CHAPTER 6 CLIMATE CHANGE ADAPTATION MEASURES FOR WATER RESOURCES MANAGEMENT PLANS OF THE BRANTAS RIVER BASIN

6.1 Planning Methodology of the Water Resources Management Plans Reflecting Climate Change Impacts

6.1.1 Planning Methodology of Water Use

The planning method is applied in the same method under the present climate condition. The difference between the present climate and future climate is 1) a natural flow in the Brantas River basin and 2) an irrigation water demand at each irritation area.

The safety level of the water supply to each demand is the same as the present planning methodology.

6.1.2 Planning Methodology of Rainstorms and Floods

(1) Multiple Scenario Approach

The JICA Project Team 2 (Team 2) discussed with the Indonesian side the planning methodology which enables to reflect concretely climate change impacts in the water resources management plans (POLA and RENNCANA) using projection results of climate change impacts in 2050. The formulation of the water resources management plans needs to consider uncertainty inherent in the projected climate change impacts. Hence, Team 2 provided materials and discussion points concerning the "Multiple Scenario Approach (MSA)" as a planning methodology and commenced a discussion on MSA. MSA is outlined as stated hereunder.

【 Multiple Scenario Approach (MSA)[1] 】

To comprehensively cope with the occurrence of different levels of hazards in the changing conditions of vulnerable areas by socioeconomic factors such as increasing wealth, population growth, urbanization and industry agglomeration as well as the uncertainty such as climate change, a methodology to formulate a Disaster Risk Reduction (DRR) strategy is required.

Currently, most countries have been adapting the approaches which set a target protection (safety) level based on a preset particular hazard in a fixed scenario, which is the "Deterministic Approach" (see Figure 6.1.1). However, the capacity of this approach for adaptation to the uncertainty is not necessarily sufficient, and further flexibility of disaster management plans and resilience of countermeasures are also required even for a wide range of projected risks. Therefore, a concept of "Multiple Scenario Approach" is created so as to minimize the damage and losses under the multiple scenarios by a comprehensive combination of structural and non-structural measures.

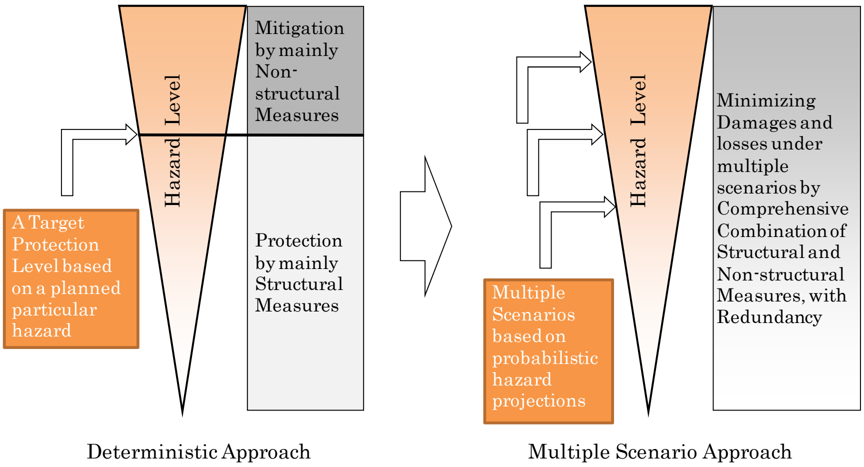
[1] Adapted from Presentation prepared for Second Seminar in the captioned Project by Dr. Hitoshi BABA, Senior Advisor, Japan International Cooperation Agency

In this approach, multiple disaster scenarios from multiple hazard scales are to be considered so as to assign the target safety levels differently to various options and coordinate the appropriate options (see Figure 6.1.1).

It is expected that most of the countermeasures planned by the different target protection levels can contribute to damage mitigation through synergetic effects and redundancy by the combination of measures.

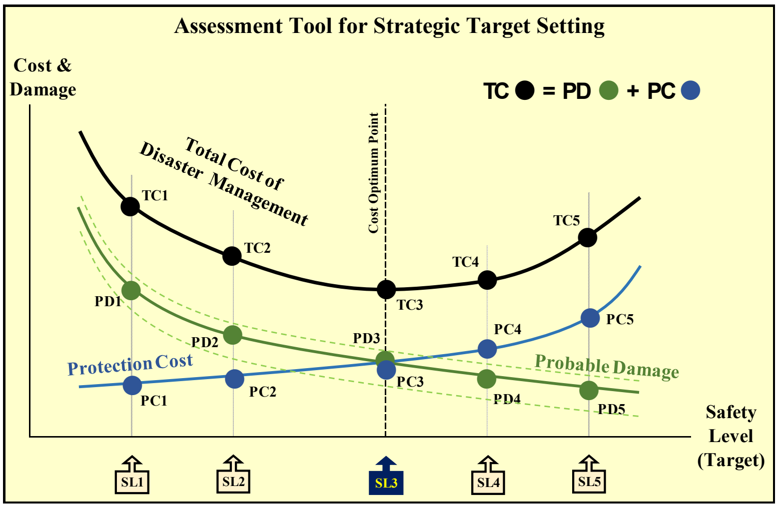
Using the tool in Figure 6.1.2, several options of (DRR) measures which should be conducted yearly can be selected.

The position on the total cost curve in Figure 6.1.2 approaches to the **Point of Cost Optimum (PCO[2])** as DRR measures are conducted year by year.



Source: Adapted from Presentation for 2nd Seminar in the Project by Dr. Hitoshi BABA, JICA

Figure 6.1.1 Approaches to Target Safety Level Setting in DRR Strategy



Source: Adapted from Presentation for 2nd Seminar in the Project by Dr. Hitoshi BABA, JICA

Figure 6.1.2 Assessment Tool for Strategic "Target Setting" in MSA

Most of the countries suffering from natural disasters might be in the left side position in Figure 6.1.2. Such situation has to be shifted to the right by investing protection and reducing

[2] located at the intersection between the probable damage and protection cost curves
The total cost of the disaster management (= probable damage + protection cost) decreases to and increases from **PCO** through taking DRR measures.

the damage cost with the aim of reducing the total cost of disaster management.

The goal of the "Basin-wide Water Resources Management Strategy" is supposed to stay in the position of PCO in the situation with uncertainty and the PCO is the best condition for sustainable execution of the management. In this approach, the respective options of measures are assessed in terms of (i) strategic policies, (ii) investment costs/financial availability, and (iii) damage mitigation value.

(2) Target Safety Level of Climate Chane Adaptation Measures

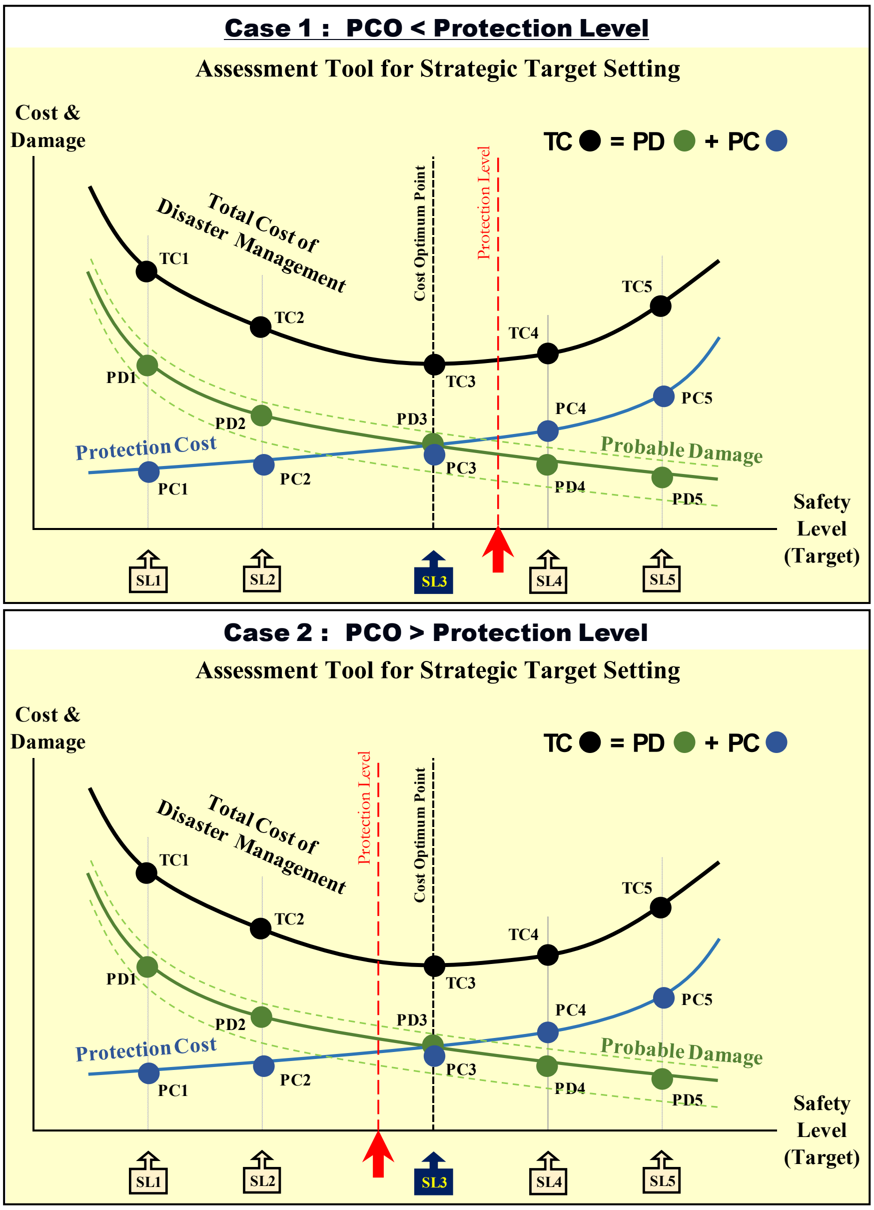
Regarding MSA, Team 2 had several discussions with the Indonesian side including three workshops in DGWR/MPWH (Jakarta) and BBWS Brantas (Surabaya) with the aim of sharing the concept and methodology of MSA. Through discussions, the following were confirmed by the Indonesian side and Team 2.

Regarding the "**Point of Cost Optimum (PCO)**" in MSA for an object area, there are two cases of relationship with criteria for "Flood Protection Level (FPL)", which are

1) In the case of (a), the safety level corresponding to the FPL shall be adopted for the climate change adaptation measures of the object area. and,

2) In the case of (b), the safety level corresponding to the PCO shall be adopted for the climate change adaptation measures of the object area.

(a) Case 1: PCO < FPL and (b) Case 2: PCO > FPL.



Source: JICA Project Team 2

Figure 6.1.3 Criteria for Protection Level

(3) Single Scenario Approach[3]

To comprehensively tackle with the occurrence of different levels of hazards, together with the changing conditions of vulnerable areas by the socioeconomic factors such as increasing wealth, population growth, urbanization, and industry agglomeration, as well as the uncertainty such as climate change, a methodology is needed to formulate a disaster risk reduction strategy which takes a consistent approach.

Most of the countries have been adapting such approaches as setting target protection level

[3] Adapted from Presentation prepared for Second Seminar in the captioned Project by Dr. Hitoshi BABA, Senior Advisor, Japan International Cooperation Agency

based on a preset particular hazard in fixed scenario, which is "Deterministic Approach" as Approach A or Approach B, as described below.

Approach A: <u>Supplemental measures for extremes over the planned security level</u>. Supplemental measures will be provided for the extreme flood or extreme drought which exceeds the originally planned rainfall or discharge based on the past hydro-meteorological data. Water system shall basically be managed without changing the original plans but with consideration of future security level change due to climate change impacts or any uncertain events. Japan is the typical example that selected this approach.

Approach B: Improving measures based on <u>periodical revision of planned security level</u>. The planned rainfall and discharge will be periodically revised by reviewing the previous ones taking into account the observed and projected variation due to climate change impacts or any uncertainty. Nederland is the typical example that selected this approach.

6.2 Optimization of the Existing Water Resources Management Facilities to Mitigate Climate Change Impacts on Rainstorms, Floods and Draughts

6.2.1 Rainstorms and Floods

The Sutami Dam has a large volume of flood control space. However, the inflow discharge under the future climate condition is increased during flood events. The flood control space requires larger space compared with the present climate condition. Therefore, it is recommended that the full supply level in the rainy season is changed from EL. 275.50m to EL. 263.50m in the medium scenario.

6.2.2 Drought

The storage volume for the water supply of the Sutami Dam has also a large volume. The inflow discharge under the future climate condition during the dry season is smaller than the present climate condition. It is required that an additional storage volume be in the reservoir. Therefore, it is recommended that the full supply level is changed from EL. 272.50m to EL. 274.90m in the medium scenario under the future climate condition.

6.3 Identification of Other Adaptation Measures against Climate Change Impacts

6.3.1 Adaptation Measures against Rainstorms and Floods

(1) Structural Measures

The four tributaries are selected through the discussion with BBWS Brantas. These river basins are frequently inundated under present climate condition.

Some structural adaptation measures can be applied against rainstorms and floods. This shows applicable structural adaptation measures to target river basins.

Table 6.3.1 Applicable Adaptation Measures to Target River Basins

	Widas	Ngotok	Sadar	Tawing
Dam	There are four dam planning. The catchment area of all dams is very small compared with the Widas River basins. Therefore, the flood control efficiency by the dams is too small. Catchment area: Whole: 1,350km^2 Semantok 61km^2 Ked.warak 32 km^2 Kuncir 70km^2 Ketandan 13km^2	There is no dam planning.	There is no dam planning.	There is no dam planning.
Retarding Basin	It is possible to construct a retarding basin. However, it requires a large amount of compensation cost.	There are many houses located in/surrounded the inundation area. It requires a large amount of compensation cost.	here are many houses located in/surrounded the inundation area. It requires a large amount of compensation cost. It is not effective due to the flooding type.	The width of the inundation area is narrow. And some villages are located in these areas. It is not effective because the space of the retarding basin is small.
Dike	Possible to construct a dike	Possible to construct a dike	Possible to construct a dike	Possible to construct a dike
Dredging/ Excavation of Riverbed	There is no actual present river cross section data. It is difficult to study the excavation of the riverbed.	There is no actual river cross section data. It is difficult to study the excavation of the riverbed.	The inundation occurs at a confluence between tributary and the Sadar River. The water level of the Sadar River impacts to water level of tributaries. Therefore, excavation of the riverbed to the tributaries is not effective.	There is no actual river cross section data. It is difficult to study the excavation of the riverbed.
Floodplain Management	There are some natural retarding basins. These areas can be utilized based on the flood plain management.	It is difficult to control land use because flood plain area is located near Mojokerto city.	It is difficult to control land use because flood plain area is located near Mojokerto city.	It is difficult to control land use because flood plain area from breach point to near the confluence of mainstream. The flood management area is a large area.
Applicability	Dike Dike + Retarding basin Dike + Floodplain management	Dike Dike+ excavation*1 (necessary to river cross section survey)	Dike	Dike

Note: * 1; It is necessary to study this alternative after the execution of the river cross section survey. (In this project, it is not studied because the survey works are not included.)

Source: JICA Project Team 2

1) Widas River Basin

(a) Alternatives to the Adaptation Measures

The following adaptation measures are selected and Table 6.3.2 shows the summary of alternatives.

i) Flood dike

ii) Flood dike + retarding basin

iii) Flood dike + floodplain management

Table 6.3.2 Summary of Alternatives (Widas River Basin)

Alternatives	Flood dike	Flood dike + Retarding basin	Flood dike + floodplain management
Structure	➢ Dike construction	➢ Dike construction ➢ Construction of the retarding basin	➢ Dike construction
Land acquisition and resettlement	➢ Dike alignment	➢ Dike alignment ➢ Alignment of the retarding basin ➢ Inside of the retarding basin	➢ Dike alignment
Damage	➢ Zero at planned safety level	➢ Zero at planned safety level	➢ Some damages are remained at the safety level of dike

Source: JICA Project Team 2

(b) Medium Scenario

a) Selection of the Applied Adaptation Measure

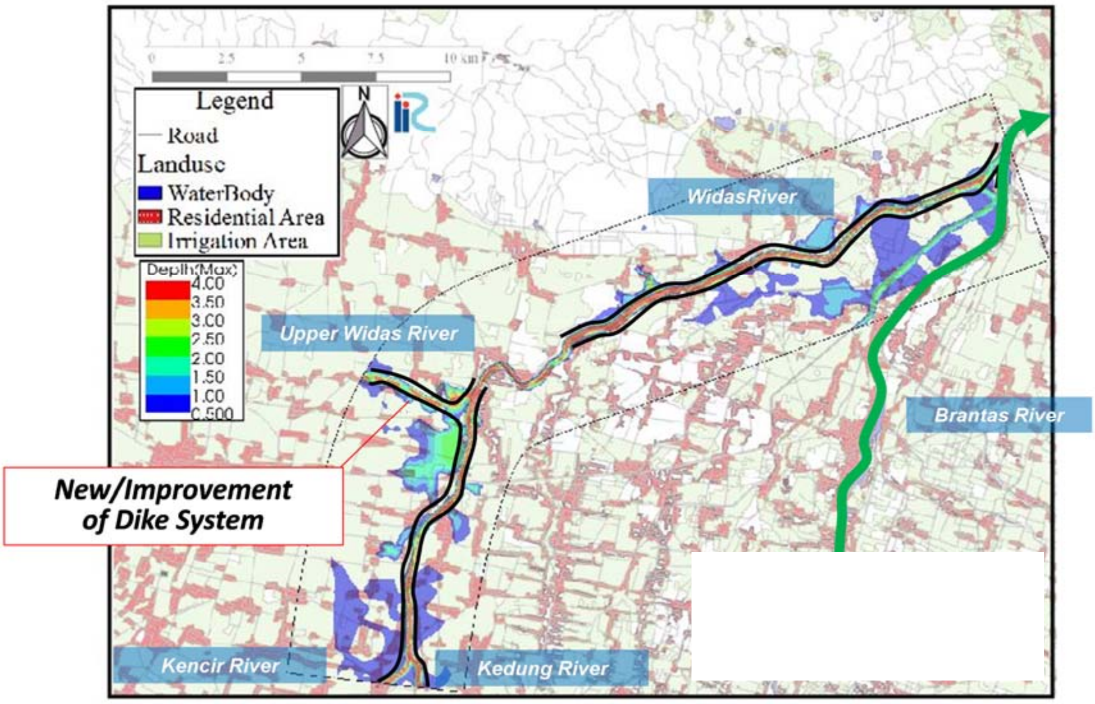
As a result of the construction cost and damage estimation, the following adaptation measures of each probable flood are selected as shown in Table 6.3.3. Table 6.3.4 shows the proposed measures and Figure 6.3.1 shows the expected flood dike alignment.

Table 6.3.3 Comparison of Alternative Structures (Medium Scenario)

(Unit: IDR Mil.)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Dike	27,757	67,408	111,331	200,213	253,481	345,871
Dike + Retarding Basin	32,139	143,477	186,673	277,590	333,074	416,262
Dike + Flood Management	29,541	61,006	93,828	110,194	118,607	128,001
Selected Alternative	Dike	Dike+ Flood Plain Management				

Note: The total cost is estimated based on the economic cost.
Source: JICA Project Team 2



Note: Figure shows the inundation area of the 30-year probable flood under the medium scenario with dike alignment.

Source: JICA Project Team 2

Figure 6.3.1 Conceptual Plan for Proposed Dike Alignment of the Widas River

Table 6.3.4 Basic Feature of the Proposed Measures (Medium Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Upper Widas						
Discharge (m^3/s)	384	527	632	855	985	1,175
Total Length (m)	5,516	6,516	6,516	6,516	7,516	7,516
Average height (m)	0.9	1.5	1.8	2.1	2.1	2.3
Kedung and Kuncir						
Discharge (m^3/s)	305	424	523	776	886	1,125
Total Length (m)	6,000	11,000	12,000	12,000	13,000	14,000
Average height (m)	0.5	0.6	1.0	1.6	1.6	1.8
Lower Widas						
Discharge (m^3/s)	654	901	996	1,014	1,021	1,038
Total Length (m)	25,000	34,000	34,000	34,000	34,000	34,000
Average height (m)	0.9	1.3	1.5	1.5	1.6	1.6
Management Area (ha)	-	100	300	500	500	500

Source: JICA Project Team 2

b) Results of inundation analysis

The inundation analysis in the Widas River basin is applied on a 2-D unsteady flow analysis by using International River Interface Cooperative (iRIC) software. The analysis results are summarized in Table 6.3.5.

Table 6.3.5 Inundation Area of Each Return Period (Medium Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	65	0.58	23	0.59	19
5	597	0.71	106	0.68	71
10	1,194	0.80	309	0.64	188
30	3,120	0.93	699	0.75	666
50	4,174	0.97	880	0.83	862
100	6,161	1.01	1,348	0.91	1,221

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

The structural measures are selected by using the multi-scenario approach. Table 6.3.6 and Figure 6.3.3 show the result of multi-scenario approach.

Table 6.3.6 Result of Selection of the Structural Measures (Medium Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	654	27,757	72,560	100,317
5	901	58,028	52,034	110,063
10	996	81,264	37,376	118,639
30	1,014	97,630	26,219	123,849
50	1,021	104,800	19,075	123,875
100	1,038	27,757	14,724	128,001

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

(c) Low Scenario

a) Selection of the Applied Adaptation Measure

As a result of the construction cost and damage estimation, the following alternatives are selected as shown in Table 6.3.7 and shows the proposed measures.

Table 6.3.7 Comparison of Alternative Structures (Low Scenario)
(Unit: IDR Mil.)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Dike	9,353	67,408	94,385	172,902	186,259	229,249
Dike + Retarding Basin	11,499	132,003	169,936	242,205	263,279	277,765
Dike + Flood Management	10,639	61,010	76,934	102,231	109,166	113,991
Selected Alternative	Dike	Dike+ Flood Plain Management				

Note: Total cost is estimated based on the economic cost.
Source: JICA Project Team 2

Table 6.3.8 Basic Feature of the Proposed Measures (Low Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Upper Widas						
Discharge (m^3/s)	307	527	597	786	833	916
Total Length (m)	5,516	6,516	6,220	6,516	6,516	6,516
Average height (m)	0.5	1.5	1.7	2.1	2.1	2.2
Kedung and Kuncir						
Discharge (m^3/s)	248	413	494	707	756	826
Total Length (m)	1,000	11,000	12,000	12,000	12,000	12,000
Average height (m)	1.7	0.6	0.8	1.4	1.5	1.6
Lower Widas						
Discharge (m^3/s)	551	901	974	1,012	1,012	1,019
Total Length (m)	21,000	34,000	34,000	34,000	34,000	34,000
Average height (m)	0.5	1.3	1.4	1.5	1.5	1.5
Management Area (ha)	-	100	300	500	500	500

Source: JICA Project Team 2

b) Results of the Inundation Analysis

The inundation analysis in the Widas River basin is applied on a 2-D unsteady flow analysis by using iRIC. The analysis results are summarized in Table 6.3.9.

Table 6.3.9 Inundation Area of Each Return Period (Low Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	30	0.57	23	0.53	6
5	463	0.68	89	0.67	36
10	925	0.77	249	0.70	95
30	2,589	0.89	571	0.73	508
50	2,949	0.92	627	0.74	624
100	3,550	0.96	751	0.79	756

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.

Source: JICA Project Team 2

Structural measures are selected by using multi-scenario approach. Table 6.3.10 and Figure 6.3.3 show the result of multi-scenario approach.

Table 6.3.10 Result of Selection of the Structural Measures (Low Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	551	9,353	43,342	52,695
5	901	58,028	33,210	91,239
10	974	69,807	25,841	95,649
30	1,012	89,662	21,283	110,945
50	1,012	95,363	16,857	112,220
100	1,019	99,265	14,726	113,991

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.

Source: JICA Project Team 2

(d) High Scenario

a) Selection of the Applied Adaptation Measure

As a result of the construction cost and damage estimation, the following alternatives are selected as shown in Table 6.3.11. Table 6.3.12 shows the proposed measures.

Table 6.3.11 Comparison of Alternative Structures (High Scenario)

(Unit: IDR Mil.)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Dike	29,797	94,385	152,742	300,891	419,979	571,166
Dike + Retarding Basin	32,139	168,327	228,436	377,201	490,657	647,539
Dike + Flood Management	29,797	80,961	109,996	138,692	159,146	185,165
Selected Alternative	Dike	Dike+ Flood Plain Management				

Note: Total cost is estimated based on the economic cost.
Source: JICA Project Team 2

Table 6.3.12 Basic Feature of the Proposed Measures (High Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Upper Widas						
Discharge (m^3/s)	384	593	717	1,069	1,305	1,629
Total Length (m)	5,516	6,516	6,516	7,516	7,516	7,516
Average height (m)	0.9	1.7	2.0	2.2	2.5	2.9
Kedung and Kuncir						
Discharge (m^3/s)	305	413	494	707	756	826
Total Length (m)	6,000	12,000	12,000	13,000	14,000	15,000
Average height (m)	0.5	0.8	1.3	1.8	2.0	2.4
Lower Widas						
Discharge (m^3/s)	696	901	974	1,012	1,016	1,019
Total Length (m)	25,000	34,000	34,000	36,000	36,000	37,000
Average height (m)	0.9	1.4	1.5	1.6	1.6	1.7
Management Area (ha)	-	390	500	500	500	500

Source: JICA Project Team 2

b) Results of the Inundation Analysis

The inundation analysis in the Widas River basin is applied on a 2-D unsteady flow analysis by using iRIC. The analysis results are summarized in Table 6.3.13.

The structural measures are selected by using a multi-scenario approach. Table 6.3.14 and Figure 6.3.3 show the results of the multi-scenario approach.

Table 6.3.13 Inundation Area of Each Return Period (High Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	223	0.62	36	0.59	74
5	872	0.78	248	0.62	263
10	2,090	0.84	451	0.65	566
30	5,094	0.98	1,173	0.73	1,479
50	6,980	1.11	1,646	0.86	2,225
100	7,871	1.24	1,997	0.98	2,564

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

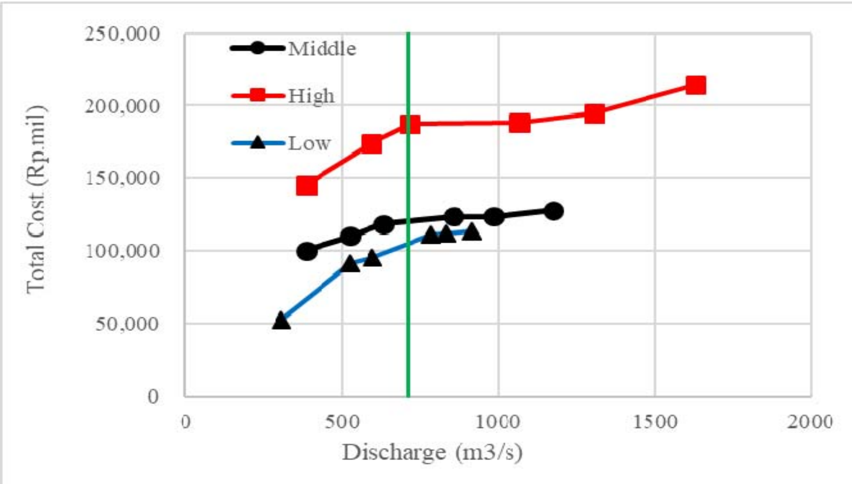
Table 6.3.14 Result of Selection of the Structural Measures (High Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	675	29,797	115,836	145,633
5	970	69,461	104,896	174,357
10	1,028	109,996	77,238	187,234
30	1,074	138,692	49,677	188,369
50	1,093	159,146	35,910	195,057
100	1,165	185,165	29,454	214,619

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

c) Selection of Target Discharge for Adaptation Measure

MSA is applied to decide the target discharge for the adaptation measures. Figure 6.3.2 shows the result of MSA.



Note: The green line is a design discharge under the present climate condition. The green color discharge is shown at the Upper Widas River basin because the flood inundation is allowed at a middle reach.
Source: JICA Project Team 2

Figure 6.3.2 Result of the Multiple Scenario Approach (Widas River Basin)

The three scenarios are not shown in the optimum point. Therefore, the target discharge is set at the same design discharge of the present climate condition. The adaptation measure of each scenario is shown in Table 6.3.15.

Table 6.3.15 Summary of the Adaptation Measure for Each Scenario (Widas River)

Climate Scenario	Medium	Low	High
Adaptation Measure	Dike + Flood Management		
Protection Level*1	17-year	22-year	10-year
Peak Discharge at the Downstream (after adaptation)	710 m^3/s(Upper Widas) *2		
Upper Widas			
Dike Hight	1.9m		
Dike Length	6.5 km		
Kedung and Kuncir			
Dike Hight	1.2 m		
Dike Length	11.5 km		
Lower Widas			
Dike Hight	1.5 m		
Dike Length	34.3 km		

Note:*1: The protection level is estimated to each scenario. *2: The design discharge under the present climate condition.

Source: JICA Project Team 2

2) Ngotok River Basin

(a) Medium Scenario

a) Results of the Inundation Analysis

The inundation analysis in the Ngotok River basin is applied on a 2-D unsteady flow analysis by using iRIC. The analysis results are summarized in Table 6.3.16.

Table 6.3.16 Inundation Area of Each Return Period (Medium Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	214	0.71	8	0.51	102
5	781	0.88	25	0.60	303
10	1,185	0.98	41	0.70	500
30	1,969	1.09	76	1.04	926
50	2,564	1.14	103	1.06	1,239
100	3,666	1.22	150	1.07	1,755

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.

Source: JICA Project Team 2

b) Alternatives of the Adaptation Measures

The dike structure is selected from the comparative study as shown in Table 6.3.1.

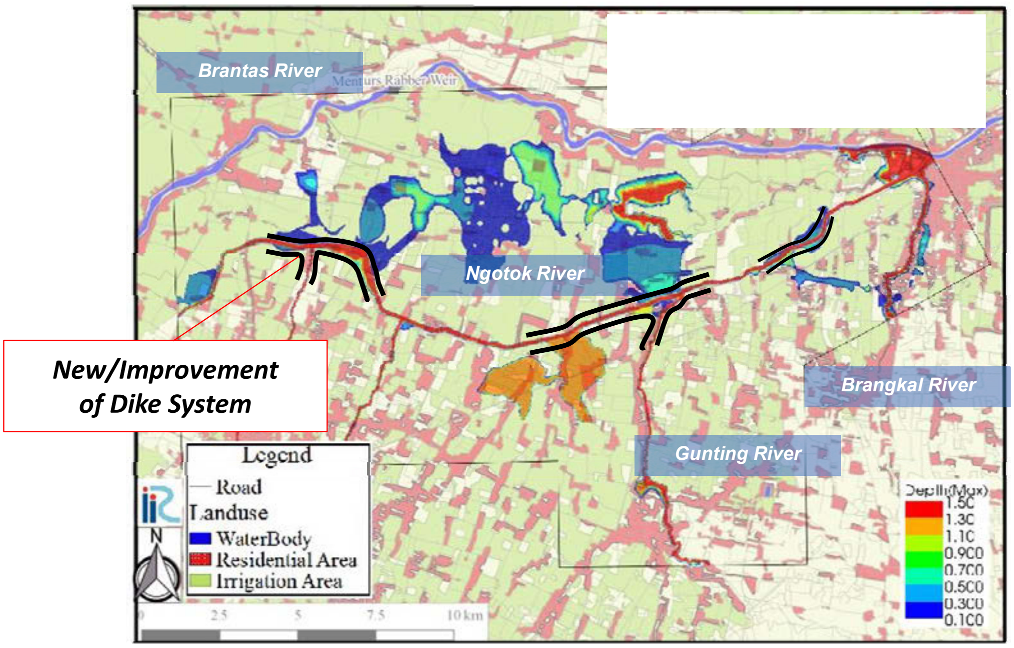
c) Selection of the Adaptation Measures

The basic feature of the selected adaptation measure is shown in Table 6.3.17 while Figure 6.3.3 shows the expected flood dike alignment.

Table 6.3.17 Basic Feature of the Proposed Flood Dike (Medium Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	600	759	910	1,228	1,457	1,832
Total Length (m)	9,600	16,500	22,300	34,900	43,100	55,500
Average Height (m)	0.6	0.7	0.8	1.0	1.3	1.7

Source: JICA Project Team 2



Note: The figure shows the inundation area of a 30-year probable flood under the medium scenario with dike alignment.

Source: JICA Project Team 2

Figure 6.3.3 Conceptual Plan for the Proposed Flood Dike Alignment of the Ngotok River

The design discharge for structural measures is selected by using the multi-scenario approach. Table 6.3.18 and Figure 6.3.3 show the results of the multi-scenario approach.

Table 6.3.18 Result of Selection of the Structural Measures (Medium Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	600	12,025	254,117	266,142
5	759	18,158	183,946	202,104
10	910	19,929	135,729	155,658
30	1,228	43,118	53,234	96,352
50	1,457	49,786	20,133	69,919
100	1,832	72,852	0	72,852

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

(b) Low Scenario

a) Results of the Inundation Analysis

The inundation analysis results are summarized in Table 6.3.19.

Table 6.3.19 Inundation Area of Each Return Period (Low Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	215	0.71	8	0.51	102
5	781	0.88	25	0.60	303
10	1,019	0.94	34	0.66	415
30	1,827	1.07	70	1.04	849
50	2,052	1.10	80	1.05	971
100	2,301	1.12	91	1.05	1,104

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

b) Alternative of the Adaptation Measures

The alternative adaptation measures are same as the medium scenario.

c) Selection of the Adaptation Measures

The reason of selection of adaptation measures is the same as the medium scenario.

The basic feature of the selected adaptation measure is shown in Table 6.3.20.

Table 6.3.20 Basic Feature of the Proposed Flood Dike (Low Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	600	759	845	1,171	1,261	1,358
Total Length (m)	9,600	16,500	20,100	32,800	36,000	39,700
Average height (m)	0.6	0.7	0.7	1.0	1.1	1.2

Source: JICA Project Team 2

The structural measures are selected by using a multi-scenario approach. Table 6.3.21 and Figure 6.3.4 show the results of the multi-scenario approach.

Table 6.3.21 Result of Selection of the Structural Measures (Low Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	600	11,483	224,637	236,120
5	759	17,261	154,466	171,727
10	845	21,073	114,418	135,491
30	1,171	39,658	38,608	78,266
50	1,261	44,634	12,651	57,285
100	1,358	49,189	0	49,189

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

(c) High Scenario

a) Results of the Inundation Analysis

The inundation analysis results are summarized in Table 6.3.22.

b) Alternative of the Adaptation Measures

The alternative adaptation measures are the same as the medium scenario.

c) Selection of the Adaptation Measures

The reason of selection of the adaptation measures is the same as the medium scenario. The basic feature of the selected adaptation measure is shown in Table 6.3.23.

The structural measures are selected by using the multi-scenario approach. Table 6.3.24 shows the total value of the cost and damage.

Table 6.3.22 Inundation Area of Each Return Period (High Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	485	0.80	15	0.54	186
5	1,040	0.95	35	0.66	425
10	1,678	1.05	63	1.04	767
30	3,115	1.18	127	1.06	1,507
50	4,492	1.28	182	1.08	2,097
100	6,408	1.42	250	1.09	2,788

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.

Source: JICA Project Team 2

Table 6.3.23 Basic Feature of the Proposed Flood Dike (High Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	668	853	1,110	1,652	2,079	2,575
Total Length (m)	12,500	20,100	30,700	49,700	62,900	76,000
Average height (m)	0.6	0.7	0.9	1.5	2.1	2.9

Source: JICA Project Team 2

Table 6.3.24 Result of Selection of the Structural Measures (High Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	668	13,637	464,532	478,169
5	853	21,268	366,201	387,469
10	1,110	35,613	226,120	261,733
30	1,652	64,629	88,036	152,665
50	2,079	92,294	31,966	124,260
100	2,575	130,646	0	130,646

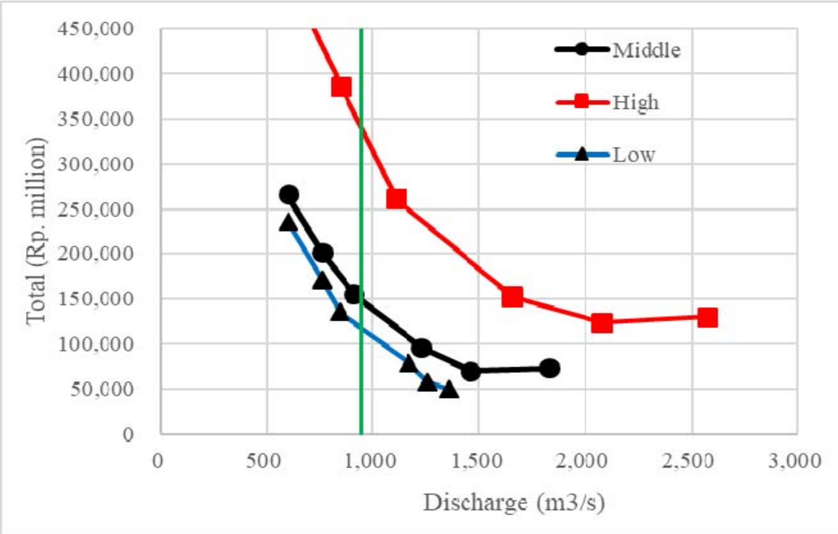
Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.

Source: JICA Project Team 2

d) Selection of Target Discharge for Adaptation Measure

MSA is applied to decide the target discharge for the adaptation measures. Figure 6.3.4 shows the result of the MSA.

The total cost and damage optimum point obtained are from the medium and high scenarios. The low scenario does not show the optimum point. Therefore, the target discharge is set at the same design discharge of the present climate condition. The adaptation measure of each scenario is shown in Table 6.3.25.



Note: The green line is a design discharge under the present climate condition
Source: JICA Project Team 2

Figure 6.3.4 Result of the Multiple Scenario Approach (Ngotok River Basin)

Table 6.3.25 Summary of the Adaptation Measure for Each Scenario (Ngotok River)

Climate Scenario	Medium	Low	High
Adaptation Measure	Dike		
Protection Level*1	50-year	17-year	50-year
Peak discharge (before adaptation)	835 m^3/s	660 m^3/s	991 m^3/s
Peak discharge (after adaptation)	1,457 m^3/s	947 m^3/s*2	2,079 m^3/s
Dike Hight	1.3 m	0.8 m	2.1 m
Dike Length	43.1 km	24.1 km	62.9 km

Note:*1: The protection level is estimated to each scenario. *2: The design discharge under the present climate condition
Source: JICA Project Team 2

3) Sadar River Basin

(a) Medium Scenario

a) Results of the Inundation Analysis

The inundation analysis in the Sadar River basin is applied to a 2-D unsteady flow analysis by using iRIC. The analysis results are summarized in Table 6.3.26.

The dike structure is selected from comparative study as shown in Table 6.3.1.

b) Alternatives of the Adaptation Measures

The dike structure is selected from comparative study as shown in Table 6.3.1.

c) Selection of the Adaptation Measures

The basic feature of the selected adaptation measure is shown in Table 6.3.27 while Figure 6.3.5 shows the expected flood dike alignment.

Table 6.3.26 Inundation Area of Each Return Period (Medium Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	294	0.88	107	1.11	56
5	355	0.94	144	1.11	65
10	396	0.94	174	1.11	71
30	447	0.96	193	1.11	75
50	504	0.96	208	1.11	83
100	610	0.97	262	1.11	97

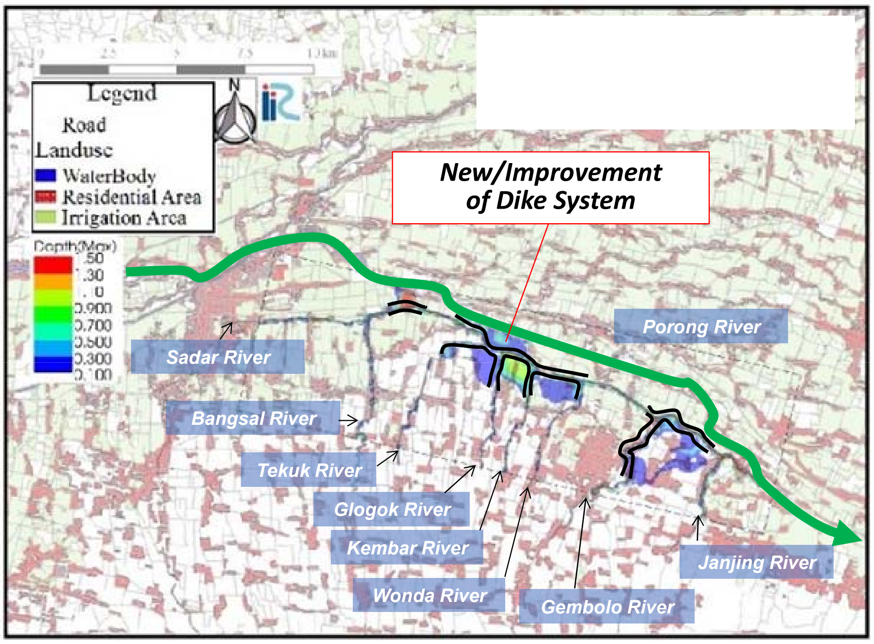
Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.

Source: JICA Project Team 2

Table 6.3.27 Basic Feature of the Proposed Flood Dike (Medium Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	82	108	118	161	178	199
Total Length (m)	2,720	3,840	5,180	10,920	11,340	12,100
Average height (m)	0.30	0.40	0.50	0.50	0.60	0.70

Source: JICA Project Team 2



Note: The figure is shown in the inundation area of a 30-year probable flood under the medium scenario with dike alignment.

Source: JICA Project Team 2

Figure 6.3.5 Conceptual Plan for the Proposed Flood Dike Alignment of the Sadar River

The structural measures are selected by using the multi-scenario approach Table 6.3.28 and Figure 6.3.6 show the result of multi-scenario approach.

Table 6.3.28 Result of Selection of the Structural Measures (Medium Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	82	2,521	61,850	64,371
5	108	2,751	28,335	31,086
10	118	3,111	13,360	16,471
30	161	4,017	4,275	8,292
50	178	4,548	1,374	5,922
100	199	5,228	0	5,228

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

(b) Low Scenario

a) Results of the Inundation Analysis

The inundation analysis results are summarized in Table 6.3.29.

Table 6.3.29 Inundation Area of Each Return Period (Low Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	294	0.85	107	1.11	56
5	343	0.93	138	1.11	64
10	374	0.94	162	1.11	67
30	429	0.96	186	1.11	72
50	451	0.96	194	1.11	76
100	504	0.97	215	1.11	85

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

b) Alternative of the Adaptation Measures

The alternative adaptation measures are the same as the medium scenario.

c) Selection of the Adaptation Measures

The reason of the selection of the adaptation measures is the same as the medium scenario.

The basic feature of the selected adaptation measure is shown in Table 6.3.30.

Table 6.3.30 Basic Feature of the Proposed Flood Dike (Low Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	82	108	118	149	161	168
Total Length (m)	2,720	3,840	5,180	8,050	10,920	11,340
Average height (m)	0.3	0.4	0.5	0.5	0.5	0.6

Source: JICA Project Team 2

The structural measures are selected by using the multi-scenario approach. Table 6.3.31 and Figure 6.3.6 show the results of the multi-scenario approach.

Table 6.3.31 Result of Selection of the Structural Measures (Low Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	82	2,521	60,944	63,465
5	108	2,733	27,353	30,086
10	118	3,062	12,422	15,484
30	149	3,479	3,839	7,318
50	161	3,893	1,178	5,071
100	168	4,379	0	4,379

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.

Source: JICA Project Team 2

(c) High Scenario

a) Results of the Inundation Analysis

The inundation analysis results are summarized in Table 6.3.32.

Table 6.3.32 Inundation Area of Each Return Period (High Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	305	0.90	113	1.11	57
5	367	0.94	149	1.11	67
10	410	0.94	181	1.11	72
30	519	0.96	215	1.11	84
50	621	0.99	268	1.11	97
100	1,276	0.99	503	1.11	192

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.

Source: JICA Project Team 2

b) Alternative of the Adaptation Measures

The alternative adaptation measures are the same as the medium scenario.

c) Selection of the Adaptation Measures

The reason of selection of the adaptation measures are the same as the medium scenario. The basic feature of selected adaptation measure is shown in Table 6.3.33.

Table 6.3.33 Basic Feature of the Proposed Flood Dike (High Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	89	115	130	184	210	345
Total Length (m)	2,800	5,180	11,130	11,340	12,500	17,400
Average height (m)	0.3	0.5	0.5	0.7	0.7	1.3

Source: JICA Project Team 2

The structural measures are selected by using the multi-scenario approach. Table 6.3.34 and Figure 6.3.6 show the result of multi-scenario approach.

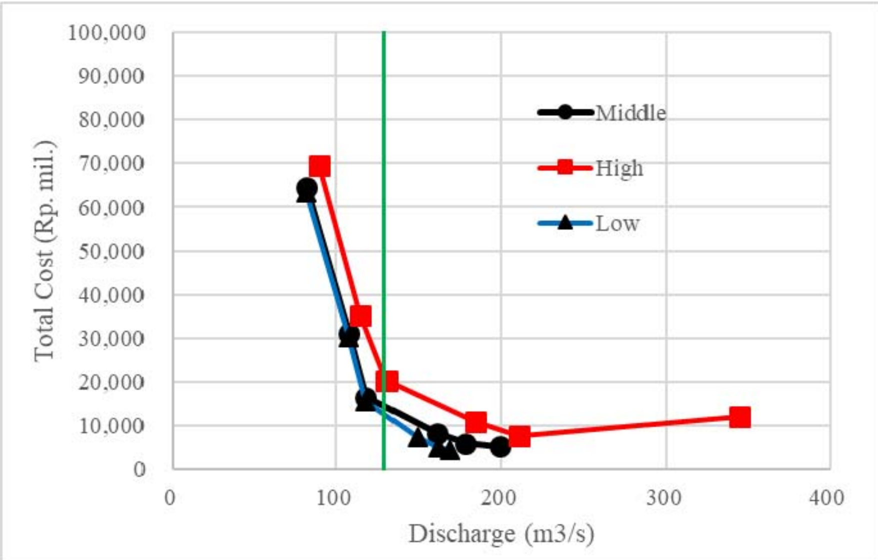
Table 6.3.34 Result of Selection of the Structural Measures (High Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	89	2,526	66,932	69,458
5	115	3,160	32,065	35,225
10	130	4,114	16,010	20,124
30	184	5,124	5,791	10,915
50	210	5,406	2,399	7,805
100	345	12,195	0	12,195

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

d) Selection of the Target Discharge for Adaptation Measure

MSA is applied to decide the target discharge for the adaptation measures. Figure 6.3.6 shows the result of MSA.



Note: The green line is a design discharge under the present climate condition
Source: JICA Project Team 2

Figure 6.3.6 Result of the Multiple Scenario Approach (Sadar River Basin)

The total cost and damage optimum point is obtained from the high scenario. The medium and low scenarios are not shown in the optimum point. Therefore, the target discharge is set at the same design discharge of the present climate condition. The adaptation measure of each scenario is shown in Table 6.3.35.

Table 6.3.35 Summary of the Adaptation Measure for Each Scenario (Sadar River)

Climate Scenario	Medium	Low	High
Adaptation Measure	Dike		
Protection Level*1	16-year	18-year	50-year
Peak discharge (before adaptation)	61 m^3/s	60 m^3/s	101 m^3/s
Peak discharge (after adaptation)	130 m^3/s*2	130 m^3/s*2	210 m^3/s
Dike Hight	0.5 m	0.5 m	0.7 m
Dike Length	6.8 km	6.8 km	12.5 km

Note:*1: The protection level is estimated for each scenario. *2: The design discharge under the present climate condition (25-year probable flood under present climate condition)

Source: JICA Project Team 2

4) Tawing River Basin

(a) Medium Scenario

a) Results of the Inundation Analysis

The inundation analysis in the Tawing River basin is applied at a 1-D and 2-D unsteady flow analysis. The analysis results are summarized in Table 6.3.36.

b) Alternatives of the Adaptation Measures

The dike structure is selected from comparative study as shown in Table 6.3.1.

c) Selection of the Adaptation Measures

The basic feature of the selected adaptation measure is shown in Table 6.3.37 and Figure 6.3.7 shows the expected flood dike alignment. The structural measures are selected by using the multi-scenario approach. and Figure 6.3.8 show the result of the multi-scenario approach.

Table 6.3.36 Inundation Area of Each Return Period (Medium Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	599	1.34	238	0.98	274
5	720	1.70	293	1.23	340
10	773	1.85	329	1.36	364
30	833	2.08	380	1.52	399
50	870	2.22	398	1.61	422
100	916	2.36	426	1.73	447

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

Table 6.3.37 Basic Feature of the Proposed Flood Dike (Medium Scenario)

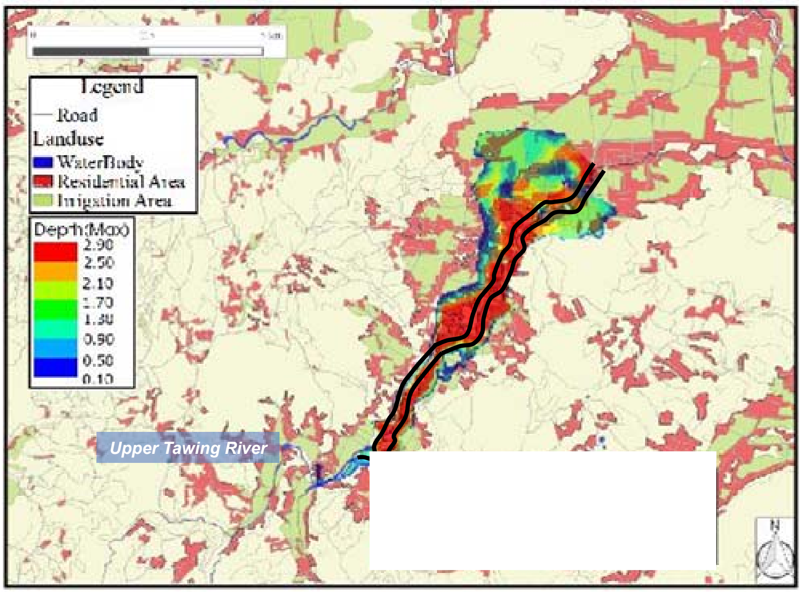
Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	185	235	288	397	456	542
Total Length (m)	14,600	18,800	21,800	26,600	27,600	28,000
Average height (m)	1.0	1.3	1.6	2.1	2.4	3.1

Source: JICA Project Team 2

Table 6.3.38 Result of Selection of the Structural Measures (Medium Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	185	7,984	97,491	105,475
5	235	12,755	43,222	55,977
10	288	18,428	18,661	37,089
30	397	30,693	5,737	36,430
50	456	37,626	1,789	39,415
100	542	53,138	0	53,138

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2



Note: The figure is showing the inundation area of a 30-year probable flood under medium scenario with dike alignment.

Source: JICA Project Team 2

Figure 6.3.7 Conceptual Plan for the Proposed Flood Dike Alignment of the Tawing River

(b) Low Scenario

a) Results of the Inundation Analysis

The inundation analysis in the Tawing River basin is applied at a 1-D and 2-D unsteady flow analysis. The analysis results are summarized in Table 6.3.39.

Table 6.3.39 Inundation Area of Each Return Period (Low Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	567	1.25	172	0.91	258
5	702	1.64	253	1.18	332
10	748	1.79	293	1.30	351
30	810	2.01	335	1.47	385
50	823	2.05	344	1.50	392
100	851	2.13	353	1.55	409

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

b) Alternatives of the Adaptation Measures

Dike structure is selected from comparative study as shown in Table 6.3.1.

c) Selection of the Adaptation Measures

The basic feature of the selected adaptation measure is shown in Table 6.3.40.

Table 6.3.40 Basic Feature of the Proposed Flood Dike (Low Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	175	217	267	352	384	418
Total Length (m)	14,000	17,400	20,200	25,800	26,600	28,000
Average height (m)	0.9	1.2	1.5	1.8	2.0	2.2

Source: JICA Project Team 2

The structural measures are selected by using the multi-scenario approach. Table 6.3.41 and Figure 6.3.8 show the result of the multi-scenario approach.

Table 6.3.41 Result of Selection of the Structural Measures (Low Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	175	7,026	94,361	101,387
5	217	10,647	41,782	52,429
10	267	15,251	17,974	33,225
30	352	23,088	5,377	28,465
50	384	27,000	1,647	28,647
100	418	31,748	0	31,748

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

(c) High Scenario

a) Results of the Inundation Analysis

The inundation analysis in the Tawing River basin is applied at a 1-D and 2-D unsteady flow analysis. The analysis results are summarized in Table 6.3.42.

Table 6.3.42 Inundation Area of Each Return Period (High Scenario)

Average Return Period (year)	Maximum Inundation Area (ha)	Irrigation Area		Housing Area	
		Inundation Depth (m)	Inundation Area (ha)	Inundation Depth (m)	Inundation Area (ha)
2	648	1.48	238	1.06	302.8
5	748	1.78	293	1.30	351
10	800	1.98	329	1.44	381
30	894	2.31	380	1.68	436
50	978	2.40	398	1.84	471
100	1,019	2.52	426	1.95	492

Note: Inundated irrigation area is applied to the average one during flood event because damage coefficient is estimated from inundation period and inundation depth. Inundation area of housing area is applied to the maximum one in the housing area during flood event because damage coefficient is estimated from inundation depth only.
Source: JICA Project Team 2

b) Alternatives of the Adaptation Measures

The dike structure is selected from the comparative study as shown in Table 6.3.1.

c) Selection of the Adaptation Measures

The basic feature of the selected adaptation measure is shown in Table 6.3.43.

Table 6.3.43 Basic Feature of the Proposed Flood Dike (High Scenario)

Hazard Scale	2-year	5-year	10-year	30-year	50-year	100-year
Discharge (m^3/s)	200	267	335	499	610	763
Total Length (m)	14,000	17,400	20,200	25,800	26,600	28,000
Average height (m)	1.1	1.5	1.8	2.7	3.5	4.3

Source: JICA Project Team 2

The structural measures are selected by using the multi-scenario approach. Table 6.3.44 and Figure 6.3.8 show the result of multi-scenario approach.

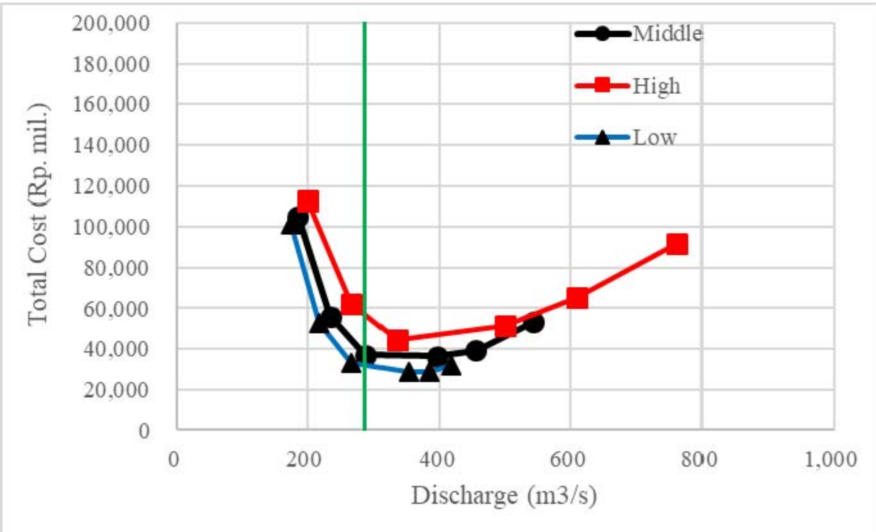
Table 6.3.44 Result of Selection of the Structural Measures (High Scenario)

Return Period (year)	Discharge with Structural Measures (m^3/s)	Cost (1) (IDR 10^6)	Damage (2) (IDR 10^6)	(1)+(2) (IDR 10^6)
2	200	9,213	103,261	112,474
5	267	16,120	46,155	62,275
10	335	23,974	20,406	44,380
30	499	44,821	6,358	51,179
50	610	63,608	1,952	65,560
100	763	91,936	0	91,936

Note: The cost and damage are applied 10% of discount rate and 10% of discount for economic cost and benefit. The construction period is assumed to be a 3-year period. The damage is accumulated during a 50-year period.
Source: JICA Project Team 2

d) Selection of Target Discharge for Adaptation Measure

The MSA is applied to decide the target discharge for adaptation measures. Figure 6.3.8 shows the result of MSA.



Note: The green line is a design discharge under the present climate condition
Source: JICA Project Team 2

Figure 6.3.8 Result of the Multiple Scenario Approach (Tawing River Basin)

The total cost and damage optimum point is obtained in all scenarios. The adaptation measure of each scenario is shown in Table 6.3.45.

Table 6.3.45 Summary of the Adaptation Measure for Each Scenario (Tawing River)

Climate Scenario	Medium	Low	High
Adaptation Measure	Dike		
Protection Level*1	30-year	30-year	10-year
Peak Discharge (before adaptation)	264 m^3/s	250 m^3/s	241 m^3/s
Peak Discharge (after adaptation)	397 m^3/s	352 m^3/s	335 m^3/s
Dike Hight	2.1 m	1.8 m	1.8 m
Dike Length	26.6 km	25.8 km	20.2 km

Note:*1: The protection level is estimated to each scenario. The planned design discharge of the present climate condition is 290 m^3/s.
Source: JICA Project Team 2

5) Porong River Basin

The protection level of the Porong River was already decided and the dike was constructed. Therefore, the heightening of the existing dike is proposed. The following height and length were proposed to a 50-year probable flood of each scenario as shown in Table 6.3.46.

Table 6.3.46 Summary of the Adaptation Measure for Each Scenario (Porong River)

Climate Scenario	Medium	Low	High
Adaptation Measure	Dike		
Protection Level*1	50-year		
Peak Discharge (after adaptation)	1,710 m^3/s	1,620 m^3/s	2,030 m^3/s
Dike Height	0.8 m	0.5m	1.0 m
Dike Length	40.1 km	28.4km	44.3km

Note:*1: The protection level is estimated at each scenario.
Source: JICA Project Team 2

(2) Non-Structural Measures

The non-structural measures against the rainstorms and floods are explained below,

All of the non-structural measures are applicable to the medium, low and high scenarios because the non-structural measures are the qualitatively ones. The non-structural measures in the Brantas River basin are;

1) Upgrading of the Flood Forecasting and Warning System (FFWS),
2) Community based Early Warning System (EWS),
3) Preparation of the Hazard Map for Several Probable Floods,
4) Designation of the Evacuation Center from the Existing Public Facilities and Construction of the Evacuation Center
5) Strengthening of the Flood Prevention Organization,
6) Preparation of the Business Continuity Plan (BCP) and Business Continuity Management (BCM) by Private Companies and Local Governments,
7) Preparation of the Flood Action Plan, and
8) Land Use Control to the Frequently Flood Inundation Area.

1) Upgrading of the FFWS

(a) Present situation

The PJT-I is operating the FFWS in the Brantas River basin since 1990s. They monitored the water levels at several important gauging stations and river structures. Recently, they installed the real time monitoring system of the rainfall data and water level data by using

Global System for Mobile communications (GSM). There are 62 rainfall gauging stations and 36 water level gauging stations. They collected hourly data from these stations.

At present, the PJT-I stand by the flood operation when the hourly rainfall or 4 hours accumulated rainfall exceed the following condition:

- More than 50mm/hr
- More than 100mm during 4 hours

In addition, the PJT-I informs related agencies when the water level becomes higher than the alert water level. There are three alert levels (Red, Yellow, and Green) in Indonesia. Figure 6.3.9 shows the flow chart of the relation among the regional agencies for the disaster management, BBWS Brantas and PJT-I. However, the PJT-I does not carry out flood forecasting.

(b) Future Climate Condition

According to the future projection results of the flood estimated by Team 1, the number of flood and peak discharge will be increased under future climate condition. The following measures are required to execute FFWS under future climate condition.

a) Cooperation with BMKG and Effective Use of Radar Rain Gauge

There are 27 weather radars operated across the country by BMKG in 2013. All of those radars are C-band doppler with single polarization. Figure 6.3.10 shows C-band doppler radar network in 2013.

As of 2013, there are 23 radar sites that have been connected via micro pulse lidar (MPL) data communications to the Hydrometeorological Decision Support System (HDSS) that is the radar mosaic system at the BMKG.

According to the masterplan of BMKG's radar network for the ten years period (2006 – 2016), the total number of weather radars of Indonesia will be 51 doppler weather radars to cover most of the provinces and cities. In the future, C-band doppler radar will cover the whole Indonesia.

Under the future climate condition, extreme flood events will be increased. At that time, data from the weather radar is useful to grasp the rainfall distribution area. Therefore, it is effective to the flood forecasting of PJT-I. The PJT-I and BBWS Brantas shall shear the data of HDSS while the rainfall data under BMKG.

b) Installation of Flood Forecasting Model

The frequency of the gate operation and alert issuance of the water level will be increased. Therefore, the lead time to action the flood fighting, gate operation, and evacuation are important things. If the flood forecasting can be done, they have a lead time to prepare these actions.

c) Store of Data

The PJT-I shall store hourly data to each flood event. These data are effective to analyze the planned design flood and/or inundation analysis under future climate condition. And these data are useful to the water utilization plan. It is required for the big capacity data storage server.

The proper arrangement and density of the gauging stations promote the improvement of the flood forecasting accuracy.

d) Review of the Designated Water Level

According to the PJT-I staffs, the three alert levels in the Brantas River basin are decided from the following methods.

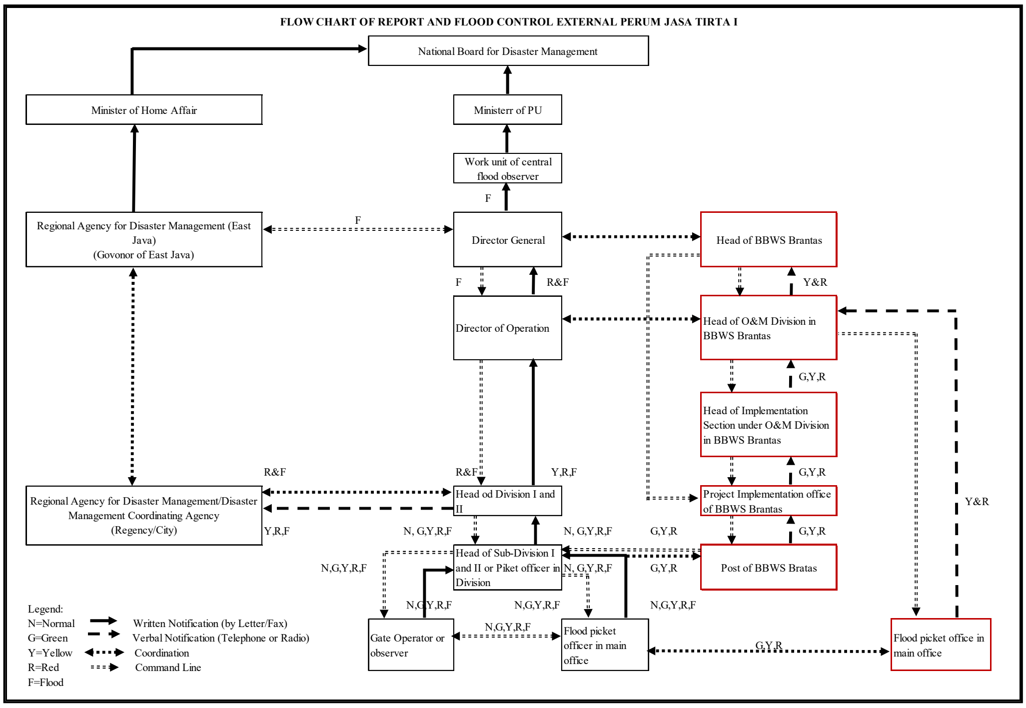
➢ Red alert level (*Siaga Merah*)

The red water level at the river station is decided below 50cm lower than crest elevation of the dike. And the water level at dam reservoir is set at a high water level that is estimated from the abnormal flood discharge.

➢ Yellow and green alert level (*Siaga Kuning* and *Siaga Hijau*)

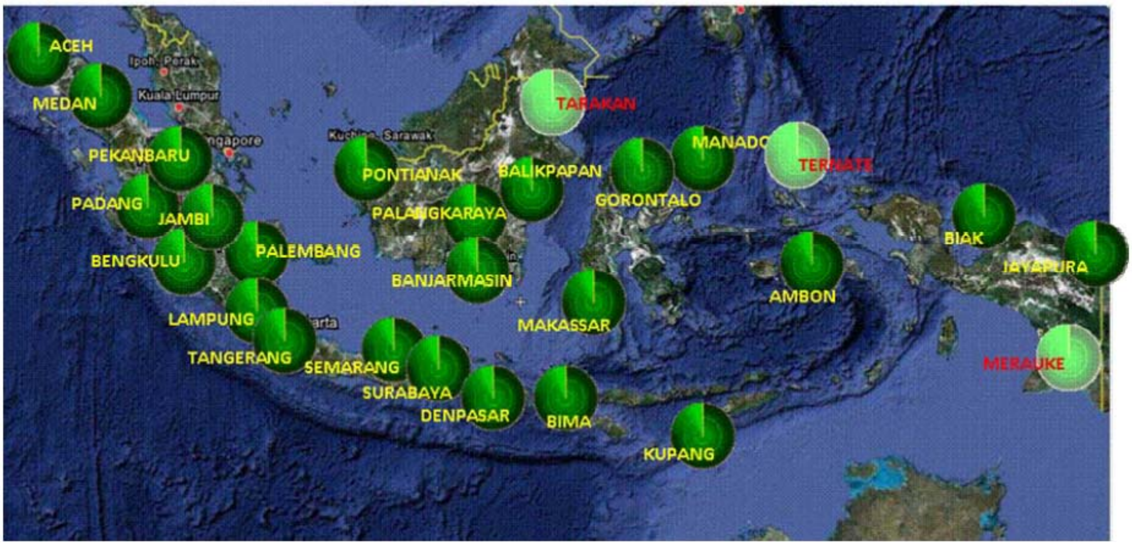
These alert levels are decided from the flow capacity and condition of the riverine area.

The present alert water level is shown in Figure 6.3.11.



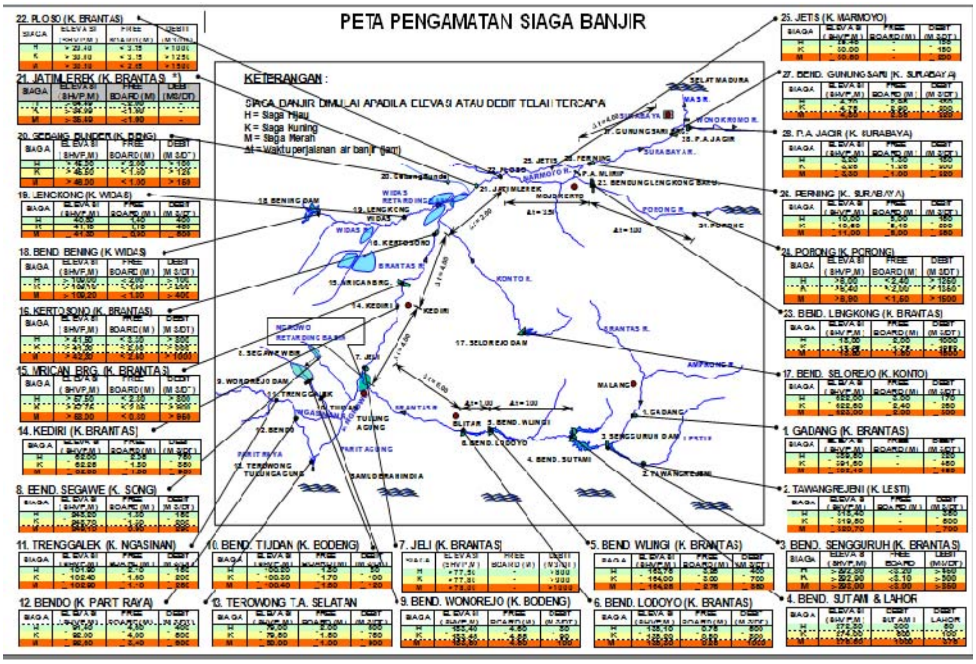
Source: PJT-I and BBWS Brantas

Figure 6.3.9 Flood Information Flow Chart among Related Agencies



Source: " **CURRENT STATUS OF WEATHER RADAR DATA EXCHANGE,** Regional Report on the current status of weather radar operated in RA V and its data exchange, submitted by Riris Adriyanto, WMO, 19.04.2013"

Figure 6.3.10 Indonesia C-Band Doppler Weather Radar Network (as of April 2013)



Keterangan : Pengendalian banjir meliputi satu kesatuan daerah pengaliran sungai (Hulu, Tengah,

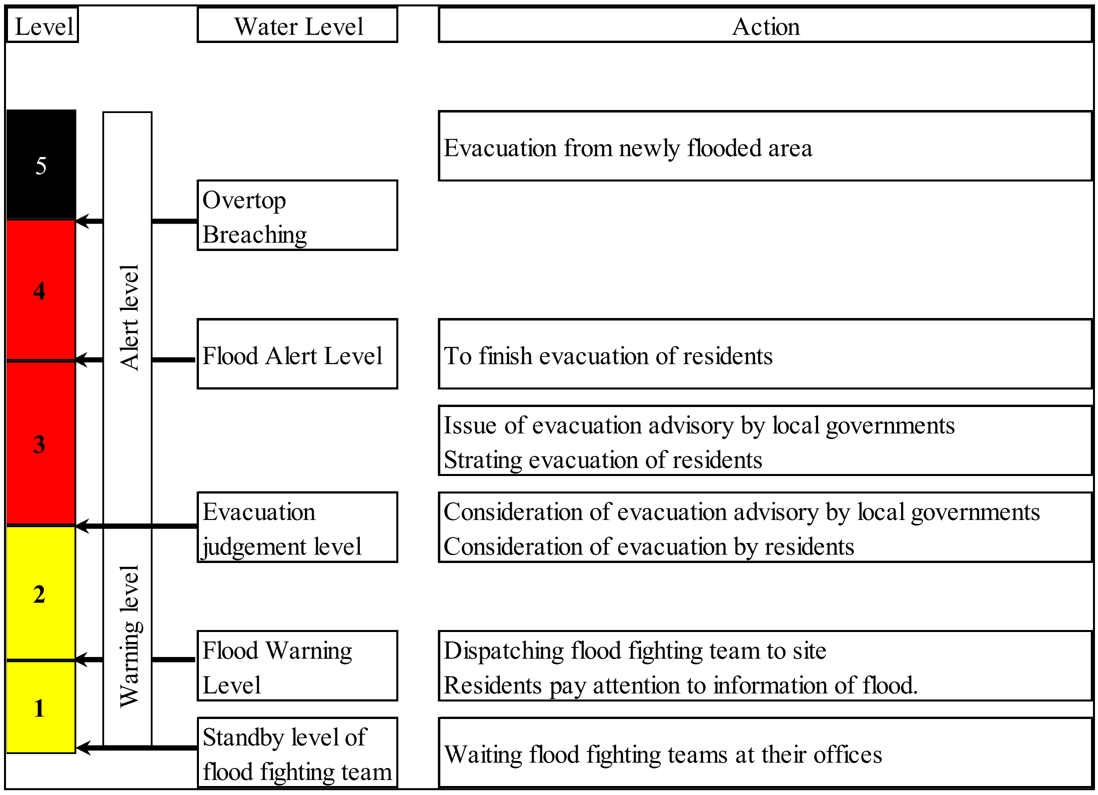
Source: BBWS Brantas

Figure 6.3.11 Alert Water Level in the Brantas River Basin

➢ Establishment of the alert water level in Japan

In Japan, four kinds of water levels are established as shown in .

Warning and alert water levels shall be re-studied considering the lead time for evacuation and mobilization of flood fighting team. The water level setting concept and methodology shall be decided by MPWH DGWR because of the different criteria of each river basin and no consideration of lead time for the evacuation and mobilization of the flood fighting team.



Source: Ministry of Land, Infrastructure, Transportation and Tourism Japan

Figure 6.3.12 Setting Water Levels for Floods

2) Establishment of Community based Early Warning System (EWS)

The community based EWS shall be established at frequently flood inundation areas. Twenty one villages were established a community based EWS in the Brantas River basin handled by the PJT-I.

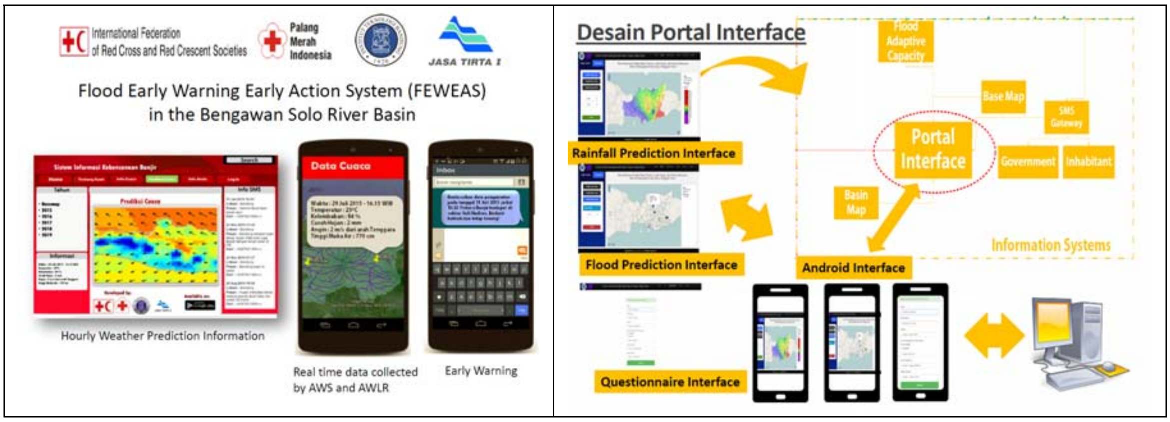
In the Bengawan Solo River basin, the flood information system for community based EWS was established under the PJT-I (see Figure 6.3.13). However, these systems are not established in the Brantas River basin due to lack of budget.

3) Preparation of Several Flood Hazard Maps for Several Probable Floods

Several inundation maps of the past flood events were mentioned in some papers and reports. However, authorized flood hazard map of the probable flood is not found in the website of the local governments.

The hazard map is an important tool for an evacuation or planning of flood management. The peak discharge and flood volume will be increased under the future climate condition. The flood damage under the future climate condition will become worse from the present condition. Several flood inundation maps of several probable floods are required for planning.

It is important to establish an updated system/procedure of hazard maps when the climate condition, geographical condition, urbanization, and advancing technology are changed.



Source: Flood management in the Brantas and Bengawan Solo River Basin, Indonesia Material for Asian Water Cycle Simposium,2016 prepared by PJT-I

Figure 6.3.13 Community Based Early Warning System in the Bengawan Solo

4) Designation of the Evacuation Center from the Existing Public Facilities and Construction of the Evacuation Center

If the flood inundation situation occurs at a residential area, people will evacuate out of the inundation area. Afterwards, they rest at public facilities such as a mosque, school ground, stadium, etc. Some public facilities cannot be used due to flood inundation.

The local governments shall designate an evacuation center and decide the evacuation route by using several flood inundation maps.

And if the evacuation centers are not enough, new evacuation centers shall be planned and constructed to consider the increasing number of floods and deeper and wider inundation area from the hazard maps.

On the other hand, many persons do not evacuate to the evacuation center in the present situation because they worry that someone would steal their assets when they evacuate.

When the residents do not consider evacuating out of the inundation area, affected people need to respond to the vertical evacuation. The following measures are considered to the vertical evacuation;

- When they construct a new building, a raised-floor-style building is constructed.
- When they construct a new building, a two-story building is constructed. During the flood event, the important assets and residents evacuate to the second floor.
- In addition, residents who carry out vertical evacuation give information to a village leader. The village leader grasps who is located in the evacuation center and their own houses.

5) Strengthening of the Flood Prevention Organization

(a) Capacity Development of the Flood Fighting Team

The flood fighting is one of the tasks of the regional agency for disaster management (BPBD) of regency. The flood fighting team belonging to BPBD takes actions towards flood prevention with BBWS Brantas, PJT-I and other concerned agencies. The BPBD Team is a main actor to flood fighting. It is necessary to keep a high level of knowledge and skills to flood fighting. Therefore, the capacity development of the BPBD Team and related agencies is required.

(b) Improvement of the Equipment to Flood Fighting Activities

The removal type flood wall is a useful equipment to protect overtop of flood water from the dike.

<Planning of Removal type flood wall>

Firstly, the breaching points along the existing dike are studied by using the inundation analysis results. Then, the required height and length of the removable type flood wall are evaluated. Based on the analysis results, the removable type flood walls are purchased and stocked near the breaching points. The flood fighting team shall study how to construct removal type flood walls through the capacity development program.

6) Preparation of the Business Continuity Plan (BCP) and Area Business Continuity Management (BCM) by Private Companies and Local Governments

A business continuity plan (BCP) is a plan to help ensure that business processes can continue during a time of emergency or disaster. In order to reduce flood damages, BCP shall be prepared by the private companies and local governments because the frequency of flood events will be increased under future climate condition. The central government shall prepare guidelines of the BCP.

In addition, the collaboration of each industrial company, local governments, and other companies is necessary to restart the operation of each company as soon as possible. Therefore, preparation of the Area BCM is required to be collaborated with them.

7) Preparation of the Advance Flood Action Plan

The water resources management team (*Tim Koordinasi Pengelolaan Sumber Daya Air*: TKPSDA) shall prepare the advance flood action plan that is organized for action of the disaster prevention (flood) and implementing agencies in time series focusing on “when”, “who”, and “what to do”.

8) Limitation of Land Use at Frequently Inundated Area

The local governments prepare the spatial plan. At that time, they shall consider the frequently inundated area from several flood hazard maps. Under the future climate condition, the inundated area will be expanded compare with the present condition.

The local governments shall consider land use control at flood inundation area in future.

6.3.2 Adaptation Measures against Drought

(1) Structural Measures

1) Saving Water

(a) Reduction of Non-Revenue Water (NRW) of PDAM Water

The domestic water demand in 2050 was estimated considering the reduction of NRW. There are two kinds of target that were set from the present NRW as shown in Figure 6.3.14 and Table 6.3.47.

The adaptation measures to save intake water are considered reducing NRW from 25% to 20%. Water demand at intake location with adaptation measures is reduced 1.411 m^3/s. Adaptation measure is considered replacement of distribution pipes.

(b) Reduction of Leakage Water from Irrigation Canal

In the DGWR design criteria, the irrigation efficiency is defined based on the water conveyance loss of the irrigation canal. As the design target, the loss is set at 10% for 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). In the Brantas River basin, 484 surface water irrigation schemes with design command area over 100 ha share about 75% of the whole command areas by 484 schemes accounting for 13%. It is commonly understood that the current level of conveyance loss of the tertiary canal system is still around 30% and thereby reduction of the leakage water from the existing irrigation canal systems is one of the effective adaptation measures against drought from the viewpoint of water saving. As the high level of conveyance loss is caused by deteriorated or not yet facilitated condition of tertiary canal system, it is essential to implement a tertiary canal system improvement works such as the replacement to pre-cast concrete block lining canal.

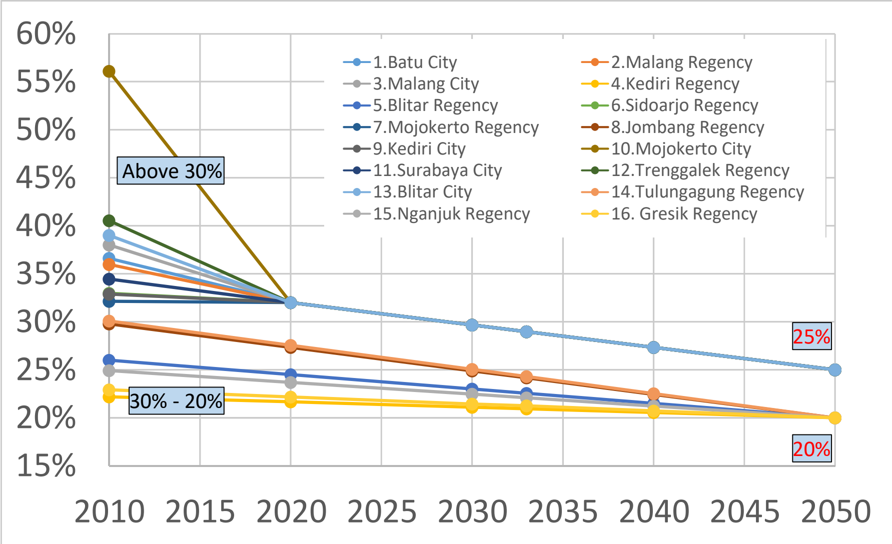
(c) Recycle Plant of Industrial Companies

For the reduction of industrial water demand, the adaptation measure to save industrial water is the installation of recycle plant. The re-use ratio from the sewage is about 1.4% in Japan. Therefore, it is assumed that the industrial water is reduced to 1% of the industrial water demand. The industrial water will be saved 0.210 m^3/s (18,144m^3/day).

Table 6.3.47 Each Target Group for Demand Forecast in 2050

Target of NRW	25%	20%
Regency/ City	➢ Batu City ➢ Malang Regency ➢ Malang City ➢ Sidoarjo Regency ➢ Mojokerto Regency ➢ Kediri City ➢ Mojokerto City ➢ Surabaya City ➢ Trenggalek Regency ➢ Blitar City	➢ Kediri Regency ➢ Blitar Regency ➢ Jombang Regency ➢ Tulungagung Regency ➢ Nganjuk Regency ➢ Gresik Regency

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 6.3.14 NRW until 2050 for the Demand Forecast in 2050

2) Increasing Store Water

(a) Proposed Dams

a) Water Resource Development Plan

In the course of the Project, the data and information related to the proposed river facilities in the Brantas River basin have been collected and reviewed. The data sources are shown below:

- POLA 2010
- RENCANA 2013 (Draft)
- Review POLA 2015(Draft)

(i) POLA 2010

In POLA 2010, there were 13 proposed dams for the water resources development plan in the Brantas River basin as shown in Table 6.3.48.

Table 6.3.48 Proposed Dams in the Brantas River Basin in POLA 2010

No	Dam Reservoir	Short term (2006-2010)	Medium term (2011-2020)	Long term (2021-2030)
1	Genteng I Reservoir	Study, pre-design, D/D	Implementation	
2	Tugu Reservoir	Study, pre-design, D/D	Implementation	
3	Beng Reservoir	Study, pre-design, D/D	Implementation	
4	Kedungwarak Reservoir	Study, pre-design, D/D	Implementation	
5	Ketandan Reservoir		Study, pre-design, D/D	Implementation
6	Semantok Reservoir		Study, pre-design, D/D	Implementation
7	Kuncir Reservoir	Study, pre-design, D/D	Implementation	
8	Babadan Reservoir		Study, pre-design, D/D	Implementation
9	Lesti III Reservoir	Design Details	Study, pre-design, D/D	
10	Kepanjen Reservoir		Study, pre-design, D/D	Implementation
11	Lumbang Sari Reservoir		Study, pre-design, D/D	Implementation
12	Kesamben Reservoir	Study, pre-design	D/D	Implementation
13	Konto II Reservoir		Study, pre-design, D/D	Implementation

Source：POLA(2010)

(ii) RENCANA 2013 (Draft)

In RENCANA 2013 (Draft), there were 10 proposed dams presented in the figure of water resources development plan. Comparing with the POLA 2010, there were six proposed dams (Bagong, Kampak, Nglemi, Sumber Agung, Kembangan, and Kali Lanang) that were newly added.

(iii) Review POLA 2015(Draft)

The concept of water resources development until 2030 in Review POLA 2015 (Draft) has been revised from POLA 2010. The list of dam structures is changed, and the list of ponds, development plan of ponds and long storage structures are added to Review POLA 2015 (Draft).

In Review POLA 2015 (Draft), there were 23 proposed dams listed up with their location, storage capacity and function. Comparing with the RENCANA 2013 (Draft), 10 proposed dams were newly added.

(iv) List of Proposed Dams in Water Resource Development Plan

Consequently, there are 29 proposed dams in total in the Brantas River Basin based on the above plans. The list of the proposed dams is presented in Table 6.3.49.

b) Status of the Proposed Dams until 2030

In Review POLA 2015 (Draft), there are five (5) dams to be constructed in the Brantas River basin until 2030, which are:

By Year 2020: Tugu Dam, Lesti III Dam,

By Year 2025: Bagong Dam, Semantok Dam, and

By Year 2030: Beng Dam.

c) Status of Other Proposed Dams

The latest information for the proposed dams and river facilities are collected as presented in Table 5.3.31.

The site inspection for major proposed dams, i.e. Lesti III, Genteng I, Kont II, Tugu, Babadan and Semantok Dams was carried out in September, 2016. The main finding is shown in Table 6.3.50.

Table 6.3.49 List of the Proposed Dams in the Past and Current Water Resources Plans

No.	Name	MP 1998	POLA 2010*1	RENCANA 2013*2	REVIEW POLA (2015)
1	Genteng I Dam	o	Scenario 1,2	L	o
2	Tugu Dam	o	Scenario 1-2	S	o
3	Beng Dam	o	Scenario 1,2,3	-	o
4	Kedungwarak Dam	o	Scenario 1,2,3	L	o
5	Ketandan Dam	o	Scenario 1	-	o
6	Semantok Dam	o	Scenario 1	S	o
7	Kuncir Dam	o	Scenario 1,2	-	o
8	Babadan Dam	o	Scenario 1	-	o
9	Lesti III Dam	o	Scenario 1,2,3	-	o
10	Kepanjen Dam	o	Scenario 1	-	o
11	Lumbang Sari Dam	o	Scenario 1	-	o
12	Kesamben Dam	o	Scenario 1,2,3	-	o
13	Konto II Dam	o	Scenario 1	-	o
14	Bagong Dam	-	-	S	-
15	Kampak Dam	-	-	M	-
16	Nglemi Dam	-	-	M	-
17	Sumber Agung Dam	-	-	M	-
18	Kembangan	-	-	M	-
19	Kali Lanang	-	-	L	-
20	Krangkates IV&V	-	-	-	o
21	Marmoyo Dam	-	-	-	o
22	Brangkal – Plandaan Dam	-	-	-	o
23	Kembar Dam Jenesgelaran – Jurangbang	-	-	-	o
24	Kopen Dam	-	-	-	o
25	Jarak Dam	-	-	-	o
26	Gembrong Dam	-	-	-	o
27	Jatijejer Dam	-	-	-	o
28	Jinggring Dam	-	-	-	o
29	Sabo Dinoyo Dam	-	-	-	o
	Number of Proposed Dams	13	13	10	23

Note: *1 Scenario 1- Strong Economic Condition, Scenario 2- Normal Economic Condition, Scenario 3- Weak Economic Condition, *2 S: Short Term, M: Medium Term: L: Long Term

Source: JICA Project Team 2

Table 6.3.50 Present Status of the Proposed Dam in the Brantas River Basin as of December 2016

No.	Name	Updated Information based on the Interview with BBWS, as of December 2016
1	Genteng I Dam	The Study has not yet been completed. The implementation is postponed after 2017 because of the tight budget and government policy is given to irrigation.
2	Tugu Dam	See Table 5.3.31.
3	Beng Dam	See Table 5.3.31.
4	Kedungwarak Dam	Social issues are arisen and the project is almost canceled. It is the same as the last time.
5	Ketandan Dam	Social issues are arisen and the project is almost canceled.
6	Semantok Dam	See Table 5.3.31.
7	Kuncir Dam	The study was finished in 2015. The construction of the weirs was completed.
8	Babadan Dam	Only a small dam was constructed in 2007. The rehabilitation study of the dam is being undertaken.
9	Lesti III Dam	See Table 5.3.31.
10	Kepanjen Dam	No information
11	Lumbang Sari Dam	No information
12	Kesamben Dam	PJT-1/PLN has a plan to construct a weir for the power supply.
13	Konto II Dam	The construction works of the small consolidation dam was stared in 2016. There are series of facilities for sediment control.
14	Bagong Dam	See Table 5.3.31.
15	Kampak Dam	F/S is being undertaken by the local consultant. The Final Report will be provided within 2016. People in Brenggolo Sub Village, Bogoran Village, Kampak District Sub District, and Trenggalek Regency at June 2016 had demonstrations rejecting the establishment of the Kampak Dam. Approximately 106 households were affected, where they are restless because until now the plan is not socialized in detail, regarding the area to be affected as well as the relocation process. The residents are asked to fill out questionnaires related to the development plan. The contents of the questionnaire also lead to land acquisition, whereas the study for the construction of the dam is still in the feasibility study stage. At the Study Investigation Design (SID), there are three alternatives locations. The Benefit Cost Ratio (BCR) was declared unfit because of an error calculation of the impact of flooding, so it is necessary to do re-calculation. (BCR for flood control <1)
16	Nglemi Dam	F/S will be conducted in 2020's
17	Sbr Agung Dam	F/S will be conducted in 2020's
18	Kembangan	Plan for study in 2016 if fund is available. The design is prepared by the local government (Trenggalek Regency), and the design proposes a small dam (they called EMBUNG) for irrigation.
19	Kali Lanang	Plan for study in 2016 if fund is available
20	Krangkates IV&V	Plan for additional hydroelectric power generation.
21	Marmoyo Dam	Only a leaflet is available. The plan is a small dam (H=6m, V=96,000m^3) for irrigation and domestic water.
22	Brangkal – Plandaan Dam	No information
23	Kembar Dam Jenesgelaran – Jurangbang	No information
24	Kopen Dam	No information
25	Jarak Dam	No information
26	Gembrong Dam	The Study Investigation Design (SID) was already finish at 2010. The plan is for a small dam (H=14m, V=144,000m^3) for irrigation, domestic and industrial water supply.
27	Jatijejer Dam	No information
28	Jinggring Dam	The SID was already finished in 2016. Initially, it was planned to build a large dam but got cancelled. The present plan is a small dam (H = 15m, V = 71,000m^3) for irrigation water supply. In the SID, the design covers another dam site for the Janging Dam adjacent to the Jinggring Dam. The present plan of the Janging Dam is also a small dam (H = 15 m, V = 31,000m^3) for irrigation water supply.
29	Sabo Dinoyo Dam	No information

Source: JICA Project Team 2

Table 6.3.51 Result of Site Inspections for the Major Proposed Dams

No.	Name	Main Findings of Site Inspection*1
1	Genteng I Dam	・ F/S was already done in 2002. The proposed dam is a large dam with 82 m in height. It is necessary to construct saddle dams, a large area of land acquisition, resettlements and replacement of primary roads. ・ At the time of the inspection, the number of affected houses is increased due to the development of the proposed reservoir area because it has passed 14 years since the completion of its F/S.
2	Tugu Dam	・ The construction works is on-going, as of Sept 3, 2016 the progress of construction ± 53.8 %. ・ At the time of the inspection, the excavation works of the dam is almost finished, and the foundation works has been started. The geotechnical problems are arisen because the dam site is located in the land sliding areas. Many large cracks are found on the shotcrete covering the slopes of the abutment at both left and land sides. BBWS Brantas is currently undertaking the study for the countermeasures.
6	Semantok Dam	・ There are two alternative dam sites. BBWS Brantas had proposed the Alternative-2 (more upstream than Alternative-1), but it was rejected by the local government. At present, the local government proposes the construction of the Alternative-1. ・ At the time of the inspection for the Alternative-1, it was confirmed a necessity for land acquisition and resettlement of around 200 houses. The dam type is a kind of structure having the functions of dike embankment and retarding basin. As per information from the chief of the village, the local residents do not object for the project implementation.
8	Babadan Dam	・ The plan of the dam was prepared in MP1985. It was planned as a trans basin scheme. At present, BBWS Brantas has no information for the dam. ・ At the time of inspection, it was confirmed that the land use is mainly for agriculture and few people are living in the proposed site. Because the site is hilly area, the dam type will be similar as the Benin Dam.
9	Lesti III Dam	・ The D/D was completed in 2014. The dam is designed as a gated dam with a height of around 30 m considering mitigation of the social impacts. ・ The dam site seemed to be good for construction from the viewpoints of access and topography. Since the sediment yield from the basin is large, the sediment management system shall be necessary.
13	Konto II Dam	・ The plan of the dam was prepared in MP 1985. ・ At present, the construction of small dams is proposed in the upstream of the Selorejo Dam to control the sediment inflow.

Note: *1: Number is referred to Table 6.3.51, *2 Site Visit Sep. 8-10, 2011

Source: JICA Project Team 2

d) Priority of Proposed Dams

As mentioned above, there are 29 proposed dams, which will be confirmed through the data collection in the course of the Project.

These dams are classified into three categories as shown below:

Category A

At present, the Government of Indonesia identifies 65 priority dams which are prioritized for implementation as National Strategic Projects. Among these dams, three dams are Tugu Dam, Semantok Dam, and Bagon Dam, which are identified in the Brantas River basin.

In addition, as mentioned in the above there are five dams to be constructed in the Brantas River basin until 2030 in Review POLA 2015 (Draft), which are the following:

By Year 2020: Tugu Dam, Lesti III Dam,

By Year 2025: Bagong Dam, Semantok Dam, and

By Year 2030: Beng Dam.

The above five dams are considered as the first prioritized dams in the Brantas River basin.

Category B

The dams to be classified in the Category B are the ones that have detailed plan and information based on the previous master plans, feasibility studies and detailed designs.

Category C

The dams to be classified in the third class are the ones that have no or very few detail information.

Based on the above criteria, the 29 proposed dams are classified as shown in Table 6.3.52.

Table 6.3.52 Priority of the Proposed Dams in the Brantas River Basin

Priority	Dam
Category A (Strategic Projects listed in REVIEW POLA 2015)	Tugu Dam, Beng Dam, Semantok Dam, Lesti III Dam, and Bagong Dam
Category B (Projects that are completed study and design)	Genteng Dam, Kedungwarak Dam, Ketandan Dam, Kuncir Dam, Babadan Dam, Kepanjen Dam, Lumbang Sari Dam, Kesamben Dam, Konto II Dam, and Kampak Dam
Category C	Nglemi Dam, Sbr Agung Dam, Kembangan, Kali Lanang, Krangkates IV&V, Marmoyo Dam, Brangkal – Plandaan Dam, Kembar Dam,Jenesgelaran – Jurangbang Kopen Dam, Jarak Dam, Gembrong Dam, Jatijejer Dam, Jinggring Dam, and Sabo Dinoyo Dam

Source: JICA Project Team 2

e) Effects of the Proposed Dams in the Project

For the proposed dams of Categories A and B, the basic information of the dam location, purpose, dam type and basic dimension, and reservoir storage capacity is presented in Table 6.3.53.

These proposed dams are taken into consideration of the other climate change adaptation measures against droughts by increasing the store water.

Table 6.3.53 Type and Basic Dimension of Proposed Dams

No	Name	River Basin/ River	Purpose	Dam			Reservoir Capacity (Million m^3)		
				Type	Length (m)	Height (m)	Gross	Effective	Dead
1	Genteng I Dam	Lesti River basin/ Genteng River	F, I, SC	R	441.0	84.0	82.0	76.1	5.9
2	Tugu Dam	Ngrowo River basin/ Keser River	F, I, U	R	245.9	81.0	9.3	7.8	1.6
3	Beng Dam	Beng River	I, P,U	R	70.0	32.0	121.6	88.1	33.5
4	Kedungwarak Dam	Widas River basin/ Kedungwarak River	I, P,U	R	164.3	25.3	13.6	9.0	4.6
5	Ketandan Dam	Widas River basin/ Ketandan River	I	R	128.5	33.5	6.1	4.9	1.2
6	Semantok Dam	Widas River basin/ Semantok River	F, I, P	R	92.5	38.5	22.4	18.3	4.1
7	Kuncir Dam	Widas River basin/ Kuncir River	F, I, P, U	R	450.5	100	30.5	22.5	8.0
8	Babadan Dam	Bendokrosok	F, P, U	R	179	80	100.0	84.0	16.0
9	Lesti III Dam	Lesti River basin/ Lesti River	I, P, SC	R	346	30	7.4	4.0	3.4
10	Kepanjen Dam	Brantas River	P, SC	E	320	20	1.3	0.5	0.8
11	Lumbang Sari Dam	Brantas River	P, SC	E	378	28	5.7	0.9	4.8
12	Kesamben Dam	Brantas River	P, U	GW	171	11.5	6.6	6.2	0.4
13	Konto II Dam	Konto River	F, P, SC	R	1004	120	73.0	63.0	10.0
14	Bagong Dam	Bagon River		R	330	81.79	17.4	-	-
15	Kampak	Tugu River	F, U	R	316	70	6.20	5.67	0.53

Note: U: Urban water supply, I: Irrigation, F: Flood control, P: Hydropower, SC: Sediment control
R: Rockfill, E: Earthfill, GW: Gated Weir
Source: The Latest Reports/Documents collected by JICA Project Team 2

(b) Heightening of Sutami Dam

a) Function of Dam Heightening

The reservoir storage volume to be developed by the proposed dam heightening can be utilized for i) water use, ii) flood control, or iii) for both purposes by introducing the control water level. It will be necessary to carry out a detailed study in order to determine this. In this preliminary study, it is assumed that the dam heightening is aiming at developing the water use storage taking into account more urgent requirements and benefits in the Brantas River basin.

b) Preliminary Study for Dam Heightening

The study for the dam heightening is the target for Sutami Dam which has the largest storage capacity in the Brantas River basin. Since Sutami Dam reservoir is directly connected with the Lahr Dam reservoir through a connecting channel, the following three cases are considered:

Case 1: Sutami Dam heightening

Case 2: Lahor Dam heightening

Case 3: Heightening of both dams

Table 6.3.54 shows the feature of both dams.

The increased volume by 1 m heightening of each case is roughly estimated based on the

H-V curve. In this study, Case 1 is adopted considering the larger increased volume by heightening.

Table 6.3.54 Reservoir Condition of Both Dams

Item	Sutami Dam	Lahor Dam
Flood Water Level (FWL)	EL.277.0 m	EL. 275.7 m
Reservoir Area (at FWL)	19 km^2 (at EL. 277 m)	4.0 km^2
Reservoir Area (at EL. 280 m)	21 km^2 (at EL. 280 m)	5.0 km^2 (at EL. 280 m)
Increase of the Storage Volume by 1m heightening	20MCM/m	5MCM/m

Source: JICA Project Team 2

c) Height of Dam Heightening

The topography of Sutami Dam site shows that the ground elevation in the surrounding area of the left dam abutment is around EL. 280.0 m. Referring to the topographic maps of the scale of 1:50,000, the number of bridges and villages to be affected by the proposed dam heightening is roughly counted as shown in Table 6.3.55. And the present conditions surrounding Sutami Dam is shown in Figure 6.3.14.

If it is assumed that the reservoir area of EL. 287.5 m (Case 2), there are a lot of existing bridges and villages to be relocated in connection with the dam heightening. On the other hand, as shown in Case 1: a small scale of dam heightening, the social impact can be mitigated. In addition, in the previous geological study report pointed out that there is a pervious sandy layer at the right dam abutment in the area with elevation of around 278.0 m.

Table 6.3.55 Dam Heightening Case

Case	Case1	Case 2
Dam Heightening	(+2.5 m)	(+15.0 m)
	NWHL=EL. 275 m	NWHL=EL. 287.5 m
Number of affected bridges	14	22(4)
Number of affected villages	0	23 (5)

Note: *1 This study is conducted for two cases referring to available contour lines (EL. 275.0 m, EL. 287.5 m) in the existing topographic map of 1:50:000, *2 The value in parenthesis shows the data of Lahor Dam

Source: JICA Project Team 2

Taking into consideration the above, dam heightening by 5 m was adopted in this study to mitigate the social impact and technical condition. Table 6.3.56 shows the expected features. In this proposal, the NHWL is raised from EL. 272.7 m to EL. 277.5 m, and the dam crest elevation is raised from EL. 279.0 m to EL. 284.0 m.

Table 6.3.56 Additional Case of Dam Heightening

Item	Dimension	Remarks
Height of Dam Heightening	5.0 m	
Downstream Slope of the Heightening	1:2.6	Ref. Design of Murayama Reservoir in Japan
Embankment Volume	1,198,000 m^3	Preliminary estimate
Required Facility	New spillway	L = 460m
	Gate at connecting channel	
	Saddle Dam	L = 1,000 m, H = 3m

Source: JICA Project Team 2

Source: Google Earth Pro

Figure 6.3.15 Present Conditions surrounding Sutami Dam Reservoir

d) Layout of Dam Heightening

The layout plan of the dam heightening is presented in Table 6.3.15.

(c) Dredging of Reservoir

At present, Sutami Dam, Sengguruh Dam, Wlingi Dam and Selorejo Dam are carried out the maintenance dredging. Table 6.3.57 shows the present annual dredging volume of each dam reservoir.

Table 6.3.57 Annual Dredging Volume of Each Dam Reservoir

Dam	Annual Dredging Volume (m^3)
Sengguruh Dam	270,000
Sutami Dam	375,000
Wlingi Dam	370,000
Selorejo Dam	280,000

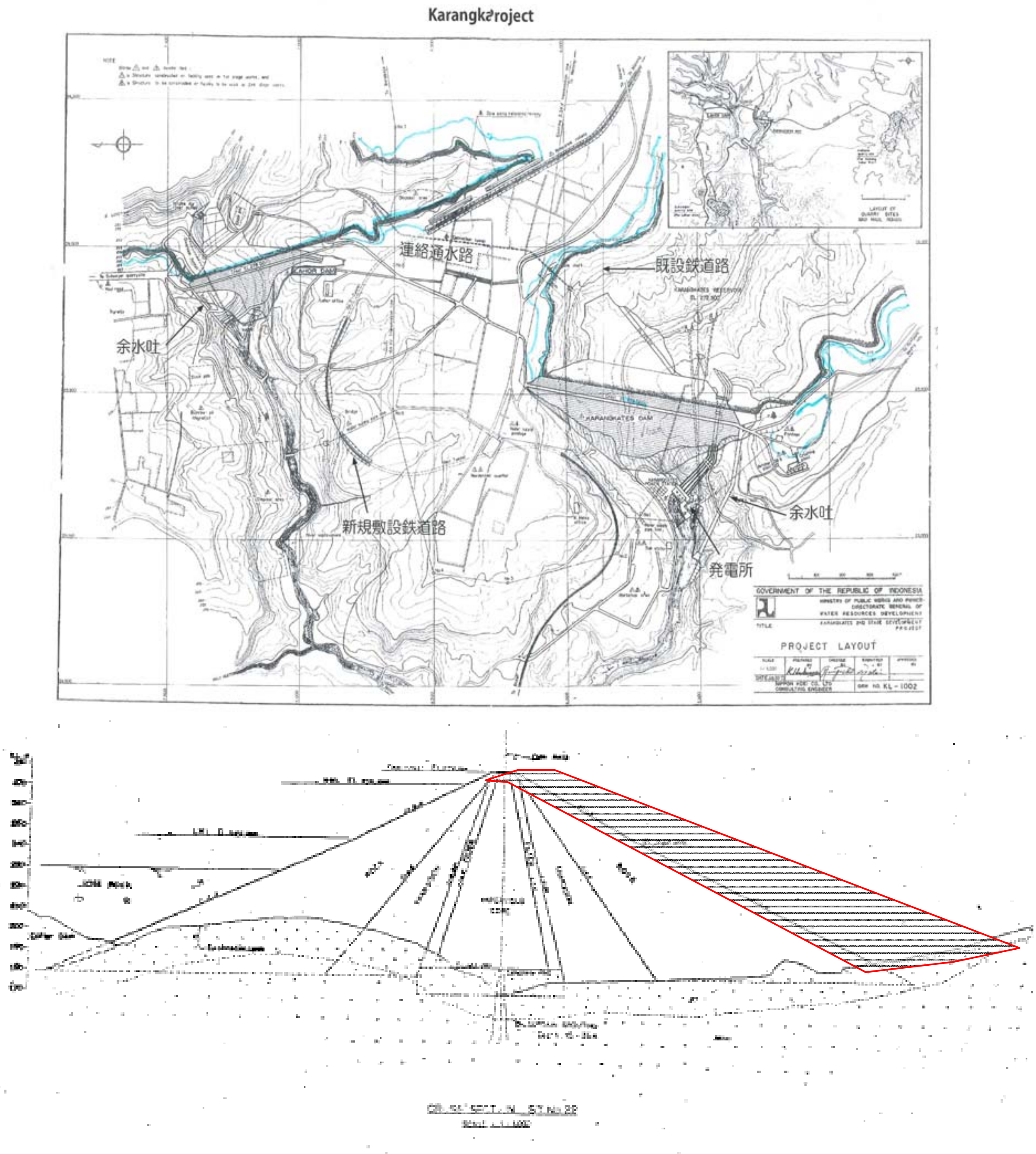
Source: Result of Interview to PJT-I on March 16, 2016

On the other hand, the sediment inflow will increase under future climate conditions because of the higher rainfall intensity and other impacts. Table 6.3.58 shows sediment inflow volume under the present and future climate conditions.

Table 6.3.58 Annual Sediment Inflow under Present and Future Climate Conditions

Dam	Present Sediment Inflow (SP) (10^3m^3)	Future Sediment Inflow (SF) (10^3m^3)			Incremental Sediment Inflow due to Climate Change (10^3m^3)		
		Medium (α=1.15)	Low (α=1.10)	High (α=1.25)	Medium	Low	High
Sengguruh	5,400	6,210	5,940	6,750	810	540	1,350
Sutami	4,850	5,578	5,335	6,063	728	485	1,213
Wlingi	5,600	6,440	6,160	7,000	840	560	1,400
Selorejo	680	782	748	850	102	68	170

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure 6.3.16 Layout of Sutami Dam Heightening

The required number of dredgers are estimated from the actual annual dredging volume as shown in Table 6.3.59.

Even the dredger is required from 1 to 5, additional spoil banks of the dredging material are required. The required spoil bank volume is shown in Table 6.3.60.

Table 6.3.59 Required Number of Dredger against Climate Change Impact

Dam	Present Annual Dredging Volume (10^3m^3)	Increment Volume due to Climate Change (10^3m^3)			Required Number of Dredger (nos.)		
		Medium	Low	High	Medium	Low	High
Sengguruh	270	810	540	1,350	3	2	5
Sutami	375	728	485	1,213	2	1	3
Wlingi	370	840	560	1,400	2	2	4
Selorejo	280	102	68	170	1	1	1

Source: JICA Project Team 2

Table 6.3.60 Required Volume of Spoil Bank

Dam	Required Volume of Spoil Bank (10^3m^3)			Required Vol./Present Annual Dredging Volume		
	Medium	Low	High	Medium	Low	High
Sengguruh	1,080	810	1,620	4.0	3.0	6.0
Sutami	1,103	860	1,588	2.9	2.3	4.2
Wlingi	1,210	930	1,770	3.3	2.5	4.8
Selorejo	382	348	450	1.4	1.2	1.6

Source: JICA Project Team 2

It is difficult to maintain a spoil bank surrounding the reservoir area except the Selorejo Dam because the spoil bank volume is required around three to four times of present spoil bank.

(2) Non-Structural Measures

The non-structural measures against the drought are proposed as follows;

1) Changing the water source from the surface water to groundwater
2) Intermittent and shallow depth irrigation practice
3) Introducing system of rice intensification (SRI)
4) Public relations of the reservoir water level of each dam
5) Domestic water supply support system among adjacent river basin
6) Preparation of the advance drought action plan (Timeline for drought)

1) Changing the Water Source from the Surface Water to Groundwater

The surface water demand is bigger than the groundwater demand. Therefore, a part of the surface water demand is shifted to the groundwater considering the available groundwater potential.

2) Intermittent and Shallow Depth Irrigation Practice

The minimum requirement for promoting this non-structural on-farm level irrigation water management practice is to facilitate tertiary irrigation and drainage canal system coupled with land leveling work of paddy field. Prior to meeting such requirement, it is also needed to set up institutional arrangement activities and to strengthen the receptive capacity of the stakeholders concerning on-farm level irrigation water management practices. If land acquisition activity is required for facilitating tertiary drainage canals, it is indispensable to take community-based actions for achieving consensus among stakeholders. Therefore, non-structural practice is limitedly recommendable for the irrigation schemes with fewer requirements for social consideration.

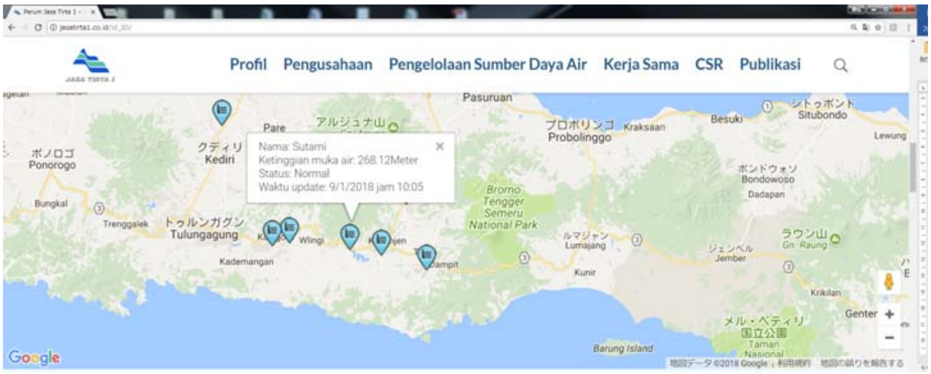
3) System Rice Intensification (SRI)

In relation to improve the efficiency of irrigation water use through promoting the SRI method, the main concern of Government of Indonesia (GOI) is to make the SRI more popular in intensive rice cultivation areas. The core practices of the SRI are to supply quality seed and fertilizers, to extend the line planting method of young-aged seedlings, to carry out through leveling works of paddy field, and to conduct intermittent and shallow depth irrigation practices. The Ministry of Agriculture has encouraged the provincial governments to establish and operate demonstration plots for disseminating the SRI method to rice farmers focusing on the demonstration of line planting and qualified farm inputs. Although the effectiveness of the SRI method on irrigation water saving has yet to be commonly quantified on the area-wise basis in any irrigation scheme, the Bogor Agricultural University in Indonesia reported its experimental result indicating that the irrigation water consumption for the dry season could be reduced by 3.35% by applying the SRI method.

4) Public Relations of Reservoir Water Level of Each Dam

To recognize the drought situation in the residential people in the Brantas River basin, PJT-I shall promote a public relation of the reservoir condition,

At present, everybody can see today's reservoir water level on PJT-I web page (see Figure 6.3.17).



Source: Web page of PJT-I (http://jasatirta1.co.id/id_ID/)

Figure 6.3.17 Today's Reservoir Water Level of Each Reservoir operated by PJT-I

To explain the severe situation during drought year, it is important to show the time series of the actual reservoir water level and planned water level and the actual release water discharge and planned one.

5) Domestic Water Supply Support System among the Adjacent River Basin

At present, there is no agreement of assistance to the adjacent river basin among TKPSDA when a serious drought has happened at adjacent river basins.

They shall make a framework of this agreement and discuss the condition of supply rule, water source, and supply method.

The Brantas River basin adjoins the WS. Bengawan Solo, WS. WELANG-REJOSO and WS. BONDOYUDO-BEDADUNG.

And the water conveyance method shall be established such as the preparation of tank lories, increasing water conveyance capacity of pipeline, etc.

6) Preparation of the Advance Drought Action Plan

TKPSDA shall prepare the advance drought action plan that is organized for action of disaster prevention (drought) and implementing agencies in time series focusing on "when", "who", and "what to do". It shall be considered to study the action of drought during the dry season before the actual drought situation.

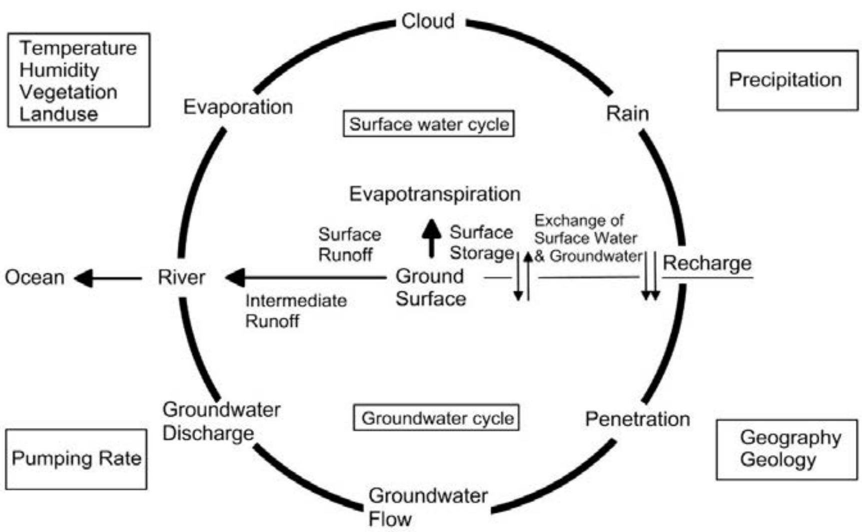
(3) Groundwater Resources Management

1) Sustainable Groundwater Cycle

A conceptual diagram of the water cycle and its regulatory factors is shown in Figure 6.3.18. The groundwater is one of the components constituting the water cycle of the Earth. The groundwater flowing through a recharge area - flow area - discharge area path forms a regional water circulatory system from a shallow unconfined groundwater to deep confined groundwater. The adaptation measures for the groundwater resources under the future climate change are nothing but these measures will keep this groundwater cycle sound and sustainable.

Although the individual components are constantly changing in the groundwater cycle, it can be considered that the dynamic equilibrium state of the cycle is maintained. When some changes occur in the components, the cycle shifts to the new dynamic equilibrium state by the natural regulating function. However, if the change exceeds the capacity of the function, e.g., sudden and significant changes like climate change, the dynamic equilibrium state of the cycle may collapse and the groundwater resources may eventually fall into critical situation.

A sustainable water cycle is a state of the water cycle in which the function of water for the human activities and environmental preservation are properly maintained and it includes not only the physical aspect but also the chemical/ecological and cultural aspects of the water cycle.



Source: Round-table conference on future groundwater use (2007); retouched

Figure 6.3.18 Conceptual Diagram of Water Cycle and its Regulatory Factors

The process of restoration in the groundwater resources from the viewpoint of the water cycle is shown in Table 6.3.61. First, the causes of the groundwater problems such as well drying-up, land subsidence, salt water intrusion, disappearance of spring water, decrease in spring water volume, and groundwater pollution need to be removed and the use of groundwater shall be optimized. Next, the groundwater cycle improvement, which is strengthening the function of the groundwater cycle, improving the groundwater quality and conserving the ecosystems shall be implemented. Finally, the groundwater cycle is to be maintained through sustainable conservation activities on a local basis.

Table 6.3.61 Process for Restoration in Groundwater Resource

Step	Objective	Measures for Restoration
1	Resolution of the groundwater problems	Prohibition of excessive pumping extraction (Optimization of groundwater use)
2	Improvement of the groundwater circulation	Enhancement of groundwater cycle system (Recharge area - Flow area - Discharge area), water quality improvement / ecosystem conservation
3	Conservation of the groundwater circulation	Sustainable conservation activities on a local basis (residents and municipalities)

Source: JICA Project Team 2

In the Brantas River basin, there might be a high possibility that the groundwater problems mentioned above are progressing quietly along with the economic development especially in the urban areas. However, the actual conditions of these groundwater problems are not grasped accurately now. If the influence of the future climate change is added to the present conditions, it is obvious that the situation will become worse. The important things to do are to start implementing measures for the groundwater resources as soon as possible.

2) Impacts of Climate Change on Groundwater Resources

The impacts on the groundwater resources due to climate change in the Brantas River basin can be divided largely into direct and indirect items.

I. Direct items

- The impacts on the groundwater recharge caused by the change of amount, duration and intensity of precipitation (aspect of groundwater quantity)
- The reduction of the groundwater recharge due to increase in evapotranspiration accompanying temperature rise (aspect of groundwater quantity)
- The saltwater intrusion into coastal areas and rivers and changes in groundwater flow system caused by sea level rise (aspect of groundwater quantity and quality)

II. Indirect items

- The impacts on the groundwater recharge due to the change of covering conditions of the soil: natural vegetation and growing crops (aspect of groundwater quantity)
- The increase in the dependency on groundwater due to instability of surface water resources (aspect of groundwater quantity)
- The groundwater pollution in the alluvial areas caused by frequent flooding (aspect of groundwater quality)

Since the impact of drought on groundwater resources is particularly concerned in the Brantas River basin, adaptation measures of the groundwater resources against droughts are described here. In the groundwater resources, the components that are most directly and indirectly affected by the droughts are the groundwater recharge and pumping rates. The amount of groundwater recharge may reduce due to the decrease of precipitation and increase of evapotranspiration caused by temperature rise.

To know the degree of influence by climate change on groundwater recharge, the data of the present situation and future situation (Medium Scenario) in watersheds provided by Team 1 for each of the 16 municipalities is compiled and compared in Table 6.3.62. The ratios (%) of the future groundwater recharge to current groundwater recharge drastically decreases as going downstream (lower altitude) under the future climate conditions, the measures for recharge in the middle stream and downstream areas are required to maintain a sustainable groundwater cycle.

Table 6.3.62 Ratios of Future Groundwater Recharge to Current Groundwater Recharge

Area in the Brantas River Basin	Ratio of Groundwater Recharge (Future in Medium Scenario/ Present)
Most upstream (Batu Regency)	92%
Middle stream (Blitar Regency etc.)	70 to 80 %
Downstream (Mojokerto City etc.)	50 to 60 %

Source: JICA Project Team 2

3) Measures for Groundwater Resources

The adaptation measures for groundwater resources are largely divided into structural and non-structural measures. The structural measures are to improve the storage capacity in an aquifer using structures or to strengthen a groundwater extraction capacity from the pumping wells. Meanwhile, the non-structural measures are aiming at a sustainable use of groundwater by grasping the actual usage of groundwater, establishing appropriate rules of conservation and management methods through laws and regulations, and complying with them.

The actual measures considered for the Brantas River basin are shown in Table 6.3.63. However, most realistic facilities are injection wells among the proposed facilities under the present situation to improve effectively.

Table 6.3.63 Actual Measures Considered for the Brantas River Basin

Type of Measure	Method	Purpose and Example
Structural	Improvement of the aquifer storage capacity	To strengthen a recharge capacity and promote recharging, the artificial recharging into aquifers is effective; such as injection wells, rainwater storage, and infiltration facilities, and promotion of underground penetration from paddy fields, reservoirs, and check dams. The location should be decided based on the groundwater potential study and additional detailed groundwater survey.
	Strengthening of the groundwater extraction capacity	To acquire an alternative water source to unstable surface water under the future climate change, new well construction as additional groundwater development which should be proposed based on a groundwater potential study. The location of the well should be decided as the result of an additional detailed groundwater survey.
Non-structural	Survey on the actual condition of the groundwater use	To understand the current situation of groundwater problems and identify areas which require restriction of pumping and groundwater development regulation.
	Resolution of the groundwater problems	To control the pumping rates and groundwater development regulations which are carried out based on the survey results of the actual usage
	Conservation of the groundwater cycle	To establish laws and regulations concerning the groundwater conservation and sustainable management system

Source: JICA Project Team 2

6.3.3 Sabo Management

(1) Target for Sabo Management

The Sabo plan in the Brantas River basin has been prepared for unstable sediment, which is defined as sediment flowed out by rain. For example, the surface soil disturbed by the deforestation has the conditions which are likely to be eroded by rain. The cultivated land developed vastly is put in the same situation as well. Also, landslide, slope failure, riverbank erosion, and riverbed erosion are thought to be a source of sediment discharge.

The total amount of unstable sediment in the Brantas River basin was estimated to be 114.8 million m^3. Those in the upper Brantas and the upper Lesti areas are estimated to be approximately 7.6 million m^3 and 5.5 million m^3. (Refer to the Report on Engineering Studies for the Brantas River and the Bengawan Solo River Basins Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project (JBIC LOAN NO. IP-510 (2005)).

(2) Existing Plan and Actions

The implementation of sediment control works was divided into three stages in consideration of harmful river conditions and construction costs, as presented in Table 6.3.64 by the above mentioned JBIC Report (2005). The Urgent Plan was already implemented and completed, then the Mid Term Plan is being implemented as the second stage.

This Sediment Management Plan is planned until 2050, without the consideration of climate change.

Table 6.3.64 Proposed Comprehensive Basin-wide Sediment Management Plan

Phased Plan	Target Year	Sediment Management Plan	Remarks
Urgent Plan	2008	• Sabo plan (Urgent Sabo works) • Riverbed management plan	Implemented by the Project (WREFR & CIP) JBIC Loan No. IP-510
Mid Term Plan	2025	• Watershed conservation M/P	• Upper Brantas River basin • Brangkal River basin • Lekso River basin • Upper Konto River basin
		• Sabo plan (Priority Sabo works)	Sabo facilities on harmful rivers of high priority
Long Term Plan	2050	• Sabo plan (Long term Sabo works)	Sabo facilities on harmful rivers of middle and low priority

Source: Main Report, WREFR & CIP Project, JBIC Loan No. IP-510

The climate change will bring about an increase in unstable sediment production, so the above plan should be reviewed in consideration of climate change. However, the production of the unstable sediment is not related with the rainfall well, hence it is difficult to estimate the amount of surplus unstable sediment. An increase of heavy rain by the climate change may accelerate the production of unstable sediment, and hence it is recommended that the above Comprehensive Basin-wide Sediment Management Plan be implemented earlier than scheduled in the JBIC Report (2005).

(3) Proposed Measures

The increase ratio of sediment inflow under the future climate (2050) was shown in Table 6.3.65. It was calculated based on the change of "I" (maximum hourly rainfall in a series of rainfall) of the USLE formula and is expected to be 15% against the dam reservoirs on an average in comparison with that under the present climate (2000).

Table 6.3.65 Ratios of the Sediment Increase

(Average)

Scenario	Whole Basin	6 Dams*
Low (2050/2000)	1.19	1.09
Medium (2050/2000)	1.12	1.12
High (2050/2000)	1.33	1.24
Average	1.21	1.15

Note: *: Sengguruh, Sutami, Wlingi, Lodoyo, Selorejo, and Wonorejo Dams
Source: JICA Project Team 2

The measures against production and sedimentation of fine-grained sediment are considered as stated below:

- Use of coagulant against fine-grained sediment,
- Dredging/Excavation of the Sabo facility, and
- Watershed conservation in the Sabo management

6.3.4 Watershed Conservation

(1) Adaptation Measures against Rainstorms and Floods

1) Water Quality Management against Heavy Rain

The water quality degradation by the heavier rain should be controlled by reducing soil degradation of Sabo measures such as the check dams, contour cropping, gabions, and agroforestry. These structural adaptation measures are included in the Sabo management.

2) Water Quality Management against Fertilizer Application

The appropriate application of fertilizer contributes to keeping the discharge of eutrophication substances by flood.

The water quality degradation during lower water should be controlled by (1) keeping the current lowest water level as well as (2) wastewater treatment

3) Watershed Management

Improving of the water retaining capacity in a watershed by the forest cover will contribute to the adaptation measures against rainstorms and floods by reducing the surface runoff as well as facilitating the rainwater absorption into the ground.

However, it is noted that forest stands (trees) will worsen the damage in combination with water and soil in case of the strong flush flood and/or landslide.

The priority target areas will be considered from 1) the existence of forest areas, 2) upper watershed (in consideration of settlement directly below), 3) relationship with important aquifers, and 4) critical land area. Considering the future land use, keeping the forest land at the present level is important and the improvement of the quality of forest is also effective. Since the production forest counts for nearly 70% of the recorded forest land, it is very important that the production forest is sustainably managed by the well-planned cycle from plantation to harvest.

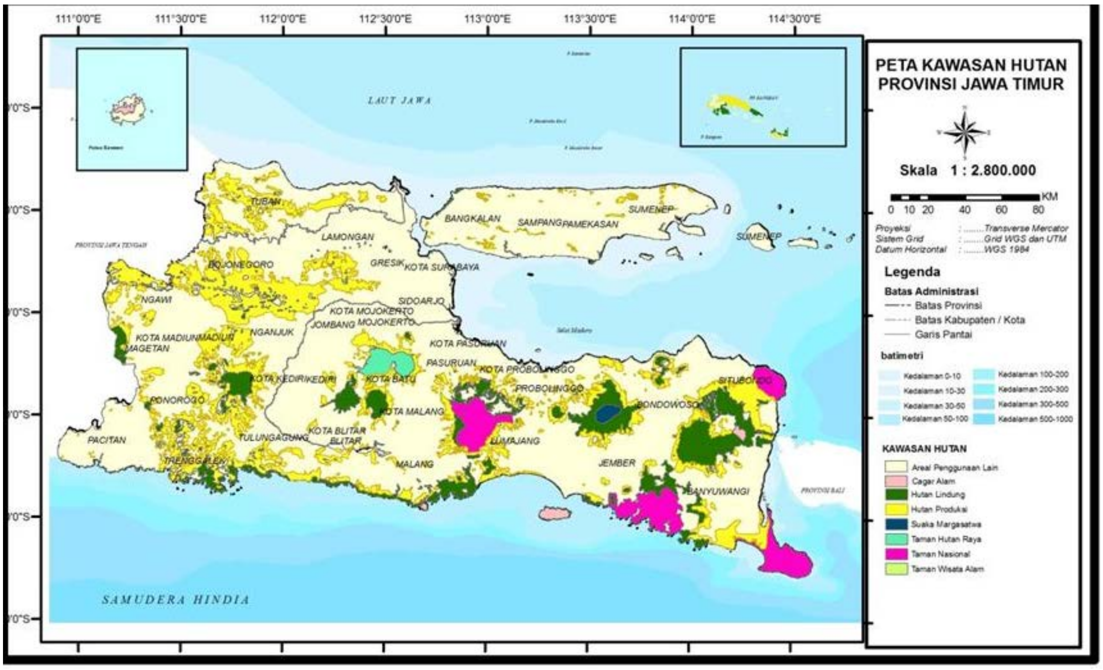
The plantation outside these forestlands should also be promoted to increase the forest area without changing the land use.

To maximize the adaptation capacity with watershed conservation, it is also necessary to monitor the impact to the vegetation by climate change such as rainfall pattern change, temperature rise, and forest fires.

Table 6.3.66 Watershed Conservation against Rainstorms and Floods

No.	Forest type	Target Area	Ratio (forest land)	Consideration points for prioritization
1	Conservation forest	51,582ha	9.9%	- Protection - Fire prevention - Monitoring
2	Protection forest	113,918ha	21.9%	- Protection - Conservation work - Fire prevention - Monitoring
3	Production forest	354,944ha	68.2%	- Sustainable management - Fire prevention - Monitoring
4	Outside the recorded forest land	All Brantas River basin	-	- Promotion of plantation in the slopes - Promotion of plantation for fencing for the residential area and agriculture area - Promotion of agroforestry - Promotion of green area in the city

Source: JICA Project Team 2, Review POLA 2015 indicates total recorded forest land is 520,498.7ha.



Source: Forest Department, East Java Province

Note: ◎: Conservation forest, ○: Protection forest, ●: Production forest

Figure 6.3.19 Forestland in East Java Province

(2) Adaptation measures against droughts

1) Water Quality Management by Wastewater Treatment

The water quality degradation during the lower water can be controlled by promoting the wastewater treatment system such as waste water treatment plant, septic tank and *Jokaso*. However, these measures are not climate change adaptation measures but the normal water quality management activities.

2) Water Quality Management by Water Level

The water quality degradation during the lower water should be controlled by keeping the current lowest water level.

Since it is difficult to estimate the water quality change by the flow level change, it is recommended to keep the water level in every existing monitoring points as the current lowest water level. On the other hand, the priority points can be identified with the water quality. It is more necessary to keep the water level in the points with lower water quality.

3) Watershed Conservation

The contribution of watershed conservation effort against droughts is difficult to be evaluated, while the forest cover is regarded to be effective to some extent. The forest cover will help retaining the water resources and stabilize the water discharge from the water source area which mitigates the impact on the drought in the lower watershed. Thus, the climate change adaptation measures by watershed conservation is to improve the forest management especially in the upper watershed.

However, it is also known that the forest cover will negatively contribute to the water resources by evaporation through the breathing of the trees and vegetations.

The green areas can nurture the ground water resources by allowing the rainfall to be absorbed efficiently especially in the development areas covered by the concrete.

Table 6.3.67 Watershed Conservation against Droughts

No.	Forest type	Target Area	Ratio (forest land)	Consideration points for prioritization
1	Conservation forest	51,582ha	9.9%	- Protection - Fire prevention - Monitoring
2	Protection forest	113,918ha	21.9%	- Protection - Rehabilitation work - Fire prevention - Monitoring
3	Production forest	354,944ha	68.2%	- Sustainable management - Fire prevention - Monitoring
4	Outside the recorded forest land	All Brantas River basin	-	- Promotion of green area in the city

Source: JICA Project Team 2, Review POLA 2015 indicates total recorded forest land is 520,498.7ha.

6.4 Strategic Environmental Assessment (SEA)

The Project examined the adaptation measures for the forecasted climate change conditions in 2050. In this examination, the Strategic Environmental Assessment (SEA) was applied to consider environmental and social impacts from the early stage of formulating the plans/projects. Then, the adaption measures selected in the process of SEA were examined at the Initial Environmental Evaluation (IEE) level.

This section explains the legal framework of the environmental assessment including SEA in Indonesia, the study method of the Project and the results of environmental and social considerations at IEE level.

6.4.1 Legal Framework on Environment in Indonesia

(1) Legal Framework related to Environmental Assessment and SEA in Indonesia

In Indonesia, Law No. 32/2009, namely Law on Environmental Protection and Management (UU No. 32/2009) is the principle law on conservation of natural resources and management of environment by clarifying the environmental permission for implementing a project.

The law defines to conduct an Environmental Impact Assessment (AMDAL in Bahasa Indonesia), Environmental Management/Monitoring Efforts (UKL-UPL in Bahasa Indonesia) or Environmental Statement (SPPL in Bahasa Indonesia) according to the scale of the business and/or activity. The criteria for AMDAL and UKL-UPL related to the adaptation measures of the Project are summarized in Table 6.4.1.

UU No. 32/2009 requests the government and regional governments to conduct SEA for: i) spatial plan including regional long/mid-term development plan and ii) policies, plans and/or programs potential to cause environmental impacts and/or risks by involving communities and stakeholders. The law requests to contain assessment in SEA below:

- the capability of the environment to support and carry development,
- estimated environmental impact and risks,
- performance of service/ecosystem service,
- efficiency in the utilization of natural resources,
- vulnerability and capacity of adaptation to climate change, and
- security and potential of biological diversity

Table 6.4.1 Criteria on Environmental Study

	AMDAL (Permen LH No.5/2012)	UKL-UPL[1] (Permen PU No.10/2008)	SPPL
(1) Constructing new dams	➢ Height: More than 15 m ➢ Inundate area: More than 200 ha ➢ Water storage: More than 500,000 m^3	➢ Height: 6 to 15 m ➢ Inundate area: 50 to 200 ha ➢ Water storage: 300,000 to 500,000m^3	Small scale project not classified as AMDAL or UKL-UPL
(2) Rehabilitating the irrigation canal and distribution of the pipelines of PDAMs	None	Not mentioned, but UKL-UPL is necessary	Ditto
(3) Changing the water source from the surface to groundwater by constructing new wells	Intaking groundwater more than 50 liters/second	➢ Community use: 2.5 to 50 liters/second ➢ Commercial use: 1.0 to 50 liters/second	Ditto
(4) Constructing dike[2]	[Large City] ➢ Length: More than 5km ➢ Dredging: More than 500,000m^3 [Medium City] ➢ Length: 10km ➢ Dredging: More than 500,000m^3 [Rural Area] ➢ Length: 15km ➢ Dredging: More than 500,000m^3	[Large City] ➢ Length: 1 to 5km ➢ Dredging: 50,000 to 500,000m^3 [Medium City] ➢ Length: 3 to 10km ➢ Dredging: More than 100,000 to 500,000m^3 [Rural Area] ➢ Length: 5 to 15km ➢ Dredging: 150,000 to 500,000m^3	Small scale project not classified as AMDAL or UKL-UPL

Note: 1: More detailed criteria to conduct UKL-UPL is defined by the governor.
2: Permen LH No. 5/2012 does not show conditions to conduct the environmental study for dike constructions. However, canal is sometimes regarded as dike in Indonesian language. Accordingly, canal for flood described in No. 5 of Section I in Appendix I was applied.

Source: JICA Project Team 2

In order to improve such a situation, Government Regulation No. 46/2016 on Process for the Implementation of Strategic Environmental Assessment (PP No.46/2016), was issued in 2016. PP No. 46/2016 stipulates the procedure for approving SEA and contents to be studied in SEA as summarized in Table 6.4.2.

Table 6.4.2 Summary of SEA in PP No. 46/2016

Target Projects	Contents to be Studied	Approval Procedure
➢ Spatial plan including detailed plans ➢ National long-term development plan (RPJP)for a period of 20 years ➢ Regional RPJP ➢ National med-term development plan (RPJM) for a period of five years ➢ Regional RPJM ➢ Coastal zone and small island plans including the detailed plans ➢ Zoning plans for specific national strategic areas and marine conservation areas ➢ Policies, plans and/or programs with potential impact to the living environment such as: - Land use policies/plans including air and/or water use - Other policies, plans or program based on request from public	➢ Assessment of the effectiveness and impact of a policy, plan, and/or program from the viewpoint of environment ➢ Examine alternatives ➢ Prepare recommendation to improve the policy, plan and/or program suitable for sustainable development	➢ A policy maker submits the SEA application (i.e., SEA report) to the minister or the governor. ➢ The minister or the governor reviews the completeness of the SEA application within three working days from receipt of the application. ➢ The minister or the governor validates the SEA application within a maximum period of 20 working days. ➢ The minister or the governor announces the approval of the SEA application within three days. ➢ If the minister or the governor regards the SEA application as not completed, it is returned to the policy maker.

Source: JICA Project Team 2 based on PP No. 46/2016

(2) Current Status of SEA in Indonesia and East Java Province

The Ministry of Foreign Affairs of Denmark (DANIDA) is considered as a major funding agency in supporting the SEA framework in Indonesia, and has been a supporter since 2008 through the Environmental Support Program Phase 2 (ESP 2) and the Phase 3 (ESP 3). Approximately 130 to 150 SEAs have been implemented in Indonesia as of September 2016 according to DANIDA's investigation[4].

It was found from the interview with BAPPEDA in the East Java Province in September 2016 that SEA study in BAPPEDA was implemented from 2014 since No. 67/2012 was actually implemented from 2014 in East Java Province.

Regarding the regional environmental agency (*Badan Linkungan Hidup Daerah*: BLHD) in East Java Province, there was no SEA study in BLHD in East Java Province as of September 2016 according to the interview with BLHD officers.

6.4.2 Study Approach on Environmental and Social Considerations for the Project

The JICA Guidelines for Environmental and Social Considerations (April 2004 and April 2010) introduces the concept of SEA when the Master Plan studies are conducted, and encourage the project proponents to ensure environmental and social considerations from the early stage of project planning. The JICA Guidelines indicates the following procedure as the

4 Referred from Restricted procedure: National Conference on Strategic Environmental Assessment (SEA)-Indonesia (Available from http://um.dk/en/danida-en/business/contracts/short/contract-opportunitie/newsdisplaypage/?newsid=834e6bdb-c958-4040-b283-fe932a4aaf3e, accessed on 5 Jan. 2018)

standard for conducting SEA[5].

i) Survey of basic conditions (policies, regulations, and geography, etc.),

ii) Formulate development scenario/alternatives,

iii) Scoping and setting indicators for evaluation,

iv) Stakeholder meetings,

v) Survey, prediction, analysis, evaluation of impacts,

vi) Mitigation measures, and

vii) Selection of programs/projects

Referring to the SEA steps in Indonesia, the preparation procedure of RENCANA for the Brantas River basin, the JICA Guidelines and the characteristics of the Project such as conditions and progress, environmental and social considerations for the Project was examined with the steps below and illustrated in Figure 6.4.1.

i) First of all, the first stakeholder meeting was held to explain the project outline, the study method and the concept of SEA,

ii) The current conditions were confirmed by collecting secondary data and three scenarios of the future climate change conditions in 2050 (i.e., low, medium and high scenarios) were forecasted based on the current conditions,

iii) With and without adaptation measures were examined,

iv) Alternatives under climate change in 2050 were examined,

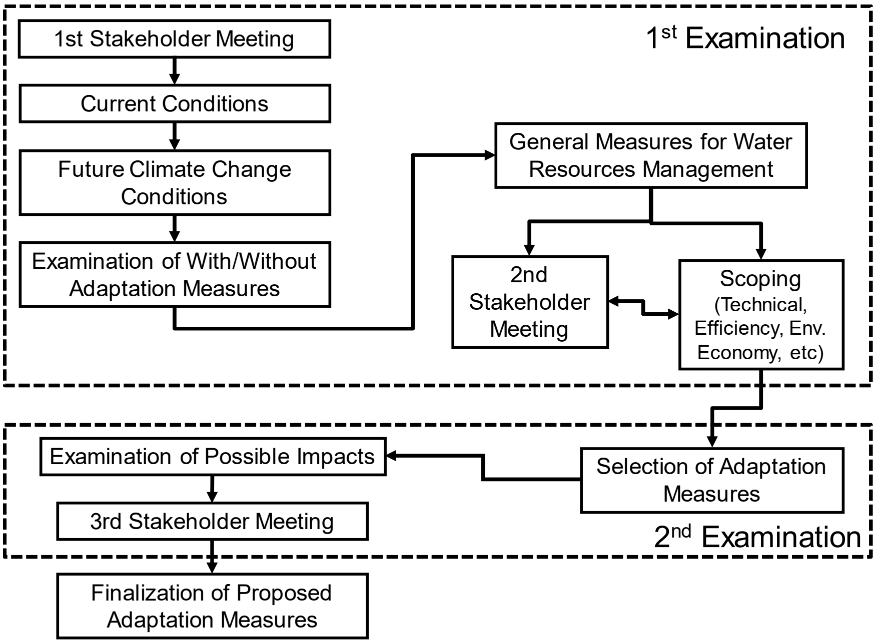
v) The third stakeholder meeting was held to refresh the project outline, to explain the method of scoping, and to have opinion exchanging on the alternatives,

vi) Applicable adaptation measures were selected from the alternatives referring to the comments at the second stakeholder meeting, specific measures at each category of adaptation measure under each scenario were examined, and possible environmental impact to specific adaptation measures were examined,

vii) The third stakeholder meeting was held to explain the scoping results and to have opinion exchanging on the adaption measures to be applied, and

viii) The final adaptation measures were examined referring to the comments raised at the second stakeholder meeting.

[5] Referred from Strategic Environmental Assessment (SEA) for Master Plan Study in Developing Countries: Experience under JICA's Guidelines for Environmental and Social considerations (available from http://conferences.iaia.org/2013/pdf/Final%20papers%20review%20process%2013/Strategic%20Environmental%20Assessment%20(SEA)%20for%20Master%20Plan%20Studies%20in%20Developing%20Countries.pdf, accessed on 5 Jan. 2018)



Source: JICA Project Team 2

Figure 6.4.1 SEA Study Flow for the Project

6.4.3 Examination Results

(1) Examination of “With and Without Adaptation Measures”

The “With” and “Without” Adaptation Measures under the climate change conditions in 2050 was examined. The Without Adaptation Measures means not implementing any adaptation measures under the forecasted climate change conditions in 2050 while the With Adaptation Measures means implementing adaptation measures. As a result of the examination of the With and Without Adaptation Measures as shown in Table 6.4.3, implementing the adaptation measures is considered as necessary under the future climate conditions in 2050.

(2) Alternative Examinations

There are structural and non-structural measures for the adaptation measures. The structural measures are to tackle future climate conditions by constructing the structures while non-structural measures are to tackle the future climate conditions by improving and/or enhancing soft components such as social institutions including raising the public awareness.

Table 6.4.4 shows the outline of alternatives on structural and non-structural measures.

Generally, the implementing measures related to the soft components will not bring physically adverse impact to natural and social environment since it will enhance or strengthen the social system or people’s awareness. Thus, the alternatives were examined by focusing on the structural measures from technical, efficiency, and environmental viewpoints. Table 6.4.5 is the summary of structural measures listed in Table 6.4.4.

The result of alternatives examinations related to the structural measures is shown in Table 6.4.6

Table 6.4.3 Comparison of With and Without Adaptation Measures

Category	Without Adaptation Measures	With Adaptation Measures
Water Resources Conservation	➢ The current forest cover may be degraded due to the change of rainfall and temperature. ➢ Flood, drought, and water temperature rise may affect the ecosystem (habitat, seasonal migration, and life cycle). ➢ [By higher peak discharge and rainfall] the pollutants from the non-point sources such as fertilizer from the agricultural land, sedimentation will be increased. ➢ [By drought] the water quality will be deteriorated by the enrichment effect during lower discharge.	➢ Keeping the forest cover and improving its quality through appropriate and sustainable forest management actions. ➢ Monitoring and adapting the measure on ecosystem. ➢ Reducing the load of pollutant into river system from non-point sources such as fertilizer from the agricultural land and sedimentation. ➢ Maintaining the water quality by keeping the water level.
Water Resources Utilization	➢ The reservoir volumes will be reduced compared with the present ones. ➢ The supply side will not be able to satisfy the safety level of the water utilization. This situation will be severe. ➢ The sediment inflow will be increased compared with the present situation.	➢ Increasing the water supply capacity by constructing new dams and heightening of existing dams. ➢ Saving water loss by replacing old pipelines of PDAMs and rehabilitating irrigation canals. ➢ Saving the water demand by applying SRI. ➢ Improving the sediment situation.
Water Destructive Force Control	➢ The dike will be broken frequently due to extreme flood events. ➢ The peak discharge will be higher than the present situation and the frequency of the flood events will be also increased due to climate change condition. ➢ The damage area of the dike, public infrastructures, houses, industrial companies, and crop will be expanded. The magnitude of the rehabilitation works will be increased.	➢ Reducing the impact in the flooded area by constructing structures such as dikes and implementing non-structural measures such as FFWS.

Source: JICA Project Team 2

Table 6.4.4 Outline of Alternatives

Category	Sub-Category	Types of Measures	Alternatives
Water Resources Management	Surface Erosion	Structural Measures	➢ Erosion control works (ex. check dams, gabions, etc.)
		Non-structural Measures	➢ Land use management ➢ Forest plantation, rehabilitation and conservation ➢ Contour cultivation
	Recharge of Groundwater	Structural Measures	None
		Non-structural Measures	➢ Water conservation works (e.g., expansion of green areas) ➢ Forest plantation, rehabilitation and conservation ➢ Land use management
	Water Quality	Structural Measures	➢ Erosion control works (ex. check dams, gabions, etc.)
		Non-structural Measures	➢ Land use management ➢ Forest plantation, rehabilitation and conservation ➢ Contour cultivation ➢ Law enforcement of waste water discharge ➢ Control of fertilizer and pesticide application
	Forest Management	Structural Measures	None
		Non-structural Measures	➢ Planning of plantation and forest conservation considering the temperature rise and water availability
	Illegal Logging	Structural Measures	None
		Non-structural Measures	➢ Patrolling ➢ Law enforcement on the export of logs
	Securing Water Volume	Structural Measures	➢ Replacement of irrigation channel ➢ Replacement of water pipe
		Non-structural Measures	➢ Enhancing education on water-saving
Water Resources Utilization	Demand	Structural Measures	None
		Non-structural Measures	➢ Reducing per capita (Education) ➢ Reducing irrigation water (Real time operation, SRI)
	Supply	Structural Measures	[To increase storage volume] ➢ To reduce the sediment inflow by constructing sand pocket, check dam, groundsill, and bank protection ➢ Heightening of the existing dams ➢ Construction of new dams, ponds, and other storage structures [To create additional water] ➢ Construction of desalination plant
		Non-structural Measures	[To increase storage volume] ➢ To use coagulant against fine-grained sediment ➢ To dredge/excavate the Sabo facility ➢ Watershed conservation ➢ To increase dredging capacity (increasing the number and capacity of the dredger) ➢ To change the full supply level (Reservoir operation) [To utilize treated water] ➢ Flushing the water of toilet in hotels, buildings, factories, etc. ➢ Cooling water in factories

Category	Sub-Category	Types of Measures	Alternatives
Water Destructive Force Control	-	Structural Measures	➢ Heightening of the dike ➢ To create flood control space in the existing dams (Reservoir operation) ➢ To create flood control space in the new dams ➢ Construction of the retarding basin (artificial)
		Non-structural measures	➢ To apply temporary structure such as movable type flood wall* ➢ Construction of sufficient number of substantial evacuation centers* ➢ Capacity development of the flood fighting teams ➢ Installation of high accuracy the Flood Forecast Warning System (FFWS) ➢ Installation of community based early warning system ➢ Strengthening of the rainfall and discharge measurement network (Increase of equipment and new technology) ➢ Preparation of hazard maps and evacuation root maps ➢ Changing the reservoir operation rule ➢ To keep natural retarding basin (limitation of land use)

Note: * These measures are actually constructing structures. Since the scale of structures is small, they are regarded as non-structural measure in this Project.

Source: JICA Project Team 2

Table 6.4.5 Summary of Alternatives on Structural Measures

Category	Alternatives on Structural Measures
Water Resources Conservation	➢ Erosion control works (ex. check dams, gabions etc.)
Water Resources Utilization	➢ Rehabilitation of irrigation channel ➢ Replacement of water pipe ➢ Reduce sediment flow (sand pocket, check dam, groundsill, and bank protection) ➢ Construction of new dams, ponds, and other storage structures ➢ Heightening of existing dams ➢ Construction of desalination plant ➢ Utilize treated water (recycle plant)
Water Destructive Force Control	➢ Heightening of existing dikes ➢ Construction of dikes ➢ Allocation of flood control space in new dams and heightening of existing dams ➢ Construction of retarding basin (artificial)

Source: JICA Project Team 2

Table 6.4.6 Results of Alternative Examinations/ Scoping

Alternative Measures	Technical Aspect	Environment	Efficiency	Evaluation
1. Water Resources Conservation				
Erosion Control Work	-	-	The effective adaptation measures on water resources conservation are basically considered as combination of the structural measures related to water resources utilization (shown in “Reduce sediment flow” 2.	-

Alternative Measures	Technical Aspect	Environment	Efficiency	Evaluation
			Water Resources Utilization) and non-structural measures on water resources conservation. As for non-structural measures on water resources conservation, control for using pesticide or management of water level in a river are considered as applicable.	
2. Water Resources Utilization				
Rehabilitation of the irrigation channel	Rehabilitate the existing irrigation channel is much easier and more practical than constructing a new irrigation channel.	The rehabilitation work will be conducted only at the current irrigation channel and will not require additional area. Thus, significant environmental impact will not be assumed.	The rehabilitation of tertiary canal is considered as efficient to the reduce water loss and economical than constructing new irrigation channel.	○
Replacement of the water pipe	Same as the rehabilitation of the irrigation channel, replacement of water pipe is easier and more practical than constructing new water pipe.	Same as the rehabilitation of irrigation channel, replacement work will be conducted only at the current water pipe area and additional area will not be required. Thus, the significant environmental impact will not be assumed.	Same as rehabilitation of the irrigation channel, replacement of water pipe is considered as efficient and economical than constructing a new water pipe.	○
Reduce sediment flow (sand pocket, check dam, groundsill, and bank protection)	<u>Groundsill:</u> Groundsill is effective to improve the sediment while it will have a possibility to cause scoring at the downstream area.	<u>Groundsill:</u> Groundsill will have a possibility to change the habitation conditions of aquatic fauna and landscape.	<u>Groundsill:</u> The groundsill is able to improve the sedimentation by stabilizing the riverbed from an abrasive action. The construction cost of the groundsill itself will not be high, but the cost for regular maintenance will be required.	×
	<u>Bank Protection:</u> There will be no complicated technical issues although it depends on the actual field condition.	<u>Bank Protection:</u> The bank protection is considered as the changing aquatic fauna at the river bank area though it depends on the type of bank protection.	<u>Bank Protection:</u> Same as groundsill, bank protection is able to improve sedimentation by stabilizing river bank from an abrasive action, but regular maintenance will be required.	×

Alternative Measures	Technical Aspect	Environment	Efficiency	Evaluation
	Check Dam: There will be any no complicated technical issues on construction and operation of check dam although it depends on the topographical and geographical condition.	Check Dam: A check dam will require a large area and is considered to cause quite a large scale of natural and social environmental impact although the possible impact is dependent on the location and scale of a structure.	Check Dam: This method may be functioned to improve the sedimentation conditions. However, natural and social environmental impact is considered as quite large. Overall, this method is considered as not efficient.	×
	Sand Pocket: Same as check dam, there will be no complicated technical issues on construction and operation of sand pocket although it depends on the topographical and geographical condition.	Sand Pocket: A sand pocket will require a large area and is considered to cause quite a large scale of natural and social environmental impact although the possible impact is dependent on the location and scale of a structure.	Sand Pocket: Due to the same reason as the check dam, this method is also considered as not efficient.	×
Construction of new dams, ponds, and other storage structures	-	-	New dams that are studied by BBWS Brantas were examined and a total of seven dams were selected as recommended/applicable adaptation measures although some of the new dam construction will contain natural and social environmental impact. The details are shown in Table 6.4.7 and Supporting Report J.	○
Heightening of existing dams	There will be no complicated technical issues on the heightening of the Sutami Dam. However, regular sediment management in the Sutami Dam will be required for an effective dam operation.	Acquiring some area will be required for the heightening of the Sutami Dam.	From the existing dams, the heightening of the Sutami Dam is considered as efficient from its location and the largest storage capacity in the Brantas River basin.	○
Construction of desalination plant	It will create water but needs large volume of energy in the process of creating water.	There will be an impact to the aquatic flora and fauna due to a discharge of concentrated water, thermal discharge, or large volume of sludge.	The cost for construction and operation of a plant is considered as high.	×

Alternative Measures	Technical Aspect	Environment	Efficiency	Evaluation
Utilize treated water (recycle plant)	-	-	To reduce water demand, recycle plant is necessary to be examined by each industrial company (This shall be examined separately from the Project).	-
3. Water Destructive Force Control				
Heightening of the existing dikes	There will be no complicated technical issues on the heightening existing dikes.	The heightening of the existing dikes is considered not to cause any significant natural and social environmental impact	It is efficient to heighten the existing dikes to protect the areas along the river.	○
Construction of new dikes	There will be no any complicated technical issues on constructing new dikes.	There will be an impact to natural and social environment since the area currently has no existing structure.	Other influent areas do not have dike. Thus, construction of a new dike in these areas is necessary.	○
Allocation of flood control space in new dams and heightening of existing dams	The reservoir volumes are firstly allocated to the water supply and the remaining capacity will be allocated for flood control. In this case, there is a possibility to decrease water volumes for water utilization if sedimentation occurs although it depends on the function and capacity of a dam.	There will be an impact on water utilization in case enough water volumes for water utilization is not secured.	It will be economical compared with other structural measures. However, a measure for sedimentation is necessary to be additionally applied to let this method function. Thus, it is less efficient compared with the other measures.	×
Construction of retarding basin (artificial)	The construction of the retarding basin will not be complicated than widening/improving the existing rivers.	The retarding basin can be used as a green area under the normal operation condition, and there is a record in Japan that such green area can be developed as a rich habitation of flora and fauna. However, since the retarding basin will require large scale of land acquisition and change in land use, the impact to social environment is considered as significant.	The flood will be effectively controlled for a short period compared with the normal river condition (i.e., without retarding basin). In addition, the construction cost is considered as economical compared with constructing a structure.	×

Note: Evaluation, O: Recommendable, X: Not recommendable, -: Not applicable

Source: JICA Project Team 2

Adaptation measures for "Erosion Control Work" in Water Resources Management are considered as combination of structural measures for "Reduce sediment flow" in Water Resources Utilization and non-structural measures in Water Resources Management. Accordingly, there were no structural measures established in the Water Resources Management. As for the "Reduce sediment flow" in water utilization, there was no recommendable structural measures. Accordingly, only the non-structural measures such as using coagulant against the fine-grained sediment, dredging/excavating Sabo facilities and watershed conservation were recommended as adaptation measures.

In the process of alternative examinations/ scoping, the examinations for selecting new dams from the lists of dams in RENCANA for the Brantas River basin was conducted. Among the 28 dams listed in RENCANA, a total of seven dams were selected from the technical, efficiency, and environmental viewpoints. The environmental issues are explained in Supporting Report J.

(3) Impact Evaluation for the Selected Structural Measures

These specific structural adaptation measures selected in Table 6.4.7 were conducted.

Generally, the conceivable environmental and social impacts by the Project were preliminary identified based on the Project description and general environmental and social conditions in and around the Project area. Then, the impacts of pollution, natural environment and social environment, health and safety, and emergency risk are evaluated. However, there were many restrictions for conducting scoping in the Project. Accordingly, scoping for the Project was conducted with the conditions and method as explained below:

- For constructing new dams, there were studies for the selected seven dams. Thus, the scale and location examined in the existing studies were used for scoping.
- For rehabilitating irrigation canal and distribution pipelines of PDAMs, there was no specific information on scale and location. Thus, the general idea for rehabilitating irrigation canal and distribution pipelines was used for scoping.
- For changing water sources from the surface to groundwater, the location and size of wells were not specifically examined in the project although necessary numbers of wells at the region-wise were examined. Thus, scoping was conducted to a general idea for constructing new wells.

The environmental and social impacts were evaluated as A to D in accordance with the following criteria;

- **A** (+/-): The significant positive/negative impact is expected at this study level.
- **B** (+/-): The positive/negative impact is expected but not significant at this study level.
- **C:** The extent of the 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.

The summary of scoping results is explained in Table 6.4.9 and detail study results are explained in Supporting Report J.

Table 6.4.7 Examination Results for Selecting Dam

No.	Name of Dams in RENCANA	Evaluation	Project Status
1	Genteng I Dam	Selected	F/S report was prepared in 2002
2	Tugu Dam	-	Currently under construction
3	Beng Dam	-	F/S report was prepared in 2003
4	Kedungwarak Dam	Selected	F/S report was prepared in 2005
5	Ketandan Dam	Selected	F/S report was prepared in 2005
6	Semantok Dam	-	Currently under construction
7	Kuncir Dam	Selected	F/S report was prepared in 2008
8	Babadan Dam	Selected	Study was conducted in 1985 as a part of M/P for the Brantas River basin
9	Lesti III Dam	-	Project status was not sure though there was a F/S report prepared in 1995
10	Kepanjen Dam	-	This is included as a part of M/P for the Brantas River basin conducted in 1985
11	Lumbang Sari Dam	-	This is included as a part of M/P for the Brantas River basin conducted in 1985
12	Kesamben Dam	-	Review F/S report was prepared in 1982
13	Konto II Dam	Selected	This is included as a part of M/P for the Brantas River basin conducted in 1985
14	Bagong Dam	-	F/S report was prepared in 2013 and LARAP was prepared in 2016
15	Kampak Dam	Selected	F/S report was prepared in 2016
16	Nglemi Dam	-	Report was not available
17	Sumber Agung Dam	-	Report was not available
18	Kembangan	-	Report was not available
19	Kali Lanang	-	Report was not available
20	Marmoyo Dam	-	Brief material report was prepared in 2010.
21	Brangkal – Plandaan Dam	-	Report was not available
22	Kembar Dam Jenesgelaran – Jurangbang	-	Report was not available
23	Kopen Dam	-	Report was not available
24	Jarak Dam	-	Report was not available
25	Gembrong Dam	-	A study was prepared in 2010
26	Jatijejer Dam	-	Report was not available
27	Jinggring Dam	-	Brief material report was prepared in 2016
28	Sabo Dinoyo Dam	-	Report was not available

Source: JICA Project Team 2

Table 6.4.8 Selected Structural Measures

Categories	Structural Adaptation Measures
Water Resources Utilization	1. Constructing new dams 2. Heightening the Sutami dam 3. Rehabilitation works of tertiary irrigation canal 4. Replacement of the PDAMs' pipeline 5. Constructing new wells 6. Constructing sand pocket for dredging and using coagulant against fine-grained sediment
Water Destructive Force Control	1. Heightening the existing dikes 2. Constructing new dikes

Source: JICA Project Team 2

Table 6.4.9 Summary of Impact Evaluation for the Selected Structural Measures

	Natural Environment		Social Environment		Brief Description of Possible Major Impacts
	Protected Area	Ecosystem	Land Acquisition and Resettlement	Livelihood	
1. Water Resources Utilization					
Constructing new dams	D～B-	B-～A-	B-～A-	B-/B+*	Constructing new dams requires land acquisition and changing land use, which may cause impact on the ecosystem, resettlement and livelihood.
Heightening of Sutami Dam	B-	B-	B-～A-	B-/B+	Heightening may require some areas behind the existing dam. Although the impact may be small compared with constructing new dams, land acquisition and changing land use may cause impacts to the ecosystem, resettlement and livelihood.
Rehabilitation of tertiary canal	D	D	D	B-/B+	Rehabilitation may be implemented within the area of the current canal and pipelines. Thus, there may not be any negative impacts although temporary limitation of irrigation may be occurred during the rehabilitation work.
Replacement of PDAMs pipeline	D	D	D	B-/B+	Replacement may be implemented within the area of the PDAM pipelines. Thus, there may not be any significant negative impacts although the temporary limitation of water use may be occurred during the replacement work.
Changing water source from surface to groundwater by constructing new wells	D～B-	B-	B-	B-/B+	The impact on the resettlement and land use may be very limited. However, while the water volume may be secured due to new wells, there is a possibility that the water quality and water flow at the surround areas may be affected.
2. Water Destructive Force Control					
Heightening the existing dike	D～B-	B-	B-	B-/B+	Heightening the existing dikes will not require additional areas. So, the impact to natural and social environment is considered as small.
Constructing new dikes	D～B-	B-	B-	B-/B+	Constructing dikes requires some areas. Although the relocation impact at the rural area will be small, it will be caused at some extent in the medium area.

Note: * Impact related to number of affected households or size/ location of land to be acquired is not able to be exactly identified from existing information. In case that large number of households will be affected or large area will be acquired, impact to livelihood may be categorized as A-.
Source: JICA Project Team 2

The requirements of the environmental and social considerations based on the project description currently examined for each specific adaptation measure were confirmed. There was no specific project description for rehabilitating the irrigation canal and distribution pipelines as the previous section explained, the environmental requirements were examined in general. In case resettlement will be identified, preparation of a resettlement action plan is necessary following to the international standards although its preparation is not necessarily mandated under the Indonesian legal framework of land acquisition and resettlement. Table 6.4.10 to Table 6.4.12 shows the confirmation results.

Table 6.4.10 Environmental Requirements for Constructing Selected Seven Dams

	Kedung warak	Babadan	Kont II	Kuncir	Genteng I	Ketandan	Kempak
Environmental Requirement	AMDAL						
Resettlement	No[1]	No[2]	No[2]	Large	Large	No[3]	Small-Large

Note: 1. F/S report (2005) showed 644 houses in two villages would be affected. According to the satellite image, however, the houses were not confirmed for the area where we visited. Thus, the resettlement was regarded as "no" in this report.
2. There was no information on the land acquisition impact in the M/P report. Houses were not confirmed around the area where the JICA Project Team 2 visited. Accordingly, the resettlement was regarded as "no" in this report. There were houses at the surrounding area of the visited point as per satellite image.
3. M/P report (1895) showed ten affected houses although the houses were not confirmed around the area where the JICA Project Team 2 visited. Thus, the resettlement was regarded as "no" in this report. There were small number of houses at the surrounding area of the visited point as per satellite image.

Source: JICA Project Team 2

Table 6.4.11 Environmental Requirements for Rehabilitating Canal and Pipelines and Changing Water Sources

	Environmental Requirement	**Resettlement**
Rehabilitating irrigation canal and distribution pipelines of PDAMs	SPPL	Small (Not required unless the area for canal or pipelines is expanded)
Changing water source from surface to groundwater by constructing new wells	UKL-UPL or SPPL	Small (As per location and size of wells)

Source: JICA Project Team 2

Table 6.4.12 Environmental Requirements for Dike Construction

	Widas River (Rural Area)	**Sadar River (Medium Area)**	**Brangkal River (Medium Area)**	**Tawing River (Rural Area)**
Environmental Requirement	AMDAL			
Resettlement	Small	Small	Small-Medium	Small-Medium

Source: JICA Project Team 2

(4) Provisional Mitigation Measures to Possible Environmental Impact by Implementing Selected Adaptation Measures

The mitigation measures for the possible negative impact of the selected adaptation measures were examined as shown in Table 6.4.13.

Table 6.4.13 Summary of Provisional Mitigation Measures to Possible Environmental Impact by Applying Selected Adaptation Measures

	Possible Major Impacts	Provisional Mitigation Measures to Possible Negative Impact of Selected Adaptation Measures
Water Resources Utilization		
Constructing new dams	**[Natural Environment]** ➢ Terrestrial and aquatic flora and fauna will be impacted due to decreasing green area and decreasing river flow. Aquatic flora and fauna at the downstream may be more seriously affected than the terrestrial flora and fauna due to decreasing water quality and reducing water volume. ➢ There is a possibility to change the hydrological conditions due to construction of new dams. ➢ There is a possibility that a new dam construction will affect topography or geology in case it is not stable. **[Social Environment]** 1. Constructing new dams requires land acquisition and changing land use, which may cause impact on resettlement and livelihood.	**[Natural Environment]** 1&2 Keep environmental flow by controlling water flow to downstream 3. Examine the appropriate design of the dam and a construction method to minimize the impact to topography or geology **[Social Environment]** ➢ Preparing a relocation/resettlement plan by enhancing the participation of the project affected households through holding consultation meetings in a timely manner and obtaining an agreement from them before staring relocation/resettlement.
Rehabilitation of tertiary canal	**[Natural Environment]** ➢ Rehabilitation may be implemented within the area of current canal. Thus, there may not be any negative impacts. **[Social Environment]** 1. There may be temporary limitation of water supply to irrigation areas. 2. There is a possibility of a temporary disturbance of access to social infrastructure during rehabilitation works.	**[Social Environment]** 1. Schedule rehabilitation works to minimize the limitation of supplying water to irrigation areas 2. Secure accessibility to social infrastructure by arranging the deter roads
Replacement of PDAMs pipeline	**[Natural Environment]** 1. Replacement work may be implemented within the area of the current pipelines. Thus, there may not be any negative impacts. **[Social Environment]** 1. There may be a temporary limitation of water supply to the households during replacement work 2. There is a possibility of temporary disturbance of access to social infrastructure during the replacement works	**[Social Environment]** 1. Schedule the replacement works to minimize the limitation of water supply to households 2. Secure accessibility to social infrastructure by arranging the deter roads
Changing water source from surface to groundwater by constructing new wells	**[Natural Environment]** ➢ Constructing new wells requires a small area, and the areas to install new wells are the urbanized areas. Thus, the impact to natural environment is considered as limited. **[Social Environment]** 1. While water volume may be secured due to new wells, there is a possibility that the water quality and water flow at the surround areas may be affected.	**[Social Environment]** 1. Examine areas and depth of wells considering the conditions of wells at the surrounding area.

	Possible Major Impacts	Provisional Mitigation Measures to Possible Negative Impact of Selected Adaptation Measures
Heightening of the existing dam (Sutami Dam)	**[Natural Environment]** 1. There is a possibility that the water volume and water quality at the downstream may be deteriorated. **[Social Environment]** 1. Heightening may require some areas behind the existing dam. Although the impact may be smaller than constructing new dams, land acquisition and changing land use may cause impacts to resettlement and livelihood.	**[Natural Impact]** 1. Keep environmental flow by controlling water flow to downstream. **[Social Environment]** 1. Preparing relocation/resettlement plan by enhancing participation of project affected households through holding consultation meetings in timely manner, and obtaining agreement from them before staring relocation/resettlement.
Construction of sand pocket for dredging	**[Natural Environment]** ➢ Constructing sand pocket requires a large area, which may cause an impact on terrestrial and aquatic flora and fauna. **[Social Environment]** 1. Constructing sand pocket requires land acquisition and changing land use, which may cause impact on resettlement and livelihood.	**[Natural Environment]** 1. Examine the design of sand pocket to minimize necessary construction areas, and cut trees only at the designated area. **[Social Environment]** 1. Preparing relocation/resettlement plan by enhancing participation of project affected households through holding consultation meetings in timely manner, and obtaining agreement from them before staring relocation/resettlement
Water Destructive Force Control		
Heightening the existing dikes	**[Natural Environment]** 1. Heightening the existing dikes will include bank protection and it will affect aquatic flora and fauna at the river bank areas. **[Social Environment]** ➢ Heightening the existing dike will not require land. Thus, there will not be any impact of land acquisition and resettlement.	**[Natural Environment]** 1. Use environmentally friendly method of bank protection
Constructing new dikes	**[Natural Environment]** 1. Constructing dikes may disturb the animals to cross a river. 2. Same as heightening the existing dikes, constructing new dikes may affect aquatic flora and fauna at the river bank areas. **[Social Environment]** 1. Constructing new dikes requires land acquisition. For the areas of less population such as rural areas, altering land use may be necessary while the resettlement will be at medium areas.	**[Natural Environment]** 1. Check the animal movement at the dike construction areas, and examine the necessity to arrange the roads for animal moving. 2. Use environmentally friendly method of bank protection **[Social Environment]** 1. Preparing the relocation/resettlement plan by enhancing the participation of the project affected households through holding consultation meetings in a timely manner and obtaining agreement from them before starting the relocation/resettlement. For altering land use, prepare the income rehabilitation plan by holding the consultation with eligible households in timely manner.

Source: JICA Project Team 2

(5) Stakeholder Meetings

A total three times of Stakeholder Meetings (SHM) were held to explain the project outline and examination results as well as having an opinion exchange. The summary of each stakeholder meeting is shown in Table 6.4.14 and related documents of SHM are explained in Supporting Report J.

Table 6.4.14 Summary of Stakeholder Meeting

	Date and Venue	No. of Participants	Major Discussion Points
1st SHM	5 Feb. 2016 10:00 – 11:30 Hall BBWS Brantas, Surabaya	32 persons	➢ There was a question whether the project dealt with the climate change only or not. It was answered by the JICA Project Team 2 that other factors would consider separately. ➢ There was a suggestion to make a guideline of the proper water management to improve the current problematic conditions of water use. ➢ There was a question of difference between SEA and EIA. It was answered by the JICA Project Team 2 that SEA evaluates broader issues at more comprehensive level through obtaining feedback from key stakeholders.
2nd SHM	15 Sep. 2016 15:00 – 16:30 Swiss Belinn Tunjungan, Surabaya	33 persons	➢ There was a request to explain the calculation method of the maximum flood discharge in 2050. It was answered by the JICA Project Team 2 that two approaches (i.e. i) calculation for the large catchment area, and ii) calculation for tributaries as small catchment area). ➢ There was a comment of importance on people's education since the types of problem may be differed at the upper, middle and downstream. It was answered from the JICA Project Team 2 that the continuous education by NGO is important. ➢ There was a comment of weakness on law enforcement to implement regulations though there were many regulations. It was suggested by the JICA Project Team 2 to mention law enforcement when POLA is revised.
3rd SHM	29 Nov. 2017 9:00 – 11:30 Regent's Park Hotel, Malang	60 persons	➢ There was a comment to examine water quality in SEA since water quality in the Brantas River basin was serious. It was answered by the JICA Project Team 2 that water quality was examined in this Project and the examination result would be included in the final report. ➢ There was a comment to examine more rational adaptation measures and the possibility to heighten the Sutami Dam. It was answered by the JICA Project Team 2 that more rational adaptation measures were examined. As for Sutami Dam, behind the existing Sutami Dam (not heightening Sutami Dam itself) would be heightened.

Source: JICA Project Team 2

6.5 Formulation of Priority Actions, Preliminary Cost Estimation and Implementation Schedule for Adaptation and Mitigation Measures against Climate Change Impacts

6.5.1 Rainstorms and Floods

(1) Methodology

1) General

As there is no manual or guideline for economic analysis of flood protection sector in Indonesia, the economic evaluation is conducted based on the "Manual of Economical Investigation of Flood Disaster" developed by the Ministry of Land, Infrastructure and Transportation and Tourism (MILT), in Japan.

Basically, the reduced flood damages of many kinds of assets influenced by the project implementation are considered as the economic benefits of the project. Based on this manual, the flood damages are broadly divided into categories of direct damages and indirect damages. The direct damages are physical damage on assets and crops caused by flood, while indirect damages are other economic losses such as suspension of economic activities. The categorization of damage items by the manual and the quantified economic damages in this Project are shown in Table 6.5.1

Table 6.5.1 Major Direct and Indirect Damage

Categorization of Damage	Damage Item	Calculation in this Analysis
Direct Damage	House	Done
	Household Asset	Done
	Fixed Asset for Business Use	-
	Stock Asset for Business Use	-
	Fixed Asset for Agricultural and Fishery Household Use	-
	Stock Asset for Agricultural and Fishery Household Use	-
	Agricultural Crops	Done
	Infrastructure	Done
Indirect Damage	Operation Loss of Enterprise due to Business Suspension	Done, assumed at 10% of House and Household Asset Damage
	Income Loss of the Household due to the Expense from the Flood	
	Suspension of Transportation	
	Economic Loss by Suspension of Lifeline	
	Mental Damage by Flood	

Source: JICA Project Team 2

2) Each Damage Item

The formula for estimating of each damage item is described in Table 6.5.2.

Table 6.5.2 Estimation Formula for Major Direct and Indirect Damage

Damage Item	Formula for Estimating Damage Calculation
Damage to Houses	"Number of Affected Household" x "Average Value of House" x "Damage Rate"
Damage to Household Asset	"Damage to House" x 10%
Damage to Agricultural Crops	"Affected Area of Agricultural Field" x "Crop Yield " x "Economic Value of Paddy" x "Damage Rate"
Damage of Infrastructure	"Direct Damage of House and Household Asset" x 131.1%
Indirect Damage	"Direct Damages" x 10%

Source: JICA Project Team 2

3) Estimation of the Expected Annual Average of Damage Reduction

To estimate "the expected annual average of damage reduction", firstly "averted damage by project" in each of the return period is calculated; secondly "average damage reduction" and "provability" of each return period are multiplied to calculate the "annual average damage reduction".

The "expected annual average damage reduction", which shows the difference of the damage under "With" and "Without" case scenario will be the economic benefit in the calculation of EIRR in ECONOMIC ANALYSIS AMD PROJECT EVALUATION in Supporting Report L.

Table 6.5.3 Estimation Method of Expected Average Annual Damage Reduction

Return Period	Flood Damage			Average of Damage Reduction	Provability	Annual Average Damage Reduction
	Without Project (a)	With Project (b)	Averted Damage by Project (a) – (b)			
1 year			D0=0			
				(D0+D1)/2	1-(1/2)= 0.500	d1=(D0+D1)/2 x 0.500
2 years	L1	L2	D1=L1-L2			
				(D1+D2)/2	(1/2)-(1/5)= 0.300	d2=(D1+D2)/2 x 0.300
5 years	L3	L4	D2=L3-L4			
				(D2+D3)/2	(1/5)-(1/10)= 0.100	d3=(D2+D3)/2 x 0.100
10 years	L5	L6	D3=L5-L6			
				(D3+D4)/2	(1/10)-(1/20)= 0.050	d4=(D3+D4)/2 x 0.050
20 years	L7	L8	D4=L7-L8			
				(D4+D5)/2	(1/20)-(1/30)= 0.017	d5=(D4+D5)/2 x 0.017
30 years	L9	L10	D5=L9-L10			
				(D5+D6)/2	(1/30)- (1/50)= 0.013	d6=(D5+D6)/2 x 0.013
50 years	L11	L12	D6=L11-L12			
				(D6+D7)/2	(1/50)-(1/100)=0.010	d7=(D6+D7)/2 x 0.010
100 years	L13	L14	D7=L13-L14			
Expected Annual Average Damage Reduction			d1+d2+d3+d4+d5+d6+d7			

Source: JICA Project Team 2

(2) Structural Measures

The structural measures are summarized in Table 6.5.4.

Table 6.5.4 Structural Measures for Floods

Scenario	River	Discharge (m^3/s)	Type	Height (m)	Length (km)
Medium	Widas	710 (Upper)	Dike(New)+FM	1.9*1	6.5*1
				1.2*2	11.4*2
				1.5*3	34.3*3
	Ngotok	1,457	Dike(New)	1.3	43.1
	Sadar	130	Dike(New)	0.5	6.8
	Tawing	397	Dike(New)	2.1	26.6
	Porong	1,710	Dike(Heightening)	0.8	40.1
Low	Widas	680	Dike(New)+FM	1.9*1	6.5*1
				1.2*2	11.4*2
				1.5*3	34.3*3
	Ngotok	947	Dike(New)	0.8	24.1
	Sadar	130	Dike(New)	0.5	6.8
	Tawing	352	Dike(New)	1.8	25.8
	Porong	1,620	Dike(Heightening)	0.5	28.4
High	Widas	680	Dike(New)+FM	1.9*1	6.5*1
				1.2*2	11.4*2
				1.5*3	34.3*3
	Ngotok	2,079	Dike(New)	2.1	62.9
	Sadar	210	Dike(New)	0.7	12.5
	Tawing	335	Dike(New)	1.8	20.2
	Porong	2,030	Dike(Heightening)	1.0	44.3

Note: FM means Flood Management, *1: Upper Widas, *2: Kedung and Kuncir, *3: Lower Widas

Source: JICA Project Team 2

(3) Preliminary Cost Estimation

The cost of the following structural measures for water resources management is estimated.

<u>Target flood control measures</u>

- ➢ New dike construction
- ➢ Dike heightening

<u>Procedure of cost estimation</u>

i) Set the standard cross sections for each target river

ii) Calculate the unit cost of the dike embankment based on the cost of each works such as earth fill, sod facing, stripping and surface coarse and draw the unit cost curve

iii) Calculate the construction at several cases based on the assumed unit cost

1) Basic condition

The basic condition for the preliminary cost estimation is as follows:

- ➢ Convert the unit cost at 2011 value to the cost at 2017 value
- ➢ The project cost is calculated based on the following items.
  - • Direct cost
  - • Compensation cost：Land acquisition cost, resettlement cost
  - • Administration cost
  - • Engineering service

- Contingency cost：Physical contingency, Price escalation
- Value-added tax (VAT)

➢ According to the past study reports and implementation programs of other similar projects, each of the cost rate is set as follows.

- Administration cost：10% of direct cost
- Engineering service：12% of direct cost
- Physical contingency : 7% of direct cost, administration cost, compensation cost, engineering service and price escalation
- Price escalation：No consideration in the Project
- Compensation cost : 40% of direct cost (Land acquisition cost and resettlement cost)
- VAT : 10% of direct cost, engineering service, physical contingency, and price escalation

2) Cost of Heightening of Dike Construction

The direct cost of the dike heightening for the Porong River is shown in Table 6.5.5

Table 6.5.5 Direct Cost of Dike Heightening for the Porong River

Scenario	Medium	Low	High
Height (m)	0.8	0.5	1.0
Length (km)	40.1	28.4	44.3
Direct Cost (IDR Mil.)	42,758	19,675	59,433

Source: JICA Project Team 2

3) Cost of New Dike Construction

The direct cost of the new dike construction to each river is shown in Table 6.5.6 to Table 6.5.9.

Table 6.5.6 Direct Cost of the Widas River

	Upper	Kedung & Kuncir	Lower
Height (m)	1.9	1.2	1.5
Length (km)	6.5	11.5	34.3
Direct Cost (IDR Mil.)			54,362

Source: JICA Project Team 2

Table 6.5.7 Direct Cost of the Ngotok River

Scenario	Medium	Low	High
Height (m)	1.3	0.8	2.1
Length (km)	43.1	24.1	62.9
Direct Cost (IDR Mil.)	32,438	11,816	75,579

Source: JICA Project Team 2

Table 6.5.8 Direct Cost of the Sadar River

Scenario	Medium	Low	High
Height (m)	0.5	0.5	0.7
Length (km)	6.8	6.8	12.5
Direct Cost (IDR Mil.)	2,582	2,582	6,097

Source: JICA Project Team 2

Table 6.5.9 Direct Cost of the Tawing River

Scenario	Medium	Low	High
Height (m)	2.1	1.8	1.8
Length (km)	26.6	25.8	20.2
Direct Cost (IDR Mil.)	38,851	31,760	26,285

Source: JICA Project Team 2

4) Project Cost

The project cost is estimated based on several assumptions as explained above. Table 6.5.10 to Table 6.5.14 show the project cost of each river basin.

Table 6.5.10 Project Cost of the Porong River

(Unit: IDR Mil.)

Scenario		Medium	Low	High
Direct Cost	a	42,758	19,675	59,433
Compensation Cost	b=a x 0.4	17,103	7,870	23,773
Administration Cost	c=a x0.1	4,276	1,967	5,943
E/S Cost	d=a x 0.12	5,131	2,361	7,132
Price Escalation		0	0	0
Physical Contingency	e=(a+b+c+d)x0.07	4,490	2,066	6,240
Sub-total	f	73,758	33,939	102,521
VAT	g=f x 0.1	7,376	3,394	10,252
Total	f+g	81,134	37,333	112,773

Source: JICA Project Team 2

Table 6.5.11 Project Cost of the Widas River

(Unit: IDR Mil.)

Scenario		Medium, Low, High
Direct Cost	a	54,362
Compensation Cost	b=a x 0.4	21,745
Administration Cost	c=ax0.1	5,436
E/S Cost	d=a x 0.12	6,523
Price Escalation		0
Physical Contingency	e=(a+b+c+d)x0.07	5,708
Sub-total	f	93,774
VAT	g=f x 0.1	9,377
Total	f+g	103,151

Source: JICA Project Team 2

Table 6.5.12 Project Cost of the Ngotok River

(Unit: IDR Mil.)

Scenario		Medium	Low	High
Direct Cost	a	32,438	11,816	75,579
Compensation Cost	b=a x 0.4	12,975	4,727	30,231
Administration Cost	c=a x0.1	3,244	1,182	7,558
E/S Cost	d=a x 0.12	3,893	1,418	9,069
Price Escalation		0	0	0
Physical Contingency	e=(a+b+c+d)x0.07	3,406	1,241	7,936
Sub-total	f	55,956	20,384	130,373
VAT	g=f x 0.1	5,596	2,038	13,037
Total	f+g	61,552	22,422	143,410

Source: JICA Project Team 2

Table 6.5.13 Project Cost of the Sadar River

(Unit: IDR Mil.)

Scenario		Medium	Low	High
Direct Cost	a	2,582	2,582	6,097
Compensation Cost	b=a x 0.4	1,033	1,033	2,439
Administration Cost	c=a x0.1	258	258	610
E/S Cost	d=a x 0.12	310	310	732
Price Escalation		0	0	0
Physical Contingency	e=(a+b+c+d)x0.07	271	271	640
Sub-total	f	4,454	4,454	10,518
VAT	g=f x 0.1	445	445	1,052
Total	f+g	4,899	4,899	11,570

Source: JICA Project Team 2

Table 6.5.14 Project Cost of the Tawing River

(Unit: IDR Mil.)

Scenario		Medium	Low	High
Direct Cost	a	38,851	31,760	26,285
Compensation Cost	b=a x 0.4	15,540	12,704	10,514
Administration Cost	c=a x0.1	3,885	3,176	2,628
E/S Cost	d=a x 0.12	4,662	3,811	3,154
Price Escalation		0	0	0
Physical Contingency	e=(a+b+c+d)x0.07	4,079	3,335	2,760
Sub-total	f	67,017	54,786	45,341
VAT	g=f x 0.1	6,702	5,479	4,534
Total	f+g	73,719	60,265	49,875

Source: JICA Project Team 2

5) Economic Evaluation

The economic evaluation is conducted for the major flood control measures; where there are 12 economic analyses are made, i.e., in the four river basins (Widas, Sadar, Ngotok, and Tawing) under three climate scenarios (low, medium, high). The results of the economic evaluation are summarized in Table 6.5.15.

From the table the following considerations are made:

- Since the proposed measures for the Ngotok, and Sadar River basins have a considerably high EIRR in all cases of the scenarios which is greater than 9% to 12% of the minimum required discount rates for international donors, they seem to be economically feasible.
- In case of EIRR for Widas and Tawing River basin, they are lower than the minimum required rate therefore it is recommended that the plans should be reviewed and/or modified if necessary.
- This analysis is a rough estimation as the future climate change is not easy to forecast. Considering all of the EIRRs of the four river basins, there is so much difference among them; it is recommended that these plans should be modified if necessary, considering the climate change and other situation in the future.

Table 6.5.15 Summary of Economic Evaluation (Rainstorms and Floods)

Scenario	River Basin	EIRR (%)	NPV (Billion IDR)	B/C
Low	Widas	3.0%	-31	0.4
	Ngotok	82.7%	101	9.3
	Sadar	118.4%	51	22.9
	Tawing	6.4%	-12	0.7
Medium	Widas	5.7%	-27	0.6
	Ngotok	50.9%	194	5.3
	Sadar	117.6%	68	23.0
	Tawing	4.9%	-26	0.6
High	Widas	8.8%	-8	0.9
	Ngotok	41.3%	337	4.2
	Sadar	74.4%	68	10.5
	Tawing	7.2%	-10	0.8

Source: JICA Project Team 2

6) Possible Fund Source of the Project

Most of the fund sources of the measures proposed in this project have not been decided. However, the most probable fund source of these measures would be the national budget (*Anggaran Pendapatan dan Belanja Negara*; APBN) as the construction or heightening of the dike is normally not conducted by donor project considering that the necessary amount of fund is not comparatively much and the necessary technical level is not high.

In order to secure the APBN, the necessary procedures should be followed.

(4) Non-Structural Measures

All considerable non-structural measures against rainstorms and floods shall be carried out. The following measures are considered. The detail explanation of the non-structural measures is mentioned in Section 6.3.1.

1) Upgrading of Flood Forecasting and Warning System (FFWS),
2) Community-based Early Warning System (EWS),
3) Preparation of the Hazard Map for Several Probable Floods,
4) Designation of the Evacuation Center from Existing Public Facilities and Construction of Evacuation Center
5) Strengthening of Flood Prevention Organization,
6) Preparation of Business Continuity Plan (BCP) and area Business Continuity Management (BCM) by Private Companies and Local Governments,
7) Preparation of Flood Action Plan, and
8) Land Use Control to Frequently Flood Inundation Area.

6.5.2 Drought

(1) Structural Measures

1) Replacement of PDAM's Pipeline

As described in the above section 6.3.2, the replacement of pipelines in order to reduce the ratio of non-revenue water would be implemented. The cost of repairing pipe for non-revenue water is shown in Table 6.5.16.

2) Construction of Recycle Plant

For the reduction of industrial water demand, the adaptation measure uses to save industrial water is the installation of recycle plant. The re-use ratio from sewage is about 1.4% in Japan. Therefore, it is assumed that industrial water is reduced by 1% of the industrial water demand. The industrial water that will be saved is 0.210 m^3/s (18,144 m^3/day).

The unit cost of construction of the recycling plant of sewage treatment is applied which is referred to the data of existing project in Indonesia. The cost of the recycling plant for sewage water is shown in Table 6.5.17.

Table 6.5.16 Cost of Repairing Pipe for Non-Revenue Water

USD1=13,341.82IDR

City and Regency	Population (person)	Total (km)	NRW 2010	NRW2050	Reduction	Total Cost (USD)	Total Cost (USD)	Pipe Replacement Initial Cost	
						NRW 2010	NRW 2050	USD	IDR(billion Rp.)
									13341.82
1.Batu City	190,184	176.8	37%	25%	12%	1,896,032	1,325,282	570,750	7.615
2.Malang Regency	2,446,218	1,500.0	36%	25%	11%	11,977,500	8,227,500	3,750,000	50.032
3.Malang City	820,243	1,692.7	38%	25%	13%	17,674,834	12,767,884	4,906,950	65.468
4.Kediri Regency	1,499,768	429.0	22%	20%	2%	550,176	550,176	0	0.000
5.Blitar Regency	1,116,639	513.8	26%	20%	6%	1,793,130	1,793,130	0	0.000
6.Sidoarjo Regency	1,941,497	1,461.0	33%	25%	8%	9,481,890	5,829,390	3,652,500	48.731
7.Mojokerto Regency	1,025,443	319.7	32%	25%	7%	2,616,989	1,540,039	1,076,950	14.368
8.Jombang Regency	1,202,407	713.0	30%	20%	10%	5,715,450	5,715,450	0	0.000
9.Kediri City	268,507	339.5	33%	25%	8%	2,218,369	1,357,869	860,500	11.481
10.Mojokerto City	120,196	0.2	56%	25%	31%	7,220	6,220	1,000	0.013
11.Surabaya City	2,765,487	4,262.7	34%	25%	9%	30,798,152	20,141,352	10,656,800	142.181
12.Trenggalek Regency	674,411	402.2	41%	25%	16%	5,263,380	3,980,880	1,282,500	17.111
13.Blitar City	131,968	378.1	39%	25%	14%	3,768,650	2,776,900	991,750	13.232
14.Tulungagung Regency	990,158	453.0	30%	20%	10%	2,868,083	2,868,083	0	0.000
15.Nganjuk Regency	1,017,030	300.0	25%	20%	5%	984,000	984,000	0	0.000
16. Gresik Regency	1,177,042	817.4	23%	20%	3%	1,267,199	1,267,199	0	0.000
						98,881,052	**71,131,352**	**27,749,700**	370.232

Source: Prepared by JICA Project Team 2 based on the data from Direktori Perpamsi 2010

Table 6.5.17 Cost of Recycling Plant Construction

Item	Unit cost (IDR million /m^3)	Plant capacity (m^3)	Cost (IDR billion)
Recycling plant construction cost	4.251	75,200	319.68

Source: JICA Project Team 2

3) Rehabilitation of Tertiary Irrigation Canal

The following approach is prerequisite for improvement of tertiary canal system:

- To identify the target schemes with the design irrigation command area of over 100 ha;
- To undertake the inventory survey in a participatory manner for the purpose of confirming the farmers' needs and generating their consensus;

- To promote the participatory design work of the tertiary canal network layout using a precast concrete block for minimizing the unusable paddy field on contribution basis; and
- To collaborate with local agencies concerned for realizing the public financial assistance to participatory implementation of the tertiary canal improvement works.

4) Construction of New Dams

For the proposed dams of Categories A and B, basic information of the dam location, purpose, dam type and basic dimension, and reservoir storage capacity is presented in Table 6.3.53.

These proposed dams are taken into consideration of the other climate change adaptation measures against droughts by increasing store water. There are additional dams to be considered for adaptation measures which are summarized in Table 6.5.18.

Table 6.5.18 Summary of Additional Dams for Each Scenario

New Dam	Medium	Low	High
Genteng I	O	-	O
Kempok	-	-	O
Babadan	O	O	O
Kont II	O	O	O
Kuncir	O	-	O
Kedungwarak	O	O	O
Ketandan	-	-	O

Note: ”O” applied as an adaptation measure, “-“ not applied as an adaptation measure
Source: JICA Project Team 2

5) Preliminary Cost Estimation

The cost of following drought control measures for climate change adaptation is estimated.

<u>Target drought control measures</u>

- Construction of new dam
- Heightening the dam body of Sutami dam
- Rehabilitation of tertiary irrigation canal
- Replacement of PDAM’s pipeline
- Construction of recycle plant

(2) Estimation of Unit Cost

1) Construction of New Dam

The construction cost of the new dam is calculated from the unit cost of dam body per volume. The unit cost is estimated from the direct construction cost of the existing dams.

The basic conditions for the preliminary cost estimation are the following:

- The construction cost means direct construction cost without tax excluding the cost of land acquisition, compensation for affected people, and site management.
- Exclude the cost of the power house

- Target the dams which were constructed after 1998
- Set August 2017 as standard month of inflation rate
- To convert to the cost at August 2017, use the inflation rate of public investment and construction cost shown in the website of Statistics Indonesia (BPS)
- Consider the construction cost index by province excluding the dams located in the East Java Province (Jatibarang Dam ; Central Java)

Procedure for Cost Estimation

i) Set unit cost of dam construction per cubic meter based on the existing data of the volume of dam body and total construction cost

ii) Convert the unit cost to the present value (price in August 2017)

iii) Draw the cost curve based on the converted unit cost

iv) Estimate the cost of the target dams

The unit cost curve of new dam construction is created based on existing eight rockfill dams and two earthfill dams. The result of the unit cost of rockfill dam is shown in Table 6.5.19 and the result of unit cost curve in Figure 6.5.1. The result of unit cost of earthfill dam is shown in Table 6.5.20 and the result of unit cost curve in Figure 6.5.2.

Table 6.5.19 Unit Cost of Direct Construction Cost (Rockfill Dam)

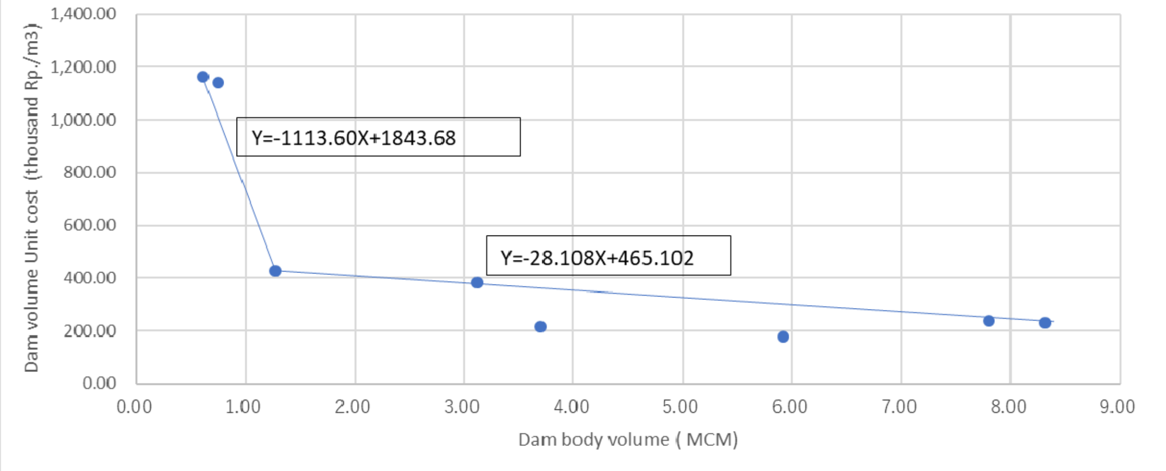
No.	Dam Name	Prov.	Vol. (10^6 m^3)	Unit Cost (IDR $10^3/m^3$)	Coefficent*1	Unit Cost at 2017 (IDR $10^3/m^3$)
1	Babadan	East Java	8.32	50.89	4.527	230.38
2	Genteng I	East Java	3.12	84.42	4.527	382.17
3	Kuncir	East Java	5.91	123.83	1.428	176.83
4	Kampak	East Java	1.27	414.53	1.033	428.21
5	Tugu	East Java	7.80	210.16	1.125	236.43
6	Bagong	East Java	3.70	198.33	1.088	215.78
7	Bajulmati	East Java	0.75	570.17	2.003	1,142.05
8	Jatibarang	Central Java	0.61	857.62	1.357	1,163.79

Note: Coefficient is estimated from escalation from estimated year to 2017 and regional economic condition.
Escalation of base year is applied 2000 year.
Escalation is estimated from inflation rate of public investment (website of Statistics Indonesia (BPS), https://www.bps.go.id/subject/4/konstruksi.html#subjekViewTab3)).
Source: JICA Project Team 2 estimated based on data from BBWS Brantas and BBWS Pemali Juana

Table 6.5.20 Unit Cost of Direct Construction Cost (Earthfill Dam)

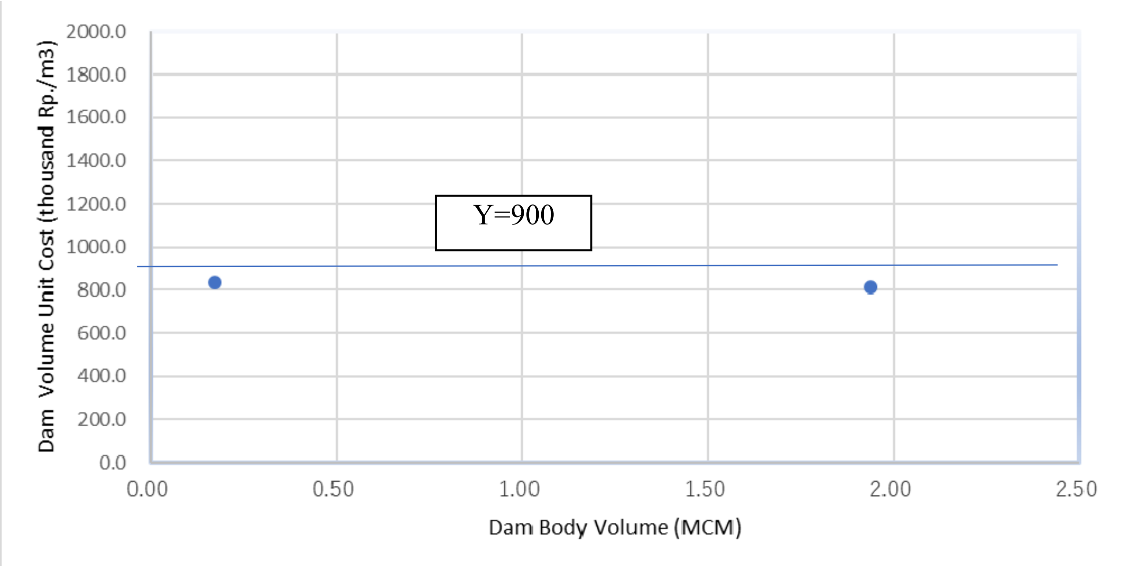
No.	Dam Name	Prov.	Vol. (10^6 m^3)	Unit Cost (IDR$10^3/m^3$)	Coefficent*1	Unit Cost at 2017 (IDR $10^3/m^3$)
1	Kedungwarak	East Java	0.17	323.4	2.572	831.78
2	Semantok	East Java	1.94	783.7	1.038	813.48

Note: Coefficient is estimated from escalation from estimated year to 2017 and regional economic condition.
Escalation of base year is applied 2000 year.
Escalation is estimated from inflation rate of public investment (website of Statistics Indonesia (BPS), https://www.bps.go.id/subject/4/konstruksi.html#subjekViewTab3)).
Source: JICA Project Team 2 estimated based on data from BBWS Brantas



Source: JICA Project Team 2

Figure 6.5.1 Relation between Dam Body Volume and Direct Cost (Rockfill Dam)



Source: JICA Project Team 2

Figure 6.5.2 Relation between Dam Body Volume and Direct Cost (Earthfill Dam)

2) Heightening the Dam Body of the Sutami Dam

The unit cost is set based on the existing dams' construction cost of the embankment, spillway, and spillway gate. The data of the Tugu Dam, Bagong Dam, Semantok Dam and Jatibarang Dam are referred because they have the construction cost divided by the construction type. The unit cost of the embankment, spillway, spillway gate and gate at connecting channel are shown from Table 6.5.21 to Table 6.5.25.

Table 6.5.21 Unit Cost of Direct Construction Cost (Embankment)

No.	Dam Name	Prov.	Vol. (10^6 m^3)	Cost (IDR Mil.)	Unit Cost (IDR $10^3/m^3$)	Coefficent*1	Unit Cost at 2017 (IDR $10^3/m^3$)
1	Bagong	East Java	3.70	409,248	110.6	1.037	115
2	Tugu	East Java	7.80	879,532	112.8	1.125	127
Average							121

Note: Coefficient is estimated from escalation from estimated year to 2017 and regional economic condition.
Escalation of base year is applied 2000 year.
Escalation is estimated from inflation rate of public investment (website of Statistics Indonesia (BPS), https://www.bps.go.id/subject/4/konstruksi.html#subjekViewTab3)).
Source: JICA Project Team 2 estimated based on data from BBWS Brantas

Table 6.5.22 Unit Cost of Direct Construction Cost (Spillway)

No.	Dam Name		Area (m^2)	Cost (IDR Mil.)	Unit Cost (IDR 10^3)	Coefficent*1	Unit Cost at 2017 (IDR 10^3)
1	Bagong	30m x 300m	9,000	194,067	21,563	1.037	22,361
2	Semantok	46.2m x 110m	5,082	124,749	24,547	1.125	27,615
Average							25,000

Note: Coefficient is estimated from escalation from estimated year to 2017 and regional economic condition.
Escalation of base year is applied 2000 year.
Escalation is estimated from inflation rate of public investment (website of Statistics Indonesia (BPS), https://www.bps.go.id/subject/4/konstruksi.html#subjekViewTab3)).
Source: JICA Project Team 2 estimated based on data from BBWS Brantas

Table 6.5.23 Unit Cost of Direct Construction Cost (Spillway Gate)

No.	Dam Name	Prov.	Width (m)	Cost (IDR Mil.)	Unit Cost (IDR 10^3)	Coefficent*1	Unit Cost at 2017 (IDR 10^3)
1	Tugu	East Java	35	12,015	343,286	1.125	386,197

Note: Coefficient is estimated from escalation from estimated year to 2017 and regional economic condition.
Escalation of base year is applied 2000 year.
Escalation is estimated from inflation rate of public investment (website of Statistics Indonesia (BPS), https://www.bps.go.id/subject/4/konstruksi.html#subjekViewTab3)).
Source: JICA Project Team 2 estimated based on data from BBWS Brantas

Table 6.5.24 Unit Cost of Direct Construction Cost (Gate at Connecting Channel)

No.	Dam Name			Cost (IDR 10^3)	Unit Cost (IDR 10^3)	Coefficent*1	Unit Cost at 2017 (IDR 10^3)
1	Jatibarang	Flap Gate	600mm	36,852	36,852	1.357	50,008

Note: Coefficient is estimated from escalation from estimated year to 2017 and regional economic condition.
Escalation of base year is applied 2000 year.
Escalation is estimated from inflation rate of public investment (website of Statistics Indonesia (BPS), https://www.bps.go.id/subject/4/konstruksi.html#subjekViewTab3)).
Source: JICA Project Team 2 estimated based on data from BBWS Pemali Juana

3) Restoration of Irrigation Canal

The unit cost of the restoration of tertiary irrigation canal is set as below referring to the unit cost used in a Yen Loan project.

Table 6.5.25 Unit Cost of Construction Cost (Tertiary Canal)

Item	2017/2	2017/8
Unit cost of the restoration of tertiary irrigation canal (IDR Million/ha)	19.45	19.78
Year index	1.000	1.017

Source: JICA Project Team 2

4) Replacement of the PDAMs' Pipeline

The cost of updating the water pipe is estimated not by unit cost but by direct cost calculation.

5) Installation of Recycling Plant for Sewage Water

The unit cost of the construction of recycling plant of sewage treatment is applied as seen in Table 6.5.26, which is referred to the data of the existing project in Indonesia.

Table 6.5.26 Unit Cost of Recycling Plant Construction

Item	Unit cost (IDR Million/m^3)
Unit cost of recycling plant construction	4.251

Source: JICA Project Team 2

(3) Cost Estimation

1) Construction of New Dam

The direct construction costs of seven new dams are estimated based on the assumed unit cost. The results of the construction cost are shown in Table 6.5.27.

Basic Condition

- According to the existing report, each cost rate is set as follows.

(Ratio of direct construction cost)

・Administration cost：10%

・Engineering service：15%

・Physical contingency：6%

・Price escalation：No consideration in the Project

・Compensation cost：25% (Land acquisition cost and resettlement cost)

・VAT：10%

Table 6.5.27 Construction Cost of New Dams

(Unit: IDR Mil.)

Dam Name		Kedungwarak	Kuncir	Babadan
Dam Type		Earthfill	Rockfill	Rockfill
Embankment (10^3m^3)		216	6,850	8,300
Direct Cost	a	194,400	1,870,050	1,925,600
Compensation Cost	b=a x 0.25	48,600	467,513	481,400
Administration Cost	c=a x0.1	19,440	187,005	192,560
E/S Cost	d=a x 0.15	29,160	280,508	288,840
Price Escalation		0	0	0
Physical Contingency	e=(a+b+c+d)x0.06	17,496	168,305	173,304
Sub-total	f	309,096	2,973,381	3,061,704
VAT	g=f x 0.1	30,910	297,338	306,170
Total	f+g	340,006	3,270,719	3,367,874

Dam Name	Kont II	Genteng I	Ketandan	Kempak
Dam Type	Rockfill	Rockfill	Rockfill	Rockfill
Embankment (10^3m^3)	9,300	3,000	158	1,270
Direct Cost	1,897,200	1,143,000	263,544	544,830
Compensation Cost	474,300	285,750	65,886	136,208
Administration Cost	189,720	114,300	26,354	54,483
E/S Cost	284,580	171,450	39,532	81,725
Price Escalation	0	0	0	0
Physical Contingency	170,748	102,870	23,719	49,035
Sub-total	3,016,548	1,817,370	419,035	866,281
VAT	301,655	181,737	41,904	86,628
Total	3,318,203	1,999,107	460,939	952,909

Source: JICA Project Team 2

Table 6.5.28 Summary of Total Cost to Each Scenario

(Unit: IDR Bil.)

New Dam	Medium	Low	High
Genteng I	1,999	-	1,999
Kempak	-	-	953
Babadan	3,368	3,368	3,368
Kont II	3,318	3,318	3,318
Kuncir	3,271	-	3,271
Kedungwarak	340	340	340
Ketandan	-	-	461
Total	12,296	7,026	13,710

Note: ”O” applied as an adaptation measure, “-“ not applied as an adaptation measure
Source: JICA Project Team 2

2) Heightening of the Dam Body of the Sutami Dam

The direct construction cost of heightening the dam body of the Sutami Dam is estimated based on the assumed unit cost. The width of the spillway is assumed as 20 m. The results are shown in Table 6.5.29.

Basic Condition

- According to the existing report, each cost rate is set as follows.

(Ratio of direct construction cost)

・Administration cost：10%

・Engineering service：15%

・Physical contingency：6%

・Price escalation：No consideration in the Project

・VAT：10%

・Compensation cost：25% (Land acquisition cost, resettlement cost)

Table 6.5.29 Project Cost of Heightening Dam Body of Sutami Dam

Item	Unit	Unit Price (IDR 10^3)	QTY	Amount (IDR 10^6)	Remark
Heightening of main dam	m^3	121	1,198,000	144,958	H=5m
Replacement of spillway	m^2	25,000	920	23,000	460mx20m
Replacement of Spillway Gate	m	387,000	20	7,740	W=20m
Replacemen tof gate at connecting chanel	LS	50,000	1	50	600mm
Saddle Dam	m^3	121	2,250	272	H=3m
Direct Cost	a			175,748	
Compensation Cost	b=a x 0.25			43,937	
Administration Cost	c= a x 0.10			17,575	
Engineering Service	d= a x 0.15			26,362	
Price Escalation	e			0	
Physical Contingency	f=(a+b+c+d) x 0.06			3.817	
Sub-total	g			267,439	
VAT	h=g x 0.1			26,744	
Total				294,183	

Source: JICA Project Team 2

3) Restoration of Irrigation canal

The cost of the restoration of irrigation canal is estimated referring to a report of a Yen Loan Project. The results are shown in Table 6.5.30.

4) Replacement of PDAMs' Pipeline

The cost of repairing pipe for the non-revenue water is shown in Table 6.5.16.

5) Recycling Plant for Sewage Water

The cost of the recycling plant for the sewage water is shown in Table 6.5.17.

Table 6.5.30 Construction Cost of Restoration of Irrigation Canal

	Irrigation Scheme	Irrigaiton Area (ha)	Irrigaiton Canal repair cost (million Rp./ha)	Irrigation Tertiary Canal cost (billion Rp.)
Tributaries	DI_Kedung kandang	5,160	19.78	102
	DI_Molek	3,883	19.78	77
	DI_Jaruma I & II	2,449	19.78	48
	DI_Ngasinan	1,185	19.78	23
	DI_Bagong	857	19.78	17
	DI_Siman	23,060	19.78	456
	DI_Bening	8,752	19.78	173
	DI_Kedung Soko	1,554	19.78	31
	DI_Bareng	800	19.78	16
	Di_Padi Pomahan	4,309	19.78	85
Main Stream	DI_Lodagung	12,217	19.78	242
	DI_Mrican Kanan	17,612	19.78	348
	DI_Mrican Kiri	12,729	19.78	252
	Di_Jatimlerek	1,812	19.78	36
	DI_Mentrus	3,632	19.78	72
	DI_Jatikulon	638	19.78	13
	DI_BrantasDelta	12,206	19.78	241
Total		112,855		2,232

Source: JICA Project Team 2

6) Economic Evaluation

The economic evaluation is conducted for the major measures for the water resources development and water supply. Three of the economic analyses under the three climate scenarios (low, medium, high) are conducted. The results of the economic evaluation are summarized in Table 6.5.31.

From the table, the following considerations are made:

- Since the proposed measures in the case of low scenario have a considerably high EIRR of 13.8% that is greater than 9% to 12% of the minimum required discount rates for international donors, it seems to be economically feasible.
- In the other scenarios, the proposed measures are not economically feasible, and it is recommended that the plans be reviewed and/or modified if necessary.
- This analysis is a rough estimation as the future climate change is not easy to forecast therefore these plans should be modified if necessary, considering climate change and other situation in the future.

Table 6.5.31 Summary of Economic Evaluation (Drought)

Scenario	EIRR (%)	NPV (IDR in Billion)	NPV(B/C)
Low	13.8%	4,169	1.6
Medium	3.2%	-6,309	0.3
High	3.5%	-6,788	0.3

Source: JICA Project Team 2

7) Possible Fund Source of the Project

Most of the fund sources of the measures proposed in this project have not been decided.

In the Brantas River basin; some of the new dams, namely; Tugu Dam, Semantok Dam, and Bagong Dam, are under construction and financed by APBN.

As above mentioned, some of the donors are considering to organize a financial support for these measures in the areas, therefore not only APBN but also donor loans including JICA loan could be another source in the future.

(4) Non-structural Measures

All considerable non-structural measures against drought shall be carried out. The following measures are considered. A detail explanation of non-structural measures is mentioned in Section 6.3.2.

1) Changing water source from surface water to groundwater

2) Land leveling and readjustment of paddy field

3) Intermittent and shallow depth irrigation practice

4) Step-wise Introducing system of rice intensification (SRI)

5) Public relations of reservoir water level of each dam

6) Domestic water supply support system among adjacent river basin

7) Preparation of advance drought action plan

6.5.3 Groundwater Resources Management

Groundwater is an environmental element which supports an ecosystem for animals and plants which plays an important role in people's daily life and economic activities as water resources as well and has fostered local societies and culture. Furthermore, multifaced uses of groundwater are being made in recent years, for example as emergency water sources at the time of natural disasters (e.g. big earthquakes, volcanic eruptions, floods etc.) or regional tourism using spring water and artesian wells.

However, from the technical, temporal and financial aspects, it is difficult for the Brantas River basin to develop such kinds of societies quickly where advanced utilization of groundwater can be practiced. Therefore, it is desirable for the Brantas River basin to promote adaptation measures by use of structural measures in conjunctions with grasping actual conditions of groundwater use and to introduce appropriate regulations and management. There are no universal adaptation measures to minimize the impact of climate change on groundwater, and hence the goal is to mitigate its impact by using realistic measures. Therefore, it is necessary to deal with direct and indirect impacts due to climate change by incorporating adaptation measures into the water resources management plans (Review POLA2015 (Draft) / RENCANA) and enhancing existing relevant management systems and measures.

(1) Structural Measures for Brantas River Basin

The structural measures include enhancement of the aquifer storage capacity and strengthening of groundwater extraction as well as improvement of physical infrastructure and technology to minimize groundwater pollution. The recommended structural adaptation measures for groundwater resources in the Brantas River basin are as follows:

- To enhance aquifer storage capacity: Installation of injection wells

  It is the measures for urban municipalities where groundwater resources may be tight. Malang City, Mojokerto City, Kediri City and Blitar City can be identified as target areas.

- To strengthen groundwater extraction: Additional groundwater development by drilling new wells

  Groundwater should be developed as an alternative water source of surface water when a drought event comes. It is possible to introduce it in Batu City, Malang Regency, Kediri Regency, Blitar Regency, Jombang Regency, Blitar City, Tulungagung Regency, and Nganjuk Regency except for municipalities whose groundwater demand is already tight and those located in coastal areas. However, further investigation is necessary to identify appropriate development areas.

(2) Non-structural Measure for Brantas River Basin

- Short-term plan (first ten years from the start):

  The first step is to grasp the actual conditions of groundwater utilization by an inventory survey and to promote regulations and use them properly, especially placing importance to (i) restriction of groundwater extraction to prevent saltwater intrusion and land subsidence in coastal areas and (ii) groundwater development regulation to prevent depletion of groundwater resources in urban areas.

- Long-term plan (second ten years from the start):

  A system will be provided to establish appropriate conservation and sustainable use by cooperating with concerned parties for each region.

The procedures for the adaptation measures in the Brantas River basin are summarized in Table 6.5.32.

Table 6.5.32 Procedures for Adaptation Measures in the Brantas River Basin

Stage	Expected Duration	Structural Measure	Non-structural Measure
1	5 years	• Enhancing the capacity of aquifers: Promotion of groundwater recharge • Groundwater development survey: Detailed investigation for the development of new groundwater	Grasp actual groundwater usage and emergency measures
2	5 years	• Strengthening the groundwater extraction: New groundwater development • Enhancing the capacity of aquifers: Promotion of groundwater recharge (continued)	Regulation for pumping and groundwater development (resolution of groundwater problems)
3	10 years	Monitoring, evaluation and additional measures concerning the capacity enhancement of aquifer	Preservation of groundwater environment through institutional improvement/ strengthening (Conservation of groundwater cycle)

Source: JICA Project Team 2

(3) Priority actions for Brantas River basin

The recommended process to implement adaptation measures is as follows:

➢ First Stage (5 years)

Strengthening the capacity of aquifer should be started because it is necessary to increase groundwater quantities in aquifers from the viewpoint of preserving groundwater, maintaining an ecosystem by groundwater, and underground storage of water. In addition, a groundwater development survey should be conducted to strengthen the groundwater extraction management. Meanwhile, surveys on actual groundwater usage for pumping restrictions and groundwater development regulations are also conducted, and the restrictions and regulations are to be issued urgently if necessary.

➢ Second Stage (5 years)

Water conservation is promoted to disperse water sources and to reduce the risk of water shortage during drought. New groundwater development should be based on the results of the groundwater development survey. Strengthening the capacity of aquifers should also be conducted. Meanwhile, it is expected that groundwater problems will be resolved by implementing pumping restrictions and groundwater development regulations based on a groundwater usage survey.

➢ Third Stage (10 years)

Monitoring and evaluating the capacity improvement of the aquifers will be conducted and additional measures should be taken if necessary. As institutional improvements are made to promote the use of groundwater, and discussions on the way of groundwater management should be carried out.

(4) Approximate Well Construction Cost for Additional Groundwater Demand

1) Basic Specifications and Unit Prices

The approximate construction cost of the new well was examined for the additional groundwater demand. The basic specifications and unit prices set in the study are as shown in Table 6.5.33 and Table 6.5.34. The basic specifications and unit prices differ between mountainous areas and plains. Any specifications and unit prices are applied considering the groundwater development area of each municipality.

Since basically the groundwater is taken from rock formation in mountainous areas, the specifications are set as follows: i) maximum supposed discharge is 1,000m^3/day, ii) depth of the borehole is 200m, and iii) diameter of casing is 150 mm. On the other hand, the groundwater is pumped from the sedimentary aquifer in the plains, and the capacity of aquifer should be high. Therefore, the specifications are set as follows: i) maximum supposed discharge is 2,000m^3/day, ii) depth of borehole is 150m, and iii) diameter of casing is 200mm.

The preliminary survey such as electrical sounding is usually conducted before drilling. The drilling cost per meter is different between mountainous areas and plains and the unit price of drilling in mountainous regions is more expensive than in plains. After drilling, the pump is installed after test pumping and water quality analysis, but the price of pump depends on the pumping capacity. The estimated installation cost per well finally became the same for mountainous regions and plains in this study.

Table 6.5.33 Basic Specifications for Drilling Borehole

Zone	Maximum Supposed Discharge	Depth of Borehole	Diameter of Casing
	m^3/day	m	mm
Mountain	1000	200	150
Plain	2000	100	200

Source: JICA Project Team 2

Table 6.5.34 Unit Prices and Total Cost for Well Construction Works

(Unit: IDR in Million)

Zone	Preliminary Survey	Cost of Drilling		Test Pumping etc.	Pump Installation	Total Cost
	/ well	/ m	/ well	/ well	/ well	/ well
Mountain	36	1.8	360	120	36	552
Plain	36	3.0	300	120	96	552

Source: JICA Project Team 2

2) Approximate Well Construction Cost

Based on the specifications, the unit prices and additional groundwater demand for each municipality, the installation cost of new wells was estimated. Table 6.5.35 shows the approximate well construction costs for the initial additional groundwater demand while Table 6.5.36 shows the approximate well construction cost when allocating the groundwater demand exceeding the groundwater recharge in Blitar City to Blitar Regency. The latter is more expensive because it requires another new well for the additional groundwater demand in Blitar City and Blitar Regency. In order to cover the additional groundwater demand through drilling new wells and installing pumps, it was estimated that roughly IDR 60 billion as budget would be necessary.

Table 6.5.35 Approximate Well Construction Costs for Initially Supposed Additional Groundwater Demand

City / Regency	Additional Water Demand		Zone	Specification				Cost (10^6 Rp.)						
				Maximum Supposed Discharge	No. of BH	Depth of BH	Diameter of Casing	Preliminary Survey	Cost of Drilling		Test Pumping etc.	Pump Installation	Total Cost	
	m^3/s	m^3/day		m^3/day	-	m	mm	/ well	/ m	/ well	/ well	/ well	/ well	Total
1. Batu C.	0.18	15,552	Mountain	1000	16	200	150	36	1.8	360	120	36	552	8,832
2. Malang R.	0.48	41,472	Mountain	1000	42	200	150	36	1.8	360	120	36	552	23,184
3. Malang C.	0.00	0	Mountain	-	-	-	-	-	-	-	-	-	-	-
4. Kediri R.	0.06	5,184	Plain	2000	3	100	200	36	3.0	300	120	96	552	1,656
5. Blitar R.	0.01	864	Mountain	1000	1	200	150	36	1.8	360	120	36	552	552
6. Sidoarjo R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
7. Mojokerto R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
8. Jombang R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
9. Kediri C.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
10. Mojokerto C.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
11. Surabaya C.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
12. Trenggalek R.	0.00	0	Mountain	-	-	-	-	-	-	-	-	-	-	-
13. Blitar C.	0.49	42,336	Mountain	1000	42	200	150	36	1.8	360	120	36	552	23,184
14. Tulungagung R.	0.01	864	Mountain	1000	1	200	150	36	1.8	360	120	36	552	552
15. Nganjuk R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
16. Gresik R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
Total	**1.23**	**106,272**												**57,960**

Source: JICA Project Team 2

Table 6.5.36 Approximate Well Construction Cost When Allocating Groundwater Demand Exceeding Groundwater Recharge in Blitar City to Blitar Regency

City / Regency	Additional Water Demand		Zone	Specification				Cost (10^6 Rp.)						
				Maximum Supposed Discharge	No. of BH	Depth of BH	Diameter of Casing	Preliminary Survey	Cost of Drilling		Test Pumping etc.	Pump Installation	Total Cost	
	m^3/s	m^3/day		m^3/day	-	m	mm	/ well	/ m	/ well	/ well	/ well	/ well	Total
1. Batu C.	0.18	15,552	Mountain	1000	16	200	150	36	1.8	360	120	36	552	8,832
2. Malang R.	0.48	41,472	Mountain	1000	42	200	150	36	1.8	360	120	36	552	23,184
3. Malang C.	0.00	0	Mountain	-	-	-	-	-	-	-	-	-	-	-
4. Kediri R.	0.06	5,184	Plain	2000	3	100	200	36	3.0	300	120	96	552	1,656
5. Blitar R.	0.35	30,505	Mountain	1000	31	200	150	36	1.8	360	120	36	552	17,112
6. Sidoarjo R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
7. Mojokerto R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
8. Jombang R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
9. Kediri C.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
10. Mojokerto C.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
11. Surabaya C.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
12. Trenggalek R.	0.00	0	Mountain	-	-	-	-	-	-	-	-	-	-	-
13. Blitar C.	0.15	12,695	Mountain	1000	13	200	150	36	1.8	360	120	36	552	7,176
14. Tulungagung R.	0.01	864	Mountain	1000	1	200	150	36	1.8	360	120	36	552	552
15. Nganjuk R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
16. Gresik R.	0.00	0	Plain	-	-	-	-	-	-	-	-	-	-	-
Total	**1.23**	**106,272**												**58,512**

Source: JICA Project Team 2

6.5.4 Sabo Management

(1) Use of Coagulant against Fine–grained Sediment

At present, the sediment dredged in a reservoir is disposed to a spoil bank around the reservoir. However, the place for a spoil bank is usually filled up soon and it is difficult to look for alternative places near the reservoir. At that time, the use of coagulant against fine-grained sediment in a dam reservoir is an effective measure.

Recently, in Japan, experiments were carried out for the use of civil engineering materials and agricultural materials by mixing coagulant with soil with high clay content. Putting sediment solidified by coagulant into and mixing it with cultivated soil is considerably expected to be effective against soil erosion. An experiment for practical use in the Brantas River basin may solve the said problem. **Photo. 6.5.1** shows an improvement example with coagulant.

Sample like Sludge

Agitation by Backhoe

Gradually begin to coagulate

Completely coagulated Condition

Source: http://www.pref.okinawa.lg.jp/site/kankyo/hozen/mizu_tsuchi/redclay/info/h27kouryuusyuukai_yokousyuu.html

Photo 6.5.1 Improvement Example with Coagulant

(2) Dredging of Sabo Facilities

Regular dredging of existing Sabo facilities increases their trap capacities. This is effective in trapping unstable sediments, as well as fine-grained sediments. Dredging is conducted when the reservoir of Sabo facilities is filled up by sediment. The dredging of Sabo facilities in the upstream area of the Sengguruh Dam is highly prioritized, due to the existence of large amount of unstable sediments produced by Mt. Semeru.

(3) Watershed Conservation under Sabo Management

The factors of sediment discharge are presumed to be mainly surface erosion, riverbank/riverbed erosion, slope failure and watershed development such as deforestation and extension of cultivated lands.

The former are natural phenomena. Therefore, prevention measures are mainly structural such as the Sabo facilities. But the latter has a possibility of an artificial factor. Therefore, it is important that restriction of development considering the prevention of surface soil erosion should be carefully conducted. Specifically, these operations are proper preservation and management on the forest or cultivated land. Sabo facilities are structural measures but such operations are non-structural measures.

Proper preservation and management on the forest meant a multiple-layered forest and agro-forestry. Specifically, the management on the forest floor is one of the indispensable managements to prevent surface soil erosion.

One proper development of cultivated land is to make terraces with reverse slopes, which is called "Terracing", this will prevent surface soil outflow. It is also important to cover the ground by grass straw or something to prevent erosion by raindrops. A good example is observed in the Brantas River basin (Photos 6.5.2 and Photos 6.5.3).


Cassava & Undergrowth


Forest & Cultivated Land

Source: JICA Project Team 2

Photo 6.5.2 Example of Proper Agro-Forestry (Hillside of Mt. Wilis; 23/05/2014)


Terracing with Reverse Slope


Bare Ground covered by Dead Grass

Source: JICA Project Team 2

Photo 6.5.3 Example of Proper Development (Hillside of Mt. Wilis ; 23/05/2014)

6.5.5 Watershed Conservation

(1) Priority Actions as Climate Change Measures on Rainstorms and Floods

1) Water Quality Management

As discussed in 6.3.4 (1), the priority action is to control the excessive fertilizer application in agriculture. The action is non-structural measures.

2) Watershed Conservation

As discussed in 6.3.4 (1), the priority actions are to maximize the water retaining capacity by keeping the forest cover and improving the quality of forest. These actions are non-structural measures.

Table 6.5.37 Watershed Conservation against Rainstorms and Floods

No.	Priority actions	Detail actions	Target Forest	Consideration points for prioritization
1	Protection of forest	- Protection from illegal felling	- Conservation forest - Protection forest	- Upper watershed - Area where larger rainfall change is expected (especially more rainfall) - Area with higher productive aquifers - Critical area
2	Fire prevention	- Fire prevention works - Preparation for firefighting equipment - Monitoring of hot spots	- Conservation forest - Protection forest - Production forest	- Upper watershed - Area where larger rainfall change is expected (especially less rainfall) - Area where lower ground water level is expected - Critical area
3	Rehabilitation work	- Regeneration improvement works	- Protection forest	- Upper watershed - Area where larger rainfall change is expected (especially more rainfall) - Area with higher productive aquifers - Critical area
4	Sustainable management	- Sustainable forestry practice	- Production forest	- Upper watershed - Area where larger rainfall change is expected (especially more rainfall) - Area with higher productive aquifers - Area where lower ground water level is expected - Critical area - Large forest concession holder
5	Monitoring	- Monitoring of impact to the ecosystem by climate change	- Conservation forest - Protection forest - Production forest	- Area where rainfall pattern is changed - Area where higher temperature rise is expected - Area where disease or pest attack is recorded - Critical area where soil is degraded by climate change
6	Promotion of plantation outside forest land	- Public information and environmental education - Technical support and seedling production	- Outside forest land	- Upper watershed - Area with the slopes - City area

Source: JICA Project Team 2

(2) Priority Actions as Climate Change Measures against Droughts

1) Water Quality Management

As discussed in 6.3.4 (2), the priority action is to keep the current lowest water level especially in the river system whose water quality is degraded. The action is the non-structural measures.

2) Watershed Conservation

As discussed in 6.3.4 (2), priority actions are to maximize the water retaining capacity by keeping the forest cover and improving the quality of forest. It is also noted that the forest cover is generally appreciated for its water retaining capacity, while it may also increase the evaporation by the breath of trees and eventually reduces the available water volume in the watershed.

Table 6.5.38 Watershed Conservation against Drought

No.	Priority actions	Detail actions	Target Forest	Consideration points for prioritization
1	Protection of forest	- Protection from illegal felling	- Conservation forest - Protection forest	- Upper watershed - Area where larger rainfall change is expected (especially more rainfall) - Area with higher productive aquifers - Critical area
2	Fire prevention	- Fire prevention works - Preparation for firefighting equipment - Monitoring of hot spots	- Conservation forest - Protection forest - Production forest	- Upper watershed - Area where larger rainfall change is expected (especially less rainfall) - Area where lower ground water level is expected - Critical area
3	Rehabilitation work	- Regeneration improvement works	- Protection forest	- Upper watershed - Area where larger rainfall change is expected (especially more rainfall) - Area with higher productive aquifers - Critical area
4	Sustainable management	- Sustainable forestry practice (such as	- Production forest	- Upper watershed - Area where larger rainfall change is expected (especially more rainfall) - Area with higher productive aquifers - Area where lower ground water level is expected - Critical area - Large forest concession holder
5	Monitoring	- Monitoring of impact to the ecosystem by climate change	- Conservation forest - Protection forest - Production forest	- Area where rainfall pattern is changed - Area where higher temperature rise is expected - Area where disease or pest attack is recorded - Critical area where soil is degraded by climate change
6	Promotion of plantation outside forest land	- Public information and environmental education - Technical support and seedling production	- Outside forest land	- Upper watershed - Area with the slopes - City area

Source: JICA Project Team 2

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

The contents of the adaptation and mitigation measures which are proposed to be incorporated into POLA and RENCANA in the next review stage reflecting climate change impacts are stated hereunder. The adaptation measures are compiled to (i) water resources management, (ii) sabo management, (iii) watershed conservation and (iv) groundwater management. And Table 6.6.1 is compiled based on the study results of the adaptation and mitigation actions against climate change impacts as of the target year 2050.

Table 6.6.1 Climate Change Measures to Five Pillars

1. Water Resources Conservation

Goals / Targets to be Achieved	Climate Change Measure
(1) Protection and conservation of Water Resources	
Boundary of a watershed conservation area must be defined in spatial plans prepared by local governments	➢ Boundary of watershed conservation area must be defined in spatial plans as soon as possible.
Adjustment of land use plan between provincial government and each regency/ city	➢ Adjustment of land use in each spatial plan by regencies must be adjusted as soon as possible.
<u>Construction of recharge wells</u> Legislation for construction of recharge well at each house to obtain building permit.	➢ Construction of recharge wells is itself one of the climate change measures for groundwater resources protection and conservation. However, the effective area for recharge wells in regional scale may be changed from the present climate condition. ➢ Legislation for construction of recharge wells at each house is to obtain building permits that shall be developed as soon as possible.
Green open space (RTH) is set at more than 30% in the rural forest area.	➢ Considering more risk on the forest fire and fire prevention measures need to be strengthened. ➢ Impact on the ecosystem by climate change shall be monitored and studied to keep and/or improve the current vegetation. Selection of the plantation species should also be considered to adopt the climate change.
Society has a high understanding to the importance of the environmental management and conservation for river water in the Brantas River basin	➢ Considering more importance of the environmental management and conservation for river water in Brantas River basin, the environmental education and public information shall be strengthened.
Establishment of the water resources utilization zone considering water demand and location of the water source developed area.	➢ At present, this method is useful due to the sufficient water. Under the future climate condition, the water resources utilization zone shall be changed from the present climate condition. ➢ Monitoring of the intake discharge and supply discharge from the storage structures shall be carried out following present monitoring system.
Utilization of water resources in the zones and control of supply water from water resources	➢ To follow present water allocation system At present, TKPSDA considers run-off in the Brantas River in a drought year, normal year and rich year. The water demands are collected from request of the farmers associations and license volume of PDAMs and industrial companies. Based on the three cases, PJT-I carries out simulation of water allocation to use water demand and run-off. PJT-I adjusts water demand from the trial and error simulation. Finally, TKPSDA decides that the water allocation to next year in the Brantas River basin.

Goals / Targets to be Achieved	Climate Change Measure
	Under the future climate condition, PJT-I shall use simulated run-off data.
Control of upland cultivation	➢ To maintain a small size of wetland paddy field plots on slope for keeping sustainable water retention capacity ➢ To rehabilitate or improve the function of terracing in dry upland field areas for reducing surface soil loss by erosion and sedimentation in reservoir
Reducing the degraded land (critical land)	➢ The degraded land shall be rehabilitated as soon as possible to reduce the risk of flood and soil removal to keep water conservation capacity of the watershed.
Preservation of protected forests, nature reserves and conservation area	➢ Conservation of protected areas especially in the upper river basin will be more important for enhancing water retaining capacity ➢ Considering the increase in risk of the forest fire, fire prevention measures need to be strengthened. ➢ Impact on the ecosystem from the climate change shall be monitored and studied to protect flora and fauna.
(2) Water Preservation	
Construction of new infrastructure, rehabilitation and maintenance of water supply infrastructure for water saving	➢ Replacement of PDAM's pipeline ➢ Rehabilitation and/or reconstruction of tertiary canal ➢ Construction of the recycle plant by each industrial company
Construction of recharge wells in all houses	➢ Recharge wells enhance groundwater storage capacity under the future climate condition.
Improvement water quality from the environmental management	➢ Water quality degradation by the heavy rain shall be controlled by reducing soil degradation by Sabo measures such as check dams, contour cropping, gabions, and agroforestry. The appropriate application of fertilizer also contributes to keep the discharge of eutrophication substances by the flood. ➢ Water quality degradation during lower water by climate change impact shall be controlled by (1) keeping the current lowest water level as well as (2) wastewater treatment.
Construction of storage structures	➢ Five new dams are proposed to the medium scenario.
Water license is given to the actual water demand.	➢ At present, an amount of the water right is sometimes bigger than an actual water intake volume. This matter shall be settled under the present climate condition.
Control of groundwater source	➢ To develop new groundwater resource, an investigation of the groundwater development for drilling new well shall be needed. ➢ It is important to monitor the groundwater level and spring water discharge continuously. The monitoring system shall be developed immediately for the future climate change. ➢ The survey on the actual use of groundwater shall be implemented to identify the area for regulation. Then compiling laws and regulations on groundwater at an operational level should be developed as soon as possible to control the groundwater use.
Enabling community's role in storing water	➢ Water storing facilities, such as rainfall storage by tank and underground, are installed in each village and each house.
(3) Water quality management and water pollution control	
Maintaining Program-based pollution control management (PROKASIH) activities regularly throughout WS Brantas	➢ Wastewater treatment facilities are installed and properly operated for companies and human settlement with the law enforcement to meet the wastewater quality standard.

2. Water Resources Utilization

Goals / Targets to be Achieved	Climate Change Measure
(1) Water Resources Operation/ Maintenance	
Achievement adjustment of the spatial plan to collaborate the local governments (East Java Province and Regency/ City)	➢ To adjust a spatial plan considering the demand center and availability of surface water in future spatial plan
Application of the water utilization zone maps	➢ Future water utilization zone maps shall be prepared based on future spatial plan
Water demand forecast up to 20 years	➢ It is noted that the unit water requirement is affected from the climate change condition.
(2) Water Resources Provision	
Construction of new infrastructure, rehabilitation and maintenance of water supply infrastructure	➢ Five new dams shall be constructed under the medium scenario. ➢ Rehabilitation of tertiary canals in irrigation schemes. ➢ Replacement of PDAM's pipeline ➢ Construction of recycle plant by each industrial company.
(4) Water Resources Use	
Even the available water in the Brantas River basin is an adequate volume, uneven distribution of water demand occurred.	➢ The available water under the future climate condition will not be enough. Additional measures (saving water and increasing storage water) shall be applied. ➢ The local governments shall consider water allocation in their territories during the preparation of spatial plan.
(5) Water Resources Development	
Utilization and re-development of existing water sources	➢ Heightening of the Sutami Dam, if necessary. ➢ Rehabilitation of existing ponds
(6) Water Resources Extension	
Creation of incentive and disincentives mechanisms for water management by all parties in WS Brantas	➢ Already created this system and implemented by PJT-1.

3. Water Destructive Force Control

Goals / Targets to be Achieved	Climate Change Measure
(1) Disaster Prevention	
Achievement of the comprehensive flood control	➢ Extreme flood will be increased under future climate condition. Therefore, strengthening of non-structural measures is an important issue. ➢ Mainstream was already constructed dike system. In Brantas River, flood control structure shall be constructed to tributaries. At this time, several conditions, such as climate condition, and land use, shall be considered. The protection level in the tributary shall be considered from the above condition and protection level of mainstream. ➢ Strengthening of the non-structural measures ➢ Preparation of flood management plan considering climate change impact (It shall be included in POLA) ➢ Execution of the detailed study to selected rivers. ➢ Construction of flood management structure based on the flood management plan ➢ Preparation of advance flood action plan
Achievement to establish a community-based early warning system	➢ To increase the number of community-based EWS (present: 21 villages) ➢ Installation of EWS by using smart phone in the Brantas River basin (PJT-I already developed this system in Bengawan Solo.)
Development of river degradation control from	➢ Some control structures were already installed. BBWS Brantas shall execute construction works following the

Goals / Targets to be Achieved	Climate Change Measure
technical and non-technical measures	proposed structures under the Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project.
Improvement sediment dredging program and review of POLA of Reservoir operation (All Reservoirs in the Brantas River basin)	➢ Installation of additional dredger to Selorejo Dam

4. Water Resources Information System

Goals / Targets to be Achieved	Climate Change Measure
(1) Improvement of Government Role	
Achievement of the comprehensive flood control	➢ Preparation of advance Flood Action Plan and shearing of its plan. It is organized for action of disaster prevention (flood) and implementing agencies in time series focusing on “when”, “who”, and “what to do”.
(2) Provision of accurate information	
Achievement of the water resources information system including the development of inter-agency management information system	➢ Water resources information system was already developed by BBWS Brantas. Some information and data related to the water resources by BBWSBS were stored in this system. However, local governments are not put into their own data; even they exchange a memorandum of understanding. Firstly, related agency put into their data, such as rainfall, water level, and structural information to the data server. The information and data under PJT-I are not sheared. These problems shall be settled as soon as possible.

Source: JICA Project Team 2

6.6.1 Climate Change Measures against Rainstorms and Floods

(1) Water Resources Management

Structural Measures

The structural measures are decided from the protection level under the future climate condition. The protection level is set from damage cost (MSA) considering the priority of the development schemes in the Brantas River basin and balance of protection level of other tributaries. The proposed structures considering the future climate condition can increase the protection level for the present. However, it is necessary to consider the combination of the dike and other structural measures when the detail flood management planning under future climate condition is carried out.

The target protection level is reconsidered when the climate condition and land use are changed and assets of the affected people are increased.

Non-Structural Measures

It is necessary that the affected people and related agencies take action based on the non-structural measures, when the extreme flood event is occurred.

The climate change measures are studied in above sections. Table 6.6.2 and Table 6.6.3 show climate change measures.

Table 6.6.2 Structural Measures against Rainstorms and Floods (Medium Scenario)

Location	Measures	Protection Level
Widas River	Dike construction (Height = 1.9 m at upper Widas R., 1.2 m at Kedung R. and 1.5 m at lower Widas R., Length = 52.3k m)	17 year
Ngotok River	Dike construction (Height = 1.3 m, Length = 43.1 km)	50 year
Sadar River	Dike construction (Height = 0.5 m, Length = 6.8 km)	16 year
Tawing River	Dike construction (Height = 2.1 m, Length = 26.6 km)	30year
Porong River	Dike construction (Height = 0.8 m, Length = 40.1 km)	50 year

Source: JICA Project Team 2

Table 6.6.3 Non-Structural Measures against Rainstorms and Floods

Measure	Details
Upgrading FFWS	➢ Developing the flood forecasting model ➢ Flood forecasting information service to concerned agencies and communities ➢ Storing hourly rainfall and water level data to server
Community based EWS	➢ Increasing the number of target communities ➢ Developing the information system by using smart phone
Evacuation	➢ Preparation of hazard maps for several probable floods ➢ Designation of the evacuation centers considering inundation area ➢ Construction of the evacuation centers considering inundation area
Land Use Control	➢ Local governments prepare a spatial plan considering inundation area ➢ Local governments shall consider the restricted areas which are frequently inundated area.
Flood Action Plan	➢ It is organized for action of disaster prevention (flood) and implementing agencies in time series focusing on “when”, “who”, and “what to do”.
Capacity Development of Flood Fighting Team	➢ It is necessary to keep a high level of knowledge and skills to flood fighting. Therefore, the capacity development of the flood fighting teams and concerned agencies are required.
Business Continuity Plan/ Management	➢ A business continuity plan/ management (BCP/ BCM) is a plan to help ensure that business processes can continue during a time of emergency or disaster. The private companies and local governments shall prepare BCP or BCM.

Source: JICA Project Team 2

(2) Sabo Management

The climate change measures for the Sabo management are studied in the previous sub-sections. Table 6.6.4 shows non-structural measures against climate change impact. The structural measure is to implement the current basin-wide sediment management plan ahead of the original schedule.

Table 6.6.4 Non-Structural Measures against Sedimentation for Sabo Management

Measures	Details
Use of coagulant against fine–grained sediment	➢ Consolidation of dredged sediment ➢ Able to use for civil engineering materials or agricultural materials
Dredging	➢ Regular dredging of existing Sabo facilities to increase their trap capacity ➢ Highest Priority: Dredging of Sabo facilities in the upstream areas of Sengguruh Dam
Comprehensive Sediment Management Plan	➢ Basin-wide Sabo plan in addition to the volcanic Sabo plan against the Brantas River basin

Source: JICA Project Team 2

(3) Watershed Conservation

Regarding the watershed conservation against the rainstorm and floods, in POLA, the forest management is generally described from the point of forest land classification and critical land.

The climate change may make an impact more serious and preventive measures to keep and improve the current forest cover are the key for adaptation. Yet, the impact on the forest ecosystem is unknown by the climate change, and it is important to start the preventive measures as well as monitoring of the forest ecosystem especially in the priority areas which is contributing to water retaining capacity or which is to be affected by the rain pattern change and temperature rise.

Thus, it is proposed to include in POLA and RENCANA as follows.

Policy level: to keep and improve the forest cover in the forest land as well as the whole Brantas watershed.

6.6.2 Climate Change Measures against Drought

(1) Water resources management

Tables 6.6.5 and 6.6.6 show adaptation measures to future climate condition.

(2) Groundwater Resources Management

The operational policies on groundwater resource management in current Review POLA/RENCANA are presented in Table 6.6.7. The directions of the operational policies for managing groundwater resources in the Brantas River basin are related to two aspects: Water Resource Conservation and Water Resources Utilization.

Table 6.6.5 Structural Measures against Drought

Measures	Location	Details
Kedungwarak Dam	Widas River basin	Type: Rockfill, Hight:25.3m, Crest length:164.3m
Kuncir Dam	Widas River basin	Type: Rockfill, Hight:100m, Crest length:450.5m
Babadan Dam	Bendokrosok	Type: Rockfill, Hight:80m, Crest length:179m
Kont II Dam	Konto River	Type: Rockfill, Hight:120m, Crest length:1,004m
Genteng I Dam	Kesti River	Type: Rockfill, Hight:84m, Crest length:441m

Source: JICA Project Team 2

Table 6.6.6 Non-structural Measures against Drought

Measure	Details
Changing water sources from surface water to groundwater	➢ PDAM Water of Blitar: 0.48m^3/s ➢ Industrial Water: Upper reach: 0.66m^3/s Middle reach: 0.09m^3/s ➢ Additional wells are required.
Introducing SRI	➢ Even though the effectiveness of SRI method on irrigation water saving has yet to be commonly quantified on the irrigation scheme basis, experimental works done by the Bogor Agricultural University in Indonesia revealed that SRI method applied to dry season rice cultivation can be reduced by 3.35% of irrigation water consumption and increased by 9.15% of irrigation water productivity (g grain/ kg water) compared with conventional irrigation regimes.
Preparation of drought action plan	➢ It is organized for the action plan of local governments, private companies, hospitals, and residents before and during drought situation.
Public relations of reservoir water level of each dam	➢ PJT-I shows time series of actual and planned water levels in the website. ➢ When the actual water level is lower than the planned water level, the local governments shall inform the residential people through public relation.
Domestic water supply support system	➢ When the domestic water supply is in severe situation in the Brantas River basin compared with the adjacent river basins, domestic water supply from the adjacent basins by using tank lories and increasing supply water volume through pipeline shall be carried out. ➢ It is necessary to make an agreement among the representative agencies at the adjacent river basins.

Source: JICA Project Team 2

Table 6.6.7 Review POLA/RENCANA

Aspects	Strategy in Review POLA/ RENCANA	Operational Policy Proposed in Review POLA/RENCANA
Water Resources Conservation	Construction of infiltration well in every house as set in the Regional Regulation, which can be associated as the requirement for obtaining a Building Construction Permit (IMB), power supply and other facilities (entire area of Brantas River basin)	Selective issuance of IMB (Building Construction Permit) and provision of other public service facilities such as electricity and telephone.
Water Resources Utilization	Groundwater use permit and groundwater allocation as well as control of the distribution of groundwater exploited by optimizing the water's benefits (the entire Brantas River basin)	Compiling the laws and regulations on groundwater at the operational level. Providing counseling or imposing sanctions to those who extract groundwater without permission

Source: JICA Project Team 2

The preservation of groundwater should consider maintaining a balance between recharging and groundwater extraction. Some methods of groundwater management are (1) artificial groundwater recharging and (2) control of groundwater extraction. The construction of infiltration (injection) wells in every house as set in the Regional Regulation is a measure to enhance a groundwater storage capacity, while groundwater use permit and groundwater allocation as well as control of groundwater distribution are measures to prevent uncontrolled groundwater extraction.

The countermeasures proposed in the Review POLA/RENCANA and adaptation measures against droughts under the climate change with the target year of 2050 are compared in Table 6.6.8. The measures presented in the Review POLA/RENCANA are effective against future climate change, but some additional measures targeting a drought in 2050 can be proposed here. The additional measures are to establish basic data to enable a wider response to climate change which is difficult to predict and adapt to, and to make the measures in the Review POLA/RENCANA more specific.

Table 6.6.8 Countermeasures in Review POLA/RENCANA and Proposed Additional Adaptation Measures in 2050

Countermeasures in Review POLA/ RENCANA	Proposed adaptation measures against droughts in 2050
Artificial groundwater recharging using injection well	➢ Artificial groundwater recharging using injection well ➢ Investigation of the groundwater development for drilling new well including groundwater potential study ➢ Establishment of monitoring system for groundwater level and spring water
Control of groundwater extraction under the lows and regulations	➢ Survey on the actual use of groundwater to identify the area for regulation ➢ Control of groundwater extraction under the laws and regulations

Source: JICA Project Team 2

(3) Watershed Conservation

Regarding the watershed conservation against droughts, in POLA, the forest management is generally described from the point of forest land classification and critical land.

The climate change may make an impact more serious and preventive measures to keep and improve current forest cover is the key for adaptation. Yet the impact on the forest ecosystem is unknown by the climate change, and it is important to start preventive measures as well as monitoring of the forest ecosystem especially in the priority areas which is contributing to the water retaining capacity of which is to be affected by the rain pattern change and temperature rise.

Thus, it is proposed to include in POLA and RENCANA as follows.

Policy level: to keep and improve the forest cover in the forest land as well as the whole Brantas watershed.

6.6.3 Organization and Institution

(1) Relevant Agencies

As presented in Table 6.6.1, the proposed climate change adaptation measures in the Brantas River basin cover a lot of ground and thus there are various implementing and related agencies. Table 6.6.9 summarizes the goals/ targets of the proposed adaptation measures and expected implementing agencies. Among others, the key relevant agencies and coordinating bodies at the basin level are enumerated in Table 6.6.9.

Table 6.6.9 Proposed Measures and Expected Implementing Agencies

Aspect	Sub-aspect	No.	Goals / Targets of Climate Change Measure	Expected Agencies
1. Water Resources Conservation	1.1 Protection and conservation of water resources	1	Definition of watershed conservation areas	BPDASHL, Dishut, forest departments of LGs
		2	Adjustment of land use plan between province and each regency/ city	DPRKPCK, BAPPEDA, spatial planning departments of LGs
		3	Legislation for construction of private recharge well	ESDM of LGs, BBWS-B
		4	Achievement of green open space (RTH) of more than 30%	BPPW JTIM, settlement departments of LGs
		5	Environmental education and public information	DLH, PJT-I, Others
		6	Establishment of water resources use zone considering water demand and water source	BBWS Brantas, BAPPEDA, water resources departments of LGs
		7	Utilization of water resources in the zones and control of water supply	TKPSDA, PJT-I, BBWS Brantas, PDAMs, Others, Private sector
		8	Control of upland cultivation	Agriculture departments of LGs
		9	Reducing degraded land (flood critical land)	BAPPEDA, BBWS Brantas
		10	Preservation of protected forests, nature reserves and conservation area	BPDASHL, Dishut, PJT-I, Perum Perhutani
	1.2 Water preservation	11	Construction, rehabilitation and maintenance of water supply infrastructure for water saving	BBWS Brantas, PJT-I, PDAMs, LGs, Private sector
		12	Construction of recharge wells in all houses	ESDM of LGs, BBWS Brantas
		13	Improvement of water quality through environmental management	BBWS Brantas, DLH, PJT-I, LGs, Private sector
		14	Construction of storage structures	BBWS Brantas, LGs
		15	Provision of water license to actual demand	BBWS Brantas, PJT-I
		16	Control of groundwater source	ESDM of LGs
		17	Enabling community's role in storing water	LGs, Others
	1.3 Water quality management and pollution control	18	Maintaining Program-based pollution control management (PROKASIH) activities	DLH, LGs, Others
2. Water Resources Utilization	2.1 Water resources operation/ maintenance	19	Adjustment of spatial plan considering demand center and surface water availability	DPRKPCK, BAPPEDA, LGs
		20	Application of water utilization zone maps	DPRKPCK
		21	Water demand forecast up to 20 years	BBWS Brantas, PDAMs
	2.2 Water resources provision	22	Construction, rehabilitation and maintenance of water supply infrastructure	BBWS Brantas, PJT-I, PDAMs, LGs, Private sector
	2.3 Water resources use	23	Implementation of measures for efficient water use (in terms of water saving, storage, allocation, etc.)	TKPSDA, BBWS Brantas, PJT-I, PDAMs, Private sector, LGs, Others
	2.4 Water resources development	24	Utilization and re-development of existing water sources	BBWS Brantas, PJT-I, LGs
	2.5 Water resources extension	25	Creation of incentive and disincentives mechanisms for water management	PJT-I, BBWS Brantas
3. Water Destructive Force Control	3.1 Disaster prevention	26	Implementation of comprehensive flood control	BBWS Brantas, PJT-I, LGs
		27	Establishment of a community-based early warning system	BBWS Brantas, PJT-I, BPBD
		28	Control of river degradation through technical and non-technical measures	BBWS Brantas, PJT-I
		29	Improvement of sediment dredging program and review of reservoir operation	PJT-I, BBWS Brantas
4. Water Resources Information System	4.1 Improvement of government role	30	Implementation of comprehensive flood control	TKPSDA, BBWS Brantas, PJT-I, BPBD, LGs
	4.2 Provision of accurate information	31	Establishment of water resources information system including the development of Inter-Agency Management Information System	BBWS Brantas, PJT-I, LGs

Notes: 1) Abbreviations other than those listed below are commented in the following main body.
LGs (Local Governments): relevant sectoral departments of provincial and city / regency governments
ESDM (*Energi dan Sumber Daya Mineral*) = Energy and Mineral Resources
BPPW JTIM *(Balai Prasarana Permukiman Wilayah Jawa Timur*) = East Java Regional Settlement Infrastructure Agency
Perum Perhutani is a state-owned enterprise that has the duty and authority to plan, manage, exploit and protect forests.
2) Expected implementing agencies were discussed with some agencies through interviews mentioned below and comments and suggestions from the agencies have been reflected in the above table.

Source: JICA Project Team 2

(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 6.6.10. Since some questions are not applicable for some agencies, the questions were properly selected depending on the agency. Besides, the emphasis was put on identifying the issues through discussions rather than collecting information itself.

Table 6.6.10 Summary of Questions on Organizational and Institutional Concerns

Category	Questions
Organizational Functions	Q 1-1) Implementing 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

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

The major findings from the interviews are summarized and enumerated in Table 6.6.11. The source of description is presented at the end of each description.

Table 6.6.11 Findings through Interview Survey

Findings	Source
Organization functions (for Q1-1 to Q1-3)	
Responsibility of the spatial planning at a provincial level was changed from BAPPEDA to DPRKPCK in January 2019 in accordance with the Government Regulation No.18/2016.	BAPPEDA JATIM, DPRKPCK JATIM
BAPPEDA is responsible for short/medium/long-term planning and budgeting at the provincial level. Once the budget is allocated, the respective departments (dinas) are supposed to implement the projects. The demarcation and procedure are clear.	BAPPEDA JATIM
ESDM is generally considered responsible for groundwater management, although BBWS Brantas also has a section dealing with groundwater.	Dinas PU SDA JATIM
A hydrological, hydrogeological and hydro-climatological information system named SIH3[6] is being developed jointly by BBWS Brantas, PJT-I, BMKG and the local governments. However, it has not been discussed which agency will be proactive in operating it in the future.	BBWS Brantas, Dinas PU SDA JATIM, PJT-I,
TKPSDA and Forum DAS are coordinating bodies established under the frameworks of MPWH and MEF, respectively. Water resources management and watershed management sometimes overlap.	PJT-I
DLH is responsible for controlling water pollution from industries. On the other hand, the water quality of overall river is managed by BBWS Brantas and PJT-I.	DLH JATIM
BPPW, which was newly established in 2019 in each province, will be a leading agency of green open space (RTH) to be implemented in urban areas. BPDASHL is basically responsible for forest areas.	BBWS Brantas
Coordination between agencies (for Q1-4)	
TKPSDA holds regular meetings basically four times a year. In addition, BBWS-Brantas' O&M division that is a leading body of TKPSDA holds individual discussions with member agencies.	BBWS Brantas
Water allocation is annually determined by TKPSDA meetings through discussions among BBWS Brantas, PJT-I and the local governments. PJT-I estimates the detailed water demand at each intake point, while BBWS Brantas is responsible for the overall water balance calculation for the basin by using the detailed calculation results provided by PJT-I.	BBWS Brantas, PJT-I
Since various forums are organized, there are no obvious problems in coordination even among different sectors.	BAPPEDA JATIM, DLH JATIM
Regional Spatial Planning Coordination Team (TKPRD[7]) is a coordinating body established at the provincial and city/regency levels, respectively and its members are relevant departments and stakeholders.	Dinas PU SDA JATIM DPRKPCK JATIM
The discrepancy of spatial plans between the province and city/regency is sometimes caused by planning time-lag. In other cases, it is caused by a policy difference in either conservation or development. In that case, provincial BAPPEDA should coordinate	BBWS Brantas DPRKPCK JATIM

[6] SIH3 (*Sistem Informasi Hidrologi Hidrogeologi Hidroklimat*)
[7] TKPRD (*Tim Koordinasi Perencanaan Ruang Daerah*)

Findings	Source
with both sides.	
The recognition of the initial response in the event of a disaster has not been shared among agencies. The general matters have been determined, while details have not in some cases.	Dinas PU SDA JATIM
Law enforcement to illegal behaviors (for Q2-1 to Q2-3)	
TKPSDA engages in educational activities on illegal dumping and illegal mining. However, neither TKPSDA nor PPNS have authority to control the illegal behaviors. BBWS is not authorized to directly control factories that cause water pollution therefore, only informs the authorities by an official letter	BBWS Brantas
DPRKPCK is not in a position to perform law enforcement even if illegal buildings or activities are found. They can only inform the authorities. The surveillance systems should be established by city/regency governments.	DPRKPCK JATIM
Local governments have a system of Satpol PP for environmental conservation and maintaining security in the area. Satpol PP is authorized to take actions against illegal behaviors including removal of illegal building in the river area	DPRKPCK JATIM, Dinas PU Bina Marga dan SDA Kab. Sidoarjo
DLH is authorized to perform law enforcement. For example, if a problem is found through a periodic surveillance, the factory operations can be suspended	DLH JATIM
Regulations to be added or improved (for Q2-4)	
General regulations to be referred by BAPPEDA seem adequate, while more detailed regulations to be referred by each sectoral department may be improved or added.	BAPPEDA JATIM, DPRKPCK JATIM
Since the ministerial regulations are legislated by each sector, sometimes they are not directly applicable to operations of local governments. To define them clearly and in more detail, the regional regulations are legislated at a local level.	DLH JATIM, Dinas PU Bina Marga dan SDA Kab. Sidoarjo
Local governments tend not to deal with issues outside the jurisdiction in order to avoid problems in audits. It is better to create a regulation that can deal with such cases more flexible.	BBWS Brantas
Human resources (for Q3-1 & Q3-2)	
Although entire BAPPEDA has about 200 staff, the sub-division dealing with climate change issues has only ten staff. There is a lack of expertise in climate change.	BAPPEDA JATIM
The decision-making level of the staff is sufficient, but the practical level of the staff in the field is insufficient in terms of both quality and quantity.	Dinas PU SDA JATIM
DPRKPCK has about 30 staff for the section dealing with spatial planning. However, they are also in charge of evaluating city/regency spatial plans and thus manpower is not sufficient.	DPRKPCK JATIM
Technical field that require capacity development are: climate change*1, spatial mapping using GIS*2, civil engineering and water resources management*3, and basic civil engineering, especially water resources management*4.	*1: BAPPEDA JATIM *2: DPRKPCK JATIM *3: Dinas PU Bina Marga dan SDA Kab. Sidoarjo *4: BBWS Brantas

Findings	Source
Financial arrangements (for Q4-1 to Q4-3)	
When an unexpected budget is required, a special budget can be applied for if it is caused by a disaster event. However, if it is caused by a sudden event other than a disaster, the budget could not be secured. Since the emphasis tends to be placed in the construction stage, a sufficient budget for planning could not be secured. In those cases, the satisfactory analysis may not be conducted at the survey and planning stage. Financial capacities of most local governments do not seem to be adequate and therefore they often rely on BBWS Brantas.	BBWS Brantas
There are no obvious problems in the financing system itself.	BAPPEDA JATIM, DRPKPCK JATIM, Dinas PU Bina Marga dan SDA Kab. Sidoarjo
Despite the increasing impacts of climate change, the budget for the countermeasures remains at the previous level with little increase	BAPPEDA JATIM
A new budgeting system will be introduced from next year. It enables allocation of river-specific budget from the national government to provincial government	Dinas PU SDA JATIM
There are no obvious problems in the financial capacity. The funds are operated in accordance with the priorities considering community opinions as well	Dinas PU Bina Marga dan SDA Kab. Sidoarjo
Others	
There is no trouble in administrative boundaries of the existing lands in East Java. However, there are cases in which the administrators of the newly-generated lands due to sedimentation or eruption could not be definitively determined. In other cases, when the administrative boundaries do not match the topographical conditions, then both sides are confused on the use of the land	DRPKPCK JATIM

Source: JICA Project Team 2

(4) Considerations

As stated above, the interview surveys revealed the both good and poor aspects. As a whole, the existing institutional framework and organizational arrangement for water resources management in the Brantas River basin seem adequate. However, some significant concerns were identified. Since some of them are common to that of the Musi River basin, remedial actions are recommended in Chapter 12 together with the Musi River basin.