	3,994	3,355	297,725	78,952
Medium	2 years	996	618	148,183	58,543
	5 years	1,695	1,172	201,386	58,843
	10 years	2,190	1,543	220,663	60,043
	25 years	2,742	2,040	259,626	61,943
	50 years	3,063	2,307	248,570	62,943
	100 years	3,360	2,593	280,549	63,843
Low	2 years	694	450	109,492	58,201
	5 years	1,258	805	182,205	58,843
	10 years	1,695	1,172	201,409	58,843
	25 years	2,235	1,582	221,812	59,643
	50 years	2,553	1,865	248,806	61,343
	100 years	2,866	2,127	260,849	61,943

Source: JICA Project Team 2

Source: JICA Project Team 2

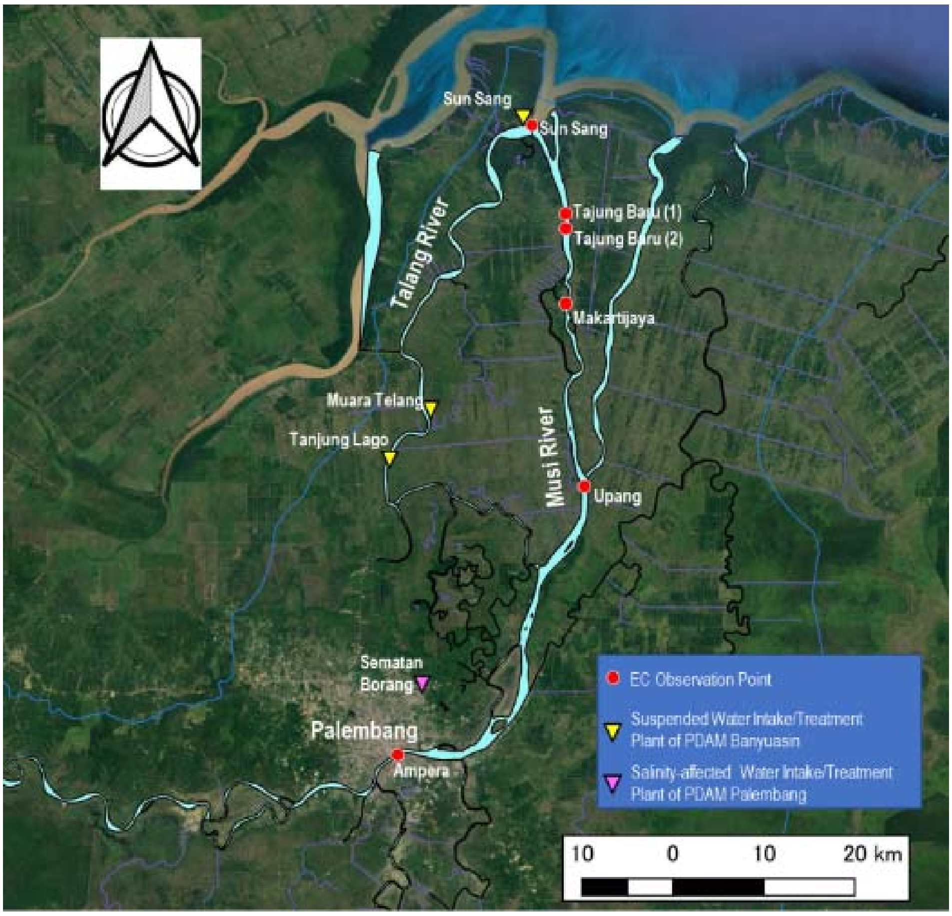
Photo 9.5.1 Pillar Houses in Flood Plains

9.6 Other Impacts

9.6.1 Sea Water Intrusion

Sea level rising is one of the most important impacts of climate change. As discussed in Section 9.4.3, 0.5cm/year of sea level rising is projected in the Musi River mouth. Some 300,000 people are living in the low-lying tidal areas where most of the people are engaged in agriculture. Sea water intrusion that will be augmented by the sea level rising is anticipated to be one of the most significant threats to the people living in the low-lying coastal areas. There are appearing tangible signs of such threat.

According to interviews to farmers and officials concerned, no significant damage to agriculture has been reported yet. According to PDAM Banyuasin, however, they installed RO (Reverse Osmosis) as a measure against high salinity system at three water intake/treatment plants that are located along the Talang River as shown in Figure 9.6.1. The operation of the three water intake/treatment plants have been suspended for two years because the budget for replacement of the RO membranes could not be secured. In addition, it has been reported that high salinity was once detected at the Sematan Borang water intake/treatment plant in Palembang.

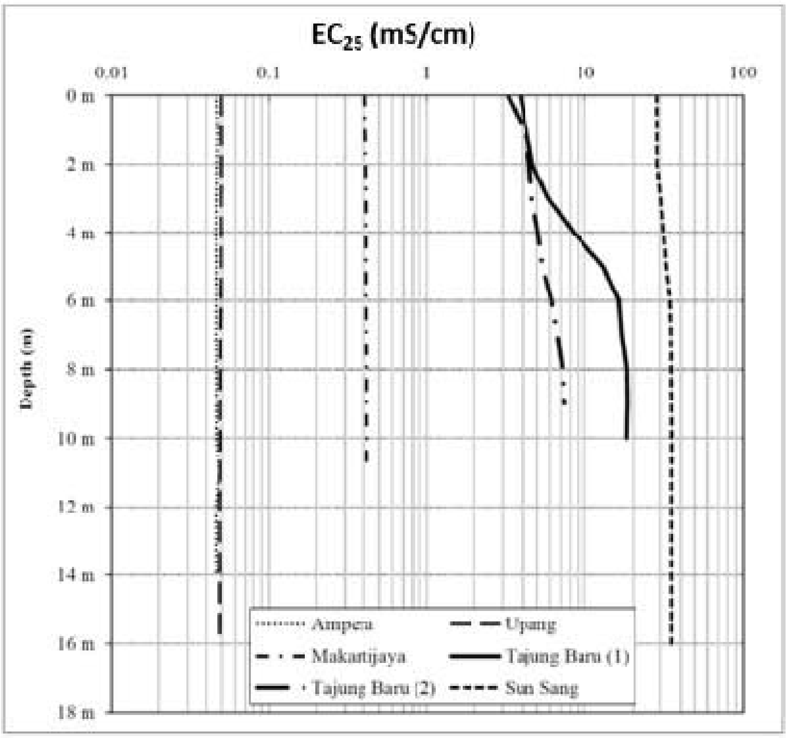


Source: JICA Project Team 2

Figure 9.6.1 Location of Salinity-affected Water Intake and Treatment Plants, and EC Observation Points

From Figure 9.6.2 the followings are considered:

- The EC value of Sun Sang is almost that of sea water.
- The EC values at Upang and Ampera that are located about 45km and 90km upstream from the river mouth are almost that of fresh river water.
- There is a sign of formation of salt wedge at Tanjung Baru (1) that is about 15km upstream from the river mouth. The deeper from the water surface, the larger the EC value is.
- Based on Table 9.6.1, Makartijaya that is located about 25km form the river mouth is almost the lowest limit where harmless water in terms of salinity is available.
- It is noted that the above considerations are just made only based on the one-time observation on December 6, 2013, and that salinity of the river water near the river mouth generally varies very much according to the tide level and river discharge. In order to identify the characteristics of salinity distribution, therefore, it is necessary to accumulate EC or salinity data by continuing the monitoring of EC or salinity.



Source: JICA Project Team 2

Figure 9.6.2 Results of EC Observation in December 2013

Table 9.6.1 EC Value and Type of Water

Type of Water	EC_{25} Value Range	Remarks
Fresh River water	Around 0.1 mS/cm	
Allowable Maximum EC for Paddy	0.3 mS/cm or less	Japanese Standards
Allowable Maximum EC for Drinking Purposes	0.6 to 1 mS/cm	Estimated by JICA Project Team 2
Sea Water	Around 45 mS/cm	

Note: EC25 is the EC value after conversion to the reference temperature of 25°C.
Source: JICA Project Team 2

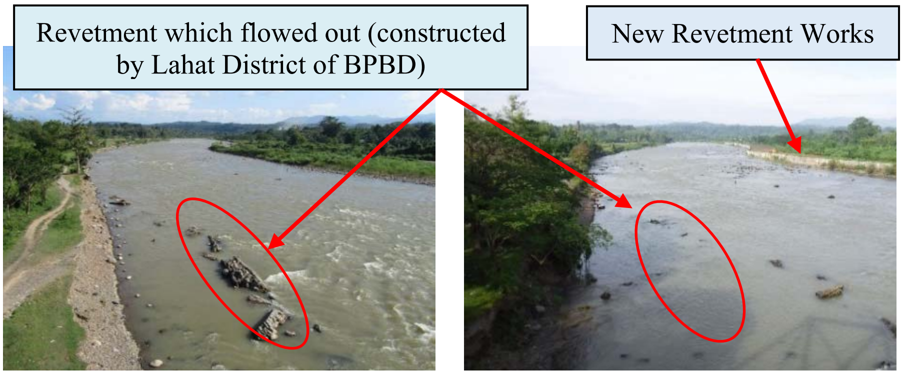
9.6.2 Sediment Discharge

Sediment discharge under current and future climate is as follows:

(1) Current Situation of Sediment Discharge

- Serious sediment disasters such as large-scale landslides and huge slope failures were not observed in the Basin. Therefore, there is no sediment discharge caused by them.
- The main sources of sediment discharge are presumed to be supplied by cultivated land and the river.
- The sediment distributed in the vast plain is thought to be transported gradually to the downstream with floods.
- A huge riverbed deposit was observed in the middle reaches of the Komering River. These deposits are presumed to be volcanic sediments which had been transported by erosion in Pleistocene.

- Riverbank erosion was observed at several parts of the rivers (Photo 9.6.1), that is thought to be the source of the sediment discharge.



Riverbank erosion observed at the lower terrace in the Lematang River (June 2014)

The same site as the photo on the left (July 2018)

River erosion in the midstream of the Musi River (Near Sekayu City: July 2018)

River erosion in the midstream of the Musi River (Near Sekayu City: July 2018)

Sourece: JICA Project Team 2

Photo 9.6.1 Current Situation of River Erosion (June/2014, July/2018)

(2) Sediment Discharge under the Future Climate

The amount of sediment discharge amount under the future climate is estimated by using the formula USLE. The estimation methodology is the same as the one applied for the Brantas River basin (Refer to Supporting Report H).

- Increase rates of sediment discharge of the Musi River basin under the future climate (2050), which is calculated based on the change of I (maximum hourly rainfall in a series of rainfall) of the formula USLE, are shown in Table 9.6.2.
- According to Table 9.6.2, the increase ratio of sediment discharge is expected to be on average at 15% against the present climate (2000).
- Increase ratio of rainfall amount in the future is shown in Table 9.6.2. The increase ratio is expected to be on average at 3%.

Table 9.6.2 Increase Ratios of Sediment Discharge and Rainfall Amount

1) Increase Ratio of Sediment Discharge

Basin ID	1-19
High (2050/2000)	1.37
Middle (2050/2000)	1.11
Low (2050/2000)	0.98
Ave	1.15

2) Increase Ratio of Rainfall Amount

Basin ID :	1-19
High (2050/2000)	1.08
Middle (2050/2000)	1.07
Low (2050/2000)	0.94
Ave	1.03

Source: JICA Project Team 2

(3) Issues about Erosion Analysis by USLE

At present, regarding sediment discharge, USLE used for soil erosion is adopted in Pola. However, the following problems can be pointed out.

- ULSE (Universal Soil Loss Equation) is adopted as erosion analysis at the present.
- According to this formula, erosion depth is calculated approximately more than 30mm/year in the most serious case. Considering the actual condition, this depth is assumed to be too high. Probably, it is desirable to use the value calculated by this formula as a relative evaluation.
- This formula consists of many parameters. Therefore, it is so difficult to verify. The observation of sediment concentration is thought to be one of verifiable methods.

(4) Issues about Sediment Management

- Deforestation and disorderly land development are thought to be the main reasons 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. Excavation and monitoring plans are required.
- Subsidence and deformation of revetment works are observed at several parts of the river. Construction plan and management of revetment works based on the proper design criteria are required.

9.7 Risk and Resilience of Water Resources Management

9.7.1 Concept of Risk and Resilience Assessment for Water Resources Management

The concept is the same as that in "Study for Brantas River Basin", and is as referred to in Section 5.5.2.

9.7.2 Risk and Resilience of Water Resources Management

Based on the preceding discussions, conceivable risks caused by climate change and conceivable resilience measures are summarized as presented in Table 9.7.1, focusing on four significant hazards, drought, flood, sea water intrusion and sediment discharge. The resilience measures are mostly non-structural measures that could be implemented by existing resources with less cost. Full-scaled structural and non-structural measures that require huge inputs of financial, technical and human resources are dscussed in the next chapter.

Table 9.7.1 Summary of Risk and Resilience of Water Resources Management

Hazard	Risk	Resilience Measures
Drought	• Reduction of Agricultural production • Shortage of water for households, urban facilities and industries • Damages to ecosystem • Degradation of water quality	Irrigation water demand management • Change of rice variety (high resistance against high temperature and less water) • Agriculture operation based on real-time weather forecast • Change of cropping calendar • Use of groundwater • Application of system of Giliran (rotation irrigation method) and/or Golongan (staggered irrigation method) DUI water demand management • Promotion of saving of water consumption • Rainwater harvesting
Flood	• Direct damages to human lives, houses, infrastructures, agricultures, etc. • Loss to economic activities (suspension of business operation, etc.)	• Strengthening of response activities (evacuation based on early warning, rescue, relief supply, etc.) • Publicization of flood hazard maps • Preparation of BCP (Business Continuation Plan) • Flood plain management (land use regulation and guidance, promotion of building flood-resilient houses (pilotis-type houses, etc.)
Sea Water Intrusion	• Salt damages to agriculture, potable water, ecology	• Careful gate operation based on EC monitoring
Sediment discharge	• Bank erosion • Reduction of river channel capacity (flood) • Difficulty of navigation	• Monitoring and control of sand mining • Monitoring of change of river channel (regular river cross section survey • Channel maintenance dredging

Source: JICA Project Team 2

(1) Drought

As explained in Sections 9.4.1 and 9.5.1, the total water deficit volume is anticipated to increase by 18% to 74% under climate and landuse changes, while the occurrence probability of drought year at sub-basin level depends upon the climate change scenario very much as presented in Figure 9.5.1. Accordingly risks of reduction of agricultural production, shortage of water for DMI (Domestic, Municipal and Industrial) purposes, damages to ecosystem, degradation of water quality, etc. might increase.

The resilience measures are broadly divided into two, namely irrigation water demand management and DMI water demand management. The irrigation demand management includes change of rice variety (application of those of high resistance against high temperature and less water), agriculture operation based on real-time weather forecast, change of cropping calendar, use of groundwater, application of system of Giliran (rotation irrigation method) and/or Golongan (staggered irrigation method), etc. It is necessary to empower stakeholders of both public and private sectors in order to implement them more efficiently and effectively, although some of them have already been practiced traditionally.

(2) Flood Hazard

As explained in Section 9.5.2, the impacts on flood would increase under climate and/or land use changes, depending upon the scenario as presented in Table 9.5.1. Accordingly, risks of direct damages to human lives, houses, infrastructures, agricultures, etc. and losses to economic activities (suspension of business operation, etc.) might increase.

The conceivable resilience measures include strengthening of response activities such as evacuation based on early warning, rescue, relief supply, etc., publicization of flood hazard maps, preparation of BCP (Business Continuation Plan) and flood plain management. The flood plain management is further composed of land use regulation and guidance, and promotion of building flood-resilient houses, etc. Like the drought hazard, empowerment of stakeholders is a key for the success of the resilience measures.

(3) Seawater Intrusion

Sea level rising of 0.5cm/year is projected at the Musi River mouth as an impact of climate change and there are already some signs of sea water intrusion in the low-lying tidal areas as explained in Sub-section 9.5.3 (1). As the sea level rises, the sea water intrusion will definitely become worse. Thus it is concerned that salt damages to agriculture, DMI, ecology, etc. will become more and more tangible in the near future.

The conceivable resilience measures might be limited for the time being when structural measures such as barrages are not existing. In the tidal swamp irrigation areas frequent and careful gate operation based on EC monitoring might be required to prevent intrusion of sea water in the secondary/tertiary canals.

(4) Sediment Discharge

According to the preliminary analysis of sediment discharge based on the USLE method, the sediment discharge of the Musi River basin will increase or decrease by 37% (High scenario), 11% (Medium scenario) or -2% (Low scenario), depending on the scenario as an impact of climate change. Thus sedimentation in the river channel might be augmented, resulting in aggradation of riverbed that further leads to overflow of flood water from the river banks and difficulty of navigation. In addition, river discharge increased by climate change might accelerate the river bank erosion.

The conceivable resilience measures are monitoring of change of river channel (regular river cross section survey) and channel maintenance dredging against sedimentation. Control and monitoring of sand mining are also a conceivable resilience measures to protect the river bank erosion.

CHAPTER 10 CLIMATE CHANGE ADAPTATION MEASURES FOR WATER RESOURCES MANAGEMENT PLANS OF MUSI RIVER BASIN

10.1 Planning Methodology of Water Resources Management Plans Reflecting Climate Change Impacts

The planning methodology is the same as that in "Study for Brantas River Basin", and is as referred to in Section 6.1.

10.2 Planning Policies of Adaptation Measures

There are no large-scaled water resource management facilities in the Musi River basin except for a few headworks such as Perjaya and Lakitan Headworks. The construction of Tiga Dihaji Dam has started since 2019. A plenty of water is still flowing to the sea without utilization.

As for flood control, there is no master plan that covers the entire Musi River basin except for the flood control master plan of Palembang City, based on which construction of a pump station is now ongoing on the Bendung River. Accordingly, neither diagram of design flood discharge distribution of the Musi River and its tributaries has been prepared, and nor notably significant flood control works have been implemented so far.

As explained in the above, the development of the Musi River basin is far behind the other river basins represented, for example, by the Brantas River basin that has several dam reservoirs in it, is urgently required to catch up with those river basins.

The Vision of the Spatial Plan 2016 of South Sumatra Province says “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“.

To attain the vision under the uncertainty of climate change impact, comprehensive actions composed of structural and non-structural measures are proposed not only for the adaptation to climate change impact but also for the river basin development specially in terms of water resources development and supply and flood control.

10.3 Optimization of Existing Water Resources Management Facilities to Mitigate Climate Change Impacts on Rainstorms and Floods and Droughts

10.3.1 Optimization of Existing Water Resources Management Facilities for Mitigation of Climate Change Impacts on Floods

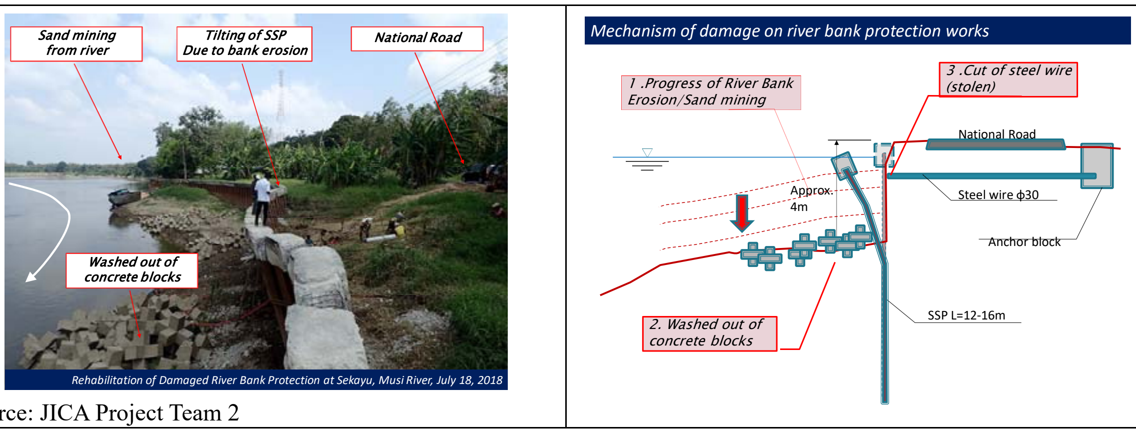
(1) River Bank Protection Works

As mentioned in Section 7.3.1, 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 the flood risk management.

The mechanism of the damage on existing river bank protection in Sekayu in Banuasin regency and basic approach to propose durable countermeasures were studied and discussed with the staff of BBWS-S8.

For optimization of exiting river bank protection works for mitigation of the climate change impact in the Musi River, the following points are recommended to be implemented by BBWS-S8:

- Preparation of inventory of river bank erosion
- Study (survey, geological investigation, river morphology, and riverbed material survey)
- Risk assessment of river bank erosion
- Selection of priority area for improvements of river bank protection works
- Preparation of design standard and guideline
- Control and regulation of quarry in the river channel and its monitoring



Source: JICA Project Team 2

Figure 10.3.1 Location Map and Site Photograph of River Bank Erosion at Sekayu

(2) Connecting Channels between Komering and Organ Rivers

As mentioned in Section 7.3.1, there are five (5) connecting canals (RAJASIAR Canals) and regulators between Komering and Ogan Rivers. The main functions of the regulators are i) flood diversion from Komering River to Ogan River in the rainy season, and ii) discharge control to secure water supply in downstream of Komering in the dry season.

For optimization of exiting regulators for mitigation of the climate change impact, the following points should be noted in terms of the facility management of the regulator:

- It is important to make/update plan and design of regulators considering the climate change impacts to control the discharge and sediment load properly in lower Komering and Ogan Rivers
- There is an existing plan showing the discharge distribution, but it shall be reviewed in detail and updated through topographic survey and river survey (cross -longitudinal section), hydrological analysis, and sediment balance study.

- It is recommended to study the necessity of forecasting system of river flow conditions and formulating related organizations by monitoring and recording river information, such as water levels, discharges, sediment loads and riverbed materials, and hydro-meteorological data.
- It is necessary to prepare an operation and maintenance manual of the regulators based on the updated plan.
- In addition, improvement of river bank protection and maintenance dredging in the canals would be necessary to secure the safety of the regulator and canals

10.3.2 Optimization of Existing Water Resources Management Facilities for Mitigation of Climate Change Impacts on Droughts

(1) Modification of Operation of Ranau Regulating Facility (RRF)

1) General

Lake Ranau is the second largest lake in Sumatra which expands over two provinces, namely, South Sumatra and Lampung. The Ranau Lake that has a surface area of about 125 km^2 and the catchment area of 500 km^2 is the water source of the Komering River. The lake is planned to be developed as the field of integrated economics, tourism and water resources.

As shown in Figure 10.3.2, the lake water is released down into the Komering River through the Ranau Regulating Facility (RRF). The released water is used for hydropower generation by a hydropower plant owned by the Mandiri Bank as well as for irrigation of the agricultural area in Ranau Village. The run-of-river hydropower station is located at around 900 m downstream of RRF, which generates electric power with two 750kW turbines by using a head of 11m.

The lake water level is currently operated by RRF in the range of 0.7m from 541.2 m and 541.9 m according to the gate keeper of RRF, although the actual water level exceeded 242.0 m in 2006 and 2010 as shown in Figure 10.3.3. On the other hand, the possibility of more effective use of the lake water, especially for irrigation water supply for the Komering Irrigation schemes, has been discussed among officials concerned since a few decades ago as shown in Table 10.3.4. In 2015, a new operation that aims to use the lake water in the range of 1.5m from 540.2 m to 541.7m was proposed in “the Komering Irrigation Project Stage II Phase 2 Completion Report, Nippon Koei, July 2015.” The effectiveness and expected issues of the proposed lake water level operation are discussed below.

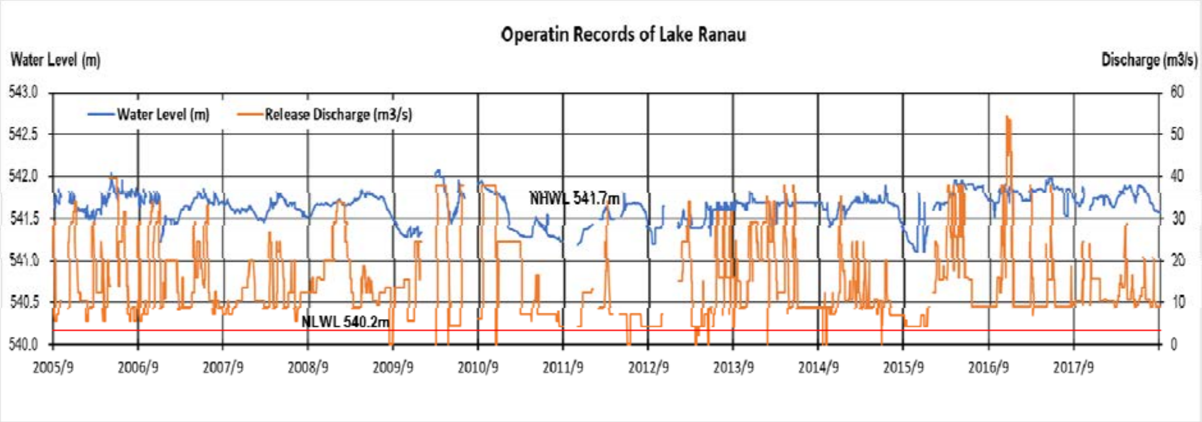
Table 10.3.1 Current and Proposed Operation of Ranau Lake

Operation	NHWL(m)	LWL (m)	Effective Storage Volume (MCM)
Current	541.9	541.2	106
Proposed by the Komering Irrigation Project in 2015	541.7	540.2	190

Source: BBWS-S8

Source: JICA Project Team 2

Figure 10.3.2 Location of Ranau Regulating Facility and Hydropower Plant



Source: JICA Project Team 2

Figure 10.3.3 Water Levels and Release Discharge Records of RRF

2) Effects of Change of Water Level Operation on Droughts

In order to evaluate the effects of the proposed operation rule, a water balance analysis is conducted under the following conditions:

Table 10.3.2 Conditions of Water Balance Analysis for Evaluation of Proposed RRF Operation

Item	Condition
Analysis Area	Komering Sub-system covering 9,725km^2
Calculation Period	15 years from (October 1985 to September 2000)
Discharge Data	Runoff Analysis Data Provided by JICA Project Team-1(Observed rainfall Case)
Water Demand	DMI Water Demand and Irrigation Water Demand. Newly estimated irrigation demand explained in Table 10.4.18 are used as the Irrigation Water Demand.
Calculation unit time	10 days
River maintenance flow	Downstream of RRF: m^3/s, Downstream of Perjaya Headwork:
Analysis Case	2 cases (Current and Proposed Operation of RRF)

Source: JICA Project Team 2

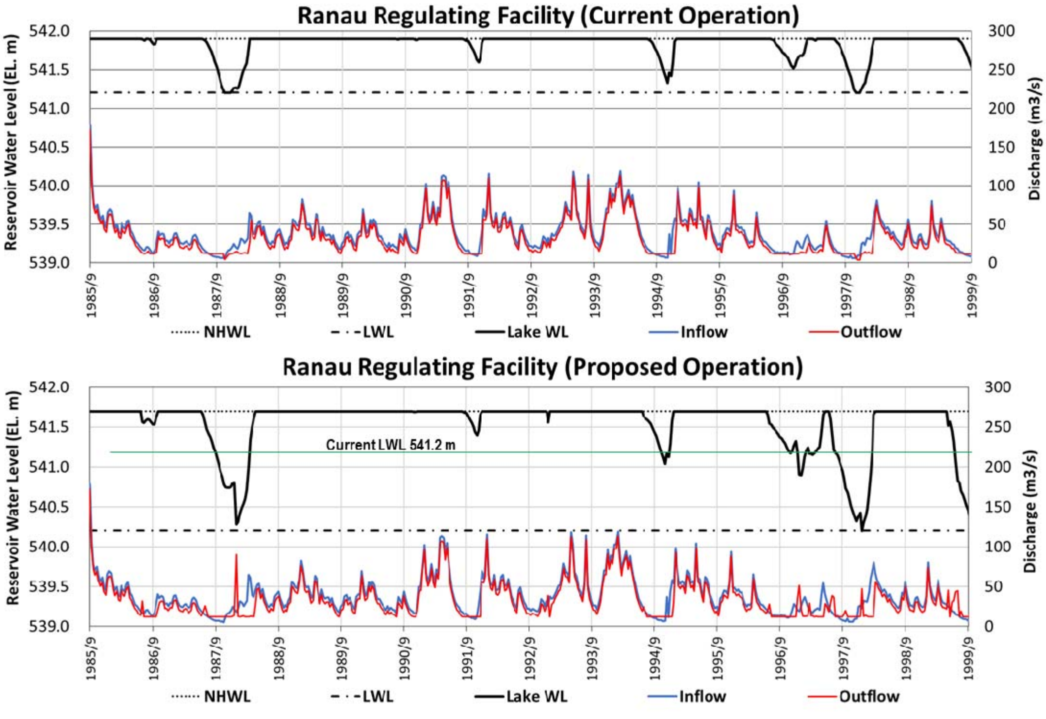
The analysis of the results is summarized in Table 10.3.3, and the simulated lake water levels and the released discharges from RRF, and the simulated deficit discharges at the Perjaya Headwork are plotted as shown in Figure 10.3.4 and Figure 10.3.5, respectively. The considerations are made as follows:

- The proposed operation rule is so effective that the irrigation sufficiency rate will be improved considerably.
- The power generation will increase very slightly.
- The lake water level will be lowered to the proposed LWL of 540.2m for only 10 days in the 15 years, and the total duration when the lake water level is lower than the current LWL of 541.2m is about 21 months.

Table 10.3.3 Results of Water Balance Simulation by RRF Operation

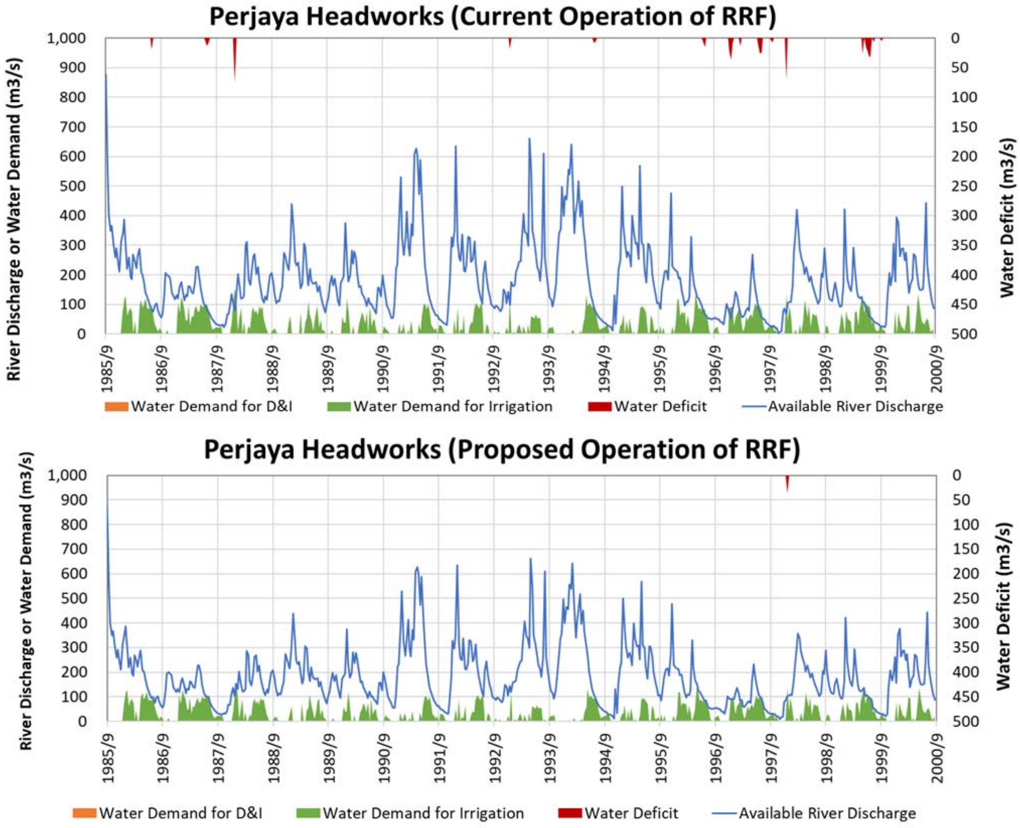
Operation	DMI Sufficiency Rate (%)	Irrigation Sufficiency Rate			Deficit (MCM/year)	Frequency of drought year	Power Generation (10^6 kWh/year)
		MH	MK1	MK2			
Current	100.0	91.9%	92.2%	97.4%	51.4	80.0%	9.39
Proposed	100.0	98.6%	100.0%	100.0%	18.1	66.7%	9.42

Note: DMI Water Sufficiency rate (%) = Supplied Water/Water Demand
Irrigation Water Sufficiency Rate (%) = Average value of Annually Minimum (Supplied Water/Water Demand)
Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 10.3.4 Simulated Lake Water Level and Released Discharge from RRF



Source: JICA Project Team 2

Figure 10.3.5 Simulated Water Deficit at Perjaya Headwork

3) Social and Environmental Issues

The Ranau Lake is the largest lake in South Sumatra, with an area of approximately 125km^2, and around 90,000 people live in the surrounding municipalities (Table 10.3.4). The primary industries are tourism, fisheries, and agriculture.

Table 10.3.4 Population of Districts Surrounding Ranau Lake

Province	District	Total
S. Sumatra	Kec. Banding Agung	22,517
S. Sumatra	Kec. BPR Ranau Tengah	18,624
S. Sumatra	Kec. Warkuk Ranau Selatan	20,153
Lampung	Kec. Sukau	26,666
	Total	87,960

Source: UKL-UPL of Water Level Lowering of Ranau Lake, BBWS-S8 (2011)

In the original operation plan, Upper Komering River Basin Development Project (1981) by JICA, it was planned to utilize the Ranau Lake water by decreasing 1.5m from HWL. After that, the operation plan introduced by the Indonesian side was 1.7m (1998) and 2.0m (2011) which is 0.5m larger than the original plan. Since the RRF is designed to handle the water levels from EL. 539 m to EL. 543 m and no modification is necessary as the facility. However, at present, it is operated with much smaller range than planned probably due to the considerations for the local issues. The figures related to the water level are summarized in Table 10.3.5. The reasons for this are multiple operational issues as follows:

Table 10.3.5 Figures Related to Water Level of Ranau Lake

	Upper-Komering River Dev't Project[2] (1981)	BBWS-S8 Original Plan (1998)	BBWS-S8 Revised Plan (2011)	Customary Operation by RRF[1] (Present)	Komering Irrigation Project (2015)
NHWL	EL. 542.3 m	EL. 541.7 m	EL. 541.7 m	EL. 541.9 m	EL. 541.7 m
LWL	EL. 540.8 m	EL. 540.0 m	EL. 539.7 m	EL. 541.1 m	EL. 540.2 m
Range of fluctuation	1.50 m	1.7 m	2.0 m	0.8 m	1.5 m
Recipient body	-	KIDP[3] (50,000 ha)	KIDP+LIDP[4] (63,500 ha)	-	

Source:
1) JICA Project Team 2 interview with the gate keeper of RRF (Nov. 2018)
2) Pre-feasibility Study on the Upper Komering River Basin Development Project (1981) JICA
3) Komering Irrigation Development Project
4) Lempuing Irrigation Development Project

(a) Bedrock at Lake Outlet

According to Mr. Medy Ramadhan, Head of Operation and Maintenance, BBWS-S8, the elevation of the outcrop of the bedrock at the outlet of the Ranau Lake is EL. 541.0 m and the lake water level does not fall below the elevation of this rock surface. It is necessary to remove this rock to lower the lake level, but it is difficult to do so, and excavation has failed so far. Mr. Ramadhan said that if it is technically possible BBWS-S8 has the intention to remove it. Besides the technical difficulty in excavating it, the residents believe that the rock was sacred, and can't discard it easily.

(b) Fisheries

Aquaculture using fish cages in shallow water is being one of the primary industries in the lake area. The main cultured fish are as follows: Nila (Oreochromis niloticus: tilapia), Mas (Carassius auratus: goldfish), and Patin (Pangasius bocourti: basa), etc. In fishing grounds other than aquaculture, floating nets are installed in the -2 to -4 m zone where aquatic plants grow. In general, throwing nets, stab nets and tackle net fishing are carried out in water areas shallower than -6 m. The yearly average income of the fish business in Ranau Lake is Rp.148,459,460.

According to interviews with the gate keeper of RRF of BBWS-S8, it is empirically known that the residents complain if the water level falls below EL. 541.1 m. Therefore, the RRF is operated not to lower the water level below that level.

It is known that if there is a long-term fluctuation of water level, vegetation will not grow easily on the bottom of the lake and the biota will become thin. As a countermeasure, if cost and convenience are neglected, conversion of the ordinary aquaculture net to the floating cage or concrete ponds could be the substitutes.

(c) Navigation

Navigation using the lake surface is an important means of transportation to the surrounding communities. If the water level drops about 1 m below the current level, it is expected that some piers will dry up and the ships will not be able to dock at the existing piers, which will have a significant impact on traffic and transportation of the villages. As a countermeasure for this, it is conceivable to upgrade to a pontoon jetty.

(d) Tourism industry

The Ranau Lake area is one of the largest tourist destinations in South Sumatra. BBWS-S8 needs to coordinate with the Ministry of Tourism when using the lake water since it is designated as the National Tourism Strategic Area in the legal plan (Decree No. 50/2011, National Tourism Development Master Plan for 2010-2025). There are many cottage-style accommodation facilities on the lakeside, and there are also hot springs and a beach. Significant events are carried on around the Ranau Lake, and the ability to attract visitors is regarded as a vast tourist resource. Generally, the shoreline becomes a barren land surface, so there could be some cases that disturb the landscape, so tourism income may decrease in the dry season when the water level falls.

(e) PDAM intake

If the water level falls, the PDAM intake will rise over the water surface, so it will need to be reconstructed.

10.4 Identification of Other Adaptation and Mitigation Measures against Climate Change Impacts

10.4.1 Adaptation Measures against Rainstorms and Floods

(1) Flood Issues

The flood issues in the Musi River basin might be summarized as follows:

- Extensive flood inundation occurs in the midstream and downstream areas
- Urban areas such as Palembang, Lubuk Linggau, etc. are vulnerable to drainage problems during rainstorms.
- Flash flood occurs in mountainous upstream areas.
- Low tidal areas are affected by sea level rise.

1) Extensive Inundation in Midstream and Downstream Area

As discussed in Sub-section 9.5.2, there are extensive swamp areas in the midstream areas. In the downstream area there are extensive agricultural areas that used to be tidal swamp areas. These areas are vulnerable to habitual inundation.

2) Drainage Problem in Urban Areas

Many urban (settlement) areas in the Musi River basin as well as Palembang are suffering from problems of drainage during rainstorms. Even if it rains a little, a puddle will quickly form here and there, resulting in traffic jams and damage to houses and properties. This drainage problem is one of in the biggest constraints against social and economic activities for the urban areas in the Musi River basin. As discussed in Subsection 9.4.4, the frequency of heavy rainfall will generally increase in the future. The measures against inland floods in urban areas should be strengthened.

Source: SRIPOKU.COM, Palembang

Source: SRIPOKU.COM, Palembang

Photo 10.4.1 Inundation of Palembang during Rainstorm on April 25, 2019

3) Flash Flood and Sediment Disasters in Upstream Areas

In the mountainous and upstream areas, especially in Lahat, Muara Enim and Musi Rawas Regencies flash floods as well as sediment disasters such as landslide occur frequently. These situations also could also be further accelerated by climate change.

4) Low Tidal Area Affected by Sea Level Rise

As shown in Figure 9.4.5, the flood inundation will be expanded in the low tidal areas by the sea level rise. These areas were originally tidal swamp areas, which have been reclaimed into agricultural fields by the Indonesian Government since the 1960s.

(2) Conceivable Measures

In order to comprehensively cope with the above flood issues that might worsen through climate change, the following combination of structural and non-structural adaptation measures listed in the following table is conceived.

As discussed below, orthodox structural measures represented by dikes and dam reservoirs are generally not so effective in the Musi River basin due to topographical, hydrological and social conditions. In addition to the inland flood mitigation measures for the urban areas, the non-structural measures represented by flood plain management should be more emphasized as important adaptation measures for the Musi River basin.

Table 10.4.1 Conceivable Adaptation Measures against Rainstorms and Floods

Structural/ Non-structural	Measure	Expected effects
Structural	Dike	Protection of flood inundation
	Dam reservoirs	Reduction of flood discharge just downstream of the dam (flash floods)
	Dredging	Increase of river channel capacity
	River bank protection	Protection of river bank erosion
	Road heightening	Ensuring of road transportation during floods
	Comprehensive measures against inland floods	Reduction of inland flood damages in urban areas
	Sabo works	Reduction of sediment disasters
Non-structural	Flood plain management	Reduction of flood damage potential
	Strengthening of response activity	Reduction of flood damage and ensuring early recovery
	Early warning	Reduction of human losses and damages to properties
	Watershed conservation	Reduction of flood discharge and sediment disasters

Source: JICA Project Team 2

(3) Structural Measures

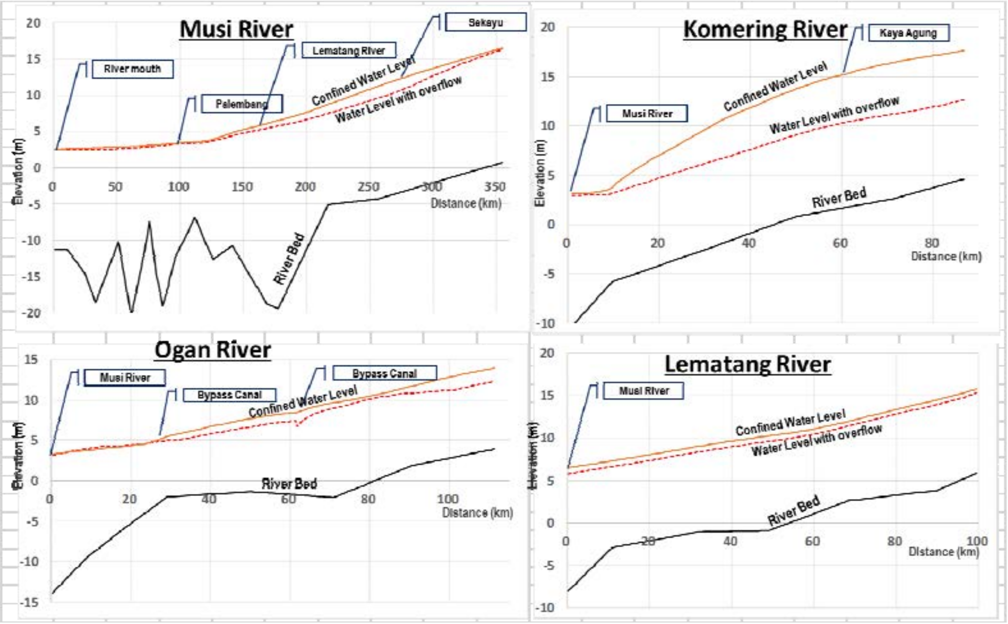
1) Dike

Dike (embankment) is generally one of the most orthodox structural measures against floods. The Dike aims to protect low-lying areas from overflow of river flood water, and generally categorized into two types, namely, continuous dike and ring dike. The continuous dike is constructed for long stretches along the river bank to protect properties distributed for long stretches along the river, and the ring dike is constructed so as to surround an isolated area to be protected from floods. However, there are neither continuous dikes nor ring dikes in the Musi River basin at present probably because these dikes are not effective due to the following reasons:

- The continuous dikes confines flood water in the river, resulting in heightening of river water level. Figure 10.4.1 compares the river water levels simulated with and without continuous dike under the High scenario of a 100-year return period. The with-case confines all flood water in the river channel, while the without-case allows overflow from the river banks as the existing conditions. It is understood that the river water level is raised by the confinement by the continuous dikes. Especially the water level of the Komering River, along which overflow occurs at many places under the existing conditions, is raised by as much as 5 m.
- The ring dike generally protects an isolated settlement area from floods. As seen in Figure 10.4.2, however, most of the important settlement (urban) areas in the downstream and midstream areas of the Musi River basin are located in comparatively higher locations and narrowly out of the flood inundation areas. It is deemed that there are almost no right settlement areas that should be protected by the ring dikes for the time being, although ring dikes would be necessary in the future for low-lying areas that will be newly developed.
- As understood from Table 9.5.1, as many as 200,000 to 300,000 houses are situated in the flood inundation areas. Since most of them are pillar houses, they seem to be rather resilient against flood inundation. In addition, they are scattered along roads and river

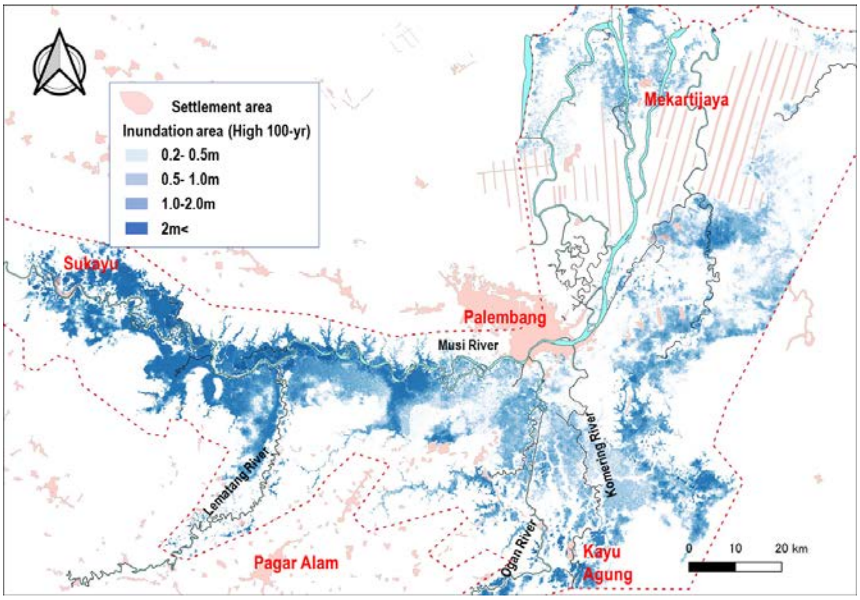
banks in the swampy areas. Therefore, it is not economically advantageous to construct dikes to protect these scattered houses. However, ring dikes might be necessary and effective for residential and/or industrial estates that will be developed in the low-lying areas in the future.

In conclusion, dike seems to be not generally effective against flood in the Musi River basin for the time being, although ring dikes might become necessary in new development areas. It seems wiser to conserve the existing retarding function of the extensive inundation areas by appropriate flood plain management instead.



Source: JICA Project Team 2

Figure 10.4.1 Water Level Rise Caused by Confinement in the River Channel (High Scenario, 100-year Return Period)



Source: JICA Project Team 2

Figure 10.4.2 Flood Inundation Area and Settlement Area

2) Dam Reservoirs

There is no dam reservoir in the Musi River basin at present. However, the Indonesian Government has a strong intention to urge water resources development through dam construction. Accordingly, the construction of the first dam has started at Tiga Dihaji on the Komering River, and there are eight (8) proposed and potential dam sites including Tiga Dihaji in the Musi River basin as shown in Table 10.4.2 and Figure 10.4.3.

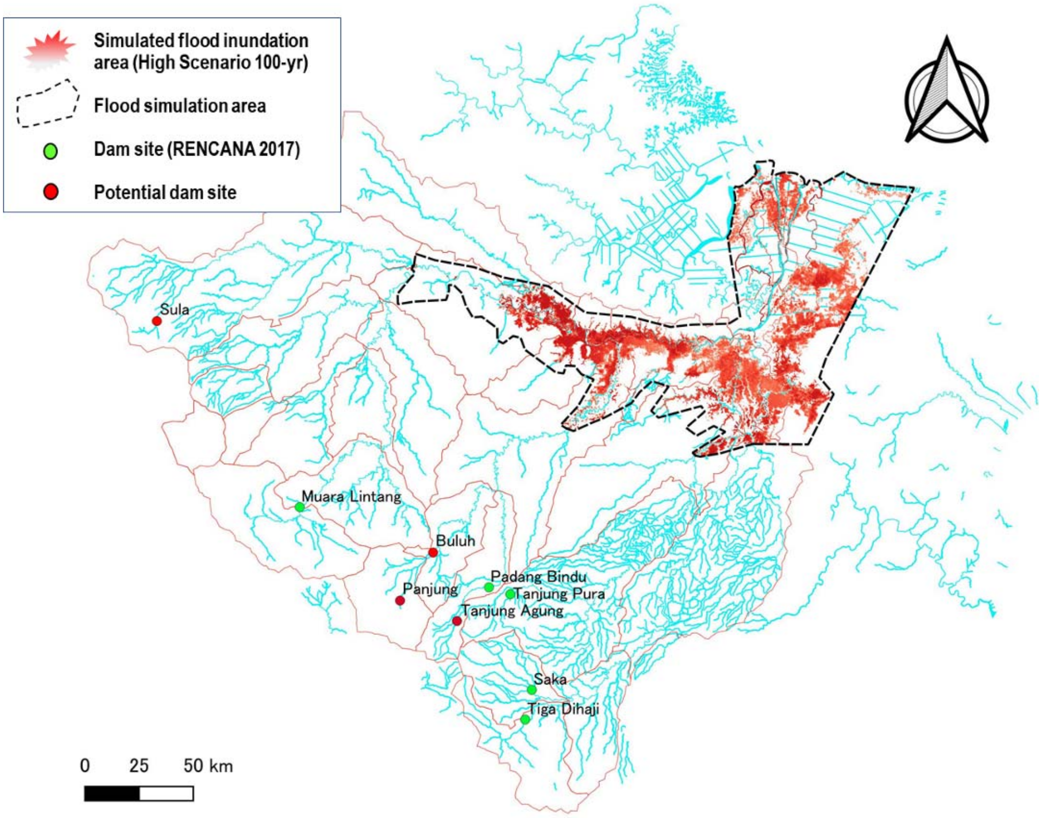
A dam reservoir is effective against floods if it has a specific volume for flood control and is located close to the area to be protected. However, none of them has a storage reservoir volume dedicated for flood control because they were primarily intended to serve for DMI (Domestic, Municipal and Industrial) water, irrigation and/or hydropower generation. Due to the topographical constraints, all of them are located close to the western basin boundary, and very far from the extensive inundation areas in the midstream and downstream areas. The total catchment area of the eight dam reservoirs is 6,100 km^2, just 10% of the Musi River basin of 59,300 km^2.

Therefore, the proposed and potential dam reservoirs are not effective for the extensive flood inundation areas in the midstream and downstream areas. It is also unrecommendable to redesign the dam reservoirs as flood control purposed ones. However, these dam reservoirs will be sometimes effective in stretches just downstream of the dams, depending on how much empty storage volume is left before the flood.

Table 10.4.2 Proposed and Potential Dam Sites in Musi River Basin

Name of dam	Sub-river Basin	Purpose	Catchment Area (km^2)	Total Storage Vol. (MCM)	Effective Storage Vol. (Storage)	Present Status
Tiga Dihaji	Komering	DMI, IR, HP	1,156	106	65	Under construction
Saka	Komering	DMI, IR, HP	386	43	20	F/S completed in 2013
Tanjung Pura	Ogan	DMI, IR, HP	125	51	No data	Pre-F/S completed in 2015
Padang Bindu	Lematang	DMI, IR, HP	468	110	53	Pre-F/S completed in 2015
Muara Lintang	Musi	DMI, IR, HP	2,954	21,623	17,306	Described in RENCANA 2017
Tanjung Agung	Lematang	HP	226	80	43	Potential Dam
Buluh	Lematang	DMI, IR, HP	391	433	No data	Potential Dam
Panjung	Lematang	HP	220	150	106	Potential Dam
Sula	Rawas	IR, HP	235	583	No data	Potential Dam
Total			6,141	23,179	(17,595)	

Note: DMI: Domestic, Municipal and Industrial water, IR: Irrigation, HP: Hydraulic Power
Source: BBWS-S8 and JICA Project Team 2



Source: BBWS-S8

Figure 10.4.3 Location of Proposed and Potential Dam Sites

3) River Dredging

A huge riverbed deposit is observed in the middle stretches of the Komering River. It is said that this is due to a decrease of traffic force caused by the decrease of river discharge. A considerable portion of the river discharge is taken at the Perjaya Headwork. As a result, the riverbed surface is becoming higher between Menanga and Cempaka, raising the river water level during floods. The reduced capacity of the river channel is one of the causes of the large-scale overflow from the Komering River.

As part of the river channel maintenance, river dredging is very important. For this purpose, regular river channel survey of every 2 to 5 years should be conducted. This river survey information is also useful for the management of sand mining activity. Then a dredging plan should be made based on the river channel survey.

4) Road Heightening

Some arterial roads in the midstream and downstream areas of the Musi River basin are vulnerable to flood inundation. Road traffic cut by flood hampers flood response activities such as evacuation, rescue and materials supply as well as ordinary daily activities.

Source: JICA Project Team 2

Photo 10.4.2 Impassable Road Due to Flood Inundation

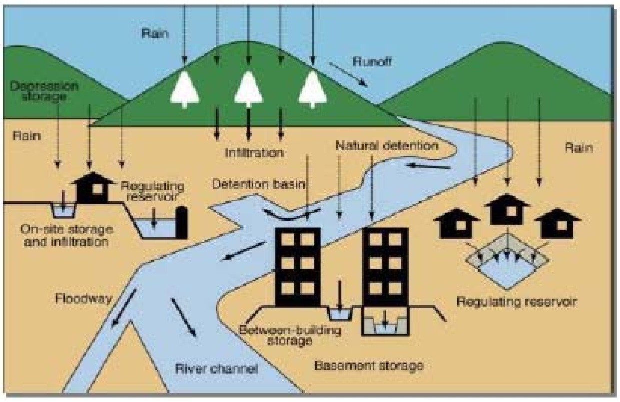
To ensure normal road traffic even during a flood, low portions of the arterial roads should be heightened. For this purpose, an inventory survey should be conducted to identify such low portions by an interview survey, detailed road elevation survey, hydrological and hydraulic survey, etc. Based on the inventory survey, the priority order for implementation is set. Then road heightening should be implemented according to the priority order.

5) Comprehensive Measures against Inland Floods in Urban Areas

As explained in Subsection 10.3.1 (1) 2), the existing drainage facilities in the urban areas are so poor that habitual inundation occurs in the urban areas, causing heavy flood damages to urban infrastructures as well as economic activities and daily lives of the local residents. The recent and future urban development is also enhancing the flood risk including indirect losses such as disruption of traffic and telecommunication, business suspension and incoveniences of daily lives as well as direct damege to urban infrastuctures and facilities as urban specific issues. This inland flood problem is becoming one of the biggest constraints against social and economic activities for the urban areas in the Musi River basin. In addition, this Project revealed that the frequency of heavy rainfall is likely to increase due to climate change. Under these situations, the importance of implementation of comprehensive measures against inland floods is increasing.

To cope with these inland floods, comprehensive flood mitigation measures, which generally consist of instream measures (river normalization, diversion channel, etc.), watershed measures (retention ponds, surface water infiltration, land use regulation, flood proofing buildings, etc.) and information measures (early warning, response activities, etc.) should be applied. Moreover, if the socio-economic functions of the urban areas in the region is taken into consideration, preparation of BCP (Business Continuity Plan) also should be added to the comprehensive flood mitigation measures against inland floods in collaboration with all stakeholders including private sectors.

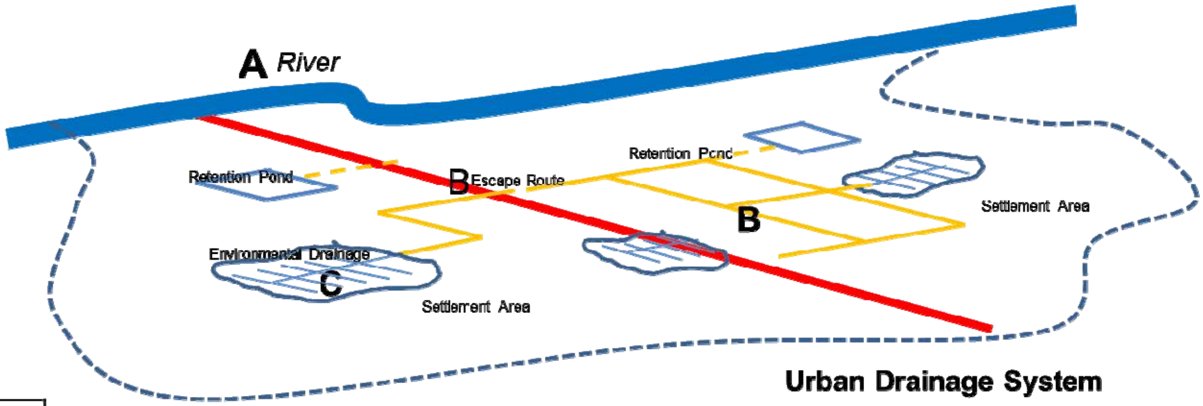
In 2014 BBWS-S8 prepared a flood control master plan of Palembang City, and is now implementing drainage improvement projects in accordance with the master plan. The master plan generally follows the concept of the comprehensive flood mitigation measures.



Source: Flood Control Master plan of Palembang, 2014

Figure 10.4.4 Concept of Measures against Urban Floods

For the other urban areas including Lahat, Pagaralam, and Lubuk Linngau, similar master plans should be prepared and then implemented in coordination among Directorate General of Water Resources, Directorate General of Human Settlements, Directorate General of Highways and the Province and the City Governments.



A	handling is carried out by the directorate general of water resources
B	handling is carried out by the regency/city, handling is carried out by the province if cross regency/city with guidance by the Directorate General of Water Resources, management by the Directorate General of Water Resources if it is a national strategic interest
C	handling by regency/city with the guidance of the Directorate General of Human Settlements. Handling can also be done by the Directorate General of Human Settlements for National Strategic Interest.

Source: BBWS-S8

Figure 10.4.5 Responsibilities of Central, Province and Regencies for Urban Drainage System

6) Sabo Management

For the preparation against climate change, the following items can be pointed out:

- Sediment discharge is caused not only by land development but also by seasonal variation. It cannot be concluded whether present changes of sediment discharge are caused by climate change or not.
- Therefore, it is necessary to record, map, and monitor the present changes periodically. When changes are assumed by climate change, countermeasure works should be accelerated ahead of the schedule. It is necessary to establish a sediment management plan based on periodical monitoring for that purpose.

- Mainly fine sand and mud have been steadily eroded from the cultivated land and the plantation until the growing of understory vegetation.
- As the land development is spread, sediment discharge would be increasing. This fine sediment will accumulate around the estuary in the future. In addition, it is assumed that the deposition rate will accelerate with climate change.
- Increase in rainfall intensity becomes a risk under the climate change. It is desirable to make clear and evaluate the change of sediment discharge quantitatively by periodical observation.

(4) Non-Structural Measures

1) Flood Plain Management

There are extensive swamp areas in the midstream areas. In the downstream area there are extensive agricultural areas that used to be tidal swamp areas. These areas are vulnerable to habitual inundation. According to the flood simulation results, the total inundation area of a 100-year return period of the High Scenario is as large as 4,000 km^2 and the inundation volume is 3,400 MCM, where approximately 300,000 houses are situated .

Fortunately, the major existing settlement areas, which are located higher in elevation, narrowly escapes the flood inundation. In addition, most of the population in the swampy flood plains are living in pillar houses and are very familiar with how to live with floods. This is one of the reasons why the extensive flood inundation is not a top priority disaster issue in the Musi River basin for the time being at least. However, the situation would possibly change, depending upon the flood plain management from now on. Land use control is very important in order not to increase flood damage potential while maintaining the existing retarding effect of the swampy and low-lying areas of the Musi River basin. The South Sumatra Province Spatial Plan 2016-2036 also requires the maintenance of the function of the flood prone-areas and zoning regulations as follows:

- Determination of floodplain boundaries;
- Utilization of floodplains for green open spaces and construction of low-density public facilities; and
- Prohibition on the use of space for settlement activities and other important public facilities.

Any concrete actions following the spatial plan have not been initiated yet by regency governments except for Palembang City that enacted a regional regulation for control and utilization of swamps. According to BAPPEDA officials of South Sumatra Province, these regency governments have not understood the necessity of the flood plain management very well yet.

The flood plain management is one of the most effective measures for the Musi River basin where typical structural measures such as dike and dam reservoirs seem to be not so effective. Continuous efforts should be made to convince all of the stakeholders of its importance. As an example of “Good Practice, a challenge of Palembang City to manage swamp areas is introduced below:

(a) Management of Swamp Area by Palembang City

Palembang City enacted the Regional Regulation No. 11 of 2012 on Guidance of Control and Utilization of Swamp to achieve the realization of community welfare, carried out by preparing facilities and infrastructure intended for the purposes of settlement, agriculture, plantation, fisheries, livestock, forestry, industrial, transportation and tourism land use as well as for reducing GHG emissions by maintaining and protecting the swamp ecosystem as a source and reservoir of water and improving its functions and benefits.

The regulation classifies the swamps into three categories, namely: Conservation Swamp, Cultivation Swamp and Reclamation Swamp, as presented in Table 10.4.3 and Figure 10.4.6. The swamps which have been designated as “Conservation Swamps” covering an area of 2,106 ha are prohibited from being converted into other functions. The swamps that have been designated as “Cultivation Swamps” covering an area of 2,811 ha can be used as agricultural land, fishery areas, plantations or settlements with pillar houses without landfilling or reclamation. The swamps that have been designated as “Reclamation Swamps” can be converted to community interests after obtaining the mayor's permission. According to the regulation, the supervision of the control and utilization of swamps is carried out by the community and the mayor. The regulation includes provisions of sanctions and penalty against violators.

To ensure the conservation of the Conservation Swamps, Palembang City is now proceeding with land acquisition under an immediate plan to acquire 100 ha, of which 10 to 15% were already acquired.

Table 10.4.3 Three Categories of Swamp Areas by Palembang City

Swamp	Area (ha)	Purpose	Management
Conservation	2,106	Water source of water and flood control reservoir	Prohibited from being converted into any other functions.
Cultivation	2,811	Functioning as swamp for agriculture and settlement	Used for agriculture, fisheries, plantations and settlement with pillar-houses without land filling and reclamation.
Reclamation	Not specified	Utilization of swamp area by landfilling.	A reclamation permit is issued by the mayor.

Source: Palembang City

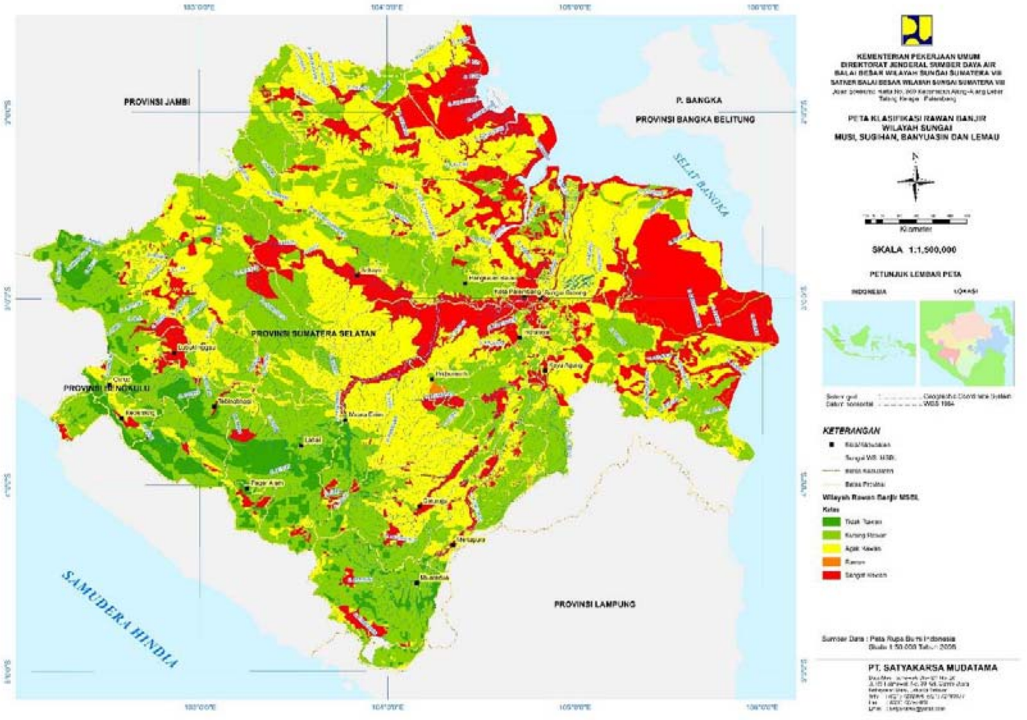
(b) Flood Map

As a first step of the flood plain management, precise and detail flood maps are indispensable to identify flood-prone areas. There are available two flood area maps prepared by BBWS-S8 and BPDASHL Musi (Balai Pengelolaan Daerah Aliran Sungai and Hutan Lindung Musi: Musi Watershed and Protected Forest Management Organization).

These maps of which scales are 1/1,500,000 and 1/1,750,000 respectively, are very useful to obtain an overview image of the flood areas at the river basin scale. However, they are too small to precisely identify the boundary of the flood area for a practical use for the flood plain management. The map scale should be 1/50,000 to 1/10,000 at least for the practical flood plain management at the regency level, following the swamp area map of Palembang as shown in Figure 10.4.6 of which scale is 1/35,000.

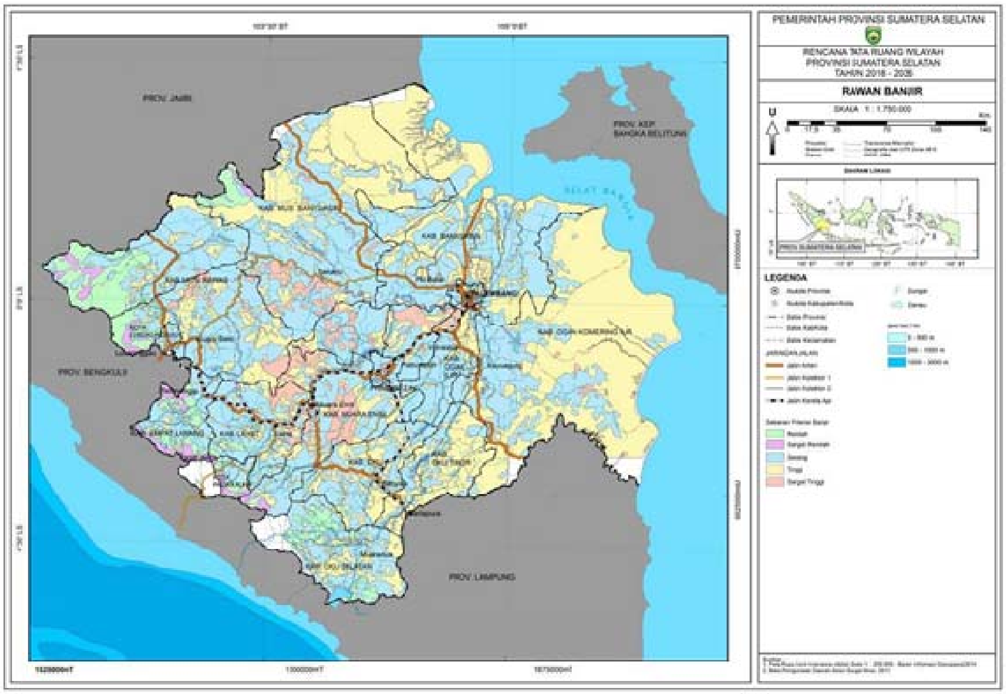
Source: Palembang City

Figure 10.4.6 Swamp Area Map of Palembang City



Source: BBWS-S8

Figure 10.4.7 Flood Prone Area Map by BBWS-S8



Source: Spatial Plan 2016-2036 of South Sumatra Province

Figure 10.4.8 Flood Area Map by BPDASHL

2) Strengthening of Flood Emergency Response Activities

The flood emergency response activities include flood fighting, evacuation, rescue, relief supply, etc. These activities are mainly made by BPBD (Regional Disaster Management Agency) in collaboration with local governments.

Since it is very difficult to substantially reduce flood inundation by structural measures, a certain flood inundation has to be accepted, and efforts should be made to minimize flood damage and to ensure early recovery. For this purpose, strengthening of the flood emergency response activities is very important. As a first step to the activity, a flood emergency response plan should be prepared for every local unit. The flood emergency response plan should include the followings:

- Nature of the flood threat;
- Areas that could be affected by flooding;
- Sources of flood intelligence (for example, fundamental data through constant monitoring of floods);
- Roles and responsibilities of listed agencies before, during and after flood episodes;
- Control arrangements;
- Trigger conditions for plan activation;
- Liaison and communication arrangements;
- Arrangements for public education, warning, the passage of information to flood-affected communities, road control, sandbagging, evacuation, re-supply, rescue, registration and welfare of evacuees, initial recovery and post-flood debriefing; and
- Training

3) Flood Early Warning

Probably because most of the telemetry stations of BBWS-S8 are out of order as described in Subsection 10.3.5, BBWS-S8 is hardly involved in the activities of early flood warning at present. According to BPBD, there are three warning levels, namely “Ready to go”, “Warning” and “Emergency”, and directions are propagated from the governor to the Provincial BPBD, and then from the Provincial BPBD to BPBDs at the regency/city level. BPBD receives disaster information including earthquake, flood and tsunami from BMKG, but nothing from BBWS-S8.

Accurate flood information such as river water level data and rainfall data is indispensable for ensuring appropriate and prompt response activities. As understood from Table 10.4.28, the development of flood early warning system is designated as one of the effort activities of the RENCANA 2017. It is strongly recommended that the development of flood early warning system be realized as proposed in the RENCANA and be sustainably operated and maintained.

4) Watershed Conservation

(a) Cause of flood occurrence caused by watershed management

In South Sumatra Province, forests are decreasing as the land use progresses. With the expansion of urban areas, farmland and plantations, the runoff of rainwater is promoted, and the runoff rate is increasing. As a result, a large amount of rainwater flows into the river in a short time, making the downstream prone to flooding.

The loss of the original forest makes it easy to generate surface flow. The direct impact of the raindrops on the soil and the increase in surface water velocity destroy the soil clod and induce runoff of soil particles. The soil that has flowed into the river causes the rise of the riverbed, causing a decrease in the discharge capacity and causes a flood. In general, it is known that the sediment tends to accumulate at a point where the river’s longitudinal slope changes where flood is likely to occur.

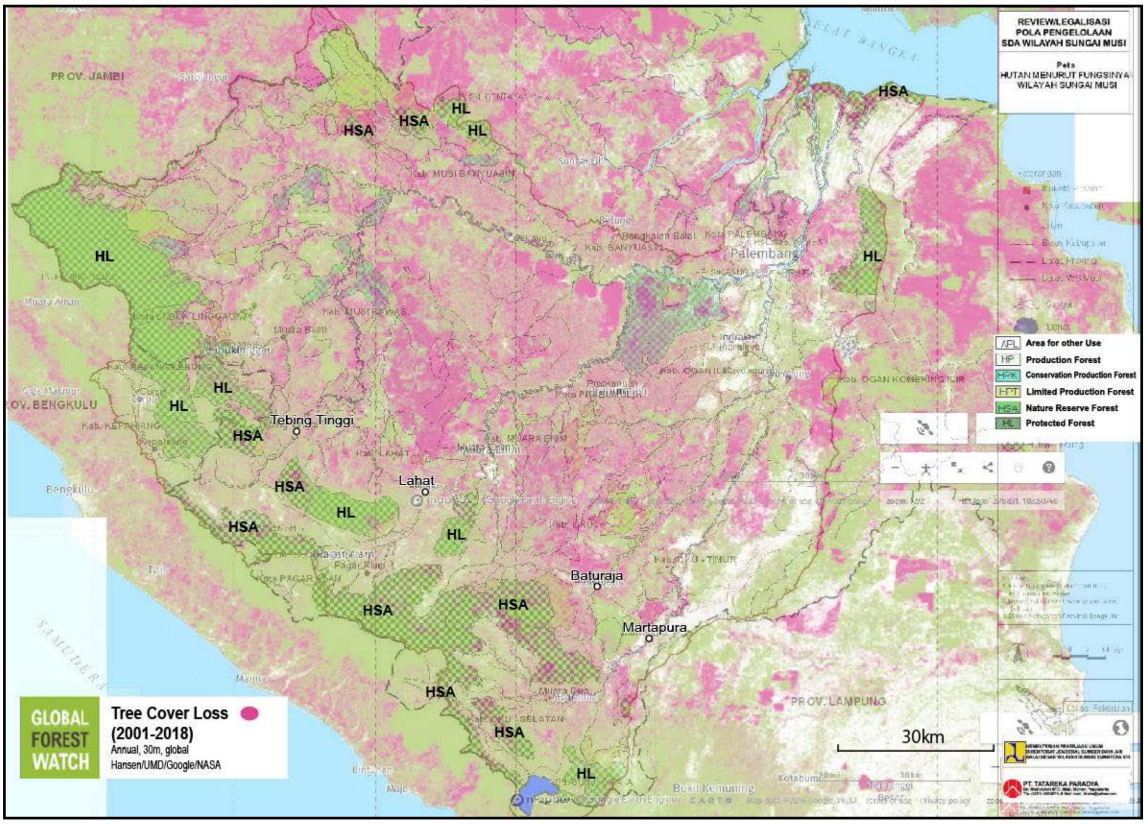
Continuous infrastructures such as roads and railways are often constructed parallel to the rivers. Originally, the flooded river water spreads out over the riverbanks, but if the spilling water is blocked by the embankment road or rail, or the culvert does not function well, the water level in the riverside area may reach a higher level than before. The water level may increase more rapidly, and as well as the flow of velocity. The Musi River basin, especially, due to the increase of population and development of plantation, may create new settlements may be created in places that used to be wetlands or in flood-prone areas such as old rivers. The old settlements are often located in relatively safe areas, but the newly developed areas, for some reasons that have not been used so far and may be the areas that are inherently vulnerable to floods.

(b) Relationship between Topographical Characteristics of the Musi River basin and Flooding

The watershed of the Musi River is generally a lowland below 50 meters above the sea level, which continues until up to 220 km inland, and from there to the ridge of the topmost Barisan Mountains has the characteristic of a mountainous area. Therefore, the flood-prone areas with flow velocity are limited to the mountainous region, and 'floods' in low plains are generally called inundation. Thus, the destructive force which needs to be concerned occurs in the upstream regions of Martapura (Komering River), Baturaja (Ogan River), Lahat (Lintang River), and Tebing Tinggi (Musi River). Notably, these areas have a higher population density than the middle reaches, which is one of the reasons why flood control is important.

(c) Countermeasure Plan for the Watershed

Article 16 of Forest Protection (No. 45/2004) stipulates that forests shall be restored by reforestation with fast-growing trees or crop species in hydraulically critical areas. Expanding the protected forest nature reserve forest area or prohibiting conversion of forest area to plantation area especially in slopes. The plantation practice of oil palm trees in the sloping area must not be the same as the practice in the flat terrain. Although returning the plantations to the forestland is the best practice, it is recommended to transform the ordinary palm plantation pattern to the mixed cultivation compulsory. A map of forest loss and areas of the protected forest in South Sumatra Province is shown in Figure 10.4.9.



Source: Global Forest Watch

Figure 10.4.9 Forest Cover Loss and Protected Forest (HL) and Nature Reserve Forest (HSA)

For the bare land after clear-cutting, it is recommended to implement measures against sediment runoff appropriate to the area so that rainwater does not wash the exposed topsoil.

The flood disaster inventory should be formed by utilizing data of the Regional Disaster Management Agency (BPBD). If the magnitude of flood disaster with the location and precise description on the circumstances including land use pattern in the upstream area, it can be used for analyzing the causes of the flood and can contribute for formulating countermeasures for the watershed area. Also, making a flooding map for the dangerous areas and make them known to residents and developers about the hazardous areas. The restricted areas for development can also be known to the developers and local regencies by using the map.

(d) Collaboration with Other Agencies

Many of the slope areas belonging to the Balisan Mountains are under the jurisdiction of the Provincial Forestry Department. The other agencies such as the Provincial Environmental Land Department (DLHP), BAPPEDA, the central government's Forest Management Center (BPDAS HL), and BPBD should also be invited to TKPSDA to agree on the new watershed protection measures which focus on reconstructing wholesome watershed area by new land use management.

10.4.2 Adaptation Measures against Droughts

(1) Issues in Droughts

The followings are conclusions of the water balance analysis in Subsection 9.5.1:

- As shown in Figure 9.5.1, in all the cases drought occurs only in upstream sub-basins, but there is no drought in middle and lower river basins. These water-short sub-basins include those of the Komering, Lematang, Kelingi and Lakitan Rivers where existing and proposed large-scaled irrigation intake facilities are concentrated.
- A few dam reservoirs have been planned/proposed for the water-short sub-basins of the Komering and Lematang Rivers. However, those of the Kelingi and Lakitan Rivers have no planned/proposed dam site.
- DMI water which is prioritized more than irrigation water in terms of water security will be secured almost 100% in all the climate change scenarios. However, almost all the deficit volume is for irrigation water.

Based upon the above-mentioned situations, the following adaptation measures are conceived for the Musi River basin. A combination of these measures should be taken comprehensively to address the uncertainty of climate change impact as well as to cope with the increasing water demand.

Table 10.4.4 Conceivable Adaptation Measures against Drought

Structural/ Non-structural	Measure	Expected effects
Structural	Dam reservoirs	Development of water resources
	Embung	Development of water resources
	Utilization of groundwater	Development of water resources
	Reduction of leakage from irrigation canals	Saving of irrigation water
	Reduction of non-revenue water (Leakage from DMI water)	Saving of irrigation water
	Recycling of industrial water	Saving of industrial water
	Rain harvesting	Development of water resources
Non-structural	Modification of operation of RRF	Development of water resources by lowering of water level of Ranau Lake
	Irrigation water demand management	Saving of DMI water
	DMI water demand management	Saving of DMI water
	Watershed conservation	Conservation of water resources

Source: JICA Project Team 2

(2) Structural Measures

1) Development of Dam Reservoirs

Focusing on the four river basins where water shortage is likely to occur, necessity and effectiveness of the proposed dam reservoirs are examined through water balance analysis. Each of the four river basins has a water supply target as presented in Table 10.4.5. The water balance analysis aims to check if the target is attained or not by the proposed dam reservoirs.

Table 10.4.5 Water Supply Targets in 2050

Period	River Basin	Catchment Area (km^2)	Irrigation Water Supply				DMI Water Supply	
			Irrigation Area* (ha)			Safety Level (%)	Water Demand** (m^3/s)	Safety Level (%)
			MH	MK1	MK2			
Present	Komering	9,725	74,717	64,221	30,847	80	0.18	90
	Lematang	7,608	50,860	16,095	4,786	80	0.31	90
	Kelingi	1,931	12,387	8,470	3,848	80	0.29	90
	Lakitan	2,784	12,634	10,786	5,237	80	0.17	90
	Total	22,048	150,597	99,573	44,718	80	0.95	90
Future Target (2050)	Komering	9,725	98,208	87,712	42,593	80	2.92	90
	Lematang	7,608	55,160	29,518	12,392	80	2.60	90
	Kelingi	1,931	15,387	11,470	5,348	80	1.04	90
	Lakitan	2,784	12,634	10,786	5,237	80	0.62	90
	Total	22,048	181,388	139,487	65,569	80	7.18	90

Note: *: Estimated based on the assumptions in Table 10.4.18.
**: NRW is included.
Source: JICA Project Team 2

There are two planned dam reservoirs in the Komering River basin. The Tiga Dihaji Dam of which purposes are supply of DMI and irrigation water and hydropower generation have been under construction since 2019 which is expected to be completed in 2022. The Saka Dam has been also planned for the purposes of DMI and irrigation water and hydropower generation in the feasibility study in 2013. In addition to these two dam reservoirs, the modification of the operation of RRF (Ranau Regulating Facility) is also expected to contribute very much to the mitigation of the water shortage in this river basin as explained in Subsection 10.2.2, although its environmental issues are yet to be cleared.

In the Lematang River basin there are a planned dam and two proposed dam sites that might be effective for the mitigation of the water shortage in the river basin. For the Padang Bindu Dam a pre-feasibility study was conducted in 2015, but almost no study has been conducted for the Tanjung Agung and Panjung Dams. Their approximate locations are only indicated as the potential hydropower dam sites in some documents of BBWS-S8.

In the Kelingi and Lakitan River basins, which are also vulnerable to water shortage, there are no planned/proposed dam sites, unfortunately.

In order to evaluate the effect of these dam reservoirs and then to establish long-term strategies for the water resources development in the Musi River basin, water balance analysis is conducted under the conditions presented in Table 10.4.7.

Table 10.4.6 Planned/Proposed Dam Reservoirs

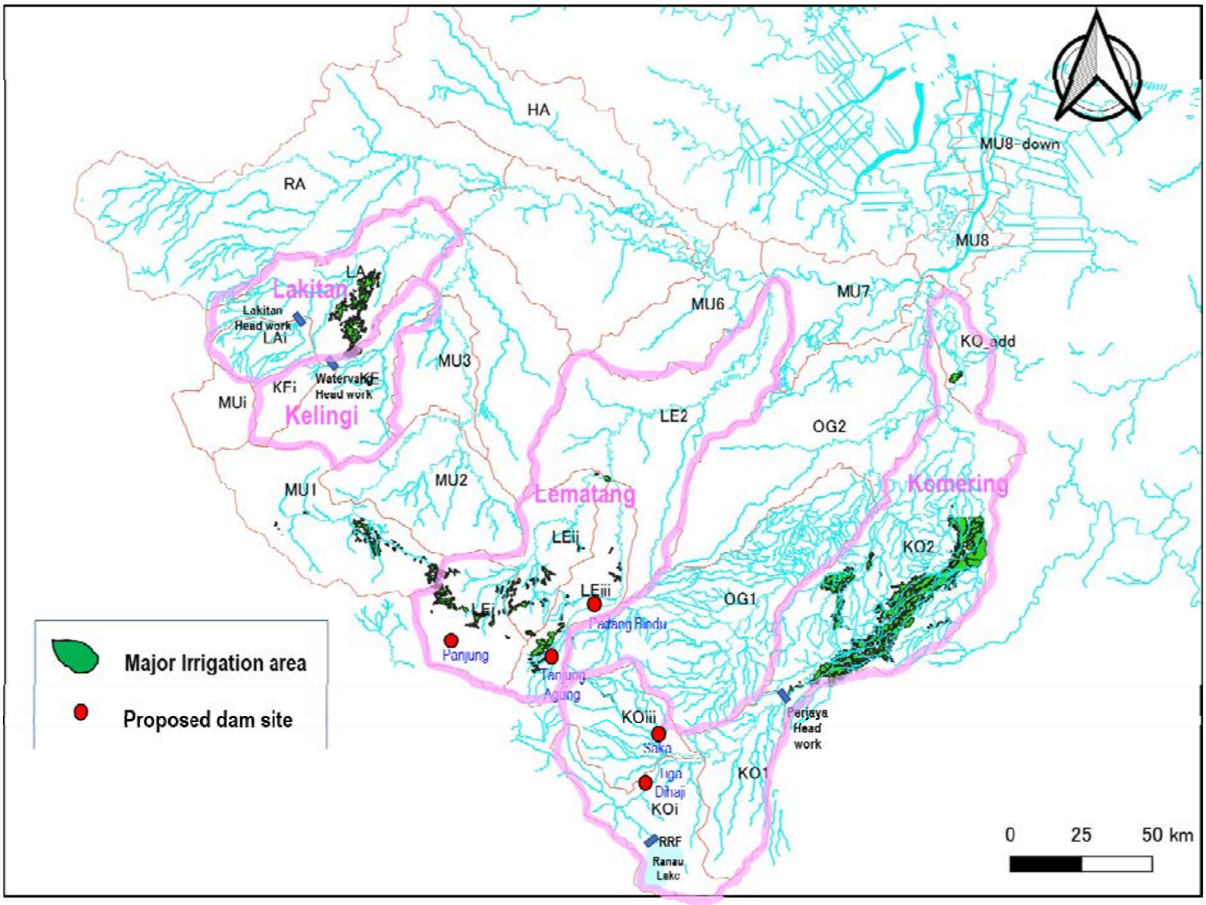
Sub-river system	Name of dam	Purpose	River	Catchment Area (km^2)	Type of Dam	Dam Height (m)	Total Storage Volume (MCM)	Effective Storage Volume (MCM)	Present Status
Komering	Tiga Dihaji	DMI water, irrigation and hydropower	Komering River	1,156	Rock-fill	122	106	65	Under construction since 2019
	Saka	DMI water, irrigation, and hydropower	Saka River	386	Rock-fill	75	43	20	F/S completed in 2013
Lematang	Padang Bindu	DMI water, irrigation and hydropower	Enim River	468	Rock-fill with center core	109	110	53	Pre-F/S completed in 2015
	Tanjung Agung*	Hydropower		226	Not Specified	130	80	43	Potential dam
	Panjung*	Hydropower	Lahat River	220	Not specified	170	150	106	Potential dam

Note: *: The two potential dams, Tanjung Agung Dam and Panjung Dam are very roughly designed based on SRTM DEM data.
Source: BBWS-S8 and JICA Project Team 2

Table 10.4.7 Conditions of Water Balance Analysis

Item	Condition
Analysis Area	Komering River basin: 9,725km^2, Lematang River basin: 7,608 km^2, Kelingi River basin: 1,931 km^2, Lakitan River basin: 2,784 km^2
Calculation Period	Present Case: 15 years from (October 1985 to September 2000), Future Case: 15 years (October 2050 to September 2065)
Discharge Data	Runoff Analysis Data provided by JICA Project Team 1 are used.
Water Demand	DMI Water Demand and Irrigation Water Demand are considered. Newly estimated irrigation demand explained in Table 10.4.18 are used as the Irrigation Water Demand.
Calculation Unit Time	10 days
River Maintenance Flow	Maintenance flow is set up for Downstream of RRF: 11.7m^3/s, Downstream of Perjaya Headwork:35m^3/s for rainy season and 25 m^3/s for dry season Downstream of dam sites: 95% discharge of duration curve of natural flow.
Hydropower Generation at Dams	Hydropower generation is considered for Tiga Dihaji and Saka Dams and the small hydropower station just downstream of RRF but not considered for the three dams in Lematang River basin because information is insufficient.

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 10.4.10 Location of Planned/Proposed Dam Sites and Major Irrigation Areas

(a) Komering River Basin

Results of the water balance analysis are summarized in Table 10.4.8. Figure 10.4.11 compares the water deficits at the Perjaya Headwork to grasp how much the water deficit could be reduced by the two new dam reservoirs and the proposed operation of RRF, of which operations are shown in Figure 10.4.12. From the table and the figures, the following considerations are made:

- The water deficit at Perjaya Headwork will be reduced considerably by the three measures, i.e., Tiga Dihaji Dam, Saka Dam and the modification of the RRF operation. However, some more measures are necessary to completely reduce it to the required safety level (90% for DMI water and 80% for irrigation water) or zero.
- Low scenario seems to be more severe in terms of the sufficiency rates and the deficit volume than Medium scenario.
- The water shortage affects the irrigation water, while the DMI water sufficiency rate is almost a 100% in all the cases.

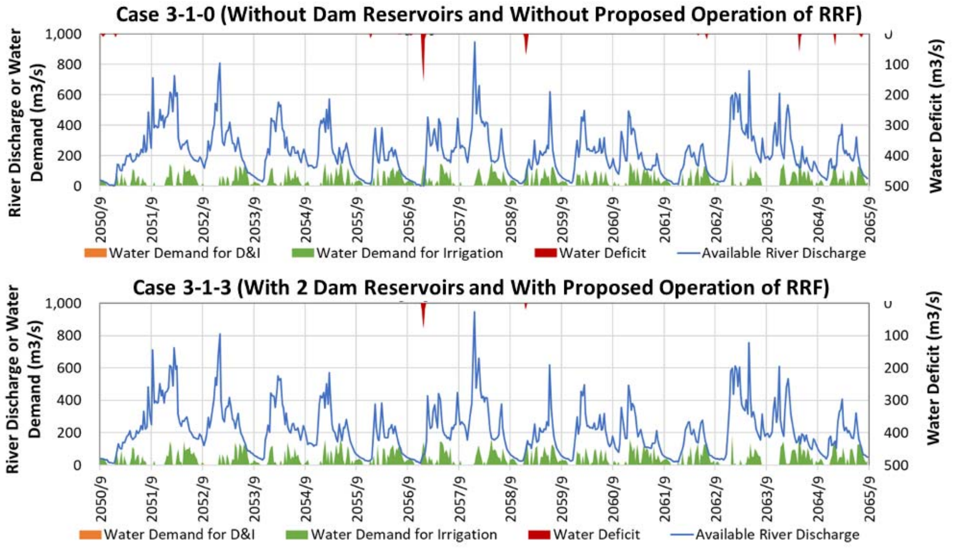
Table 10.4.8 Results of Water Balance Simulation for Komering River Basin

Case No.	Scenario	Irrigation Area	Dam Reservoir		RRF Operation	DMI Sufficiency Rate	Irrigation Sufficiency Rate			Deficit (MCM/yr)	Frequency of Drought Year	Power Generation (10^6 kWh/yr)
			Tiga Dihaji	Saka			MH	MK1	MK2			
1-1	Present	Present	No	No	No	100.0%	91.9%	92.2%	97.4%	51.4	80.0%	9.39
2-0	Low	Present	No	No	No	99.9%	92.0%	94.4%	98.7%	63.2	53.3%	30.6
2-1-0	Low	Future	No	No	No	100.0%	90.9%	87.5%	96.6%	113.3	73.3%	61.2
2-1-1	Low	Future	Yes	No	No	100.0%	90.9%	92.0%	97.5%	84.8	73.3%	543.9
2-1-2	Low	Future	Yes	No	Yes	99.9%	93.9%	96.1%	95.5%	69.4	73.3%	544.4
2-1-3	Low	Future	Yes	Yes	Yes	99.9%	93.8%	95.4%	95.5%	67.8	60.0%	631.0
3-0	Medium	Present	No	No	No	99.9%	90.0%	99.2%	100.0%	43.6	66.7%	24.8
3-1-0	Medium	Future	No	No	No	100.0%	85.6%	96.3%	97.6%	61.3	86.7%	49.6
3-1-1	Medium	Future	Yes	No	No	100.0%	91.6%	100.0%	100.0%	32.0	80.0%	448.3
3-1-2	Medium	Future	Yes	No	Yes	100.0%	95.7%	100.0%	100.0%	18.9	80.0%	448.3
3-1-3	Medium	Future	Yes	Yes	Yes	100.0%	95.9%	100.0%	100.0%	10.5	40.0%	520.1
4-0	High	Present	No	No	No	99.8%	73.7%	93.5%	97.7%	107.2	80.0%	22.4
4-1-0	High	Future	No	No	No	99.9%	70.8%	87.6%	95.9%	152.3	93.3%	44.8
4-1-1	High	Future	Yes	No	No	99.9%	79.1%	93.3%	96.8%	101.9	93.3%	404.8
4-1-2	High	Future	Yes	No	Yes	99.9%	86.0%	98.6%	93.1%	76.5	93.3%	404.9
4-1-3	High	Future	Yes	Yes	Yes	99.9%	84.8%	98.5%	94.8%	61.8	73.3%	470.5

Note: DMI Water Sufficiency rate (%) = Supplied Water/Water Demand

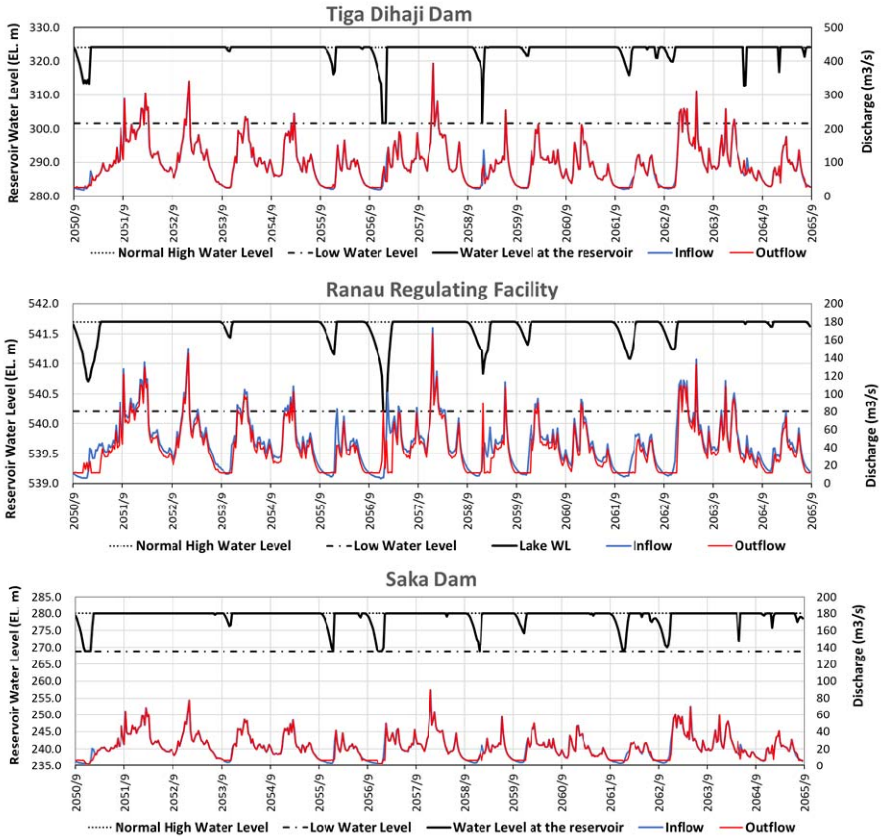
Irrigation Water Sufficiency Rate (%) = Average of Annually Minimums of Values of Supplied Water/Water Demand

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 10.4.11 Comparison of Water Deficit at Perjaya Headwork



Source: JICA Project Team 2

Figure 10.4.12 Operation of Tiga Dihaji and Saka Dam Reservoirs and RRF (Case 3-1-3)

(b) Lematang River Basin

Regarding the Padang Bindu Dam of which a pre-feasibility study was already conducted in 2015, basic information such as dam height, reservoir capacity, and dam dimensions was obtained and utilized for this Project. However, almost no information on the two potential dams, Tanjung Agung and Panjung except for their approximate locations. So the JICA Project Team 2 designed the two potential dams very roughly as the topographically allowably highest dams, based on SRTM DEM data only for the water balance analysis and the cost estimation for the economic analysis in Subsection 10.5.4. Therefore, it should be noted that the JICA Project Team 2 cannot guarantee the viability of the two potential dam sites.

Results of the water balance analysis are summarized in Table 10.4.9. Figure 10.4.13 compares the water deficits in the LEi Sub-river basin to check how much the water deficit could be reduced by the three new dam reservoirs, of which operations are shown in Figure 10.4.14. From the table and the figures the following considerations are made:

- The water deficit in the Lematang River basin as well as at the sub-basin LEi will be eliminated by the three dams.
- As seen in Figure 10.4.14, however, the large storage volumes of the three dams are not fully used. Their reservoir water levels have never been even once lowered to the Low Water Levels (LWLs) in the 15 years. The reservoir capacities are too

large compared with the water demands. It is suggested that more realistic and effective dam reservoirs be planned based on more detailed surveys including a geological survey.

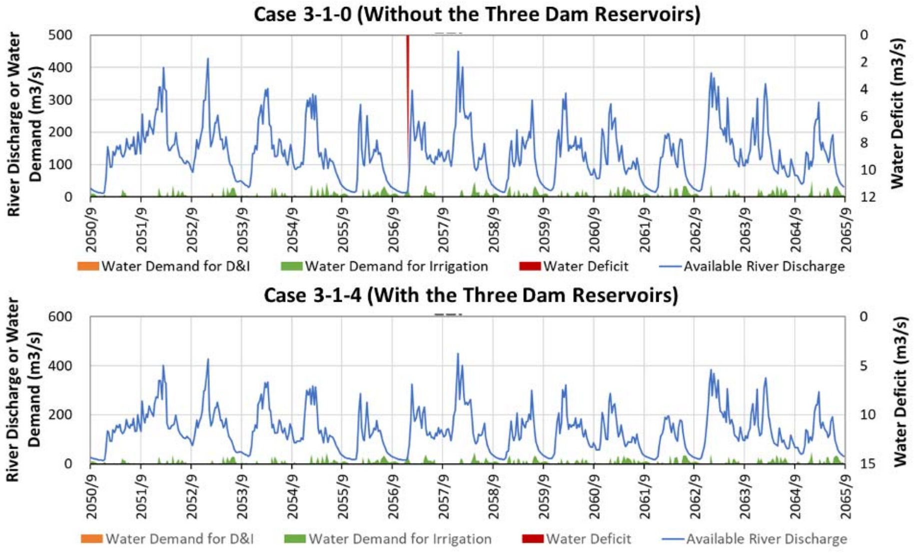
- The medium scenario seems to be the most severe in terms of sufficiency rates and deficit volume among the three scenarios.
- The water shortage affects the irrigation water, while the DMI water sufficiency rate is almost a 100% in all the cases.

Table 10.4.9 Results of Water Balance Simulation for Lematang River Basin

Case No.	Scenario	Irrigation Area	Dam Reservoir			DMI Sufficiency Rate	Irrigation Sufficiency Rate			Deficit (MCM/yr)	Frequency of drought year
			Padang Bindu	Tanjung Agung	Panjung		MH	MK1	MK2		
1-1	Present	Present	No	No	No	100.0%	88.2%	93.7%	98.5%	44.4	93.3%
2-0	Low	Present	No	No	No	100.0%	94.2%	97.1%	100.0%	13.9	86.7%
2-1-0	Low	Future	No	No	No	99.5%	99.9%	100.0%	99.2%	7.0	46.7%
2-1-1	Low	Future	Yes	No	No	99.6%	99.9%	100.0%	99.5%	4.5	46.7%
2-1-2	Low	Future	Yes	Yes	No	99.8%	99.9%	100.0%	99.8%	3.2	46.7%
2-1-3	Low	Future	Yes	No	Yes	99.9%	100.0%	100.0%	99.7%	1.3	33.3%
2-1-4	Low	Future	Yes	Yes	Yes	100.0%	100.0%	100.0%	100.0%	0.0	0.0%
3-0	Medium	Present	No	No	No	100.0%	93.0%	98.5%	100.0%	33.9	86.7%
3-1-0	Medium	Future	No	No	No	98.5%	97.2%	100.0%	98.6%	31.8	60.0%
3-1-1	Medium	Future	Yes	No	No	99.1%	97.8%	100.0%	99.2%	16.3	60.0%
3-1-2	Medium	Future	Yes	Yes	No	99.5%	98.5%	100.0%	99.7%	8.7	60.0%
3-1-3	Medium	Future	Yes	No	Yes	99.5%	99.3%	100.0%	99.5%	7.6	60.0%
3-1-4	Medium	Future	Yes	Yes	Yes	100.0%	100.0%	100.0%	100.0%	0.0	0.0%
4-0	High	Present	No	No	No	100.0%	81.6%	92.9%	96.5%	63.5	100.0%
4-1-0	High	Future	No	No	No	98.5%	98.3%	99.5%	98.4%	26.1	66.7%
4-1-1	High	Future	Yes	No	No	99.1%	98.7%	99.7%	99.1%	13.8	66.7%
4-1-2	High	Future	Yes	Yes	No	99.5%	99.2%	99.9%	99.6%	7.6	66.7%
4-1-3	High	Future	Yes	No	Yes	99.5%	99.6%	99.8%	99.4%	6.2	66.7%
4-1-4	High	Future	Yes	Yes	Yes	100.0%	100.0%	100.0%	100.0%	0.0	0.0%

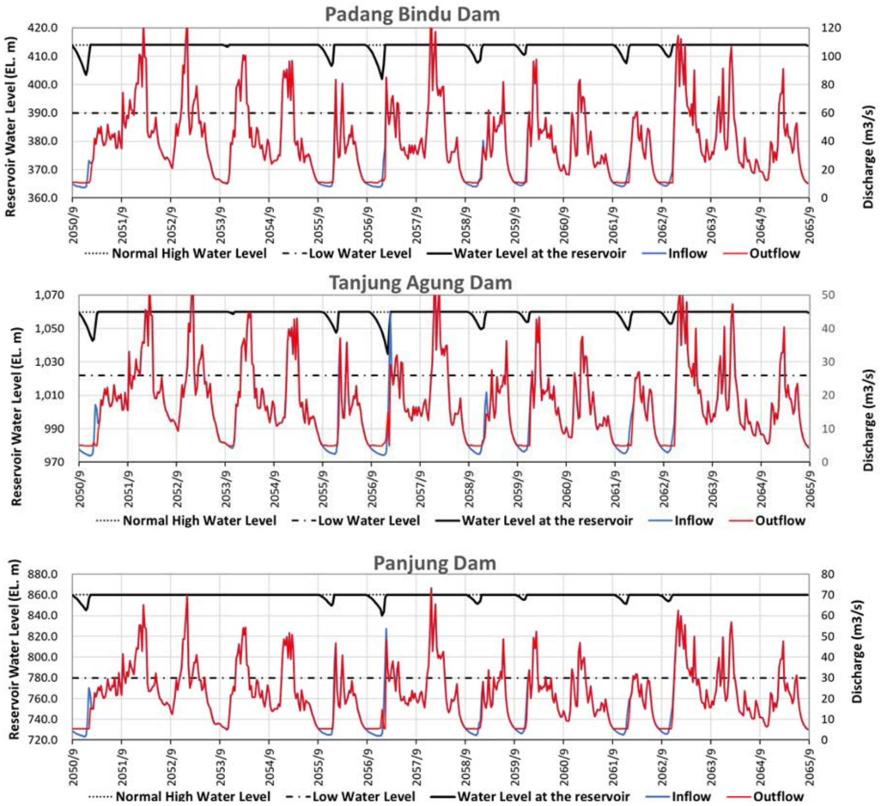
Note: DMI Water Sufficiency rate (%) = Supplied Water/Water Demand
Irrigation Water Sufficiency Rate (%) = Average of Annually Minimums of Values of Supplied Water/Water Demand

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 10.4.13 Comparison of Water Deficit in Sub-basin LEi



Source: JICA Project Team 2

Figure 10.4.14 Operation of Padang Bindu, Tanjung Agung and Panjung Dam Reservoirs

(c) Kelingi and Lakitan River Basins

There is no planned/proposed dam site in the Kelingi and Lakitan River basins, although water shortage is anticipated according to the water balance analysis. A water balance analysis is conducted to assess the climate change impact on water use for the two river basins.

Results of the water balance analysis are summarized in Table 10.4.10 and Table 10.4.11. Figure 10.4.15 and Figure 10.4.16 compare the water deficits in the sub-rivers, KEi and LAi. From these tables and figures the following considerations are made:

- For both two river basins Medium scenario is the most severe scenario in terms of the sufficiency rates and the deficit volume among the three scenarios.
- In the Kelingi River basin irrigation water shortage will occur in all the scenarios.
- In High scenario of the Lakitan River basin no water shortage will occur. However, the irrigation water shortage will occur in Low and Medium scenarios.

Table 10.4.10 Results of Water Balance Simulation for Kelingi River Basin

Case No.	Scenario	Irrigation Area	DMI Sufficiency Rate	Irrigation Sufficiency Rate			Deficit (MCM/yr)	Frequency of drought year (%)
				MH	MK1	MK2		
1-1	Present	Present	100.0%	88.0%	96.7%	100.0%	6.0	60.0%
2-0	Low	Present	100.0%	93.3%	100.0%	100.0%	2.1	26.7%
2-1-0	Low	Future	100.0%	94.3%	100.0%	100.0%	1.6	26.7%
3-0	Medium	Present	100.0%	58.5%	78.4%	98.0%	42.5	93.3%
3-1-0	Medium	Future	100.0%	60.7%	81.2%	98.4%	35.9	93.3%
4-0	High	Present	100.0%	94.6%	99.5%	100.0%	1.4	33.3%
4-1-0	High	Future	100.0%	95.8%	99.9%	100.0%	0.9	33.3%

Note: DMI Water Sufficiency rate (%) = Supplied Water/Water Demand
Irrigation Water Sufficiency Rate (%) = Average of Annually Minimums of Values of Supplied Water/Water Demand

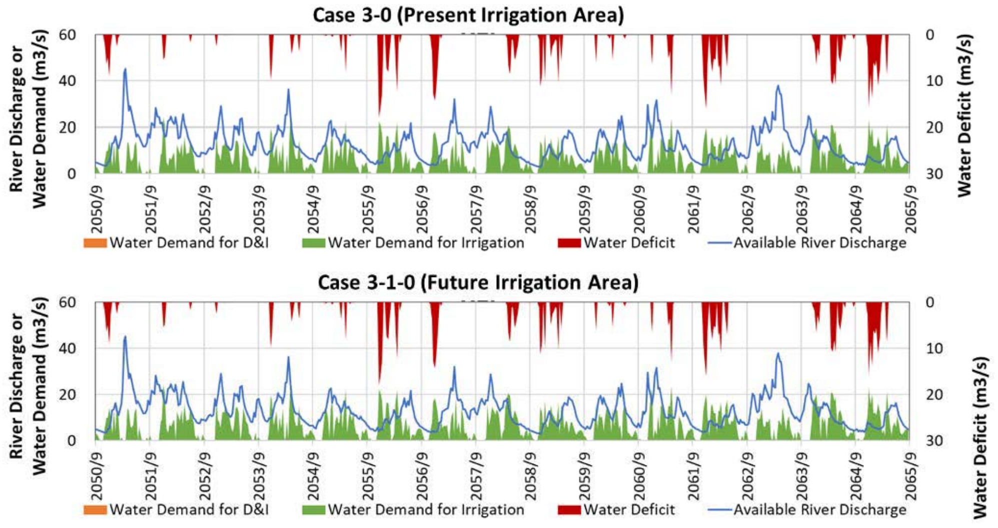
Source: JICA Project Team 2

Table 10.4.11 Results of Water Balance Simulation for Lakitan River Basin

Case No.	Scenario	Irrigation Area	DMI Sufficiency Rate (%)	Irrigation Sufficiency Rate (%)			Deficit (MCM/yr)	Frequency of drought year (%)
				MH	MK1	MK2		
1-1	Present	Present	100.0%	97.4%	100.0%	100.0%	0.7	26.7%
2-0	Low	Present	100.0%	99.1%	100.0%	100.0%	0.1	6.7%
2-1-0	Low	Future	100.0%	99.6%	100.0%	100.0%	0.1	6.7%
3-0	Medium	Present	100.0%	78.9%	94.4%	100.0%	14.5	80.0%
3-1-0	Medium	Future	100.0%	84.8%	96.6%	100.0%	11.0	73.3%
4-0	High	Present	100.0%	100.0%	100.0%	100.0%	0.0	0.0%
4-1-0	High	Future	100.0%	100.0%	100.0%	100.0%	0.0	0.0%

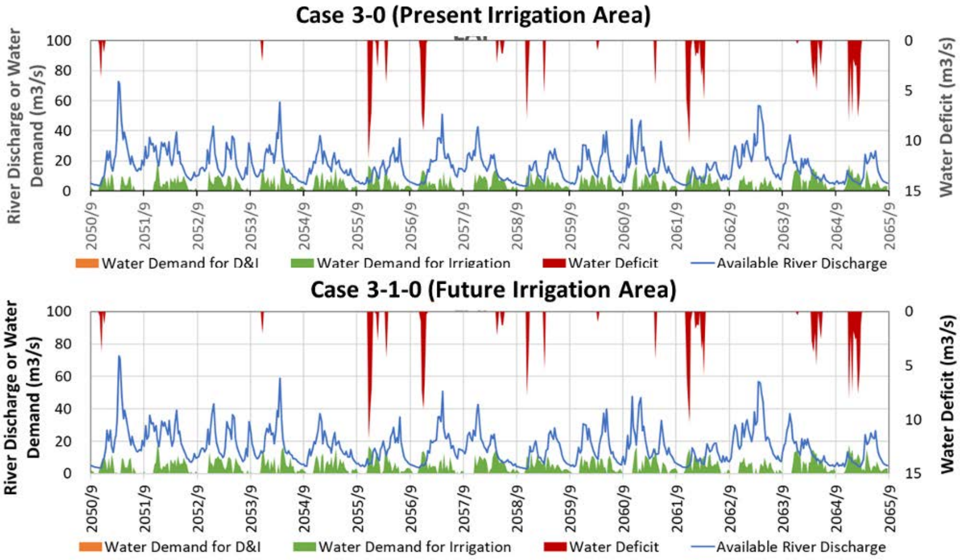
Note: DMI Water Sufficiency rate (%) = Supplied Water/Water Demand
Irrigation Water Sufficiency Rate (%) = Average of Annually Minimums of Values of Supplied Water/Water Demand

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 10.4.15 Comparison of Water Deficit in Sub-basin KEi (Watervang Headwork)



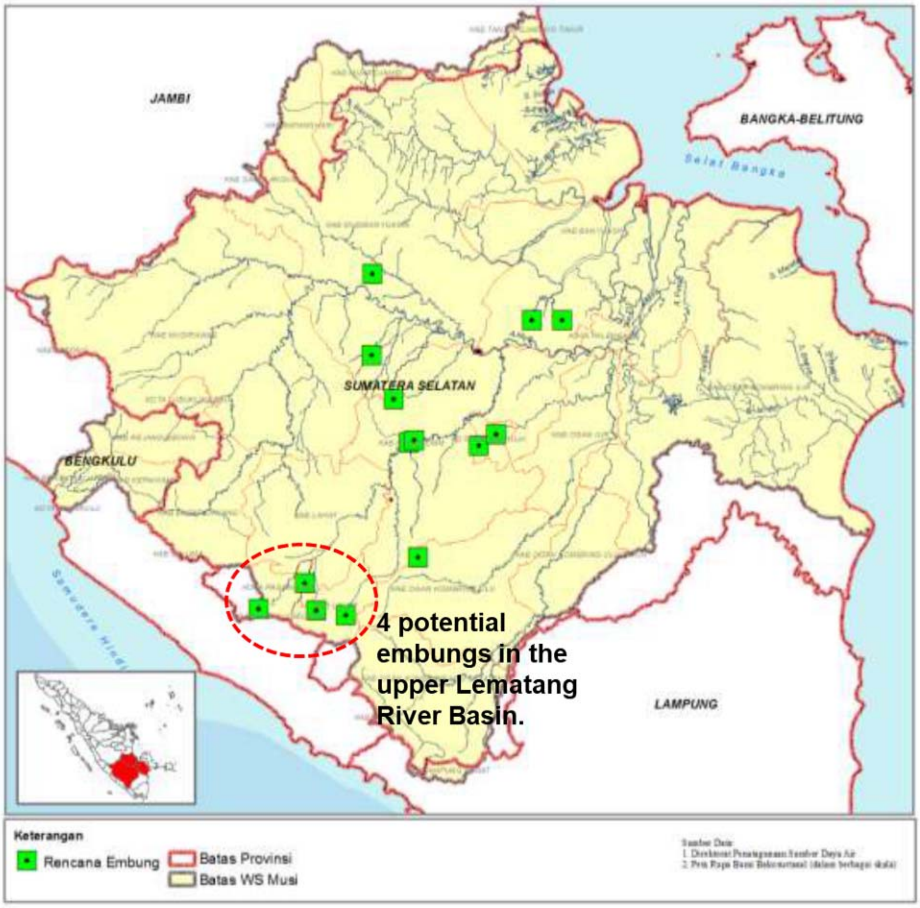
Source: JICA Project Team 2

Figure 10.4.16 Comparison of Water Deficit in Sub-basin LAi (Lakitan Headwork)

2) Development of Embungs

The embung (pond) is a small reservoir which can reserve excessive water in the rainy season and utilize it in the dry season. The embung is utilized for many purposes, such as providing water for agricultural purposes, fishery, and household needs.

The embung, which are generally constructed with less cost and conventional technologies, has a potential to be an alternative of large dam reservoirs. Environmental and social impacts of embungs are much less than those of dam reservoirs. BBWS-S8 has identified potential embungs as shown in Figure 10.4.17. According to the figure, there are four potential embung sites in the upper Lematang River basin. If these embungs are constructed, they might contribute to mitigation of water shortage in the Lematang River basin in a more efficient manner than the planned/proposed dam reservoirs. In the Kelingi and Lakitan River basins where no dam site has been identified yet, the embungs could be one of alternative solutions against water shortage. From this point of view it is recommended that site survey for embungs as well as dam reservoirs be conducted.



4 potential embungs in the upper Lematang River Basin.

Source: RENCANA 2017

Figure 10.4.17 Location of Potential Embung Sites

3) Utilization of Groundwater

Table 10.4.12 shows groundwater use in the Musi River basin based on existing data. The ratio of groundwater use to the total water use in the Musi River basin is only about 2%. Even if economic growth in Indonesia after 2003 is taken into consideration, it is estimated to be 10% or less.

Table 10.4.12 Total Water Use and Groundwater Use

Utilization	A: Water Use ($\times$1000m^3/y)	B: Groundwater Use		B / A (%)
		($\times$1000m^3/y)	(%)	
Domestic	101,000	8,168	7.2%	8.1
Industrial	377,000	66,892	58.6%	17.7
Mining	115,000	30,617	26.8%	26.6
Irrigation	2,760,000	92	0.1%	0.0
Swamp Area	1,961,000	-	-	-
Aquaculture	514,000	265	0.2%	0.1
Tourism	150	-	-	-
Livestock	17,400	8,045	7.1%	46.2
Hydropower	0	0	0.0%	0.0
Total	5,845,550	114,079	100.0%	2.0

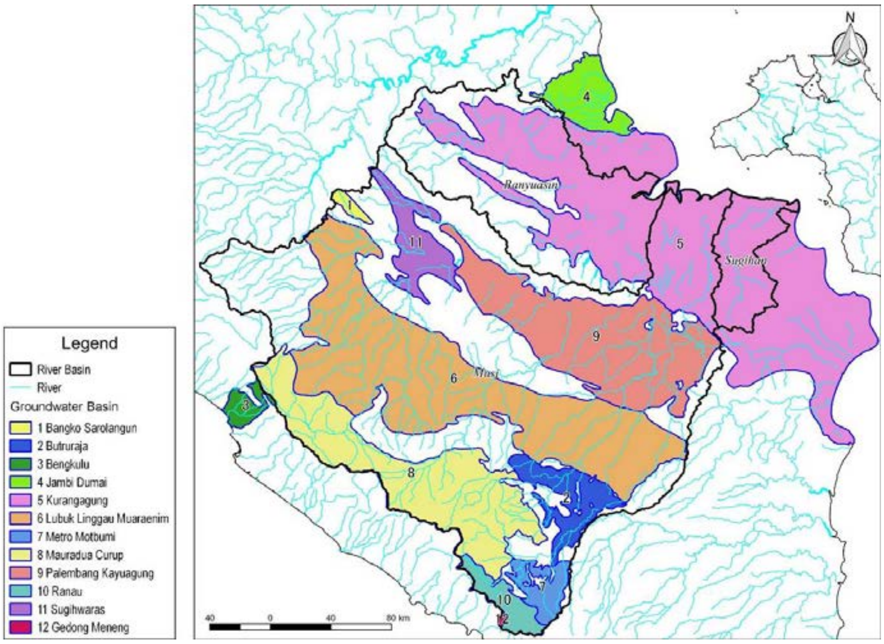
Source: The Study on Comprehensive Water Management of Musi River Basin in the Republic of Indonesia (2003), JICA

The possible reasons are as follows:

- The current water demand should be met with surface water.
- In Palembang, the largest city of Musi River basin, the groundwater has high concentration of Iron ion and it is not suitable to be used.

However, when considering the future increase in water demand and the change in water resources balance under climate change, it is necessary to estimate the present groundwater potential and its changes in the future.

The groundwater basin was established by the Indonesian government in accordance with Presidential Decree No. 26 of 2011. Twelve groundwater basins shown in Figure 10.4.18 is located to the Musi River basin, but some basins are only part of the whole basin may be included in the Musi River basin. The study of groundwater potential by Badan Geologi had been carried out before the Presidential Decree was issued. This published groundwater potential of each groundwater basin by Badan Geologi related to the Musi River basin is shown in Table 10.4.13 and the groundwater potential in the Musi River basin was calculated using this value. The total amount of the present groundwater potential was estimated to be 25,841million m^3/y.



Source: JICA Project Team 2

Figure 10.4.18 Groundwater Basin in Musi River Basin

Table 10.4.13 Present Groundwater Potential by Groundwater Basin

No.	Groundwater Basin	Area	Groundwater Potential		Musi River Basin Area	Groundwater Potential
		(km^2)	(million m^3/y)	(mm/y)	(km^2)	(million m^3/y)
1	Bangko Sarolangun	6,072	4,221	695	231	161
2	Butruraja	2,404	1,151	479	1,838	880
3	Bengkulu	4,888	3,836	785	18	14
4	Jambi Dumai	69,776	20,401	292	7	2
5	Kurangagung	22,860	12,977	568	14,655	8,319
6	Lubuk Linggau Muaraenim	15,400	6,062	394	14,937	5,880
7	Metro Motbumi	21,640	12,331	570	994	567
8	Mauradua Curup	8,521	4,389	515	7,847	4,042
9	Palembang Kayuagung	8,652	3,759	434	8,592	3,733
10	Ranau	1,501	934	622	997	620
11	Sugihwaras	1,794	1,549	863	1,853	1,600
12	Gedong Meneng	1,412	1,185	839	29	24
Total (Average)		164,920	72,795	(441)	51,997	25,841

Source: JCA Project Team 2

The following method was used to estimate the future groundwater potential:

- Calculate the ratio (%) of present groundwater potential to present effective rainfall.
- In the case of forecasting, the effective rainfall of each scenario is multiplied by above ratio (%) to estimate the amount of groundwater potential.

The ratio of present groundwater potential to the present effective rainfall is shown in Table 10.4.14. Since “4. Jambi Dumai” was not included in the analysis and examination area by the JICA Project Team 1, the result of “5. Karangagung” was used, which is assumed to be almost the same hydrological environment. The climate change scenarios were selected using effective rainfall. The detailed process of the selection of climate change scenarios is presented in the Supporting Report C. Finally, the three scenarios were adopted: GFDL_2_1 as High scenario, MIUB_ECHO as Medium scenario, and GFDL_2_0 as Low scenario.

Table 10.4.14 Ratio of Present Groundwater Potential to Present Effective Rainfall

No.	Groundwater Basin	Musi Area (km^2)	A: R-ET (Historical) (mm/y)	B: Present Potential (mm/y)	Ratio (B / A) (%)
1	Bangko Sarolangun	231	1,370	695	51
2	Butruraja	1,838	1,563	479	31
3	Bengkulu	18	1,723	785	46
4	Jambi Dumai*	7	1,578	292	19
5	Kurangagung	14,655	1,578	568	36
6	Lubuk Linggau Muaraenim	14,937	1,703	394	23
7	Metro Motbumi	994	1,596	570	36
8	Mauradua Curup	7,847	1,710	515	30
9	Palembang Kayuagung	8,592	1,513	434	29
10	Ranau	997	1,653	622	38
11	Sugihwaras	1,853	1,503	863	57
12	Gedong Meneng	29	1,653	839	51
Total (Average)		51,997	(1,638)	(441)	(27)

Note: * : Substitution of "Karangagung" data because of no available data from the JICA Project Team 1
Source: JICA Project Team 2

With the exception of High scenario, the average rainfall in the Musi River groundwater basin area will increase more than present, but the increase in evapotranspiration caused by temperature rise will exceed the increase in rainfall, and the effective rainfall will eventually decrease. The amount of groundwater potential (groundwater recharge) may decrease under climate change in the future. However, it is considered that large amount of groundwater resource to be able to develop still exists in the Musi River basin.

Table 10.4.15 Groundwater Potential in Future and Change from Present

No.	Groundwater Basin Name	Historical Potential (million m^3/y)	Future Potential (million m^3/y)			Change (million m^3/y)		
			High	Medium	Low	High	Medium	Low
1	Bangko Sarolangun	161	156	182	195	-4	21	34
2	Butruraja	880	926	870	900	46	-10	20
3	Bengkulu	14	10	14	15	-4	-0	0
4	Jambi Dumai*	2	1	1	2	-1	-1	-0
5	Kurangagung	8,319	6,014	5,986	6,823	-2,305	-2,333	-1,496
6	Lubuk Linggau Muaraenim	5,880	5,043	5,496	5,824	-837	-384	-56
7	Metro Motbumi	567	653	577	607	86	10	41
8	Mauradua Curup	4,042	3,347	3,843	3,981	-694	-199	-61
9	Palembang Kayuagung	3,733	3,132	3,454	3,727	-601	-279	-6
10	Ranau	620	715	629	652	95	9	31
11	Sugihwaras	1,600	1,399	1,645	1,786	-201	45	186
12	Gedong Meneng	24	28	24	25	4	0	1
Total		25,841	21,425	22,721	24,536	-4,417	-3,120	-1,306

Note: * : Substitution of "Karangagung" data because of no available data from the JICA Project Team 1
Source: JICA Project Team 2

4) Reduction of NRW

In order to indicate the effectiveness of water saving by non-revenue water (NRW) reduction activities, the water supply volumes required for meeting net demands in the four sub-basins taken up in the previous section are shown in the table below, for the following two cases.

Case-1: Achievement of the target NRW reduction

Case-2: No NRW reduction activities (NRW ratio in 2015 is not improved.)

A major reason for the increase of net water demand without considering the loss due to NRW is the increase of PDAM coverage. PDAM water supply is presumed to mainly cover an urban area. In terms of distribution of urban population, the water demand projection in this project is conducted assuming that the urban population ratio to the total population of a city/regency is not changed from years 2010 to 2050, that is the population of an existing urban area which increases year by year raising up the population density and expanding the urban area to the outskirt.

When considering the future development of the water supply pipe network in the PDAM coverage area, it is assumed the pipe network is developed following the population increase and the expansion pattern of urban area as discussed above. It is apparent that the future pipe network will be constructed based on the existing pipe network keeping close linkage with them. The existing pipe network will still be an important part of the future pipe network.

Therefore, as calculated in the above table, it might be necessary to produce around 1.5 to 2 times more volume of supply water for meeting the water demand in 2050 if no NRW reduction activities are conducted. It is an effective measure for saving water (equivalent to the capacity of a medium to large-scale water treatment plant) and adapting the drought impact to water supply works.

Table 10.4.16 Effectiveness of NRW Reduction Activities

(Unit: m^3/day)

Year	2015	2020	2025	2030	2035	2040	2045	2050
Komering Sub-system 5								
Target NRW Ratio (%)	60	46	39	35	31	28	25	23
Net Demand	6,167	27,464	51,334	77,523	105,360	134,257	164,013	194,600
Required Supply (Case-1)	15,411	50,393	84,794	119203	153,278	186,710	219,616	252,221
Required Supply (Case-2)	15,411	68,631	128,281	193,726	263,289	335,501	409,860	486,295
Supply Difference	0	18,238	43,487	74,523	110,011	148,791	190,244	234,074
Lematang Sub-system 5								
Target NRW Ratio (%)	29	29	28	26	25	23	22	21
Net Demand	18,748	35,313	54,686	76,457	100,302	125,643	151,785	178,698
Required Supply (Case-1)	26,366	49,563	75,515	103,584	133,261	163,786	194,296	224,805
Required Supply (Case-2)	26,366	49,563	76,907	107,524	141,058	176,696	213,461	251,310
Supply Difference	0	0	1,392	3,940	7,797	12,910	19,165	26,505
Lakitan Sub-system 2								
Target NRW Ratio (%)	58	50	44	40	36	32	29	25
Net Demand	6,166	10,622	15,370	20,326	25,387	30,390	35,134	39,657
Required Supply (Case-1)	14,577	21,202	27,589	33,677	39,451	44,712	49,240	53,215
Required Supply (Case-2)	14,577	25,111	36,336	48,053	60,017	71,845	83,060	93,753
Supply Difference	0	3,909	8,747	14,376	20,566	27,133	33,820	40,538
Kelingi Sub-system 2								
Target NRW Ratio (%)	52	47	43	39	36	33	30	27
Net Demand	12,046	18,940	26,146	33,910	41,770	50,006	57,986	65,606
Required Supply (Case-1)	24,843	35,487	45,592	55,608	64,998	74,195	82,394	89,627
Required Supply (Case-2)	24,843	39,061	53,922	69,934	86,144	103,130	119,587	135,302
Supply Difference	0	3,574	8,330	14,326	21,146	28,935	37,193	45,675

Source: JICA Project Team 2

5) Recycling of Industrial Water

In terms of the volume around 80 % of supplied water is generally estimated to be discharged into the river or sea as wastewater. Therefore, if the wastewater can be utilized again as recycled water after treating, it would be an effective adaptation measure against future critical drought impact. However, construction of a recycling water system is subject to availability of a sewerage system, including wastewater collection facilities, conveyance facilities and treatment plant. There are no currently operated public sewerage systems in the project area though a sewerage project (final target population of 100,000 persons) is going on in the city center of Palembang City. Furthermore, according to the interview at PDAM Palembang and PDAM Banyuasin, their current concerns are not the availability of raw water but insufficient treatment capacity and distribution pipe network. As far as considering the above situation, the recycle use of wastewater would not be a realistic adaptation measure against drought for a short-term and middle-term aspects.

On the other hand, the recycle use of wastewater in a factory would be a more realistic adaptation measure against drought. It will not be difficult to install collection pipes, a simple treatment facility and supply pipes inside the factory premises for multipurpose use except for drinking. Depending on the industry type, the recycled water may be used for the production process as well. Although some extent of investment is required for construction of recycled water system, it is considered to be useful and eventually profitable to establish a self-water supply system for securing or complementing the production continuity of the factory during water shortage due to various troubles of public water supply as well as future critical drought.

6) Rainwater Harvesting

Rainwater can be used by storing in a water tank in each house and building, generally for domestic use including toilet water, sprinkling, and washing, except drinking purpose. This activity is an individual house basis and depends on the effort and investment of each house. Although large volume of water is not expected from this source and the availability is also affected by weather condition, the small efforts of many households will contribute to a certain portion of adaptation for the drought impact.

According to the interview results of the PDAM Office of Banyuasin Regency that covers a large extent of low-lying swamp area in the Musi River delta, people currently living in the tidal swamp area utilizes the rainwater stored in a tank as well as river water directly taken from the river by themselves. The individual house has a water tank, such as roof top plastic tank with capacity of 200 to 300 L, for domestic use including drinking purpose during the rainy season. During the dry season, people purchases bottled water and/or PDAM water with portable tank, for domestic use including drinking water. This is a normal practice of residents living in the swamp area to obtain domestic water and they are not expecting development of a piped water supply system.

Source: JICA Project Team 2

Photo 10.4.3 Current Situation of Rainwater Use

In terms of the availability, rainwater harvesting is an easy and low-cost source but limited to the rainy season, therefore it may not be expected as a prospective water source for adaptation against critical drought. However, irrespective of the location if there observed some water quality problem for domestic use in conventional water sources including river water and groundwater, rainwater harvesting is considered as an alternative source.

(3) Non-structural Measures

1) Irrigation Water Demand Management

(a) On-farm Level Adaptation Measures against Droughts

On-farm level of paddy field in surface water irrigation scheme areas, there are three practical adaptation measures under the jurisdiction of MPWH as follows:

- Rotation system of irrigation water distribution within the command area of each surface water irrigation scheme;
- Optimization of cropping calendar focusing on the land preparation work period for the wet season paddy cultivation; and
- Improvement of irrigation efficiency through upgrading tertiary irrigation canal network with a legal amendment.

(b) Rotation System of Irrigation Water Distribution

In any irrigation scheme command area, shorter duration of irrigation water distribution causes to make peak water supply requirement more. Aiming to reduce the peak water requirement, the command area is divided into three blocks and thereby the starting of irrigation water distribution of three blocks slides with a ten-day interval. Through adapting such rotation system, the duration of practicing the land preparation and crop management works will be longer according to the work period of each work.

(c) Optimization of Cropping Calendar

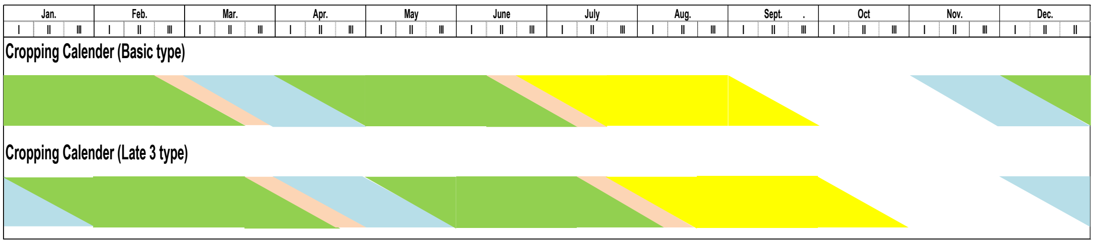
At present, all the existing surface water irrigation schemes in the MBSL River basin depend irrigation water sources on natural flow of water source rivers. When the wet season starts in October, available river flow falls to the lowest level. Therefore, the water requirement for land preparation works of wet season paddy cultivation needs to be met by rainfall as much as possible. In this regard, a focal point is put over the frequency of occurrence to fully meet water requirement for land preparation works with effective rainfalls. Under the observed climate situation in a 1/5 probability drought year, the optimum land preparation period of wet season is examined for seven cases starting from October 1 to December 1 with a ten-day interval and a 30-day work period each. As a result, the following two types of land preparation period for the wet season are selected:

- Basic type of land preparation works for the wet season paddy cultivation starting from November 1; and
- L3 type starting from December 1.

To establish an optimum cropping calendar taking these measures into account, the following conditions are set up:

- Crop growth period is 110 days for wet season paddy and 100 days for dry season paddy, both including 20-day nursery period, and 70 days for dry season secondary crop;
- Rotation system of irrigation water distribution is introduced;

- Complete dried-up period of irrigation canal system is fixed at 30 days once a year.
- Thus, the following two types of cropping calendar as illustrated in Figure 10.4.19 are established;
- Basic type with crop cultivation works for the wet season paddy starting from November 1 and ending March 31, the dry season paddy starting from March 1 and ending July 20 and the dry season secondary crop starting from June 21 to September 30; and
- L3 type with crop cultivation works for the wet season paddy from December 1 to April 30, the dry season paddy from April 1 to August 20 and the dry season secondary crop from July 21 to October 31.



Wet season paddy Dry season paddy Dry season secondary crop

Note: Blue-colored part; Land preparation period, Green-colored part; Rice growing period under irrigated condition, Pink-colored part; Rice growing period under dried-up condition, Yellow-colored part; Secondary crop growing period under irrigated condition

Source: JICA Project Team 2

Figure 10.4.19 Optimized Cropping Calendar for Surface Water Irrigation Scheme in MSBL Basin

The above two types of cropping calendar are to be applied to surface water irrigation scheme areas as follows:

- Basic type for schemes located in Musi Rawas and Musi Rawas Utara Regencies; and
- L3 type for schemes located in OKU, OKI, Muara Enim, Lahat, OKU Selatan, OKU Timur and Empat Lawang Regencies as well as Pagar Alam and Lubuk Linggau Cities.

(d) Improvement of Irrigation Efficiency

In command areas of the existing surface irrigation schemes in the MBSL basin, the on-farm level tertiary irrigation canal system is limitedly available and plot-to-plot irrigation water distribution method is common. Up to now, tertiary canal system has been provided to the existing surface irrigation schemes throughout Indonesia under the responsibility of the Ministry of Agriculture, but due to the very small amount of allocated national budget the performance level is far behind farmers' needs. On the other hand, DGWR has included in the scope of works for developing some of new irrigation schemes, especially financed by the foreign aids. Therefore, it is desirable to make necessary legal amendment for promoting tertiary canal network system in the future.

In the DGWR design criteria, the irrigation efficiency is defined based on water conveyance loss of irrigation canal. As the design target, the loss is set at 10% for the main canal and 15% for the secondary and tertiary canals and thereby the irrigation efficiency is calculated at 65% (=0.9 x 0.85 x 0.85). Actually, it is commonly recognized that the loss level of tertiary canal system is more than 20% and thereby the irrigation efficiency is from 50% to 60%.

As one of the on-farm-level practical adaptation measures against the droughts, therefore, improvement of irrigation efficiency through the canal lining method is to be taken up.

(e) Cropping Intensity

Comparing the fixed statistical data as shown in Table 7.2.7 with the design area of each registered surface irrigation scheme as shown in Table 7.2.8, it can be justified that the actual irrigated areas are functional parts of the existing surface water irrigation schemes, while the non-irrigated areas consist of rainfed paddy field areas including the not functioned part of the existing surface water irrigation schemes as well as the paddy growing areas in the tidal and inland swamp irrigation schemes. Further, the cropping intensity as shown in Table 7.2.7 indicates actual utilization of wetland paddy field by the farmers for rice cultivation purpose. Considering these data, it is assumed that the future cropping intensity of wetland paddy field in the surface water irrigation scheme areas will be as shown in Table 10.4.16, while the cropping intensity in the rainfed paddy field areas will be a 100% during the wet season only.

Table 10.4.17 Future Cropping Intensity in Surface Water Irrigation Scheme Area

Authority / Size / Cropping Intensity			Wet Season		Dry Season 1		Dry Season 2	
BBWS-S8	Over 3,000 ha	250%	Rice	100%	Rice	100%	Secondary crop	50%
Province	3,000 – 1,000 ha	150%	Rice	100%	Rice	40%	Secondary crop	10%
Regency / City	Below 1,000 ha	125%	Rice	100%	Rice	20%	Secondary crop	5%

Source: JICA Project Team 2

(f) Salient Features of Irrigation Water Demand Estimate Basis

Table 10.4.18 shows the salient features of basic items applied to estimate irrigation water demand concerning both cases such as the POLA/ RENCANA-based cropping pattern for selecting three models from the nine GCMs (applied in the water balance analysis in Chapter 9) and the optimized cropping pattern for the assessment of the drought risks under three selected GCMs (applied in the water balance analysis in Chapter 10).

Table 10.4.18 Comparison of Irrigation Water Demand Calculation

Item		Chapter 9	Chapter 10
1.	Objective	To clarify the difference of irrigation water demand data between POLA and JICA Project	To assess impacts of the future three typical climate models on irrigation water demand after practicing adaptation measures of irrigation water management against droughts and thereby to provide necessary data for estimating cost and benefit of climate change adaptation measures.
2.	Calculation method of irrigation water requirement criteria	POLA: Indonesian National Standard (SNI 19-6728-1-2002) JICA Project: DGWR's Irrigation Planning Standard, Design Criteria for Irrigation Networks (KP-1)	KP-1
3.	Unit water requirement	POLA: Fixed rate of 1.0 l/s/ha JICA Project: Varied rates related to crop consumptive use data	Varied rates related to crop consumptive use data
4.	Parameter related to climate	None	Precipitation and evapotranspiration
5.	Irrigation efficiency	605	60% for observed climate and 65% for future climate
6.	Irrigation water distribution system	Not considered	Rotation system on the block basis with 10-day interval for commencement date
7.	Cropping calendar	Fixed farm operation schedule with no relation to rainfall patterns	Optimized cropping calendar with the least water requirement for land preparation work of wet season
	Wet season paddy	October 1 to February 15	Base type: Nov. 1 to Mar.31 L3 type: Dec. 1 to Apr.30
	Dry season paddy	February 1 to June 15	Base type: Dec. 1 to Apr. 30 L3 type: Jan.1 to May 31
	Dry season secondary crop	June 16 to September 30	Base type: June 21 to Sept.30 L3 type: July 21 to Oct. 31
8.	Work period of each farming	15 days	30 days
9.	Cropping intensity	300% (100% each for wet season paddy, dry season paddy and dry season secondary crop each)	250% for BBWS-S8 managed schemes, 150% (100%-40%-10%) for province managed schemes and 125% (100%-20%-5%) for local government

Source: JICA Project Team 2

(g) Adjustment of Future Surface Irrigation Scheme Areas

In the MBSL River basin, the target irrigation command areas of the following two surface water irrigation schemes, which have been recently completed under JICA's financial assistance, are fixed in each project completion reports prepared as follows:

- Under the Participatory Irrigation Rehabilitation and Management Project (PIRIMP), the existing irrigation system of the Air Lakitan Sub-project covering 6,920 ha in total was completed in 2016. The follow-up activity for providing a tertiary system by allocating national budget from 2017;
- To continue financial assistance to the Komering Irrigation Project Stage III (KIP-III), the new Loan Agreement was signed between JICA and DGWR in March 2017 for expanding the irrigation area of 13,491 ha. Under KIP Stage II Phase 2 completed in 2016, the irrigation command area of 14,157 ha was newly developed and thereby the total scheme area became 59,167 ha including the diverted area of 5,048 ha to Lampung Province; and

- In the RENCANA, nine surface irrigation schemes are planned to be implemented for 20 years from 2016 to 2035 with a total design area of 58,491 ha. Considering the current distribution of paddy field as shown in Table 7.2.7, it is predicted that the existing rainfed paddy field areas of 39,491 ha will be newly upgraded to new six surface water irrigation schemes, while the existing small-scale surface irrigation schemes under the provincial and local governments' management covering 19,000 ha will be integrated into three new surface water irrigation schemes to be managed by BBWS-S8.

Taking the above into account, the design area of the future surface water irrigation schemes are adjusted as shown in Table 10.4.19.

Table 10.4.19 Adjusted Surface Irrigation Areas under Present and Future Conditions

Regency (R) and City (C) with Surface Water Irrigation Schemes	Present Irrigation Area			Conversion		Future Irrigation Area		
	BBWS-S8 (ha)	Local Gov. (ha)	Total (ha)	Rain-fed (ha)	Local Gov. (ha)	BBS-S8 (ha)	Local Gov. (ha)	Total (ha)
Pagar Alam C.	3,050	10,004	13,054	0	7,000	10,050	3,004	13,054
Lubuk Linggau C.	1,322	1,529	2,851	0	0	1,322	1,529	2,851
OKI R.	5,000	0	5,000	8,500	0	13,500	0	13,500
OKU Timur R.	49,119	5,570	54,689	4,991	0	54,110	5,570	59,680
OKU R.	0	3,824	3,824	0	0	0	3,824	3,824
OKU Selatan	0	9,980	9,980	0	0	0	9,980	9,980
Muara Enim	0	33,212	33,212	0	0	0	33,212	33,212
Lahat	0	23,791	23,791	0	10,000	10,000	13,791	23,791
Empat Lawang	9,244	7,114	16,358	0	0	9,244	7,114	16,358
Musi Rawas	15,761	12,576	28,337	13,000	2,000	30,761	10,576	41,337
Musi Rawas Utara	0	640	640	3,000	0	3,000	640	3,640
Sub-total	83,496	110,240	191,736	29,491	19,000	131,987	89,240	221,227
Lampung	5,048	0	5,048	10,000	0	15,048	0	15,048
Sub-total	5,048	0	5,048	10,000	0	15,048	0	15,048
Total	88,544	108,240	196,786	39,491	19,000	147,035	89,240	236,275

Source: JICA Project Team 2

(h) Unit Irrigation Water Requirement

Aiming to quantify the effect of the three climate change models (risk high, medium and low) on irrigation water demand in consideration of the on-farm level adaptation measures against the droughts for irrigation water management, the unit irrigation water requirement is calculated by substituting the evapotranspiration and effective rainfall (5.5 to 80.0 mm/day) data of observed, GCM-3, GCM-6 and GCM-8 in the KP-1 formula. The calculation works are carried out on the 10-day period basis for 16 years from 1985/86 wet season to 2001 dry season for the observed climate pattern and 2050/51 wet season to 2065 dry season for the future climate model patterns.

The calculation results for nine sub-basins where surface irrigation schemes exist are shown in the form of average value for each crop season in Table 10.4.20. In case of the observed climate pattern, the unit irrigation water requirement is calculated under the irrigation efficiency of 60% before lining the tertiary canal network and 65% after lining.

Table 10.4.20 Area-wise Average of Unit Irrigation Water Requirement with Adaptation Measures

Case / Season / Crop		**Area-wise Average of Unit Irrigation Water Requirement by Crop Season (l/s/ha)**								
		OKI & OKU-T	**OKU**	**OKU Selatan**	**Muara Enim**	**Lahat**	**Pagar Alam**	**Musi Rawas**	**Empat Lawang**	**Lubuk Linggau**
Cropping Calendar		L3	L3	L3	L3	L3	L3	Basic	L3	L3
Observed Climate Condition (Irrigation efficiency: 60%)										
W/S	paddy	0.53	0.51	0.55	0.43	0.45	0.55	0.33	0.43	0.43
D/S	paddy	0.96	0.93	0.95	0.96	1.00	0.88	0.82	0.79	0.79
D/S	secondary	0.29	0.28	0.29	0.24	0.26	0.24	0.25	0.20	0.20
Observed Climate Condition (Irrigation efficiency: 65%)										
W/S	paddy	0.49	0.47	0.51	0.40	0.42	0.51	0.30	0.40	0.40
D/S	paddy	0.89	0.85	0.88	0.89	0.92	0.81	0.76	0.73	0.73
D/S	secondary	0.27	0.26	0.27	0.23	0.24	0.22	0.23	0.18	0.18
Future Climate Condition with Low Risk Scenario <GCM-3> (Irrigation efficiency: 65%)										
W/S	paddy	0.48	0.48	0.48	0.38	0.40	0.29	0.47	0.45	0.33
D/S	paddy	1.07	1.11	1.11	0.89	0.87	0.89	0.53	0.81	0.77
D/S	secondary	0.22	0.27	0.27	0.18	0.18	0.22	0.25	0.14	0.16
Future Climate Condition with Medium Risk Scenario <GCM-8> (Irrigation efficiency: 65%)										
W/S	paddy	0.48	0.32	0.32	0.22	0.21	0.21	0.80	0.41	0.32
D/S	paddy	0.80	0.71	0.71	0.61	0.60	0.53	0.79	0.72	0.74
D/S	secondary	0.31	0.31	0.32	0.29	0.29	0.29	0.29	0.25	0.30
Future Climate Condition with High Risk Scenario<GCM-6> (Irrigation efficiency: 65%)										
W/S	paddy	0.42	0.43	0.43	0.49	0.57	0.58	0.58	0.53	0.67
D/S	paddy	0.86	0.82	0.82	0.82	0.84	0.76	0.56	0.75	0.84
D/S	secondary	0.31	0.31	0.31	0.29	0.29	0.29	0.29	0.25	0.30

Note: W/S; Wet season, D/S; Dry season

Source: JICA Project Team 2 (Data Book E2)

(i) Irrigation Water Diversion Requirement

Aiming to estimate the irrigation water diversion requirement of each surface water irrigation scheme, the unit irrigation water requirement is applied in the following manner:

- The unit irrigation water requirement is applied;
- Cropping intensity as shown in Table 10.4.17; and
- The design area is applied to each surface water irrigation scheme (Table 10.4.19) based on the official data of Ministerial Ordinance (No.14/PRT/M/2015 tentang Kriteria dan Status Daerah Irigasi) as well as the RENCANA of BBWS-S8.
- The calculation results are presented as the annual averaged basis in the Supporting Report E.

Taking into account, the above items coupled with the future irrigation area given in Table 10.4.19 and the unit irrigation water requirement given in Table 10.4.20 into account, irrigation water diversion requirements by sub-basin are estimated as shown in Table 10.4.21. Detailed information is compiled in the Supporting Report E.

Table 10.4.21 Area-wise Average of Irrigation Water Diversion Demand with Adaptation Measures

Case / Season / Crop		Area-wise Average of Irrigation Water Diversion Requirement by Crop Season (m^3/s)								
		OKI & OKU-T	OKU	OKU Selatan	Muara Enim	Lahat	Pagar Alam	Musi Rawas	Empat Lawang	Lubuk Linggau
Cropping Calendar		L3	L3	L3	L3	L3	L3	Basic	L3	L3
Observed Climate Condition (Irrigation efficiency: 60%)										
W/S	paddy	35.9	1.9	5.5	14.3	10.8	1.7	18.9	1.2	9.0
D/S	paddy	62.2	0.7	2.8	8.1	6.8	2.7	15.4	1.3	11.1
D/S	secondary	9.9	0.1	0.2	0.5	0.5	0.4	2.7	0.2	1.2
Observed Climate Condition (Irrigation efficiency: 65%)										
W/S	paddy	33.1	1.8	5.1	13.2	9.9	1.5	17.5	1.1	8.3
D/S	paddy	57.4	0.7	2.6	7.5	6.3	2.5	14.2	1.2	10.2
D/S	secondary	9.1	0.1	0.2	0.5	0.4	0.4	2.5	0.1	1.1
Future Climate Condition with Low Risk Scenario <GCM-3> (Irrigation efficiency: 65%)										
W/S	paddy	48.6	2.2	5.7	14.8	10.5	4.8	21.1	1.5	6.3
D/S	paddy	90.4	0.9	3.3	7.5	12.4	9.9	21.3	1.3	8.5
D/S	secondary	9.3	0.1	0.2	0.4	1.1	1.2	4.9	0.1	0.8
Future Climate Condition with Medium Risk Scenario <GCM-8> (Irrigation efficiency: 65%)										
W/S	paddy	42.6	1.2	3.1	7.3	4.5	2.7	36.1	1.2	5.1
D/S	paddy	67.5	0.5	2.1	5.1	8.5	5.9	31.7	1.2	8.1
D/S	secondary	13.0	0.1	0.2	0.6	1.7	1.5	5.7	0.2	1.5
Future Climate Condition with High Risk Scenario <GCM-6> (Irrigation efficiency: 65%)										
W/S	paddy	36.5	1.6	4.2	16.1	12.9	7.5	10.9	1.5	7.5
D/S	paddy	72.6	0.6	2.4	6.9	11.9	8.4	22.7	1.2	8.4
D/S	secondary	14.4	0.1	0.3	0.6	1.7	1.4	3.6	0.2	1.4

Note: W/S; Wet season, D/S; Dry season
Source: JICA Project Team 2 (Data Book E2)

(j) Sufficiency Rate of Effective Rainfall for Paddy Field of Rainfed Ecosystem

For the case of conversion of the existing rainfed paddy field to new surface water irrigation scheme areas, the sufficiency rate of effective rainfall against the consumptive use of wetland paddy grown in the wet season is calculated for the purpose of evaluating climate change impact as shown in Table 10.4.22.

Table 10.4.22 Sufficiency Rate of Effective Rainfall against Consumptive Use of Rainfed Paddy

New Surface Water Irrigation Scheme	Sufficiency Rate of Effective Rainfall against Crop Consumptive Use			
	Observed	GCM-3 (Low)	GCM-6 (High)	GCM-8 (Medium)
Air Rawas	0.91	0.94	0.93	0.90
Kembanhang	0.91	0.94	0.93	0.90
Muara Beliti	0.91	0.94	0.93	0.90
Komering	0.94	0.93	0.95	0.94
Komering / Tulang Bawang	0.94	0.93	0.95	0.94

Source: JICA Project Team 2

(k) Future Paddy Production

The future annual harvested area, the target yield and the annual production of wetland paddy by regency/city in 2050 is predicted for the surface and swamp irrigation scheme areas as well as the remaining rainfed paddy field distributed in dry land areas, tidal swamp areas and inland swamp areas as shown in Table 10.4.23.

Table 10.4.23 Future Wetland Paddy Production by Regency/ City in South Sumatra

Regency (R) / City (C)	Surface Irrigation Schemes			Swamp Irrigation Schemes			Rainfed Paddy Field Area		
	Area (ha)	Yield (t/ha)	Product (ton)	Area (ha)	Yield (t/ha)	Product (ton)	Area (ha)	Yield (t/ha)	Product (ton)
Palembang C.	0	0.00	0	0	0.00	0	0	0.00	0
Prabumulih C.	0	0.00	0	0	0.00	0	0	0.00	0
Pagar Alam C.	24,005	5.00	120,024	0	0.00	0	0	0.00	0
Lubuk Linggau C.	4,479	5.50	24,633	0	0.00	0	0	0.00	0
OKI R.	27,000	6.00	162,000	53,461	2.50	133,653	123,387	2.00	246,774
Ogan Ilir R.	0	5.50	0	31,528	2.50	78,820	36,099	2.00	72,198
OKU Timur R.	7,668	5.50	42,174	7,550	2.50	18,875	29,573	2.00	59,146
OKU R.	4,589	5.50	25,238	0	0.00	0	5,628	2.00	11,256
OKU Selatan R.	121,156	6.50	787,515	0	0.00	0	1,941	3.00	5,823
Muara Enim R.	41,631	4.00	166,526	1,200	3.00	3,600	19,422	3.00	58,266
PALI R.	0	4.50	0	0	0.00	0	6,579	2.00	13,158
Lahat R.	38,038	4.00	152,151	0	0.00	0	1,680	3.00	5,040
Empat Lawang R.	27,325	4.50	122,962	0	0.00	0	986	3.00	2,958
Musi Rawas R.	75,416	5.00	377,079	6,000	2.50	15,000	11,030	2.00	22,060
Musi Rawas Utara R.	6,768	3.00	20,304	0	0.00	0	6,716	2.00	13,432
Musi Banyuasin R.	0	5.50	0	43,706	2.50	109,265	10,104	2.00	20,208
Banyuasin R.	0	5.00	0	164,197	2.50	410,493	59,321	2.00	118,642
South Sumatra Total	378,074		2,000,607	307,642		769,705	312,466		648,961

Source: JICA Project Team 2

2) DMI Water Demand Management

The successful management/control of water demands eventually depends on individual consumer’s effort to save daily water use. The people’s water consumption is closely related to the lifestyle and the local culture. Therefore, a short-term achievement of demand control effects cannot be expected. However, as indicated in the case of Tokyo, the unit water consumption of 370 lpcd in the 1990s has been decreased to 250 lpcd in 2015. This is derived from the efforts of saving water by both consumers and suppliers. It is apparent that accumulation of water saving by individuals contributes to saving large volume of water. To realize the successful demand management, the following measures are considered.

(a) Customer/Potential Customer Awareness

The available tool in demand management aims to ensure that the customer is fully informed of the current situation regarding water resources and water production. If the customer is not provided with any service then he is likely to both abuse the system and not pay the bill. Most people who have a social conscience will try to preserve the importance of water resource, if they know what to do. Most water companies in the developing countries have promotional information to provide in the media and the customer.

(b) Publicity

It is currently presumed that any agencies concerned as well as PDAMs in the project area are in a reactive situation for publicity. In order to be proactive, it is necessary to keep the media informed of the major issues as well as what they are doing about it. In this way the story can be presented in a positive way and not a negative one. There is little doubt that this will take some time in order to develop a good relationship with the media. To this end it is desirable that a public relations officer be dedicated to provide a positive outlook for this task.

(c) Education

In order to obtain the people's perception of demand management it is necessary to educate as many people as possible in the issues that face PDAMs. Most of the water companies take the opportunity to issue publicity materials to schools and major companies within its supply area. It is also desirable for lectures to be given to schools on the "Water Cycle", including tourism to treatment plant and what the most valuable resource is. When the children grow up they will have a more positive attitude towards the issues being faced by the water company. The development of the relationships with the water using businesses is also important. Where businesses are using lots of water they would like to know how they could use it more efficiently in particular how they recover and re-use the water. An example for water use and conservation is in hotels. The education of hotel guests in terms of the water use can pay dividends. The hotel can then present a positive image in terms of a more caring attitude for the environment and for being "Green".

(d) Relationships

The psychology of presenting a positive image to the customer and the media is important. There is also a need to develop good relationships with the "Opinion Formers" that exist within society. It is therefore necessary to keep these people informed of progress as well as the issues being faced within PDAMs.

The current PDAM coverages of each city/regency in the project area are 3% to 30 % except Palembang City and this situation implies the major numbers of the people that have never been benefited by the pipe water supply. This situation may be easier for PDAMs to take the initiative for managing future water demands, compared with the case of Tokyo as mentioned above.

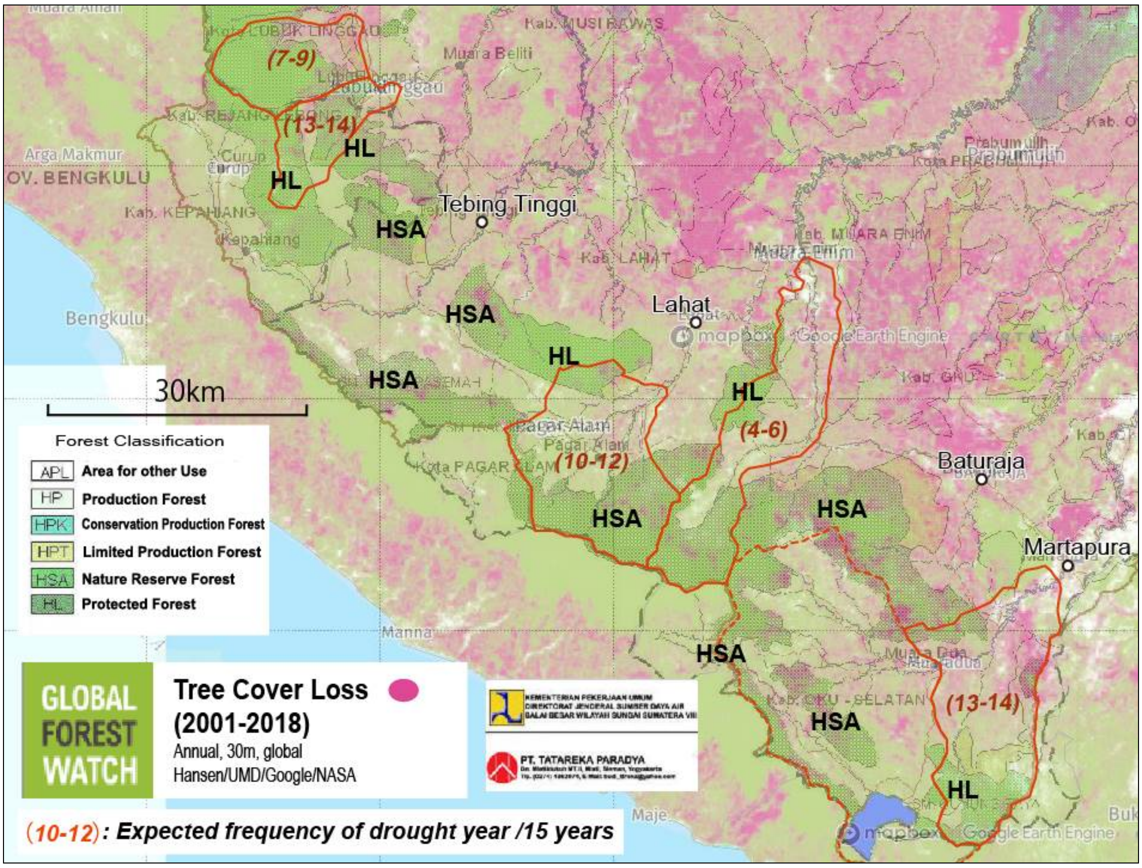
3) Watershed Management

The expected water-short areas, where droughts might occur for four years or more in 15 years, predicted by the JICA Project Team 2 are the five sub-basins as presented in Table 10.4.24. These are located at the most upstream end of the Musi main river and tributaries, and the development is prohibited in about half of the areas designated as the protected forest and nature reserve forest (Figure 10.4.20). For the rest of the non-protected forests, the primary forests are rapidly being transformed to the palm oil tree plantations, urban areas, and coal mining areas and eventually losing the original function as a water resource recharging area.

Table 10.4.24 Expected Drought Areas and Protected Forest Area

Expected Water-short Area	Expected Drought Occurrence Years in 15 Years of Time	Total Area	Protected Forest and Nature Reserve Forest Area	
LAi	7- 9	630 km^2	440 km^2	(70%)
KEi	13-14	460 km^2	290 km^2	(63%)
LEi	10-12	1,335 km^2	660 km^2	(49%)
LEiii	4- 6	1,290 km^2	460 km^2	(36%)
KO1	13-14	1,420 km^2	360 km^2	(25%)

Source: JICA Project Team 2



Source: Global Forest Watch

Figure 10.4.20 Expected Water-short Areas in Protected Forest and Nature Reserve Forest

Unlike in the case of flood control, the measures for drought is required to delay the runoff time of rainwater by about three months until the next wet season arrives. To promote the infiltration of rainwater to the underground, forest preservation is the most biologically suited and effective way of contributing to recharging groundwater than structural measures.

It is also known that the expansion of plantations results in a substantial reduction of spring water and which means less ability in recharging groundwater when compared with the original forest. Thus, it is desirable to control the construction of large-scale plantations in the uppermost Musi River basin from the viewpoint of securing its groundwater recharge function.

10.4.3 Adaptation Measures against Sea Water Intrusion

As discussed in Subsection 9.6.1, sea water intrusion is one of the most significant impacts of climate change. The structural and non-structural adaptation measures are proposed as follows:

(1) Structural Measures

1) Installation of Gates on Secondary and Tertiary Canals in Tidal Irrigation Areas

The Musi River delta, where the agricultural field is currently expanded, used to be a tidal flat which was formerly covered by mangrove forests and has been cleared by national reclamation projects since 1960. Therefore, the elevation of the delta farmland is uniformly low, and the main point for the success of agriculture development in the tidal lowland reclamation areas is how farmers are capable to control the water levels at the farm level to fulfill crop water requirement. For this water level control at the farm level, the gates on the secondary and tertiary canals as shown in Photo 10.4.4 are indispensable. These gate structures will also be very effective to block the rising saline water. However, about 60% of the tidal reclamation areas are not equipped with these gates and remain in the condition of open and uncontrolled water management system. The installation of gate structures should be accelerated not only to enhance the agricultural productivity but also to prepare the sea water intrusion caused by the sea level rise.

1) Gates on Secondary Canal

2) Gates on Tertiary Canals
Source: Sriwijaya University

Photo 10.4.4 Gates on Secondary and Tertiary Canals

2) Desalination for Water Supply

In case there is no availability of other water sources for meeting demand, including surface water and groundwater in terms of both quantity and quality, water supply from the desalination plant will be in reality. However, it will still not be feasible to construct a desalination plant for the purpose of water supply to the public. The construction cost of the desalination plant is normally known approximately USD1,500/m^3 and it is around 3 times of the conventional water treatment plant cost (USD400 to 500/m^3). In addition, the water production cost of USD1.0/m^3 is considerably high compared with that of conventional water treatment plant (around USD0.15/m^3).

There are low-lying tidal swamp areas in the project area, such as the Musi River delta area in Banyuasin Regency. In these areas the river water is affected by sea water intrusion and cannot be used for water supply purpose. According to information from PDAM Banyuasin, there are three desalination plants that were constructed in Sungsang for the public water supply for 300 households. However, all these plants are not in operation since 2 years ago because of fund shortage of renewal of fine filter (reverse osmosis).

Based on the above discussion and the actual case in Banyuasin Regency, desalination may not be suitable as an adaptation measure for public water supply against sea water intrusion in the project area. Instead, it may be feasible as the adaptation measure for bulk water supply for special purpose, such as special economic zone (SEZ) or large-scale resort area.

(2) Non-structural Measures

1) Capacity Development on Gate Operation in the Tidal Irrigation Areas

The capacity development of farmers is a key to ensure the appropriate water level control at the farm level. Training in preparation for the sea water intrusion is also necessary. BBWS-S8, farmer's associations, NGOs and experts should be involved in the capacity development activities.

2) Monitoring

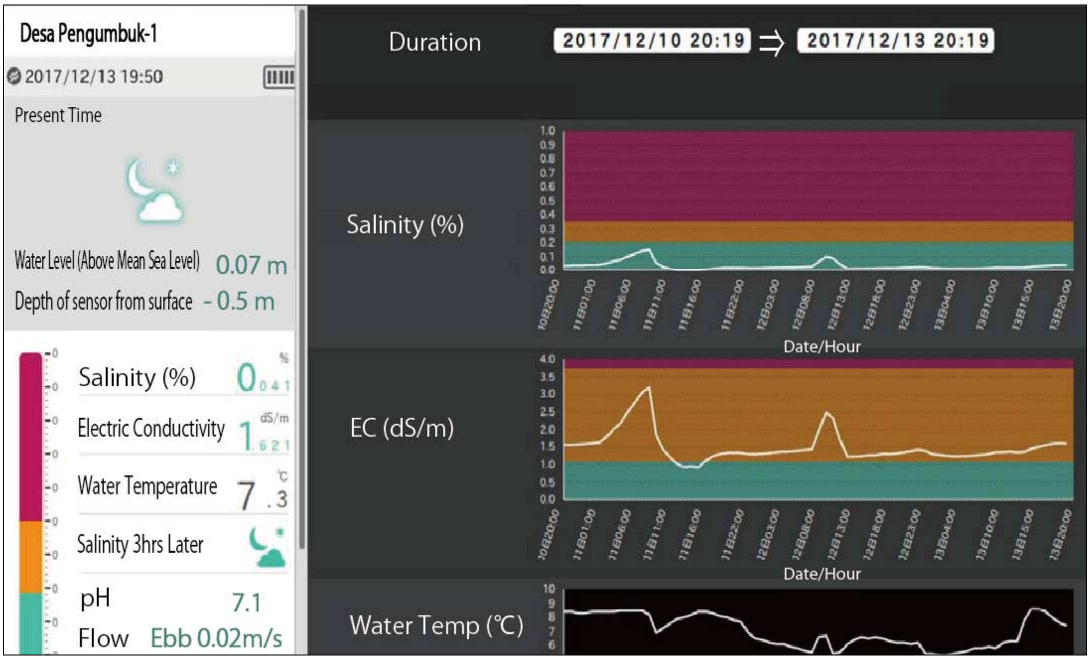
(a) Monitoring for Water Supply for Households

The salinity concentration in the Palembang City area and the downstream rivers varies depending on the following various environmental conditions such as geographical location / elevation of intake facilities, tide level (flood tide / ebb tide), river flow rate, intake volume, intake depth, location of intake in the river, wind, etc.

In the ideal picture, continuous hourly monitoring of water quality, especially the salt content, is essential for adequate intake of the required amount. Long-term monitoring of salinity at the Banyuasin Regency and Kota Palembang intake sites will allow prediction of future changes in salinity and formulation of raw water intake plan. It is ideal to simultaneously record the hourly tide level (water level), flow direction and pH at each location automatically and upload to the cloud system. Also, it is proposed that the data in each intake facility be unified, shared, and made public for the use of the non-governmental sector. It is relatively easy to make the application and share with all users. Figure 10.4.21 shows the screen image of monitoring application.

(b) Agriculture and Water Use

The farmers in tidal swamp irrigation area have a traditional method for censoring salinity. When water is drawn into the field, the farmers judge each time according to the taste, a simple and reliable method. As the salt content level differs depending on the farmland's hydro-topography and the water movement, the complicated monitoring systems that require considerable input for installation, operation and maintenance seem to be not practical. Moreover, as long as the sea level does not overtop the gate's level, in the long run, it is considered that there will be no problem with the salinity intrusion in 2050. In practice, the higher seawater level is even appreciated for tidal irrigation because of the increased head of irrigation water.



Desa Pengumbuk-1

2017/12/13 19:50

Present Time

Water Level (Above Mean Sea Level) 0.07 m

Depth of sensor from surface - 0.5 m

Salinity (%) 0.041 %

Electric Conductivity 1.621 dS/m

Water Temperature 7.3 ℃

Salinity 3hrs Later

pH 7.1

Flow Ebb 0.02m/s

Duration 2017/12/10 20:19 ⇒ 2017/12/13 20:19

Source: NTT, modified by JICA Team 2

Figure 10.4.21 Screen Image of Monitoring Application for Intake Facility at Musi River (Desa Pengumbuk-1)

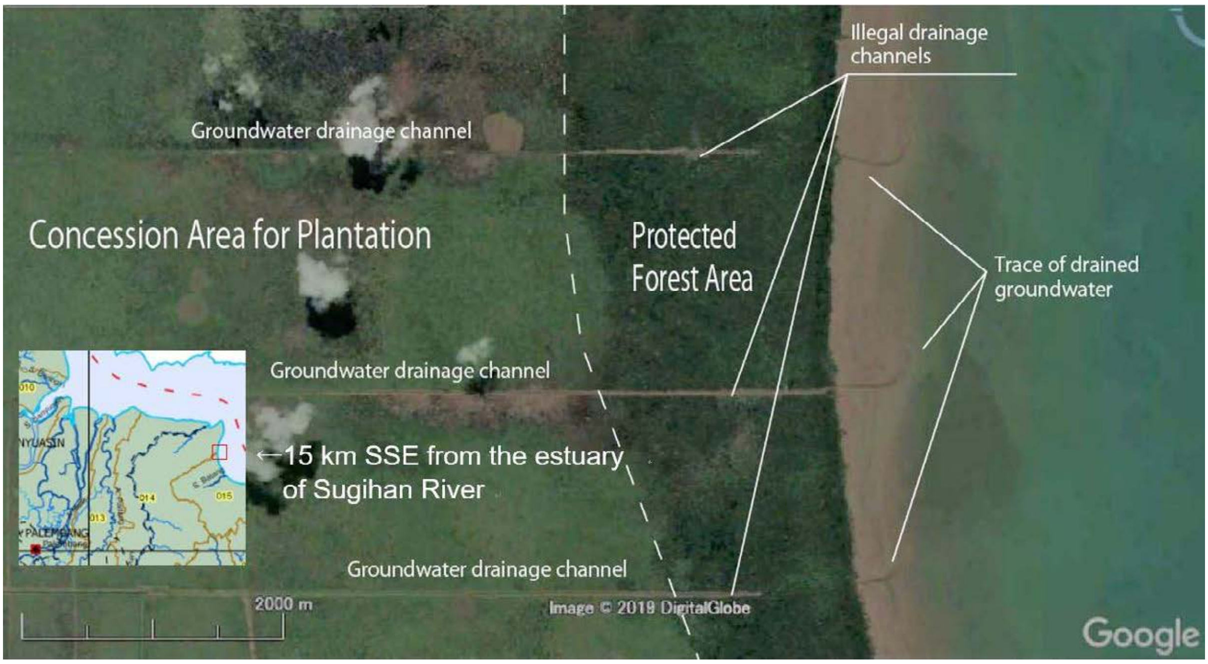
10.4.4 Peat Land Management

(1) Actions for Suppressing Peatland Fire

The Central Government allowed 3.063 (million) hectares of forest development on the Sumatra in 2010-2015. However, in recent years, under the president Joko administration, the moratorium by the government regulation holds a forest development permit, and plantation areas with a peat layer thickness of more than 3 m are required to restore the original forest condition. Moreover, the plantation businesses are ordered to keep the groundwater level shallower than -40 cm below the ground surface.

Peatland Restoration Agency (BRG), under direct control of the president, was established by the Presidential Decree Number 1 of 2016, and Provincial Peat Restoration Team (TRGD) was also created in seven provinces where peatland management is necessary. TRGD, on the other hand, is designated under the direct control of Governor of South Sumatra Province. Although BBWS-S8 and Forestry Department are responsible for their designated areas, the South Sumatra TRGD is the only agency responsible for peatland reconstruction and management in the province. Its responsible areas overwrap with other agencies (Figure 10.4.22). TRGD conducts coordination meetings, in which measures are determined and authorized with relevant agencies in the South Sumatra Province. BBWS-S8 is not a member of the committee yet, and PU's own peatland restoration project cannot be conducted, as all efforts on the recovery of peatland in the South Sumatra will need to be referred to this coordination meeting and passed as its resolution.

The current main peat restoration projects are to identify channels that private plantation business has illegally excavated to lower the groundwater level as well as to construct weirs or gates on these channels for preventing groundwater drainage from the wetland forest (Figure 10.4.22).

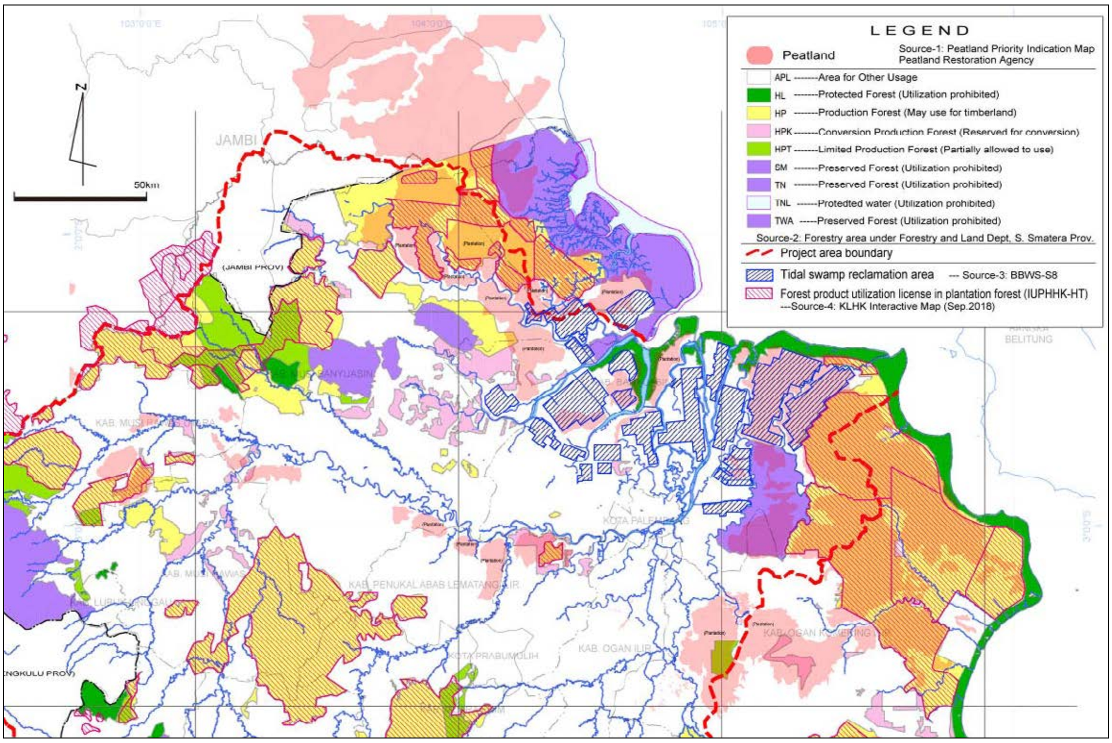


Source: JICA Project Team 2

Figure 10.4.22 Illegal Groundwater Drainage from Peatland

Th effort is to halt the lowering of the groundwater levels that eventually dry the land and to prevent the concession contractors from setting fire on the dried-up forest. BBWS-S8 can contribute in suppressing the peatland fire by reducing the poverty in the delta area by the development of the delta areas by constructing effective irrigation systems in which farmers can grow products even in the dry season. There is a small-scale good practice in the delta enhancing the local agriculture and raising the standard of living. Propagating and supporting this type of agriculture may eventually eliminate illegal logging and peatland fire triggered by the poor farmers.

For the cooperating action for TRGD by BBWS-S8, it is crucial to receive the implementation plan and data such as hydro-topography maps of peatland which TRGD is now preparing and necessary to avoid interference with water canal and gate constructed by BBWS-S8. Since BBWS-S8 has not participated in the TRGD Coordination Meeting; it is necessary for the Planning Department of BBWS-S8 to participate in the conference and exchange of information for the most appropriate project operation in the delta area as the river and channel manager. The channels without gates may drain the groundwater from the subject area and dry the surrounding land which may induce forest and peat fire.



Source: TRGD

Figure 10.4.23 Distribution of Peatland and Overwrapping Jurisdictions

(2) Change in Groundwater Environment

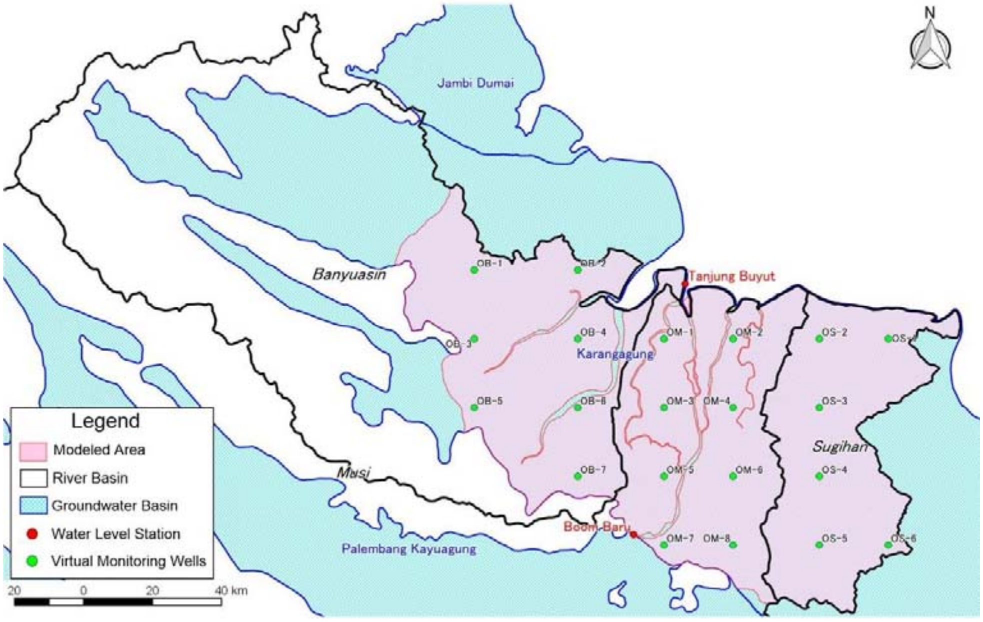
It is known that the risk of wild fires increases as the peatland becomes dry. It was estimated how the groundwater level in the coastal peatland areas change under climate change, taking into consideration the sea level rise. The study was implemented using the groundwater flow model MODFLOW in consideration of the sea level rise with the groundwater recharge (groundwater potential) evaluated in Subsection 10.3.2 (2) 3. The analysis area is the lowest Musi River basin and the tidal area where the tropical peatland extends.

The three-dimensional groundwater flow model MODFLOW was used to evaluate the change of groundwater environment in the coastal peatland area. The analysis conditions are shown in Figure 10.4.21. The tide data used for analysis has many missing periods. Since it is necessary to use continuous data for analysis, it is selected to use the same data from 2000/9/1 to 2005/8/31 (5 years) repeatedly 3 times for 15 years forecast. In addition, 1985/9/1 to 2000/8/31 (15 years) of the same period as regional groundwater potential analysis is used to evaluate for the present groundwater condition. Unfortunately, there is no hydrogeological information, aquifer constant, and groundwater observation data as the calibration target. The meteorological data from the JICA Project Team 1 to estimate the groundwater recharge is provided only for the Musi River basin. Therefore, this data is applied for the Banyuasin River basin and Sugihan River basin. The sea level rise is assumed to be 0.25m in the future forecast. The analysis area is shown in Figure 10.4.24. The detail explanation is mentioned in the Supporting Report C.

Table 10.4.25 Analysis Conditions

Item		Condition	Remarks
Analysis code		MODFLOW2005	One of the codes used worldwide
Analysis area		Coastal area of Kurangagung groundwater basin	See Figure 10.4.24
		-200m (model bottom)	
Grid size		1 km×1km	Same as Brantas model
Analysis period	Present	1985/9/1～2000/8/31（15years）	Adopt this period according to the change evaluation of regional groundwater potential
	Future	2050/9/1～2066/8/31（15years）	Consider sea level rise (+0.25 m)
Time step		1 month	Same as Brantas model
Hydrogeological structure		Estimated from Regional Geological Map	Whole area is assumed to be peatland. DEMNAS data is processed and incorporated for ground surface of the model. Three hydrogeological layers are assumed: shallow (unconfined) aquifer, transition zone, and deep (confined) aquifer
Aquifer constant		General value	The same value used in peatland groundwater analysis in Kalimantan is set.
Calibration target		No data	
Boundary condition	Ocean	Tanjung Buyut Tidal Data	the same data from 2000/9/1 to 2005/8/31 (5 years) repeatedly 3 times for 15 years forecast
	Upstream of the river	Boom Baru Water Level Data	the same data from 2000/9/1 to 2005/8/31 (5 years) repeatedly 3 times for 15 years forecast
Future Scenarios		GCM (High, Medium, Low)	High: GFDL_2_1, Medium: MIUB_ECHO, Low: GFDL_2_0
Groundwater recharge		Estimated value of Kurangagung groundwater basin	Groundwater potential is assumed as groundwater recharge

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 10.4.24 Analysis Area and Virtual Monitoring Wells

The virtual monitoring wells are set in the model for each river basin (Figure 10.4.24) to acquire output of groundwater level. Table 10.4.26 shows the average groundwater level fluctuations in 15 years for each virtual monitoring well and comparisons of present and future climate. All future groundwater levels will be lowered than the present despite sea level rise.

The risk of wild fires in tropical peatland is generally increased when the groundwater level drops below 0.4m from ground surface (for example, Henk Wösten et al., 2010). Therefore, it means that the risk of wild fires in the coastal peatland area will increase in the future caused by the lowering of groundwater level. Although the sea level is expected to be 0.25 m higher than the present level, it is considered that the decrease in groundwater recharge more than the sea level rise resulted in the possibility of lowering the groundwater level in coastal peatland area. On the other hand, the sea level rise also means increasing the risk of saltwater intrusion.

Table 10.4.26 Average Groundwater Depth in 15 Years and Change from the Present

No.	River Basin	Virtual Monitoring Wells	Present (m)	Future (m)			Water Level Change (m)		
				High	Medium	Low	High	Medium	Low
1	Musi	OM1-OM8	0.31	0.42	0.42	0.39	-0.11	-0.11	-0.08
2	Banyuasin	OB1-OB7	0.48	0.65	0.66	0.61	-0.16	-0.18	-0.13
3	Sugihan	OS1-OS6	1.39	1.63	1.64	1.58	-0.24	-0.25	-0.19
Average			0.68	0.84	0.85	0.80	-0.17	-0.17	-0.13

Source: JICA Project Team 2

10.4.5 Strengthening of Hydrological Monitoring

Hydrological data are indispensable for water resources management. Without sufficient and reliable hydrological data in quantity and quality, any appropriate water resources management is never realized. Through this project, however, it is found that there are critical issues of hydrological observation and data management. These poor data made the climate impact assessment and the runoff analysis by JICA Project Team 1 very difficult. Accordingly, the JICA Project Team 1 pointed it out in its Final Report that long-term and quality data, even at a small number of stations, is indispensable for climate change impact assessments.

(1) Existing Condition of Hydrological Observation

BBWS-S8 has 34 water level stations, 14 rainfall and 11 climatology stations in the MBSL River basin. As of 2018, however, more than one third of these stations are not working normally, mainly due to poor maintenance, as shown in Table 10.4.27. All of the automatic water level stations and 3 rainfall stations were once equipped with GSM-based telemetry equipment, but most of the telemetry equipment are already out of order.

It is also noted that BBWS-S8 has a sophisticated discharge measurement system, an Acoustic Doppler Current Profiler (ADCP). The ADCP is a strong system for discharge measurement that can measure the water depth and flow velocity simultaneously. However, the actual use of the expensive system is very limited. In 2018 no discharge measurement was conducted, while it was conducted a few times in 2017.

Table 10.4.27 Condition of Hydrological Observation Stations of BBWS-S8 as of 2018

Type of Station	Number of Stations			Remarks
	Working Normally	Not working	Total	
Automatic Water Level Station	23	11	34	All the 34 stations are telemetered, but only 6 stations are working normally as telemetry stations. The other 17 stations are used as manual stations because the telemetry equipment is out of order.
Rainfall Station	8 (manually)	6	14	3 stations are telemetered but used as manual stations because the telemetry equipment is out of order.
Climatology Station	4	7	11	
Total	35	24	59	

Source: JICA Project Team 2

ADCP sensor attached to a boat

Receiver and laptop PC for monitoring

Base station

Observation by ADCP

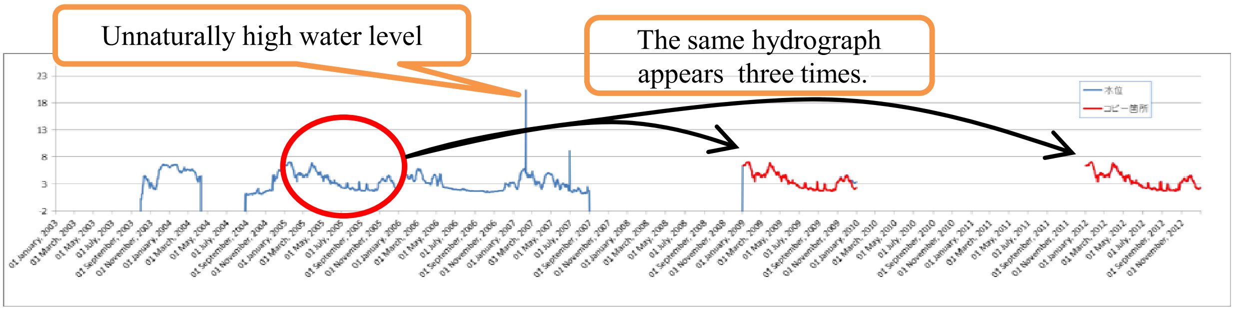
Source: JICA Project Team 2

Photo 10.4.5 Discharge Measurement by ADCP

(2) Data Quality

The issues of data quality and data management also should be pointed out. The typical issues are data coping and the abnormal data as explained below:

Figure 10.4.25 shows a water level hydrograph at No.2 S. Lematang_S. Rotan Station plotted based on data provided by BBWS-S8. The same portion of the water level hydrograph appears three times in 2005, 2009 and 2012. It is guessed that the portion data of 2005 was copied to those of 2009 and 2012. Moreover, an unnaturally high water level is also seen in the hydrograph. Such coping and abnormal data are not limited to this station, but were found in almost all the stations.



Source: JICA Project Team 2

Figure 10.4.25 Example of Abnormal Water Level Data (No.2 S. Lematang S. Rotan Station)

(3) Effort Activities Proposed in RENCANA 2017

To improve the abovementioned situations of hydrological monitoring, effort activities have been proposed in RECANA 2017 as presented in Table 10.4.28. All of these efforts are very important and should be implemented steadily as proposed. In order to sustainably implement these effort activities, however, it should be noted that the technical and financial supports from the central level are indispensable.

Table 10.4.28 Effort Activities on Aspect of Water Resources Management Information in RENCANA 2017

No	Effort Activities
A.	NON PHYSICAL ACTIVITIES
1	Coordination of BBWS-S8 and Provincial PSDA Office
2	Coordination with TKPSDA
3	Corporate Coordination
4	Set up standard water resources information system format
5	Data collection and management
6	Increased capacity of data management units
7	Data management training
8	Increased public participation in data management SDA
B.	PHYSICAL
1	Procurement of equipment
2	Repair, maintenance and replacement of equipment
3	Early warning installation in all major rivers
4	Development of Flood Early Warning System
5	Development and upgrading of integrated SISDA software
6	Preparing equipment for easy access to information

Source: RENCANA 2017

10.5 Strategic Environmental Assessment (SEA)

10.5.1 Applicable Laws and Regulations

The SEA is a mechanism to integrate any environmental and sustainability issues into strategic options onto the development process.

(1) Environmental Protection and Management Act (EPMA) No.32/2009

In formulating the national or state policies, regional plans and programs, it was decided to achieve sustainable outcomes based on the procedures of strategic environmental assessment (SEA). Paragraph 16 of the Act also calls on policy, plan and program developers to describe their potential for vulnerability and adaptation to climate change.

(2) Procedures for Operating Strategic Environmental Study, Government Regulation No. 46/2016

The Government Regulation stipulates on the necessity of the SEA and determining particular “policy, plan and program” which are required to go through SEA procedures. This Government Regulation decides that SEA work shall follow the procedure stipulated in the Decree of Ministry of the Environment (No.9/2011).

SEA is required for a long-term and mid-term development plan formulated by the Central, provincial, regency/city, and county government, a spatial plan (ditto), and projects listed in the schedule of Ministerial Decree No.9/2011. The examples of the subjected policy, plan, and program for SEA are listed below.

- RPJP (National/Provincial/District/City Level) Long-term Development Plan
- RPJM (National/Provincial) Medium-term Development Plan
- Masterplan for Acceleration and Expansion of Indonesia's Economic Development (MP3EI)
- RTRW (National/Provincial/District/City Level) Spatial Plan

(3) MoE Regulation of General Guideline for Conducting Strategic Environmental Assessment (SEA), Ministerial Decree No.9/2011

This regulation stipulates a general guideline of SEA.

10.5.2 Comparison of Alternative Structure Measures

Alternative examinations were conducted for the structural measures shown in Table 10.5.1 from necessity, efficiency, technical and environmental viewpoints.

Based on the results of the alternative examinations shown in Table 10.5.1, the adaptation measures shown in Table 10.5.2 were considered as applicable for the forecasted future climate conditions in 2050.

Table 10.5.1 Examination of Alternatives on Structural Measures of Adaptation

Category	Structural Alternatives	Purpose	Examination Results
Water Resources Conservation	1. Dam construction	Reserving water for dry season	Although positive impacts are expected by the projects, the effectiveness and environmental impact need to be verified. Further examination is necessary for each proposed dam
	2. Modification of Ranau Lake regulation facility and operation	Increasing water supply capacity by using water in Ranau Lake	More than 10 billion m^3 of additional water per year is available if the original plan would have been implemented. However, further examination of the effectiveness and environmental and social impact needs to be verified.
Water Resources Utilization	3. Rehabilitation of irrigation channel	Efficient agricultural water use	Rehabilitation of existing canals is considered as effective to reduce water loss, and it may not cause significant environmental impact. Thus, it is considered as the appropriate adaptation measure if it is economically viable.
	4. Replacement of distribution pipe	Prevention of leakage (Elimination of non-revenue water)	Replacement of water distribution pipes is considered as effective to reduce water loss, and it may not cause significant environmental impact. Thus, it is considered as the applicable adaptation measure if it is economically viable.
	5. Desalinization plant	Use of seawater for drinking water	It is already proven that a desalination plant is not economically sustainable in Banyuasin Regency: it is not recommended as an adaptation measure unless there are new buyers who can afford higher-priced drinking water.
	6. Water treatment facility	Recycling sewage water	Water treatment facilities can increase the amount of water supply to the users as pollution level to the sources of raw water is increasing. It is affirmative as an adaptation plan if results of economic and financial analyses are favorable ones.
	7. Estuary barrier	Preventing seawater intrusion at the Musi River estuary area	It is physically impossible to prevent seawater intrusion because of the interconnected rivers and canals at the estuary area. The area is essential as a navigation route to Palembang, and they must not be interrupted by river-crossing structures.
Water Damage Control	8. Dam	Flood control operation as an additional function of the new dams	The effectiveness depends on the dam location and capacity allocated for flood control in addition to irrigation capacity.
	9. Embankment/ Polder	Preventing overflow of water from the Musi River	The characteristics of flood in the Musi River basin and dikes may induce higher and longer inundation in the landside area and considered that it is not practical in the region.
	10. Retarding basin	Retaining flood water as spillover in the mid-stream area	A retarding basin will require a large area, which will cause large-scale resettlement. Thus, it is not recommended.
	11. Erosion control measures (Check dam, river channel works, groundsill, etc.)	Preventing sediment runoff from the catchment area and keep sufficient cross-section of the river	Large areas of the South Sumatra Province are now classified as in critical condition, but the degradation is caused by the conversion of forest to plantations. An application of new land use regulation in the sloping area is far more effective technically and economically to prevent sedimentation in the river.

Source: JICA Project Team 2

Table 10.5.2 Major Structural Measures for Adaptation

Categories	Structural Adaptation Measures
Water Resources Utilization	1. Dam construction 2. Modification of Ranau Lake Regulation Facility and operation 3. Rehabilitation of irrigation channel 4. Replacement of distribution pipe 5. Water treatment facility
Water Damage Control	–

Source: JICA Project Team 2

10.5.3 Scoping

The adaptation measures, selected at the first stage of examination, are shown in Table 10.5.3. The environmental and social impacts of these measures will be examined together with other parameters shown in the followings.

In the regular AMDAL (EIA) process, the outlines of the project are rather clearer than the SEA stage. The specifications of the project such as the exact location, type of facility, and the dimension are not determined yet but the nature of the facility, approximate functions, and locations. For appropriate scoping in SEA stage, the methods are determined as listed below.

- For constructing new dams, all proposed dams are examined. The studies have completed two dams, namely, Tiga Dihaji, and Saka Gilas, the specific information of other dams is not known except their approximate locations.
- For rehabilitating irrigation canals, distribution pipelines, water treatment facility, there is no specific information on a scale and a location yet. Thus, the general idea was used for scoping.

The environmental and social impacts were evaluated as A to D by the following criteria;

A (+/-): Significant positive/negative impact is expected at this study level.

B (+/-): Positive/negative impact is expected but not significant at this study level.

C: Extent of impact is unknown or not clear. Further examination is needed. It should be taken into consideration that impacts may become clear as the study progresses.

D: Negligible or no impact is expected at this study level.

Table 10.5.3 Summary of Scoping Results

	Natural Environment		**Social Environment**		**Remarks**
	Protected Area	**Eco-system**	**Land Acquisition & Resettlement**	**Livelihood**	
Water Resources Conservation					
1. Dam Construction					
(1) Tiga Dihaji Dam	A-	A-	A-	A-	➢ Resettlement completed already (751 H/H affected) ➢ Acquired the community support ➢ In protected forest area (partly)
(2) Komering-1 Dam	A-	A-	A-	A-	➢ In the buffer zone of protected zone ➢ In protected forest area ➢ More than 600 H/H affected ➢ This project was canceled due to the environmentally important location
(3) Saka-Gilas Dam	B-	B-	B-	A-	➢ AMDAL completed ➢ A trunk bridge will be submerged

	Natural Environment		Social Environment		
	Protected Area	**Eco-system**	**Land Acquisition & Resettlement**	**Livelihood**	**Remarks**
(4) Maura Lingtang Dam	B-	B-	A-	A-	➢ Outside the drought-expected area ➢ More than 15,000 H/H affected ➢ No further study due to the ineffective location as for a drought solution
(5) Laham (Tanjung Pura) Dam	B-	B-	A-	A-	➢ Outside the drought-expected area ➢ More than 50 H/H affected ➢ No further study due to the ineffective location as for a drought solution
(6) Enim (Padang Bindu) Dam	B-	A-	A-	B-	➢ In the buffer zone of protected zone ➢ Existing agriculture land needs to be purchased for the dam and the reservoir
(7) Tanjung Agung Dam	A-	A-	B-	B-	➢ In protected forest area ➢ In protected zone
(8) Sula Dam	A-	A-	B-	B-	➢ Outside the drought expected area ➢ In UNESCO World Heritage site area ➢ In protected zone ➢ No further study due to the ineffective location as for a drought solution
(9) Buluh (Lematang) Dam	B-	B-	B-	B-	➢ Outside the drought expected area ➢ No further study due to the ineffective location as for a drought solution
(10) Panjung Dam	A-	A-	A-	B-	➢ In protected zone ➢ In protected forest area
2. Modification of Ranau Lake Operation	B-	A-	B-	A-	➢ Lowering the water level affects: use of jetties, water depth of aquaculture fish cages, aesthetic view as the tourism resource, PDAM intake function, aquatic biology in the shallow water habitat
Water Resources Utilization					
3. Rehabilitation of Irrigation Channel	D	D	D	B-/B+	➢ No significant environmental and social impacts are expected because the rehabilitation will take place in the same irrigation area. However, temporary discontinuation of irrigation water supply may occur during the rehabilitation work.
4. Replacement of PDAM Pipeline	D	D	D	B-/B+	➢ No significant environmental and social impacts are expected because a replacement will be done within the area of PDAM pipelines. However, temporary discontinuation of water supply may occur during the rehabilitation work.
5. Water Treatment Facility	D	D	B-	B-/B+	➢ Limited area of land acquisition will be necessary for the new facilities near the river. Significant environmental and social impact is not expected.

Source: JICA Project Team 2

10.5.4 Stakeholders Meeting

The stakeholder Meetings (SHM) were held thrice to explain the project outline and examination results followed by discussions. The summary of each stakeholder meeting is shown in Table 10.5.4. Refer to the Supporting Report J: Environmental and Social Considerations for the detail.

Table 10.5.4 Summary of Stakeholder Meeting

SHM	Date and Venue	No. of Participants	Agenda
1st SHM	1 Nov. 2018 10:20 – 11:20 Conference Hall of 101 Rajawali Palembang Hotel, Palembang	82 persons	Application of Strategic Environmental Assessment (SEA) in the Project as a demonstration The general outline of the Project
2nd SHM	19 Feb. 2019 13:00 – 17:00 The Conference Hall of BBWS-S8, Palembang	12 persons	Assessment of climate change Impacts in the Musi River basin Conceivable Adaptation Measures Impact assessment for the adaptation measures
3rd SHM	25 Apr. 2019 19:20 – 20:40 The Conference Hall of Horison Ultima Hotel, Palembang	60 persons	Assessment of climate change impacts in the Musi River basin Conceivable adaptation measures Impact assessment for the adaptation measures Environmental and social impacts of selected structural measures

Source: JICA Project Team 2

10.6 Formulation of Priority Actions until 2050 and Incorporation into POLA and RENCANA for Adaptation and Mitigation against Climate Change Impacts

10.6.1 Proposed Priority Actions

Based on the discussions in the previous sections, priority actions that should be implemented in the three periods, 2020 to 2030, 2031 to 2040, and 2041 to 2050 are compiled in the following table, which is similar to those of POLA and RENCANA, as presented in Table 10.6.1. The project area has a great potential, but its development is still delayed. Therefore, the proposed actions are regarded not only as adaptation measures to climate change impact but also as measures that will comprehensively develop the project area especially in terms of water resources development and supply and flood control. The differences between the proposed actions and those in the present POLA and RENCANA are also summarized in Table 10.6.2.

Table 10.6.1 Proposed Measures and Actions until 2050

Aspect	Sub-aspect	Measure	Purpose	Target Area	Proposed Actions			Implementing and Related Agencies
					2020-2030	2031-2040	2041-2050	
1. Water Resources Conservation	1.1Water Resource Protection and Preservation	Revision of land use - Control plantation development in water resource area by restricting the approval system	1. Conservation of forest in water resource area 2. To restrict development in slope area 3. To establish erosion-resilient plantation pattern	Slope areas in the Musi River Basin	Sharing status of 1. sediment accumulation in Musi River and flooding as the result 2. Depletion of springs and decrease of groundwater in dry season with relevant agencies	Change the spatial plan and establish suitable plantation method in the slope area and OM	OM	Dishut (Prov. Forestry Dept.), DLHP (Envt.Dept.), BPDASHL (Min. of Forestry), BAPPEDA, Ministry of Land and Spatial Planning, BBWS-S8
		Adding water to groundwater layer	Water filling on water source	Central plain area	FS, EIA	OM	OM	BBWS-S8, government of regencies/cities and ESDM
	1.2 Water Preservation	Renewal of water supply pipes	Reduction of NRW (water leaks)	All Cities/regencies	Leak detection and replacement	Leak detection and replacement	Leak detection and replacement	PDAM
		Water demand management activities (non-structural measures)	Control/reduction of water demands	All cities and regencies	Formulation of action plans and implementation	Formulation of action plans and implementation	Formulation of action plans and implementation	PDAM, BBWS-S8, other related authorities
		Controlling groundwater use by prioritizing the use of surface water.	Integrated water use between surface water and groundwater use	All regencies/cities related to groundwater basin	1) Preparation of regional regulation on land use utilization 2) Socialization of PERDA concerning regulation of groundwater utilization	Enforcement	Enforcement	ESDM, Mining and Energy Agency of South Sumatra Province
		Groundwater level control	greenhouse gas emission reduction	Coastal peatland area	Legal countermeasure	Enforcement	Enforcement	BRG, TRGD
	1.3 Management of Water Quality and Control of Water Pollution.	Sewer collection & treatment in Palembang city	Improvement of sanitary condition and quality of water bodies	City center of Palembang city	Construction and OM	OM	OM	Cipta Karya Palembang city, Balai PPW
		Sewer collection & treatment in other 3 cities	Improvement of sanitary condition and quality of water bodies	City center of Lubuk Linggau, Pagar Alam and Prabumulih	FS, EIA, DD and Construction	Construction and OM	OM	City Cipta Karya
		Sewer collection & treatment in other major regencies	Improvement of sanitary condition and quality of water bodies	Urban area of other major regencies	F/S, EIA	D/D Construction	OM	Cipta Karya of each regency
	1.4 Routine Activities							
2. Water Resources Utilization	2.1 Stewardship of Water Resources							
	2.2 Provision of Water Resources							
	2.3 Utilization of Water Resources	Komering Irrigation Project Stage III	Extension of irrigation command area of 13,491 ha	Komering river basin	DD, Construction and OM	OM	OM	BBWS-S8

Aspect	Sub-aspect	Measure	Purpose	Target Area	Proposed Actions			Implementing and Related Agencies
					2020-2030	2031-2040	2041-2050	
		Komering Irrigation Project / Tulang Bawang	Diversion of irrigation water for 10,000 ha to Lampung Province	Tulang Bawan river basin (Lampung)	-	-	DD and Construction	BBWS-S8
		Lematang Irrigation Project	Integration of the existing Province-managed irrigation schemes of 2,000 ha	Lematang River Basin	DD, Construction and OM	OM	OM	BBWS-S8
		Air Gegas Irrigation Project	Integration of the existing local government managed irrigation schemes of 2,000 ha		DD, Construction and OM	OM	OM	BBWS-S8
		Air Rawas Irrigation Project	Provision of new irrigation facilities to rainfed area of 10,000 ha	Rawas River Basin	DD, Construction and OM	DD, Construction and OM	OM	BBWS-S8
		Kembahang Irrigation Project	Provision of new irrigation facilities to rainfed area of 3,000 ha	Ogan River Basin	-	DD and Construction	OM	BBWS-S8
		Muara Beliti Irrigation Project	Provision of new irrigation facilities to rainfed area of 3,000 ha	Rawas River Basin	-	DD, Construction and OM	OM	BBWS-S8
		Merapi Irrigation Project	Integration of the existing irrigation schemes of Province managed 1,479 ha and local government managed 3,521 ha	Lematang River Basin	-	DD and Construction	OM	BBWS-S8
		Dongku Kiri / Kanan Irrigation Project	Integration of the existing irrigation schemes of Province managed 3,000 ha and local government managed 7,000 ha	Lematang River Basin	-	-	DD, Construction and OM	BBWS-S8
		Irrigation Efficiency Improvement Project	Provision of tertiary canal system to the existing irrigation schemes of Province managed 35,062 ha and local government managed 54,178 ha	South Sumatra Province	-	DD, Construction (30,000 ha)	DD, Construction (59,240 ha)	BBWS-S8
		Upgrading of Channels and Gates for Tidal	1. For using lesser river water wisely	Delta area in the Musi Delta area	1. Sharing information on tidal	Renovation and construction	Renovation and construction	Department of agriculture, Lowland-Wetl

Aspect	Sub-aspect	Measure	Purpose	Target Area	Proposed Actions			Implementing and Related Agencies
					2020-2030	2031-2040	2041-2050	
		Irrigation	by agriculture in the delta 2. Raising standard of living of farmers in the delta for avoiding illegal cutting of trees		irrigation with related agency and farmers 2. Establish appropriate action plan 3. Renovation and construction of channels and gates	of channels and gates	of channels and gates	and-Coastal Area Data Info. Center, BBWS-S8, Farmers Association, Banyuasin Regency
	2.4 Development of Water Resources.	Tiga Dihaji Dam	Increase of available river water	Komering river basin	Construction, OM	OM	OM	BBWS-S8
		Modification of RRF Operation	Increase of available river water	Komering river basin	FS, EIA, Implementation	OM	OM	BBWS-S8
		Saka Dam	Increase of available river water	Komering river basin	DD, Construction	OM	OM	BBWS-S8
		Padang Bindu Dam	Increase of available river water	Lematang river basin	FS, DD, Construction	Construction, OM	OM	BBWS-S8
		Tanjug Agung Dam	Increase of available river water	Lematang river basin	FS	DD, Construction	Construction, OM	BBWS-S8
		Panjung Dam	Increase of available river water	Lematang river basin	-	FS, DD	Construction	BBWS-S8
		MP of Water Resources Development	Preparation of MP on Water Resources Development	Lematang, Kelingi & Lakitan Basins	MP	-	-	BBWS-S8
		Construction of Dams Proposed by MP	Increase of available river water	Lematang, Lakitang and Kelingi Basin	FS, DD, Construction	FS, DD Construction, OM	FS, DD Construction, OM	BBWS-S8
		Construction of Embungs	Increase of surface water	Komering, Lematang, Kelingi & Lakitan Basins	FS, DD, Construction, OM	FS, DD Construction, OM	FS, DD Construction, OM	BBWS-S8
	2.5 Water Resources Exploitation							
3. Water Damage Control	3.1 Prevention	River bank Protection	Bank erosion protection	All rivers	Inventory survey, DD, Construction, OM	DD, Construction, OM, Monitoring	DD, Construction, OM, Monitoring	BBWS-S8
		Sabo Works	Protection of sediment disasters	Mountainous Areas	MP, FS, DD, Construction, OM	FS, DD, Construction, OM	FS, DD, Construction, OM	BBWS-S8
		Road Heightening	Ensuring road transportation during floods	Flood-prone area	Inventory Survey, Implementation, OM	Implementation, OM	Implementation, OM	Bina Marga
		Drainage Works	Protection of urban areas from rainstorms	Urban areas	MP, FS, DD, Construction, OM	MP, FS, DD, Construction, OM	MP, FS, DD, Construction, OM	BBWS-S8, Cipta Karya, Bina Marga, Regencies/Cities
		River Dredging	Increase of river channel capacity	All river channels	Inventory Survey, Implementation, Monitoring	Inventory Survey, Implementation, Monitoring	Inventory Survey, Implementation, Monitoring	BBWS-S8
	3.2 Countermeasures	Preparation Precise Flood Hazard Maps by Regency	Identification of flood prone areas	All regencies/cities	Air-borne Survey, Flood mapping,	Revising of Flood maps	Revising of Flood maps	Regencies/Cities, BBWS-S8 BPBD
		Enactment of Ordinance for Management of Flood-prone Areas	Appropriate management of flood-prone areas	All regencies /cities except Palembang City	Enactment	Socialization, Enforcement	Enforcement	Regencies/Cities, BBWS-S8 BPBD

Aspect	Sub-aspect	Measure	Purpose	Target Area	Proposed Actions			Implementing and Related Agencies
					2020-2030	2031-2040	2041-2050	
		Establishment of Early Warning System	Providing warning about coming flood risks	All areas	MP, FS, DD, System Installation	OM, training	Renewal of system OM, training	Regencies/Cities, BBWS-S8 BPBD
		Strengthening of Emergency Response Activities	Reduction of flood damage and early recovery	Flood prone areas	Preparation of response plan, Training, Operation	Revision of response plan, Training, and Operation	Revision of response plan, Training, and Operation	BBWS-S8
	3.3 Recovery							
4. Water Resources Information	4.1 Information on water resources	Establishment of Saline Water Monitoring System	To provide information of saline water movement in the Musi River for effective water intake in less freshwater environment	Low-lying tidal areas	F/S, DD, system installation and OM	OM	OM	PDAM Kota Palembang, Banyuasin Regency, BBWS-S8, Provincial Environmental Agency
		Rehabilitation of Hydrological Observation System	Improvement of hydrological observation	Musi, Banyuasin, and Sugihan River Basins	MP, FS, DD and Installation	OM	OM and System Renewal	BBWS-S8
	4.2 Management of Information system							
5. Empowerment and Monitoring	5.1 Involving Role of Community in Water Resources Management	Capacity Development of Farmers on Tidal Irrigation	Capacity development of farmers on water management for tidal irrigation	Tidal Swamp irrigation	Preparation of manuals Training	Training	Training	BBWS-S8, NGO, Experts
		Capacity Development on Anti-drought Measures at Farm Level	Capacity development of farmers on anti-drought measures	Surface water irrigation area	Preparation of manuals Training	Training	Training	BBWS-S8, NGO, Experts

Source: JICA Project Team 2

Table 10.6.2 Summary of Differences between Proposed Actions and POLA and RENCANA

Item	POLA (2014) and RENCANA (2017)	Proposed Actions in this Project	Remarks
Target Year	POLA: 2033 RENCANA: 2036	2050	
Target Area	MSBL River Basins (86,00km^2)	Musi, Sugihan and Banyuasin River basins (76,000 km^2)	Refer to Subsection 7.4.2
Aspects Covered	The five aspects, conservation of integrated water resources, utilization of water resources, water damage control, water resources information system and empowerment and enhancement of the role of the community and business community are covered.	The five aspects of POLA and RENCANA are covered, but more focusing on utilization of water resources and water damage control.	
Consideration of Climate Change Impacts	It is described in POLA that two climate change scenarios (no significant climate change and significant climate change impact) are considered, but there is no description about how these climate change scenarios were incorporated in the operational policies.	Three climate scenarios (High, Medium and Low) are considered. The quantitative analyses were also conducted for assessment of climate change impacts on flood and drought.	
Proposed Activities/Actions	Several hundreds of activities that cover the five aspects are proposed in RENCANA.	More important actions are proposed for water resources development, water supply and flood management as well as adaptation to climate change impacts on flood and drought.	There are a lot of common activities/actions between RENCANA and Table 10.6.1

Source: JICA Project Team 2

10.6.2 Preliminary Cost Estimation for Water Resources Development and Water Supply

The project cost of the water resources development and water supply of the four river basins for the 2050 targets presented in Table 10.4.5 is estimated as presented in Table 10.6.3. The details of the estimation are explained in the Supporting Report L. The total project cost is estimated at about IDR90 trillion.

Table 10.6.3 Summary of Project Cost Estimation for Water Resources Development

River Basin	Category	Measures	Project Cost (IDR Billion)	Remarks
Komering	Dam Reservoirs	Construction of Tiga Dihaji Dam	6,271	Hydropower included.
		Modification of RRF Operation	0	
		Construction of Saka Dam	3,045	Hydropower included.
		Sub-total	9,316	
	Development of DMI Water Supply	Construction of WTP	2,369	
		Development of Pipe Network	977	
		Reduction of NRW	76	
		Sub-total	3,421	
	Development of Irrigation Water Supply	Development of Main Canals	642	
		Development of Secondary Canals	3,088	
		Development of Tertiary Canals	6,461	
		Management of Drains and Filed Works	2,096	
		Sub-total	12,286	
		Sub-total	25,024	
Lematang	Development of Dam Reservoirs	Construction of Padang Bindu Dam	7,219	
		Construction of Tanjung Agung Dam	13,630	
		Construction of Panjung Dam	28,690	
		Sub-total	49,539	
	Development of DMI Water Supply	Construction of WTP	2,004	
		Development of Pipe Network	1,699	
		Reduction of NRW	61	
		Sub-total	3,764	
	Development of Irrigation Water Supply	Development of Main Canals	464	
		Development of Secondary Canals	1,314	
		Development of Tertiary Canals	3,629	
		Management of Drains and Filed Works	1,177	
		Sub-total	6,585	
		Sub-total	59,888	
Kelingi	Development of DMI Water Supply	Construction of WTP	678	
		Development of Pipe Network	569	
		Reduction of NRW	73	
		Sub-total	1,320	
	Development of Irrigation Water Supply	Development of Main Canals	-	
		Development of Secondary Canals	-	
		Development of Tertiary Canals	831	
		Management of Drains and Filed Works	270	
		Sub-total	1,101	
		Sub-total	2,420	
Lakitan	Development of DMI Water Supply	Construction of WTP	395	
		Development of Pipe Network	374	
		Reduction of NRW	47	
		Sub-total	816	
	Development of Irrigation Water Supply	Development of Main Canals	82	
		Development of Secondary Canals	395	
		Development of Tertiary Canals	1,012	
		Management of Drains and Filed Works	265	
		Sub-total	1,753	
		Sub-total	2,570	
Total		Development of Dam Reservoirs	58,856	
		Development of DMI Water Supply	9,321	
		Development of Irrigation Water Supply	21,725	
		Grand Total	89,902	

Source: JICA Project Team 2

10.6.3 Implementation Schedule

The abovementioned measures for water resources development and water supply are proposed to be implemented from 2020 to 2050 as shown in Table 10.6.4, taking into considerations followings:

- It is assumed that all the measures will be completed by the target year 2050.
- This schedule is common for the three scenarios.
- The implementation order of the dam reservoirs is determined based on the cost efficiency. Therefore, those of the Komering River basin are implemented prior to those of Lematang River basin.
- It was found in the water balance analysis that the three dam reservoirs in the Lematang River basin are not very effective, and that they should be replaced by more effective dam sites that should be identified in a future study. However, the three dam reservoirs are provisionally kept in the table until the more effective dam sites are identified.
- According to the results of the water balance analysis, even if all the measures presented in Table 10.6.3 are implemented, water shortage, especially for irrigation, will not be able to be avoided. Therefore, other measures proposed in Table 10.4.4 should be additionally implemented to comprehensively cope with the impact of climate change.

Table 10.6.4 Tentative Implementation Schedule

River Basin	Work	Year																														
		20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Komering	Costruction of Tiga Dihaji Dam	■	■	■																												
	Modification of RRF Operation				■	■																										
	Costruction of Saka Dam						■	■	■	■	■																					
	Development of DMI Water Facitily	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Development of Irrigation Facility	■	■	■	■	■	■	■	■	■	■																					
Lematang	Construction of Padang Bindu Dam											■	■	■	■	■																
	Construction of Tanjung Agung Dam																■	■	■	■	■	■	■									
	Construction of Panjung Dam																							■	■	■	■	■	■	■	■	■
	Development of DMI Water Facitily	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Development of Irrigation Facility											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Kelingi	Development of DMI Water Facitily	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Development of Irrigation Facility	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Lakitan	Development of DMI Water Facitily	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Development of Irrigation Facility	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: JICA Project Team-2

10.6.4 Organization and Institution

(1) Relevant Agencies

As presented in the above tables, there are various implementing and related agencies for the proposed climate change adaptation measures in the Musi River basin. Among others, the key relevant agencies and coordinating bodies at a basin level are enumerated as follows:

Sumatra VIII River Basin Organization (BBWS-S8[4]):

BBWS-S8 was established in accordance with Ministerial Regulation No.13/PRT/M/2006 which is under and is responsible to Director General of Water Resources, Ministry of Public Works and Housing. BBWS-S8 is responsible for executing water resources management of the Musi-Sugihan-Banyuasin-Lemau (MSBL) River basin.

Water Resources Management Coordinating Team (TKPSDA[5]):

TKPSDA was established in 2013 as a coordinating body for water resources management in the MSBL River basin with a total of 88 members. The tasks of TKPSDA include formulation of POLA and RENCANA for water resources management.

Musi Watershed and Protected Forest Management Organization (BPDASHL[6]):

The Musi BPDASHL is a technical implementation unit for the management of watersheds and protection forests, which is under and is responsible to the Director General of Watershed and Protected Forest Management, Ministry of Environment and Forestry. The Musi BPDASHL manages watershed areas of about 86,000 km^2.

Regional Development Planning Agency (BAPPEDA[7]) of South Sumatra Province:

BAPPEDA is a regional technical institution in the field of regional development research and planning, which is under and is responsible to the Governor through the Regional Secretary.

Regional Disaster Management Agency (BPBD[8]) of South Sumatra Province:

BPBD is a non-departmental government agency that carries out disaster management tasks in the provincial areas based on policies determined by the National Disaster Management Agency (BNPB[9]).

Department of Public Works, Highway and Spatial Planning (PUBM-TR[10]) of South Sumatra Province:

PUBM-TR is an implementing unit of the provincial government in the field of public works, highways and spatial planning. The major functions of PUBM-TR Office are formulation of technical policies for development and management, technical supervision and control, and guidance of regency/city's infrastructure services.

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[4] BBWS-S8 (*Balai Besar Wilayah Sungai Sumatra VIII*)

[5] TKPSDA (*Tim Koordinasi Pengelolaan Sumber Daya Air*)

[6] BPDASHL (*Balai Pengelolaan Daerah Aliran Sungai dan Hutan Lindung*)

[7] BAPPEDA (*Badan Perencanaan Pembangunan Daerah*)

[8] BPBD (*Badan Penanggulangan Bencana Daerah*)

[9] BNPB (*Badan Nasional Penanggulangan Bencana*)

[10] Dinas PUBM-TR (*Dinas Pekerjaan Umum Bina Marga dan Tata Ruang*)

Department of Environmental and Land (DLHP[11]) of South Sumatra Province:

DLHP is an agency which is domiciled as the office of environmental management in the province of South Sumatra. Broadly speaking, the strategic function carried is to facilitate sustainable development in accordance with the mandate of Law No.32/2009 concerning environmental protection and management.

Department of Forestry (Dishut[12]) of South Sumatra Province:

Dishut is the implementing unit of the provincial government in the field of forestry. The major functions of Dishut are formulation of policies for the management in the forestry sector, coordination of forest management, and supervision and evaluation of forest management.

Provincial Peat Restoration Team (TRGD[13]) of South Sumatra Province:

Peat Land Restoration Agency (BRG[14]) was established in 2016 at the national level in accordance with the Presidential Regulation No.1/2016. Following this, TRGD of South Sumatra Province was established in 2017. TRGD is a non-departmental agency under and is responsible to the governor. TRGD is a coordinating body for the respective departments in the province.

Various Departments of the respective City/Regency in the Musi River basin:

Within the Musi River basin, there are 17 cities/regencies including Palembang City and Banyuasin, Ogan Komering Ilir and Muara Enim Regencies. Each city/regency has similar departments to that of the Government of South Sumatera Province as stated above.

Tirta Musi Regional Water Utility Company (PDAM[15]):

PDAM is a regional-owned business unit, which is engaged in the distribution of clean water to the general public. PDAM Tirta Musi covers the area of 401 km^2 in and around Palembang City and the population of 1.6 million people. It has three units of intake along the Musi River and six units of water treatment plants in the area.

(2) Outline of Interview Surveys on Organizational and Institutional Concerns

Most of the proposed climate change adaptation measures are supposed to be implemented by more than one agency and to involve various sectors. In order to clarify the issues and concerns in implementing the proposed measures, interview surveys were conducted in August 2019.

The interview was conducted based on the questionnaire, which is composed of four aspects, namely organizational functions, institutional constraints, human resources and funding as summarized in Table 10.6.5. Since some questions are not applicable for some agencies, the questions were properly selected depending on the agency. Besides, emphasis was put on identifying issues through discussions rather than collection of information itself.

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[11] BLHP (*Dinas Lingkungan Hidup dan Pertanahan*)
[12] Dishut (*Dinas Kehutanan*)
[13] TRGD (*Tim Restorasi Gambut Daerah*)
[14] BRG (*Badan Restorasi Gambut*)
[15] PDAM (*Perusahaan Daerah Air Minum*)

Table 10.6.5 Summary of Questions on Organizational and Institutional Concerns

Category	Questions
Organizational Functions	Q 1-1) Implementing and related agencies for the respective measures Q 1-2) Demarcations of roles and responsibilities between agencies Q 1-3) Inefficiencies in operation due to overlapping functions and so forth Q 1-4) Issues in coordination
Institutional Constraints	Q 2-1) Unharmonized laws and regulations between sectors Q 2-2) Surveillance systems of illegal behaviors Q 2-3) Law enforcement of illegal behaviors Q 2-4) Improvement of existing regulations
Human Resources	Q 3-1) Shortage of human resources Q 3-2) Personnel capacity to be strengthened
Funding	Q 4-1) Issues in budgetary arrangement system Q 4-2) Performance of fund management Q 4-3) Financial capacity of local governments

Source: JICA Project Team 2

The interviews were conducted by separately visiting the agencies listed in Table 10.6.6. The target agencies for interview survey were selected in consultation with BBWS-S8 considering importance of the roles in the proposed measures.

Table 10.6.6 List of Interviewees for the Musi River Basin

No.	Date	Name of Agency (Division/Section of Principal Interviewee)
1	Aug 12, 2019	BBWS-S8 (General Program and Planning Division)
2	Aug 12, 2019	BBWS-S8 (General Planning Section)
3	Aug 13, 2019	BPBD of South Sumatra Province (Rehabilitation and Reconstruction Division)
4	Aug 13, 2019	BBWS-S8 (Operation and Maintenance Division)
5	Aug 14, 2019	Department of Public Works and Spatial Planning of Palembang City (Water Resources, Irrigation and Waste Division)
6	Aug 14, 2019	TRGD of South Sumatra Province
7	Aug 15, 2019	PDAM Tirta Musi
8	Aug 16, 2019	Department of Public Works of Ogan Komering Ilir Regency (Planning Division)
9	Aug 16, 2019	BAPPEDA of South Sumatra Province (Infrastructure and Regional Development Division)

Source: JICA Project Team 2

(3) Results of Interview Surveys on Organizational and Institutional Concerns

Major findings from the interviews are summarized and enumerated below. The source of description is presented at the end of each description by referring to the above interview no. in parentheses.

1) Organizational functions (for Q1-1 to Q1-3)

   a) Even though different agencies have similar functions, the responsibilities are different. Therefore, there are no overlapping functions that may cause a problem [No.1,5].

   b) The demarcation of roles of hazard map preparation is not clearly recognized among agencies [No.3,4,5,8].

   c) There is more than one agency that are willing to establish and operate a flood early warning system in the future [No.3,4,5].

   d) Although a clear leading agency of a saline water monitoring system could not be confirmed in the interviews, BBWS-S8 suggested provincial DLHP [No.4,7].

   e) The demarcations of roles have been previously discussed among agencies each time the measures are implemented. Palembang City is in the process of issuing a letter to BBWS-S8 regarding roles in implementing river projects [No.5].

f) In implementing sewerage projects, an implementing agency (province or city) is flexibly determined depending on available budget at the time. To achieve a national slogan for sanitation, agencies at each level work together cooperatively [No.5].

g) TRGD is only a coordinating body and thus does no implement a project. Groundwater control is supposed to be implemented by BRG [No.6,8].

h) The responsibility of land use planning has been changed from BAPPEDA to the provincial department of public works, highways and spatial planning [No.9].

2) Coordination between agencies (for Q1-4)

a) In some cases, lack of coordination is caused by personal insufficient capacity or negligence rather than by an institutional defect [No.1].

b) There was a case in which a conflict was caused due to water shortage when the both BBWS-S8's and provincial irrigation areas utilize the same water source [No.4].

c) There is another case in which a conflict was caused among fisheries and paddy farmers. In this case, water users' association was not well-functional [No.4].

d) In implementing structural measures in the conservation forest close coordination with BPDASHL, which is responsible for watershed management, is required [No.4].

e) There are two coordinating bodies at a basin level, namely TKPSDA and Forum DAS Musi, and sometimes enough coordination between the two is not ensured [No.9].

3) Law enforcement to illegal behaviors (for Q2-2 & Q2-3)

a) Agencies responsible for water resources management such as BBWS-S8 and local government's department of public works do not have authority to perform law enforcement. They only monitor and report [No.1,4,5,8].

b) There is a civil servant investigator (PPNS[16]) system. BBWS-S8 staff who is appointed as an investigator has the authority to carry out criminal investigations [No.1].

c) Palembang City established the "River Care Community" and the "Flood Care Community" for monitoring of dumping and building in riparian areas [No.5].

4) Regulations to be added or improved (for Q2-4)

a) Although various ministerial regulations were stipulated after the Water Resources Law was revoked in 2014, these are not enough. The new law is still

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[16] PPNS (*Penyidik Pegawai Negeri Sipil*)

in process [No.4].

b) A recent regulation enabled BBWS or the province to implement drainage projects even in areas under the jurisdiction of the city when the city does not have enough budget [No.5].

c) Before stipulating ordinances at a city level to encourage the public to keep a river clean, there is a necessity of national-level or ministerial-level regulations [No.5].

d) A new regulation regarding an irrigation participation system, which is in process, will enhance public participation under the legal framework [No.9].

5) Map problems (not included in the questionnaire)

   a) From a technical point of view, there are issues in sharing maps. Since each department creates its own map, some parts are inconsistent [No.9].

   b) Some parts of administrative boundaries of regency are not clearly recognized. This issue may make it difficult to change land use planning when the two overlapped regencies have different policies [No.9].

   c) The demarcation of responsibility in implementing irrigation projects is clearly determined by the ministerial regulation. However, the inconsistencies in the maps produce inaccurate irrigation areas and result in overlapping functions [No.9].

6) Human resources (for Q3-1 & Q3-2)

   a) BBWS-S8 has enough human resources in terms of numbers, while there is a sense of inadequacy due to insufficient personal capacity [No.1].

   b) All divisions of BBWS-S8 are short of staff. In particular, O&M Division could not outsource and thus require more staff [No.4].

   c) Palembang City has enough human resources in terms of both quantity and quality [No.5].

   d) Ogan Komering Ilir Regency and BAPPEDA require more staff [No.8,9].

   e) Since TRGD was established by gathering various back-grounded staff, it requires systematic capacity development [No.6].

   f) Technical field that require capacity development are: engineering and water resources management [No.1], emergency response [No.3], civil, water resources and geology [No.4], climate change, peat management and water management [No.6], planning [No.8], and information & IT [No.9].

7) Financial arrangements (for Q4-1 to Q4-3)

   a) Although not all budgetary requests are approved, priorities are determined within the allocated budget [No.1,4,5,9].

   b) Since a disaster occurrence could not be predicted in advance, financial surplus or deficit depends on the disaster scales [No.3].

c) There are no obvious problems in the existing budgetary arrangement system and the fund management [No.1,4,5,6,8].

(4) Considerations

As stated above, the interview surveys revealed both the good and poor aspects. On the whole, the existing institutional framework and organizational arrangement for the water resources management in the Musi River basin seem adequate. However, some significant concerns were identified. Since some of them are common to that of the Brantas River basin, remedial actions are recommended in Section 12.2.2 together with the Brantas River basin.

10.6.5 Economic Analysis and Project Evaluation

(1) Economic Evaluation

Economic Evaluation is conducted for the major measures for the water resources development and water supply of the four proposed river basins as presented in Table 10.6.3 and Table 10.6.4. The results of the economic evaluation are summarized in Table 10.6.7, and its details are presented in the Supporting Report L.

From the table, the following considerations are made:

- The EIRR for the total river basins is 8.6% for the low scenario, 7.4% for the medium scenario, and 7.1% for the high scenario. It is noted that there is an EIRR range of as much as 1.5%, depending upon the climate change scenario.
- Since the proposed measures for the Komering River basin have a considerably high EIRR from 11.5% to 13.6% which is greater than 9% to 12% of the minimum required discount rates for international donors, these seem to be economically feasible.
- For other river basins the proposed measures are not economically feasible, and it is recommended that the dam plans and the irrigation area development plans be reviewed and/or modified if necessary.

Table 10.6.7 Summary of Economic Evaluation

Scenario	River Basin	EIRR (%)	NPV* (IDR billion)	B/C*
Low	Komering	13.6%	4,870	1.3
	Lematang	N/A	-5,394	0.4
	Kelingi	N/A	-811	0.3
	Lakitan	3.4%	-531	0.5
	Total	8.6%	-1,866	0.9
Medium	Komering	12.3%	3,154	1.2
	Lematang	N/A	-5,468	0.4
	Kelingi	N/A	-784	0.3
	Lakitan	3.7%	-513	0.5
	Total	7.4%	-3,611	0.9
High	Komering	11.5%	2,110	1.1
	Lematang	N/A	-4,826	0.5
	Kelingi	N/A	-807	0.3
	Lakitan	3.5%	-528	0.5
	Total	7.1%	-4,050	0.8

Note: *: Discount rate for estimaiton of NPV and B/C is 10%.
Source: JICA Project Team 2

(2) Possible Fund Source of the Project

Most of fund sources of the measures proposed in this project have not been decided except the dam construction of the Tiga Dihaji Dam and the Komering Irrigation Project Phase III. The construction of the Tiga Dihaji Dam was started since 2019, financed by Anggaran Pendapatan dan Belanja Negara (APBN), State Budget of Indonesia. The Komering Irrigation Project Phase III will be financed by the JICA loan.

The most probable fund source of the other measures would be APBN although donor fund or other fund sources are also possible. In order to secure the APBN, which is most probable case for each measure, necessary procedures should be followed.

From a budgetary perspective, according to the information from BBWS-S8, the budget in 2019 (Approximately IDR 11 trillion) is 2.7 times as much as in 2015 (Approximately IDR 4 trillion), which shows the trend of high growth rate of the budget.

In order to consider whether the project cost (IDR 90 trillion) is affordable or not for BBWS-S8, simple estimation is conducted using the above budget amount in 2019, and the GDP growth rate of Indonesia from 2017 to 2018 (5.17%) instead of the above high growth rate, to make the estimation conservative. The total estimated budget from 2020 to 2050 become at approximately IDR84 trillion which is a little lower than the amount of total budget of this project. Considering this figure, the said trend of budget increase, and the fact that priority project will be selected from other projects by national policy, the project cost would not be unrealistic.

10.7 Proposed Climate Change Measures to be Incorporated into POLA and RENCANA

The current POLA and RENCANA were approved in 2014 and 2017 respectively. These policy and strategy documents that cover 20 years onwards are supposed to be revised every five years. Therefore, the next revision will be made around 2019 for POLA and around 2022 for RENCANA, respectively, and therefore, the proposed actions for the years from 2020 to 2040 listed in Table 10.6.1 should be incorporated in the next POLA and RENCANA.

Part 4

CAPACITY STRENGTHENING

CHAPTER 11 CAPACITY STRENGTHENING

11.1 Workshops

JICA Project Team 2 held workshops in Jakarta, Surabaya and Palembang in the course of the Project as part of their capacity strengthening activities for the Indonesian side. The number of workshops as well as the number of participants in each venue are compiled in Table 11.1.1. In the workshops, the respective experts of Team 2 provided presentations about topics/subjects on their expertise, including lectures on survey/study methods and introduction of study examples in Japan and other countries, for the participants with the aim of deepening their technical knowledge and understanding closely related to the Project through discussions and exchange of opinions among all participants, inviting several engineers, mainly working-level officials from relevant counterpart agencies.

Table 11.1.1 Summary of Workshops Held in the Project

Venues	Phase 1		Phase 2		Total	
	TNWS	TNP	TNWS	TNP	TNWS	TNP
JKT	1	4	4	58	5	62
SBY	10	approx.130	8	83	18	213
PLM	8	80	8	85	16	165
Total	19	214	20	226	**39**	**440**

Notes: Phase 1 : June 2013 to June 2016, Phase 2 : July 2016 to January 2020
TNWS = Total number of workshops (time)
TNP = Total number of participants (person) excluding members of JICA Project Team 2
Source: JICA Project Team 2

11.2 Country-focused Training in Japan

The Project includes a JICA country-focused training program to strengthen the capacity of the Indonesian side to plan water resources management through assessing climate change impacts. Four country-focused trainings in total were conducted in Japan with the cooperation of JICA Project Teams 1 and 2 during the project phases 1 and 2, as reported hereunder.

Phase 1 Training

In Phase 1 of the Project (from June 2013 to June 2016), the first and second country-focused trainings as outlined in Table 11.2.2 were carried out by the JICA Project Team 2 in cooperation with the JICA Project Team 1, headed by Prof. Dr. Koike, the University of Tokyo, in charge of Project Component 1: “Climate Change Impact Assessment and Runoff Analysis”, based on the tentative training program on “Assessment of Climate Change Impacts” presented in Table 11.2.1.

Table 11.2.1 Program of Training on Assessment of Climate Change Impacts (Tentative)

Item	Contents
Trainee	4 persons in total (from PUSAIR, DGWR, and BMKG)
Period	4 weeks x 2 times (The same trainees will be invited twice.)
Purpose	To learn methods for assessment of climate change impacts and runoff analysis
Topics	First 4 weeks: Learning methods through lectures and practices Second 4 weeks: Deepening understanding through study work by themselves
Trainer	Project Team for "Climate Change Impact Assessment and Runoff Analysis"

Source: JICA Project Team 2

Table 11.2.2 Outline of JICA First and Second Country-focused Trainings in Japan for Assessment of Climate Change Impacts

<table>
<tr><th colspan="3">I. JICA First Training in Japan</th></tr>
<tr><td>Title of Course:</td><td colspan="2">Simulation and Evaluation of Climate Change Impacts by Downscaling and Hydrological Modeling 1</td></tr>
<tr><td>Objectives of Training</td><td colspan="2">To build up technical knowledge for the trainees:
(1)To assess climate change impacts in consideration of uncertainty in climate change impacts, and
(2)To consider adaptation measures based on quantitative assessment of climate change impacts</td></tr>
<tr><td>Period:</td><td colspan="2">31 March to 26 April 2014 (27days)</td></tr>
<tr><td>Trainees</td><td colspan="2">
<table>
<tr><th>No.</th><th>Names</th><th>Organizations</th><th>Positions</th></tr>
<tr><td>1</td><td>Mr. HARIADI Mugni Hadi</td><td>BMKG</td><td>Researcher of Climate Change and Air Quality</td></tr>
<tr><td>2</td><td>Mr. WICASONO Fajar Baskoro</td><td>DGWR, MPWH</td><td>Staff of Hydrology & Water Quality</td></tr>
<tr><td>3</td><td>Mr. Heruyoko</td><td>PUSAIR, MPWH</td><td>Staff of Experimental Station for Hydrology and Water Management</td></tr>
<tr><td>4</td><td>Ms. SEIZARWATI Wulan</td><td>PUSAIR, MPWH</td><td>Staff of Experimental Station for Hydrology and Water Management</td></tr>
</table>
</td></tr>
<tr><td>Training Venue:</td><td colspan="2">JICA/Tokyo, University of Tokyo</td></tr>
<tr><td>Training Items</td><td colspan="2">- Overview of climate system and climate change impact assessment
- Bias correction, dam operation
- WEB-DHM[1] training for Musi River and Brantas River basins (introduction, preparation of input data)
- Evaluation of future conditions using WEB-DHM with GCM data
- Crop model/coupled water-rice model with irrigation module</td></tr>
<tr><td>Photos</td><td></td><td></td></tr>
<tr><td></td><td>**Lecture by Prof. Dr. T. Koike**</td><td>**Presentation of Training Report/ Evaluation Meeting of Training**</td></tr>
</table>

<table>
<tr><th colspan="2">II. JICA Second Training in Japan</th></tr>
<tr><td>Title of Course:</td><td>Simulation and Evaluation of Climate Change Impacts by Downscaling and Hydrological Modeling 2</td></tr>
<tr><td>Objectives of Training</td><td>Same as in the First Training</td></tr>
<tr><td>Period:</td><td>27 May to 24 June 2015 (29days)</td></tr>
<tr><td>Trainees</td><td>
<table>
<tr><th>No.</th><th>Names</th><th>Organizations</th><th>Positions</th></tr>
<tr><td>1</td><td>Mr. Mohammad Ridwan Nur Prasetyo</td><td>BMKG</td><td>Staff of Climate Early Warning Sub Division,</td></tr>
<tr><td>2</td><td>Mr. Heruyoko</td><td>PUSAIR, MPWH</td><td>Staff of Experimental Station for Hydrology and Water Management</td></tr>
<tr><td>3</td><td>Ms. SEIZARWATI Wulan</td><td>PUSAIR, MPWH</td><td>Staff of Experimental Station for Hydrology and Water Management</td></tr>
</table>
</td></tr>
<tr><td>Training Venue:</td><td>JICA/Tokyo, University of Tokyo, ICHARM[2], JAXA[3], JMA[4], Nippon Koei Co., Ltd.</td></tr>
<tr><td>Training Items</td><td>- Analysis of climate change
- Overview of WEB-DHM
- Study result of Brantas River basin with WEB-DHM
- Work on development of WEB DHM
- Study on agricultural issues</td></tr>
</table>

Note: 1,WEB-DHM = Water Energy Budget-based Distributed Hydrological Model, 2, ICHARM = International Centre for Water Hazard and Risk Management, 3, JAXA = Japan Aerospace Exploration Agency, 4. JMA = Japan Meteorological Agency

Source: JICA Project Team 2

Phase 2 Training

In Phase 2 of the Project (from July 2016 to January 2020), the third and fourth country-focused trainings as outlined in Table 11.2.4 were conducted by the JICA Project Team 2, based on the tentative training program on “Water Resources Management Plan” presented in Table 11.2.3.

Table 11.2.3 Program of Training on Water Resources Management Plan (Tentative)

Item	Contents
Trainee	8 persons in total (from DGWR, BBWS in Brantas and Musi, and PJT I)
Period	15 days x 2 times (Different trainees will be invited for the respective times.)
Purpose	To learn way of thinking about climate change impacts and method of formulating/implementing water resources management plans in Japan, aiming to contribute to formulation and implementation of water resources management plans by reflecting climate change impacts in Indonesia.
Topics	First 1 week of 15 days : Lecture on formulation of water resources management plan reflecting climate change impacts Second 1 week of 15 days : Training in fields
Trainer	Lecture: Consultants for the Component on “Water Resources Management Plan” Field visit: to be decided based on consultation with relevant parties

Source: JICA Project Team 2

Table 11.2.4 Outline of JICA Third and Fourth Country-focused Trainings in Japan for Water Resources Management Plan

I. **JICA Third Training in Japan**	
Title of Course:	Indonesia Water Resources Management Plan
Objectives of Training (1)	To consider adaptation measures based on quantitative assessment results of climate change having uncertainties, and contribute to formulation and implementation of water resources management plans with considerations for climate change impacts in Indonesia
Period:	30 September to 13 October 2018 (14days)
Trainees	see below
Training Venue:	JICA/Tokyo, Nippon Koei Co., Ltd.
Training Items	- To be able to understand and/or explain the outline of method for climate change projection (General Circulation Model: GCM selection, bias correction, downscaling, etc.) - To be able to understand and/or explain methods and case studies of flood inundation analysis and water balance analysis to formulate water resources management plans (flood and water use management) - To be able to understand and/or explain the methodology for water resources management plans in consideration of the uncertainties in climate change projection (including a case study of plan formulation for Brantas River basin) - Field observation
Photos	 **Program Orientation**  **Office for Integrated Control of the Dams in the Yodo River System**

Trainees:

No.	Names	Organizations	Positions
1	Ms.Lucky Dyah Ekorini	BBWS Brantas	Head of Sub Directorate of Operation and Maintenance, MOPWH
2	Mr.Arie Adrian Lubis	BBWS Sumatra VIII	Head of Sub Directorate of General Planning, MOPWH
3	Mr.Gede Santika Darma	PJT 1	Staff of Operation and Maintenance, Perum Jasa Tiruta 1

II. **JICA Fourth Training in Japan**	
Title of Course:	Water Resources Management Plan
Objectives of Training (1)	To consider adaptation measures based on quantitative assessment results of climate change having uncertainties, and contribute to formulation and implementation of water resources management plans with considerations for climate change impacts in Indonesia
Period:	12 to 25 May 2019 (14days)

<table>
<tr><th colspan="3">II. JICA Fourth Training in Japan</th></tr>
<tr><td>Trainees</td><td colspan="2">
<table>
<tr><th>No.</th><th>Names</th><th>Organizations</th><th>Positions</th></tr>
<tr><td>1</td><td>Mr. Widi Pradipta</td><td>Pemali Juana River Basin Office</td><td>Program Section Chief of Planning and Programming Sector, MOPWH</td></tr>
<tr><td>2</td><td>Ms. Ardhiantanti Febby</td><td>Brantas River Basin Office</td><td>Program Section Chief of Planning and Programming Sector, MOPWH</td></tr>
<tr><td>3</td><td>Ms. Hartini Komang Sri</td><td>Center for Data and Information Technology</td><td>Head of Geospatial Data and Information Sub Division, MOPWH</td></tr>
<tr><td>4</td><td>Mr. Meidiansyah Doddy</td><td>BBWS Sumatra 8</td><td>Commitment Making Officer of Planning and Program, MOPWH</td></tr>
</table>
</td></tr>
<tr><td>Training Venue:</td><td colspan="2">JICA/Tokyo, Nippon Koei Co., Ltd., Yodogawa Integrated Dam Management Office, Watarase Retarding Basin Branch Office</td></tr>
<tr><td>Training Items</td><td colspan="2">- To be able to understand and/or explain the outline of method for climate change projection (General Circulation Model: GCM selection, bias correction, downscaling, etc.)
- To be able to understand and/or explain methods and case studies of flood inundation analysis and water balance analysis to formulate water resources management plans (flood and water use management)
- To be able to understand and/or explain the methodology for water resources management plans in consideration of the uncertainties in climate change projection (including a case study of plan formulation for Brantas River basin)
- Field observation</td></tr>
<tr><td>Photos</td><td></td><td></td></tr>
<tr><td></td><td>Lecture in Nippon Koei Office</td><td>Explanation at Gazebo in WATARASE Retarding Basin Area</td></tr>
</table>

Source: JICA Project Team 2

11.3 Seminars

JICA Project Team 2 conducted the first to fourth seminars in Jakarta, Surabaya and Palembang with the support and cooperation of JICA and JICA Project Team 1, of which the outlines are compiled in Table 11.3.1. The second seminar in JKT (19 May 2014) invited the participants from MPW (currently called MPWH; JKT Head Office and Balai offices), provincial/regency governments, MOE, BMKG, BAPPENAS, people's representatives, universities, Japanese consultant companies in Indonesia, etc. and made efforts of dissemination and publicity regarding the project outcomes, including press reporting. This seminar started with an opening address by Dr. Ir. Basoeki Hadimoeljono, DG of Spatial Planning, MPW (currently MPWH).

The third seminar was held in Palembang and Jakarta, which was started with the opening addresses by Ir. Jarot, General Manager of BBWS Sumatra VIII in PLMB and Ir. Imam Santoso, DG of Water Resources, MPWH in JKT, respectively.

The fourth seminar was held in Surabaya, Palembang and Jakarta as the last seminar of the Project so that the outputs of the Project would be widely shared, including the handbook to be applicable to formulation of the Water Resources Management Plans in Indonesia, taking climate change issues into account.

Table 11.3.1 Outlines of First to Fourth Seminars in Indonesia

I. First Seminar in Jakarta	
Items	**Descriptions**
Venue	Conference Room of 8th Floor, Directorate General of Water Resources, MPW (Jakarta)
Date	24 June 2013
Major contents	1) Approach of Climate Change Impact Assessment on River Basin by Using WEB-DHM 2) Approach of Evaluation of Climate Change Impacts on Food Production 3) Climate Change Prediction (Case of PUSAIR) 4) Climate Change Prediction (Case of BMKG) 5) Water Resources Management Plan with Climate Change Impacts 6) Adaptation for Climate Change in Each Country
Speakers	1) Prof. Dr. Toshio Koike, the University of Tokyo 2) Dr. Koki Homma, the University of Kyoto 3) Ir. Bambang Hargono, PUSAIR 4) Dr. Evin Aldrian, Director, Center for Climate Change & Air Quality, BMKG 5) Dr. Baba Hitoshi, JICA Senior Advisor 6) Mr. Kunihiro Moriyasu, MLIT, Japan
Moderators	Dr. Ir. Mochammad Amron: President of HATHI Dr. Ir. Djaja Murni Wargadalam
Participants*	31 people

<table>
<tr><th colspan="3">II. Second Seminar in Jakarta and Surabaya</th></tr>
<tr><th>Items</th><th colspan="2">Descriptions</th></tr>
<tr><td>Venues</td><td>Jakarta: Conference Room of 8th Floor, Directorate General of Water Resources, MPW</td><td>Surabaya: Singgasana Hotel</td></tr>
<tr><td>Dates</td><td>19 May 2014</td><td>20 May 2014</td></tr>
<tr><td>Major contents</td><td colspan="2">1) Lecture：“New Paradigm to Formulation of WRM Strategy in Uncertainty”
2) Explanation of study results on climate change impacts and runoff analysis in the Brantas River basin
• Introduction of climate change impacts and adaptation
• Climate change impact evaluation on water resources management and hydrological simulation
• Paddy field division and application to simulation model
• Development of hydrological model coupled with rice cropping
3) Presentation of study outcomes by the time of this seminar
• Proposal of approaches for water balance and flood inundation analyses based on specific conditions in object river basin related to water resources management</td></tr>
<tr><td>Speakers</td><td colspan="2">1): Dr. Baba Hitoshi, JICA Senior Advisor
2): Team 1
3): Team 2</td></tr>
<tr><td>Moderators</td><td>Dr. Eka Nugraha Abdi,
Head of Subdid of Hydrology and Water Quality, PU</td><td>Ir. Anggia Satrini,
Head of Division for Program and Planning, Balai Brantas</td></tr>
<tr><td>Participants*</td><td>42 people</td><td>65 people</td></tr>
</table>

<table>
<tr><th colspan="3">III. Third Seminar in Palembang and Jakarta</th></tr>
<tr><th>Items</th><th colspan="2">Descriptions</th></tr>
<tr><td>Venues</td><td>Palembang: Conference Room of 3rd Floor, BBWS Sumatra VIII, MPWH</td><td>Jakarta: Conference Room of 8th Floor, DGWR, MPWH</td></tr>
<tr><td>Dates</td><td>2 February 2017</td><td>3 February 2017</td></tr>
<tr><td>Major contents</td><td colspan="2">1) Lecture：“Strengthening Climate and Disaster Resilience is Essential to Sustainable Development” (JKT; Professor Toshio Koike/University of Tokyo)
2) Explanation of outline of the Project
3) Explanation of study outcomes on Component 1: Climate change impacts assessment and runoff analysis in the Musi River basin by the time of this seminar
• Climate change impact assessment of the water cycle in the Musi River basin
• Climate change impact on rice production in the Musi River basin</td></tr>
<tr><td>Speakers</td><td colspan="2">1): Ir. Jarot, General Manager of BBWS Sumatra VIII MPWH (PLMB)
2): Ir. Imam Santoso, M.Sc, Director General of Water Resources, MPWH (JKT)
3): Dr. Andi Eka Sakya, M. Eng, Head of BMKG (JKT)
4): Mr. Shinya Goto, Deputy Director of Global Environment Department, JICA/Tokyo (JKT)
5): Team 1
6): Team 2</td></tr>
<tr><td>Moderators</td><td>Mr. Roy Panagom Pardede, ST.M.
Tech Chief of Water Utilization Network Implementation Division, BBWS Sumatra VIII</td><td>Dr. Eka Nugraha Abdi,
Head of Subdid of Hydrology and Water Quality, MPWH</td></tr>
<tr><td>Participants*</td><td>46 people</td><td>74 people</td></tr>
</table>

IV. Fourth Seminar in Surabaya, Palembang and Jakarta	
Items	**Descriptions**
Venues	**Surabaya** (SBY)**:** Meeting Room of 3rd Floor, BAPPEDA JATIM **Palembang** (PLM)**:** Conference Room of 3rd Floor, BBWS Sumatra VIII, MPWH **Jakarta** (JKT)**:** Conference Room of 8th Floor, DGWR, MPWH
Dates	SBY: 12 November 2019, PLM: 14 November 2019, JKT: 19 November 2019
Major contents	1) Lecture：“ History and Overview of the Project, Latest Situation of Technology in Japan, etc. (Dr. Baba Hitoshi, JICA Senior Advisor) 2) Explanation of outline of the Project 3) Explanation of major project results including proposed climate change adaptation measures for Brantas and Musi River basins 4) Handbook for assessing and integrating climate change impacts into water resources management plans
Speakers	1): **Ir. Fauzi Idris**, Director of Directorate of Water Resources Management, DGWR, MPWH (JKT) 2): **Ir. Birendrajana**, General Manager of BBWS Sumatra VIII, MPWH (PLMB) 3): **Mrs. Novia Rosalita**, Head of Program & Planning Division, BBWS Brantas, MPWH (SBY) 4): **Mr. Ryo Ogawa**, Senior Representative of JICA Indonesia Office (JKT) 5): **Dr. Baba Hitoshi**, JICA Senior Advisor, JICA/Tokyo 6): Team 2
Moderators	SBY: Mrs. Novia Rosalita, Head of Program & Planning Division, BBWS Brantas PLM: Mr. Samadi, Chief of Water Utilization Network Implementation Division, BBWS Sumatra VIII JKT: Mr. Idham Riyando Moe, Section Head of Hydrology and Water Quality, DGWR
Participants*	Surabaya : 51 people, Palembang : 47 people, Jakarta : 93 people

Note *: Excluding JICA Project Teams 1 and 2

Source: JICA Project Team 2

Part 5

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 12 CONCLUSIONS AND RECOMMENDATIONS

12.1 Formulation of Climate Change Adaptation Measures for POLA and RENCANA

The Project formulated climate change adaption measures consisting of structural and non-structural measures with the aim of mitigating the damage which is anticipated to be inflicted on the water resources management by climate change for the POLA and RENCANA of the Brantas and Musi River basins, selected as pilot areas, as referred to in "Sections 6.6 and 10.6" respectively.

The adaption measures were worked out in 4 sectors of water resources management, groundwater resources management, Sabo management and watershed conservation by adopting technically conventional measures which have been being applied to water resources management in Indonesia also and preliminarily assessing the measures from economic, environmental and social aspects.

However, these measures have been drawn out based on the data and information including those which were barely accepted for the Project in addition to projected future climate data with uncertainty that is inherent in them. Therefore, it is essential to carry on taking actions in due consideration of the following recommendations and items in Table 12.1.1 toward the stages coming for:

(1) Review of the climate change adaptation measures formulated in the Project for the Brantas and Musi River basins as well as their POLAs and RENCANAs, and

(2) Formulation of climate change adaptation measures to be incorporated in POLAs and RENCANAs for other river basins in Indonesia.

Table 12.1.1 Recommendations and Items subject to Attention

(1) for Review of CC* Adaptation Measures for Brantas and Musi River Basins	
Disciplines/Sectors	**Recommendations**
Hydrology/ Hydraulics	• To improve quantity and quality of meteorological and hydrological data since these data are the bases for the CC impact assessment • To select suitable hydraulic inundation models, to be dependent on terrain of flood inundated area and type of inundation flow • To conduct river cross-section survey, topographic survey and river water level/discharge measurements for inundation analysis • To analyze water balance in consideration of spatial distribution of water demands since in particular irrigation water which occupies most of water demand is intercepted at several points along a mainstream and its tributaries.
Hydrogeology/ Groundwater	• Brantas River basin: to conduct investigation and study for plan of additional groundwater development since groundwater development has been substantially carried out • Musi River basin: to prepare a management plan of groundwater use since the groundwater is regarded as sustainable water resources in future climate conditions
Agriculture/ Irrigation	• To re-estimate irrigation water demand, which has been overestimated by means of fixed unit water requirement (1.0 l/s/ha) stipulated in SNI, through applying KP-1 formula of DGWR and using effective rainfall data calculated from observed rainfall data
Water Supply/ Sewerage	• To update the forecast of water supply demand that is being increased yearly • To formulate a master plan for waste water sector to keep raw water clean in parallel with water supply development

Natural/Social Environment	• Brantas River basin: To conduct an exchange of opinions with stakeholders about the adaptation measures and their possible positive/negative impacts since the measures include construction of new structures and improvement of existing ones and possible natural/social impacts are assumed in and around the areas • Musi River basin: To provide countermeasures against water use of Ranau Lake thorough discussions with stakeholders since significant social impacts are expected due to lowering of lake water level resulting from the water use
Water Resources/ River Management	Flood: • To re-estimate flood damage based on the data on damage ratios in the inundation areas, referring to the Japanese way used in the Project, • To apply Multiple Scenario Approach (MSA) in selecting a target flood discharge at each climate change scenario for 4 selected tributaries Drought: • To study additional dam structures through water balance calculation for Balai to consider addition of dams with careful assessment of social issues
(2) for Formulation of CC* Adaptation Measures for Other River Basins in Indonesia	
Disciplines/Sectors	**Items subject to Attention**
Hydrology/ Hydraulics	• To improve quantity and quality of meteorological and hydrological data since these data are the bases for the CC impact assessment • To select suitable hydraulic inundation models, to be dependent on terrain of flood inundated area and type of inundation flow • To conduct river cross-section survey, topographic survey and river water level/discharge measurements for inundation analysis
Hydrogeology/ Groundwater	• To estimate actual groundwater usage and amount of groundwater development potential based on water balance study or groundwater flow simulation • To plan proper management of groundwater, paying careful attention to conservation and improvement of groundwater circulation
Agriculture/ Irrigation	• To consider adaptation of non-structural measures such as optimization of cropping calendar coping with local climate conditions and enforcement of rotation block irrigation water distribution method as well as structural measure like on-farm level water saving practices such as improvement of tertiary canal system by lining
Water Supply/ Sewerage	• To consider non-structural measure such as water saving which could contribute to reduce water supply demand as a fundamental measure to CC
Wet Land/ Watershed	• To stress on the necessity of conservation of forestland and restriction of plantation development in slope areas when updating a spatial plan since one of the main cause of abnormal water discharge, sediment runoff, shallowing river course and decline in groundwater recharge capacity is the development of plantations that usually cut down forests on sloped land, and regulation of plantation development on slopes is extremely effective as a countermeasure for increasing the frequency of flooding in downstream areas and weakening agriculture.
Natural/Social Environment	• To prepare a SEA report for POLA / RENCANA to apply SEA method effectively and discuss it at each basin committee's regular meetings since SEA is now a legal obligation in formulating POLA / RENCANA
Water Resources/ River Management	Flood: • To consider the approach of safety level setting for the future climate based on specific conditions of target river basin (MSA and others), Drought: • To calculate a unit water requirement under future climate conditions since it might be largely different with that in present climate conditions • To select adaptation measures from the results of existing studies on storage structures as much as possible when a storage structure is required

Note: * CC = Climate Change
Source: JICA Project Team 2

12.2 Organization and Institution

12.2.1 Agriculture and Irrigation Sector

(1) Present Status

The Ministerial Ordinance No.14/PRT/M/2015 on Criteria and Status Determination of Irrigation Scheme stipulates the list of surface water irrigation schemes by management authority. The number and designed command area of surface water irrigation schemes are as shown in Table 12.2.1. These schemes are facing environmental changes such as increasing population, limited water availability, increasing competition among water users, and decreasing watershed performance. As a result, the functionable rates of surface irrigation scheme design areas are 66.5% in Indonesia, 81.9% in the Brantas River basin and 58.4 % in the Musi River basin as of 2015.

Table 12.2.1 Number and Design Area of Surface Water Irrigation Schemes

Area	Central Government		Provincial Governments		Local Governments		Total	
	(nos.)	(ha)	(nos.)	(ha)	(nos.)	(ha)	(nos.)	(ha)
Indonesia	**283**	**2,376,521**	**984**	**1,105,474**	**46,761**	**3,663,173**	**48,028**	**7,145,168**
Brantas	**8**	**109,296**	**54**	**32,618**	**3,636**	**172,689**	**3,698**	**314,603**
Musi	**7**	**94,493**	**28**	**41,541**	**696**	**67,190**	**731**	**198,176**

Source: Ministerial Ordinance No.14/PRT/M/2015

(2) Future Direction

Aiming to improve the prevailing circumstance of the existing irrigation system through making participatory irrigation management services more efficient, effective and sustainable, the future direction is toward developing the reliability of five targets: (i) Better water availability; (ii) Good infrastructures; (iii) Improving irrigation management; (iv) Institutional strengthening; and (v) Empowerment of human resources. The focal points for approaching these targets are: (i) Environmental-basis, participatory and conjunctive use of water; (ii) Harmonization of downstream-upstream management; and (iii) Improving farm-level management.

(3) Recommendations

1) Horizontal Coordination and Vertical Collaboration among Stakeholders

Among the enable stakeholders, horizontal coordination for improving irrigation management activities is recommended to be carried out in DGWR and its river basin management offices from planning to implementation and OM sections aiming to overcome bureaucracy. In addition, vertical collaboration for institutional strengthening purpose is recommended to be realized among DGWR, Directorate General of Land and Water (DGLW) under the Ministry of Agriculture (MOA), Irrigation Service Offices of Provinces and local governments, Irrigation Commission chaired by the head of local government (Bupati), water users association (WUA), and knowledge and technology centers.

2) Actions for Institutional Strengthening and Empowerment of Human Resources

It is recommended to practice actions for institutional strengthening and empowerment of human resources in participatory manner as shown in Table 12.2.2.

Table 12.2.2 Substances and Actors of Institutional Strengthening and Empowerment of People

Action	Key Actor
Institutional Strengthening	
1. Establishing/ revitalizing of irrigation commission and setting-up of modern irrigation implementer unit and basin water management coordination team	Director General (DG) of DGWR, DG of DGLW of MOA, Governor, and Bupati
2. Setting-up of design & knowledge management center	
3. Setting-up of irrigation and agriculture empowerment unit	
4. Supporting irrigation guards	
5. Setting-up of mobile maintenance unit	
6. Organizing/ revitalizing of WUA	
Empowerment of Human Resources	
1. Stimulating self-awareness of status position	Minister, DG of DGWR, Governor, and Bupati
2. Issuing training certificate	
3. Establishing the recruitment system and career planning	
4. Introducing an incentive system	

Source: JICA Project Team 2

12.2.2 Other Sectors

(1) General Overview

As a whole, the existing institutional framework and organizational arrangement for water resources management in both river basins seem adequate. However, some significant concerns and challenges were identified. It is recommended to bear in mind these matters and to deliberate remedial actions when incorporating the proposed adaptation measures into POLA. The points of attention are outlined below.

(2) Integrated Management of Surface Water and Groundwater [for Both Basins]

Groundwater conservation has been proposed as part of the water preservation measures in the both Brantas and Musi River basins. Many agencies answered in an interview that ESDM[1] would be an implementing agency for groundwater-related measures. As for the Musi River basin, TRG[2]/BRG[3] will be also involved. That would be correct according to the division of duties.

However, groundwater flows and exists as a form of hydrological cycle. The surface water and groundwater are likely to affect each other. In order to properly conserve and utilize the groundwater resources, it is necessary to consider the groundwater resources and surface water resources in an integrated manner. The integrated management will be executed through i) sharing of groundwater information, ii) formulation of groundwater use plan integrated with surface water, and iii) coordination in various measures. It is advisable for both agencies responsible for groundwater and surface water to get started with information exchange.

(3) Clarification of the Roles in Flood-related Actions [for Both Basins]

As part of non-structural measures against floods, flood hazard mapping and early warning system have been proposed. In the interviews, more than one agency gave its willingness to lead the implementation of those measures.

However, disaster-related information is ultimately provided to the public and therefore different information must not be released by different agencies to avoid needless confusion. In particular, a flood early warning system is operated in emergency time and thus smooth

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[1] ESDM (Energi dan Sumber Daya Mineral) = Energy and Mineral Resources; there are the Ministry of ESDM as well as local government's departments dealing with ESDM.

[2] TRG (Tim Restorasi Gambut) = Peat Restoration Team

[3] BRG (Badan Restorasi Gambut) = Peat Land Restoration Agency

actions are required. The roles should be clearly determined well in advance.

Flood hazard maps may be prepared for various purposes such as the public's evacuation and government's planning. In preparing a hazard map, intended end-usage and people to be shared should be clarified. On the other hand, various agencies are involved in operating a flood early warning system at each step from hydrological monitoring to data analysis, warning issuance and warning dissemination. The roles and procedures need to be discussed and recognized among agencies through documentation.

(4) Enhancement of Coordination through TKPSDA for Establishment of SIH3 [Brantas]

A hydrological, hydrogeological and hydro-climatological information system named SIH3 is being developed jointly by BBWS-B, PJT-I, BMKG and local governments. One of the challenges they have faced so far is aggregating all the data observed by the respective agencies. There is no specific rule of data sharing even between BBWS-B and PJT-I.

Facilitation of SIH3 development is one of the tasks of TKPSDA. It is deemed desirable to facilitate the system development by explicitly writing the tasks of TKPSDA and improving the operation of TKPSDA in accordance with the explicit tasks and by determining how to practically share the data owned by the respective agencies.

(5) Effective Coordination among Key Agencies for Watershed Management [Brantas]

Watershed conservation is positioned as one of the water resources conservation measures in the Brantas River basin. BBWS-B implements water resources management in a joint effort with PJT-I and there is TKPSDA as a coordinating body. Similarly, Brantas-Sampean BPDASHL and *Perhutani*[4] implement forest management under the framework of the Ministry of Environment and Forestry and there is *Forum DAS* as a coordinating body. In addition, the relevant departments of local governments at the provincial and city/regency levels are also involved in watershed management. As described, there are many groups relating to watershed management in the basin.

Although BPDASHL is supposed to be a leading agency for watershed management, these four major agencies, namely two *Balai* plus two *Perum*, need to closely coordinate toward harmonized implementation of watershed conservation activities.

(6) Reconciliatory Coordination by BAPPEDA in Land Use Planning [Musi]

The revision of land use has been proposed for the Musi River basin as part of water resources conservation measures. According to BAPPEDA of South Sumatra Province, there is an issue that some parts of administrative boundaries of regencies are not clearly and properly recognized among local governments. This issue may make it difficult to plan and/or change land use of indefinite areas when the overlapped two regencies have different policies.

The Ministry of Home Affairs (MHA) is responsible for determining the regency boundaries. The provincial BAPPEDA is expected to officially inquire at MHA about the exact boundaries and to reconcile both regencies as needed. BAPPEDA is supposed to play a key role in coordinating two regencies when they insist on different policies in formulating development plans or land use plans.

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[4] Perum Perhutani, which is a state-owned enterprise that has the duty and authority to carry out planning, management, exploitation and protection of forests in its working area. It was established initially based on the Government Regulation No.15/1972.

12.3 Handbook

In Indonesia, POLA and RENCANA are being developed to properly manage water resources, based on the Law No. 17/2019 on the Water Resources and the Ministerial Regulation of "NOMOR 10/PRT/M/2015 TENTANG RENCANA DAN RENCANA TEKNIS TATA PENGATURAN AIR DAN TATA PENGAIRAN[5](hereinafter referred to as "the Ministerial Regulation"). The Law and the Ministerial Regulation require to formulate POLA and RENCANA (hereinafter referred as "the Water Resources Management Plans") corresponding to the impacts of future climate change.

In such a situation, the Project has assessed climate change impacts in 2050 in terms of vulnerability/risk and resilience of water resources and formulated proposals for reflecting climate change impacts in the Water Resources Management Plans, selecting the Brantas and the Musi River basins as pilot areas. In addition, the Project has prepared a handbook to be applicable to the Water Resources Management Plans for other river basins in Indonesia, taking climate change issues into account. The handbook is prepared, incorporating the findings/lessons learned in the course of the Project as well as the approaches employed to formulate the climate change adaptation measures for both river basins, with the chief concept of formulating adaptation measures which aim to materialize less rework and less disaster risk.

The basic principles for preparation of the handbook were set down as stated hereunder.

(1) The handbook shall explain data/information, field survey/observation, assessment items, analysis methods which do not necessarily need to be used in formulation of the Water Resources Management Plans under the present climate and were used in the Project in order to formulate the climate change adaptation measures for both pilot river basins. Therefore, the handbook shall function as a practical guide in formulating climate change adaptation measures for other river basins in Indonesia.

(2) It is required in the Law and the Ministerial Regulation that the Water Resources Management Plans be formulated in consideration of climate change. Thus, to substantiate this, the handbook shall be referred to.

(3) The handbook is to be applied to the river basins which have been managed under the jurisdiction of BBWS organized in DGWR, MPWH, as the first phase and that those in the next phase be dependent on the policy of the Indonesian side, since the Japanese side is not necessarily familiar with all the river basins in Indonesia.

(4) Regarding the target year for future climate projection, several discussions were made between the Japanese and Indonesian sides, including the following explanation by JICA Project Team 2:

    (a) The impacts and plan/strategy of the Climate Change are to be considered separately.

    (b) To assess the impacts and formulate the plan/strategy, a long-term target year and a target year after two decades shall be set up respectively.

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[5] No. 10/PRT/M/2015 REGARDING PLAN AND TECHNICAL PLAN OF WATER ARRANGEMENTS AND IRRIGATION SYSTEM

(c) As a long-term target year, supposed is generally the year 2050 or 2100: in this case the back data for the impact assessment with the present technology has been complete and its medium- to long-term trend could be found.

Through deep discussions between both sides it was decided to describe the following sentences:

"The Handbook is calculated based on the Study by JICA on the Brantas-Musi River basins. There must be some discrepancy if it is used for other river basins." and "This Handbook is calculated for impacts of Climate Change up to 2050. It is not necessarily to be applied in other river basins."

Besides, the Project, which commenced in 2013, has been conducted in reference to the IPCC Fourth Assessment Report, so called "AR4". Hence, it is important that the assessment reports to be issued in the future by IPCC shall be referred to as the need arises for the application of the Handbook to the Water Resources Management Plans.

12.4 Conclusions and Recommendations

Valuable knowledge and lessons were accumulated by the Project in the course of projecting the future climate conditions up to 2050 and formulating the climate change adaptation measures for the Brantas and Musi River basins, and have been shared between the Japanese and Indonesian sides. These knowledge and lessons have been entirely incorporated into the above-mentioned handbook with close collaboration between both sides.

In view of the above, it is recommended to push forward the formulation of climate change adaptation measures to be included in POLAs and RENCANAs of other river basins in Indonesia without any delay by properly using the handbook so as to respond to the need of adaptation measures, placing particular importance on those of the people who would be vulnerable to negative impacts on water resources from the anticipated future climate change in Indonesia.