THE REPUBLIC OF INDONESIA
DIRECTORATE GENERAL OF
WATER RESOURCES
MINISTRY OF PUBLIC WORKS AND HOUSING

THE REPUBLIC OF INDONESIA
THE PROJECT FOR ASSESSING AND INTEGRATING CLIMATE CHANGE IMPACTS INTO THE WATER RESOURCES MANAGEMENT PLANS FOR BRANTAS AND MUSI RIVER BASINS
（Water Resources Management Plan）

FINAL REPORT

VOLUME-II MAIN REPORT

December 2019

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
THE UNIVERSITY OF TOKYO

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THE PROJECT
FOR
ASSESSING AND INTEGRATING CLIMATE CHANGE IMPACTS INTO THE WATER RESOURCES MANAGEMENT PLANS
FOR
BRANTAS AND MUSI RIVER BASINS
(Water Resources Management Plan)

Composition of Final Report

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REPORT ON COMPONENT 1（ANNEX）

HANDBOOK

Volume IV DATA BOOK/CD

Brantas River Basin

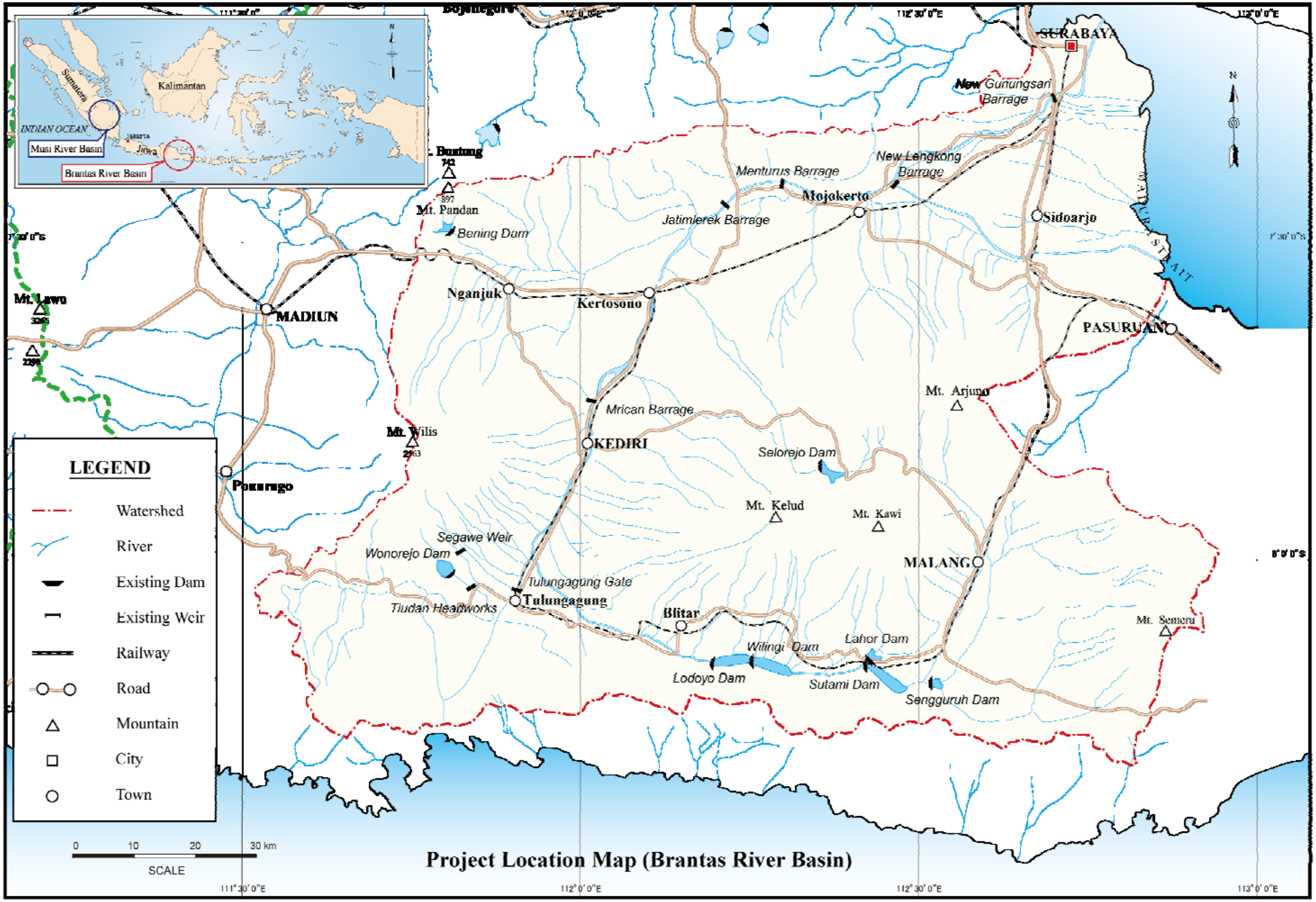
Cost Estimate: August 2017 Price

Exchange Rate: USD 1.0 = IDR 13,341.82 = JPY 109.84

Musi River Basin

Cost Estimate: March 2019 Price

Exchange Rate: USD 1.0 = IDR 14,230.00 = JPY 111.10


Project Location Map (Brantas River Basin)
LEGEND
Watershed
River
Existing Dam
Existing Weir
Railway
Road
Mountain
City
Town
0
10
20
30 km
SCALE
Kalimantan
Sumatera
INDIAN OCEAN
Musi River Basin
Brantas River Basin
Jawa
SURABAYA
New Gunungsari Barrage
New Lengkong Barrage
Menturus Barrage
Mojokerto
Jatimlerek Barrage
Sidoarjo
PASURUAN
Mt. Pandan
Bening Dam
Nganjuk
Kertosono
MADIUN
Mt. Lawu
Mt. Arjuno
Mrican Barrage
Mt. Wilis
KEDIRI
Selorejo Dam
Ponorogo
Mt. Kelud
Mt. Kawi
Segawe Weir
Wonorejo Dam
MALANG
Tulungagung Gate
Tulungagung
Tiudan Headworks
Blitar
Mt. Semeru
Wlingi Dam
Lahor Dam
Lodoyo Dam
Sutami Dam
Sengguruh Dam
111° 30' 0"E
112° 0' 0"E
112° 30' 0"E
113° 0' 0"E
8° 0' 0"S

Project Location Map (Musi River Basin)

1. Brantas River Basin (1/2)

Mrican Barrage

Jatimlerek Rubber Dam

New Lengkong Dam

Gunugsari Barrage

Sutami Dam

Wlingi Dam

1. Brantas River Basin (2/2)

Sengguruh Dam (Maintenance Dredging in the Reservoir)

Wonorejo Dam

Porong Automatic Water Level Gauging Station

Ploso Water Quality Monitoring Station

Seminar (Surabaya)

Strategic Environmental Assessment

2. Musi River Basin (1/2)

Ampera Bridge (Musi River)

Sekayu (Musi River)

Tidal Swamp Area (Talang I)

Fresh Water Swamp Area (Rumbutan)

Komering Irrigation Area (Belitang)

Perjaya Headwork (Komering Irrigation System)

2. Musi River Basin (2/2)

Water Vang Head Work (Tughumulyo Irrigation System)

Groundwater Observation Well at Mambang

BMKG Kenten Station

Pelindo-II Tide Level Station at Boon Baru

Plenary Meeting in Bengkulu at BWS Sumatra VII

Plenary Meeting in Palembang at BBWS Sumatra VIII

Abbreviations

	English	Indonesia
ADB	Asian Development Bank	-
ADCP	Acoustic Doppler Current Profiler	-
AMDAL	Environmental Impact Assessment	Analisis Mengenai Dampak Lingkungan
APBD	Regional Revenue and Expenditures Budget	Anggaran Pendapatan dan Belanja Daerah
APBN	National Budget	Anggaran Pendapatan dan Belanja Negara
BAKOSURTANAL	National Coordinating Agency for Surveying and Mapping	Badan Koordinasi Survei dan Pemetaan Nasional
BAPPEDA	Regional Planning Agency	Badan Perencanaan Pembangunan Daerah
BAPPENAS	Ministry of National Development Planning	Badan Perencanaan Pembangunan Nasional
BAU	Business as Usual	
BBWS	Large River Basin Organization	Balai Besar Wilayah Sungai
BCM	Business Continuity Management	-
BCP	Business Continuity Plan	-
BCR	Benefit Cost Ratio	-
BIG	Geospatial Information Agency	Badan Informasi Geospasial
BKSDA	Natural Resources Conservation Agency	Balai Konservasi Sumber Daya Air
BLHD	Regional Environment Agency	Badan Linkungan Hidup Daerah
BLU	-	Badan Layanan Umum
BMKG	Meteorological, Climatological, and Geophysical Agency	Bandan Metorologi, Klimatologi, dan Geofisika
BNPB	National Disaster Management Agency	Badan Nasional Penanggulangan Bencana
BOD	Bio-chemical Oxygen Demand	
BPBD	Regional Agency for Disaster Management	Badan Penanggulangan Bencana Daerah
BPDAS	Center for Watershed Management	Balai Pengelolaan Daerah Aliran Sungai dan Hutan Lindung Unda Anyar
BPDASHL	Brantas-Sampean Watershed and Protected Forest Management Organization	Balai Pengelolaan Daerah Aliran Sungai dan Hutan Lindung
BPPW	Regional Settlement Infrastructure Agency	Balai Prasarana Permukiman Wilayah
BPS	Central Agency on Statistics	Badan Pusat Stasistik
BRG	Peatland Restoration Agency	Badan Restorasi Gambut
COD	Chemical Oxygen Demand	-
COP	Conference of Parties	-
DANIDA	Danish International Development Agency	-
D/D	Detailed Design	-
DEM	Digital Elevation Model	-
DGWR	Directorate General of Water Resources	Direktorate Jenderal Sumber Daya Air
Dishut	Department of Forestry	Dinas Kehutanan
DLH	Department of Environmental	Dinas Lingkungan Hidup
DMI	Domestic, Municipal and Industry	-
DNPI	National Council on Climate Change	Dewan Nasional Perubahan Iklim
DO	Dissolved Oxygen	-
DRR	Disaster Risk Reduction	-
DPRKPCK	Regional Development Planning Agency	Dinas Perumahan Rakyat, Kawasan Permukiman dan Cipta Karya
DSM	Digital Surface Model	-
DTM	Digital Terrain Model	-
EC	Electric Conductivity	-
EGM96	Earth Gravity Model 1996	-

	English	Indonesia
EIA	Environmental Impact Assessment	Analisis Mengenai Dampak Lingkungan
EIRR	Economic Internal Rate of Return	-
ENSO	El Nino-Southern Oscillation	-
ESDM	Energy and Mineral Resources	Kementerian Energi dan Sumber Daya Mineral
EWS	Early Warning System	Sistem Peringatan Eini
F/S	Feasibility Study	-
FFWS	Flood Forecasting and Warning System	Sistem Peramalan dan Peringatan Banjir
FPL	Flood Protection Level	-
FSL	Full Supply Level	-
FY	Fiscal Year	-
GCM	Global Climate Model	-
GCP	Geodetic Control Point	-
GDP	Gross Domestic Product	-
GHG	Greenhouse Gas	-
GIS	Geographic Information System	-
GIZ	German Corporation for International Cooperation	-
GOI	Government of Indonesia	-
GOJ	Government of Japan	-
GRDP	Gross Regional Domestic Product	-
GSM	Global System for Mobile communications	-
HDI	Human Development Index	-
HDSS	Hydrometeorological Decision Support System	-
HydroSHEDS	Hydrological data and maps based on SHuttle Elevation Derivatives at multiple Scales	-
IBA	Important Bird Area	-
ICCSR	Indonesia Climate Change Sectoral Roadmap	-
IDR	Indonesia Rupiah	-
IEE	Initial Environmental Evaluation	-
IMB	Building construction permit	Izin Mendinikan Bangnan
IPCC	Intergovernmental Panel on Climate Change	-
iRIC	International River Interface Cooperation	-
IWRM	Integrated Water Resources Management	Pengelolaan Sumber Daya Air Terpadu
JATIM	East Java	Jawa Timur
JBIC	Japan Bank for International Cooperation	-
JCM	Joint Crediting Mechanism	-
JICA	Japan International Cooperation Agency	-
KLHK	Ministry of Environment and Forestry	Kementerian Lingkungan Hidup dan Kehutanan
KP	Design Criteria for Irrigation Networks	Kriteria Perencanaan
KPH	Forest management unit	Kesatuan Pemangkuan Hutan
KPHP	Unity of Production Forest Management	Kesatuan Pengelolaan Hutan Produksi
LARAP	Land Acquisition and Resettlement Action Plan	-
LIBOR	London Interbank Offered Rate	-
LP2B	Preservation of sustainable food production base	Lahan Pertanian Pangan Berkelanjutan

	English	Indonesia
LWL	Low Water Level	-
MEF	Ministry of Environment and Forestry	Kementerian Lingkungan dan Kehutanan
MSBL	Musi-Banyuasin-Sugihan-Lemau	Musi-Sugihan-Banyuasin-Lemaure
MDGs	Millennium Development Goals	-
MH	Rainy season	Musim Hujan
MLIT	Ministry of Land, Infrastructure and Transportation and Tourism	-
MK	Dry season	Musim Kemarau
MOL	Minimum Operation Level	-
M/P	Master Plan	-
MPL	Micro Pulse Lidar	-
MPW	Ministry of Public Works	Kementerian Pekerjaan Umum
MPWH	Ministry of Public Works and Public Housing	Kementerian Pekerjaan Umum dan Perumahan Rakyat
MSA	Multiple Scenario Approach	-
NGO	Non-Governmental organization	-
NPV	Net Present Value	-
NRW	Non-Revenue Water	-
O&M	Operation & Maintenance	-
ODA	Official Development Assistance	-
OKI	-	Ogan Komering Ilir
OKU	-	Ogan Komering Ulu
P2AT	Groundwater Development Project	Proyek Pengembangan Air Tanah
PALI	-	Penukal Abab Lematang Ilir
PCO	Point of Cost Optimum	-
PDAM	Indonesian Regional Water Utility Company	Perusahaan Daerah Air Minum
PELINDO	Indonesian Port Corporation	PT Pelabuhan Indonesia
PIRIMP	Participatory Irrigation Rehabilitation and Management Project	-
PJT-I	Jasa Tirta I Public Corporation	Perum Jasa Tirta I
PKL	Develop Local Activity Centers	-
PKN	National Activity Center	-
PKW	Regional Activity Center	-
PLN	State Electric Company	Perusahaan Listrik Negara
POLA	Water Resources Management Strategic Plan	Rencana Strategis Manajemen Sumber Daya Air
PP	Government regulation	Peraturan Pemerintah
PSDA	Water Resources Management	Pengelolaan Samer Daya Air
PUSAIR	Research center for water resources	Pusat Penelitan dan Pengembangan Sumber Daya Air
RAD-GRK	National Action Plan on Greenhouse Gas	Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca
RAN-API	National climate change adaptation action plan	Rencana Aksi Nasional Adaptasi Peubahan Iklim
PANPI	National Action Plan Addressing Climate Change	Rencana Aksi Nasional Perubahan Iklim
RBO	River Basin Organization	Balai Wilayah Sungai
RENCANA	Water Resources Management Implementation Plan	Rencana Penerapan Manajemen Sumber Daya Air

	English	Indonesia
RO	Reverse Osmosis	-
RPJM	Mid-term Development Plan	Rencana Pembangunan Jangka Menegah
RPJMD	Medium Term Development Plan of Region	Rencana Pembangunan Jangka Menegah Daerah
RPJP	Long-term Development Plan	Rencana Pembangunan Jangka Panjang
RTH	Green open space	Ruang Terbuka Hijau
RTRW	Spatial Plan	Rencana Tata Ruang Wilayah
RUPTL	Electricity Supply Business Plan	Rencana Usaha Penyediaan Tenaga Listrik
RWL	Reservoir Water Level	-
SEA	Strategic Environmental Assessment	-
SHM	Stakeholder Meetings	-
SHVP	Surabaya Haven Vaste Peil	Surabaya Haven Vloed Peil
SID	Study Investigation Design	-
SIH3	Information system for hydrology, hydrogeology and hydrometeorology	Sistem Informasi Hidologi Hidorogeologi Hidroklimat
SNI	Indonesian National Standard	Standar National Indonesia
SPPL	Statement of readiness to manage and monitor the environment	Surat Pernyataan Pengololaan Lingkungan
SRI	System Rice Intensification	-
SRTM	Shuttle Radar Topography Mission	-
SSBSAP	South Sumatra Biodiversity Strategy and Action Plan	-
TKPSDA	Water Resources Management Coordination Team	Tim Koordinasi Pengelolaan Sumber Daya Air
TOT	Training of Trainers	-
TPA	Development of regional Ultimate Waste Management System	-
TRGD	Regional Peat Restoration Service Team	Tim Restorasi Gambut Daerah
UKL-UPL	Environmental Management and Monitoring Plan	Upaya Pengelolaan Lingkungan Hidup dan Upaya Pemantauan Lingkungang Hidup
UNFCCC	United Nations Framework Convention on Climate Change	-
UNISDR	United Nations International Strategy for Disaster Reduction	-
USLE	United Soil Loss Equation	-
UU	Law	Undang-Undang
VAT	Value Added Tax	-
WATSP	Structural Adjustment Program of Water Resources Sector	-
WB	World Bank	-
WEB-DHM	Water Energy Budget-based Distributed Hydrological Model	-
WREFR & CIP,	Water Resources Existing Facilities Rehabilitation & Capacity Improvement Project	-
WUA	Water Users Association	-
WWF	World Wide Fund for Nature	-

SUMMARY

<< GENERAL >>

1. INTRODUCTION

(1) The Project consists of two components, which are:

- Component-1: Climate Change Impact Assessment and Runoff Analysis, and
- Component-2: Water Resources Management Plan.

This Final Report (FR) deals with the Component-2.

(2) The project area covers the following two river basins (hereinafter referred to as "both river basins"), of which the location maps are shown in the frontispieces of this report.

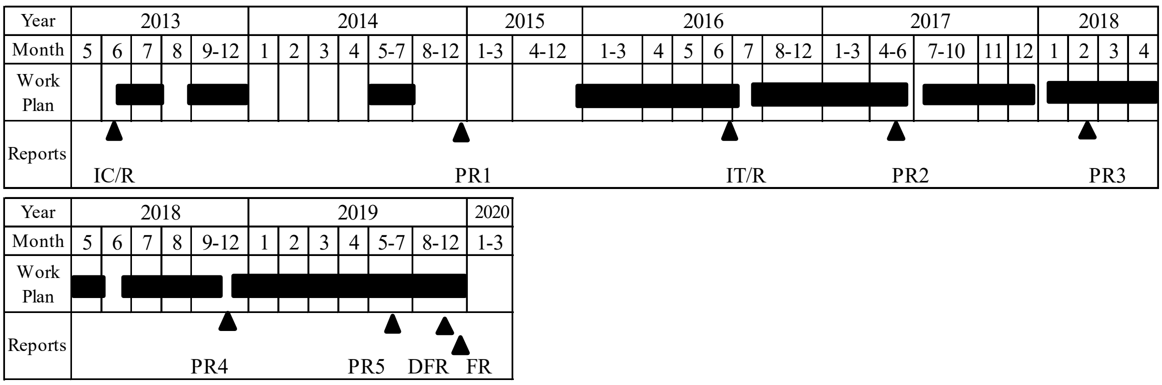
- Brantas River basin in Jawa (approximately 12,000 km^2)
- Musi River basin in Sumatra (approximately 60,000 km^2)

The Musi River basin in the Project includes downstream lowland swamp areas of the Banyuasin and Sugihan River basins adjacent to this river basin.

(3) The objectives of the Component-2 are:

- Assessment of water resources management risk/vulnerability under climate change impacts and formulation of proposals for reflecting climate change impacts in water resources management by using the outputs of the Component-1,
- Preparation of guidelines applicable to other river basins in Indonesia, and
- Capacity enhancement for water resources management in consideration of climate change impacts in Indonesia through the two objectives above.

(4) The project period (revised) of the Component-2 is 79 months from June 2013 to December 2019, and is divided into Phase 1 and Phase 2. Figure S-1 shows the overall schedule of the Component-2.



Source: JICA Project Team 2

Figure S-1 Schedule of the Project (Component-2)

The scope of each phase is as follows:

(a) Phase 1: June 2013 to June 2016

- Collection of data and information to be used for the Component-1,
- Assessment of water resources management risk/vulnerability and resilience under climate change impacts, particularly in terms of flood and drought in both river basins,

(b) Phase 2: July 2016 to December 2019

- Proposal for reflecting climate change impacts in POLA and RENCANA (hereinafter referred to as "the water resources management plans"), and
- Preparation of guidelines which are to be applicable to the water resources management plans in other river basins in Indonesia, taking climate change issues into account.

Besides, capacity enhancement for formulation of water resources management plans with strategies for climate change impacts in Indonesia will be conducted in both phases.

(5) This FR is prepared as the product which states the project outcomes in the Phase 1 and the Phase 2 works conducted from June 2013 to December 2019.

2. MOVEMENT RELEVANT TO WATER RESOURCES IN INDONESIA

2.1 Movement of River Basin Water Resources Management

(1) Integrated Water Resources Management (IWRM) at River Basin Level

Indonesia stipulated 1) role-sharing among central and local governments, 2) fulfillment of basic human needs, 3) introduction of water right and 4) water resources conservation in the Law on Water Resources No.7/2004 (see "Section 2.3"), pressing forward with decentralization after 1999 and the Structural Adjustment Program of Water Resources Sector (WATSP) led by the World Bank. According to these stipulations, it has been important in Indonesia to execute integrated water resources management (IWRM) at a river basin level through participation of the central/local governments and other stakeholders.

(2) River Basin Organization (RBO)

The ministerial regulations, such as No.11A/PRT/M/2006, No.12/PRT/M/2006, No.13/PRT/M/ 2006 and No.26/PRT/M/2006, decided that 5,590 river basins covering the whole Indonesian territory be divided into 133 river regions, and 63 river regions of these be directly managed by MWP (PU). MWP established 33 river basin organizations (RBO; "Balai" in Bahasa Indonesia) in respective sites: RBOs shall be engaged in development and management of these regions. As for the other river basins, about 50 RBOs to be controlled by respective provincial governments have been gradually organized.

(3) POLA and RENCANA

Indonesia has been formulating the following plans (statutory plans) to appropriately realize water resources management for 63 river regions, following the Law on Water Resources No.7/2004:

(a) POLA (Water Resources Management Strategic Plan) which delineates the direction of river basin management, and

(b) RENCANA (Water Resources Management Implementation Plan) which is a concrete plan for implementation of river basin management on the basis of POLA.

Both plans are provided in Government Regulation No.42/2008 for water resources management in Indonesia, wherein several key contents are:

- Water resources management is conducted based on water resources management policies at the national, provincial and regency/municipal levels.
- The water resources management policies consist of the aspects on water resources conservation, water resources utilization, water resources control and information systems.
- POLA is formulated for twenty years, and can be evaluated at least every five years. And
- RENCAN is also formulated for twenty years and can be evaluated at least every five years through public consultation.

(4) TKPSDA (Water Resources Management Coordination Team)

TKPSDA, which is usually chaired by the head of BAPPEDA, is formed as a coordinating organization at the river basin level, of which the major functions are:

- Consultation with agencies concerned for acceleration of IWRM in river basin in charge,
- Promotion of integration and coordination of interests and concessions, etc. among sectors, regions and other stakeholders related to water resources management in river basin in charge,
- Monitoring and evaluation on implementation of programs and plans on water resources management in river basin in charge, and
- Draft POLA deliberation/formulation and draft RENCANA deliberation.

(5) Role Sharing among Central and Local Governments

The role sharing of central and local governments provided in the Law on Water Resources No.7/2004 regarding major items of water resources management is presented in Table S-1.

Table S-1 Role Sharing among Central and Local Governments

Roles	Central Government	Provincial Government	Regency/Municipal Governments
Jurisdictional areas	Cross-provincial, cross-country, and national strategic river basins	Cross-regency/ municipal river basins	River basins in regency/ municipality
Preparation of norm, standards, etc.	Preparation of norm, standards, guidelines, manuals	-	-
Flood control	Nation-wide flood control	Province-wide flood control	Regency/municipality wide flood control
Construction/ improvement of irrigation canals	Primary and secondary irrigation canals in Jurisdictional areas	(Same as the left)	(Same as the left)
Operation/ maintenance and improvement of irrigation systems	Primary and secondary irrigation systems (irrigation areas of more than 3,000ha)	Primary and secondary irrigation systems (irrigation areas of more than 1,000ha and less than 3,000ha)	Primary and secondary irrigation systems (irrigation areas of less than 1,000ha)

Source: Pre-evaluation Report on Project for Capacity Development of RBOs for Practical Water Resources Management in Indonesia, JICA, May 2009

2.2 Movement of Climate Change Measures in Indonesia

The geographical position of Indonesian is very vulnerable to climate change impacts, and Indonesia has been making its efforts and taking actions towards the implementation of the commitments as a Non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC). In 2009, the Indonesia's President committed at the G-20 meeting in Pittsburgh and at COP15 in Copenhagen to an ambitious, world-leading target of 26% reduction in carbon emissions from Business As Usual (BAU) by 2020 to participate in the reduction of GHG emissions. With this commitment, Indonesia has been taking a low carbon development path.

(1) Institutional context

To effectively cope with UNFCCC, the GOI has made a number of significant steps in mainstreaming climate change issues. The first step was the issuance of the National Action Plan addressing Climate Change (MoE, November 2007). The National Development Planning Agency (BAPPENAS) developed a Climate Change Sectoral Roadmap (ICCSR, December 2009), in order to bridge the said National Action Plan into the 5 year National Mid-Term Development Plan (RPJMN) 2010-2014, and to provide inputs for the subsequent RPJMN until 2030.

(2) Organizations concerned

The institutional arrangements coping with climate change have been strengthened at the national and ministerial/agency levels in Indonesia.

(a) National level

The "National Council on Climate Change (DNPI)" to be chaired by the President of Indonesia was established as a cross-ministerial organization in July 2008 according to Presidential Decree (PD) No.46/2008, of which the functions are:

- Formulation of national policies, strategies and action plans,
- Coordination of activities,
- Formulation of policy and procedures of carbon credit mechanism,
- Monitoring and evaluation of climate change activities, and
- Aggrandizement of the country's position through fulfilling its responsibilities to the developed countries.

(b) Ministerial level

Major ministries coping with projection of climate change impacts in Indonesia are: (i) Meteorology, Climatology and Geophysics Agency (BMKG) and (ii) Ministry of Public Works and Housing (MPWH, formerly MPW).

2.3 Repeal of Law No.7/2004 on Water Resources

Indonesia's Constitutional Court ruled that the Law No. 7/2004 on Water Resources was unconstitutional for the following reason, and decided to revoke this law on 18 February 2015:

"The Constitution of the Republic of Indonesia (1945) secures a citizen's right to use water. Hence, a certain restriction shall be laid on the entry of private sector companies into water-supply business."

JICA Project Team 2 for the Component-2 carried out hearings in the Directorate of Water Resources Management, MPWH and also PJT-I in January 2016, aiming to clarify influences of this repeal on the Project. Through these hearings, it was confirmed that the Project can move forward as planned.

<< STUDY FOR BRANTAS RIVER BASIN >>

3. CURRENT CONDITIONS OF BRANTAS RIVER BASIN

3.1 Physical Setting

(1) The Brantas River basin, the second largest river basin in Java, lies between 110˚ 30’ and 112˚ 55’ east longitude and between 7˚ 01’ and 8˚ 15’south latitude in East Java Province. It is bounded by Mt. Bromo (EL. 2,392m) and Mt. Semeru (EL. 3,676m) in the east, a series of low Kidul ridges (EL. 300-500m) in the south, Mt. Willis (EL. 2,169m) and its families in the west, and Kedung ridges and the Madura strait in the north. The Arjuno Mountain Complex consisting of Mt. Arjuno (EL. 3,339m), Mt. Butak (EL. 2,868m) and Mt. Kelud (EL.1,731m) is located in the center of the basin.

(2) The Brantas River originates from the spring of Mt. Arjuno and flows down clockwise round Mt. Kelud. The average riverbed slop gradually changes from 1/200 near the river origin to 1/2,000 in the middle reaches. The Brantas River has a catchment area of about 12,000 km^2 and a length of about 320 km at the point immediately upstream from New Lengkong Barrage where it bifurcates into the Surabaya and the Porong Rivers. Both rivers flow in a very flat plain lower than 25 m in elevation (SHVP) after the bifurcation

(3) The present climate in the Brantas River basin is dominated by the tropical monsoon. Normally, the rainy and the dry seasons prevail from November to April and from May to October, respectively. The average annual rainfall over the basin is around 2,100 mm with a variation of 2,250 mm in a water-rich year and 1,850 mm in a drought year. The annual mean temperature ranges from 24.6 ˚C in Malang to 26.8 ˚C in Porong and the annual mean relative humidity ranges from 74 % to 83 %.

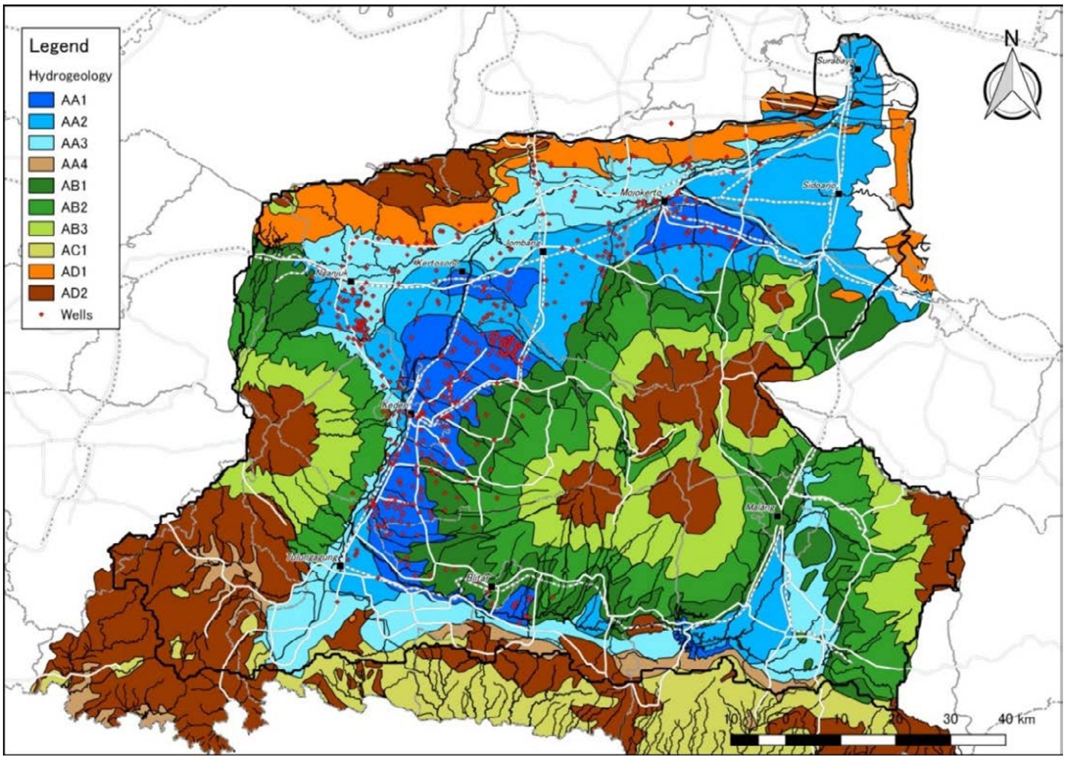
(4) The sea water level at a port in Surabaya City varies from -180 cm to 160 cm with the daily fluctuations of 320 cm at maximum and 70 cm at minimum.

(5) Major aquifers in the Brantas River basin distribute along the Brantas River and its tributaries. A hydrogeological map of 1/250,000 including the Brantas River basin was published in 1984 by the Ministry of Mines and Energy (currently called “Ministry of Energy and Mineral Resources”) as shown in Figure S-2. The hydrogeological classifications in the map are explained in Table S-2.

Table S-2 Hydrogeological Classifications in Brantas River Basin

Classifications	Aquifer Feature	Descriptions
AA1	Extensive and highly productive aquifers	Moderate to high transmissivity; water table or piezometric head of groundwater near or above land surface; wells yield generally 5 to 10L/s, locally more than 50L/s.
AA2	Extensive and productive aquifers	Aquifer of moderate transmissivity; water table or piezometric head of groundwater near or above land surface; wells yield generally 5 to 10L/s, in some places more than 20L/s.
AA3	Extensive, moderately productive aquifers	Aquifer of low to moderate transmissivity; groundwater table from near land surface to a depth of more than 10m; wells yield generally less than 5L/s.
AA4	Locally, moderately, productive aquifers	Mostly incoherent aquifer of low thickness and transmissivity; wells yield generally less than 5L/s.
AB1	Extensive and highly productive aquifers	Aquifers of largely varying transmissivity; depth to water table varies in wide range; wells yield generally more than 5L/s.
AB2	Extensive, moderately productive aquifers	Aquifers of largely varying transmissivity; depth to groundwater generally great; wells yield generally less than 5L/s.
AB3	Locally productive aquifers	Aquifers of largely varying transmissivity; generally no groundwater exploitation by drilling to great depth to the groundwater table; locally small springs can be captured.
AC1	Highly to moderate productive aquifers	Groundwater flow is limited to fissures, fracture zones and solution channels; well yields and spring discharges vary in an extremely wide range.
AD1	Poor productive aquifers of local importance	Generally very low transmissivity; locally, limited shallow groundwater resources can be obtained in valleys and weathered zones of solid rocks
AD2	Region without exploitable groundwater	–

Source: JICA Project Team 2



Source: Adapted from Hydrogeological Map of 1/250,000 (1984), Ministry of Mines and Energy

Figure S-2 Hydrogeological Map for Brantas River Basin

(6) The natural environment situations in the Brantas River basin are as summarized hereunder.

(a) Recorded forestland is 520,498.7ha (2015, Review Pola): wherein, production forest is 354,944ha (68.2%), protection forest is 113,918ha (21.9%) and conservation forest is 51,582ha (9.9%).

(b) Bromo Tengger Semeru National Park is overlapping with the Brantas watershed. No wildlife reserve (Suaka Margasatwa) is located in the watershed, while three nature reserves (Cagar Alam) are set in Besowo Gadungan, Manggis Gadungan and Gunung Abang. Besides, five of Important Bird Area (IBA) are located in the watershed.

(c) The watershed is in East Java Ecoregion, where tropical rainforest vegetation and 103 species of mammals are recorded: important to be protected as endemic species are Javan Warty Pig (Sus verrucosus, endangered/EN), Yellow-throated Marten (Martes flavigula robinsoni) and Javan Leopard (Panthera pardus melas) among others.

(d) In terms of landscape, Gunung Baung Nature Tourism Park (Taman Wisata Alam) and Tretes Nature Tourism Park are designated. Besides, Batu area is famous in Indonesia as a tourist destination.

3.2 Socio-economy

(1) The Brantas River basin is situated in East Java Province, and nine (9) regencies and six (6) cities included in Table S-3 are located in the basin. The population in the basin was about 16.2 million in 2010 and projected to be about 16.9 million in 2015.

Table S-3 Regencies and Cities Located in Brantas River Basin

Regencies	Sidoarjo, Mojokerto, Malang, Blitar, Kediri, Nganjuk, Jombang, Tulungagung, Trenggalek
Cities	Surabaya, Mojokerto, Malang, Batu, Kediri, Blitar

Source: Brantas River Basin Water Resources Management Plan (2010)

(2) The present land use map prepared by BBWS Brantas indicates that about 65% of land in the Brantas River basin is utilized for agricultural purpose and many farmers are engaged in food crop cultivation work.

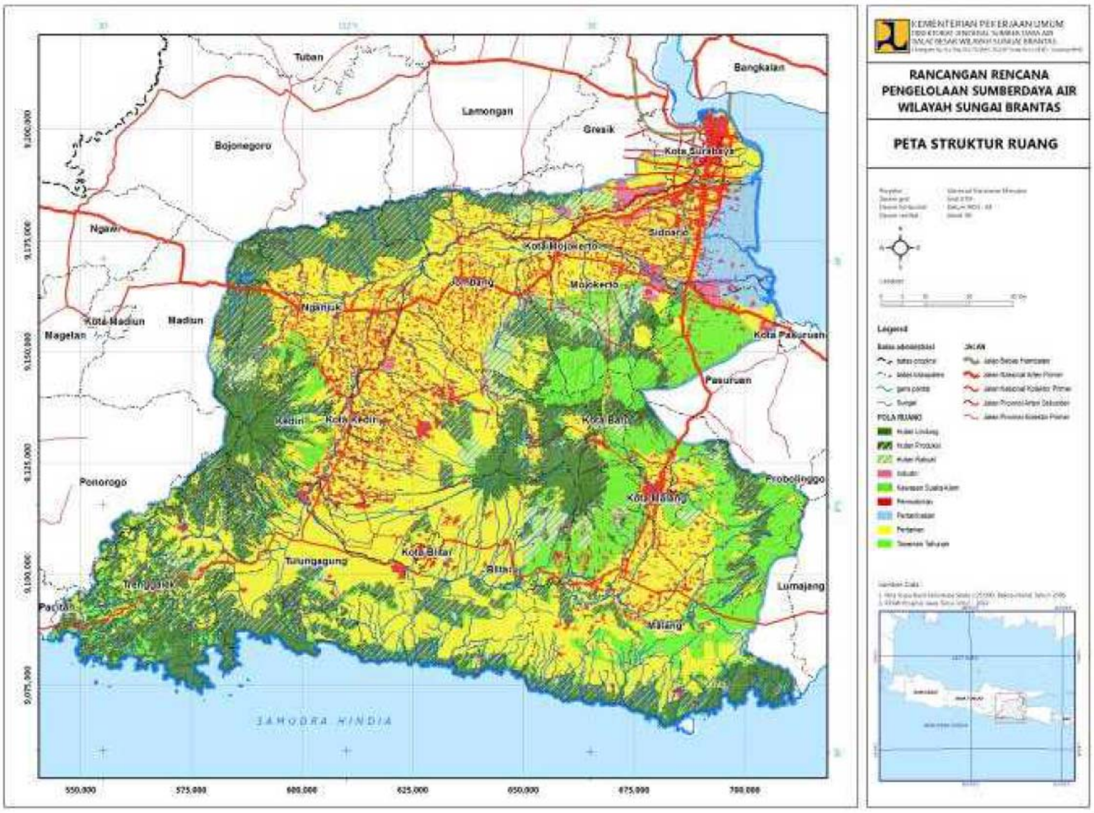
(3) The historical trend of Gross Regional Domestic Product (GRDP) in East Java Province reached IDR. 1,482 trillion in 2017 at the constant price level of 2010. Compared with the value in 2013, the GRDP increased to 24% in real term. The average annual growth rate is estimated at 5.6% for the period from 2013 to 2017. In the industrial sector, the “Manufacturing” sector produces 29% of the whole GRDP in East Java Province, and “Trade, Repair of Motor Vehicle”, “Agriculture, livestock, forestry and fishery” and “Construction” sectors follow.

(4) The average monthly salary in East Java Province was Rp. 1,786,000 in 2016, approximately 18% lower than the average of whole Indonesia. The unemployment rate is 4.14% in 2016, 1.36% lower than the national average.

3.3 Current State of Water Sector

(1) East Java Province prepared regional development plans related to water resources, such as a long-term development plan (RPJP, 2005-2025) and middle term plans. In addition, the province has prepared a spatial plan (2011-2031), of which the purpose was determined based on the vision and mission of the RPJP (2005-2025). The spatial vision of the province expects that the agriculture sector becomes one of the main development drivers in East Java Province.

(2) BBWS Brantas prepared in their Review POLA a map which depicts protection and utilization zones in the Brantas River basin, as illustrated in Figure S-3. Based on this map, 23.5% of the total area of 14 regencies and cities in the Brantas River basin is demarcated as the protection zone, such as protection forest and nature reserved areas, and the remaining 76.5% as the utilization zone for residential, industrial and agricultural purposes as well as miscellaneous zones.



Source: BBWS Brantas

Figure S-3 Protection and Utilization Zones in Brantas River Basin

(3) The POLA in the Brantas River basin was approved in 2010, while the draft RENCANA was under preparation in 2016. At present, BBWS Brantas has prepared a Review POLA according to the Ministerial Regulation No.10/PRT/M/2015.

(4) The domestic and industry water supply in the Brantas River basin has been being conducted in the following three situations.

(a) Water supply from PDAM: PDAMs (like water supply companies) have been supplying water to the fields of (i) domestic water, (ii) non-domestic water and (iii) industrial water in urban areas, each of which is defined as follows:

- Domestic water: Water consumption in bath, kitchen and restroom in residential areas,
- Non-domestic water: Commercial water consumption in shopping malls and public areas such as schools and government offices, among others, and
- Industrial area: Water consumption of industrial clusters, private factories, etc.

The water sources for the fields above are surface water and groundwater.

(b) Domestic and non-domestic water in non-PDAM areas (areas with no PDAM) : The domestic and non-domestic water relies mainly on groundwater.

(c) Industrial water in non-PDAM areas: The water sources of industrial water are both surface water and groundwater.

4. ASSESSMENT OF CLIMATE CHANGE IMPACTS IN 2050

4.1 Safety Level

(1) Safety Level against Droughts

- In the present climate, the safety level of municipal and industrial water supply is kept at a 10-year dependable level and the total cropping intensity of irrigation with a 5-year dependable level is kept at 224%.
- The safety level of water use in the future climate was examined using the following conditions.

Conditions	Present	Future
Climate	Present	Climate Change
Scenario	-	Medium
Irrigation Demand	Present	Present
M&I Demand	Present	Present
Reservoir Volume	Present	Future

Source: JICA Project Team 2

Table S-4 summarizes the change of future safety level for water use in comparison to one in the present climate.

Table S-4 Safety Level Change on Water Use between Present and Future Climates

< Irrigation Water Supply>

River Course	Irrigation Scheme	Irrigation Area (ha)	No. of Years with Deficit Occurrence	
			Present Climate	Future Climate
Tributaries	DI_Kedung kandang	5,160	0	4
	DI_Paingan	551	0	1
	DI_Blader	286	1	1
	DI_Siman	23,060	4	**6**
	DI_Bening	8,752	4	**10**
	DI_Padi Pomahan	4,309	3	4
Main Stream	DI_Lodagung	12,217	0	1
	DI_Mrican Kanan	17,612	0	2
	DI_Mrican Kiri	12,729	0	2
	Di_Jatimlerek	1,812	0	2
	DI_Mentrus	3,632	0	3
	DI_Jatikulon	638	0	3
	DI_Brantas Delta	17,942	0	3
	Total	108,700		

< Municipal and Industrial Water Supply>

No.	District/ Municipality	No. of Years of Failure in M&I Water Supply	
		Present Climate	Future Climate
1	Batu	0	0
2	Malang	0	1
3	Kediri	0	0
4	Blitar	0	0
5	Sidoarjo	0	0
6	Mojokerto	0	0
7	Jombang	0	0
8	Surabaya	0	0
9	Trenggalek	0	0
10	Tulungagung	0	0

No.	District/ Municipality	No. of Years of Failure in M&I Water Supply	
		Present Climate	Future Climate
11	Nganjuk	0	0
12	Gresik	0	0

< Annual Hydro-power Generation>

No.	Principal Hydropower Station	Annual Power Generation (GWh)	
		Present Climate	Future Climate
1	Sengguruh	114	92
2	Sutami	475	397
3	Wlingi	189	162
4	Lodoyo	36	33
5	Wonorejo	31	20
6	Selorejo	32	30
	Total	877	735 (86%)

Source: JICA Project Team 2

- The number of deficits in irrigation water supply is increased, especially the safety level of Siman and Bening irrigation schemes, which is lower than the 5-year dependability.
- The safety level of M&I water supply is not less than the 10-year dependability due to high priority of water supply.
- The annual hydro-power generation decreases up to 86% compared with that of the present climate.

(2) Safety Level against Floods

(a) Widas River Basin

The safety levels in the future climate decrease compared with those of the present climate as presented in Table S-5.

Table S-5 Average Return Period Estimated from Future Condition (Widas River)

Probable Floods under Present Condition (m^3/s)	Average Return Periods (year)			
	Present	Low	Medium	High
172	2	1.6	1.5	1.4
229	5	2.5	2.5	2.0
278	10	4.7	4.7	3.1
389	30	17.0	12.8	7.7
441	50	26.3	19.0	10.8
532	100	100.0	37.9	17.8

Source: JICA Project Team 2

(b) Sadar River Basin

Table S-6 Average Return Period Estimated from Future Condition (Sadar River)

Probable Flood under Present Condition (m^3/s)	Average Return Period (year)			
	Present	Low	Medium	High
51	2	1.5	1.5	1.3
67	5	2.9	2.9	2.3
78	10	6.7	6.7	4.0
95	30	19.3	17.5	11.3
105	50	30.0	25.4	15.3
114	100	100.0	37.1	20.8

Source: JICA Project Team 2

(c) Brangkal River Basin

Table S-7 Average Return Period Estimated from Future Condition (Ngotok Ring River)

Probable Flood under Present Condition (m³/s)	Average Return Period (year)			
	Present	Low	Medium	High
464	2	1.7	1.7	1.4
529	5	2.9	2.9	2.0
597	10	6.5	5.8	3.7
684	30	16.8	13.5	7.0
754	50	34.2	26.7	11.9
823	100	149.3	45.4	18.8

Source: JICA Project Team 2

(d) Tawing River Basin

Table S-8 Average Return Period Estimated from Future Condition (Tawing River)

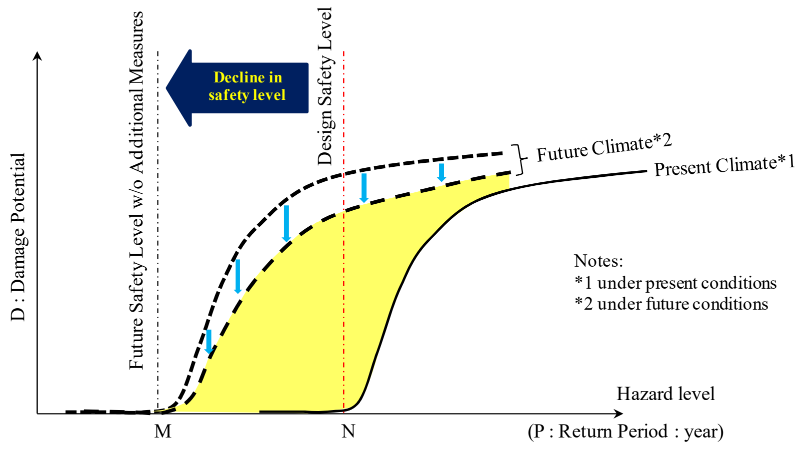
Probable Flood under Present Condition (m³/s)	Average Return Period (year)			
	Present	Low	Medium	High
165.1	2	1.7	1.3	1.1
199.9	5	3.8	2.8	2.2
231.4	10	5.8	4.5	3.4
307.3	30	15.1	12.0	7.4
350.7	50	30.0	19.5	10.1
418.3	100	100.0	39.5	17.7

Source: JICA Project Team 2

4.2 Risk and Resilience of Water Resources Management

(1) Concept of Risk and Resilience Assessment for Water Resources Management

The Project deals with the assessment of risk and resilience for water resources management under future climate change conditions on the basis of the concept presented in Figure S-4.



➢ **Risk = $\sum$ D x Δ(1/P) : Expected Value (Eq. 1)**

Legend:
-------- Before exercise of resilience
- - - - - After exercise of resilience
Blue arrow: Decrease of Risk by Exercising Resilience
Yellow: For Structural and Non-structural Measures
N, M Years (M < N)

Figure S-4 Concept of Risk and Resilience for Water Resources Management (Hazard: Flood and Drought)

The risk is estimated with Eq. 1, and the term of "Resilience" is defined below according to the UNISDR Terminology on Disaster Risk Reduction (2009).

Resilience = The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Comment: Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need.

Source: United Nations International Strategy for Disaster Reduction (UNISDR) Terminology on Disaster Risk Reduction (2009)

The orange part in Figure S-4 means the remaining risk under future climate change conditions after exercise of resilience and is to be the objective risk for consideration of additional structural and non-structural measures in the future.

(2) Risk for Water Resources Management

(a) Risk related to Droughts

The major risk related to droughts in the future climate is assessed as reduction of cropping intensity and annual hydro-power generation. Table S-9 compiles the risk (damage) in drought.

Table S-9 Damage in Drought

Case	Cropped Area (ha)			Cropping Intensity (%)	M&I (m^3/s)	Power Generation (GWh)
	Mainstream	Tributaries	Total			
Present	166,455	77,350	243,805	224	29.5	877
Future						
Medium	131,315	69,796	201,111	150	50.2	730
Low	166,465	96,348	262,813	196	50.4	767
High	93,182	63,265	156,447	116	46.7	657

Note: Safety level: Irrigation 5-year probability, Municipal & Industrial water 10-year probability
Source: JICA Project Team 2

(b) Risk related to Floods

The major risk related to floods in the future climate is flood overtopping of structures. The risk of each river is summarized hereunder.

1) Porong River

Table S-10 compiles the overtop locations in present and future climates.

Table S-10 Location of Overtop Sections

Location	Main Channel Distance from River Mouth (km)	Present	Future		
			High	Medium	Low
KB51~New Lengkong Dam	52~48	< 100 cm in several section	Overtop at New Lengkong Dam < 100 cm in several sections	<100 cm in several sections	<100 cm in several sections
KP1~KP15	48 ~ 45	<100 cm	Overtop	< 100 cm	< 100 cm
KP20~KP30	43 ~ 42	Overtop	Overtop	Overtop	Overtop
KP60~KP85	36 ~ 30	Overtop in Several sections	Overtop in almost sections	Overtop in almost sections	Overtop in almost sections

Source: JICA Project Team 2

It is examined that the overtop events from the dike near New Lengkong Barrage and at KP1-KP15, KP20-KP30 and KP60-KP85 are to take place.

2) Other Tributaries

The annualized incremental damage in the future climate is summarized in Table S-11.

Table S-11 Annualized Damage due to Flood Risk

Scenario	River Basin	Irrigation Area (ha)	Affected House (nos.)	Affected People (nos.)
Medium	Widas	100.3	31.1	634.9
	Sadar	96.9	75.5	822.8
	Ngotok	16.6	222.3	3,346.2
	Tawing	186.6	97.1	1,280.8
Low	Widas	81.4	19.0	387.2
	Sadar	94.0	74.2	808.6
	Ngotok	15.2	200.4	3,156.0
	Tawing	162.0	93.3	1,224.8
High	Widas	177.4	57.9	1,001.9
	Sadar	104.0	79.1	861.5
	Ngotok	26.6	406.7	5,439.6
	Tawing	201.9	135.5	1,337.7

Source: JICA Project Team 2

(c) Resilience against Risks

Table S-12 summarizes qualitative risk items and resilience in the Brantas River basin.

Table S-12 Summary of Risk and Resilience (except Qualitative Risk)

Hazard	Sub-aspect	Risk	Resilience	
			Structure	Non-structure
Drought	1.2 Water Preservation	・Increasing frequency of drought situation		・To control water extraction by the monitoring of related agency*1
	2.2 Water Resources Provision	・Reducing supply water volume from the reservoir	・To install rainfall utilization system (rainfall storage tank, underground rainfall storage facility, etc.)	・To change full supply level in the dry season*2 ・To carry out maintenance dredging*1 ・To carry out flushing and sluicing*1
	2.3 Water Resources Use	・Increasing frequency of drought		・To use storage between MOL and LWL at Sutami Dam*2 ・To allow over-year storage to each dam*2 ・To optimize reservoir operation of dams in Brantas River basin*2 ・To change water source from surface water to groundwater*2
Flood	3.1 Disaster Prevention	・Number of flood inundation is increased and flood inundation area is also expanded. ・Outflow from each dam is increased during the flood event	・To carry out monitoring and repairing of the dike every year based on the regular inspection*1	・To keep same flood control space at each dam (lowering FSL)*2
	3.2 Disaster Relief	・Increasing number of casualties	・To carry out the repair works of dike and evacuation center based on the result of regular inspection*1	・To carry out capacity development for the staffs of evacuation guidance *1 ・To prepare hazard map and evacuation route map*1 ・To grasp persons who need to be supported in evacuation*1 ・To carry out capacity development to the flood fighting teams*1 ・To improve accuracy of FFWS*1
	3.3 Disaster Recovery	・Flood damage is increased.	・To carry out the repair works (temporary) of dike at breaching location*1	

Note: *1: Qualitative, *2: Quantitative,
Source: JICA Project Team 2

5. FORMULATION OF CLIMATE CHANGE ADAPTATION MEASURES UP TO 2050

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

In formulating water resources management plans reflecting climate change impacts, in other words “Climate Change Adaptation Measures”, it is needed to consider uncertainty inherent in the projected climate change impacts. Therefore, JICA Project Team 2 had several discussions with the Indonesian side, providing materials and discussion points concerning “Multiple Scenario Approach (MSA)” as a planning methodology. Through the discussions, the following were confirmed mutually.

Regarding the “**Point of Cost Optimum (PCO)**” in MSA for an object area, there are 2 cases of relationship with the criteria for “Flood Protection Level (**FPL**)”, which are:
(a) Case 1: **PCO < FPL** and (b) Case 2: **PCO > FPL**.

(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.

5.2 Climate Change Adaptation Measures against Rain Storms and Floods

(1) Water Resources Management

The structural measures are selected by using MSA as summarized in Table S-13.

Table S-13 Structural Measures for Floods

Future Climate 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

In addition, any considerable non-structural measures against rainstorms and floods are useful and the following are to be considered:

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

(2) Sabo Management

(a) Use of coagulant against dredged fine–grained sediment

Currently, the sediment dredged in the reservoirs situated in the Upper Brantas and the Konto River has been being disposed into spoil banks around the reservoirs. However, the places for spoil banks are usually filled up soon and it is rather difficult to find alternative places near the reservoirs. In such a state, the use of coagulant against fine-grained sediment dredged from a dam reservoir is recommended as an effective measure.

(b) Dredging/excavation of Sabo facilities

Regular dredging/excavation of existing Sabo facilities to increase their trap capacities is effective to trap unstable sediment. In the Brantas River basin, the dredging/excavation of Sabo facilities upstream from the Sengguruh Dam is highly prioritized due to the existence of large amount of unstable sediment due to the Mt. Semeru eruption.

(c) Watershed conservation under Sabo management

The factors of sediment discharge are presumed to be mainly surface soil erosion, riverbank/riverbed erosion, slope failure and watershed development such as deforestation and cultivation land expansion. Since the deforestation and cultivation land expansion have a possibility of artificial factor, it is important that the operation of forest or cultivated land by ways of (i) development restriction and (ii) development considering prevention of surface soil erosion is to be carefully realized, by incorporating:

- Multiple-layered forest and agro-forestry,
- Terracing in cultivation land to prevent surface soil outflow, and
- Ground cover with grass straw or something to prevent from erosion due to raindrops.

5.3 Climate Change Adaptation Measures against Droughts

(1) Surface Water Resources Management

(a) Structural measures

All structural measures enumerated below shall be carried out for priority actions:

- Replacement of PDAM's pipeline,
- Construction of recycle plant at each industrial company,
- Rehabilitation of tertiary irrigation canals in each irrigation scheme, and
- Construction of 5 dams (Kedungwarak Dam, Kencir Dam, Babadan Dam, Kont II Dam, and Genteng I Dam).

(b) Non-structural measures

The non-structural measures below shall be carried out for priority actions:

- Changing water source from surface water to groundwater
- Introducing system of rice intensification (SRI)
- Public relations of reservoir water level at each dam
- Domestic water supply support system among adjacent river basins
- Preparation of drought action plan (Timeline for droughts)

(2) Groundwater Resources Management

It is desirable for the Brantas River basin (i) to promote adaptation measures by use of structural measures in conjunctions with grasping actual conditions of groundwater use and (ii) to introduce appropriate regulations and management. Since there are no universal adaptation measures to minimize the impact of climate change on groundwater, 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 through incorporating adaptation measures into the water resources management plans and enhancing existing relevant management systems and measures.

6 PROPOSED CLIMATE CHANGE ADAPTION MEASURES TO BE INCORPORATED INTO POLA AND RENCANA

The adaptation measures which are proposed to be incorporated into POLA and RENCANA in the next review/evaluation stage reflecting climate change impacts are explained hereunder. These are adaptation measures against climate change impacts as of the target year 2050.

6.1 Adaptation Measures against Rainstorms and Floods

(1) Water Resources Management

The adaptation measures are proposed as compiled in Tables S-14 and S-15.

Table S-14 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 S-15 Non-structural Measures against Rainstorms and Floods

Measure	Details
Upgrading FFWS	➢ Developing 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 number of target communities ➢ Developing information system by using smart phone
Evacuation	➢ Preparation of hazard maps for several probable floods ➢ Designation of evacuation centers considering inundation area ➢ Construction of evacuation centers considering inundation area
Land Use Control	➢ Local governments prepared spatial plan considering inundation area ➢ Local governments shall consider the restricted area which are frequently inundated areas.
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 the high level of knowledge and skills to flood fighting. Therefore, capacity development of the flood fighting teams and concerned agencies is required.
Business Continuity Plan	➢ A business continuity plan (BCP) is a plan to help ensure that business processes can continue during/in time of emergency or disaster. Private companies and local governments shall prepare BCP.

Source: JICA Project Team 2

(2) Sabo Management

As the structural measures, the existing “Basin-wide Sediment Management Plan” is to be implemented ahead of the original schedule. Therefore non-structural measures compiled in Table S-16 are recommended.

Table S-16 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 rainstorms and floods, forest management is generally described in POLA 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 are the key for adaptation. Yet the impact on the forest ecosystem by the climate change is unknown and it is important to start the preventive measures as well as monitoring of the forest ecosystem especially in the priority areas which are contributing to water retaining capacity or which are to be affected by the rain pattern change and temperature rise.

Thus, it is proposed to include the following in POLA and RENCANA:

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

6.2 Adaptation Measures against Droughts

(1) Water Resources Management

Tables 17 and 18 compile adaptation measures for the future climate conditions.

Table S-17 Structural Measures against Droughts (Medium Scenario)

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 S-18 Non-structural Measures against Droughts

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. (See groundwater management)
Introducing SRI	➢ Even though the effectiveness of SRI method on irrigation water saving has yet commonly quantified on irrigation scheme basis, experimental works done by the Bogor Agricultural University in Indonesia revealed that SRI method applied to the 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 the conventional irrigation regimes.
Preparation of drought action plan	➢ It is organized for 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 the 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 Brantas River basin compared with the adjacent river basins, domestic water supply from adjacent basins by using tank lories, increasing supply water volume through pipeline, and so on. ➢ It is necessary to make agreement among representative agencies of the adjacent river basins.

Source: JICA Project Team 2

(2) Groundwater Resources Management

In due consideration of climate change, the operational policies on groundwater resource management are presented in the Review POLA/RENCANA as referred to in Table S-19. The directions of the operational policies for managing groundwater resources in the Brantas River basin is related to two aspects, namely: Water Resource Conservation and Water Resources Utilization.

Table S-19 Review POLA and RENCANA

Aspects	Strategy in Current Review POLA/ RENCANA	Operational Policy Proposed in Current 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 the Brantas River basin)	Selective issuance of IMB (Building Construction Permit) and provision of other public service facilities such as electricity, telephone etc.
Water Resources Utilization	Groundwater use permit and groundwater allocation as well as control of distribution of groundwater exploited by optimizing the water's benefits (the entire Brantas River basin)	Compiling laws and regulations on groundwater at operational level. Providing counseling or imposing sanctions to those who extract ground water without permission

Source: JICA Project Team 2

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. Construction of infiltration (injection) wells in each house as set in the Regional Regulation is a measure to enhance the groundwater storage capacity. Groundwater use permit and groundwater allocation as well as control of groundwater distribution are measures to prevent uncontrolled groundwater extraction.

The measures presented in the Review POLA/RENCANA are effective against future climate change also, but some additional measures targeting droughts can be proposed as stated in Table S-20, which compares the measures in the Review POLA/RENCANA and the adaptation measures against droughts under the climate change with a target year of 2050. The adaptation measures aim mainly to establish basic data (i) to enable wider response to climate change and (ii) to make the measures in the Review POLA/RENCANA more specific.

Table S-20 Measures in Review POLA/RENCANA and Proposed Adaptation Measures

Measures in Review POLA/ RENCANA	Proposed Adaptation Measures against Droughts
Artificial groundwater recharging using injection well	➢ Artificial groundwater recharging using injection well ➢ Investigation of 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 laws and regulations	➢ Survey on actual use of groundwater to identify the area for regulation ➢ Control of groundwater extraction under the lows and regulations

Source: JICA Project Team 2

(3) Watershed conservation

Regarding the watershed conservation against droughts, forest management is generally described in POLA 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 are the key for adaptation. Yet the impact on the forest ecosystem by the climate change is unknown and it is important to start the preventive measures as well as monitoring of the forest ecosystem especially in the priority areas which are contributing to water retaining capacity or which are to be affected by the rain pattern change and temperature rise.

Thus, it is proposed to include the following in POLA and RENCANA.

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

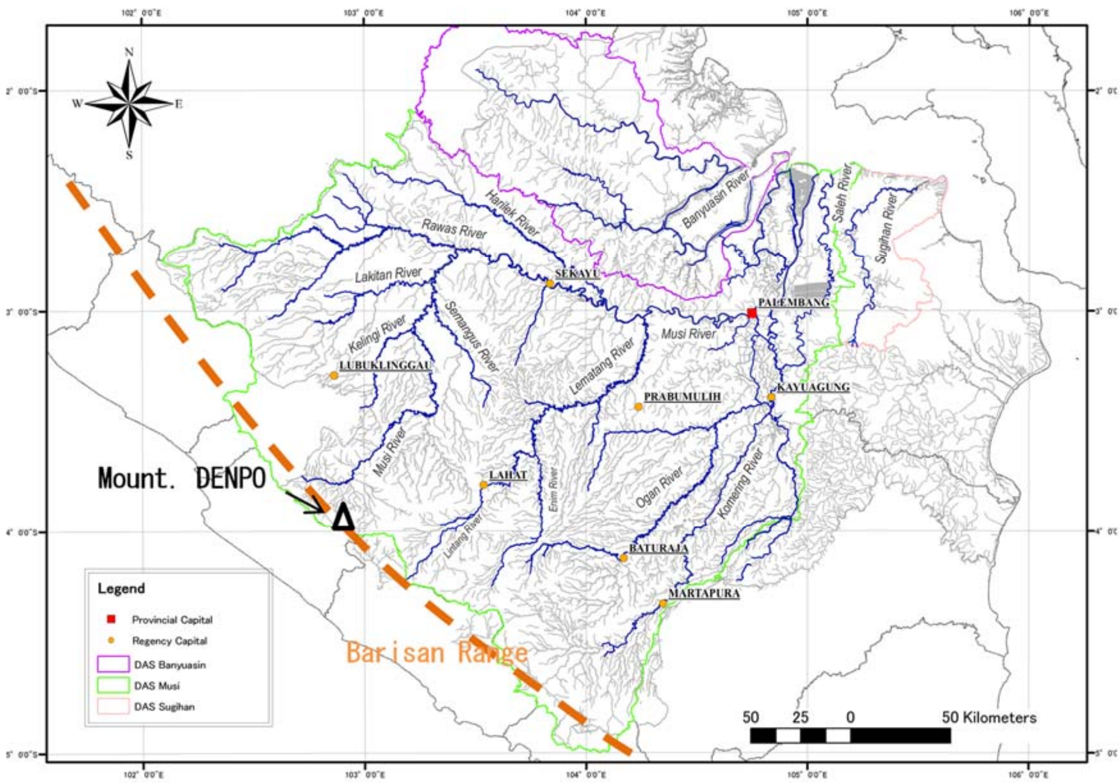
<< STUDY FOR MUSI RIVER BASIN >>

7. CURRENT CONDITIONS OF MUSI RIVER BASIN

7.1 Physical Setting

(1) The topography of the Musi River basin can be classified mainly into five zones which are the mountainous zone, piedmont zone, central plains, inland wetlands and coastal plains. The mountainous zone is distributed only to the west-southwest-south region of the basin. The remaining 60% of the basin excluding the mountainous zone and its adjacent piedmont zone is occupied by central plains, inland wetlands and coastal plains.

(2) The Musi River is the largest river in Sumatra, flowing down from west to east in South Sumatra Province. It has the fourth largest catchment area of 59,942km^2 with a length of approximately 640km in Indonesia. The Musi River and its major tributaries originate in the Barisan Range as shown in Figure S-5. The Musi River can be traced up to the foot of Mt. Dempo with an altitude of 3,159m and the average bed slope widely varies from 1/100 - 1/200 in its upper reaches to 1/10,000 in its lower ones near Palembang, and become gentler (1/20,000) toward the coastal areas. The Musi River basin is sandwiched by the Banyuasin and the Sugihan River basins in the lowest area from the east and the west sides, respectively.

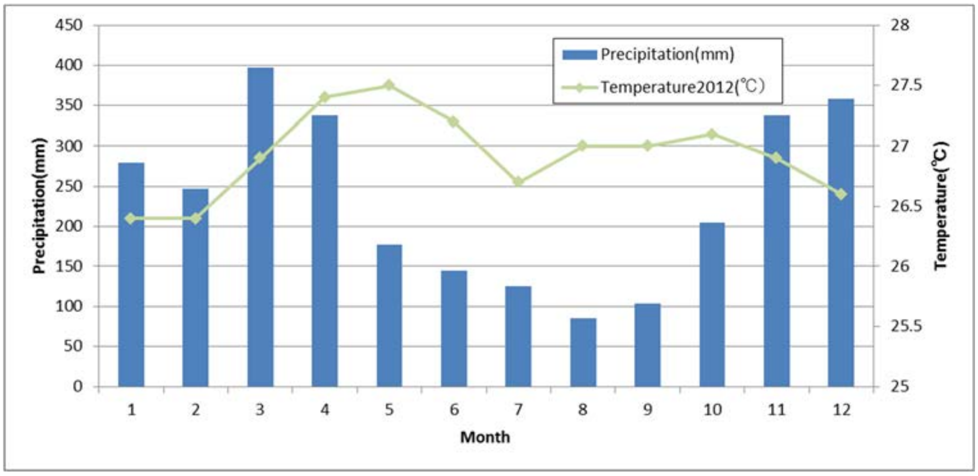


Source: JICA Project Team 2

Figure S-5 Musi, Banyuasin and Sugihan River Basins

(3) The climate of the Musi River basin is characterized by abundant rainfall which is moderately distributed through the year with wet and dry seasons much less clearly defined than those in Java and eastern Indonesia. Figure S-6 presents the monthly rainfall

and temperature observed at the Kenten Station in Palembang. The total annual rainfall is about 2,800mm with more rainfall between October and April. The monthly average temperature has little variation and is as high as about 27°C through the year. The annual potential evapotranspiration ranges from 1,200 to 1,500mm.

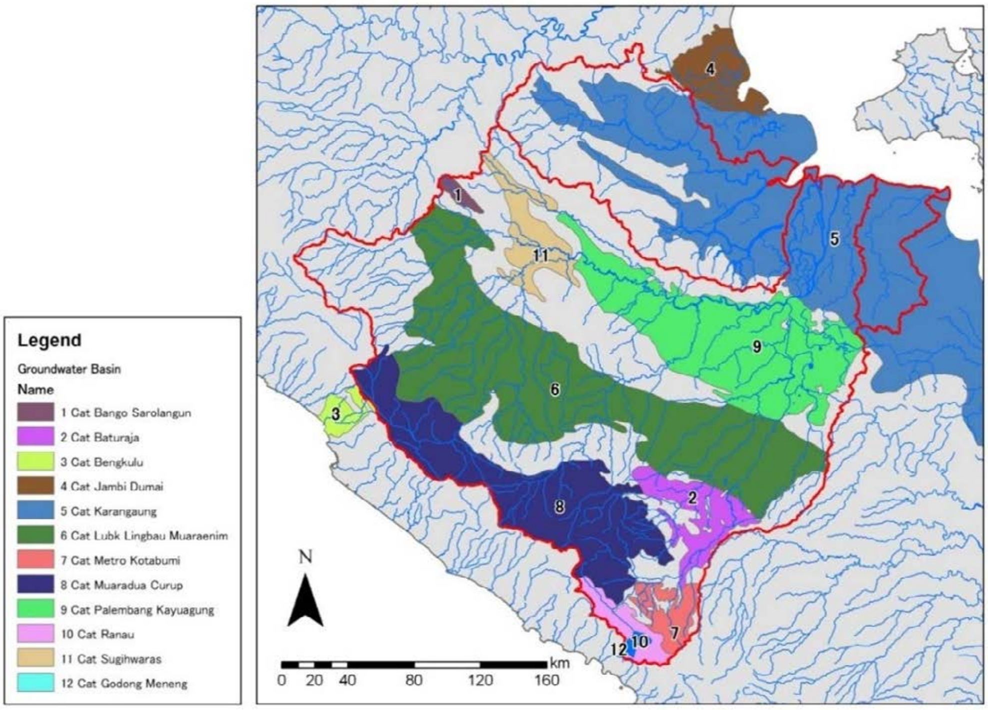


Source: JICA Project Team 2

Figure S-6 Monthly Rainfall (1985～2013）and Monthly Temperature (2012) at Kenten Station, Palembang.

(4) The average discharge in the lower stretches of the Musi River after the confluence of the Komering River is about 2,500 m^3/s with fluctuations in the dry and wet seasons between 1,400 m^3/s and 4,200 m^3/s. Normally, the Musi River and its tributaries have the highest peak discharge during the period of February and March, and the lowest one between July and September. The maximum tidal fluctuation of about 3.5m has been observed, and the highest spring tide appears generally in December and January.

(5) Groundwater basins in the Musi River basin defined by the Ministry of Energy and Mineral Resources (ESDM) are presented in Figure S-7, and the groundwater potential of each basin is compiled in Table S-21. The average groundwater development potential of 533mm/y is about 19% of 2,800mm of the average rainfall of Palembang, and is equivalent to about 40% of 1,340mm of the annual effective rainfall that is estimated by assuming 4mm of daily average evapotranspiration.



Source: JICA Project Team 2

Figure S-7 Groundwater Potential for Each Groundwater Basin

Table S-21 Total Groundwater Potential for Each Groundwater Basin

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

*1: Q1 is shallow aquifer and Q2 is deep aquifer

Source：JICA Project Team 2

7.2 Socio-Economy

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

(2) The total population in the Musi River basin in 2010 was approximately 7.95 million, and the annual growth rate of population from 2000 to 2010 is 1.06%.

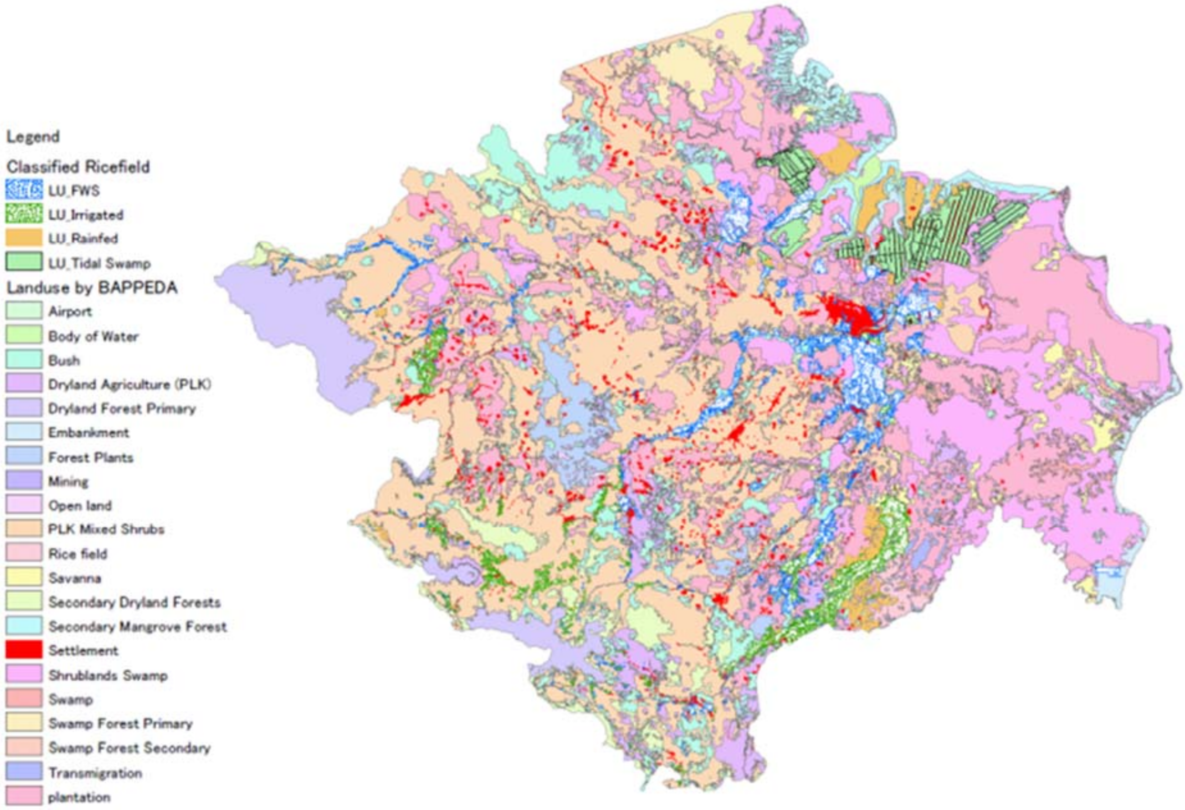
(3) The Gross Regional Domestic Product (GRDP) of South Sumatra Province was IDR 60.4 billion in 2009, which corresponds to IDR 8 million of per capita GRDP. The economic structure of South Sumatra Province is dominated by three major sectors, namely mining, agriculture, and manufacture that accounted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

South Sumatra Province is rich in fossil fuel resources. It is reported that there are approximately 24,179.98 BSCF (Billions of Standard Cubic Feet) gas reserves in South Sumatra Province or ± 13.01 % of the total natural gas reserves in Indonesia as of 2009. The province has coal reserves of approximately ± 38.44 % of the total coal reserves of the state or 22,240.47 million tons, while oil reserves in South Sumatra Province of ± 8.78 % of the total national petroleum reserve or 757.60 MSTB (Million Stock Tank Barrels).

Besides, South Sumatra Province is regarded as a food barn. The agriculture sector is divided into subsectors of food crops and horticulture, plantation, livestock and fisheries. Rice is the most important crop in the province. Other food crops are also cultivated such as maize, cassava, sweet potato, peanuts, and soybeans. Rubber, oil palm and coffee are the major cash crops of plantation subsector.

(4) JICA Project Teams 1 and 2 jointly elaborated the present land use map, based on that prepared in 2010 by BAPPEDA of South Sumatra Province, by adding 4 categories of paddy areas which are fresh water swamp, irrigated, rainfed and tidal swamp rice fields, as shown in Figure S-8.

(5) In South Sumatra Province, the average net monthly income of informal employees was IDR 1,501,000 in the 2017 statistics, whereas the minimum monthly wage was IDR 2,388,000. The percentage of poor people was 13.1% as of September 2017, and it is higher than the national average (10.12%). The rate below the poverty line was 12.36% in the urban areas, whereas 13.54% in the rural areas. The most significant source of drinking water was protected well (34.77%) in 2017, followed by bottled water (19.75%) and piped water (16.65%). The numbers of totally or severely damaged households by disaster was 196 in 2017 and 114 in 2016 which were lower than the other disaster-prone provinces.



Source: JICA Project Teams 1 and 2

Figure S-8 Present Land Use Map in Musi River Basin

7.3 Current State of Water Sector

(1) The Musi-Sugihan-Banyuasin-Lemau (MSBL) River basin, which is composed of three river basins and one watershed, namely: the Musi, Sugihan, Banyuasin River basins, and the Lemau watershed, was established by the Presidential Decree No. 12/2012 on Determination of River Basin. The cross-province river basin is being managed by BBWS Sumatra VIII under the authority of the central government. BBWS Sumatra VIII has a task to carry out the management of water resources, including planning, construction, operation and maintenance, from the aspects of water resource conservation, water resource development, water resource utilization, control of water destructive power, etc. in the river basin.

(2) In April 2013, the Water Resources Management Coordination Team (TKPSDA) was established for the MSBL River basin with a total of 88 members (44 from governmental institutions including BAPPEDA, Dinas PU, Dinas Pertanian, etc., and the other 44 from non-governmental institutions) to accommodate the aspirations of all stakeholders on the management of water resources. TKPSDA is based in Palembang, and responsible to the Minister of Public Works and Housing with six duties and three functions as compiled in Table S-22.

Table S-22 Six Duties and Three Functions of TKPSDA

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

Source: BBWS-S8

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

Two agencies, namely, BBWS Sumatra VIII and Dinas PU (PSDA Musi and PSDA Sugihan) of South Sumatra Province have been observing hydrological conditions (rainfall, water level and discharge) in the Musi River basin. PUSAIR collects and arranges data from the observation agencies to publish a yearly data book.

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

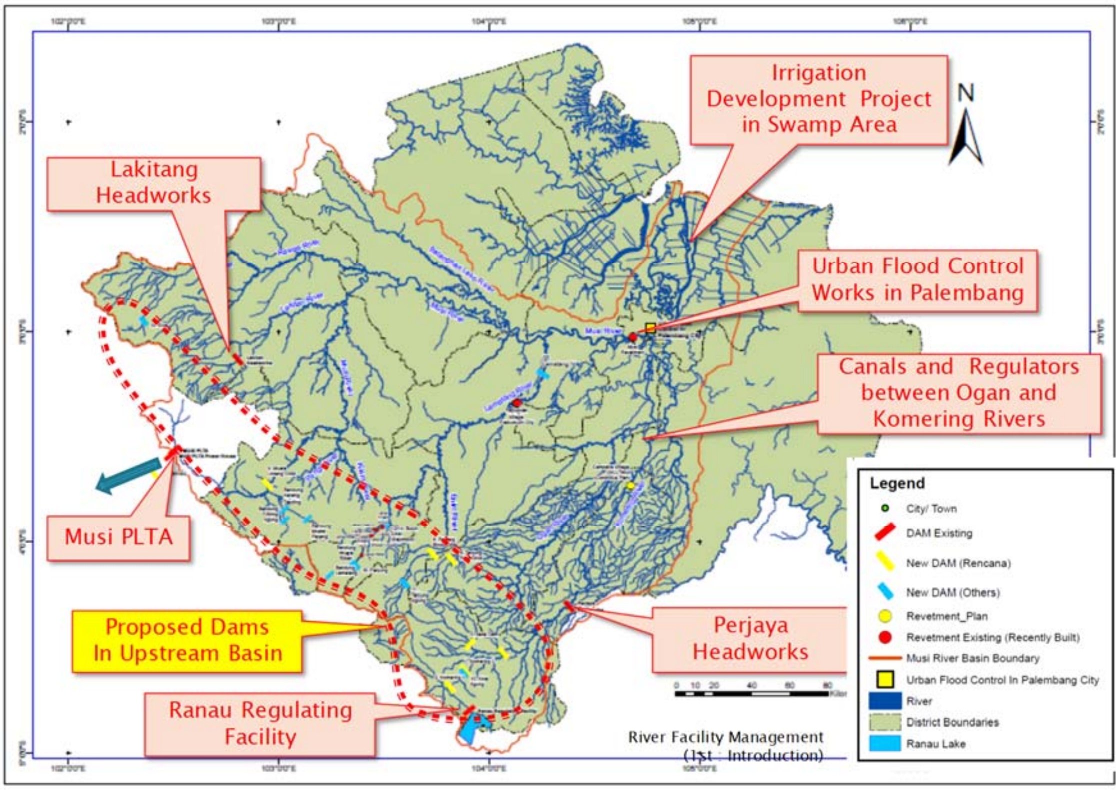
(4) Existing River Facilities

As for the major existing river facilities in the Musi River basin, the basic dimensions of dams, headworks and hydropower plants are summarized in Table S-23 and Figure S-9.

Table S-23 Major Headworks, Dam and Hydropower Plant in Musi River Basin

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

Source: JICA Project Team 2

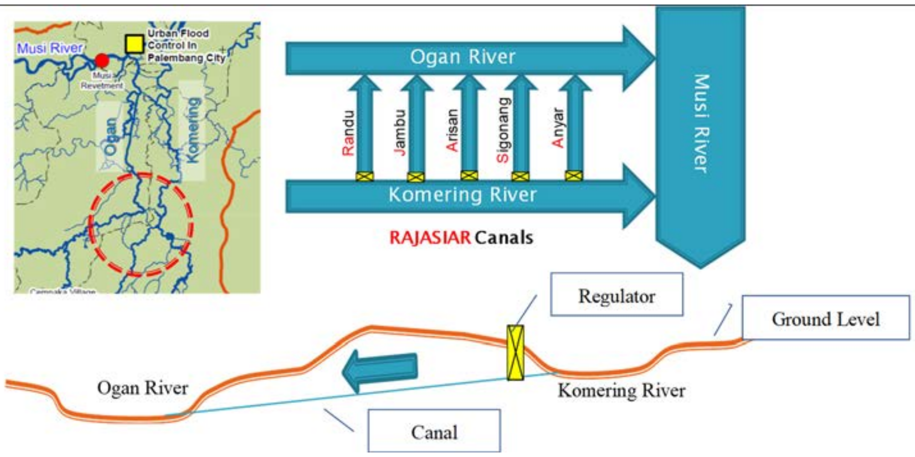


Source: Prepared by JICA Project Team 2 referring to RENCANA(2016) and others

Figure S-9 Location Map of Major Headworks, Dam and Hydropower Plant in Musi River Basin

(5) There are five (5) connecting canals (RAJASIAR Canals) and regulators between the Komering and the Ogan Rivers (see Figure S-10). The canals were constructed in the Dutch era aiming at a flood diversion from the Komering to the Ogan Rivers so as to mitigate flood damage along the lower Komering River. However, riverbed degradation and bank erosion in the canals became worse due to straight and steep alignments of the canals. Thereby drought in the lower Komering River became a problem because water had been diverted from the Komering to the Ogan Rivers even in a dry season. To cope with this situation, regulators were constructed at the inlet of each canal. The main functions of the regulators are as follows:

- In rainy season: Flood diversion from Komering to Ogan Rivers, and
- In dry season: Discharge control to secure water supply into the lower Komering.

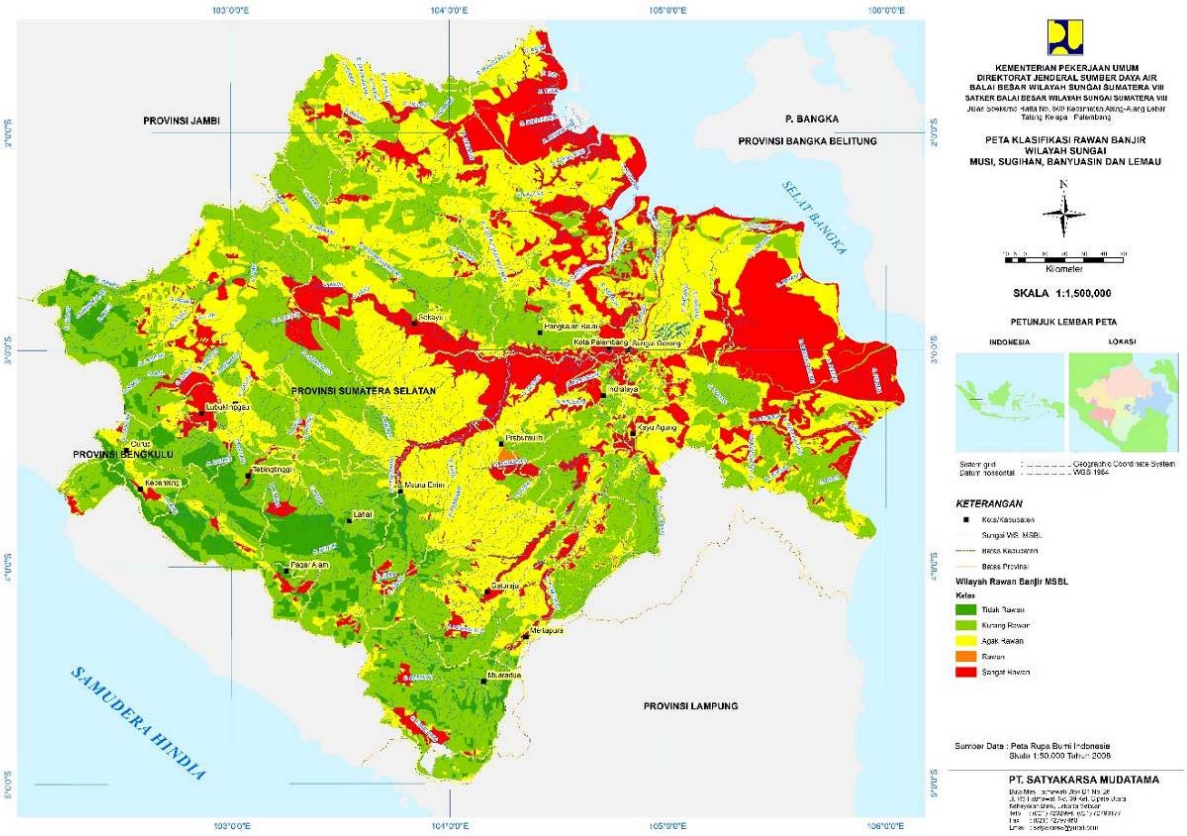


Source: JICA Project Team 2

Figure S-10 Schematic Image of RAJASIAR Canals

(6) Flood is one of the most important natural disasters in the Musi River basin. In the low-lying areas near the confluences between the Musi River and its tributaries such as the Kelingi, the Lakitan and the Rawas Rivers located in the middle stretches of the Musi River, extensive inundations occur every year. The floods have often damaged nearby roads. In Palembang City, the damage due to flood inundation was not so serious previously. However, due to rapid urbanization of the city keeping pace with the recent economic development, the urban areas of Palembang City have been expanded even to the lower flood prone areas.

A flood map was prepared for the Musi, Banyuasin and Sugihan River basins in 2014, as presented in Figure S-11.



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

Figure S-11 Flood Map in MSBL River Basin

(7) Under the Paris Agreement, Indonesia has been committed to reducing its greenhouse gas emissions unconditionally by 29% and conditionally by 41% by 2030. A research result[1] shows that among the total CO_2 emissions in Indonesia (464.18 MT[2]), those from peatland fires occupy 90% or more. Thus, fire management in peatland is one of the crucial tasks shouldered by the central government. In January 2016, the Peatland Reconstruction Agency (BRGT) was established and placed directly under the President's Office. In addition, the office in South Sumatra Province (TRGD) was founded and given the authority to plan and manage all peatland reconstruction-related activities in the province.

(8) The study on Sumatra State Spatial Plan began in 2011, and the spatial plan was approved by PUPR in 2016 and issued in the Regulation No. 11, 2016 of South Sumatra Province as the South Sumatra Province Spatial Plan for 2016-2036. The purpose of the spatial plan was set down as stated below:

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

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

(9) The POLA and RENCANA for water resources management for the MBSL River basin were promulgated in 2014 as the decree of the Minister of the Ministry of Public Works No. 196/KPTS/M/2014 and in 2017 as the decree of the Minister of the Ministry of Public Works and Housing No. 317/KPTS/M/2017, respectively. The MBSL River Basin that covers 86,100 km^2 including the Lemau River basin and coastal areas near the Banyuasin and Sugihan River basins are slightly larger than the target area (76,000 km^2) of the Project which focuses on the Musi, Banyuasin and Sugihan River basins, as illustrated in Figure S-12:

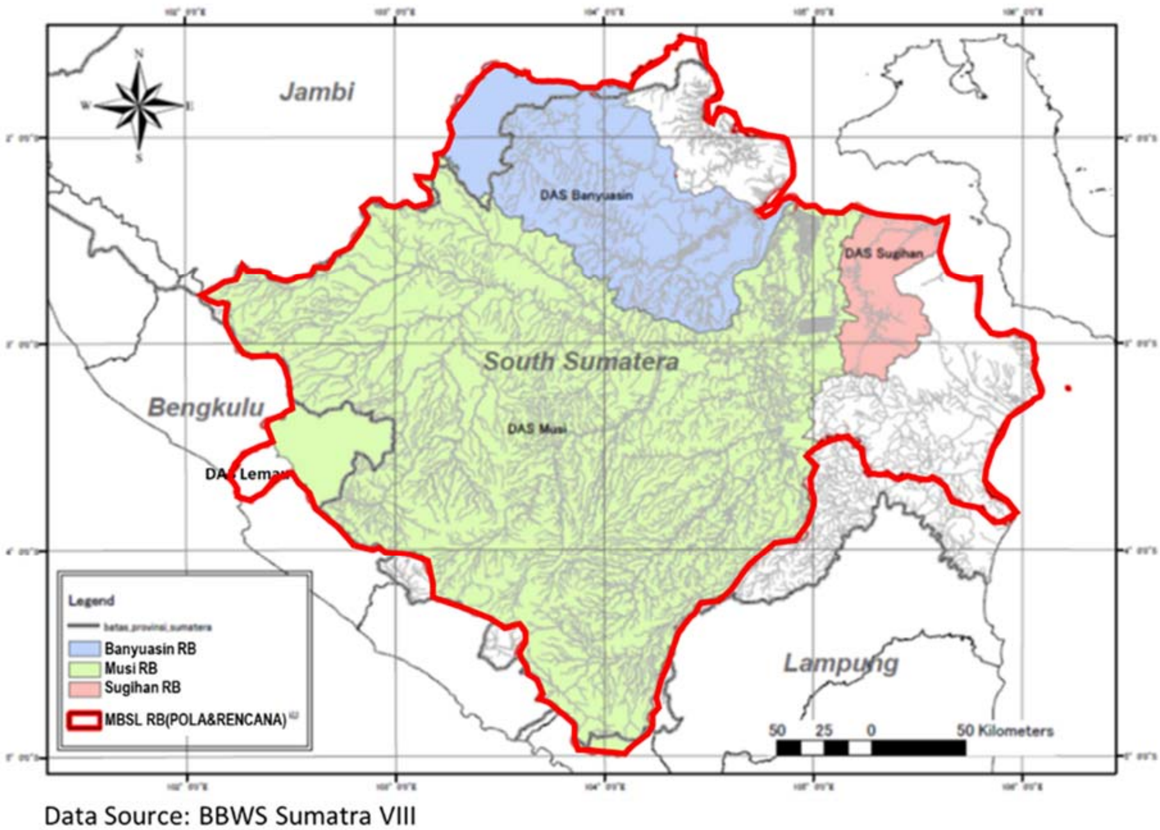


Figure S-12 Musi-Banyuasin-Sugihan-Lemau (MBSL) River Basin

(10) In RENCANA (2017), the proposed plan for construction of eight (8) dams (See Figure S-9) is presented to meet the needs of both domestic and irrigation water demands. The investment schedule of the dams within the Musi River basin is divided into four periods (5 years) as shown in Table S-24.

Table S-24 Proposed Plan of Construction of Dam in POLA/RENCAN in Musi River Basin

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

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

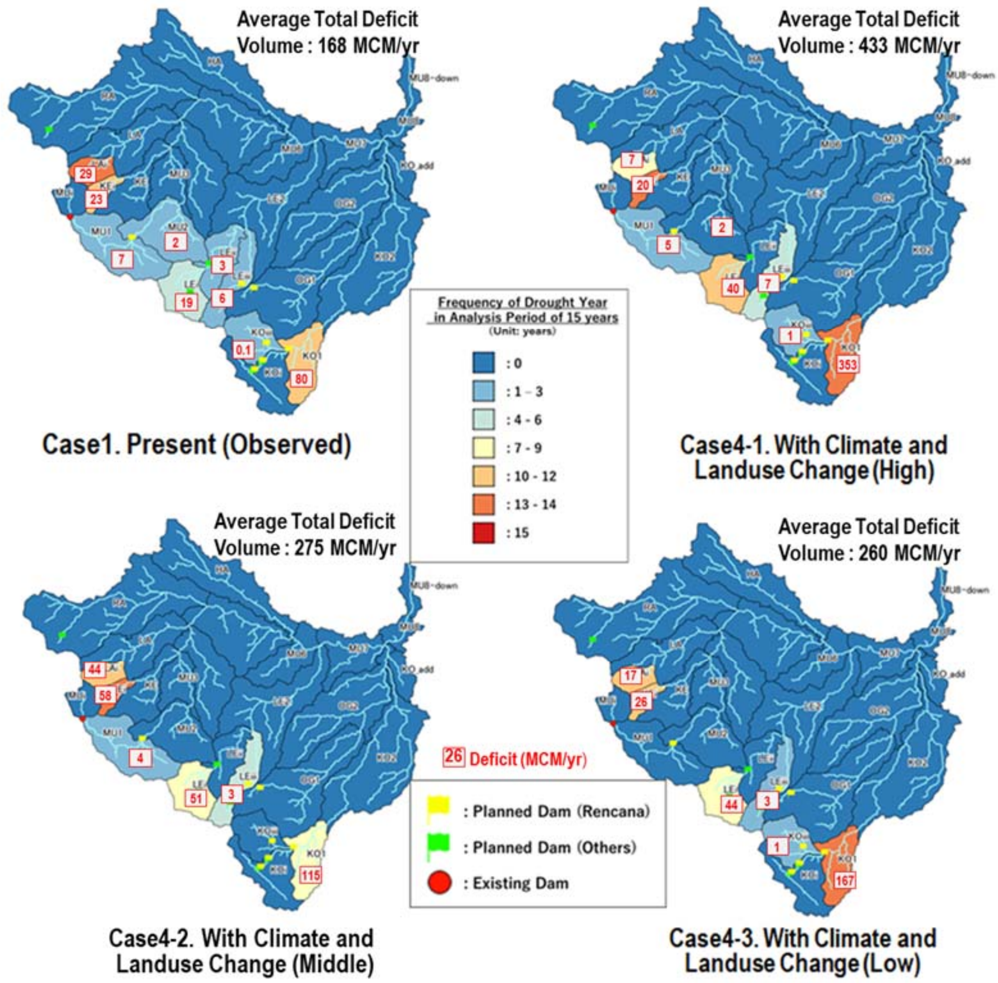
The proposed plan for the new development of 9 surface water irrigation schemes and 4 swamp drainage schemes for the next 20-year period is presented in RENCANA (2017) with implementation schedule.

8. ASSESSMENT OF CLIMATE CHANGE IMPACTS IN 2050

8.1 Droughts

In order to assess the impact of climate change on water use, the frequency of drought years was estimated as presented in Figure S-13 through water balance analysis. The frequency means the number of drought years when water deficit of irrigation and/or DMI water occurs in the water balance analysis period of 15 years and was estimated for each sub-basin. From the figure below, the following considerations are made:

- In all of high, miedium and low scenarios, drought occurs only in the upper sub-basins and there is no drought caused in the middle and lower sub-basins. These water-short sub-basins include those in the Komering, Lematang, Kelingi and Lakitan River basins where existing and proposed large-scaled irrigation intake facilities are concentrated.
- A few dam reservoirs have been planned/proposed for the water-short sub-basins in the Komering and Lematang River basins. However, those in the Kelingi and the Lakitan River basins have no planned/proposed dam site.
- DMI water which is prioritized more than the irrigation water in terms of water security, would be secured almost 100% in all the future climate scenarios, and almost all the water deficit volume would be for irrigation water.



Source: JICA Project Team 2

Figure S-13 Frequency of Drought Years and Volume of Water Deficit

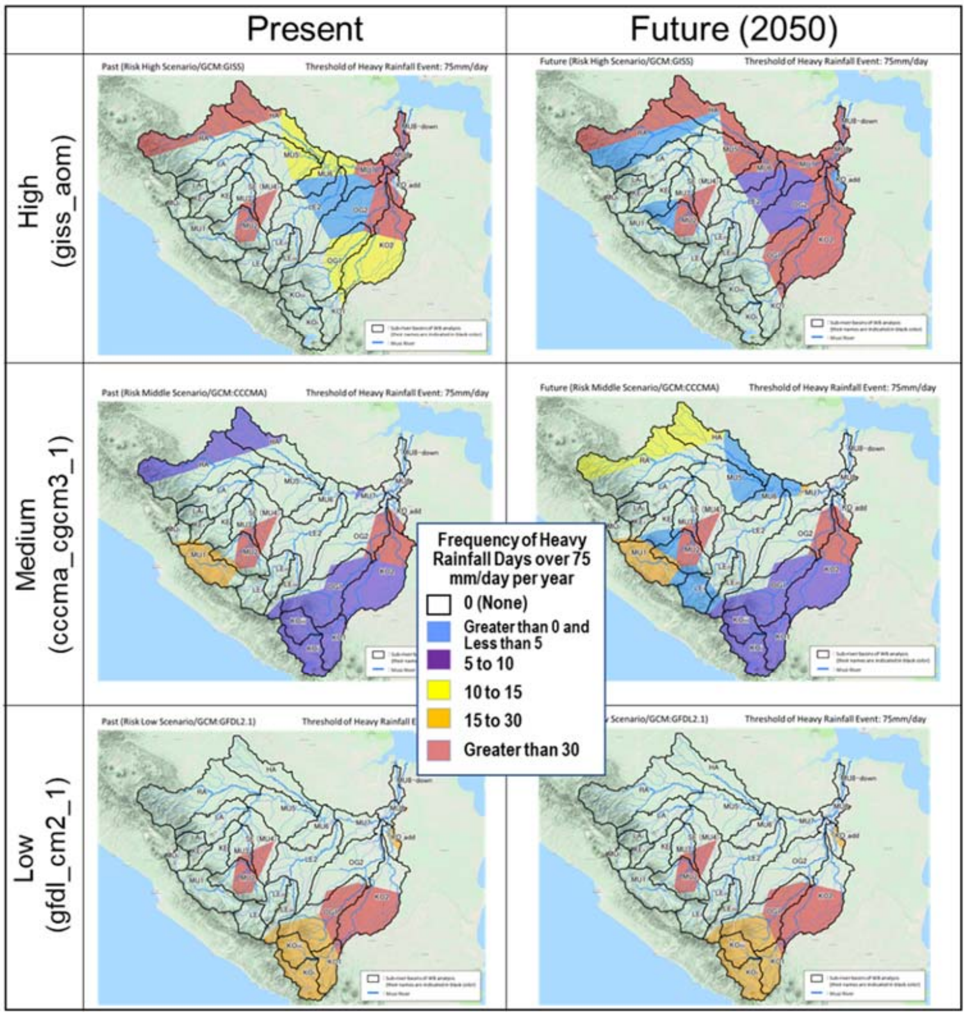
8.2 Increase of Heavy Rainfalls

In order to grasp the increase of heavy rainfall events in the future climate, a frequency analysis was carried out using bias-corrected daily rainfall data of 500m x 500m mesh areas provided by JICA Project Team 1. Table S-25 compiles the total number of heavy daily rainfalls in the Musi River basin under the present and future climates for different thresholds of rainfall intensity and also their increase rates. Figure S-14 presents the number of heavy rainfall days over 75mm/day. As seen in the table and figure, the frequency of heavy rainfall events generally increases in the future, and the increase rates in the high scenario case range from 1.5 to 7.0.

Table S-25 Numbers of Heavy Rainfall Days per Year in Present and Future Climates

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

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure S-14 Frequency of Daily Rainfall over 75mm/day

8.3 Floods

There are extensive swamp areas situated in the middle-reach areas of the Musi River basin and there are extensive agricultural areas which used to be tidal swamp areas in the lower area: both areas have been vulnerable to habitual inundations. Figure S-15 and Table S-26 present the results of a flood inundation analysis with an assumption of 25 cm sea level rise in 2050. As referred to in Figure S-15 and Table S-26, the following are considered:

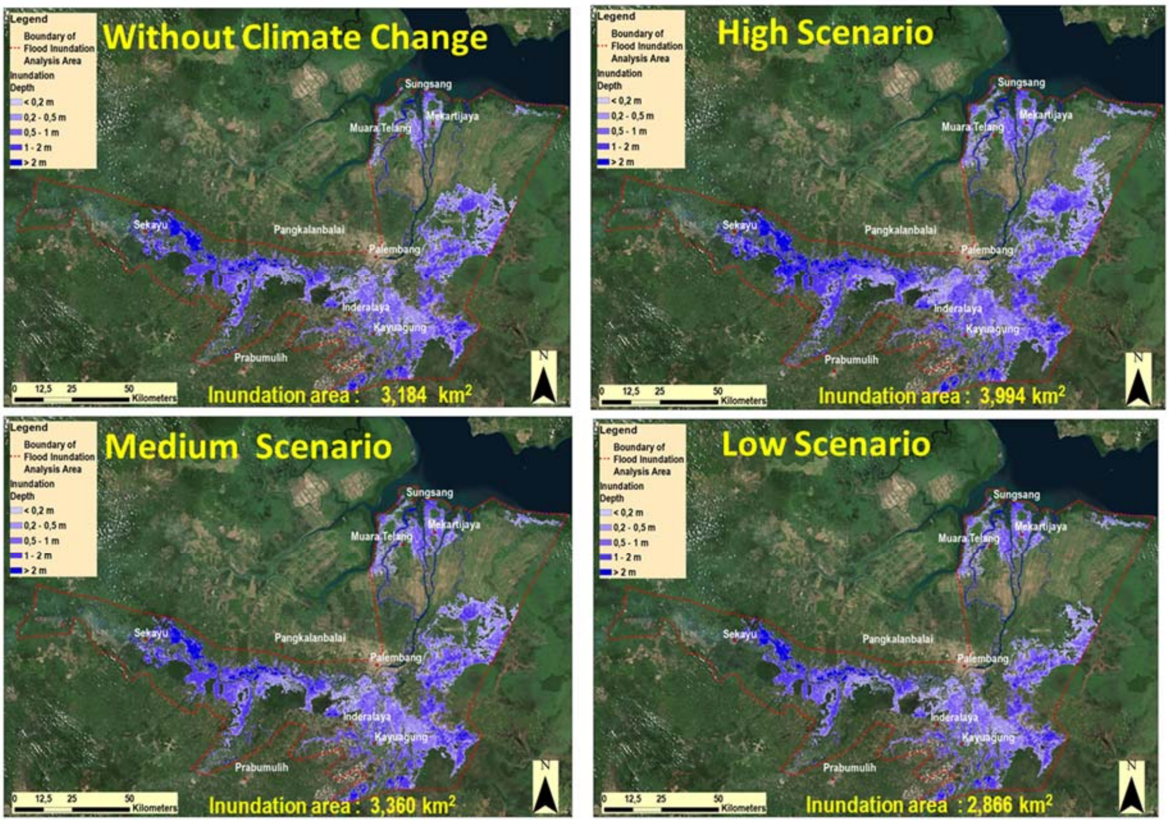
- The flood inundation area definitely increases as the return period increases, and expands especially in the lower coastal areas due to the sea level rise.
- Under the present conditions, the inundation area of 100-yr return period is estimated at about 3,200 km^2 and is to increase or decrease to 4,000 to 2,900 km^2 in 2050, depending on the future climate scenarios. And
- In 2050, some 260,000 to 300,000 houses are to be located in flooding areas.

However, it could be noted that not all houses in the flooding areas would be affected by the flooding, since most of the population in the flood plains are living in pillar houses (see Photo S-1) and are very familiar with how to live with floods. In addition, most of the major settlement areas located higher in elevation have narrowly escaped from flooding.

Table S-26 Results of Flood Inundation Analysis

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

Source: JICA Project Team 2



Source: JICA Project Team 2

Figure S-15 Simulated Inundation Areas (100-year Return Period)

Source: JICA Project Team 2

Photo S-1 Pillar Houses in Flood Plains

8.4 Sea Water Intrusion

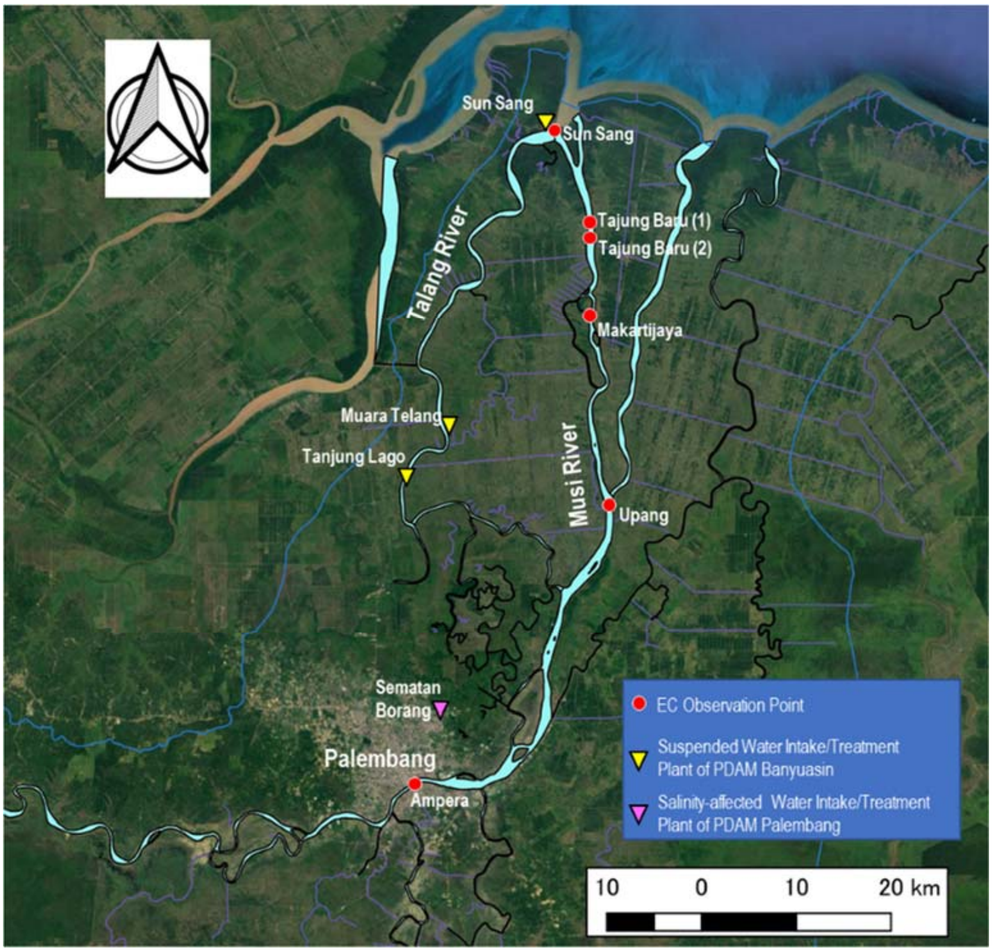
Sea level rising is one of the most important impacts of climate change. A sea level rise of 0.5cm/year is projected in the Musi River mouth. Some 300,000 people are living in the low-lying tidal areas, where most of the people are engaged in agriculture. Sea water intrusion that will be augmented by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

According to interviews with farmers and officials concerned, no significant damage to agriculture has been reported yet. However, it has been reported that high salinity was detected at the Sematan Borang Water Intake/Treatment Plant in Palembang (see Figure S-16).

Electric conductivity (EC) observation was conducted along the Musi River in December 2013 by JICA Project Team 2 (see Figure S-16), and the following are considered:

- The EC value of Sun Sang is almost that of sea water.
- The EC values at Upang and Ampera, located about 45km and 90km upstream from the river mouth, are almost that of fresh river water.
- There is a sign of formation of salt wedge seen at Tanjung Baru (1), about 15km upstream from the river mouth. The deeper from the water surface, the larger the EC value is.
- Makartijaya, about 25km from the river mouth, is almost the lowest limit where harmless water in terms of salinity is available.

The considerations above are made based only on the one-time EC observation in December 2013, and the salinity in river water near the river mouth generally varies very much due to the changes of tide level and river discharge. In order to clarify the characteristics of salinity distribution, therefore, it is necessary to accumulate EC or salinity data by continuous monitoring of EC or salinity.



Source: JICA Project Team 2

Figure S-16 Locations of Salinity-affected Water Intake and Treatment Plants, and EC Observation Points

8.5 Sediment Discharge

Sediment discharge under the current and future climates is as follows:

Current Situation of Sediment Discharge

- No serious sediment disasters such as large-scale landslides, huge slope failures are observed in the Musi River basin.
- The main sources of sediment discharge are presumed to be supplied by cultivated land and river.
- The sediment distributed in the vast plain is thought to be transported gradually to the downstream areas by floods.
- A huge riverbed deposit was observed in the middle reaches of the Komering River. These deposits are presumed to be the volcanic sediments which had been transported by erosion in Pleistocene.
- Riverbank failures were confirmed at several sites of the rivers, which are also to be the source of sediment discharge.

Sediment Discharge under Future Climate Conditions

The amount of sediment discharge under the future climate conditions was estimated by comparing it with that under current climate conditions using the formula USLE.

- The increase ratio of sediment discharge is estimated at 15% on an average against the present climate (2000), and the average increase ratio of rainfall is expected to be at 3% (see the table below).

1) Increase Ratio of Sediment Discharge

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

2) Increase Ratio of Rainfall Amount

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

8.6 Risk and Resilience of Water Resources Management

The conceivable risks caused by climate change and conceivable resilience measures are summarized as presented in Table S-27, focusing on four significant hazards, i.e., droughts, floods, sea water intrusion and sediment discharge. The resilience measures are mostly categorized into non-structural measures that could be implemented by using existing resources with less cost.

Table S-27 Summary of Risk and Resilience of Water Resources Management

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

Source: JICA Project Team 2

(1) Droughts

The total water deficit volume is anticipated to increase from 18% to 74% under climate and landuse changes, while the occurrence probability of drought year at a sub-basin level depends significantly upon the climate change scenarios. Accordingly risks of reduction of agricultural production, shortage of water for DMI (Domestic, Municipal and Industrial) purposes, damage to ecosystem, degradation of water quality, etc. might increase.

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

(2) Floods

The impacts on floods would increase under climate and/or land use changes, depending on future climate scenarios. Therefore, risks of direct damage to human lives, houses, infrastructures, agriculture and losses to economic activities (suspension of business operation, etc.) might increase.

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

(3) Seawater Intrusion

A sea level rise of 0.5cm/year is projected at the Musi River mouth as an impact of climate change, and there are already some appearing signs of sea water intrusion in the low-lying tidal areas. As the sea level rises, the sea water intrusion will definitely become worse. Thus it is concerned that salt damage to agriculture, DMI, ecology, etc. will become more and more tangible in the near future.

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

(4) Sediment Discharge

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

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

9. FORMULATION OF CLIMATE CHANGE ADAPTATIONM MEASURES UP TO 2050

The priority actions that should be implemented during the three periods of time, up to 2050, namely; (i) 2020 to 2030, (ii) 2031 to 2040 and (iii) 2041 to 2050, for the climate change adaptation measures are as compiled in Table 10.6.1 (Chapter 10): the priority actions are similar to the measures which have been formulated in the current POLA and RENCANA for the MSBL River basin. The Musi River basin (the project target area) has a great development potential, but its actual development is still delayed. Therefore, the proposed actions are to be regarded not only as adaptation measures for climate change but also as measures that could bring about comprehensive development in the project area especially in terms of water resources management. The differences between the proposed adaptation measures and the measures in the present POLA and RENCANA are also summarized in Table S-28.

Table S-28 Summary of Differences between Proposed Climate Change Adaptation Measures and Measures Formulated in POLA and RENCANA

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

Source: JICA Project Team 2

10 PROPOSED CLIMATE CHANGE MEASURES TO BE INCORPORATED INTO POLA/RENCANA

The current POLA and RENCANA were approved officially in 2014 and 2017 respectively. These policy and strategy documents that cover a period of 20 years onwards are supposed to be reviewed and evauated at least every five years, following the Ministerial Regulation of "NOMOR 10/PRT/M/2015. Therefore, the next review/evaluation would be made around 2019 for POLA and around 2022 for RENCANA, respectively and the proposed adaptation measures/actions for the period from 2020 to 2040 compiled in Table 10.6.1 (Chapter 10) should be incorporated into the next POLA and RENCANA through the review/evaluation.

<< *CAPACITY STRENGTHENING* >>

11. CAPACITY STRENGTHENING

(1) The Project Team 2 held workshops in Jakarta, Surabaya and Palembang as part of their capacity strengthening activities for the Indonesian side. In the workshops, the respective experts of JICA Project Team 2 provided presentations including lectures on survey/study methods and introduction of study examples in Japan and other countries with the aim of deepening the participants' technical knowledge and understanding through discussions and exchange of opinions among the participants, inviting mainly working-level engineers from counterpart agencies and local consultant companies for individual topics/subjects on expertise of each expert.

(2) In the Phase 1 of the Project from June 2013 to June 2016, the first and second country-focused trainings were carried out in the aspect of "Assessment of Climate Change Impacts" by JICA Project Team 2 in cooperation with JICA Project Team 1, headed by Prof. Dr. Koike, the University of Tokyo, in charge of Project Component 1, aiming to strengthen the capacity for the Indonesian side to plan water resources management in future climate conditions. Furthermore, in the Phase 2 from July 2016 to December 2019, the third and fourth country-focused trainings were conducted in the aspect of "Water Resources Management Plan" by the Team 2 with the same aim as in Phase 1.

(3) JICA Project Team 2 has held the first to fourth seminars in Jakarta, Surabaya and Palembang in the Project as part of efforts toward dissemination and publicity on the project outcomes with the support and cooperation of JICA and JICA Project Team 1. The second seminar in JKT (19 May 2014) included press reporting as well. Besides, the second seminar was started with an opening address by Dr. Ir. Basoeki Hadimoeljono, DG of Spatial Planning, MPW (currently the Minister of MPWH). The third seminar was held in Palembang and Jakarta, starting with the opening addresses by Ir. Jarot, General Manager of BBWS Sumatra VIII in PLMB and Ir. Imam Santoso, DG of Water Resources, MPWH in JKT, respectively. The fourth seminar was held as the last one in the three (3) cities above in November 2019 to widely share the outcome of the Project, including the handbook, in Indonesia.

<< CONCLUSIONS AND RECOMMENDATIONS >>

12. CONCLUSIONS AND RECOMMENDATIONS

12.1 Formulation of Climate Change Adaptation Measures for POLA and RENCANA

The Project formulated climate change adaptation measures consisting of structural and non-structural measures with the aim of mitigating the damage which is anticipated to be inflicted on the water resources management by climate change for the POLA and RENCANA of the Brantas and Musi River basins. The adaptation measures have been drawn out based on projected future climate data with uncertainty that is inherent in themselves and also the data and information including those which were barely accepted for the Project. Therefore, it is essential to carry on taking actions in due consideration of the following recommendations and items in Table 12.1.1 (Chapter 12) toward the stages coming for:

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

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

12.2 Organization and Institution

(1) Agriculture and Irrigation Sector

(a) Horizontal Coordination and Vertical Collaboration among Stakeholders

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

(b) Actions for Institutional Strengthening and Empowerment of Human Resources

It is recommended to practice actions for institutional strengthening and empowerment of human resources in participatory manner as shown in Table S-29.

Table S-29 Substances and Actors of Institutional Strengthening and Empowerment of People

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

Source: JICA Project Team 2

(2) Other Sectors

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

(a) Integrated management of surface water and groundwater [for both basins]

Groundwater conservation has been proposed as part of water preservation measures in both river basins. Groundwater and surface water are likely to affect each other. In order to properly conserve and utilize the groundwater resources, it is necessary to consider the groundwater and surface water resources in an integrated manner through (i) sharing groundwater information, (ii) formulation of groundwater use plan integrated with surface water and (iii) coordination in various measures.

(b) Clarification of roles in actions for flood hazard mapping and early warning system [for both basins]

Flood hazard mapping and early warning system have been proposed as part of non-structural measures against floods. Flood hazard maps are to be prepared for various purposes including public's evacuation.

A lot of agencies are involved in operating a flood early warning system for evacuation at each step from hydrological monitoring to data analysis, warning issuance and warning dissemination. Hence, roles and procedures need to be discussed and recognized among the agencies through documentation.

(c) Enhancement of coordination through TKPSDA for establishment of SIH3 [for Brantas]

A hydrological, hydrogeological and hydro-climatological information system named "SIH3" is being developed jointly by BBWS-Brantas, PJT-I, BMKG and local governments concerned. There is no specific rule of data sharing set down even between BBWS-Brantas and PJT-1. Since facilitation of SIH3 development is one of the important tasks of TKPSDA, it is deemed desirable to facilitate the system development by explicitly writing the tasks of TKPSDA and by determining how to practically share the data owned by the respective agencies.

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

Watershed conservation is positioned as one of the water resources conservation measures in the Brantas River basin and there are many groups, such as BBWS-Brantas, PJT-I , Brantas-Sampean BPDASHL, Perhutan3 and local governments, related to the watershed management in the basin. Although BPDASHL is supposed to be the leading agency for the management, the four major agencies, namely two Balai plus two Perum, need to closely coordinate toward harmonized implementation of watershed conservation activities.

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

Land use revision has been proposed for the Musi River basin as part of water resources conservation measures. There is an issue that some administrative boundaries of regencies are not clearly and properly delineated among local governments concerned.

BAPPEDA (South Sumatra Province) is expected to play a key role by coordinating these two regencies when they insist on different policies in formulating development plans or land use.

12.3 Handbook

POLA and RENCANA are being developed in Indonesia to properly manage water resources based on the Law No. 17/2019 on Water Resources and the Ministerial Regulation of "NOMOR 10/PRT/M/20154, which require to formulate POLA and RENCANA (hereinafter referred as "the Water Resources Management Plans") corresponding to the impacts of future climate change. The Project has formulated proposals for reflecting climate change impacts in the Water Resources Management Plans of the Brantas and the Musi River basins, and also prepared a handbook to be applicable to those for other river basins in Indonesia, taking climate change issues into account. The handbook was produced in due consideration of the knowledge and lessons obtained in the Project with the chief concept of formulating adaptation measures which aim to materialize less rework and less disaster risk.

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

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

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

12.4 Conclusions and Recommendations

Valuable knowledge and lessons were accumulated by the Project in the course of projecting the future climate conditions up to 2050 and formulating the climate change adaptation measures for the Brantas and Musi River basins. These knowledge and lessons have been entirely incorporated into the above-mentioned handbook.

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

The Republic of Indonesia

**THE PROJECT
FOR
ASSESSING AND INTEGRATING CLIMATE CHANGE IMPACTS INTO
THE WATER RESOURCES MANAGEMENT PLANS FOR
BRANTAS AND MUSI RIVER BASINS
(WATER RESOURCES MANAGEMENT PLAN)**

FINAL REPORT

VOLUME II MAIN REPORT

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PART 2 STUDY FOR BRANTAS RIVER BASIN

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Part 1
GENERAL

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

One of the impacts caused by climate change in Indonesia is considered to be the change in the water cycle. While the rainfall tends to increase in Java, Bali, Nusa Tenggara and Papua particularly in the rainy season, it tends to decrease in the other regions. In the dry season, the rainfall is projected to decrease in most of Java and South Sumatra. In addition, there are growing concerns about an increase of extreme events such as droughts and floods due to the increasing frequency of El Nino. As well as promoting development in consideration of these impacts, it is required to incorporate mitigation and adaptation strategies against climate change into the development plans at both national and regional levels in order to achieve the national reduction goal of 26% of greenhouse gas emissions in 2020 as compared with the case of not taking measures (so called, “BAU”). However, no specific methodology in the respective sectors has been organized.

In the water resources management sector, each country has been seeking concrete ways to reflect climate change impacts in planning by trial and error since no typical method has been established throughout the world yet. Therefore, it is becoming necessary to discuss the planning theory and directionality of water resources management in consideration of climate change in Indonesia as well.

Currently in Indonesia, in order to properly manage water resources, POLA which indicates the direction of river basin management and RENCANA which is a specific action plan for basin management based on POLA have been or are being developed. It is thus required to formulate a water resources management plan corresponding to the impacts of future climate change and its uncertainty. In addition to measures against floods and droughts, peat land management for (i) decrease in greenhouse gas emissions and (ii) increase in crop production is particularly viewed as a meaningful work in the national action plan and is necessary for policy reasons. The measures for peat land management should be taken on the basis of appropriate water resources management by dealing with the said issues as key policies in the Ministry of Public Works and Housing (hereinafter referred to as “MPWH”).

As to the above-mentioned issues, projects for assessment and countermeasures of climate change impacts have been implemented under the assistance of various donors in Indonesia. However, there are still some issues in the past efforts, such as:

(1) Meteorological and hydrological characteristics at the river basin level are not reflected in climate change impacts because those impacts are forecasted based on the assessments with a larger scale or a certain assumption.

(2) Climate change impacts are not able to be reflected in water resources management plans (particularly, RENCANA) because recommendations are not quantitative, nor specific. And

(3) Discussions on planning theory such as how to reflect climate change impacts in the formulation of water resources management plans have not been made within the

Government of Indonesia (GOI), and an applicable method to other river basins by the Indonesian side itself has not been developed yet.

Under such circumstances, "The Project for Assessing and Integrating Climate Change Impacts into the Water Resources Management Plans for Brantas and Musi River Basins (hereinafter referred to as "the Project")" will (i) assess the climate change impacts for both river basins in 2050 in terms of risk/vulnerability and resilience of water resources, (ii) formulate proposals for reflecting climate change impacts in water resources management plans of the river basins, and (iii) prepare guidelines to be applicable to water resources management plans in other river basins in Indonesia, taking climate change issues into account.

The Project consists of two components, which are "Component-1: Climate Change Impact Assessment and Runoff Analysis" and "Component-2: Water Resources Management Plan". This report deals with Component-2.

1.2 Goal and Expected Outputs of the Project

(1) Goal of the Project

a) Climate change impacts shall be reflected in water resources management plans in the Brantas and Musi River basins;
b) The proposed guidelines shall be approved and applied to other river basins in Indonesia; and
c) The capacity of river basin management in Indonesia is developed and strengthened, taking climate change impacts into account.

(2) Expected Outputs of the Project

i) Future rainfalls and runoffs simulated under projected climate change in the Brantas and Musi River basins,
ii) Assessment of water resources management risk/vulnerability and resilience under climate change impacts, particularly in terms of flood and drought in both river basins,
iii) Proposals for reflecting climate change impacts in water resources management plans (POLA and RENCANA) of the river basins,
iv) Proposed guidelines to be applicable to water resources management plans in other river basins in Indonesia, taking climate change issues into account, and
v) Capacity enhancement of MPWH to formulate water resources management plans with strategies for climate change impacts.

Out of these outputs, the JICA Project Team for Component-2 (hereinafter referred to as "JICA Project Team 2 or Team 2") conducts the works for the ii) to v) above, and collection of data and information for the above i).

1.3 Objectives of the Project (Component-2: Water Resources Management Plan)

The objectives of Component-2 are:

(1) Assessment of water resources management risk/vulnerability under climate change impacts and formulation of proposals for reflecting climate change impacts in water

resources management plans (POLA and RENCANA) of both river basins by using the outputs of Component-1,

(2) Preparation of guidelines applicable to other river basins in Indonesia, and

(3) Capacity enhancement for water resources management in consideration of climate change impacts in Indonesia through the (1) and (2) above.

1.4 Project Area

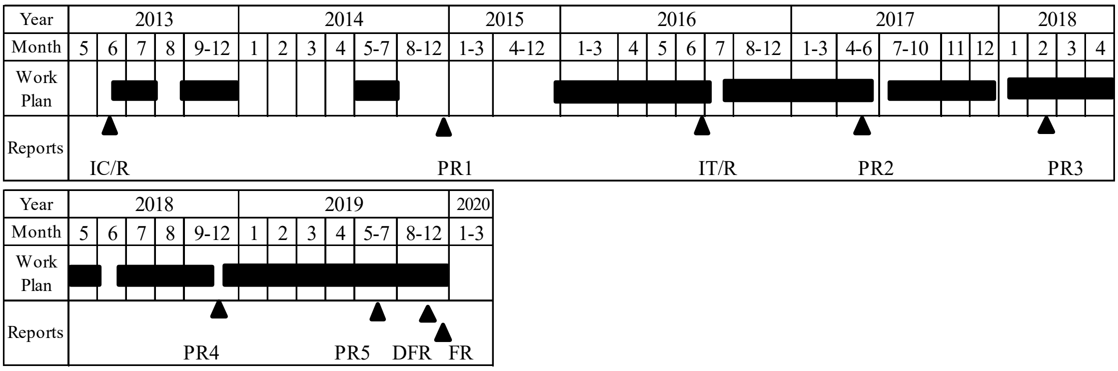
The project area covers the following two river basins. The location maps of these river basins are shown in the frontispiece of this report.

- Brantas River basin in Jawa (approximately 12,000 km^2)
- Musi River basin in Sumatra (approximately 60,000 km^2)

The above "Musi River basin" in the Project includes downstream lowland swamp areas of the Banyuasin and Sugihan River basins adjacent to the Musi River basin.

1.5 Project Schedule

The period of Component-2 was originally 36 months from June 2013 to May 2016 and was revised to 79 months from June 2013 to December 2019. The revised schedule is presented in Figure 1.5.1 below.



Source: JICA Project Team 2

Figure 1.5.1 Schedule of the Project (Component-2)

1.6 Scope of Component-2

Component-2 is divided into two phases; Phase 1 and Phase 2. The scopes of the respective phases are as follows:

- Phase 1:
  1) Collection of data and information utilized for Component-1, and
  2) Assessment of water resources management risk/vulnerability and resilience under climate change impacts, particularly in terms of flood and drought in both river basins,
- Phase 2:
  1) Proposal for reflecting climate change impacts in water resources management plans (POLA and RENCANA) of both river basins, and

2) Preparation of guidelines to be applicable to water resources management plans in other river basins in Indonesia, taking climate change issues into account.

Besides, capacity enhancement for formulation of water resources management plans with strategies for climate change impacts in Indonesia will be conducted in both phases.

1.7 Object Agencies for the Project

The following are the object agencies for the Project:

Implementing agency: Ministry of Public Works and Housing (MPWH)

Related agencies: Agency for Meteorology, Climatology and Geophysics (BMKG)

Jasa Tirta I Public Corporation (PJT I)

1.8 Final Report

This Final Report is hereby submitted as the final product of the Project which was conducted from June 2013 to December 2019.

CHAPTER 2 MOVEMENT RELEVANT TO WATER RESOURCES IN INDONESIA

2.1 Movement of River Basin Water Resources Management

In recent years, problems of rainy season floods, dry season droughts and quality aggravation of river water and groundwater are frequent in Indonesia and these problems have made it important to promote harmonized conservation and use and control of water resources through appropriate river basin management.

In such a situation, Indonesia has been formulating the following statutory plans to appropriately realize the water resources management:

(a) Water Resources Management Strategic Plan（POLA）which delineates the direction of river basin management, and

(b) Water Resources Management Implementation Plan（RENCANA）which is a concrete plan for implementation of river basin management on the basis of POLA.

(1) National Policy and Institutional Context

Indonesia stipulated 1) role-sharing among central and local governments, 2) fulfillment of basic human needs, 3) introduction of water right and 4) water resources conservation in Law on Water Resources No.7/2004 (hereinafter referred to as “the Law No.7/2004”, see “Section 2.3”), pressing forward with decentralization after 1999 and the Structural Adjustment Program of Water Resources Sector (WATSP) led by the World Bank. According to the above stipulations, it has been important to execute integrated water resources management (IWRM) at a river basin level through participation not only of the central and local governments but also of relevant stakeholders.

In addition, the National Medium-Term Development Plan (RPJMN) 2004 - 2009 set forth, 1) realization of sustainable joint water resources management, 2) flood and drought damage reduction, 3) quality enhancement of coordination and cooperation among relevant agencies, etc. as the objectives of water resources development.

The laws and ministerial regulations of the Ministry of Public Works (MoPW), currently called the Ministry of Public Works and Housing (MPWH) laid down in relation to the Law No.7/2004 are as compiled below.

Table 2.1.1 Laws and Ministerial Regulations of MoPW Related to Law on Water Resources No.7/2004

Title	Code	Contents
Law of the Republic of Indonesia	No.7/2006 Regarding Water Resources/ Elucidation	Achievement of IWRM in Indonesia, duties and responsibilities of central, provincial and regency/municipal governments and village administration
Regulation of Minister of Public Works	No.12/PRT/M/ 2006	Establishment of Balai Besar
Regulation of Minister of Public Works	No.13/PRT/M/ 2006	Establishment of Balai
Regulation of Minister of Public Works	No.11A/PRT/M/2006	133 river regions covering whole Indonesia and 69 river areas under jurisdiction of Central Government.
Regulation of the Minster of Public Works	No.544/PRT/M/2005	Organization and work procedures of the River Center
Regulation of the Minster of Public Works PEKERJAAN UMUM	No.26/PRT/M/ 2006	Establishment of Balai Besar

Source: Pre-evaluation Report on Project for Capacity Development of RBOs for Practical Water Resources Management in Indonesia, JICA, May 2009

(2) River Basin Organization (RBO)

The above ministerial regulations of No.11A/PRT/M/2006, No.12/PRT/M/2006, No.13/PRT/M/ 2006 and No.26/PTR/M/2006 decided that 5,590 river basins covering the whole Indonesian territory be divided into 133 river regions, and 63 river regions of these be directly managed by MoWP (currently MPWH). The MPWH has established 34 river basin organizations (RBO: Balai in Bahasa Indonesia, see Table 2.1.2): RBOs shall be engaged in the development and management of these regions. As for the other river regions, about 50 RBOs to be controlled by respective provincial governments have been gradually organized.

Table 2.1.2 River Basin Organizations for River Basins under Jurisdiction of MPWH

No.	Name	No.	name
1	Sumatera I	18	Brantas
2	Sumatera II	19	Kalimantan I
3	Sumatera III	20	Kalimantan II
4	Sumatera IV	21	Kalimantan III
5	Sumatera V	22	Sulawesi I
6	Sumatera VI	23	Sulawesi II
7	Sumatera VII	24	Sulawesi III
8	Sumatera VIII	25	Sulawesi IV
9	Mesuji-Sekampung	26	Pompenga-Jeneberang
10	Cidanau-Ciujung-Cidurian	27	Maluu
11	Ciliwung-Cisadane	28	North Maluku
12	Citarum	29	Bali Penida
13	Cimanuk-Cisanggarung	30	Nusa Tenggara I
14	Citanduy	31	Nusa Tenggara II
15	Pemali-Juana	32	Papua
16	Bengawan Solo	33	West Papua
17	Serayu-Opak	34	Papua Merauke

Source: JICA Project Team 2

The major tasks of RBO are as enumerated below:

- Formulation of POLA and RENCANA for the river basin in charge,
- Implementation of water resources management,
- Technical recommendations on water resources supply, distribution, use and water right for the river basin in charge,
- Execution of water resources operation and maintenance for the river basin in charge,
- Management of hydrological system,
- Preparation of water resources data and information,
- Support of activities to be conducted by the Water Resources Management Coordination Team (Tim Koordinasi Pengelolaan Sumber Daya Air: TKPSDA) in their river basin in charge, and
- Promotion of community participation in water resources management.

(3) Public Service Agency (BLU)

There is a framework of Public Service Agency (BADAN LAYANAN UMUM: BLU) set up as the way of fee collection through water resources management by RBOs in the legal system in Indonesia. The laws and regulations concerning BLU are compiled in Table 2.1.3. These enable collection of fees from users for public services and usage of the fees for operation of the organizations. In the RBO case, cited is fee collection for water supply, water use for hydropower, etc.

Table 2.1.3 Laws and Regulations concerning BLU

Title	Code	Remarks
Peraturan Menteri Keuangan RI (DEPARTEMEN KEUNAGAN RI)	➢ Nomor 07/PMK.02/2006 Persyaratan Administratif Penetapan PK BLU ➢ Nomor 08/PMK.02/2006 Pengadaan Barang/Jasa BLU ➢ Nomor 09/PKM.02/2006 Dewan Pengawas BLU ➢ Nomor 10/PMK.02/2006 Remuerasi BLU ➢ Nomor 66/PMK.02/2006 RBA dan DIPA BLU	Ministerial Regulation on BLU
PERATURAN PEMERINTAH REPUBLIK INDONESIA	NOMOR 23 TAHUN 2005 TENTANG PENGELOLAAN KEUANGAN BADAN LAYANAN UMUM	Government Ordinance on BLU
LAW OF THE REPUBLIC OF INDONESIA	NUMBER 1 YEAR 2004 CONCERNIGN STATE TREASURY	Law on BLU
LAW OF THE REPUBLIC OF INDONESIA	NUMBER 17 YEAR 2004 CONCERNIGN STATE TREASURY	Law on BLU

Source: Pre-evaluation Report on Project for Capacity Development of RBOs for Practical Water Resources Management in Indonesia, JICA, May 2009

(4) POLA and RENCANA

POLA and RENCANA are provided in the Government Regulation No.42/2008 for water resources management in Indonesia wherein several key contents are stated as shown below.

- Water resources management is conducted based on water resources management policies at the national, provincial and regency/municipal levels:
- The water resources management policies consist of the aspects on water resources conservation, water resources utilization, water resources control and information systems:
- POLA is defined as a basic framework of water resources management under (i) integrated policies of surface water and groundwater in a river basin and (ii) harmonization of water resources conservation and utilization:
- POLA is formulated for 20 years and can be reviewed at least every five years:
- RENCANA is also formulated for 20 years and can be reviewed at least every five years: and
- RENCAN is to be (i) a basic plan for preparation of program and activity plan in water resources sector, and (ii) suggestion for preparation, review and completion of spatial plan.

(5) Water Resources Management Coordination Team (TKPSDA)

TKPSDA chaired usually by the head of BAPPEDA is formed as a coordinating organization at the river basin level, of which the major functions are enumerated below:

- Consultation with agencies concerned for acceleration of IWRM in river basin in charge,
- Promotion of integration and coordination of interests and concessions, etc. among sectors, regions and other stakeholders related to water resources management in river basin in charge,
- Monitoring and evaluation on implementation of programs and plans on water resources management in river basin in charge, and
- Draft POLA deliberation/formulation and draft RENCANA deliberation.

(6) Role sharing among Central and Local Governments

The role sharing of central and local governments provided in the Law No.7/2004 regarding major items of water resources management is presented in Table 2.1.4.

Table 2.1.4 Role Sharing among Central and Local Governments

Roles	Central Government	Provincial Government	Regency/Municipal Governments
Jurisdictional areas	Cross-provincial, cross-country, and national strategic river basins	Cross-regency/ municipal river basins	River basins in regency/ municipality
Preparation of norm, standards, etc.	Preparation of norm, standards, guidelines, manuals	-	-
Flood control	Nation-wide flood control	Province-wide flood control	Regency/municipality wide flood control
Construction/ improvement of irrigation canals	Primary and secondary irrigation canals in jurisdictional areas	(Same as the left)	(Same as the left)
Operation/ maintenance and improvement of irrigation systems	Primary and secondary irrigation systems (irrigation areas of more than 3,000ha)	Primary and secondary irrigation systems (irrigation areas of more than 1,000ha and less than 3,000ha)	Primary and secondary irrigation systems (irrigation areas of less than 1,000ha)

Source: Pre-evaluation Report on Project for Capacity Development of RBOs for Practical Water Resources Management in Indonesia, JICA, May 2009

2.2 Movement of Climate Change Measures

The geographical position of Indonesian is very vulnerable to climate change impacts, and Indonesia has been making its efforts and taking actions towards the implementation of the commitments as a Non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC).

In 2009, the Indonesian President committed at the G-20 meeting in Pittsburgh and at COP15 in Copenhagen to an ambitious, world-leading target of 26% reduction in carbon emissions from “Business As Usual (BAU)” by 2020 to participate in reduction of GHG emissions. With this commitment, Indonesia has been taking a low carbon development path.

(1) Institutional context

To effectively cope with UNFCCC, the Government of Indonesia (GOI) has made a number of significant steps in mainstreaming climate change issues. The first step was the issuance of the National Action Plan addressing climate change (MoE, November 2007), which describes appropriate actions to reduce GHG emissions and adaptation activities in Indonesia. Furthermore, the National Development Planning Agency (BAPPENAS) developed a Climate Change Sectoral Roadmap (ICCSR, December 2009) in order to bridge the said National Action Plan into the 5-year National Mid-Term Development Plan (RPJMN) 2010-2014 and to provide inputs for the subsequent RPJMN until 2030.

Table 2.2.1 Overview of Institutional Context on Climate Change Measures in Indonesia

I. National Level
I-1 Enactment of Laws and Regulations
<< Adaptation Measures >>
a) Law No.25/2004 on National Development Planning System and Law No.24/2007 on Disaster Management
b) Law No. 32/2009 on Environmental Protection and Management
c) Presidential Regulation No.5/2010 on National Medium-Term Development Plan (RPJMN) 2010-2014
<< Mitigation Measures >>
a) Presidential Regulation No.61/2011 on the National Action Plan for Greenhouse Gas Emissions Reduction (RAN-GRK; BAPPENAS) September 2011
b) Presidential Regulation No.71/2011 on National GHG Inventory, October 2011
I-2 Other Major Efforts
In addition to the above laws and regulations, formulation of major institutional actions is as overviewed below.
a) National Action Plan Addressing Climate Change (RANPI), KLH (MoE), November 2007
b) National Development Planning: Indonesia Responses to Climate Change, called as “Yellow Book”, BAPPENAS, December 2007 (revised in July 2008)
c) National Appropriate Mitigation Action (NAMA) in 2009
d) Indonesia Climate Change Sectoral Roadmap (ICCSR), BAPPENAS and other agencies, December 2009
e) Indonesia Second National Communication under UNFCCC), KLH, November 2011
f) Indonesia National Action Plan on Climate Change Adaptation (RAN-API, DNPI/ BAPPENAS/KLH） 2012
II. Ministerial Level
BMKG has conducted the following activities dealing with climate change: • Projection of climate change impacts on future rainfall and water balance by the Center for Climate Change & Air Quality, • Downscaling by using conformal-cubic atmospheric model (CCAM) developed by Australia by the Center for R&D
III. Provincial Level
• Regional Action Plan for Greenhouse Gas Emission Reduction (RAD-GRK)
IV. Donor Level
a) Japan: Bilateral Cooperation on Climate Change a)-1 Bilateral Cooperation on the Joint Crediting Mechanism (JCM) a)-2 Bilateral Cooperation on Climate Change Between the Government of Japan and the Government of Indonesia, 25 November 2011 a)-3 Project of Capacity Development for Climate Change Strategies a)-4 Climate Change Program Loans
b) GIZ and Aus. AID: Climate Change Vulnerability and Adaptation Assessment
c) GIZ and WWF: Risk and Adaptation Assessment to Climate Change in Lombok Island, West Nusa Tenggara Province
d) ADB: Supporting Investment in Water and Climate Change (T/A: RETA7581)
e) WB: Java Water Resources Strategic Study（JWRSS）

Source: JICA Project Team 2

(2) Organizations concerned

The institutional arrangements which cope with climate change have been strengthened at the national level and ministerial/agency levels in Indonesia through organizing the “National Council on Climate Change (Dewan Nasional Perubahan Iklim: DNPI)” and units in charge of climate change at the ministerial/agency levels.

(a) National level

- National Council on Climate Change: DNPI (PD No.46/2008)

DNPI was established as a cross-ministerial organization in July 2008 according to Presidential Decree No 46/2008, of which the functions are:

- ➢ Formulation of national policies, strategies and action plans,
- ➢ Coordination of activities,
- ➢ Formulation of policy and procedures of carbon credit mechanism,
- ➢ Monitoring and evaluation of climate change activities, and
- ➢ Aggrandizement of the country's position through fulfilling its responsibilities to the developed countries.

(b) Ministerial level

Major ministries coping with projection of climate change impacts in Indonesia are as stated below.

- Meteorology, Climatology and Geophysics Agency (BMKG)

The Center for Climate Change &Air Quality and the Center for R&D have coped with climate change in BMKG, of which the functions include observation and data collection, data analysis, modeling and diffusion/training.

- Ministry of Public Works and Housing (MPWH)

In MPWH, the Research & Development Center for Water Resources (PUSAIR) has coped with the climate change.

2.3 Repeal of Law No.7/2004 on Water Resources

Indonesia's Constitutional Court ruled that the Law No.7/2004 was unconstitutional for the following reason and decided to revoke this law on 18 February 2015:

"The Constitution of the Republic of Indonesia (1945) secures a citizen's right to use water. Hence, a certain restriction shall be laid on the entry of private sector companies into water-supply business."

In such a state, JICA Project Team 2 carried out hearings in DGWR/MPWH and PJT-1 in January 2016, to clarify influences of this repeal on this Project, and confirmed that this Project can move forward as planned. Major findings in the hearing are stated below.

(1) The Constitutional Court decided also to reinstate the previous Law No. 11/1974 on Water Resources Development (hereinafter referred to as "the Law No.11/1974") until a new law on water resources is enacted so as to avoid the state where the water in Indonesia is not controlled by a law.

(2) The MPWH enacted in 2015, 22 ministerial regulations in Table 2.3.1 with the aim of bridging the gap between Law No.11/1974 and the actual Indonesian conditions, in the following situation.

- ➢ The Law No.11/1974 was established around forty years ago, and the socioeconomic circumstances at that time are largely different from the prevailing socioeconomic condition. Hence, some provisions of the Law No.11/1974 might be unsuitable for the existing situations in Indonesia.

- There is a large difference between the terms used in both laws. Law No.7/2004 stipulates "Integration of surface water and groundwater" and details the five pillars for water resources management, namely: information, hydrology and meteorology, construction, water management and water distribution, while Law No.11/1974 referred to surface water only and has no mention about POLA and RENCANA.

Table 2.3.1 Ministerial Regulations/2015, MPWH

No	Descriptions
PUPR04-2015	Criteria & River Basins Establishment
PUPR09-2015	Water Resources Utilization
PUPR10-2015	Plan & Technical Plan of Water Arrangement & Irrigation System
PUPR11-2015	Exploitation & Maintenance of Tidal Swamp Reclamation Network
PUPR12-2015	Exploitation & Maintenance of Irrigations Network
PUPR13-2015	Emergency Response to Disaster due to Water Damage
PUPR14-2015	Criteria & Establishment on Status of Irrigation Area
PUPR16-2015	Exploitation & Maintenance of Irrigation Network for Lowland Swamp
PUPR18-2015	Contribution for Operation and Maintenance of Building Irrigation
PUPR21-2015	Exploitation & Maintenance of Pond Irrigation Network
PUPR23-2015	Management of Irrigation Asset
PUPR28-2015	River & Lakes Boundary
PUPR06-2015	Exploitation & Maintenance of Water Resources and Irrigation Building
PUPR07-2015	Coastal Defense
PUPR08-2015	Establishment of Demarcation Lines of Irrigation Network
PUPR17-2015	Irrigation Committee
PUPR26-2015	River Diversion & Use of Former River Segment
PUPR27-2015	Dam
PUPR29-2015	Swamp
PUPR30-2015	Development and Management of Irrigation Systems
PUPR37-2015	Water Utilization Permit
PUPR50-2015	Water Resources Utilization Permit

Note: Translated into English by the JICA Project Team 2, based on material in Indonesian from DGWR

(3) These 22 ministerial regulations deal with the areas of river basin division, water resources utilization, POLA and RENCANA, development/operation/maintenance of dam/irrigation/swamp, water right, etc. among others.