THE REPUBLIC OF THE PHILIPPINES
NATIONAL ECONOMIC AND DEVELOPMENT AUTHORITY
NATIONAL WATER RESOURCES BOARD

THE REPUBLIC OF THE PHILIPPINES

DATA COLLECTION SURVEY FOR NATIONAL WATER RESOURCES DEVELOPMENT AND MANAGEMENT PLAN IN THE REPUBLIC OF THE PHILIPPINES（QCBS）

FINAL REPORT

MAIN REPORT

JULY 2023

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
JAPAN WATER AGENCY

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Data Collection Survey
for
National Water Resources Development
and
Management Plan
in the
Republic of the Philippines

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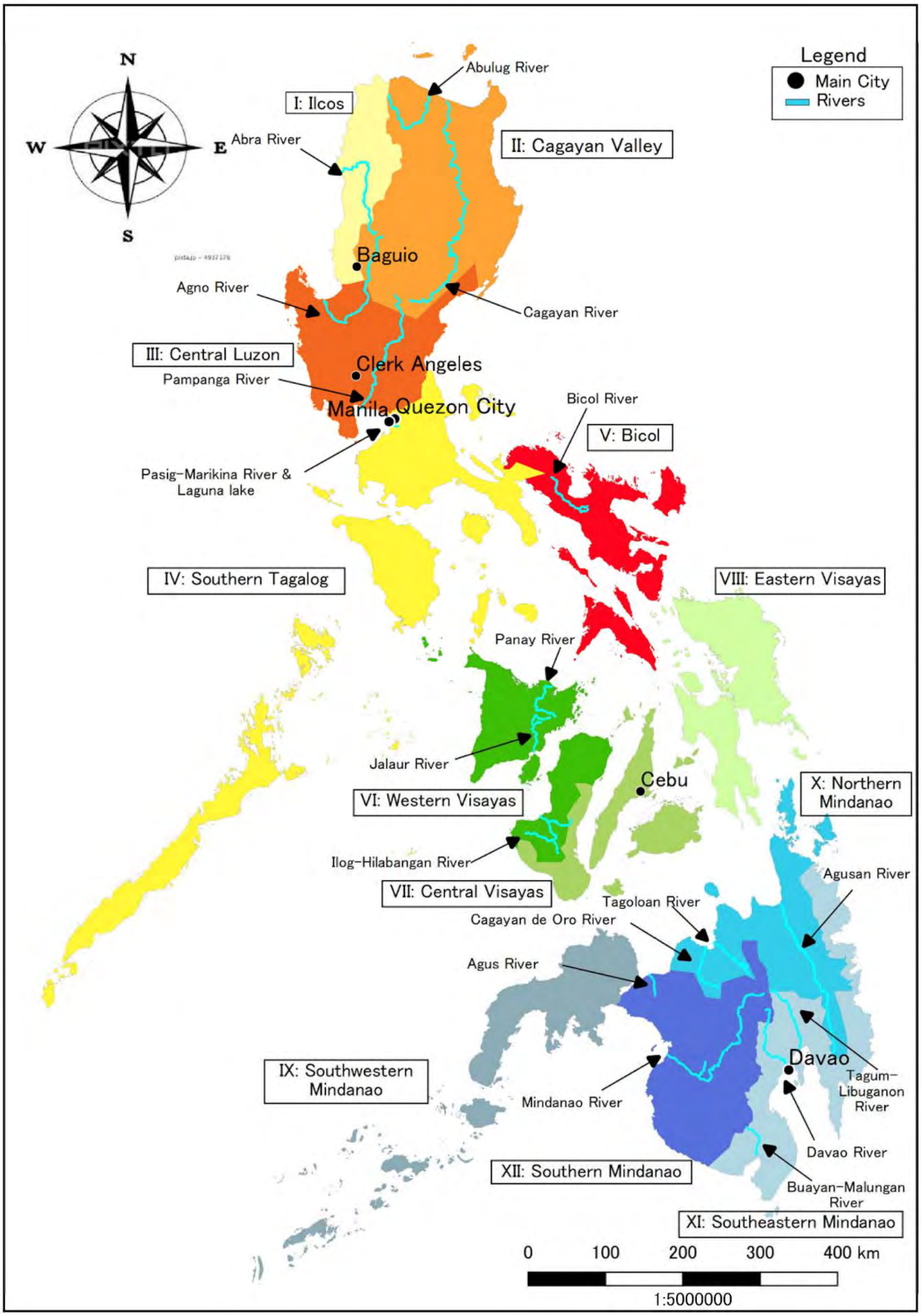
July 2023

NIPPON KOEI
CTI Engineering International Co., Ltd.
Japan Water Agency
Incorporated Administrative Agency



Source: JICA Survey Team

Location Map of the Survey Area

(12 Water Resources Regions in the Philippines and 18 Major Rivers)

12 Water Resources Regions in the Philippines and their Major Rivers, Major Cities, and Climate Classification

Water Resources Regions	Major 18 Rivers (Catchment Area)	Major Cities	Climate Classification	Island Name
WRR I Ilocos	Abra (5,125 km^2) Abulug (3,362 km^2)	Baguio	Type-I	Luzon
WRR II Cagayan Valley	Cagayan (25,469 km^2)	Tuguegarao	Type-II & III	Luzon
WRR III Central Luzon	Agno (5,952 km^2) Pampanga (9,753 km^2)	Angeles	Type-I, II & III	Luzon
WRR IV Southern Tagalog	Pasig-Laguna (4,678 km^2)	Metro Manila	Type-I & III	Luzon Mindoro
WRR V Bicol	Bicol (3,771 km^2)	—	Type-II & IV	Luzon
WRR VI Western Visayas	Panay (1,843 km^2) Jalaur (1,503 km^2) Ilog Hilabangan (1,945 km^2)	Iloilo Bacolod	Type-I & III	Panay Island Panay Island Negros Island
WRR VII Central Visayas	—	Metro Cebu	Type-III & IV	Cebu, Bohol Island, Negros Island
WRR VIII Eastern Visayas	—	—	Type-II & IV	Samar Island, Leyte island
WRR IX Southwestern Mindanao	—	Zamboanga	Type-III & IV	Mindanao
WRR X Northern Mindanao	Agusan (10,921 km^2) Tagoloan (1,704 km^2) Cagayan de Oro (1,521 km^2)	Cagayan de Oro	Type-II & IV	Mindanao
WRR XI Southeastern Mindanao	Tagum-Libuganon (3,064 km^2) Davao (1,623 km^2) Buayan Margun (1,435 km^2)	Davao	Type-III & IV	Mindanao
WRR XII Southern Mindanao	Agus (1,645 km^2) Mindanao (23,169 km^2)	—	Type-III & IV	Mindanao

Note: Climate classification: Type-I: Two prominent seasons (dry from November to April and rain for the rest of the year). Type-II: Significant rainfall from November to January, but the dry season is absent. Type-III: The seasons are not very noticeable, it is relatively dry from November to April, and it rains for the rest of the year. Type-IV: Rainfall is distributed almost evenly throughout the year.

Source: PAGASA

List of Abbreviations

Abbreviation	English	Japanese
1998 M/P	National Comprehensive Water Resources Development Plan Survey, JICA, 1998	フィリピン国　全国総合水資源開発計画調査，国際協力事業団，1998.8
AAGR	Average Annual Growth Rate	年平均成長率
AD	Ancestral Domain	先祖伝来の領地
ADB	Asian Development Bank	アジア開発銀行
ALOS	Advanced Land Observing Satellite	陸域観測技術衛星（だいち）
ARCM	Non-contact Radar Sensor Automatic Radio Current Meter	非接触レーダーセンサー電波式自動流速計
ARG	Automatic Rainfall Gauge	自記雨量計
ARSIT	Association for Rainwater Storage and Infiltration Technology	社団法人雨水貯留浸透技術協会
ASTT	Advanced Science and Technology Institute	先端科学技術研究所
AWLG	Automatic Water Level Gauge	自記水位計
BAI	Bureau of Animal Industry	畜産殖産局
BAS	Bureau of Agricultural Statistics	農業統計局
BFAR	Bureau of Fisheries and Aquatic Resources	水産水生生物資源局
BOD	Biochemical Oxygen Demand	生物化学的酸素要求量
CADT	Certificate of Ancestral Domain Title	先祖伝来領域権原証明書
CCOP	Coordinating Committee for Geoscience Programmes in East and Southeast Asia	東・東南アジア地球科学計画調整委員会
CENRO	Community Environment and Natural Resources Office	環境天然資源省コミュニ．ティ事務所
CHC	Climate Hazard Center	気候災害センター
CHIRPS	The Climate Hazards Group InfraRed Precipitation with Station data	気候災害グループ　赤外線降水量と観測所データ
CIS	Communal Irrigation System	共同灌漑組織
CLIRAM	Climate Information and Risk Analysis Matrix	気候情報とリスク分析マトリックス
CMIP	Coupled Model Intercomparison Project	結合モデル相互比較計画
COVID-19	Coronavirus disease 2019	新型コロナウイルス感染症
C/P	Counterpart	カウンターパート
CSV	Creating Shared Value Format	共通価値創造フォーマット
DA	Department of Agriculture	農業省
DCWD	Davao City Water District	ダバオ市水道区
DEM	Digital Elevation Model	全球数値標高モデル
DENR	Department of Environment & Natural Resources	環境天然資源省
DF/R	Draft Final Report	最終報告書（案）
DHI	DHI Water & Environment	デンマーク水理環境研究所
DHSUD	Department of Human Settlements and Urban Development	人間居住都市開発省
DILG	Department of Interior and Local Government	自治省
DO	Dissolved Oxygen	溶存酸素
DOF	Department of Finance	財務省
DOST	Department of Science and Technology	科学・技術省
DPWH	Department of Public Works and Highways	公共事業・高速道路省
DWR	Department of Water Resources	水資源省
ECC	Environmental Compliance Certificate	環境適合証明書

ECMWF	European Centre for Medium-Range Weather Forecasts	ヨーロッパ中長期予報センター
ECP	Environmental Critical Project	環境重要プロジェクト
EIA	Environmental Impact Assessment	環境影響評価
EIS	Environmental Impact Statement	環境影響評価書
EMB	Environment Management Bureau	環境管理局
ERA5	ECMWF Reanalysis virsion-5	ヨーロッパ中長期予報センター大気再解析データ virsion-5
ESA	European Space Agency	欧州宇宙機関
ETo	Reference Evapotranspiration	基準蒸発散量
FAO	Food and Agriculture Organization of the United Nations	国際連合食糧農業機関
FDC	Flow Duration Curve	流況曲線
FEFLOW	Finite Element Subsurface FLOW System	3 次元地中熱水分解析モデル
F/R	Final Report	最終報告書
FRM	Flood Risk Management	洪水管理
GDP	Gross Domestic Product	国内総生産
GIS	Geographic Information System	地理情報システム
GRDP	Gross Regional Domestic Product	域内総生産
GSMaP	JAXA, Global Satellite Mapping of Precipitation	JAXA 衛星全球降水マップ
GW	Groundwater	地下水
GWL	Groundwater Level	地下水位
HYDROMETS	Hydrometeorological Stations	水文気象観測所
H-Q curve	Water Height (Stage)-Discharge Rating Curve	水位-流量曲線
IA	Irrigator’s Association	水利組合
IBAT	Integrated Biodiversity Assessment Tool	生物多様性リスク測定ツール
IC/R	Inception Report	着手報告書
IMO	Irrigation Management Office	灌漑管理事務所
IP	Indigenous People	先住民族
IPCC	Intergovernmental Panel on Climate Change	国連気候変動に関する政府間パネル
ITCZ	Intertropical Convergence Zone	熱帯収束帯
IT/R	Interim Report	中間報告書
ITS	Irrigation Telemetry System	灌漑遠隔監理システム
IWRM	Integrated Water Resource Management	統合水資源管理
JAXA	Japan Aerospace Exploration Agency	国立研究開発法人宇宙航空研究開発機構
JICA	Japan International Cooperation Agency	独立行政法人国際協力機構
JST	JICA Survey Team	JICA 調査団
JWA	Japan Water Agency	独立行政法人 水資源機構
LGUs	Local Government Units	地方自治体
LWUA	Local Water Utilities Administration	地方水道公社
MCDA	Multi-Criteria Decision Analysis	多基準決定分析
MCM	Million Cubic Meter	百万立米
MCWD	Metro Cebu Water District	メトロセブ水道区
MGB	Mines and Geosciences Bureau, the Department of Environment and Natural Resources	環境天然資源省鉱山地球科学局
MLIT	Ministry of Land, Infrastructure, Transport and Tourism	国土交通省

MODFLOW	U.S. Geological Survey modular finite-difference flow model	米国地質調査所 WEAP Model,モジュラー有限差分フローモデル
MODIS	The Terra and Aqua combined Moderate Resolution Imaging Spectroradiometer	中分解能撮像分光放射計
MP or M/P	Master Plan	マスタープラン
NIMP	National Irrigation Master Plan	国家灌漑マスタープラン
NISRIP	National Irrigation System Rehabilitation and Improvement Project	国営灌漑事業改修改善計画
NWRB	National Water Resources Board	国家水資源評議会
MWSS	Metropolitan Waterworks & Sewerage System	マニラ首都圏上下水道供給公社
NAMRIA	National Mapping and Resource Information Authority of the Philippines	フィリピン国立地図・資源情報局
NARBO	Network of Asian River Basin Organizations	アジア河川流域機関ネットワーク
NASA	National Aeronautics and Space Administration	アメリカ航空宇宙局
NCCA	National Commission for Culture and the Arts	文化芸術委員会
NCIP	National Commission on Indigenous Peoples	先住民族国家委員会
NCR	National Capital Region	マニラ首都圏
NEDA	National Economic and Development Authority	国家経済開発庁
NGO	Non-governmental Organization	非政府組織
NHCP	National Historical Commission of the Philippines	フィリピン国家歴史委員会
NIA	National Irrigation Administration	国家潅漑公社
NIPAS	National Integrated Protected Areas System	国家統合保護地域制度
NIS	National Irrigation System	国営灌漑システム
NPC	National Power Corporation	フィリピン電力公社
NSE	Nash–Sutcliffe Model Efficiency Coefficient	ナッシュ・サトクリフ 係数
NWRB	National Water Resources Board	国家水資源評議会
O&M	Operation and Maintenance	運営維持管理
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration	フィリピン大気地球物理天文局
PAMB	Protected Area Management Board	保護区管理委員会
PAP	Project Affected Person	被影響住民
P-D	Water Potential minas Water Demand	水資源賦存－水需要量
P/D	Water Potential divide Water Demand	水資源賦存÷水需要量
PFI	Private Finance Initiative	民間資金等活用事業
PHIVOLCS	Philippine Institute of Volcanology and Seismology	フィリピン火山地震研究所
PHP	Philippines Peso	フィリピン・ペソ
PI	Poverty Incidence	貧困発生率
PIS	Private Irrigation System	私有灌漑システム
PKII	Philkoei International Inc.	フィルコーエイ・インターナショナル
PPP	Public Private Partnership	官民連携
PSA	Philippine Statistics Authority	国家統計局
PWMSSMP	The Philippine Water Supply and Sanitation Master Plan	フィリピン国給水衛生マスタープラン
Q&A	Question and Answer	質問と回答
RAP	Resettlement Action Plan	住民移転計画
RBCO	River Basin Control Office	流域管理事務所
RCP	Representative Concentration Pathways	代表濃度経路シナリオ

RIS	River Irrigation System	重力式灌漑組織
RSLC	Simple River Surveillance Live Camera	簡易河川監視ライブカメラ
SDGs	Sustainable Development Goals	持続可能な開発目標
SEA	Strategic Environmental Assessment	戦略的環境アセスメント
SEZ	Special Economic Zones	特別経済区域
SHER model	Similar Hydrologic Element Response Model	水循環解析モデル
SHM	Stakeholder Meeting	ステークホルダー会議
SRIP/S	Small Reservoir Irrigation Project / System	小規模溜池灌漑計画
SRTM	Shuttle Radar Topography Mission	スペースシャトル登載合成開口レーダー
SLC	Sea Level Change	海面変化
SW	Surface Water	表流水
TSP	Total Suspended Particulates	総浮遊粒子状物質
TSS	Total Suspended Solids	総懸濁固形分
USDA	United States Department of Agriculture	米国農務省
USGS	United States Geological Survey	米国地質調査所
WB	World Bank	世界銀行
WD	Water District	水道区
WEAP Model	"Water Evaluation and Planning" System Model	水の評価と計画システムモデル
WQMA	Water Quality Management Areas	水質管理区域
WR	Water Requirement	要水量
WRMO	Water Resources Management Office	水資源管理事務所
WRR	Water Resources Region	水資源区

Data Collection Survey for
National Water Resources Development and Management Plan
in the Republic of the Philippines

FINAL REPORT

Report Structure

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Volume 2: SUPPORTING REPORT (1)

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Data Collection Survey for
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FINAL REPORT

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Executive Summary

CHAPTER 1 INTRODUCTION

Background

1. More than 20 years have passed since the 1998 "Master Plan Study on Water Resources Management in the Republic of the Philippines" (hereinafter referred to as "1998 M/P"), and in order to achieve sustainable water security in the Republic of the Philippines (hereinafter referred to as "the Philippines"), it is essential to collect the latest information and conduct analysis based on it and formulate new plans on a nationwide scale. The goal of this Survey is to collect such necessary information and data to understand the water balance nationwide, formulate water resource development and management master plans for areas with large water balance gap, and propose effective countermeasures for such areas.

Purpose of the Survey

2. The purposes of this survey are as follows.

   1) To conduct water balance analysis for each water resource region with the target year of 2050 for the entire Philippines,

   2) To identify priority areas where the water balance is expected to be particularly tight in the future,

   3) To formulate a water resource development and management plan (draft) in the priority areas, and to propose effective priority project concept including development covering wide area.

Target Area

3. The target area for the Survey is the entire Philippines. The preface figure map shows the locations and lists of the 12 major water resources regions (which divides the country into 12 regions hydrologically for comprehensive water resource development), major rivers, and major cities.

Scope of the Survey

4. The Japan International Cooperation Agency (JICA) Survey Team recognizes the scope of work of this survey as follows:

   1) This survey does not formulate a master plan, but it is positioned to collect and analyze data for that purpose and provide necessary materials.

   2) This survey focuses mainly on the development and management of water resources in local cities and does not include the water resource region of Metro Manila as a priority area.

Survey Counterpart Organizations

5. The counterpart organizations in this survey are the National Economic and Development Authority (NEDA) and the National Water Resources Board (NWRB).

Survey Implementation Stage

6. The survey is phased in following four major stages.

   Stage 1: Water balance analysis for 12 Water Resources Regions (WRRs) and selection of the priority WRRs

Stage 2: Detailed water balance analysis in the priority WRRs

Stage 3: Proposal of water resources development and management plan (idea) for the priority WRRs

Stage 4: Proposal of priority project concepts

Main Meetings with Philippine Counterparts

7. In the Survey, progress meetings among NEDA, NWRB, JICA, and the JICA Survey Team have been held thirty-two times on a monthly basis. In addition, the Survey Team participated in the NEDA Board Committee on Infrastructure (INFRACOM) – Subcommittee on Water Resources (SCWR) meeting held once every six months, which is a forum for high-level discussions with water resource-related organizations on the Philippines side. The contents of the survey were explained, and a question-and-answer session was held. In response to the requests from the counterpart organizations NEDA and NWRB, a technical familiarization program was implemented in order to provide technical explanations and to hold technical discussions on analysis methods for the fields in each sector.

Stage I: Water Balance Analysis for 12 WRRs and Selection of the Priority WRRs

Socio-Economic Condition

8. The total population of the Philippines has increased from 92,337,852 in 2010 to 109,035,343 in 2020 at an average annual growth rate (AAGR) of 1.5%. Gross Domestic Product (GDP) of the Philippines has increased from 16,556,651 million pesos to 17,975,997 million pesos during the past three years from 2017 to 2020 at current price. The GDP per capita has increased from 158,940 pesos in 2017 to 164,919 pesos in 2020 at current prices.

Natural Conditions and Water Usage

9. <u>Natural Condition</u>: The Philippines has 18 major river basins, which occupy a total catchment area of 110,524 km^2, representing more than one-third of the country’s total land area. The land of the Philippines is typically delineated in accordance with two different categories, namely: boundaries of the water resources regions (WRR) and administrative regions. In the former case, the Philippines is divided into 12 WRRs in consideration of hydrological boundaries for the purpose of comprehensive planning of water resources development. Other natural conditions such as national land, topography, meteorology/hydrology, geology, land use, status of existing water resource facilities, water quality, natural environment, etc. are summarized in Chapter 2, Section 2.2 of Main Report.
10. <u>Current Status of Agricultural Water Use:</u> The agriculture sector is the main water user among all sectors and consumes a lot of water sources. The agriculture sector as the water user is mainly composed of three sub-sectors, namely: irrigation farming, inland fishery and livestock/ poultry. Based on the NIA inventory data, all irrigation systems as of December 31, 2020, total potential irrigable area is estimated at 3,128,631 ha, whose 63% are already developed as ISA. Based on the data provided by DA-BFAR, the area of aquafarms (fishpond, fish pen, fish cage, etc.) by fresh water source in 2020 is estimated at 18,851 ha. Based on the data provided by DA-BAI, the total heads of livestock/ poultry in 2020 are 2,865 thousand of carabao, 2,542 thousand of cattle, 12,796 thousand of hog and 178,265 thousand of chicken. These data are utilized for the estimation of water demands.

11. Current Status of Municipal and Industraial Water Use: The current municipal water demand for each WRR was calculated based on the municipal water demand for each administrative region as described in the Philippine Water Supply and Sewerage Master Plan 2019-2030 (PWSSMP 2019-2030) prepared by NEDA. The national total is 5,063 MCM/year. The current industrial water demand for each WRRs was calculated based on water rights data provided by NWRB. The national total is 2,703 MCM/year.

Hydrological Analysis

12. A rainfall-runoff model (Tank Model) with paddy model was constructed for national level analysis using observed discharge for a reliable period, and a long-term (1979 to 2020) period of 42 years. Three datasets: ERA5, GSMaP and CHIRPS, are proposed as the options. After evaluation of these datasets, CHIRPS is considered as the most suitable dataset for the survey. As for the estimation of groundwater potential, since the observed groundwater level data could only be obtained in a short-term period and is unevenly distributed throughout the country, it was decided to construct a groundwater flow model using Darcy's law instead. For climate change projection data, the DOST-PAGASA report (2018) was referred to, which contains detailed information.

Water Resources Potentials

13. The national surface water potential in 1/5 drought years was estimated at 283.9 billion m^3/year at present, and 217.1 billion m^3/year, 262.7 billion m^3/year and 313.6 billion m^3/year under low, medium and high climate change scenarios in 2050 respectively. Groundwater potential in 1/5 drought years was estimated at 32 billion m^3/year at present, and 27.9 billion m^3/year, 32.1 billion m^3/year, and 35.6 billion m^3/year under low, medium, and high scenarios under climate change in 2050, respectively.

Water Demand Prediction

14. Water Demand Forecast (Agricultural Use): The future irrigation area, firm-up service area and irrigated area were projected based on the two programs, (i) National Irrigation Master Plan (NIMP) 2020-2030, and (ii) NIA Annual Irrigation Programs from 2011 to 2020. The future firm-up irrigation service areas in 2050 based on (i) was estimated at 3,180,147 ha, and based on (ii) was estimated at about 3,115,000 ha. The irrigation water demands (IWD) by provinces in 2020 were calculated based on the 2020 irrigation area, and annual total demand was estimated at 31,527 MCM. The future annual irrigation demands were estimated at 60.753 MCM by (i) and 55,069MCM by (ii). The annual water demands for freshwater aquafarms were estimated at 886MCM in 2050, and the annual water demands for the livestock/poultry were estimated at 174MCM.
15. Water Demand Forecast (Municipal and Industrial Water Use): Municipal water demand projections to 2050 were made based on the current municipal water demand and the population projections of the PSA. The annual municipal water demand was projected to increase to 7,136 MCM/year in 2050. The annual industrial water demand was projected to increas to 2,875 MCM/year in 2050.

Water Balance

16. The summary comparison of results of total (surface water + groundwater) water balance analysis in 2050 by WRR are shown in the table below. In 2050 climate change case of RCP8.5 Median case, areas

with little water surplus for the total water balance (P/D) of surface water and groundwater (i.e., water balance is tight) are assigned to WRR-III, II, V, I, XI, and VII. The monthly water balance analysis results show that many areas will experience water shortages in the future dry season, especially in WRR-VII and XI, where the monthly water balance of surface water and groundwater in the dry season is expected to be tight .

Comparison of Annual Water Balance in 2050 [SW+GW] by WRR [Irrigation WR=JST]

WRR					Water Balance of This Survey (1/5-dry Year) at 2050							
No.	Water Resources Region (WRR)	Area km^2	Water Source	Year	Present Weather		RCP8.5-Low		RCP8.5-Median		RCP8.5-High	
					P/D	Rank of P/D	P/D	Rank of P/D	P/D	Rank of P/D	P/D	Rank of P/D
1	I - ILOCOS	12,717	SW+GW	2050	4.9	5	2.6	3	**3.5**	**4**	5.4	6
2	II - CAGAYAN VALLEY	38,290	SW+GW	2050	2.1	2	1.7	1	**2.1**	**2**	2.3	1
3	III - CENTRAL LUZON	27,131	SW+GW	2050	1.9	1	1.8	2	**2.1**	**1**	2.6	2
4	IV - SOUTHERN TAGALOG	44,034	SW+GW	2050	5.7	9	4.5	8	**5.6**	**9**	5.8	8
5	V- BICOL	17,821	SW+GW	2050	4.3	4	2.7	4	**3.4**	**3**	5.0	3
6	VI - WESTERN VISAYAS	20,733	SW+GW	2050	5.5	8	4.2	7	**4.8**	**7**	5.9	9
7	VII - CENTRAL VISAYAS	13,606	SW+GW	2050	5.5	7	3.3	6	**4.6**	**6**	5.7	7
8	VIII - EASTERN VISAYAS	20,768	SW+GW	2050	11.4	12	7.2	10	**10.5**	**12**	12.8	12
9	IX - SOUTHWESTERN MINDANAO	20,395	SW+GW	2050	10.2	11	7.5	12	**9.9**	**11**	11.4	11
10	X - NORTHERN MINDANAO	23,395	SW+GW	2050	9.5	10	7.2	11	**8.3**	**10**	10.1	10
11	XI - SOUTHEASTERN MINDANAO	26,486	SW+GW	2050	4.2	3	3.2	5	**3.9**	**5**	5.1	4
12	XII - SOUTHERN MINDANAO	30,461	SW+GW	2050	5.3	6	5.3	9	**5.3**	**8**	5.3	5
	All Philippines Total	299,404	SW+GW	2050	4.6	-	3.5	-	**4.3**	**-**	5.1	-

Source: JICA Survey Team

Selection of Priority Water Resources Regions

17. Out of the 12 WRRs, 3 priority WRRs were selected based on the evaluation criteria for the subsequent detailed investigation. These criteria were determined through explanation and discussions with JICA and the Philippine counterpart organizations.

Organizations and Legal Frameworks

18. <u>Current Situation on Organizations and Legal Frameworks</u>: As of 2022, there are over 30 water-related agencies with overlapping and at times conflicting mandates or functions over the country’s water resources (The Philippines Development Plan 2023-2028).

    The main legal frameworks related to water resources development and management include Water Code (Presidential Decree No.1067) and its Implementing Rules and Regulations (IRR), and Executive Order No.123, 2002, which stipulates the jurisdiction on NWRB. With regard to plans, PDP (Philippine Development Plan) is formulated at national level, and RDP (Regional Development Plan) is formulated in each region based on PDP as comprehensive plans; “The Philippine Water Supply and Sanitation Master Plan (PWSSMP) 2019-2030”, “The Irrigation Master Plan (NIMP) 2020-2030” and “The Disaster Risk Reduction and Management Plan” established both at national and local level are formulated at respective water related sub sectors; and “The Integrated Water Resources Development and Management Master Plan” is established at the 18 basins and other areas in the Philippines related to IWRM. In the Philippines, two major issues have been pointed out with regard to organizations and legal frameworks related to water resources sector: 1) institutional fragmentation/lack of coordination and 2) necessity to strengthen the regulatory functions.

19. Current Actions for Improving the Issues in Water Resources Sector in the Philippines: The creation of the Department of Water Resources (DWR) as "Apex Body" was deliberated by the former President Duterte Administration, and the present President Marcos Jr. declared in the first State of Nations on 25th July 2022 that creation of DWR is one of the priorities. With the creation of DWR, it is directed to integrate various water-related organizations/bureaus/divisions belonging to different departments into one organization. In line with the creation of DWR, the creation of the Water Regulatory Commission (WRC) as independent and quasi-judicial body is also being considered, which is placed under DWR. However, the bill for creating these new organizations has not been enacted.
On the other hand, the Executive Order for creating the Water Resources Management Office (WRMO) was issued on 27th April 2023 (E.O. No.22, 2023). WRMO, placed under the DENR, was created as the transitory body until DWR is established. WRMO, in coordination with all stakeholders, shall also be primarily responsible for the integration and harmonization of all government efforts and regulatory activities to ensure availability and sustainable management of water resources.

STAGE II: DETAILED WATER BALANCE ANALYSIS IN THE PRIORITY WATER RESOURCES REGIONS

Socio-economic Framework in Priority Water Resources Regions

20. The population of WRR V was 22,277,207 in 2020 while that of WRR VII was 16,036,711 and that of WRR XI was 17,432,066 in 2020. The population of WRR V was estimated to be 30,815,324 in 2050 while that of WRR VII was estimated to be 20,675,228 and that of WRR XI was estimated to be 23,740,600 in 2050. The GRDP of WRR V was PHP 3,080,918 million while that of WRR VII was PHP 2,015,466 million and that of XI was PHP 2,510,535 million in 2020. The GRDP of WRR V was estimated to be PHP 38,995,569 million while that of WRR VII was estimated to be PHP 25,878,866 million and that of WRR XI was estimated to be PHP 35,687,758 million in 2050.

Detailed Water Balance Analysis in WRR-VII

Natural Condition and Water Use

21. General: WRR-VII is located in the Central Visayas Islands, consisting of Cebu Island, Bohol Island, Negros East, and Siquijor Island. Administrative regions include all of Region VII and part of Region VI. It consists of four provinces, Cebu, Bohol, Negros Oriental, and Siquijor. From the perspective of water resources, especially in Cebu Island, problems such as the lowering of dam reservoir water levels during droughts and the infiltration of saltwater intrusion into groundwater have become apparent, making water resource issues urgent issues.
22. Natural Condition: Descriptions on land, topography, meteorology/hydrology, geology, land use, current status of existing water resource facilities, water quality, natural environment, etc. are summarized in Chapter 3, Section 3.3.2 of Main Report.
23. Current Water Use: The irrigation area covered by WRR VII in 2020 is 40,927 ha. The heads of livestock and poultry in 2020 are 1,539,256 heads and 18,165,378 heads. The freshwater fishpond area in 2022 is 79.87 ha. Current municipal and industrial water demands in large population cities are 238 million m^3/year in Metro Cebu, 18.6 billion m^3/year in Bohol, 32.3 million m^3/year in Dumaguete, 0.64 billion

m^3/year in Siquijor, and the existing water supply production for municipal and industrial water use are 996 million m^3/year, 8 million m^3/year, 152 million m^3/year and 25 million m^3/year, respectively. The main source of water is wells. Based on the NWRB's water permit records, a total of 753 water permit wells and 227 springs have been issued within WRR VII.

Detailed Water Balance Analysis

24. Hydrological Analysis: The SHER (Similar Hydrologic Element Response) Model was used for the detailed water balance analysis on the selected 3 priority WRRs. In WRR VII, the sub-basins were divided into 408 sub-basins. The parameters of the SHER model were calibrated in sub-basins with DPWH observed discharges, and the model parameters were used to estimate river discharges in sub-basins without observed discharges. For groundwater flow analysis, MODFLOW, a versatile simulation code, was used for the entire WRR VII. The input hydrogeological structures were estimated based on the geolegisitivity survey results conducted by NWRB. Recharge rates were set by the estimated value of SHER model for each subwatershed. The parameters, including hydraulic conductivity, were initially set to values from existing literature and the SHER model. Groundwater level distribution was estimated by calibrating MCWD groundwater level observation data.
25. Water Potentials: Surface water potentials in WRR-VII in the 1/5 drought year were estimated at 9.15 billion m^3/year at present, and 5.85 billion m^3/year, 7.84 billion m^3/year and 9.65 billion m^3/year under low, medium, and high scenarios under climate change in 2050, respectively. Groundwater potentials in 1/5 drought years were estimated at 750 million m^3/year at present, and 670 million m^3/year, 760 million m^3/year, and 890 million m^3/year under low, medium, and high scenarios of climate change in 2050 respectively. Figure 3.2.2 in the Main Report shows the distribution map of the analyzed water potential (surface water, groundwater) for each sub-basin.
26. Water Demands Forecast: Future irrigation water demands for each province in WRR VII was calculated based on past NIA financial programs. The total annual irrigation water demand in 2050 is estimated at 1.152 billion m^3/year, 560 million m^3/year in Bohol, 132 million m^3/year in Negros Oriental, and 168 million m^3/year in Cebu. Annual water demands of livestock and poultry in 2050 is estimated at 167 million m^3/year, and annual water demands of freshwater fishponds at 36 million m^3/year.

    Conditional values such as water demand per capita (lpcd), non-revenue water rate (%), and water usage (domestic, commercial, and public water) for each region in WRR VII were established based on the results of interviews in major WD and the values listed in PWWSMMP 2019-2030. Detailed municipal water demand projections for each region were made based on the population projections of the PSA and these conditional values. The total municipal water demand in 2050 is estimated at 506 million m^3/year. A correlation formula between industrial water demand and industrial GRDP was developed based on past actual industrial water demand and actual industrial GRDP. By substituting the industrial GRDP projection values into this correlation formula, industrial water demand was forecasted to be 222 million m^3/year until 2050.
27. Water Balance: In Cebu, Bohol and Siquijor islands, negative annual water balances and groundwater shortages are likely to increase in the future. In Cebu province, it was predicted that the groundwater

balance in 2050 will have -217.9 MCM/year deficit. In most cities, the groundwater balance is projected to be negative for water demand in 2050, but it will especially be large in the Metro Cebu area.

Detailed Water Balance Analysis in WRR-XI

Natural Condition and Water Use

28. General: WRR XI is located in South-eastern Mindanao. It is centered on the administrative region of Region XI (Davao), while also including parts of Region X in the north, XIII in the northeast, and XII in the southeast. The provincial division consists of 12 Provinces. In terms of water resources, there are 3 major river basins, and major cities include Davao City, Tagum City, and General Santos City. The climate is classified into Type III and IV. From the perspective of water resources, water shortages due to growing water demand in major cities, drainage problems in irrigation development, and dam sedimentation problems have become issues.
29. Natural Condition: The land, topography, meteorology/hydrology, geology, land use, current status of existing water resource facilities, water quality, natural environment, etc. are summarized in Chapter 3, Section 3.4.2 of Main Report.
30. Current Water Use: The irrigation area covered by WRR XI in 2020 is 104,352 ha. The heads of livestock and poultry in 2020 are 1,533,364 heads and 13,443,173 heads. The freshwater fishpond area in 2022 is 486.59 ha. Current municipal and industrial water demands in large population cities are 1.867 billion m^3/year in Davao WD, 747 million m^3/year in General Santos WD, and the existing water supply production for municipal and industrial water use are 146.7million m^3/year, and 39 million m^3/year respectively. The main water source in Davao is both wells and surface water while that in General Santos is wells. Based on the NWRB's water permit records, a total of 363 water permit wells and 53 springs have been issued within WRR XI.

Detailed Water Balance Analysis

31. Hydrological Analysis: Surface water analysis was performed using the SHER model, which is a physical runoff model, and groundwater analysis was performed using the MODFLOW model, using the same procedure and method as in WRR VII. In WRR XI, the basin model was divided into 345 sub-basins.
32. Water Potentials: The surface water potential in WRR XI in the 1/5 drought year was estimated at 30.5 billion m^3/year at present, and 34.63 billion m^3/year, 32.04 billion m^3/year and 32.99 billion m^3/year under low, medium, and high scenarios of climate change in 2050, respectively. Groundwater potentials in 1/5 drought years were estimated at 271 million m^3/year at present, and 244 million m^3/year, 224 million m^3/year, and 272 million m^3/year under low, medium, and high scenarios of climate change in 2050, respectively. Figure 3.4.2 in the Main Report shows the distribution map of the analyzed water potential (surface water and groundwater) for each sub-basin.
33. Water Demands Forecast: The future irrigation water demands for each province in WRR XI was calculated based on past NIA financial programs. The total annual irrigation water demand in 2050 is estimated at 3.685 billion m^3/year. Annual water demands of livestock and poultry in 2050 is estimated at 16.3 million m^3/year, and annual water demand of freshwater fishponds at 22.1 million m^3/year.

The total municipal water demand in 2050 is estimated at 581 million m^3/year. The industrial water demand was forecasted to be 248 million m^3/year until 2050.

34. Water Balance: The water balance of groundwater in 2050 in Davao del Sur, North Cotabato, South Cotabato, Sultan Kudara and Surigao del Sur provinces will be negative in future. In Davao del Sur, it is predicted that the groundwater balance in 2050 will be -475.6 MCM/year. In most cities, the groundwater balance is projected to be negative against the water demand in 2050, and the negative groundwater balance is particularly large in Metro Davao and Metro General Santos areas.

Detailed Water Balance Analysis in WRR-V

Natural Condition and Water Use

35. General: WRR V is located in the southeastern part of Luzon and includes the islands of Catanduanes and Masbate. The administrative region includes all of Region V (Bicol) and part of Region IV-A (Calabarzon) in the northwest. The provincial division includes 6 provinces of Region V and part of 1 province of Region IV-A. The major cities are Legazpi City and Naga City. In terms of water resources, there is one major river basin, the Bicol River basin. The climate is classified into Type-III and Type-IV. From the perspective of water resources, water shortages due to growing water demand in major cities, drainage problems in irrigation development, and lake sedimentation problems have become issues.
36. Natural Condition: The land, topography, meteorology and hydrology, geology, land use, current status of existing water resource facilities, water quality, natural environment, etc. are summarized in Chapter 3, Section 3.5.2 of the Main Report.
37. Current Water Use: The irrigation area covered by WRR V in 2020 is 144,352 ha. The heads of livestock and poultry in 2020 are 1,343,227 heads and 8,975,062 heads. The freshwater fishpond area in 2022 is 160.51 ha. Current municipal and industrial water demands in large population cities are 29.1 million m^3/year in Metro Naga WD, 14.0 million m^3/year in Legazi WD, 11.8 million m^3/year in Masbate-Movo WD, and the existing water supply production for municipal and industrial water use are 24.5million m^3/year, 17.2 million m^3/year, 5.82 million m^3/year, respectively. The main water source in Naga and Legazpi are wells and springs while that in Masbate is wells and surface waters. Based on the NWRB's water permit records, a total of 206 water permit wells and 135 springs have been issued within WRR V.

Detailed Water Balance Analysis

38. Hydrological Analysis: Surface water analysis was performed using the SHER model, which is a physical runoff model, and groundwater analysis was performed using the MODFLOW model, using the same procedure and method as in WRR-VII. In WRR-V, the basin model was divided into 243 sub-basins.
39. Water Potentials: Surface water potentials in WRR-V in the 1/5 drought year were estimated at 20.45 billion m^3/year at present, and 15.52 billion m^3/year, 20.17 billion m^3/year and 24.17 billion m^3/year under low, medium, and high scenarios of climate change conditions in 2050, respectively. Groundwater potentials in 1/5 drought years were estimated at 502 million m^3/year at present, and 488 million m^3/year, 490 million m^3/year, and 511 million m^3 under low, medium, and high scenarios of climate change conditions in 2050. Figure 3.5.2 in the Main Report shows the distribution map of the analyzed water potential (surface water and groundwater) for each sub-basin.

40. Water Demands Forecast: The future irrigation water demands for each province in WRR V was calculated based on past NIA financial programs. The total annual irrigation water demand in 2050 is estimated at 4.690 billion m^3/year. Annual water demands of livestock and poultry in 2050 is estimated at 14.1 million m^3/year, and annual water demands of freshwater fishponds at 7.3 million m^3/year. The total municipal water demand in 2050 is estimated at 336 million m^3/year. The industrial water demand was forecasted to be 158 million m^3/year until 2050.

41. Water Balance: In Albay, Camarines Norte, Camarines Sur and Masbate provinces, negative values of annual water balance and deficit of groundwater will increase in future. In Camarines Sur province, it is predicted that the groundwater balance in 2050 will be -169.3 MCM/year. In most cities, the groundwater balance is projected to be negative against the water demand in 2050, and the negative groundwater balance is particularly large in the Naga and Legazpi cities. The Bicol and Sipcot river basins will be negative water balance of groundwater in 2050.

Stage III: Preparation of Water Resources Development and Management Plan (idea) in Priority Water Resources Regions

Basic Policy for Plan Formulation

42. Review of the 1998 M/P: In the 1998 M/P, water resources throughout the Philippines were analyzed and evaluated in a unified manner, and the results, with high reliability and quality, have contributed in formulating national development policies. Data construction and analysis, and recommendations based on the results are still being utilized today. However, most of the large-scale projects proposed in the study have not yet been implemented.

    Based on interviews and meetings with the related organizations, the reasons can be categorized as 1) Challenges related to environmental and social considerations, 2) Challenges for upstream and downstream issues of inter-basin water transfer, 3) Challenges for organizational and legal issues for multipurpose water resources development, 4) Challenges in the implementation capacity of the executing agency, 5) Challenges of administrative continuity without influence of the political system, 6) Challenges in investment planning and development planning.

    As the result of analyzing the difference of water demand forecast results estimated in the 1998 M/P from the current water demand calculated in this survey – the water demand in the national level was predicted to be between 60.4B and 83.5B in 1998 M/P, but the current figure is 42.6B, which is actually smaller than the forecasted. This trend is the same for each type of water use for municipal, industrial, and agricultural water.

43. Basic Policy for Formulation of Water Resources Development and Management Plan (idea): Based on the lessons learned from the above review, the following approaches including IWRM concept are adopted to propose highly feasible plans when formulating the water resources development and mangement plan and proposing the priority project concepts.

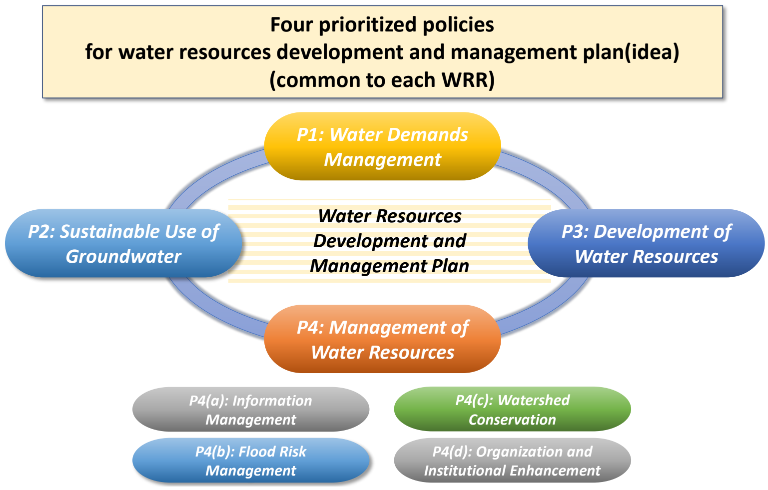
Consensus building by SEA for social environment consideration and incorporating stakeholders from the alternative planning stage,

Study and consideration of organizational and institutional aspects such as implementation system and legal framework for the proposed projects that would go beyond the existing administrative framework,
Selection of the priority projects considering financial aspects of the project implementation entity, such as the project scale and funding sources (PPP scheme, etc.),
Proposal and selection of priority projects taking into consideration the technical aspects such as the technical capabilities and operational maintenance management capabilities of the project implementation entity.

44. Basic Conditions for Plan Formulation: The target years of the plan are set at short, medium, and long terms for the years 2030, 2040, and 2050, respectively. The safety level is set at 1-5 years of irrigation water and 1-10 years of municipal and industrial water supply, and the priority of the water use is set at i) environment flow, ii) drinking water, iii) agricultural water, and iv) industrial water, in consultation with related organizations in the Philippines.

The climate change impact forecast of this Survey was carried out by referring to the detailed information on climate change forecast data for the Philippines organized in PAGASA's "Observed Climate Trend and Projected Climate Change in the Philippines" report (2018). Considering the uncertainty, this Survey referred to the future water resources potential change of the upper, middle, and lower three cases of the RCP8.5 (high) scenario.

45. Setting Priority Policy for Formulation of Sustainable Water Resources Development and Management Plan: The challenges and solutions for sustainable water use common to priority water resource regions were organized, and four priority policy for formulation of sustainable water resources development and management plan were established.



Source: JICA Survey Team

Priority Policy for Formulation of Sustainable Water Resources Development and Management Plan

Stakeholder Meetings (SHM)

46. The most feasible and optimal project concepts in the priority WRRs were selected through the SHMs as part of the environmental assessment. SHMs were conducted twice with both in-person gathering and

online participation. Opinions from relevant organizations in the SHMs were reflected in the results of thie Survey and in future recommendations (see the Main Report for details).

Priority Water Resources Region (WRR VII)

47. Study for Water Resources Development and Management Options: In the 1st to 4th field surveys, map surveys and field surveys of existing and new water sources (dams, weirs, potential reservoir sites) were conducted to investigate and organize the current status, challenges, and strategies for countermeasures of water resources facilities in each WRR. Based on these results, a primary screening of individual countermeasures was conducted to compare the adoptability to select multiple realistic plans.

For approaches to solve the future water supply and demand gaps, the following procedures were proposed: 1) promotion of current water supply development plans, 2) implementation of water demand management measures, and 3) implementation of additional water resources developments covering shortages of available water even with the implementation of demand management measures. A combination of countermeasure options considering phased development by short-term, medium-term, and long-term was examined, adopting the evaluation criteria that was established for the comparative study. In addition, the effects of the alternative plans were examined through water balance analysis to estimate the amount of possible water that can be developed and to set the scale of the proposed facilities. Details of the alternative study are shown in Section 4.3.2 of the Main Report.

48. Proposal for Water Resources Development and Management Plans (idea): Water resources development and management plan (idea) was prepared to close the water supply-demand gap up to the proposed target year 2050. The composition of the plan is shown below.

Composition Plan of Water Resources Development and Management Plan (Idea)

Water Resources Development and Management Plan (idea)	Contents	Related Agencies
1.Surface Water Development Plan	Water balance, surface water development options, short, medium, and long-term roadmap (surface water)	NEDA, NWRB
2. Groundwater Development Plan	Same as above (groundwater)	NEDA, NWRB
3. Water Supply Plan	Composed of 3-1 to 3-2 below	
3-1 Agriculture Water Use	Excerpt from agriculture sector from the surface water development plan	NIA, DA
3-2 Municipal and Industrial Water Use	Excerpt from the water supply and sewerage sector from the surface water development plan	WD, MWSS, LGUs, LWUA
4. Water Resource Management Plan	Composed of 4-1 to 4-5 below	
4-1. Water Resources Information Management Plan	Current status, management method, utilization method of hydrometeorology, groundwater, water rights, remote sensing data, etc., collected in this survey	NWRB, PAGASA, DPWH
4-2. Flood Management Plan	Current status and issues, management recommendations	DPWH
4-3. Basin Environmental Conservation Plan	Environmental and social conditions and issues, management recommendations (conservation of water source forests, improvement of dam water quality and sedimentation measures, river maintenance flow, improvement of environment around facilities)	DENR
4-4. Organization/Legal System	Current status and issues, recommendations for improving the organization and legal system, if the proposal exceeds the existing administrative	NEDA/NWRB,

	framework, the implementation system and maintenance system are included.	
4-5. Demand Management	Water-saving agriculture, rainwater utilization, greywater utilization, etc.	NWRB, NIA,

Source: JICA Survey Team

49. Water Demand Management Plan: As for the demand management measures for municipal and industrial water use, water saving and enhancement of non-revenue water measures, the reduction effect is estimated as 16% in total in the whole WRR VII. As for the demand management measures for irrigation water use, waterway leakage countermeasures, irrigation efficiency improvement by introducing ITS, the reduction effect is estimated as 7.9% in total in the whole WRR VII.

50. Groundwater Development and Management Plan: If groundwater pumping continues to increase due to increased groundwater demand until 2050, the groundwater level is expected to decline due to over-pumping in Metro Cebu, the southeastern coast of Cebu, and Tagbilaran. Saltwater intrusion has been confirmed in Metro Cebu and Tagbilaran as a problem related to over-pumping, and there are also concerns about land subsidence and sinking in the areas where groundwater table decline occurs. In order to promote sustainable groundwater development, the following 3 items are proposed for priority groundwater management plan: (1) development of a groundwater monitoring network, (2) geological and hydrological surveys to determine the current groundwater environment (hydrogeological structure, pumping rate, etc.), and (3) groundwater risk assessment.

51. Surface Water Development Plan: As a surface water development plan for WRR VII, the layout, scale, and preliminary estimated construction cost of Mananga II Dam, Kotkot Dam in Cebu, and Inabanga Dam in Bohol were preliminarily examined, and the survey, study and implementation were proposed.

52. Water Supply Plan (Irrigation Water Use): The priority irrigation development project is SRIP in WRR VII. For the implementation of SRIP as well as the improvement of the existing reservoir irrigation systems, it is indispensable to implement the watershed management plans and to introduce the irrigation telemetry system for proper water management.

53. Water Supply Plan (Municipal and Industrial Water Use): Project concepts for municipal and industrial water include measures to reduce non-revenue water, promotion of water saving activities, introduction of seawater desalination technology, introduction of sewage reclamation technology, and introduction of technology to renovate industrial water. Of these, the highly effective and feasible non-revenue water reduction measures and promotion of water saving activities were selected as priority project concepts.

54. Water Resources Management Plan (Information Management Plan): At present, meteorological and precipitation observation data are observed by many organizations, but each observes and manages them individually. As a result, valuable observation data cannot be used comprehensively. For IWRM, it is desirable to centrally manage these observation data so that the past observation data and real-time observation data can be referred to at any time in an integrated manner by the water resources manager. GIS data (especially land use/land cover maps) may not be updated. In addition, there are cases where maps such as geological maps, soil maps and hydrogeological maps are not digital data. It is also

benefitial to update and centrally manage more detailed digital geological maps, soil maps, hydrogeological maps, environmental maps, land use/land cover maps, satellite image, digital elevation data, river sub-basin maps and river line and river structural location maps, etc. as necessary.

55. Water Resources Management Plan (Flood Risk Management): The following recommendations were made based on a review of the issues in the Central Cebu Basin, where flood risk management is especially important.

- Flood control measures based on the current flood control M/P should be steadily implemented. The watershed is highly developed, and the biggest issues in project implementation are land acquisition and resettlement. In the selection of priority projects, evaluation criteria should be adopted that place more emphasis on these issues to enhance the feasibility of flood control projects.
- In the watersheds of Mananga II Dam and Kotokoto Dam, which are proposed as priority projects for water resources development in this Survey, there is no existing nor planned flood control dams, but there are potential dams that were studied as alternative measures in the current flood control M/P. These dams could be made more cost-effective by integrating various functions for flood control, water supply and irrigation as multi-purpose dams. Therefore, a feasibility study should be conducted for both dams as multi-purpose dams.

56. Water Resources Management Plan (River Basin Environmental Conservation): Metro Cebu is facing a serious water shortage problem and saltwater intrusion of groundwater due to rapidly increasing water demand. Bohol is also facing a water shortage problem in urban areas due to increasing water demand in relation to tourism development. There are developing and operating irrigation water supply facilities by NIA and a development plan that prioritizes the construction of desalination facilities by MCWD. Considering the feasibility of these facilities, environmental and social aspects should be considered and evaluated. Considering the above present conditions, the objectives of the River Basin Environmental Conservation Plan in WRR VII are as follows.

- To secure good quality and enough amount of water resources in WRR VII through environmental conservation measures.
- To protect and improve the waterfront environment and water quality that ensure the sustainability between the natural environment and development/livelihood activities towards the prosperity of communities.

57. Water Resources Management Plan (Organizations and Legal Frameworks): Possible forms of the implementation schemes for water resources development and management projects were organized; and plans for improvement in the category of organizations and legal frameworks were proposed based on the information obtained from the literature survey and field survey from the viewpoint of efficient and effective implementation of the proposed projects. Possible implementation schemes were sorted out by the 2 items, “Water Resources Development” and “Water Resources Management (Demand Management)”.

It is recognized that the following items are necessary at least for implementing multipurpose projects proposed as the priority project in this survey since different administrative bodies oversee various water-related purposes such as flood control, water supply, and irrigation.

- An integrated basin-level plan for the construction and management of multi-purpose dams that transcends the jurisdiction of departments and agencies.
- Existence of an entity to implement and maintain multi-purpose dam projects at the basin level, beyond the jurisdiction of ministries or government organizations.

Based on the above recognition, the following items are proposed for improving the issues on organizations and legal frameworks.

- Creation of DWR and integration of planning functions
- Preparation of plans for multipurpose dam projects
- Strengthening of the River Basin Committees and utilizing them for consensus building
- Development of consultative scheme for the Inabanga Dam Projects
- Proposal for "Model Project" of multipurpose dams

On the other hand, the following items are proposed for improvement from the viewpoint of organizations and legal frameworks regarding promotion of water demand management measurements.

- Strengthening of organization and human resources of the regulatory organization
- Consideration of incentive schemes for introduction of rainwater storage and infiltration

Proposal for Priority Project Concept in WRR VII

58. The water resources development and management plans (idea) were examined and proposed for each policy and sector in the previous section, and the concept of each selected priority project were studied and proposed. As a roadmap for the water resources development and management plan, the project implementation schedule for the short-term (2030), medium-term (2040), and long-term (2050) up to 2050 was summarized (refer to Table 4.3.19 in the Main Report). In addition to this, among the short-term and medium-term proposals, the projects with high feasibility and high importance were decided to be the priority projects.

59. For the following project components proposed as the priority projects in WRR VII, project title, project goals, target organizations, target areas, results, effects, and estimated costs, are summarized. Details of each component are described in Main Report Section 4.3.4.

P1: Demands Management

P1-1: Reduction of Non-Revenue Water

P1-2: Promotion of Water Saving Activities

P1-3: Introduction of Irrigation Telemetry System

P1-4: Improvement of Irrigation O&M Facility

P2: Groundwater Management

P3(1): Surface Water Development

P3-1: Study/Construction of Managa 2 Dam (low dam)

P3-2: Study/Construction of Kotkot Dam (multi-purpose use)

P3-3: Study/Construction of Inabanga Dam (Bohol-Cebu Integrated Water Utilization Project)

P3-4: Study/Upgrading Existing Dams (Buhisan Dam)

P3-5: Study/Upgrading Existing Dams (Can-Asujan Dam)

P3-6: Study/Upgrading Existing Dams (Bohol)

P3-7: Study/Upgrading Existing Dams (Negros Oriental))

P3(2): Water Supply System

P3-8: Introduction of Desalination Technology

P3-9: Introduction of Rainwater Storage and Infiltration

P4: Water Resources Management

Proposals of the Implementation Schemes for Priority Project Concepts in WRR VII

60. Promotion of IWRM (P4: Water Resources Management): In relation to IWRM, it is recommended to enact the bill for creating DWR and WRC in order to improve the issue of organizational fragmentation and overlap of the authorities and functions among water-related organizations. In addition, the following points are recommended.

- Strengthening the relation between the organizations in charge of planning/regulation and those in charge of construction and management of water infrastructures

  DWR is expected to be mainly in charge of planning and regulation, not in charge of construction and management of water infrastructures. In order to implement water infrastructure projects in line with the plan, it is necessary to strengthen the relationship between DWR and the organizations of implementing water infrastructure projects such as DPWH, and NIA.

- Strengthening the function of River Basin Committees

  River Basin Committees (RBCs) should be utilized for consensus building in implementing water resources projects, especially multi-purpose projects which require coordination of complicated stakeholders' interests. The functions of RBCs should be strengthened for that purpose.

- Expansion of regional offices for water resources management

  NWRB, currently in charge of regulatory functions, has limited human and budgetary resources, hence it appears that it is difficult to fulfill its regulatory functions adequately It is proposed that NWRB, or DWR if it can be created, should expand its regional offices to each region or WRR.

61. Implementation schemes for priority projects concepts: The outline of the proposal of implementation schemes for priority project concepts are organized in ANNEX C.

Regional Collaboration among Water Utilities in WRR VII

62. Issued to be Solved and Recommendations for Regional Collaboration

Issues on organizations and legal frameworks

- In the Philippines particularly, as described in Chapter 2, each water districts, LGU-run utilities, and private service providers belong to a different regulatory organization respectively, which makes it more difficult to enhance wide-area expansion.
- It would be appropriate to establish DWR and WRC in the future, which would also centralize regulatory authority over water utilities (e.g., Certificate of Public Convenience (CPC)) and promote consolidation of water utilities under the integrated regulatory authority of DWR and WRC.

Issues related to the overlap of service areas between multiple water utilities

- Overlap of water supply areas should be an avoidable situation from the perspective of efficient water utility management and efficient water use. The regulatory agency on water utilities including NWRB should make coordination towards elimination of such duplications.

Other issues towards promotion of regional collaboration among water utilities

- It is recommended that the Philippines side recognize that the policy on regional collaboration among water utilities may be one of the solutions for the issues related to efficiency of water use or necessity for management improvement of some of the water districts. Also, NEDA may consider the necessary frameworks including development of subsidy systems for enhancing the policy.
- In addition, it is necessary to share with the Philippines the experience and knowledge gained in Japan regarding regional collaboration among water utilities.

Environmental and Social Assessment in WRR VII

63. Environmental and Social Conditions in the Targeted Area: As part of the SEA, an initial environmental and social assessment was carried out on the priority project concepts. In the Survey, the construction of dams (Mananga II Dam, Kotkot Dam, Inabanga Dam) and the introduction of desalination facilities were selected as this assessment target, which are expected to have a significant impact on WRR VII.

Environmental and Social Conditions in the Targeted Area in WRR VII

Project	Water Quality	Protected Area	Resettlement / Land Acquisition	Poverty
Construction of Mananga II Dam	The Mananga River is classified as a Class A	Inside of protected area (Central Cebu Protected Landscape)	Affected households: approx 70 Required land: approx. 30 ha	The poverty gap is high, and the poverty gap rate is 5.7% in Cebu (3.0% nationwide)
Construction of Kotkot Dam	Kotkot River is classified as Class A	Inside of protected area (Central Cebu Protected Landscape)	Affected households: approx 30 Required land: approx. 62 ha	
Construction of Inabanga Dam	The Inabanga river is classified as Class A	Outside of protected area	Affected households: few Required land: approx. 136 ha	

Source: JICA Survey Team

64. Implementation of the Initial Assessment: Based on the environmental and social conditions around the priority projects, the impact items were scoped. Based on the results, items that should be particularly noted, i.e., the environmental and social impacts of water quality, protected areas and ecosystem, hydrology, resettlement/poverty were evaluated, and mitigation measures were set.

Priority Water Resources Region (WRR XI)

65. The procedures, methods and composition of the plan for the study of the water resources development and management alternatives are the same as those for WRR VII. Details of the alternative study in WRR XI are shown in Section 4.4.2 in the Main Report.

66. Water Demand Management Plan: As for the demand management measures for municipal and industrial water use, water saving and enhancement of non-revenue water measures, the reduction effect is estimated as 7% in total in the whole WRR XI. As for the demand management measures for irrigation water use, waterway leakage countermeasures, irrigation efficiency improvement by introducing ITS, the reduction effect is estimated as 8.0% in total in the whole WRR XI.

67. Groundwater Development and Management Plan: If groundwater pumping continues to increase due to increased groundwater demand until 2050, the groundwater level is expected to decline due to over-pumping in eastern side of Davao bay, Samal island, and eastern side of Mount Apo. In order to promote sustainable groundwater development based on an understanding of the current status of the above problem, the development of a groundwater monitoring network and geological and hydrological surveys to determine the current groundwater environment (hydrogeological structure, pumping rate, etc.) should be conducted as top priority.

68. Surface Water Development Plan: As a surface water development plan for WRR XI, the layout, scale, and preliminary estimated construction cost of Davao II Dam, Davao III Dam were preliminarily examined, and the survey, study and implementation were proposed. The original Davao III Dam has a large development scale and requires relocation of the main road upstream, so the dam height is planned to be lowered to 51.5 m in order to prevent the main road bridge from submerging.

69. Water Supply Plan (Irrigation Water Use): The new development projects as well as the improvement of the existing systems shall be implemented to focus on i) lining of main and lateral canals, ii) introducing the mechanical operation sluice gate with electric/generator power, iii) remote control operation system of the diversion dam gates, and iv) watershed management plans.

70. Water Supply Plan (Municipal and Industrial Water Use): Project concepts for municipal and industrial water include measures to reduce non-revenue water, promotion of water saving activities, introduction of seawater desalination technology, introduction of sewage reclamation technology, and introduction of technology to renovate industrial water. Of these, the highly effective and feasible non-revenue water reduction measures and promotion of water saving activities were selected as priority project concepts.

71. Water Resources Management Plan (Information Management): The descriptions related to the WRR VII given previously is also applicable for WRR XI.

72. Water Resources Management Plan (Flood Risk Management): The following recommendations are made based on a review of the issues in the 3 Major River Basin: Davao River Basin, Tagum-Libuganon River Basin and Buayan-Malungon River Basin, where flood risk management are especially important.

    - Flood control measures based on the current flood control M/Ps should be steadily implemented.

- Although no flood control dams are planned in the current flood control M/P in the Davao River basin, two multi-purpose dams (Davao II Dam and Davao III Dam) are proposed as priority projects in this Survey for the purpose of water resources development. Adding flood control functions to these dams could make them more cost-effective. A feasibility study should be conducted for both dams as multi-purpose dams that include flood control functions.
- In the current flood control M/Ps, two multi-purpose dams are planned for the Tagum Ribganon River basin and one multi-purpose dam for the Buayan Malangon River basin. These dams are proposed not only for flood control, but also as a long-term climate change adaptation measure that includes measures to cope with drought and water shortages. However, no detailed dam study has been conducted. A feasibility study for a multi-purpose dam should be conducted.

73. Water Resources Management Plan (River Basin Environmental Conservation): In WRR XI, there is a risk of groundwater shortage due to future increase of demand. There is also the problem of sedimentation of existing irrigation dams. Considering the above present conditions, objectives of the River Basin Environmental Conservation Plan in WRR XI are as follows.

- To secure good quality and enough amount of water resources in WRR XI through environmental conservation measures.
- To protect and improve the waterfront environment and water quality that ensure the sustainability between the natural environment and development/livelihood activities towards the prosperity of communities.

74. Water Resources Management Plan (Organizations and Legal Frameworks): Refer to the water resources management plan (organizations and legal frameworks) in WRR VII since the contents for WRR VII are also suitable for WRR XI.

Proposal for Priority Project Concept in WRR XI

75. Priority project concepts for short-term component of the Water Resources Development and Management Plan (idea) are reviewed and proposed, taking into account priority policies and development sectors.

76. As a roadmap for water resources development and management for WRR XI through 2050, the project implementation components for the short-term (2030), medium-term (2040), and long-term (2050) are summarized (see F/R Table 4.4.12). Priority projects are highlighted in red boxes, and out of the short-term and medium-term proposals, projects with high feasibility and importance are proposed as priority projects.

77. The following project components proposed as priority projects for WRR XI are organized by project name, goal, target agency, target area, project description, benefits, estimated costs, and other things to be noted. Details of each component are provided in Section 4.4.4 of the Main Report.

P1: Demand Management

P1-1: Reduction of Non-Revenue Water

P1-2: Promotion of Water Saving Activities

P1-3: Introduction of Irrigation Telemetry System

P1-4: Improvement of Irrigation O&M Facility

P2: Groundwater Management

P3(1): Surface Water Development

P3-1: Study/Construction of Davao 3 Dam (low dam)

P3-2: Study/Construction of Davao 2 Dam

P3-3: Study/Upgrading Existing Miral Dam in Davao Oriental

P3(2): Water Supply System

P3-4: Introduction of Desalination Technology

P3-5: Introduction of Rainwater Storage and Infiltration

P4: Water Resources Management

Proposals of the Implementation Schemes for Priority Project Concepts in WRR XI

78. The proposal for priority projects in WRR VII is also suitable for WRR XI. The outline of the implementation scheme for proposed priority projects are organized in ANNEX C.

Regional Collaboration among Water Utilities in WRR XI

79. The situation that there are multiple water utilities in the area covered by the proposed water resource was not found in the WRR XI with regard to the proposed water resources development and management plan and the priority project concept. However, the possibility that some of the water utilities ,that were not included in the Survey, may have issues on management improvement or efficiency, or may have problems with overlapping multiple water utilities in the WRR cannot be ruled out. Thus, it is recognized that regional collaboration among water utilities may be considered as one of the water demand management measurements in the future.

Environmental and Social Assessment in WRR XI

80. Environment and social conditions of priority project sites: As part of the SEA, an initial environmental and social assessment was carried out on the priority project concepts. In the Survey, the construction of dams (Davao III dam and Davao II dam) was selected as this assessment target, which are expected to have a significant impact on the WRR XI.
Characteristic environmental and social conditions in WRR XI are shown as follows.

Environmental and Social Conditions in the Targeted Area in WRR XI

Project	Construction of Davao III dam	Construction of Davao III dam
Water Quality	Davao river is classified as Class A	
Protected area	Outside of protected area	
Resettlement / Land acquisition	Affected households: few Required land: approx. 50 ha	Affected households: approx 2,200 Required land: approx. 6,125 ha
Indigenous People	There are the following Indigenous Peoples communities located especially in the upstream of Davao River	

Source: JICA Survey Team

81. Implementation of the Initial Assessment: Based on the environmental and social conditions around the priority projects, the impact items were scoped. Based on the results, the environmental and social impacts of items to be noted in particular, namely: water quality, ecosystems, hydrology, resettlement / indigenous people were evaluated, and mitigation measures were set.

Priority Water Resources Region (WRR V)

82. The procedures, methods, and composition of the plan for the study of the water resources development and management alternatives are the same as those for WRR VII. Details of the alternative study in WRR V are shown in Section 4.5.2 in the Main Report.

83. Water Demand Management Plan: As for the demand management measures for municipal and industrial water use, water saving and enhancement of non-revenue water measures, the reduction effect is estimated as 13% in total in the whole WRR V. As for the demand management measures for irrigation water use, waterway leakage countermeasures, irrigation efficiency improvement by introducing ITS, the reduction effect is estimated as 5.8% in total in the whole WRR V.

84. Groundwater Development and Management Plan: Establishment of a monitoring system to understand the groundwater environment is essential for sustainable use of groundwater resources, but at present, there are no specific monitoring networks in WRR V. In addition, if groundwater pumping continues to increase due to increased groundwater demand until 2050, the groundwater level is expected to decline due to over-pumping in western side of Naga sity, surroundings of Buhi lake, San Andres in Catanduanes island, and eastern area of Masbate island. In order to promote sustainable groundwater development based on an understanding of the current status of the above problems, the development of a groundwater monitoring network and geological and hydrological surveys to determine the current groundwater environment (hydrogeological structure, pumping rate, etc.) should be conducted as top priority.

85. Surface Water Development Plan: As a surface water development plan for WRR XI, the layout, scale, and preliminary estimated construction cost of redevelopment of Buhi Lake in Bicol River basin, and Lanang Dam in Masbate Island were preliminarily examined, and the survey, study and implementation are proposed.

86. Water Supply Plan (Irrigation Water Use): In Albay, South Camarines, and North Camarines provinces, as irrigation development plan, it is proposed to develop the future irrigated area based on the historical irrigation plans of NIA. In Masbate and Sorsogon, after verifying the future irrigated development area based on NIMP, farmland suitable for rice cultivation will be selected for the development plan. The productivity of existing irrigation systems shall be maintained and upgraded through the improvement of irrigation facilities, which includes lining of main and lateral canals, introducing the mechanical operation sluice gate with electric/generator power, and introducing the irrigation telemetry system.

87. Water Supply Plan (Municipal and Industrial Water Use): Project concepts for municipal and industrial water include measures to reduce non-revenue water, promotion of water saving activities, introduction of seawater desalination technology, introduction of sewage reclamation technology, and introduction of

technology to renovate industrial water. Of these, the highly effective and feasible non-revenue water reduction measures and promotion of water saving activities were selected as priority project concepts.

88. Water Resources Management Plan (Information Management): Refer to the descriptions related to the WRR VII; it is also applicable for the WRR V.

89. Water Resources Management Plan (Flood Risk Management): The following recommendations were made based on a review of the issues in the Bicol River Basin, where flood risk management is critical.

- Flood control measures based on the current flood control M/P should be steadily implemented. On the other hand, the current flood control M/P needs to be reviewed, and a comprehensive basin-scale flood control and sediment control M/P study should be conducted.
- Upgrading of the existing flow control structure at Lake Buhi is proposed as a priority project for water resource development in this survey. Since controlling the discharge from Lake Buhi in flood season can also contribute for flood risk reduction in the downstream, the effective and efficient operation of the structure should be studied in terms of IWRM.
- From an IWRM perspective, storing floodwaters in Bato and Baao Lakes would reduce peak flood flows downstream and increase freshwater resources during the dry season. Construction of flow control facilities at the outlets of these natural lakes would reduce the risk of both flood and drought disasters. M/P studies should be conducted for integrated lake management, including flood, drought, and water quality issues.

90. Water Resources Management Plan (River Basin Environmental Conservation): In WRR V, water shortages are caused by inappropriate management of water resources, such as aging facilities, flooding, poor drainage, sedimentation management, and saltwater intrusion. In Lake Buhi, the water quality has deteriorated due to the lowering of the water level. Considering the above present conditions, objectives of the River Basin Environmental Conservation Plan in WRR V are as follows.

- To secure good quality and enough amount of water resources in WRR V through environmental conservation measures.
- To protect and improve the waterfront environment and water quality that ensure the sustainability between the natural environment and development/livelihood activities towards the prosperity of communities.

91. Water Resources Management Plan (Organizations and Legal Frameworks): Refer to that of WRR VII since the contents for WRR VII are suitable for WRR V.

Proposals for Priority Project Concept in WRR V

92. Priority project concepts for short-term component of the Water Resources Development and Management Plan (idea) are reviewed and proposed, taking into account priority policies and development sectors.

93. As a roadmap for water resources development and management for WRR V through 2050, the project implementation components for the short-term (2030), medium-term (2040), and long-term (2050) are

summarized (see F/R Table 4.5.14). Priority projects are highlighted in red, and out of the short-term and medium-term proposals, projects with high feasibility and importance are proposed as priority projects.

94. The following project components proposed as priority projects for WRR V are organized by project name, goal, target agency, target area, project description, benefits, estimated costs, and other things to be noted. Details of each component are provided in Section 4.5.4 of F/R.

P1: Demand Management

- P1-1: Reduction of Non-Revenue Water
- P1-2: Promotion of Water Saving Activities
- P1-3: Introduction of Irrigation Telemetry System
- P1-4: Improvement of Irrigation O&M Facility

P2: Groundwater Management

P3(1): Surface Water Development

- P3-1: Study/Upgrading Buhi Lake for IWRM
- P3-2: Study/Construction of Lanang Dam (multipurpose)

P3(2): Water Supply System

- P3-5: Introduction of Rainwater Storage and Infiltration

P4: Water Resources Management

Proposals of the Implementation Schemes for Priority Project Concepts in WRR V

95. Refer to the proposal for priority projects in WRR VII since it is suitable for WRR V. as well. The outline of the implementation scheme for proposed priority projects are organized in ANNEX C.

Regional Collaboration among Water Utilities in WRR V

96. The situation that there are multiple water utilities in the area covered by the proposed water resource was not found in the WRR V with regard to the proposed water resources development and management plan and the priority project concept. However, the possibility that some of the water utilities, that were not included in our survey, may have issues on management improvement or efficiency, or may have problems with overlapping multiple water utilities in the WRR cannot be ruled out. Furthermore, some participants of the second stakeholder meeting held on 25th April 2023 in Legazpi City indicated the recognition of the necessity of wide-area water service crossing over the administrative boundaries. Thus, it is recognized that regional collaboration among water utilities may be considered as one of the water demand management measurements in the future.

Environmental and Social Assessment in WRR V

97. <u>Environment and social conditions of priority project sites</u>: As part of the SEA, an initial environmental and social assessment was carried out on the priority project concepts. In the Survey, the construction of dams (Lanang dam) and upgrading Buhi Lake were selected as this assessment target, which are expected to have a significant impact on the WRR V.
Characteristic environmental and social conditions in WRR V are shown as follows.

Environmental and Social Conditions in the Targeted Area in WRR V

Project	Upgrading Buhi Lake	Construction of Lanang dam
Water Quality	Buhi Lake is classified as Class B	Lanang river is classified as Class B
Protected area	Inside several protected areas	Outside of protected area
Resettlement / Land acquisition	Not expected	Affected households: approx 130 Required land: approx. 660 ha
Indigenous People	Ancestral domains are located on the northeastern portion of Lake Buhi	Not identified

Source: JICA Survey Team

98. Implementation of Initial Assessment: Based on the environmental and social conditions around the priority projects, the impact items were scoped. Based on the results, the environmental and social impacts of were assessed and mitigation measures were established for upgrading Buhi Lake (water quality, protected areas and ecosystem, indigenous people) and Lanang Dam construction (water quality, ecosystems, resettlement) as items requiring special attention.

Conclusion and Recommendation

99. This Survey conducted a water balance assessment foor the entire country of the Philippines, with 2050 as the target year and taking into account climate change impacts, and identified three water resources regions: V (Bicol), VII (Central Visayas), and XI (Southeast Mindanao Region) as priority areas from 12 WRRs nationwide where water balance is expected to be particularly tight in the future. In these priority WRRs, detailed water balance analysis was conducted, and through field surveys and consultations with relevant agencies, an efficient and effective water resources development and management plan (idea) and its roadmap by 2050 was developed to eliminate water shortages in each area.

100. On the organizational and institutional level, the current status and trends of the water sector were analyzed at the national level. In addition, in the priority WRRs, the implementation system of the proposed priority projects and the application for wide-area water resource development were examined, then issues and recommendations were made.

101. In terms of environmental and social considerations, an initial environmental impact assessment was conducted as a strategic environmental assessment (SEA) for the priority project concepts, whereas two stakeholder meetings were held in the 3 priority WRRs (six SHM in total). Opinions were exchanged regarding water demand gap and the status of existing facilities, and opinions and recommendations on the proposed plan and project concepts were heard in order to ultimately develop consensus-built plans and project implementations.

102. In Chapter 5 of the main report, a summary of conclusions and recommendations for the overall Survey and for each priority WRRs, as well as conclusions and recommendations regarding organizations and legal frameworks are given.

End of Document

CHAPTER 1 INTRODUCTION

1.1 Background

Source: The Philippine Star (2019.12.25).

Figure 1.1-1 Emergency Water Supply during Metro Manila Drought

The shortage of water resources has become one of the major issues in the Philippines especially since the 1990s when its economy took off for swift growth. Subsequent increase in water demand led water-related issues in the country, such as the delayed water resource development and inefficient water supply system, to become evident nationwide. In 1998, JICA conducted the Master Plan Study on Water Resource Management in which some major cities (e.g. Metro Manila, Cebu, and Baguio) were predicted to face serious water shortage in the near future, based on the water balance analysis in 12 Water Resources Regions in the country. Since then, the Government of the Philippines has promoted cross-sectoral planning of water resource management through formulation of Integrated Water Resources Management Plan in each river basins to tackle the water shortage issue. JICA also supported this initiative, examples of which includes the conduct of the Study on Integrated Water Resource Management for Poverty Alleviation and Economic Development in the Pampanga River Basin in 2011.

Even with these efforts, effective water resources development and management in the Philippines remains a challenge today. The Philippine Development Plan (PDP) 2017-2022 highlighted the need for support in developing new water sources and prioritization of surface water development, where feasible. In PDP 2023-2028, the strategy in the water sector is to implement effective water governance through integrated water resource management (IWRM) as applied in the planning and management of land, water, and coastal resources. Groundwater recharge system in the development of the surface water source for critical areas will be incorporated, wherever possible, in accordance with prescribed standards. Such are among the initiatives of the Government in attaining water security in the country as the growth of its population and economy are expected to continue. The serious water shortage in 2019 that occurred across the country due to the low rainfall caused by El Nino recalled the need for prompt action. In addition, the COVID-19 pandemic in 2020 also highlighted the importance of stable water supply from the public health perspective.

On the other hand, while there remains a need to come up with a comprehensive plan to address water security issues of the country, the Government of the Philippines has formulated the Philippine Water Supply and Sanitation Master Plan (PWSSMP), and its Key Reform Agenda (KRA) Action Plan lays out the priority interventions needed to create an enabling environment for the WSS sector towards achieving PDP 2017-2022 WSS targets and United Nations (UN) Sustainable Development Goal (SDG) of universal access to safe water supply and sanitation by 2030. The KRAs, which are critical institutional reforms needed to bridge the gaps in the sector, includes KRA 7 – Managing Data and Information. Said KRA is in light of the perennial problem on insufficient water-related data, or the lack thereof, hence, focuses on ensuring availability and accessibility of reliable data.

The purpose of the Data Collection Survey is to collect necessary information and data that are necessary to understand the water balance nationwide, to formulate water resources development and management master plans for the areas with large water balance gap, and to propose effective countermeasures for such areas.

1.2 Purpose of Survey

The purposes of this survey are as follows.

1) To conduct water balance analysis for each water resources region with the target year of 2050 for the entire Philippines.
2) To identify priority areas where the water balance is expected to be particularly tight in the future, and
3) To formulate a water resources development and management plan (draft) in the priority areas, and to propose effective priority project concept including development covering wide area.

1.3 Project Target Area

The target area for project is the entire Philippines. The preface figure map shows the locations and lists of the 12 major water resources regions (which divides the country into 12 regions hydrologically for comprehensive water resources development), major rivers, and major cities.

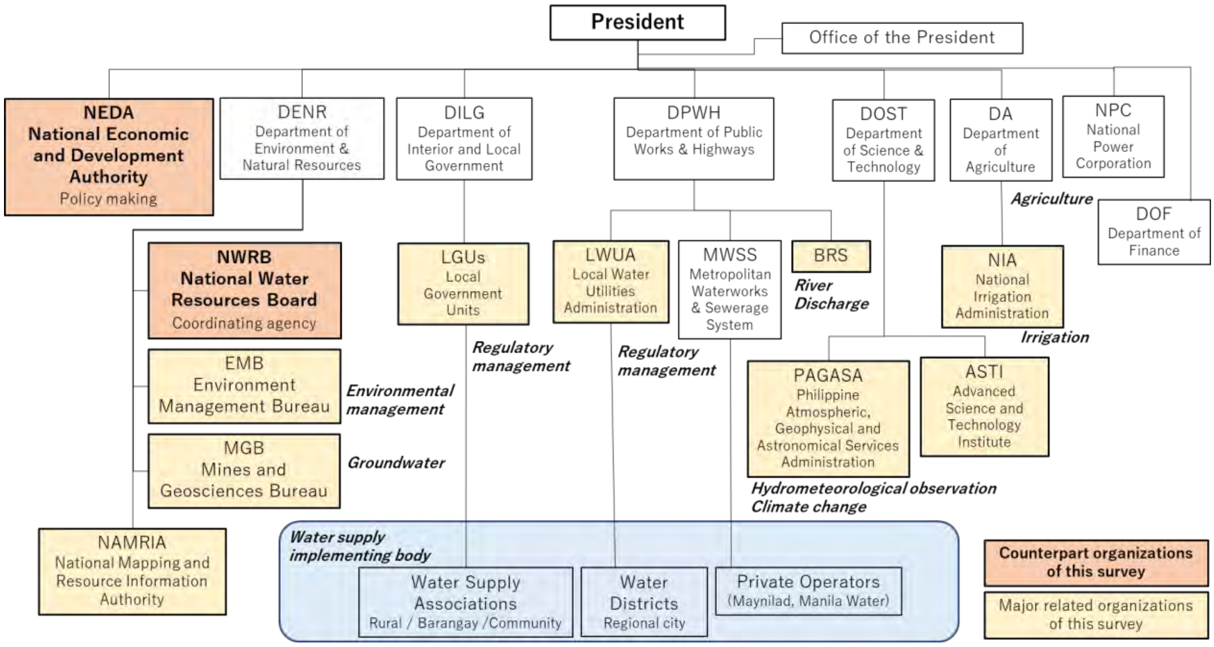
1.4 Survey Scope

The Japan International Cooperation Agency (JICA) Survey Team recognizes the scope of work of this survey as follows:

1) This survey does not formulate a master plan, but it is positioned to collect and analyze data for that purpose and provide necessary materials.
2) This survey focuses mainly on the development and management of water resources in local cities and does not include the water resources region of Metro Manila as a priority area.

1.5 Survey Counterpart Organizations

Since this survey targets national water resources development and management, cooperation with a large number of organizations and institutions is indispensable. Figure 1.5-1 shows the main related organizations in this survey. The counterpart organizations in this survey are the National Economic and Development Authority (NEDA) and the National Water Resources Board (NWRB).



Note: As of 2022

Source: Created based on the figures in the 2018 JICA Philippines Water and Sewerage Information Collection Survey Report

Figure 1.5-1 Counterpart Organizations and Major Related Organizations

1.6 Survey Implementation Stages

The survey is phased in following four major stages.

Stage 1: Water balance analysis for 12 WRRs and selection of the priority WRRs

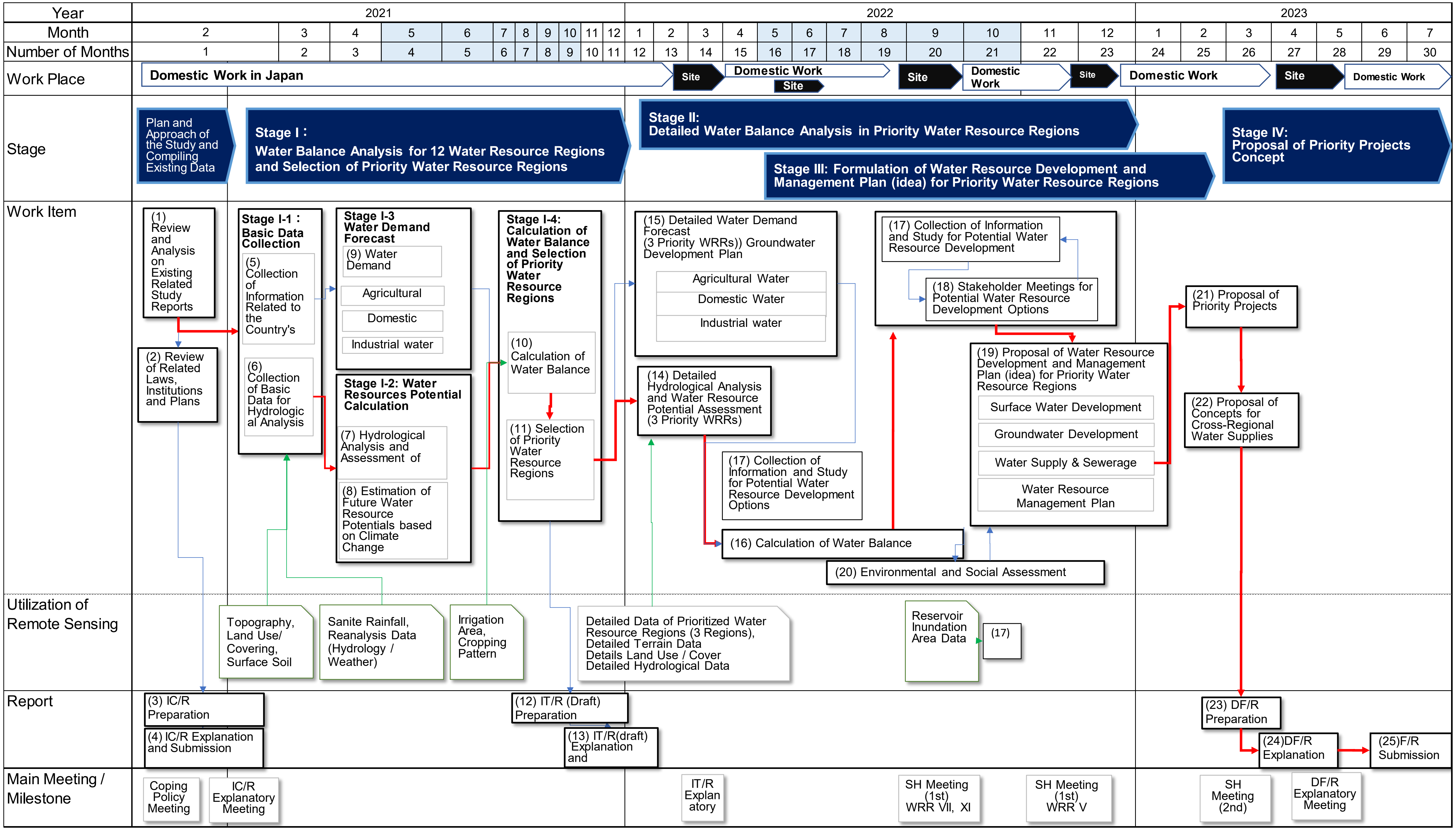
Stage 2: Detailed water balance analysis in the priority WRRs

Stage 3: Proposal of water resources development and management plan (idea) for the priority WRRs

Stage 4: Proposal of priority project concepts

1.7 Work Schedule

The work schedule and workflow are shown below. In this survey, because of delays in works in connection with restriction for movement in Philippines and restriction for travel for Japanese workers due to the COVID-19, and responding to the requests for additional work from the counterpart organizations, the target completion date was extended from November 2022 to July 2023 and the scope of the works was revised. The revised contract with a contract change was signed on November 16, 2022.



Note: IC/R: Inception Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report SH Meeting: Stakeholder Meeting ↳ Critical Path

Source: JICA Survey Team

Figure 1.7-1 Flow Chart of Survey Implementation (Revised)

1.7.1 Outline of the Study Activities

The outline of main activities of the Survey from the start of operations in February 2021 to March 2023 is shown below.

Plan and Approach of the Study and Compiling Existing Data

Table 1.7-1 Outline of the Main Activities of Each Tasks (1/5)

Tasks	Outline of the Progress of Tasks
(1) Review and Analysis of Existing Related Study Reports	・ Prior to studying the work plan and work schedule of the survey, the JICA Survey Team examined and analyzed the request from the Philippine side and the background of the survey as well as existing related information such as similar survey reports.
(2) Review of Related Laws, Institutions, and Plans	・ In the Philippines, legal frameworks and organizations related to water resources exist in a complicated form. In order to accurately understand the current situation, the JICA Survey Team collected and analyzed the latest information. The results of this work are presented in Section 2.8.
(3) Preparation of Inception Report	・ Based on the collection and analysis of existing information in (1) and (2), the basic survey approach, work plan and schedule, staff schedule, and items to be confirmed from the Philippine side were summarized in the draft inception report (English). After that, the contents were discussed with JICA on February 24, 2021 and the report was finalized thereafter.
(4) Explanation and Submission of Inception Report	・ In a remote meeting on March 8, 2021, the contents of the inception report were explained to the Philippine counterpart organizations National Economic and Development Authority (NEDA) and National Water Resources Board (NWRB) and related agencies. The JICA Survey Team obtained consent for the approach and work plan of the survey. The inception report was submitted on March 8, 2021. ・ In addition, the JICA Survey Team participated in the 36th Meeting of the NEDA Board Committee on Infrastructure (INFRACOM) – Subcommittee on Water Resources (SCWR) on March 23, 2021 and made a presentation for introduction of the survey to the subcommittee members. ・ After the submission of the inception report, there was some difficulty for the JICA Survey Team's data collection from other related agencies mainly due to data confidentiality. After several discussions between NEDA and the joint venture (JV) consortium of this survey, a Confidential Non-Disclosure Agreement (CNDA) was agreed and entered into by both parties on July 1, 2021.

Source: JICA Survey Team

Stage I: Water balance analysis for 12 WRRs and selection of the priority WRRs

Table 1.7-2 Outline of the Main Activities of Each Tasks (2/5)

Tasks	Outline of the Progress of Tasks
Stage I-1: Basic Data Collection	
(5) Collection of Information Related to the Country's Socio-economic Situation	・ The necessary information was collected for setting the socio-economic framework to estimate water demand as described in Section 2.5.
(6) Collection of Basic Data for Hydrological Analysis	・ In the hydrological analysis for Stage I, remote sensing data were obtained early in works in Japan, and data of past projects were utilized to streamline the study as described in Section 2.3 and Chapter 3.
Stage I-2: Water Resources Potential Calculation	
(7) Hydrological Analysis and Assessment of Water Resource Potential	・ Based on the basic data acquired in (6) above, a hydrological model was constructed and the water resource potentials (surface water and groundwater) in each water resource region were calculated.
(8) Estimation of Future Water Resources Potentials based on Climate Change Considerations	・ The climate change impact forecast of this survey was carried out in consideration of accuracy and data collection time referring to the PAGASA data together with the hydrological analysis.
<Stage I-3: Water Demand Forecast>	
(9) Water Demand Forecast	・ Based on the results of collecting and organizing the data of the economic framework in (5), the demands for agriculture, domestic water, and industrial water were calculated, and the future water demand in each water resources region were predicted.
<Stage I-4: Calculation of Water Balance and Selection of Priority Water Resources Regions>	
(10) Calculation of Water Balance	・ The water balance was calculated for each water resources region based on the results of Stages I-1 to I-3. In this survey, the water resource potential was calculated by dividing it into surface water and groundwater. The water resource potential of the entire water resources region was calculated based on each tributary sub-basin using the runoff model. The data related to the water balance calculation was summarized in the annual and monthly water balance tables for each water resources region.
(11) Selection of Priority Water Resources Regions	・ Out of 12 water resources regions, three priority water resources regions were selected based on the evaluation criteria for the subsequent detailed investigation. These criteria were determined through explanation and discussions with JICA and the Philippine counterpart organizations. ・ As the results, the water resources region of V (Bicol), VII (Central Visayas), and XI (South-eastern Mindanao) were finally selected as the priority WRRs.
(12) Preparation of Draft Interim Report	・ The work results up to this point were summarized in the Interim Report.
(13) Explanation and Submission of Interim Report	・ The Interim Report was submitted to JICA in January 2022. In March 2022, the details of the Interim Report were explained to the relevant organizations on the Philippine side, and consent was obtained including the results of selection of priority WRRs and the policy and approach of the Survey for Stages 2 to 4.

Source: JICA Survey Team

Stage II: Detailed Water Balance Analysis in Priority Water Resources Regions

Table 1.7-3 Outline of the Main Activities of Each Tasks (3/5)

Tasks	Outline of the Progress of Tasks
(14) Detailed Hydrological Analysis and Water Resource Potential Assessment	・ For the surface water runoff analysis model, a physical water cycle analysis model (SHER model) with higher accuracy than the national level was applied. ・ Objective area was divided into smaller basins (approximately 100 km2); more detailed than Stage 1. Hydrological analysis and calculation of water resources potential were carried out. The reproducibility and accuracy of the model was confirmed by estimating physical property values based on observed values (flow rate, groundwater level). In areas where observation values were not obtained, simulations were performed based on the physical property values of identified nearby areas. ・ The groundwater potential was analyzed using the MODFLOW model (USGS), a physical water cycle analysis model. The model was calibrated based on groundwater level observation data. In response to requests from the counterpart organizations, NEDA and NWRB, a technical familiarization program was implemented in order to provide technical explanations for detailed water balance studies in Stage 2 priority WRRs and to hold technical discussions on analysis method. From November to December 2022, technical discussions on surface water analysis were held six times. The programs on groundwater analysis, water demand forecasting, economic framework forecasting, remote sensing technology, etc. were held after.
(15) Detailed Water Demand Forecast	・ The target years for the study were set for Short-term (2030), medium-term (2040), and long-term (2050). ・ Agricultural water demand was predicted based on whole existing irrigation organizations and planned irrigation projects (NIP, CIP) located in priority WRRs, using the same method as in Stage 1, but also considering the weather conditions and climate change impacts of each region. The short-, medium-, and long-term monthly water requirements for each irrigation area were predicted. ・ Municipal and industrial water demands were predicted using information such as actual water usage, actual revenue from charges, and the latest industrial development plan, and the items organized in Stage 1 (population forecast, water supply rate, water supply unit consumption, non-revenue water rate, amount of industrial water used). In addition, the presence or absence of sewerage plans in major cities in priority water resource areas was also confirmed.
(16) Calculation of Water Balance	・ The water balance analysis in the priority WRRs is not based on the deduction of water supply and demand for each basin, but on the results of (14) and (15) above, taking into account the required development volume by season and by areas (administration, city) and by usage. ・ In addition, for the study cases of the water balance analysis, the current and future water balance were quantitatively evaluated for 4 scenarios, i.e. for current climate and 3 cases of climate change impacts.

Source: JICA Survey Team

Stage III: Proposal of Water Resources Development and Management Plans (Idea) for Priority Water Resources Regions

Table 1.7-4 Outline of the Main Activities of Each Tasks (4/5)

Tasks	Outline of the Progress of Tasks
(17) Collection of Information and Study for Potential Water Resources Development Options	• The safety level for each water use was set at 1/5 year for agricultural water use, and 1/10 year for municipal and industrial water use. • In the 1st to 4th field surveys, new water sources (dams, weirs, potential reservoir sites) were surveyed on maps and field surveys were investigated. • Alternative plans for new water resource development options were proposed, and comparative studies and water balance analysis of countermeasures were undertaken.
(18) Stakeholder Meetings for Potential Water Resource Development Options	• As a part of the Strategic Environmental Assessment (SEA), stakeholder meetings (SHM) have been carried out by a local subcontractor. • The 1st SHM was held in three priority WRRs in a hybrid meeting, explaining the outline of the plan, the results of the current water balance analysis, the expected environmental and social impacts, and the future schedule, followed by a Q&A session. • The results of discussions, the presence/absence of conflicts and their situations, were organized and fed back to (17) Comparative examination of development options. They were also reflected in the proposal of the water resources development and management plan (draft) in (19).
(19) Proposal of Water Resources Development and Management Plan (Idea) for the Priority WRRs	• The contents of the water resources development and management plan (idea) based on the water resources development options to solve the water supply-demand gap by the target year of 2050 were proposed after the above studies.
(20) Environmental and Social Assessment	• In connection with the study for the water resources development and management plan (idea) for the priority WRRs, as part of the strategic environmental assessment (SEA), the baseline of the candidate sites was organized and the environmental and social impacts were scrutinized.

Source: JICA Survey Team

Stage IV: Proposal of Priority Projects Concept

Table 1.7-5 Outline of the Main Activities of Each Tasks (5/5)

Tasks	Outline of the Progress of Tasks
(21) Proposal of Priority Projects Concept	• The priority projects concept was created by combining some components of the short-term plan proposed in the water resources development and management plan (draft) while taking into consideration the priority policies and priority development sectors in the target area.
(22) Proposal of Concepts for Cross-Regional Water Supplies	• Current status of water supply in the Philippines was examined, and integration of regional water supply authorities was preliminary studied together with the item (21).
(23) Preparation of Draft Final Report	• The Draft Final Report was prepared by compiling all the survey results and submitted to JICA on April 28, 2023.
(24) Explanation of Draft Final Report	• The content of the Draft Final Report was explained to the Philippine counterpart organizations to obtain their consent.

Tasks	Outline of the Progress of Tasks
(25) Submission of Final Report	・ Reflecting all comments obtained from the Philippine counterpart organizations on the Draft Final Report and after confirming with JICA, this Final Report was submitted on July 31, 2023.

Source: JICA Survey Team

1.7.2 Main Meetings

After the kick-off meetings, progress meetings among NEDA, NWRB, JICA, and the JICA Survey Team have been held on a monthly basis. In the progress meetings, the JICA Survey Team reported the overall progress, status of data collection, and technical topics of the survey works to exchange comments and suggestions for smooth implementation of the survey. In addition, NEDA and NWRB had a presentation to introduce their tasks and activities related to water resources development and management in the Philippines.

Table 1.7-6 Main Meetings

Date	Subject	Contents
February 24, 2021	Kick-off Meeting with JICA	Explanation of the Inception Report
March 8, 2021	Kick-off Meeting with NEDA/NWRB	Explanation of the Inception Report
March 23, 2021	The 36th Meeting of the NEDA Board Committee on Infrastructure (INFRACOM) – Subcommittee on Water Resources (SCWR)	Introduction of the Survey to INFRACOM-SCWR members
October 12, 2021	The 37th Meeting of the NEDA Board Committee on Infrastructure (INFRACOM) – Subcommittee on Water Resources (SCWR)	Explanation of Selection of Priority Water Resources Region to INFRACOM-SCWR members
March 72022	Interim Report Meeting	Explanation of the Interim Report
April 27, 2022	The39th Meeting of the NEDA Board Committee on Infrastructure (INFRACOM) – Subcommittee on Water Resources (SCWR)	Explanation of results of 1st field survey in Priority Water Resources Region to INFRACOM-SCWR members
September 8, 2022	1st Stakeholder Meeting in WRR VII	i) Project Description & Initial Activities ii) Progress of Surface Water Modeling and Water Balance Analysis iii) Progress of Groundwater Analysis iv) Environmental and Social Considerations for the Project v) Open Forum
September 15, 2022	1st Stakeholder Meeting in WRR XI	
December 7, 2022	1st Stakeholder Meeting in WRR V	
April 19, 2023	2nd Stakeholder Meeting in WRR VII	i) Results of the Survey ii) Water Resources Development and Management Plan iii) Environmental and Social Considerations for the Project iv) Concepts of Priority Projects v) Open Forum
April 25, 2023	2nd Stakeholder Meeting in WRR V	
May 9, 2023	2nd Stakeholder Meetings in WRR XI	
April 2021 - June 2023	1st ~ 32nd Progress Meeting	i) Overall Progress of the Survey ii) Explanation and Discussion on the progress and outputs of each task with NEDA/NWRB iii) Q & A

Source: JICA Survey Team

CHAPTER 2 STAGE I: WATER BALANCE ANALYSIS FOR 12 WRRS AND SELECTION OF THE PRIORITY WRRS

2.1 Socio-Economic Situation

2.1.1 Social-Economic Situation

(1) Population

1) Nation

The total population of the Philippines has increased from 92,337,852 in 2010 to 109,035,343 in 2020 at an average annual growth rate (AAGR) of 1.5% as shown in Table 2.1-1.

Table 2.1-1 National and Regional Population in the Philippines

Administrative Region	Census Report			Average Annual Growth Rate	
	2010	2015	2020	2010-2015	2015-2020
PHILIPPINES	92,337,852	100,981,437	109,035,343	1.7%	1.5%
National Capital Region (NCR)	11,855,975	12,877,253	13,484,462	1.6%	0.9%
Cordillera Administrative Region (CAR)	1,616,867	1,722,006	1,797,660	1.2%	0.9%
REGION I - ILOCOS	4,748,372	5,026,128	5,301,139	1.1%	1.1%
REGION II - CAGAYAN VALLEY	3,229,163	3,451,410	3,685,744	1.3%	1.3%
REGION III - CENTRAL LUZON	10,137,737	11,218,177	12,422,172	2.0%	2.1%
REGION IV-A - CALABARZON	12,609,803	14,414,774	16,195,042	2.6%	2.4%
REGION IV-B - MIMAROPA REGION	2,744,671	2,963,360	3,228,558	1.5%	1.7%
REGION V - BICOL	5,420,411	5,796,989	6,082,165	1.3%	1.0%
REGION VI - WESTERN VISAYAS	7,102,438	7,536,383	7,954,723	1.3%	1.1%
REGION VII - CENTRAL VISAYAS	6,800,180	7,396,898	8,081,988	1.8%	1.8%
REGION VIII - EASTERN VISAYAS	4,101,322	4,440,150	4,547,150	1.5%	0.5%
REGION IX - ZAMBOANGA PENINSULA	3,407,353	3,629,783	3,875,576	1.2%	1.3%
REGION X - NORTHERN MINDANAO	4,297,323	4,689,302	5,022,768	1.7%	1.4%
REGION XI - DAVAO	4,468,563	4,893,318	5,243,536	1.7%	1.4%
REGION XII - SOCCSKSARGEN	4,109,571	4,545,276	4,360,974	1.9%	-0.8%
REGION XIII - CARAGA	2,429,224	2,596,709	2,804,788	1.3%	1.6%
Bangsamoro Autonomous Region in Muslim Mindanao (BARMM)	3,256,140	3,781,387	4,944,800	2.9%	5.5%

Note: The 2010 total population includes Filipinos in Philippine embassies, consulates, and missions abroad numbering 2,739.
The 2015 total population includes Filipinos in Philippine embassies, consulates, and missions abroad numbering 2,134.
The 2020 total population includes Filipinos in Philippine embassies, consulates, and missions abroad numbering 2,098.
Source: Philippine Statistics Authority (PSA) (2017) "2015 Census of Population, Report No. 2–Demographic and Socioeconomic Characteristics Philippines", (2020) "Census of Population and Housing"

2) Region

The population of Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) increased at the highest AAGR of 5.5% which includes new Province, followed by those of Calabarzon (Region IV-A) and Central Luzon (Region III) from 2015 to 2020 as shown in Table 2.1-1. On the other hand, the population of SOCCSKSARGEN (Region VII) decreased at the lowest AAGR of -0.8% since Cotabato City was included in BARMM in 2019. Eastern Visayas (Region VIII) increased at the second lowest AAGR of 0.5%, followed by those of The National Capital Region (NCR) and Cordillera Administrative Region (CAR).

The population of Calabarzon (Region IV-A) accounts for the highest share of 14.9% of national population, followed by those of National Capital Region (NCR) and Central Luzon (Region III) in 2020. The population of CAR is the lowest (1.6% of the national population), followed by those of Caraga (Region XIII), 2.6%, and Mimapora (Region IV-B), 3.0%.

(2) GDP and GRDP

1) GDP

Gross Domestic Product (GDP) of the Philippines has increased from 16,556,651 million pesos to 17,975,997 million pesos during the past three years from 2017 to 2020 at current prices as shown in Table 2.1-2. It was 17,175,978 million pesos in 2017 and 17,527,234 million pesos in 2020 at constant 2018 prices. GDP has decreased from 2019 to 2020 due to the impact of COVID-19. The GDP per capita has increased from 158,940 pesos in 2017 to 164,919 pesos in 2020 at current prices while it was 164,885 pesos in 2017 and 161,137 pesos in 2020 at constant 2018 prices.

Table 2.1-2 GDP of the Philippines

Price	Item	2017	2018	2019	2020
At current prices	GDP (Mil. Philippine Pesos)	16,556,651	18,265,190	19,517,863	17,938,582
	GDP Growth Rate (%)	9.4%	10.3%	6.9%	-8.1%
	GDP per Capita (Philippine Pesos)	158,940	172,712	181,920	164,919
At constant 2018 prices	GDP (Mil. Philippine Pesos)	17,175,978	18,265,190	19,382,751	17,527,234
	GDP Growth Rate (%)	6.9%	6.3%	6.1%	-9.6%
	GDP per Capita (Philippine Pesos)	164,885	172,712	180,661	161,137

Source: PSA (2021) "National Accounts of the Philippines" for data from 2017 to 2020

2) GRDP

Regarding the Gross Regional Domestic Product (GRDP), BARMM has increased from 210,664 million pesos in 2017 to 260,254 million pesos in 2020 at current prices at the highest AAGR of 7.3%, followed by Davao Region (Region XI) as shown in Table 2.1-3. NCR has the largest share of 32.3% in the Philippines about the total GRDP in 2020, followed by Calabarzon (Region IV-A) of 14.3%, Central Luzon (Region III) of 10.4% and Central Visayas (Region VII) of 6.5%.

Table 2.1-3 GRDP of Region

At Current Prices (Unit: Mil. PHP)

GRDP	2017	2018	2019	2020
National Capital Region	5,327,124	5,814,440	6,294,195	5,797,058
Cordillera Administrative Region	280,806	308,267	322,106	296,523
Ilocos Region	527,801	587,597	630,301	597,982
Cagayan Valley	358,687	385,061	399,371	367,096
Central Luzon	1,860,324	2,062,394	2,184,815	1,862,908
CALABARZON	2,423,069	2,706,995	2,865,793	2,565,124
MIMAROPA Region	321,949	370,745	375,590	341,983
Bicol Region	465,966	522,015	560,835	515,794
Western Visayas	791,282	860,108	919,163	850,747
Central Visayas	1,067,273	1,180,946	1,270,612	1,164,719
Eastern Visayas	397,387	444,384	455,534	413,292
Zamboanga Peninsula	344,668	379,428	399,109	394,568
Northern Mindanao	737,898	821,122	885,224	861,506
Davao Region	748,539	841,429	922,614	889,458
SOCCSKSARGEN	420,128	454,305	474,893	467,906
Caraga	273,088	290,562	302,930	291,665
Bangsamoro Autonomous Region in Muslim Mindanao	210,664	235,393	254,779	260,254
Total	16,556,651	18,265,190	19,517,863	17,938,582

Source: PSA (2021) "Regional Accounts of the Philippines" for data from 2017 to 2020

3) GDP by Major Industry

GDP of agriculture, forestry and fishing sector has increased from 1,685,956 million pesos to 1,827,010 million pesos during the past three years from 2017 to 2020 at current prices as shown in Table 2.1-4. Additionally, GDP of industry sector has increased from 4,987,948 million pesos to 5,094,222 million pesos. Furthermore, GDP of services sector has increased from 9,882,747 million pesos to 11,017,351 million pesos. Services sector has the largest share of the total GDP in 2020 with 61.4%, followed by agriculture, forestry and fishing by 28.4% and industry by 10.2%.

Table 2.1-4 GDP by Major Industry

At Current Prices (Unit: Mil. PHP)

Major Industries	2017	2018	2019	2020
Agriculture, Forestry and Fishing	1,685,956	1,762,616	1,721,539	1,827,010
Industry	4,987,948	5,582,525	5,919,281	5,094,222
Services	9,882,747	10,920,048	11,877,043	11,017,351
Gross Domestic Product	16,556,651	18,265,190	19,517,863	17,938,582

Source: PSA (2021) "Regional Accounts of the Philippines" for data from 2017 to 2020

(3) Characteristics of Land Use of 12 Water Resources Regions in Regional Physical Framework Plan and Regional Development Plan

Characteristics of land use of 12 WRRs in Regional Physical Framework Plan and Regional Development Plan is presented in Annex-B.

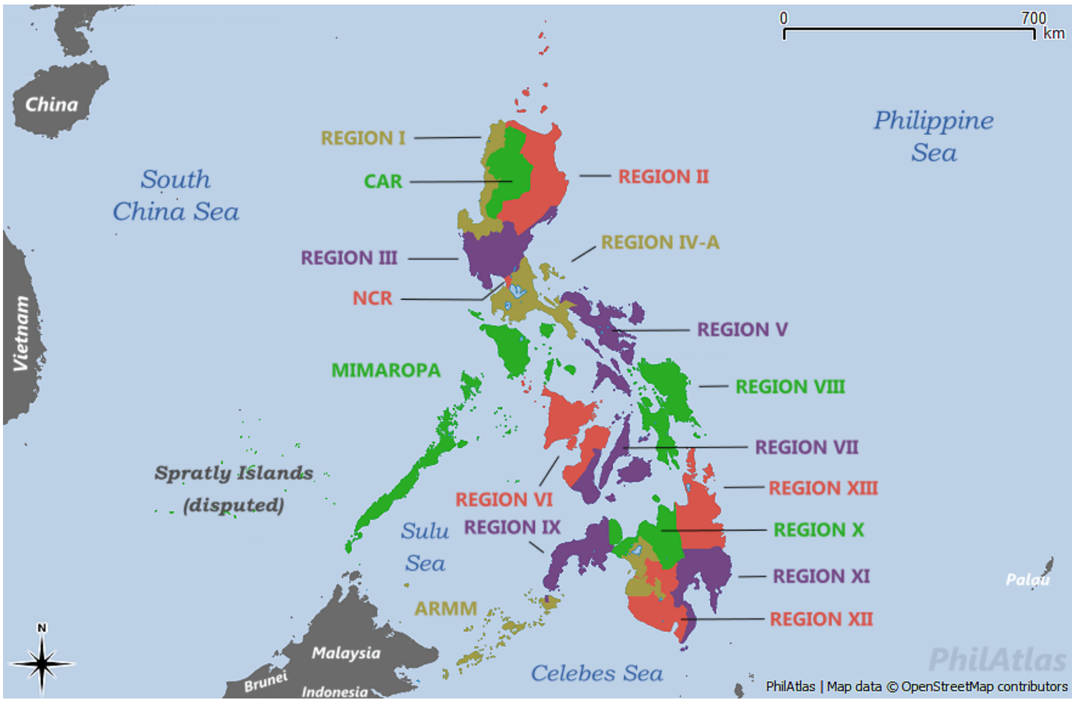
2.2 Natural Conditions and Water Usage

2.2.1 Water Resources Regions and Administrative Regions

The land of the Philippines is typically delineated in accordance with two different categories, namely: boundaries of the water resources regions (WRR) and administrative regions.

In the former case, the Philippines is divided into 12 WRRs in consideration of hydrological boundaries for the purpose of comprehensive planning of water resources development.

From the administrative aspect, the Philippines is divided into 17 regions, namely: Region I to Region XIII, and four other regions. The administrative regions are shown in Figure 2.2-1.



Source: PhilAtlas (https://www.philatlas.com/regions.html)

Figure 2.2-1 Administrative Regions in Philippines

2.2.2 Land Area and Topography

(1) Land Area

The Philippines, which is an archipelago composed of 7,641 islands and islets, lies between latitude 4° 23' N and 21° 25’ N and between longitude 116° E and 127° E. The archipelago is bounded by the South China Sea on the west, by the Pacific Ocean on the east, by the Sulu and Celebes seas on the south, and by the Balintang Channel on the north.

The total land area of the Philippines is approximately 300,000 km^2, about 94% of which is contained within the 11 principal islands, namely: Luzon, Mindanao, Samar, Negros, Palawan, Panay, Mindoro, Leyte, Cebu, Bohol, and Masbate, in order of their sizes. The rest, consisting of small coral islets, is mostly uninhabited. Luzon is the largest island, while Mindanao, the southernmost major island, is the second largest. The country is divided into three major island groups, namely: Luzon with an area of 141,000 km^2, Mindanao with 102.000 km^2, and Visayas with 57,000 km^2.

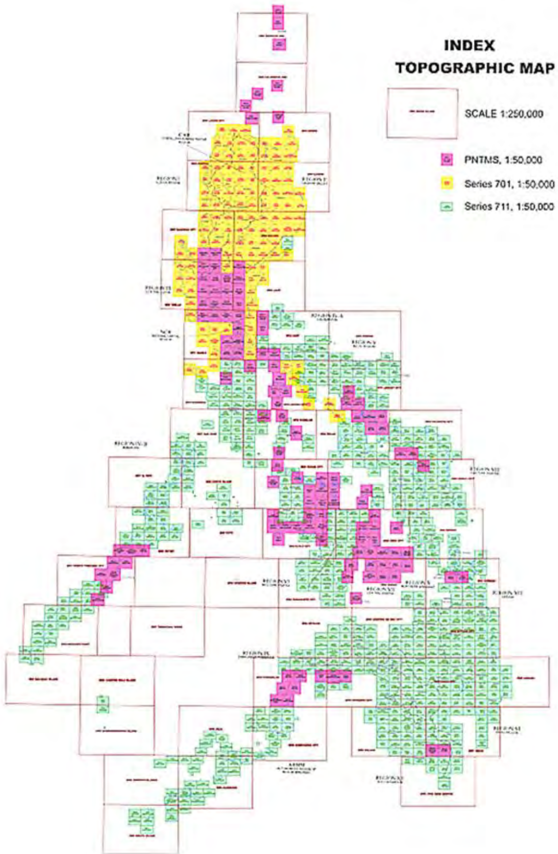
Owing to its archipelagic nature, topographic variations characterize the Philippines. The previous study of the geological history of the archipelago exhibits that the islands are actually the peak of mountains uplifted from the sea floor by the horizontal pressure exerted by the Indo-Australian Plate and the Asiatic Plate on the eastern boarders of the Philippine Plate during the Miocene Period. The series of small islands composed of "half-drowned mountains" form part of a long and wide cordillera extending from Indonesia to Japan while other peaks are of volcanic origin.

(2) General Topography and Geology

The Philippines is considered as an archipelago consisting of 7,641 islands, which are grouped into three major islands, namely: Luzon, Visayas, and Mindanao. The country is surrounded by several water bodies: Luzon Strait to the north, Pacific Ocean to the east, Celebes Sea to the south, and West Philippine Sea to the west (DENR-EMB, 2014).

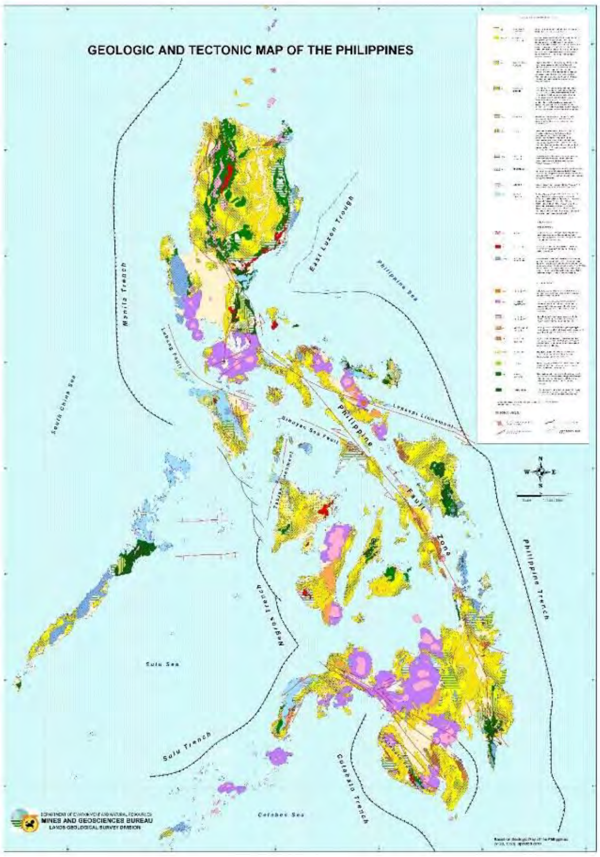
The topography of the country extremely varies, with the presence of volcanic mountain masses in most of the islands. The highest point in the Philippines is located in Mount Apo (Mindanao) with an altitude of 2,954 m above sea level (DENR, 2015). In addition, the Philippine Institute of Volcanology and Seismology (PHIVOLCS) categorized volcanoes according to their eruptive history: active, potentially active, and inactive. Currently, the country has 24 active volcanoes where 13 are found in Luzon, three in Visayas, and eight in Mindanao. Figure 2.2-2 presents the Philippine index topographic map generated by National Mapping and Resource Information Authority (NAMRIA).

Similar to the topography, the geologic formation in the entire Philippines varies – it is classified into igneous, sedimentary, and metamorphic rocks. Igneous rock formation is further divided into two categories, namely: intrusive, and volcanic rocks (MGB, 2010). Figure 2.2-3 shows the geologic and tectonic map of the Philippines.



Source: National Mapping and Resource Information Authority

Figure 2.2-2 Philippine Index Topographic Map



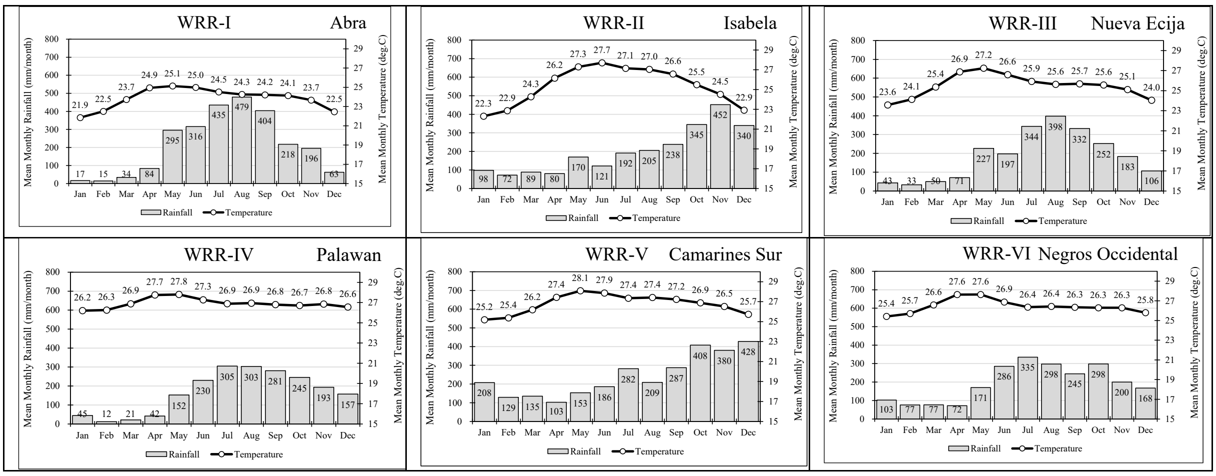
Source: Mines and Geoscience Bureau

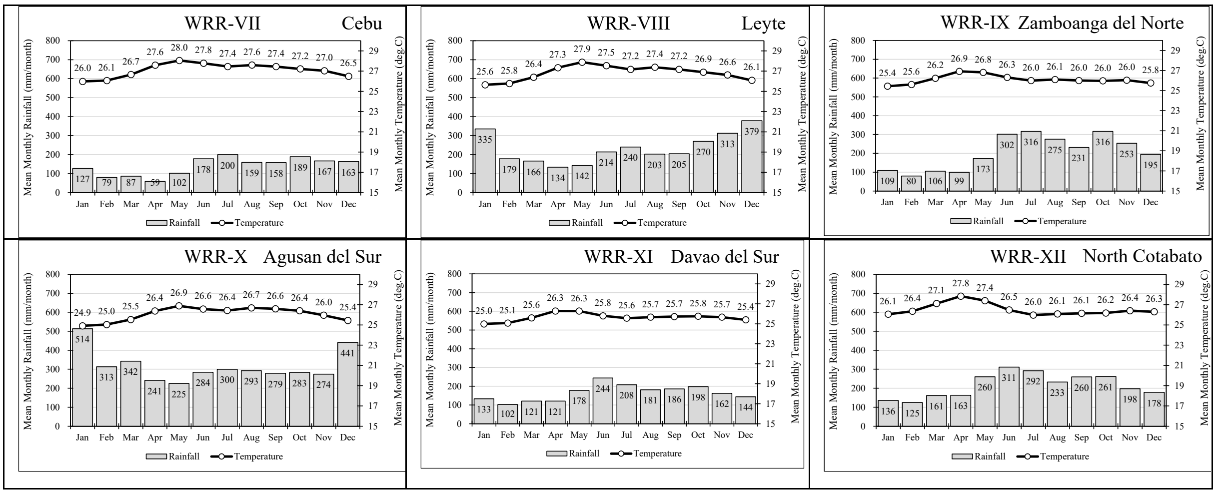
Figure 2.2-3 Geologic and Tectonic Map of the Philippines

2.2.3 Meteorology and Hydrology

(1) Climatological Data

Daily mean temperature from 1979 to 2020 of ERA5 (0.25-degree grid; approximately 31 km mesh) were collected from the ECMWF reanalysis data sets. Provincial mean monthly rainfall and mean monthly temperature from 1979 to 2020 (42 years) in each water resources region are shown in Figure 2.2-4.





Source: JICA Survey Team, based on ERA5 and CHIRPS data.

Figure 2.2-4 Provincial Mean Monthly Rainfall and Mean Monthly Temperature from 1979 to 2020 (42 Years) in Each WRR

(2) Climate and Climate Regions of the Study Area

There are four climatological types that exist in the Philippines, characterized as follows:

1) Type I: Two pronounced seasons, dry from November to April, wet during the rest of the year
2) Type II: No dry season with a very pronounced maximum rainfall period from November to January
3) Type III: Seasons are not very pronounced with relatively dry season from November to April and wet season during the rest of the year
4) Type IV: Rainfall more or less distributed throughout the year

Figure 2.2-5 shows the distribution of these climate regions for the entire study area. Rainfall intensity in the study area ranges from very light to heavy and may occur as continuous, intermittent, or showery. Precipitation is influenced by prevailing air streams or monsoons, tropical typhoons, the Intertropical Convergence Zone (ITCZ), topography, fronts, easterly waves, and local thunderstorms. The significance of each of these climatic influences varies with the time of the year.

Source: PAGASA (http://bagong.pagasa.dost.gov.ph/information/climate-philippines)

Figure 2.2-5 Climate Regions in Philippines

Temperature

Based on the average of all weather stations in the Philippines excluding Baguio, the mean annual temperature is 26.6°C. The warmest month is May, during which temperature averages 28.3°C, while the coolest month is January, during which temperature averages 25.5°C.

Humidity

Humidity refers to the moisture content of the atmosphere. Humidity is relatively high due to the inherently high temperatures and the surrounding waters serving as a source of moisture. As a result, humidity ranges from 71 to 85 percent.

Rainfall

Rainfall distribution throughout the country differs from one region to another, depending upon the direction of the moisture-bearing winds and the location of the mountain systems. The mean annual rainfall of the Philippines varies from 965 to 4,064 millimetres annually.

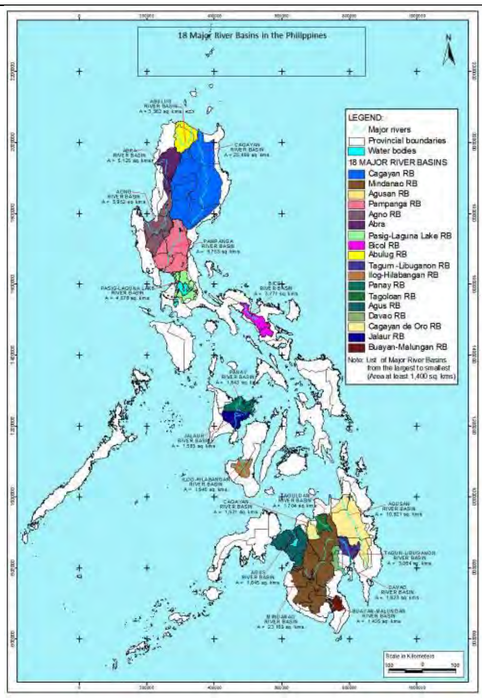
2.2.4 River and Water Resources

(1) Hydrological Situation

1) Major River Basins

The Philippines has 18 major river basins, which occupy a total catchment area of 110,524 km^2, representing more than one-third of the country's total land area. Among these river basins, the largest in the country (and in Luzon) is the Cagayan River basin with a total catchment area of 27,494 km^2 encompassing CAR and Region II, as well as the province of Aurora in Region III. It is utilized for hydroelectric power as several dams and power plants are built within its proximity. The second largest in the country (and largest in Mindanao) is the Mindanao River basin with a total catchment area of 20,855 km^2 encompassing Region X, Region XII, and ARMM. The largest in Visayas (and eleventh largest in the country) is the Ilog-Hilabangan River basin. It has a total catchment area of 1,945 km^2 encompassing Region VI and Region VII. The catchment area and map of the major river basins in the Philippines is shown in Figure 2.2-6.

No.	Name of River Basin	Catchment Area (km^2)
1	Cagayan River Basin	27,494
2	Mindanao River Basin	20,855
3	Agusan River Basin	11,937
4	Pampanga River Basin	10,435
5	Agno River Basin	6,219
6	Abra River Basin	5,125
7	Pasig-Laguna de Bay River Basin	4,109
8	Bicol River Basin	3,171
9	Apayao-Abulug River Basin	3,776
10	Tagum-Libuganon River Basin	3,064
11	Ilog-Hilabangan River Basin	1,945
12	Panay River Basin	2,204
13	Ranao (Agus) River Basin	1,987
14	Tagoloan River Basin	1,801
15	Davao River Basin	1,760
16	Cagayan de Oro River Basin	1,374
17	Jalaur River Basin	1,765
18	Buayan-Malungon River Basin	1,505
TOTAL		110,524



Source: DENR-RBCO

Figure 2.2-6 Major River Basins in the Philippines

2) Lakes

According to the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture (DA), there are 79 lakes in the country that are mostly utilized for fish production, with ten of them considered as major hosts for aquaculture production. The largest among these lakes is the Laguna Lake with a total area of 900 km^2. It is surrounded by NCR and Region IV-A encompassing the provinces of Laguna and Rizal, and some cities in Metro Manila. It is also considered as one of the five largest lakes in Southeast Asia. On the other hand, Lake Lanao is the largest lake in Mindanao with a total area of 347 km^2. Table 2.2-1 lists the major lakes in the Philippines.

Table 2.2-1 Major Lakes in the Philippines

Rank	Name of Lake	Location	Surface Area (km^2)
1	Laguna Lake	Laguna and Rizal	900.00
2	Lanao	Lanao del Sur	347.00
3	Taal	Batangas	237.00
4	Mainit	Agusan del Norte and Surigao del Norte	140.00
5	Naujan	Oriental Mindoro	110.00
6	Buluan	Maguindanao and Sultan Kudarat	65.00
7	Bato	Camarines Sur	38.00
8	Buhi	Camarines Sur	18.00
9	Dapao	Lanao del Sur	10.00
10	Sebu	South Cotabato	9.64
11	Wood	Zamboanga del Sur	7.92
12	Manguao	Palawan	6.43
13	Baao	Camarines Sur	6.00
14	Paoay	Ilocos Norte	4.20
15	Maughan	South Cotabato	3.14
16	Danao	Cebu	2.60
17	Pagusi	Agusan del Norte	2.53
18	Pinamaloy	Bukidnon	2.52
19	Balut	Maguindanao	2.06
20	Imelda/Danao	Leyte	1.97
21	Bito	Leyte	1.50
22	Nunungan	Lanao del Norte	1.48
23	Sampaloc	Laguna	1.02
TOTAL			1,918.01

Note: Only those with area greater than 1 km^2 are listed
Source: DA-BFAR, Philippine Fisheries Profile 2018

3) Coastal and Marine Waters

As a result of its archipelagic nature, the Philippines' coastline is considered the fifth longest in the world with a total length of 36,289 km. Greater proportions of its provinces (66 out of 81), cities (88 out of 145), and municipalities (812 out of 1,489) lie along coastal areas. Its coastal and marine waters cover a total area of about 266,000 km^2, where the locals depend for livelihood and sustenance. Table 2.2-2 lists the major fishing grounds in the Philippines which consist of seas, bays, gulfs, and straits.

Table 2.2-2 Major Fishing Grounds in the Philippines

Marine Waters	Name of Fishing Grounds	Location	Area (km^2)
Seas	West Sulu Sea	Palawan	29,992.5
	South Sulu Sea	Zamboanga del Sur/Sulu/Tawi-Tawi	11,2642
	East Sulu Sea	Zamboanga del Norte/Negros	9,288
	Sibuyan Sea	Aklan/Masbate/Romblon	8,127
	Bohol Sea	Bohol	7,946
	Samar Sea	Samar/Masbate/Leyte	3,870
	Visayan Sea	Panay/Negros/Cebu/Masbate	3,096
	Camotes Sea	Cebu/Leyte/Bohol	2,476.8
Bays	Lamon Bay	Quezon/Camarines Norte	2,838
	Tayabas Bay	Quezon	2,213
	Illana Bay	Lanao del Sur/Maguindanao	2,128.5
	Manila Bay	Manila/Bataan/Cavite	1,935
	Sibugay Bay	Zamboanga del Sur	1,935
	Iligan Bay	Misamis Occidental/Lanao del Norte	1,811.16

Marine Waters	Name of Fishing Grounds	Location	Area (km²)
	Imuruan Bay	Palawan	1,087.8
	San Miguel Bay	Camarines Sur	7,74
	Taw-tawi Bay	Tawi-Tawi	592.4
	Butuan Bay	Agusan del Norte	516
Gulfs	Moro Gulf	Zamboanga del Sur/Maguindanao/Sultan Kudarat	12,900
	Davao Gulf	Davao del Sur/Davao del Norte/Davao Oriental	4,024
	Ragay Gulf	Camarines Sur/Quezon	3,225
	Leyte Gulf	Leyte Island/Samar Island	2,724
	Panay Gulf	Iloilo/Negros Occidental	2,311
	Lingayen Gulf	Pangasinan	2,064
	Lagonoy Gulf	Albay/Camarines Sur/Catanduanes	1,935
	Asid Gulf	Masbate	619
	Albay Gulf	Albay	412.8
Straits	Tablas Strait	Tablas Island/Mindoro Occidental	3,870
	Mindoro Strait	Palawan/Mindoro Occidental	3,426.2
	Tañon Strait	Cebu/Negros	2,786.4
	Cebu Strait	Cebu/Bohol	1,818.9
	Iloilo Strait	Iloilo/Guimaras	1,006
TOTAL			235,698.46

Notes: Excluding channels and passages
Source: DA-BFAR, Philippine Fisheries Profile 2018

(2) River Systems and Major River Basins

There are 343 independent principal river basins that have at least 40 km^2 of basin area each identified over the whole country. Out of these, 18 river basins that have at least 1,400 km^2 of basin area each are identified as the major river basins. These are Cagayan, Pampanga, Agno, Abra, Pasig-Laguna de Bay, Bicol and Abulug River basins in Luzon Island; Mindanao, Agusan, Tagum-Libuganon, Tagoloan, Agus, Davao, Cagayan De Oro and Buayan-Malungum River basins in Mindanao Island; Panay and Jalaur River basins in Panay Island; and Ilog-Hilabangan River basin in Negros Island. The 343 principal river basins cover a total land area of 199,637 km^2 which is equivalent to 66.5% of the total land area of the Philippines.

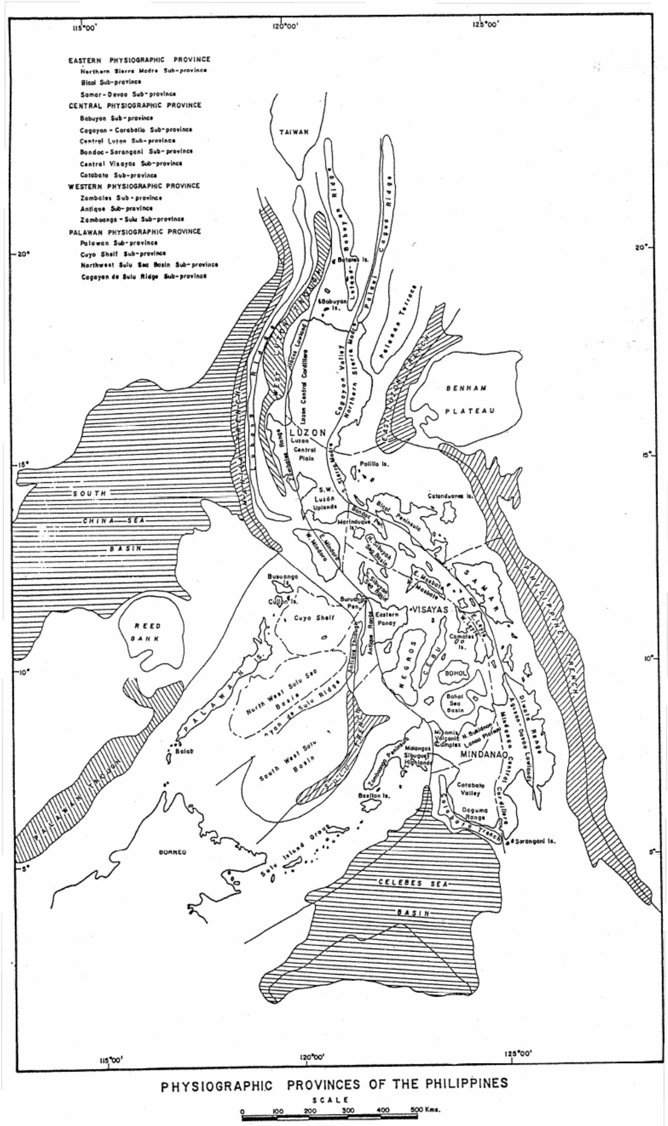
Since the Philippines is composed of comparatively small mountainous islands, its river basins in general occupy small catchments with short river lengths. According to the JICA 1998 MP, the rivers arc generally characterized by steep riverbed slopes and the coefficients of runoff mostly fall within 0.6 to 0.7. Recently, the degradation of the river basins is becoming serious, causing floods with short time of concentration and significant increase of sediment inflow as experienced in the existing Magat reservoir. In the Philippines, therefore, water resources development associated with watershed management has become necessary.

2.2.5 Geology, Hydrogeology and Soil Distribution

(1) Geology

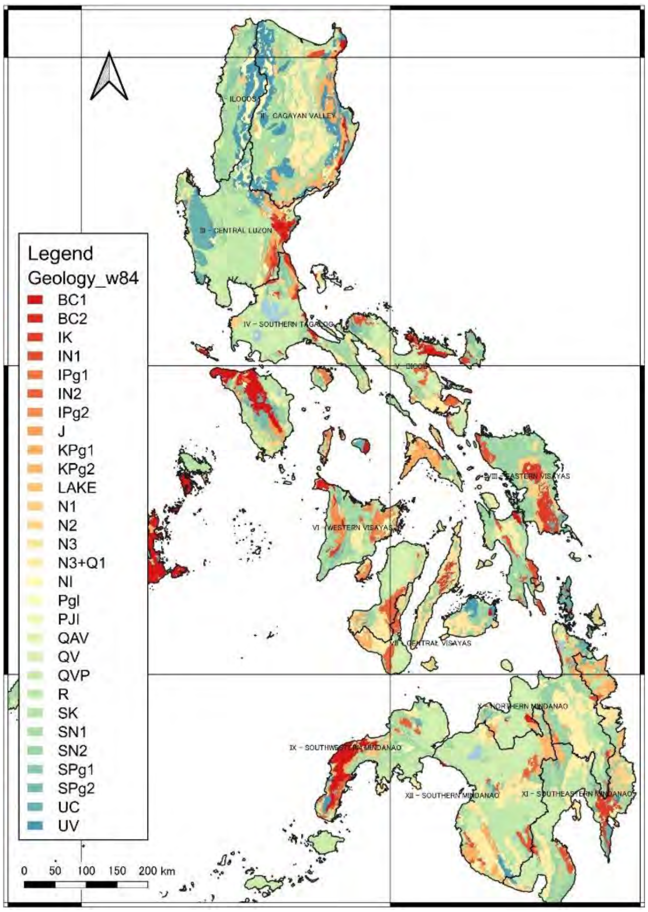
The Philippine archipelago is located on the northern side of the junction between three major plates: the Eurasia Plate, the Pacific Plate and the Indo-Australian Plate. It is bordered by the Bashi Channel to the north, the Philippine and East Luzon Trench to the east, the West Luzon and Manila Palawan Trench to the west, and the Cotabato Trench to the south (Figure 2.2-7).

Figure 2.2-7 shows the regional geological map of Philippines.



Source: Bureau of Mines and Geosciences, 1982

Figure 2.2-7 Geological Structure Map



Source: JICA Survey Team based on Geological Map of the Philippines (1963) 1:1,000,000

Figure 2.2-8 Geological Map

(2) Hydrogeology

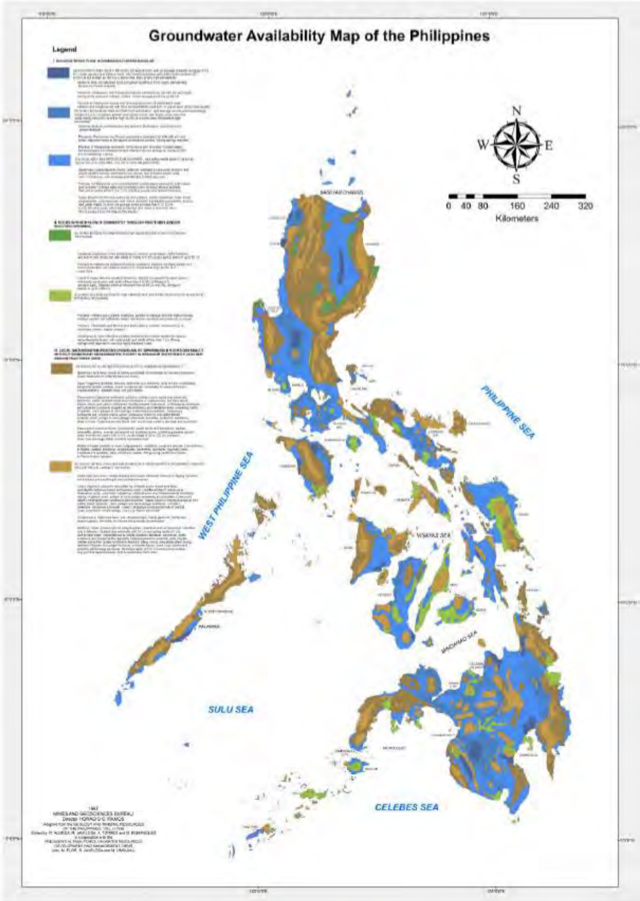
1) Groundwater Availability Map

The Groundwater Availability Map for the entire Philippines prepared by MGB is shown in Figure 2.2-9. Groundwater Availability Map classification and geology correspondence table is shown in Table 2.2-3.

Table 2.2-3 Comparison of Groundwater Availability Map and Geological Distribution

Category of Groundwater Availability Map	Geology
Rocks in which flow is dominantly intergranular	
Extensive and highly productive aquifer	Alluvium, deposit
Fairly extensive to productive aquifer	Sand, karstic limestone, mixed sediments
Local and less productive aquifer	Mixed sediments
Rocks in which flow is dominantly through fractures and/or solution openings	
Fairly extensive and productive aquifer	Volcanic rocks, limestone
Fairly to less extensive and productive aquifer	Volcanic rocks, sandstone, limestone
Local groundwater regions underlain by impermeable rocks	
Rocks with limited potential	Clay
Rocks without any known significant groundwater obtainable thorough drilled wells	Clay, volcanic rocks (unfractured)

Source: JICA Survey Team



Source: Project Report of the CCOP-GSJ-GA Groundwater Phase III Meeting (2017)

Figure 2.2-9 Groundwater Availability Map

2) Groundwater Well

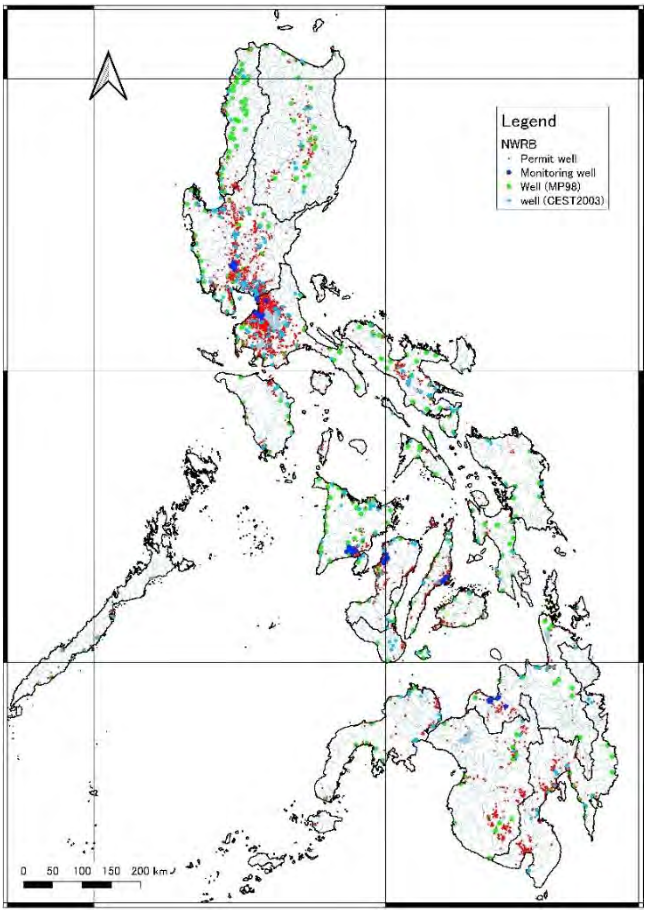
The NWRB's Permit Well, water quality survey wells from CEST (2003), and summarized well data of 1998 M/P were collected as groundwater well data. A summary of the collected data is shown in Table 2.2-4 and the distribution of wells is shown in Figure 2.2-10.

Table 2.2-4 Data Sets of Collected Well Information

Data Source	Data Nos.	Collected Information
1998 M/P	303	Average value of depth, water level, specific capacity for shallow well and deep well
NWRB Permit Well	7835	Location
NWRB Monitoring Well	21	Location, water level monitoring data, well depth
CEST (2003)	315	Well depth, yields of well, water quality data

*The 1998 MP and CEST wells contain some of the same facilities as the NWRB Permit Well.

Source: JICA Survey Team

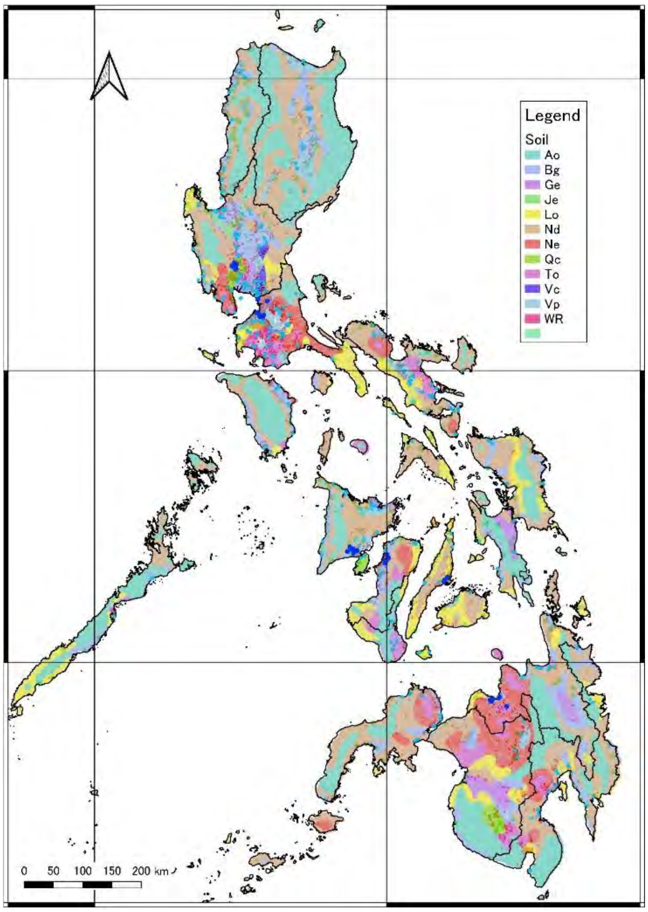


Source: JICA Survey Team

Figure 2.2-10 Well Distribution

(3) Soil Distribution

The soil map of the Philippines was collected from the global soil map (1:5,000,000 scale) published by FAO (Figure 2.2-11).



Source: FAO

Figure 2.2-11 Soil Map

2.2.6 Land Use

(1) Overview

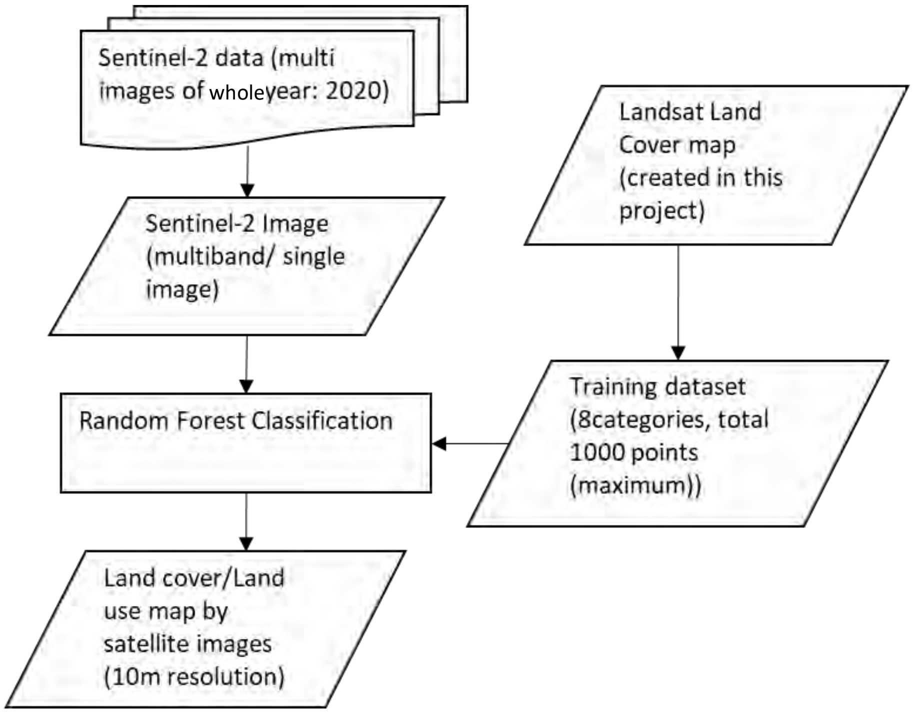
Land cover/land use map was created for the entire land of the Philippines. Satellite data was used to create the present and past land cover maps. For satellite data, the Landsat series was used, which can be used retroactively. Landsat-5, 7 and 8 are available for map creation, and historical data up to 1983 are available. The ground resolution is about 30 m, and the visible band, near infrared band, and short wavelength infrared band of optics can be used. This near infrared band and short wavelength infrared band are effective for identifying paddy fields, which are important for water balance analysis.

(2) Material and method

Landsat images were classified by Random Forest methodology to create a land cover map. Training points for Random Forest classification were obtained by referring to the MODIS land cover map (MCD12Q1 V6) that was created and provided by NASA. The classification category is given in Table 2.2-5. For the input Landsat image, a mosaic image that connects the cloudless parts from the image of the target year was used. All of this was done on Google Earth Engine. The processing flow is shown in Figure 2.2-12.

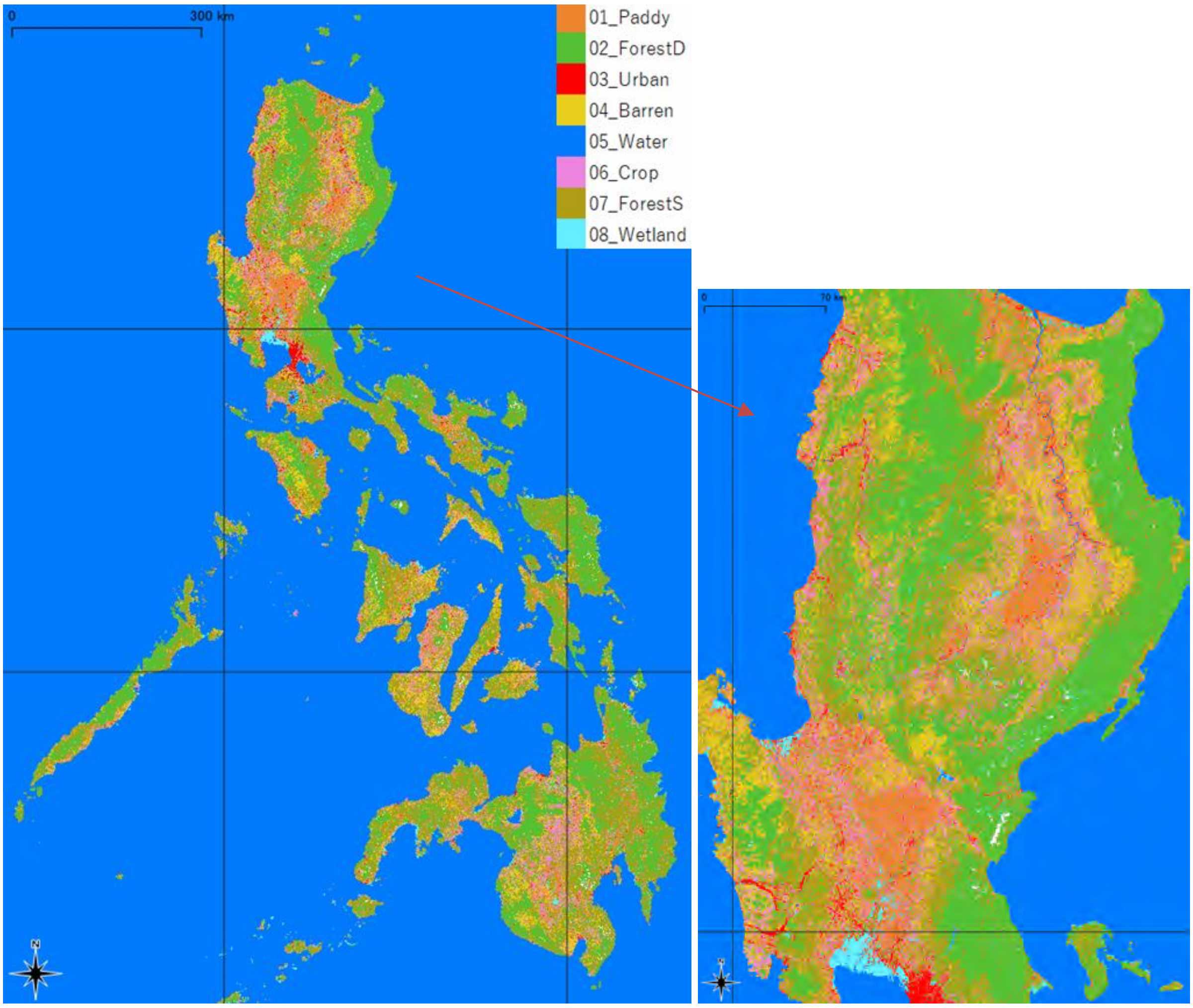
(3) Result and next plan

The land cover/land use map is shown in Figure 2.2-13. When the classification results were visually interpreted, it was confirmed that the paddy field area could be detected well. However, there were some cases that were misclassified as other crops such as corn adjacent to the paddy field area. It is necessary to verify this accuracy through field surveys and perform correction work in the next step.



Source: JICA Study Team

Figure 2.2-12 Flow of classification processing using satellite data



Source: JICA Study Team

Figure 2.2-13 Land Cover / Land Use Map of the Philippines

Table 2.2-5 List of land cover/land use map category

Classification Category
Paddy
Forest (Dense)
Urban
Barren
Water
Crop (not paddy)
Forest (Sparse)
Wetland

Source: JICA Study Team

(4) Area of paddy /irrigated field using satellite data

Table 2.2-6 shows the results of the comparison between paddy field area for each region from the land cover map created in section 2.2.6 and statistical information. As a result, the total value nationwide and the estimated value based on satellite data are close. However, since there are differences in each region, the accuracy of the land cover map will be verified and the aggregated results of the paddy field area will be scrutinized in the next step.

Table 2.2-6 Comparison of irrigated area between statistical and satellite data

Region	Total				Cropping Intensity (%)		Landsat-8 base Paddy Field Area	
	ISA (ha)	FUSA (ha)	Irrigated Area (ha)				(ha)	compare with FUSA (%)
			Wet	Dry	Wet	Dry		
CAR	102,492	96,744	73,345	70,097	75.8	72.5	39,083	40.40%
I	217,357	190,064	156,378	108,227	82.3	56.9	122,049	64.21%
II	302,143	279,513	247,944	246,141	88.7	88.1	296,734	106.16%
III	346,852	322,891	267,080	252,208	82.7	78.1	322,408	99.85%
IV-A	64,327	48,177	36,588	35,795	75.9	74.3	58,379	121.18%
IV-B	109,518	95,004	81,989	70,891	86.3	74.6	123,070	129.54%
V	143,270	118,290	78,438	75,651	66.3	64.0	100,995	85.38%
VI	128,230	114,178	82,378	66,402	72.1	58.2	172,448	151.03%
VII	50,357	44,078	35,906	32,898	81.5	74.6	40,312	91.46%
VIII	71,851	70,446	50,180	50,912	71.2	72.3	48,528	68.89%
IX	47,580	41,576	34,134	32,668	82.1	78.6	64,829	155.93%
X	73,045	60,445	46,369	44,539	76.7	73.7	66,229	109.57%
XI	70,438	68,243	53,015	52,920	77.7	77.5	61,447	90.04%
XII	127,690	117,204	106,443	99,815	90.8	85.2	105,446	89.97%
XIII	71,358	64,462	44,807	41,233	69.5	64.0	64,302	99.75%
ARMM	48,772	46,324	29,052	27,919	62.7	60.3	48,458	104.61%
Total	1,975,280	**1,777,639**	1,424,046	1,308,316	80.1	73.6	**1,734,716**	**97.59%**

Note: ISA: Irrigation service area, FUSA: Firmed up service area (FUSA)

Source: Inventory of National, Communal, Private & Other Government Assisted (OGA) Irrigation System, as of Dec 31, 2020

2.2.7 Current Status of Agricultural Water Use

The agriculture sector is the main water user among all sectors and consumes a lot of water sources. The agriculture sector is composed of 3 sub-sectors: irrigation farming, inland fishery and livestock/ poultry.

(1) Present Irrigation Farming

NIA has provided "Inventory of National, Communal, Private & Other Government Assisted (OGA) Irrigation System from 2016 to 2020" (hereinafter as NIA Inventory data), which is the database showing the irrigation areas (irrigation service area: ISA, firmed-up service area: FUSA, irrigated area, and so on) and the related data/ information of all existing irrigation systems. The irrigation systems in the Philippines are classified into 4 types, National Irrigation System (NIS), Communal Irrigation System (CIS), Private Irrigation System (PIS) and Other Government Assisted System (OGAS). For reporting purpose, the systems except NISs are generically named as "Small Scale Systems" hereinafter.

The NIS generally covers irrigation service area (ISA) of more than 1,000 ha and is constructed, operated and maintained by NIA. The operation and maintenance (O&M) works are also conducted by duly organized irrigators' cooperatives or associations (IA) together with NIA. There are 257 NISs nationwide covering ISA of 917,023 ha in 2020. The CIS is the main system among the small-scale irrigation systems with ISA of less than 1,000 ha, constructed by NIA and turned over to IA for O&M. There are 9,719 CISs nationwide covering ISA of 702,253 ha in 2020. The PIS is constructed by farmers without any financial assistance from the government and O&M works are carried out by themselves. There are 6,142 PISs nationwide covering ISA of 186,008 ha in 2020. The OGAS is constructed by other government agencies except NIA and O&M works are carried out by farmers. There are 3,855 OGASs nationwide covering ISA of 169,996 ha in 2020.

All of the irrigation systems are summarized in Table 2.2-7. Total ISA in 2020 is 1,975 thousand ha. Total potential irrigable area is estimated at 3,128,631 ha, whose 63% are already developed as ISA in 2020.

Table 2.2-7 ISA, FUIA & Irrigated Area of Irrigation Systems in 2020

(Unit: 1,000 ha)

Systems	NISs				Small Scale Systems				Total			
	ISA	FUSA	Irrigated Area		ISA	FUSA	Irrigated Area		ISA	FUSA	Irrigated Area	
			Wet	Dry			Wet	Dry			Wet	Dry
All	917	817	724	690	1,058	961	700	618	1,975	1,778	1,424	1,308
By Surface Water	914	813	722	688	919	854	621	547	1,833	1,667	1,343	1,235
By Ground Water	3.5	3.4	2.4	2.4	139.2	108.0	79.4	70.6	142.7	111.4	81.8	73.0

Source: Inventory of National, Communal, Private & Other Government Assisted (OGA) Irrigation System as of December 31, 2020

(2) Present Inland Fishery sub-sector

Aquafarms are classified into several types based on the data provided by DA-BFAR, as shown in Table 2.2-8.

Table 2.2-8 Area and Number of Aquafarms by Several Types in 2012

Type of of Aquafarms	Total Area of Aquafarms (ha)	Total Number of Aquafarms	Number by Type of Water Environment		
			Fresh Water	Brackish Water	Marine Water
Fishpond	85,606	75,002	49,065	21,987	3,950
Fish Pen	2,553	3,102	1,623	785	694
Fish Cage	2,849	16,353	9,683	2,323	4,347
Seaweed Farm	30,292	48,494	0	0	48,494
Oyster Farm	568	2,856	0	1,988	868
Mussel Farm	233	1,040	3	250	787
Fish Tanks	No Data	1,029	929	57	43
Hatchery	No Data	590	352	138	100
Others	122	228	40	5	183
Total	122,223	148,694	61,695	27,533	59,466
Total Area (ha)			**16,603**	134,740	No Data

Source : Philippine Statistics Authority

The most important data for the assessment of water resources is the area of aquafarms by fresh water source (16,603 ha). In order to estimate the area of aquafarms by fresh water source in 2020, the average annual increase rate of 1.6% (156.6/144.7 = 1.082 => $(1.016)^5$) is calculated based on the quantity of fish production in freshwater fishpond in 2012 (144.7 thousand tons) and in 2017 (156.6 thousand tons) by PSA. The area of aquafarms by fresh water source in 2020 is estimated at 18,851 ha (16,603 ha x $(1.016)^8$), that is recommended as the basis for the estimation of water demand of inland fishery sub-sector.

(3) Present Livestock/ Poultry sub-sector

The inventories of each livestock and poultry are summarized in Table 2.2-9, based on the data provided by DA-BAI. The total heads of livestock/ poultry in 2020 are utilized for the estimation of water demands.

Table 2.2-9 Total Heads of Livestock/Poultry by Type

(Unit: 1,000head)

Year	Livestock			Poultry
	Carabao	Cattle	Hog	Chicken
2012	2,964	2,493	11,863	164,192
2013	2,913	2,498	11,843	166,386
2014	2,847	2,512	11,802	167,671
2015	2,855	2,534	12,000	176,469
2016	2,877	2,554	12,479	178,793
2017	2,882	2,548	12,428	175,317
2018	2,883	2,554	12,604	175,772
2019	2,874	2,535	12,709	186,370
2020	**2,865**	**2,542**	**12,796**	**178,265**
2021	*2,849*	*2,605*	*9,943*	*176,820*
2022	*2,774*	*2,557*	*9,426*	*185,102*

Source : Philippine Statistics Authority

2.2.8 Current Status of Municipal and Industrial Water Use

(1) Water Supply Service Level

In the Philippines, water supply service level for the municipal sector is classified into three levels as follows, and the jurisdiction of each system is regulated by the municipal code or the local water district code.

1) Level III System (waterworks system)

The Level III system, or so-called individual house connection system, includes a source, a reservoir, a piped distribution network, and individual household taps. It is generally suited for densely populated urban areas where the population can afford individual connections.

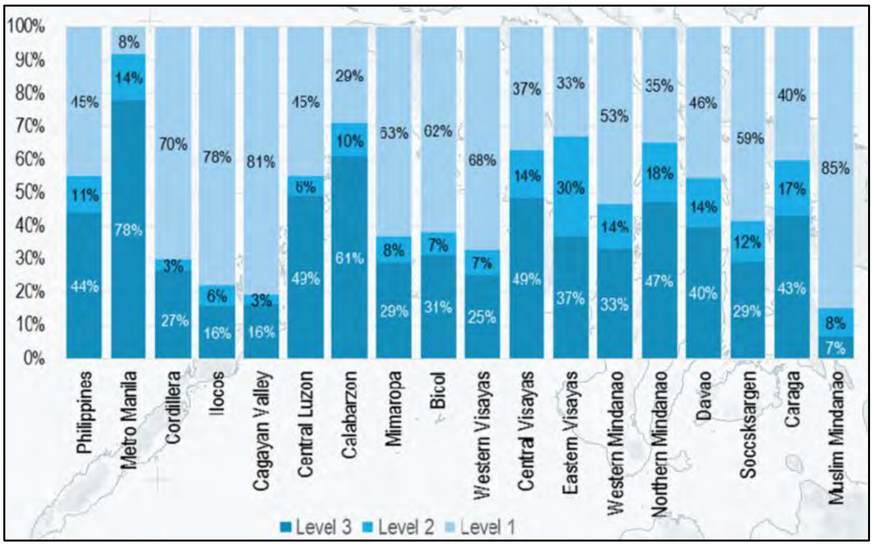
2) Level II System (communal faucet system or standpost)

The Level II system, or communal faucet system, refers to a piped system whose components include a source, a reservoir, a piped distribution network, and communal faucets. Users still go to the supply point (communal faucet) to fetch water. This simple piped system is generally suitable for rural and urban fringe areas where houses are densely clustered.

3) Level I System (point source)

The Level I system, or point source system, is common in rural barangays, the majority of which are owned privately. This service level provides a protected well or a developed spring with an outlet but without a distribution system. Hence, users go to the source to fetch water. Rural areas (where houses are thinly scattered) are generally adaptable to Level I sources.

Population served according to the water supply service level is shown in Figure 2.2-14. Approximately 44% of the population is provided with water service from Level III systems, 11% from Level II systems, and 45% from Level I systems.



Source: PWSSMP 2019-2030

Figure 2.2-14 Levels of Service in the Percentages by Region (FIES, 2015)

(2) Classification of Urban and Rural Area

The Philippine Statistic Authority (PSA) classifies the area in each region as urban when it satisfies any of the following conditions on the economic and social functions:

1) In their entirety, all municipal jurisdictions which, whether designed as chartered cities, provincial capital or not, have a population density of at least 1,000 persons per square kilometer.
2) Poblacions or central districts of municipalities and cities which have a population density of at least 500 persons per square kilometer.
3) Poblacions or central districts regardless of population size which have the following:
   - Street pattern, i.e., network of streets either at parallel or in right angle orientation,
   - At least six establishments (commercial, manufacturing, recreational and/or personal services), and
   - At least three of the following.
     i) a town hall, church, or chapel with religious services carried on at least once a month,
     ii) a public plaza, park, or cemetery,
     iii) a marketplace or building where trading activities are carried out at least once a week, and
     iv) a public building like school, hospital, culture and health center or library.

4) Barrios/barangays having at least 1,000 inhabitants and in which the occupation of inhabitants is predominantly non-farming/fishing.

All areas not falling under the urban classification are defined as rural area.

(3) Water Service Provider

The water supply service for the municipal sector is implemented by various water service provider (WSP) of different management types as in Table 2.2-10. In general, the LGU, WDs, and private operators provide water supply in urban areas, while BWSA, RWSA, and cooperatives provide water supply in rural areas.

Table 2.2-10 Water Service Provider in the Philippines

Management Type	No.	%	Level I	Level II	Level III
Brangay Water and Sanitation Associations (BWSA)	6,621	27	2,980	2,498	1,142
Rural Water Supply Association (RWSA)	1,418	6	62	619	737
Cooperative	403	2	46	90	267
Unnamed Water Service Provider	7,878	32	7,486	303	89
Local Government Unit (LGU)	4,184	17	1,147	1,608	1,429
Water District (WD)	635	3	19	4	611
Homeowners' Association	377	2	168	77	132
Real Estate Developer	107	0	8	8	91
Industrial Locator	45	0	3	3	39
Peddler	211	1	108	80	23
Ship Chandler	4	0	1	2	1
Private Operator	1,779	7	711	268	800
Refilling Station	1,162	5	1,122	24	15
Grand Total	**24,824**	**100**	**13,861**	**5,584**	**5,376**

Source: PWSSMP 2019-2030

(4) Present Water Demand for Municipal Sector

As mentioned above, water supply services in the Philippines are provided by many entities at different water supply levels, and there is no consolidated water usage record.

Therefore, the present water demand for municipal and industrial sectors was calculated using the PSA 2015 census population and the assumptions in the Philippine Water Supply and Sanitation Master Plan 2019-2030 by NEDA (PWSSMP) as shown in Table 2.2-11.

Table 2.2-11 Assumption for Present Water Demand for Municipal Sector

Assumption Item	Unit	For All Regions Except NCR and HUCs	For NCR and HUCs
Domestic Demand			
Urban	lpcd	120	150
Rural	lpcd	60	80
Commercial Demand			
Connection	capita/connection	100	100
Urban	cmd	1.0	1.3
Rural	cmd	0.7	0.8
Institutional Demand			
Connection	capita/connection	2,000	2,000
Urban	cmd	4.0	4.0
Rural	cmd	4.0	4.0
Unaccounted-for-water; Percentage of the total water demand	%	0.25	0.25

Note: NCR: The National Capital Region, HUCs: highly urbanized cities

Source: PWSSMP 2019-2030 (Raw Data of Water Demand Projection from NEDA)

The present water demand for the municipal sector in administrative region as of 2015 was calculated as in Table 2.2-12.

Table 2.2-12 Present Water Demand for Municipal Sector in Administrative Region (As of 2015)

	Domestic (MCM/Year)	Commercial (MCM/Year)	Institutional (MCM/Year)	Unacounted (MCM/Year)	Total (MCM/Year)
PHLIPPINES	3,426	258	115	1,264	5,063
NATIONAL CAPITAL REGION (NCR)	705	56	9	257	1,028
CORDILLERA ADMINISTRATIVE REGION (CAR)	53	4	3	20	80
REGION I (ILOCOS REGION)	124	10	8	47	188
REGION II (CAGAYAN VALLEY)	84	7	5	32	128
REGION III (CENTRAL LUZON)	379	27	9	138	553
REGION IV-A (CALABARZON)	506	34	13	185	738
REGION IV-B MIMAROPA REGION	82	6	4	29	121
REGION V (BICOL REGION)	147	11	8	55	222
REGION VI (WESTERN VISAYAS)	231	17	10	86	345
REGION VII (CENTRAL VISAYAS)	229	17	7	84	338
REGION VIII (EASTERN VISAYAS)	108	9	10	42	169
REGION IX (ZAMBOANGA PENINSULA)	115	9	5	43	172
REGION X (NORTHERN MINDANAO)	156	12	5	58	231
REGION XI (DAVAO REGION)	187	14	4	68	273
REGION XII (SOCCSKSARGEN)	152	11	4	55	222
REGION XIII (Caraga)	75	6	3	28	113
AUTONOMOUS REGION IN MUSLIM MINDANAO (ARMM)	94	7	6	36	143

Note: Minute differences exist between each value and the total value due to rounding to the nearest whole number.

Source: PWSSMP 2019-2030 (Raw Data of Water Demand Projection from NEDA)

Present water demand for the municipal sector in WRRs was calculated based on the above water demand in administrative region as in Table 2.2-13.

- Population of each WRR was calculated by multiplying the population density of each administrative region and overlapped area of each WRR.

- Total water demand of each WRR was calculated by the ratio of population to water demand in the Philippines.
- Water demand of each sector was calculated by the ratio of total water demand to the water demand of each sector (domestic, commercial, industrial, unaccounted-for water).

Table 2.2-13 Present Water Demand for Municipal Sector in Water Resources Region (As of 2015)

	Domestic (MCM/Year)	Commercial (MCM/Year)	Institutional (MCM/Year)	Unacounted (MCM/Year)	Total (MCM/Year)
PHILIPPINES	3,426	258	115	1,264	5,063
WRR I - ILOCOS	90	7	3	33	133
WRR II - CAGAYAN VALLEY	141	11	5	52	209
WRR III - CENTRAL LUZON	471	35	16	174	696
WRR IV - SOUTHERN TAGALOG	1,204	91	40	444	1,779
WRR V - BICOL	163	12	5	60	241
WRR VI - WESTERN VISAYAS	245	18	8	91	363
WRR VII - CENTRAL VISAYAS	217	16	7	80	320
WRR VIII - EASTERN VISAYAS	114	9	4	42	169
WRR IX - SOUTHWESTERN MINDANAO	164	12	5	60	242
WRR X - NORTHERN MINDANAO	143	11	5	53	212
WRR XI - SOUTHEASTERN MINDANAO	222	17	7	82	329
WRR XII - SOUHTERN MINDANAO	251	19	8	93	371

Source: JICA Survey Team

(5) Present Water Demand for Industrial Sector

Present water demand for the industrial sector in administrative regions was estimated through the water permits granted by NWRB as in Table 2.2-14.

Table 2.2-14 Present Water Demand for Industrial Sector in Administrative Region (As of 2017)

Administrative Region	Industrial Water Total （MCM/Year）
PHLIPPINES	2,703
NATIONAL CAPITAL REGION (NCR)	870
CORDILLERA ADMINISTRATIVE REGION (CAR)	46
REGION I (ILOCOS REGION)	86
REGION II (CAGAYAN VALLEY)	59
REGION III (CENTRAL LUZON)	304
REGION IV-A (CALABARZON)	396
REGION IV-B MIMAROPA REGION	53
REGION V (BICOL REGION)	76
REGION VI (WESTERN VISAYAS)	129
REGION VII (CENTRAL VISAYAS)	174
REGION VIII (EASTERN VISAYAS)	65
REGION IX (ZAMBOANGA PENINSULA)	56
REGION X (NORTHERN MINDANAO)	120
REGION XI (DAVAO REGION)	122
REGION XII (SOCCSKSARGEN)	69
REGION XIII (Caraga)	45
AUTONOMOUS REGION IN MUSLIM MINDANAO (ARMM)	34

Source: PWSSMP 2019-2030

Present water demand for industrial sector in WRRs was calculated based on the above present water demand for industrial sector in administrative region (see Table 2.2-15).

- Present water demand for the industrial sector in WRR was calculated by multiplying the water demand for industrial sector by area and overlapped area of each WRR.

Table 2.2-15 Present Water Demand for Industrial Sector in Water Resources Region

Water Resource Region	Industrial Water Total (MCM/Year)
PHILIPPINES*	2,703
WRR I - ILOCOS	64
WRR II - CAGAYAN VALLEY	104
WRR III - CENTRAL LUZON	402
WRR IV - SOUTHERN TAGALOG	1,232
WRR V - BICOL	86
WRR VI - WESTERN VISAYAS	140
WRR VII - CENTRAL VISAYAS	164
WRR VIII - EASTERN VISAYAS	65
WRR IX - SOUTHWESTERN MINDANAO	80
WRR X - NORTHERN MINDANAO	97
WRR XI - SOUTHEASTERN MINDANAO	138
WRR XII - SOUHTERN MINDANAO	131

Source: JICA Survey Team

2.2.9 Current Status of Existing Water Resources Facilities

(1) Surface Water Resources Development

1) Existing Dams

The inventory of existing dams in the Philippines was surveyed in "Pre-feasibility study of rehabilitation and improvement of existing dams in Philippines" (METI, 2018). There are 54 dams in the Philippines: 20 dams under NPC, 26 dams under NIA, 3 dams under MWSS, and 5 other dams. The water use functions of the dams are: 24 dams for hydropower, 30 dams for irrigation, 5 dams for urban water supply, and 2 dams for flood control including multi-purpose dams. The list and location map of existing dams are shown in Annex-G.

There are 6 major large-scale dams in the Philippines with dam height of more than 100 m, namely Ambuklao Dam, Binga Dam, San Roque Dam, Angat Dam, Magat Dam, and Pantabangan Dam (see Table 2.2-16).

Table 2.2-16 Main Features of Existing Major Dams in the Philippines

Name of Dam	Ambuklao	Binga	San Roque	Angat	Magat	Pantabangan
Construction Year	1956	1960	2003	1967	1982	1974
Refurbishment	2011	2014	-	-	-	-
Owner	Non-NPC/IPP	Non-NPC/IPP	Non-NPC/IPP	Non-NPC/IPP	NIA	NIA
Purpose of Dam	HP	HP	WS/IR/HP/FC	WS/IR/HP/FC	IR/HP/FC	IR/HP
Island	Luzon	Luzon	Luzon	Luzon	Luzon	Luzon
River	Agno	Agno	Agno	Angat	Magat	Pampanga
Type of Dam	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Earthfill
Height (m)	129.00	107.40	200.00	131.00	114.00	107.00
Crest Length (m)	452.00	215.00	1130.00	568.00	4160.00	1615.00
Reservoir Gross Storage (MCM)	327.00	87.40	850.00	850.00	1250.00	2996.00
Reservoir Usable Storage (MCM)	258.00	48.00	-	-	810.00	2083.00
Data Source	*1	*1	*1	*1	*1, *2	*1, *2

*1: Pre-feasibility study of rehabilitation and improvement of existing dams in Philippines (METI, 2018)

*2: NIA (https://bob.nia.gov.ph)

[Abbreviation] WS: water supply, IR: irrigation, HP: hydropower, FC: flood control

Source: JICA Study Team

2) Surface Water Resources Development Project Proposed in Past Studies

Large-Scale Reservoir

The development plan of large-scale reservoir for major river basins was studied in "Master Plan Study on Water Resources Management in the Republic of Philippines" (1998 M/P) by JICA in 1998.

In the Philippines, many dam potential sites have been identified as listed in the "Survey/Inventory on Water Impounding Reservoirs", which was compiled by the National Water Resources Council (original organization of NWRB) in April 1978. The total number of the sites listed in the inventory amounts to 864. Dams higher than 30 m in dam height or larger than 30 km^2 in catchment area were categorized as large-scale dams. A total of 364 sites were classified as large-scale dams in the entire Philippines.

A total of 73 dams were adopted as the candidates for water resources development schemes, and 22 projects were proposed (see Table 2.2-17 and Annex-G). Considering water deficit, 4 WRR, namely WRR II, WRR III, WRR IV, and WRR VII were prioritized. The selected priority projects for major river basins are: i) Mallig-II Multi-Purpose Dam Project, ii) Matuno Multi-Purpose Dam Project, iii) Addalam-A Hydroelectric Project, iv) Ilaguen-B Hydroelectric Project, v) Agulubu Hydroelectric Project, vi) Balog-Balog Multi-Purpose Dam Project, vii) Balintingon Multi-Purpose Dam Project, viii) Bayabas and Maasim Dam Project, and ix) Amnay Multi-Purpose Dam Project.

Table 2.2-17 List of Proposed Impounding Dam Projects for Major River Basins

No.	River Basin Name	WRR	Name of Projects	Priority Project	Status
1	Laoag	WRR I	Palsiguan-Nueva Multi-Purpose Dam Project (NIA)		Construction on-going (NIA)
2	Laoag	WRR I	Tina-Gasgas-Cura Multi-Purpose Dam Project (DPWH)		No data
3	Abra	WRR I	Binongan Multi-Purpose Dam Project (NPC)		No data
4	Cagayan	WRR II	Mallig II Multi-Purpose Dam Project	Selected	No data
5	Cagayan	WRR II	Matuno Multi-Purpose Dam Project (NIA)	Selected	Site conflict
6	Cagayan	WRR II	Addalam A Hydroelectric Project (NPC)	Selected	Site conflict
7	Cagayan	WRR II	Ilaguen B Hydroelectric Project (NPC)	Selected	Site conflict
8	Abulug	WRR II	Agulubu Hydroelectric Project (NPC)	Selected	No data
9	Agno	WRR III	Balog-Balog Multi-Purpose Dam Project (NIA)	Selected	Construction on-going (NIA)
10	Pampanga	WRR III	Balintingon Multi-Purpose Dam Project (NIA)	Selected	Planned as irrigation dam (NIA)
11	Pampanga	WRR III	Bayabas and Maasim Dam Project (NIA)	Selected	Construction on-going (NIA)
12	Amnay-Patric	WRR IV	Amnay Multi-Purpose Dam Project	Selected	No data
13	Bicol	WRR V	Talisay Multi-Purpose Dam Project		No data
14	Panay	WRR VI	Panay Multi-Purpose Dam Project (MPWH)		Planned as irrigation dam (NIA)
15	Jalaur	WRR VI	Jalaur Multi-Purpose Dam Project (NPC)		Construction on-going as irrigation dam (NIA)
16	Ilog-Hilabangan	WRR VI	Ilog No.1 Multi-Purpose Dam Project (DPWH)		No data
17	Tagoloan	WRR X	Tagoloan Multi-Purpose Dam Project		No data
18	Cagayan de Oro	WRR X	Bulag-Batang Hydroelectric Project (NPC)		Planned (IPP)
19	Tagum-Libuganon	WRR XI	Buhonao Multi-Purpose Dam Project		No data
20	Davao	WRR XI	Davao II Multi-Purpose Dam Project		No data
21	Buayan Malungun	WRR XI	Dimloc Multi-Purpose Dam Project		No data
22	Mindanao	WRR XII	Pulangi Multi-Purpose Dam Project (NPC)		Construction on-going (IPP)

Source: JICA Survey Team

The progress of proposed projects was surveyed and shown in Annex-G. The major updates are:

i) 5. Matuno Multi-Purpose Dam Project (NIA): There are 4 hydropower plant developed by independent power producers (IPPs) around the proposed dam site. The development of Matuno Multi-Purpose Dam Project might be difficult due to possibility of development site duplication.

ii) 6. Addalam-A Hydroelectric Project (NPC): There are 2 hydropower plant developed by IPPs around the proposed dam site. The development of Addalam-A Hydroelectric Project might be difficult due to possibility of development site duplication.

iii) 7. Ilaguen-B Hydroelectric Project (NPC): There are 3 hydropower plant developed by IPPs around the proposed dam site. The development of Ilaguen-B Hydroelectric Project might be difficult due to possibility of development site duplication.

iv) 9. Balog-Balog Multi-Purpose Dam Project (NIA): The project is on-going. Presently "Balog-Balog Multipurpose Project Phase II (BBMP-II)" is being implemented by NIA. The construction contract of BBMP-II was signed in 2016.

v) 10. Balintingon Multi-Purpose Dam Project (NIA): In 2010 the EO of the president was issued. Nueva Ecija Province is the implementing agency. In the M/P, it was proposed as a multi-purpose dam, but planned as an irrigation dam. However, there is possibility to add water supply function due to the urgency of water supply in Metro Manila in the future.

vi) 11. Bayabas and Maasim Dam Project (NIA): The project is on-going. "Bayabas Small Reservoir Irrigation Project (Bayabas SRIP)" is being implemented by NIA. The public scoping of Bayabas SRIP was held in 2018. Pre-F/S of Maasim Dam Project was completed.

vii) <u>14. Panay Multi-Purpose Dam Project (MPWH)</u>: The purpose of dam was changed to irrigation. "Panay River Basin Integrated Development Project (PRBIDP)" was planned by NIA. The environmental impact statement was published in 2017.

viii) <u>15. Jalaur Multi-Purpose Dam Project (NPC)</u>: The purpose of dam was changed to irrigation. "Jalaur River Multi-Purpose Project Stage II (JRMP II)" is being implemented by NIA.

ix) <u>18. Bulag-Batang Hydroelectric Project (NPC)</u>: "Bulanog-Batang Hydroelectric Power Project" was awarded as IPP project.

x) <u>22. Pulangi Multi-Purpose Dam Project (NPC)</u>: "Pulangi 5 Hydropower Project" is being implemented by IPP.

There is progress on implementation of dams under NIA. Most of hydroelectric projects and some other sites are developed by IPPs. Most of IPPs' hydroelectric projects seems to be run-off-river type, which have little or no water storage function.

<u>Water Supply System for Urban Water Use including Inter-Basin Diversion System</u>

The development plan of water supply system for urban area was studied in "Master Plan Study on Water Resources Management in the Republic of Philippines" (1998 M/P) by JICA in 1998.

A total of 17 projects were proposed as candidate projects for water supply of 9 urbanized area, and 7 projects were prioritized (see Table 2.2-18).

Table 2.2-18 List of Proposed Water Supply Projects for 9 Urbanized Areas

No.	Major City	Project Name	Priority Project	Status
1	Metro Manila	(i) Development of Laguna Lake		Operational (Maynilad /Manila Water)
2	Metro Manila	(ii) MWSP III (Laiban dam)		Canceled
3	Metro Manila	(iii) Kanan-Umiray transbasin	Selected	Construction on-going (Maynilad /Manila Water)
4	Metro Manila	(iv) Bayabas dam and Massim dam	Selected	Construction on-going (NIA)
5	Metro Manila	(v) Kaliwa-Cogco water supply	Selected	Construction on-going (MWSS)
6	Metro Manila	(vi) Pampanga water conveyance		No data
7	Metro Cebu	(i) Mananga II dam		Planned
8	Metro Cebu	(ii) Malubog-Mananga transbasin	Selected	No data
9	Metro Cebu	(iii) Lusam-Pulanbato transbasin	Selected	No data
10	Metro Cebu	(iv) Bohol-Cebu water supply	Selected	No data
11	Baguio City	(i) BOT Scheme (Bulk water supply)		Construction on-going
12	Baguio City	(ii) Rehabilitation of existing facilites		No data
13	Baguio City	(iii) Laboy dam	Selected	No data
14	Baguio City	(iv) Laboy weir and ponds		No data
15	Davao City	BOT Scheme (The Davao II multi-purpose dam is proposed as an alternative of the BOT Scheme.)		Construction on-going
16	Angeles City	Not necessary		-
17	Iloilo City	Not necessary		-
18	Bacolod City	Not necessary (The Bago multi-purpose dam is proposed as an alternative of the groundwater development.)		-
19	Cagayan de Oro City	BOT Scheme (Bulonog-Batang dam)		Planned
20	Zamboanga City	Pasonaca dam		Canceled

Source: JICA Survey Team

The progress of proposed projects was surveyed and shown in Annex-G. The major updates are:

i) 1. Metro Manila, Development of Laguna Lake: There are 3 operational water treatment plants, namely, Putatan WTP 1, Putatan WTP 2, and Cardona WTP. Construction of Putatan WTP 3 (Poblacion WTP) and East Bay Laguna Water Source Project are on-going.

ii) 2. Metro Manila, Laiban Dam: The project was canceled.

iii) 3. Metro Manila, Kanan-Umiray Transbasin: The diversion from Smag River is being constructed. "Kanan River /Agos River Phase 1a" and "Kanan /Agos River Phase 1b" are planned.

iv) 4. Metro Manila, Bayabas Dam and Massim Dam: The project is on-going. "Bayabas Small Reservoir Irrigation Project (Bayabas SRIP)" is being implemented by NIA. The public scoping of Bayabas SRIP was held in 2018.Pre-F/S of Maasim Dam Project was completed.

v) 5. Metro Manila, Kaliwa-Cogco water supply: Development of Upper Kaliwa River is planned. "New Centennial Water Source - Kaliwa Dam" is being constructed as the alternative scheme of Laiban Dam.

vi) 11. Baguio City, BOT scheme (Bulk water supply): Badiwan Mini-Bulk Water Project is under construction.

vii) 15. Davao City, BOT scheme: Davao City Bulk Water Supply Project (DCBWSP) is on-going.

viii) 19. Cagayan de Oro City, BOT Scheme (Bulonog-Batang Dam): "Bulanog-Batang Hydroelectric Power Project" was awarded as IPP project.

ix) 20. Zamboanga City, Pasonaca Dam: Pasonaca Dam was canceled. Bulk Water Supply (Pamucutan River) was newly proposed, and it is presently operational.

Most of the new water resources developments for major cities are bulk water supply under PPP scheme.

2.2.10 Current Status of Groundwater Use

The water grant amount (groundwater and surface water) permitted by NWRB in 2020 is shown in Table 2.2-19. The amount of groundwater permit grant in the Philippines is 5,017 mcm, of which about 30% is concentrated in WRR IV.

The ratio of groundwater permit grant to the total water permit grant is 2.3% nationwide. By water resources region, the ratio of groundwater permit grant is highest in NCR at 26.1%, followed by WRR VII at 10.5%.

Table 2.2-19 Present Water Permit Grants in Water Resources Region (2020)

WRR	Groundwater Permit Grants (mcm)	Surfacewater Permit Grants (mcm)	Total Water Permit Grants (mcm)	Groundwater/Total Water Permit
I	332	14,848	15,179	2.2%
II	86	45,154	45,239	0.2%
III	770	35,985	36,754	2.1%
IV	1,627	30,926	32,553	5.0%
V	243	3,916	4,160	5.9%
VI	318	8,377	8,695	3.7%
VII	380	3,234	3,614	10.5%
VIII	91	6,262	6,353	1.4%
IX	39	1,606	1,645	2.4%
X	288	34,523	34,811	0.8%
XI	243	7,048	7,291	3.3%
XII	410	17,746	18,156	2.3%
NCR	190	540	730	26.1%
Total	**5,017**	**213,444**	**218,461**	2.3%

Source: NWRB

2.2.11 Flood Risk Management (FRM)

(1) Need for flood risk management perspective

According to the Integrated Flood Management Concept Paper published by World Meteorological Organization (WMO), Associated Programme on Flood Management (APFM) and Global Water Partnership in 2009, Global Water Partnership Technical Advisory Committee defined the "Integrated Water Resources Management (IWRM)" in 2000 as a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. The Global Water Partnership interprets "management" as including both "development and management". Sustainable and effective management of water resources demands a holistic approach, linking social and economic development with the protection of natural ecosystems and providing appropriate management links between land and water uses. Therefore, water related disasters such as floods and droughts because they play an important part in determining sustainable development, need to be integrated into water resources management.

In formulating a water resources development and management plan (WRDMP), the following perspectives of flood risk management (FRM) are required; (i) Flood inundation risks in the beneficiary area of WRDMP, and (ii) Integrated planning of river projects in terms of FRM, water resources management, and social and environmental management. Since floods threaten human lives and livelihoods and hamper city development, flood inundation risks must be considered when formulating WRDMP. For example, developing water supply for city or irrigation in flood prone area, it will increase the exposure against flood hazards such as houses, factories, rice fields, etc. and cause more severe damage in the future. Thus, the water resources development projects should be planned not to increase the exposure as much as possible and to expect more benefits than damage with no casualties by future floods. River projects such as construction of dams, weirs, dikes or river dredging and excavation affects river flow pattern, sediment transportation, river morphology, water quality, ground water recharge, etc. As is the case in the Philippines, if river projects are planned separately for different purposes such as FRM, waterworks, irrigation, and hydropower generation, their impacts must be carefully studied not to give negative impacts each other. In the case that negative impacts are inevitable, it is indispensable to coordinate among the stakeholders and to modify the plan in some cases. Consequently, river basin management planning in integrated manner can make the plan more effective and efficient. A Multi-purpose dam is a representative example. Since both floods and droughts are caused by opposite sides of extreme events in natural variability of rainfall, controlling river flow variability by dam can be an effective solution.

(2) Governance of flood risk management in the Philippines

The roles related to flood risk management (FRM) are separately mandated to several government agencies in the Philippines. DPWH oversees planning and construction of flood control structures. LGUs are in charge of planning and construction of small-scale flood control structures and FRM including river dredging and drainage improvement in their administrative districts. PAGASA is responsible for flood forecasting and early warning. OCD is in charge of disaster relief and evacuation assistance. Flood hazard maps are developed by DENR-MGB, DOST, DPWH, LGUs, etc. Because FRM is a part of integrated river basin management and the above mentioned IWRM, the River Basin Control Office (RBCO) under DENR was established in 2006 for aiming to integrated river basin management and for coordinating among stakeholders.

DPWH has the role of flood control and management for large or medium sized rivers except for Metro Manila (Metro Manila Development Authority is responsible for Metro Manila). The Executive Order (EO No. 124, 1987) mandates the DPWH, as the State’s engineering and construction arm, to carry out the planning, design, construction and maintenance of infrastructure facilities, especially national highways, flood control and water resource development systems, and other public works in accordance with the national development objectives. The Department Order (DO No. 23, 2015) provides the guidelines and procedures for the implementation of flood control and drainage/slope protection projects funded by the National Government under the DPWH Infrastructure Program. Under the DPWH Infrastructure Program, flood control and river control works in major or principal river basins as defined by the National Water Resources Board are mandated to DPWH. On the other hand, the works on minor or local rivers and creeks are expected to be funded and undertaken by the local governments concerned.

The RBCO is the lead government agency to implement the Integrated River Basin Management and Development Framework. The EO (No. 510, 2006) mandated the RBCO together with

DPWH to rationalize various river basin projects and to promote and advocate an integrated river basin management in order to ensure protection of environment and people against flood and natural disasters. Under the EO (No. 816, 2009) the RBCO is mandated as the oversight agency for all government efforts and initiatives within the country's river basins. More specifically, the RBCO, as a lead government agency, has the following powers and functions; (a) Rationalize and integrate all national plans, projects and programs within the country's river catchment basins, with the authority to serve as the oversight office of all various government agencies and corporations with relevant and related river basin initiatives, projects and programs such as, but not limited to, river basin infrastructure development, flood control, environmental protection and integrated water resources management; (b) Harmonize all relevant national river basin policies and formulate new policies and create enabling policy environment that shall allow effective and efficient management and governance of the country's river basins; (c) Serve as the national policy coordination office for local government units and non-governmental organizations in the development and sustainability of all river and catchment basins, for which the RBCO shall recommend the approval and funding thereof of national government agency and corporation's support to such local and non-government river and catchment basin initiatives; (d) Serve as the DENR's implementing office in the implementation, monitoring and evaluation of DENR's programs and projects within the country's river basins; (e) Serve as central fund administrator for river basins appropriation provided under the DENR's budget that shall allow a more rationalized and optimized management of government public spending; and (f) Serve as the government's central river basin database management agency, to which all government agencies and existing river basin organizations with relevant mandates and developmental initiatives within the river basins are required to cooperate and regularly submit their updated databases for integration and consolidation by RBCO using a River Basin Integrated Information Management System.

(3) Major river basins and their flood risk management master plans

Table 2.2-20 shows flood risk management master plans (FRMMPs) in the 18 major river basins. In terms of water resources development, allocation of dam storage between flood control purpose and water resource purpose would be one of main issues. Therefore, proposed flood control dams in FRMMPs are also listed in the table. It should be also noted that even if no flood control dam is planned in the current FRRMP, there remains the possibility that a new dam will be needed in the context of increasing flood risk in the future by city development or climate change impacts.

Table 2.2-20 Flood Risk Management Master Plans (FRMMPs) in the 18 Major River Basins

River Name (Catchment Area (km^2))	FRMMP (Year/Fund)	Design Flood Safety Level*1	Proposed Flood Control Dam (incl. multi-purpose dam)
Cagayan (25,469)	1982/MPWH, OECF*2 1987/JICA	25 year	5 dams (Siffu No.1, Magat (Alimit No.1), Cagayan No.1, Malig No.2, Ilagan No.1)
Mindanao (23,169)	1974/OTCA 1980/MPW 1982/MPWH, OECF*2 2012/DPWH	100 year	-
Agusan (10,921)	1980/MPW 1982/MPWH, OECF*2 Upper Agusan: 1984/MPWH 2006/DENR, ADB (Ongoing) Korean Eximbank	Lower: 100 year, Middle & Upper: 25 year *no info. of the ongoing project	-
Pampanga (9,759)	M/P: 1970,1972/ OTCA (Flood Early Warning) 1982/MPWH, OECF*2 2011/JICA (Integrated Water Resource Management) (Ongoing) Korean Eximbank	100 year *no info. of the ongoing project	-
Agno (5,952)	1982/MPWH, OECF*2 1991/JICA 2020/DPWH, ADB, IPIF*3	100 year	2 dams (San Roque, Balog-Balog)
Abra (5,125)	2020/DPWH, ADB, IPIF*3	Dense urban zone: 100 year	-
Pasig-Laguna (4,678)	1979/MPWTC/OECF 1983/MPWH, IBRD 1990/JICA 2004/JICA (Drainage) 2012/WB	100 year	1 dam (Marikina)
Bicol (3,771)	1974/JICA 1975/AIT*4 1982/MPWH, OECF*2 1983/MPWH 1991/DPWH, ADB 2003/NEDA, WB 2015/DENR	5 year (urban zone: 10 year)	-
Abulug (3,372)	2020/DPWH, ADB, IPIF*3	no information	no information
Tagum-Libuganon (3,064)	2020/DPWH, ADB, IPIF*3	50 year	-
Ilog-Hilabangan (1,945)	1982/MPWH, OECF*2 1991/JICA (Ongoing) DPWH, ADB, IPIF*3	100 year	-
Panay (1,843)	1982/MPWH, OECF*2 1985/JICA (Ongoing) Korean Eximbank	100 year	2 dams (Panay high dam, Panay afterbay dam)

River Name (Catchment Area (km^2))	FRMMP (Year/Fund)	Design Flood Safety Level*1	Proposed Flood Control Dam (incl. multi-purpose dam)
Tagoloan (1,704)	1982/MPWH, OECF*2 2010/JICA (Feasibility Study)	25 year	-
Agus (1,645)	2020/DPWH, ADB, IPIF*3	50 year	-
Davao (1,623)	2022/DPWH, JICA	100 year	-
Cagayan de Oro (1,521)	2014/JICA	50 year	1 dam (Bulanog-Batang Dam improvement)
Jalaur (1,503)	1982/MPWH, OECF*2 1996/NIA, JICA 2020/DPWH, ADB, IPIF*3	25 year *no info. of the IPIF project	1 dam (Jalaur)
Buayan-Malungun (1,434)	2020/DPWH, ADB, IPIF*3	50 year	-

Note: *1: Design flood safety level in master plan or long-term plan
*2: Nationwide Dredging and Flood Control Project funded by Overseas Economic Cooperation Fund of Japan
*3: Technical Assistance Loan for Infrastructure Preparation and Innovation Facility funded by Asian Development Bank
*4: Asian Institute of Technology

Source: revised by JICA Survey Team based on the Final report of Data Collection Survey for Strategy Development of Disaster Risk Reduction and Management Sector in the Republic of the Philippines (JICA, 2017)

2.2.12 Water Quality

(1) Water Body Classification

As of 2019, Environmental Management Bureau (hereinafter referred to as "EMB") has classified 904 water bodies in the Philippines in terms of best usage and water quality. Out of these classified water bodies, 794 are inland surface waters (consisting of 780 rivers and 14 lakes), and 110 are coastal and marine waters.

Since water bodies have several beneficial uses, some are classified differently per reach or portion. Out of the 794 classified water bodies, 216 have multiple classifications. These sum up to a total of 1,156 classifications. The distribution of water bodies per classification and beneficial use are shown in Table 2.2-21.

Table 2.2-21 Distribution of Water Bodies Per Classification and Beneficial Use

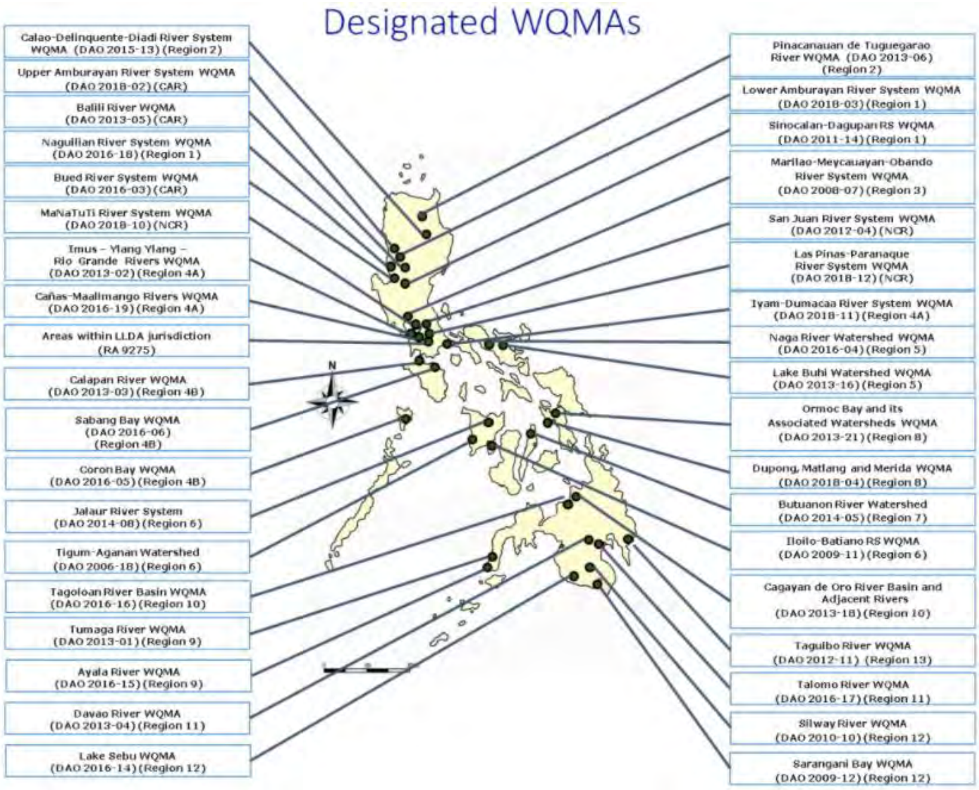
Classification	Beneficial Use	Number
INLAND SURFACE WATERS		
Class AA	Public Water Supply Class I – Intended primarily for waters having watersheds, which are uninhabited and/or otherwise declared as protected areas, and which require only approved disinfection to meet the latest PNSDW	7
Class A	Public Water Supply Class II – Intended as sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration, and disinfection) to meet the latest PNSDW	279
Class B	Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, etc.)	272
Class C	Fishery Water for the propagation and growth of fish and other aquatic resources Recreational Water Class II – For boating, fishing, or similar activities For agriculture, irrigation, and livestock watering	420
Class D	Navigable waters	38
	Number of Inland Surface Water Body Classifications	1,016
COASTAL AND MARINE WATERS		
Class SA	Protected Waters – Waters designated as national or local marine parks, reserves, sanctuaries, and other areas established by law (Presidential Proclamation 1801 and other existing laws), and/or declared as such by appropriate government agency, LGUs, etc. Fishery Water Class I – Suitable for shellfish harvesting for direct human consumption	10
Class SB	Fishery Water Class II – Waters suitable for commercial propagation of shellfish and intended as spawning areas for milkfish (*Chanos chanos*) and similar species Tourist Zones – For ecotourism and recreational activities Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, skin diving, etc.)	68
Class SC	Fishery Water Class III – For the propagation and growth of fish and other aquatic resources and intended for commercial and sustenance fishing Recreational Water Class II – For boating, fishing, or similar activities Marshy and/or mangrove areas declared as fish and wildlife sanctuaries	60
Class SD	Navigable waters	2
	Number of Coastal and Marine Water Body Classifications	140
	TOTAL NUMBER OF WATER BODY CLASSIFICATIONS	**1,156**

Source: EMB 2019
DENR Administrative Order No. 2016-08 (Water Quality Guidelines and General Effluent Standards)

(2) Water Quality Management Area

As per Section 5 of Republic Act 9275, also known as the Philippine Clean Water Act of 2004, the Department of Environment and Natural Resources (hereinafter referred to as "DENR") in coordination with NWRB was tasked to designate certain areas as water quality management area (hereinafter referred to as "WQMA") using appropriate physiographic units such as watershed, river basins or WRR.

As of August 2022, there are 40 officially designated WQMAs, including the areas within the jurisdiction of Laguna Lake Development Authority (hereinafter referred to as "LLDA") which was designated as one management area by virtue of the RA 9275. Figure 2.2-15 shows the map of designated WQMA.



Source: DENR-EMB

Figure 2.2-15 Designated WQMA as of August 1, 2018

2.2.13 Natural Condition

(1) Ecosystem

According to Ecosystems Research and Development Bureau of DENR, the Philippines has five major ecosystems which include forests, upland farms, grassland and degraded areas, coastal zone and freshwater, and urban areas.

According to the PDP 2017-2022, the following key strategies would be adapted to sustain the provision of ecosystem services and meet both the present and future demand:

1) Intensify sustainable management of natural resources through the adoption of ridge-to-reef approach;
2) Expand sustainable resource-based enterprises; and
3) Mainstream ecosystem values into national and local development planning.

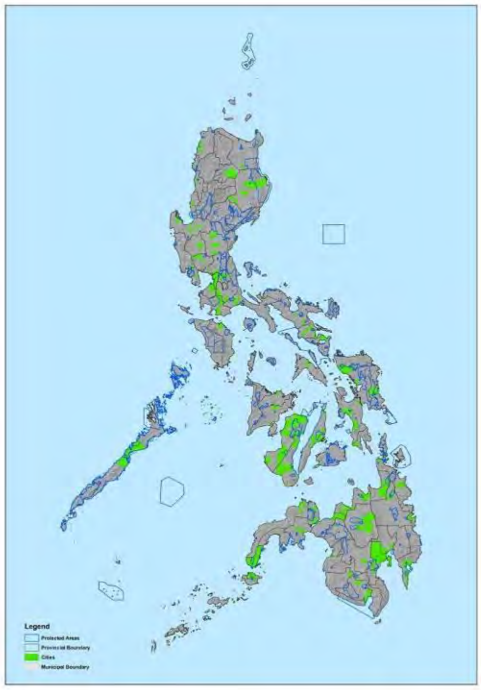
(2) Protected Area

As stated in the National Integrated Protected Areas System (NIPAS) Act of 1992, protected areas are defined as an identified portion of land and water set aside by reason of their unique physical and biological significance, managed to enhance biological diversity, and protected against destructive human exploitation. Protected areas in the Philippines are categorized as strict nature reserve, natural park, natural monument, wildlife sanctuary, protected landscapes and seascapes, and resource reserve.

As of 2019, BMB (Biodiversity Management Bureau) reported a total of 244 protected areas composed of about 7.76 million hectares which are under the Protected Area Development and Management Program. Among the 244 protected areas, 107 are legislated, 13 are proclaimed, and 124 are remaining initial components. The distribution of the protected areas among the regions in the Philippines and their location map are summarized in Figure 2.2-16.

Region	No. of Protected Areas	Area (million ha)
I	15	0.03
II	15	1.00
III	24	0.28
IV-A	22	0.23
IV-B	23	2.34
V	25	0.51
VI	14	0.21
VII	19	0.64
VIII	11	0.46
IX	14	0.31
X	12	0.14
XI	10	0.11
XII	5	0.38
XIII	12	0.41
ARMM	11	0.18
CAR	7	0.17
NCR	4	6.86 x 10-3
Offshore	1	0.36
Total	244	7.8

Source: Statistics (bmb.gov.ph)



Source: Biodiversity Management Bureau

Figure 2.2-16 Distribution of the Protected Areas and Location Map of the Protected Areas

(3) Drought

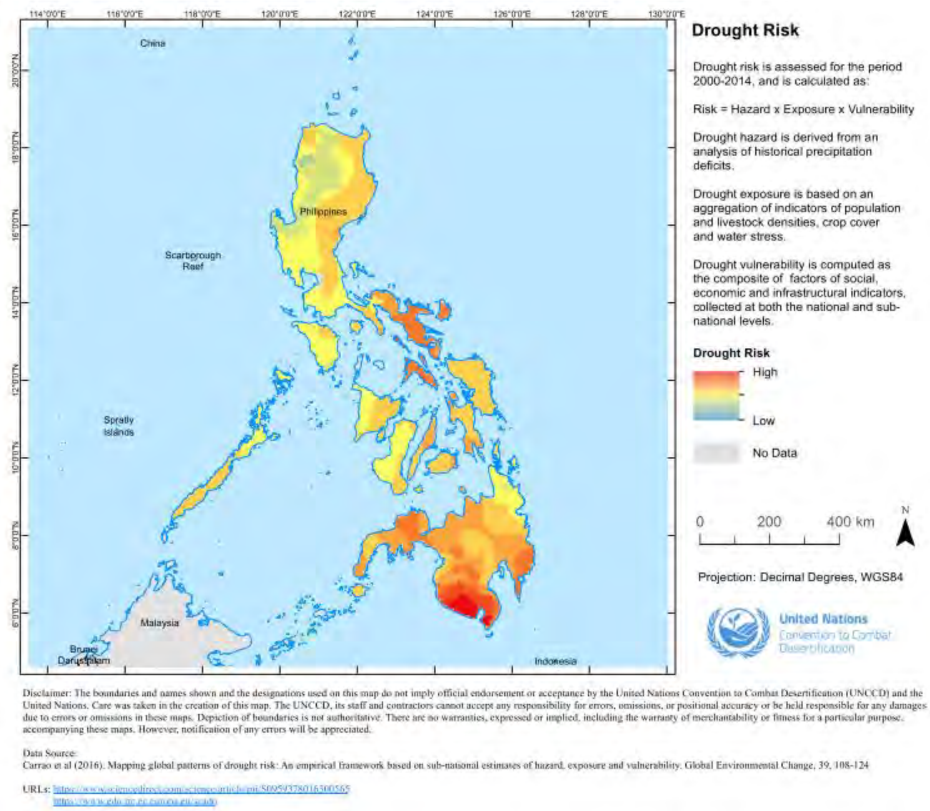
Drought is a prolonged dry period in the natural climate cycle. It is considered as one of the significant natural disasters in the Philippines. The occurrence of drought is heavily influenced by the El Niño Southern Oscillation (ENSO) and its warm and dry phase, El Niño. In the Philippines the El Niño events are associated with the late onset and early finish of the rainy season, weak monsoons, and less tropical cyclone activity. The El Niño occurred throughout the Philippines, but the southern parts of the country are particularly affected.

As shown in Table 2.2-22, there have been around 10 droughts recorded in the Philippines since 1968 which means that drought has impacted the country about every 4-5 years.

Table 2.2-22 Historical Droughts in the Philippines

Years of Drought	Areas Affected
1968 – 1969	Moderate to severe drought over most of the Philippines with Bicol region as most severely affected
1972 – 1973	Central Luzon, Palawan, Visayas, and Mindanao
1977 – 1978	All of Mindanao except Davao
Oct 1982 – Sep1983	Western and Central Luzon, Southern Tagalog provinces, Northern Visayas, Bohol, and Western Mindanao; Moderate to severe drought affected most of Luzon, Negros Occidental, and Iloilo
Oct 1986 – Sep 1987	Severe drought affected Bicol region, Southern Negros, Cebu, and Western Mindanao; Severe drought affected mainland Luzon, Central Visayas, and Western Mindanao
Oct 1989 – Mar 1990	Drought affected Cagayan Valley, Panay Island, Guimaras, Palawan, and Southern Mindanao; Affected rice and corn area: 283,562 hectares; Major multipurpose water reservoirs reduced inflow
1991 – 1992	Severe drought affected Manila, Central and Western Visayas, and Cagayan Valley; Affected agricultural area: 461,800 hectares
1997 – 1998	About 70% of the Philippines experienced severe drought; About 292,000 hectares of rice and corn area completely damaged
May 2002 – Mar 2003	Severe drought affected Western Mindanao. Central Mindanao, Bicol, Eastern Visayas, Southern Tagalog and Northern Luzon moderately affected.
Feb 2015 – July 2016	85% of provinces experienced drought. Iloilo, Guimaras, General Santos City, Isabela, Quirino, Bukidnon, Davao del Sur, Basilan, Bohol, and Cebu declared a state of calamity.
Source: National Drought Plan for the Philippines, April 2019	

Also, a drought risk assessment was completed by the Joint Research Centre of the European Commission which uses a global-scale top-down data driven approach that is consistent and applicable to all regions in the world. The drought risk in the Philippines is shown in Figure 2.2-17. As shown in the drought risk map, the eastern portion of the country has medium to high risk. The regions which have the highest risks are the Bicol region in Luzon and the whole Mindanao region.



Source: National Drought Plan for the Philippines, April 2019

Figure 2.2-17 Drought Risk in the Philippines

(4) Saltwater Intrusion (Uprush)

Saltwater intrusion occurs near an ocean coastal area wherein saltwater from the ocean intrudes or contaminates the freshwater aquifer. This happens when freshwater is being withdrawn at a faster rate that it can be replenished resulting to a decrease in the overall hydrostatic pressure.

According to the Philippines' Climate Change Risk Profile (USAID, 2017), the water quality of about 25% of the coastal areas in Luzon, Visayas and Mindanao has been affected by saltwater intrusion of coastal aquifers. It is also expected that saltwater intrusion was increased by the sea level rise.

2.2.14 Remote Sensing Data Progress of work up to the Interim Report

(1) Precipitation/Weather Data

Rain gauges have long been used for hydrological analysis. Rain gauges are considered to be highly accurate because of their continuous observation. However, the locations of the rain gauges are coarse and dense depending on the region, and their spatial representativeness is limited particularly for localized heavy rainfall and precipitation in mountainous areas.

In recent years, rain retrieval algorithm from satellite observation data has been developed with the development of satellite remote sensing technology. Satellites have the advantage of being able to observe a wide area with the same accuracy, but they are also a snapshot when they pass over. There are three types of sensors to observe precipitation: infrared radiometers, microwave radiometers, and precipitation radar. The precipitation radar has a newer history and higher accuracy, and the former two (infrared radiometers and microwave radiometers) have higher frequency of observation. Infrared radiometers established on geostationary meteorological satellites use the relationship between cloud top altitude and precipitation intensity to estimate precipitation. Microwave radiometers observe about once every three hours with multiple low earth orbit satellites. When a precipitation system develops, a large number of ice particles form in the upper layers. Rainfall is estimated using scattering information from the amount of ice particles over land. Precipitation radar is installed only on the Tropical Rainfall Measuring Mission and the Global Precipitation Measurement core satellites, and observations are made once every two days over tropics. Backscatter from precipitation particles is used to estimate precipitation intensity.

In response to a request from the Government of the Republic of the Philippines (hereinafter referred to as the "Philippines"), this survey collects information necessary for formulating a national water resources development and management plan for the Philippines, and proposes effective measures for areas with a large water supply-demand gap. Therefore, the selection of the precipitation/weather data was made considering the spatial-temporal resolution of the precipitation data (ten kilo meters/daily precipitation), the period of data provision (i.e., longer time period), and the data accessibility as required in the hydrological analysis.

ERA5 was selected because it is one of the highest spatial resolution reanalysis dataset maintained for a long-term period. Reanalysis dataset is created by numerical forecasting system assimilating observation data to simulate past weather events with homogeneous quality throughout the data provision period. Rainfall data of ERA5 is evaluated in this study.

GSMaP is a precipitation data, which is not a reanalysis data, estimated from microwave radiometers/sounders supplemented by cloud moving vectors obtained from thermal infrared bands of geostationary satellites, and corrected by ground rain gauges. It was selected because it is a new generation of rainfall data that uses a microwave radiometer-based rainfall estimation algorithm although it has relatively short data provision period.

CHIRPS is a precipitation data estimated from the thermal infrared bands of geostationary satellites with rain gauge correction. Since 2000, more reliable Tropical Rainfall Multi-satellite Precipitation Analysis (NASA's version of GSMaP) has been included. CHIRPS was adopted because it is widely used for analysis using rainfall analysis and the data provision period is sufficiently long.

For precipitation/weather data, ERA5, GSMaP, and CHIRPS data were used from each provider as listed in the ICR. The data specifications of each data are listed in Table 2.2-23.

Table 2.2-23 Data specification of ERA5, GSMaP, and CHIRPS

	ERA5	GSMaP	CHIRPS
Version	-	v6_gauge_rev	v2.0
Temporal Resolution	Hourly	Hourly	Daily
Spatial Resolution	0.25° (~31 km)	0.1° (~11 km)	0.05° (~5 km)
Period	Jan. 1979-Present	Mar. 2000-present	Jam. 1981-present
Coverage	Land and sea	Land and sea	Land
Data Input	Re-analysis data	Microwave radiometers, Thermal Infrared, and rain gauge	Thermal Infrared, and rain gauge
Provider	European Centre for Medium-Range Weather Forecasts (ECMWF)	Japan Aerospace Exploration Agency (JAXA)	U.S. Geological Survey (USGS) and Climate Hazard Center (CHC)

Source: JICA Survey Team

Among these data, ERA5 and GSMaP, which are provided in hourly precipitation, are converted to daily precipitation according to the Philippine local time. It should be noted that CHIRPS, which provides daily precipitation data, is based on Universal Time. Data for the entire Philippines was extracted from these daily precipitation data and used for the analyses in the following chapters.

(2) Data calibration of reanalysis/satellite rainfall data from gauge data

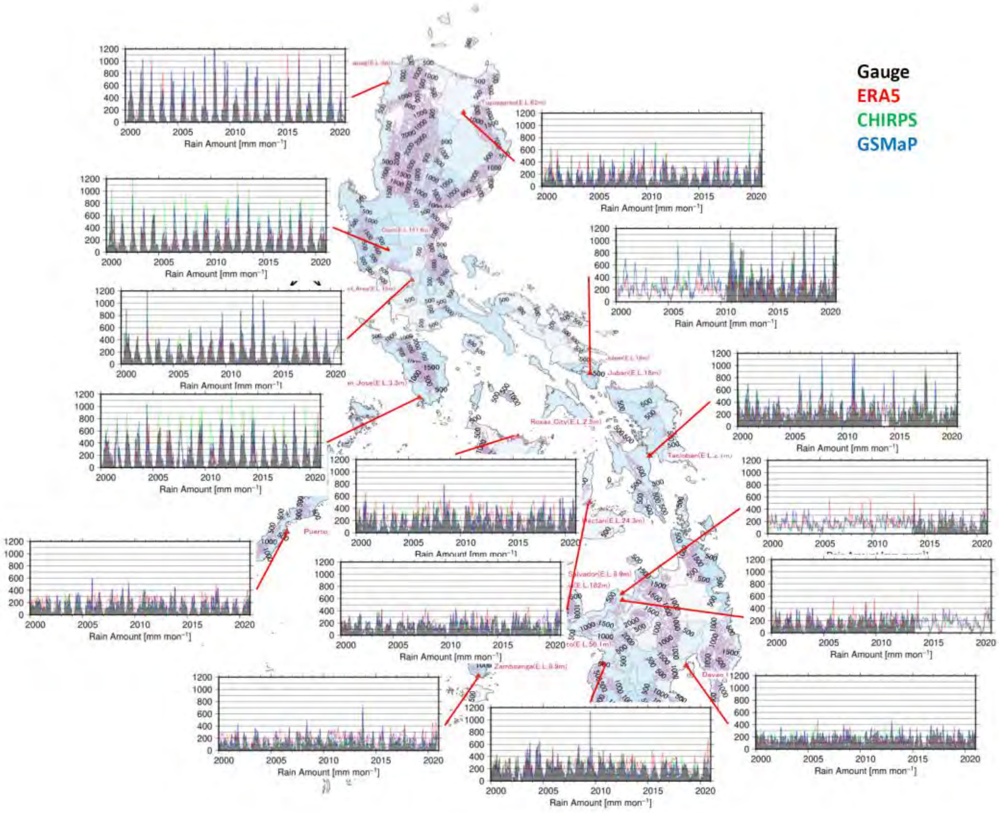
For national level analysis, rainfall data provided by PAGASA for 15 synoptic stations is used (Figure 2.2-18 & Figure 2.2-19). For most of the PAGASA synoptic stations, daily rainfall data are available for the period 1961 to 2021. Therefore, reanalysis/satellite rainfall data was converted to monthly total precipitation, and pixels containing rain gauge locations were extracted and used for analysis.

Seasonal variation of rainfall from rain gauges shows that Clark, Juban, Laoag, Port Area, and San Jose have large differences in precipitation between the dry and wet seasons, with monthly rainfall reaching 1000 mm. Juban is located in the foothills of mountains and may be affected by topography. Seasonal variations in precipitation at other sites are relatively small, with a maximum of about 500 mm.

A comparison of monthly rainfall from rain gauges and ERA5 showed that ERA5 tended to underestimate rainfall during the rainy season at most of the sites. The monthly rainfall of CHIRPS/GSMaP is generally consistent with that of most of the rain gauges with no systematic biases, indicating that the rain gauge correction of CHIRPS/GSMaP itself is working well. However, both CHIRPS and GSMaP overestimated the precipitation at Clark, and CHIRPS overestimated the precipitation at San Jose compared to the rain gauge. One of the possible causes is that the input rainfall data used for rain gauge correction is different for CHIRPS and GSMaP, and either does not represent the characteristics of the location or the rain gauge correction is not working (e.g., coastal areas may be out of the input rain gauge data). In the northwestern coastal area, where cloud top heights are high and precipitation with the formation of many solid hydrometers is expected to prevail, the infrared and microwave radiometers are considered to have overestimated precipitation.

The possibility of correction of ERA5, CHIRPS, and GSMaP by rain gauges was examined based on data and meteorological characteristics. Rain gauges are located roughly at one place in the water resources area and are not spatially representative. Monthly accumulated precipitation does not represent the bias caused by smaller time scales. In contrast, reanalysis/satellite rainfall data show precipitation characteristics (e.g., orographic rainfall) that cannot be captured by rain gauges. Since correcting the reanalysis/satellite rainfall data with rain gauge data may result in the loss of spatial characteristics, it was decided not to correct the rain gauge data for the national level analysis.

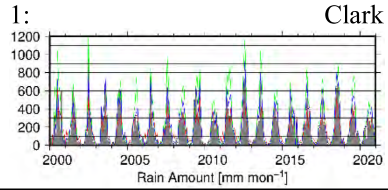
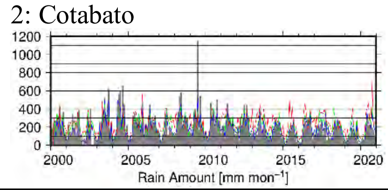
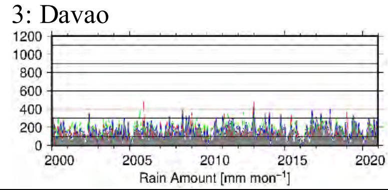
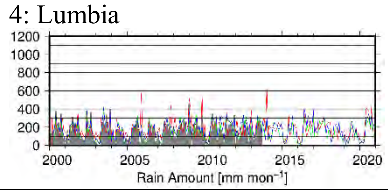
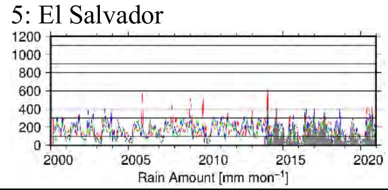
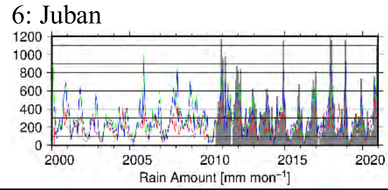
For advanced water resource analysis, correction of rainfall data using HYDROMET data (10-minute, 15-minute or hourly rainfall data) provided by DOST-ASTI is be considered. An initial quality check of the HYDROMET data revealed missing data, changes in observation intervals, and the possibility of mixed rain gauge types (not only tipping bucket type but also storage type). Rain amount is underestimated during the missing data. In the case of water storage type, it is impossible to analyze the data on a time scale shorter than the observation interval. Therefore, correlations of accumulated rainfall among rain gauges are calculated to identify usable rain gauges and to examine the possibility of supplementing missing rain observation periods. The diurnal and seasonal variations of rain gauges and CHIRPS is calculated to determine if systematic bias exists in CHIRPS. If a systematic bias is identified, we plan to correct the CHIRPS data by using this bias as the basis for a correction factor.

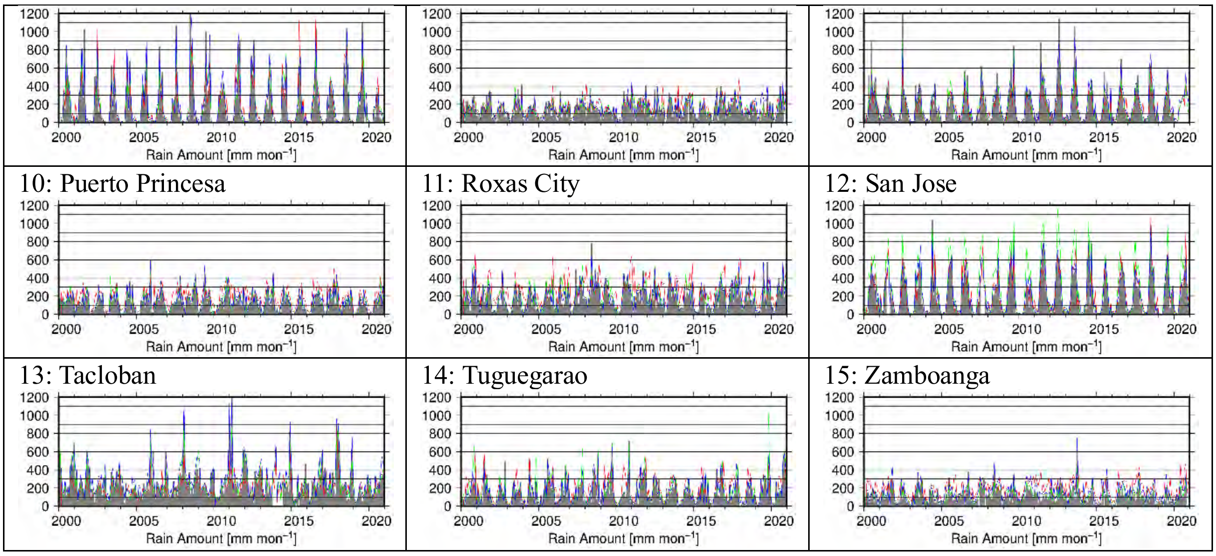


[Black bar: Rain Gauge, Red line: ERA5, Green line: CHIRPS, Blue line: GSMaP]

Source: JICA Survey Team

Figure 2.2-18 Geographical map and the time series of monthly rainfall for rain gauge, ERA5, CHIRPS, and GSMaP at PAGASA provided rain gauge station in 2000-2020

1: Clark 	2: Cotabato 	3: Davao 
4: Lumbia 	5: El Salvador 	6: Juban 
7: Laoag	8: Mactan	9: Port Area



Source: JICA Survey Team

Figure 2.2-19 Time series of monthly rainfall at each PAGASA rain gauge site

(3) Collection status of remote sensing and GIS datasets

Table 2.2-24 is a list of datasets collected and created in the project. Some datasets are continuing to be collected and updated as needed.

Table 2.2-24 List of Remote Sensing and GIS Datasets

	Dataset Name	Status
1	Administrative Regions	City / river / road data is currently being collected.
2	Digital Elevation/Terrain Model (SRTM)	Done.
3	Land cover/Land use map	The dataset has been created using Landsat dataset. The next step is verification.
4	Population Map	Predicted population data for each region / province / municipality.
5	Major/Sub River Basin	Done.
6	Iso-rainfall Contour	Created from ERA-5.
7	Location of precipitation/water level observatory (DOST-ASTI HYDROMETS Stations)	Done.
8	Yearly/Monthly temperature & evapotranspiration	JICA Survey Team based on the data of CHIRPS.
9	Location of groundwater observatory	Done.
10	Irrigation development location map	Not yet collected.
11	Location of Dam	Done.
12	Protected Area	Done.

Source: JICA Survey Team

2.3 Hydrological Analysis

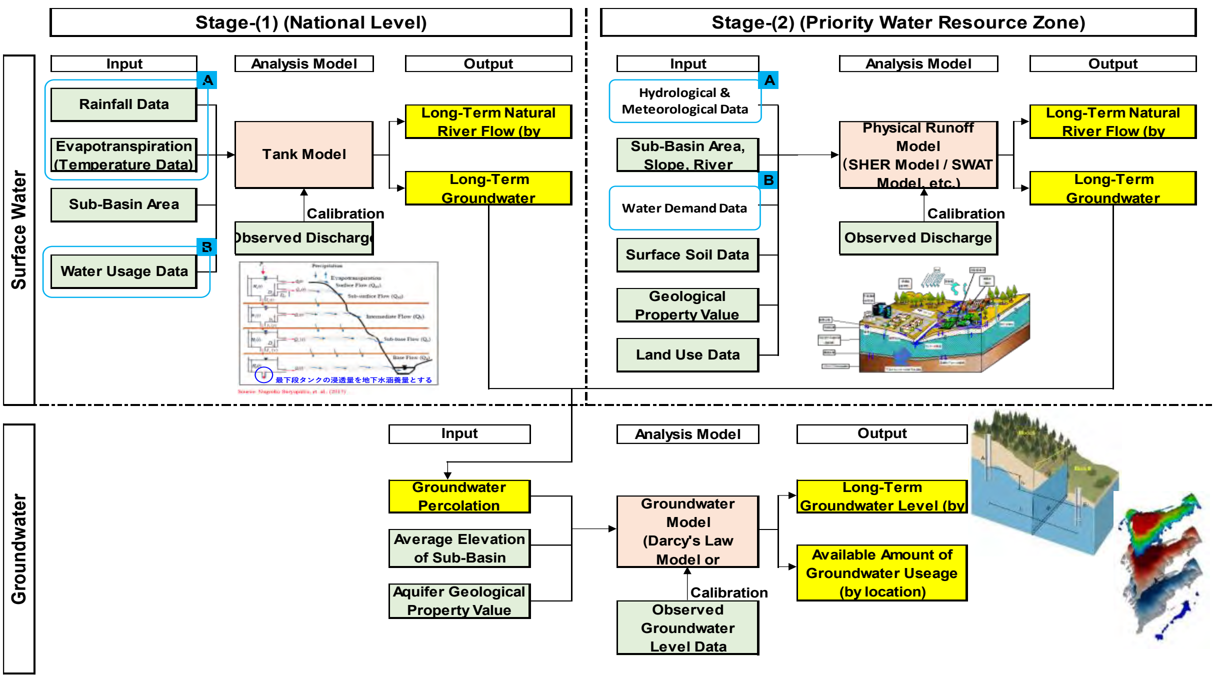
2.3.1 Outline and Workflow of Hydrological Analysis

The observed river discharge data is often missing, and the reliability of high-water discharge is particularly low. There is likewise no long-term discharge data for all WRRs. For this reason, a rainfall-runoff model (Tank Model) was constructed using observed discharge for a reliable period (annual runoff rate is from about 0.2 to 0.75), and a long-term (1979 to 2020) period of 42 years. It was decided to create long-term discharge data for each WRR.

In addition, in calculating the groundwater potential, only about 20 observational data were obtained, in which the observed groundwater level data was unevenly distributed in the region for a short period from around 2019. Therefore, it was decided to build a groundwater flow model using Darcy's Law and estimate the groundwater potential of each WRR. Each WRR was divided into small basins considering the confluence of major tributaries and reference points such as river water level gauging stations.

A hydrological analysis model is also needed to assess future climate change impacts.

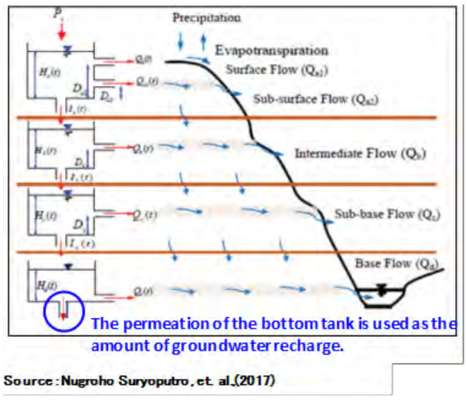
Based on the basic data acquired, a hydrological model was constructed and the water resource potentials (surface water and groundwater) in each water resources region were calculated. Figure 2.3-1 shows the workflow of the hydrological analysis.



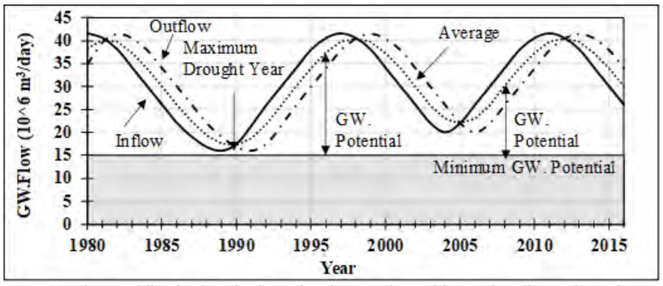
Source: JICA Survey Team

Figure 2.3-1 Workflow and Inputs and Outputs of Hydrological Analysis

The purpose of the Stage I national level hydrological analysis is to compare the balance of water resources by water resources region/basin-wide scale unit. The following methods shown in Figure 2.3-2 was adopted to rationalize the work from the viewpoint of accuracy and work time.



Surface Analysis Model (Tank Model)



Source (1): The Republic of Indonesia, the project for assessing and integrating climate change impacts into the water resource management plans for Brantas and Musi River Basins: Water Resources Management Plan: Final Report, JICA, Nippon Koei Co., Ltd. : CTI Engineering International Co., Ltd. : The University of Tokyo 2019.12
Source (2): Data Collection Survey on Water Resources Management in Central Highlands Final Report, JICA, Nippon Koei, Co., Ltd. 2018.4

Concept of Groundwater Potential (Available Groundwater Amount)

Figure 2.3-2 Concept of Surface Analysis Model (Tank Model) and Groundwater Potential

2.3.2 Hydrological Analysis (Surface Water)

(1) Selection of Re-analysis and Satellite Rainfall Data

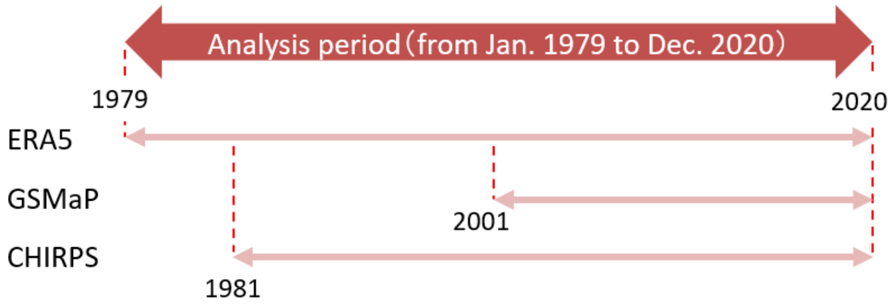
1) Proposed Datasets

Due to the limited availability of in-situ data under the coronavirus disease 2019 (COVID-19) crisis, the JICA Survey team has decided to utilize re-analysis and satellite data for daily rainfall data which is to be used for the hydrological analyses. Three datasets: ERA5, GSMaP and CHIRPS, are proposed as the options. The first option, ERA5, is a global re-analysis dataset that provides hourly estimates of atmospheric, land and oceanic climate variables by conducting numerical forecasting system analyses, using observed data as the input data. The second option, Global Satellite Mapping of Precipitation (GSMaP), is a precipitation dataset that provides hourly estimates of precipitation by integrating data obtained from multiple microwave radiometers and from thermal infrared bands of geostationary meteorological satellite. Among multiple versions of GSMaP datasets, “v6_gauge_rev” is adopted as the option as this version includes precipitation correction by ground rain gauges. The third option, Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), is a quasi-global rainfall dataset that incorporates precipitation estimation from the thermal infrared bands of geostationary satellites and rain gauge data to correct it. See Table 2.2-23 for the overview of each dataset.

(2) Evaluation of ERA5, GSMaP and CHIRPS

1) Data Availability

Target period of the hydrological analyses is from January 1st, 1979 to December 31st, 2020. As in Figure 2.3-3, ERA5 is the only dataset of the three that can cover the whole target period by itself, followed by CHIRPS, which is available from 1981 to present. GSMaP, on the other hand, has by far the shortest history out of the three and is available from March 2001 to present, which can cover less than half of the target period. As is clear from Figure 2.3-3, it is automatically determined that ERA5 is used for 1979 and 1980 since there is no other choice.



Source: JICA Survey Team

Figure 2.3-3 The Data Availability of the Three Datasets

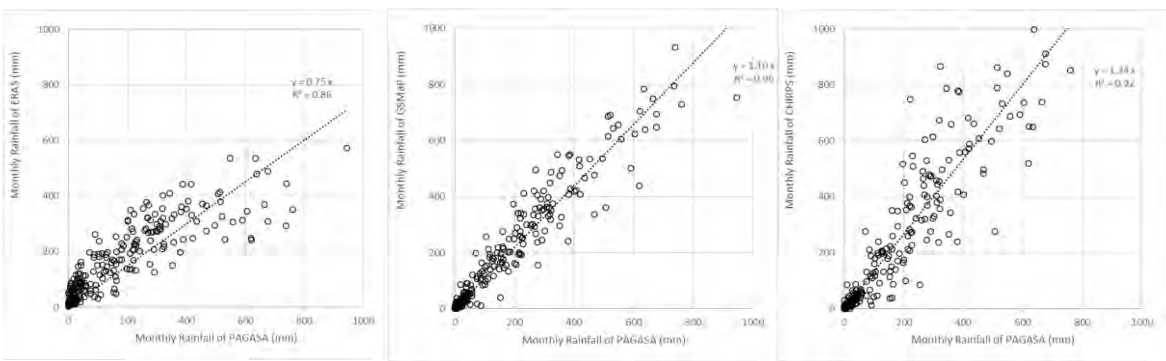
2) Data Quality

Spatial/Temporal Resolution

As is already stated in Table 2.2-23, CHIRPS is the dataset with the highest spatial resolution (0.05°) of the three datasets, followed by GSMaP (0.1°) and ERA5 (0.25°). Temporal resolution is conformed to be one day to coordinate with the temporal resolution of the hydrological analyses. This means that temporal upscaling is required in case of using ERA5 and GSMaP.

Correlation in Comparison to the In-situ Monthly Rainfall Data

Data quality of ERA5, GSMaP and CHIRPS is evaluated by comparing the monthly rainfall to that of in-situ rainfall data at 14 stations provided by the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Monthly rainfall of ERA5, GSMaP and CHIRPS are compared to that of PAGASA in scatter diagrams. A scatter diagram with approximate expression at Clark Station in Pampanga is shown as an example in Figure 2.3-4. See Annex-D for the scatter diagrams of the rest stations. The slope of the approximate expression and correlation coefficient at all the 14 stations is summarized in Table 2.3-1. In conclusion, GSMaP shows the best correlation with PAGASA's data, followed by CHIRPS. ERA5 represents the least correlation with PAGASA.



a) ERA5/ PAGASA b) GSMaP/ PAGASA c) CHIRPS/ PAGASA

Source: JICA Survey Team

Figure 2.3-4 Scatter Diagrams of Monthly Rainfall at Clark in Pampanga

Table 2.3-1 Quality Evaluation of ERA5, GSMaP and CHIRPS in Comparison to Monthly In-situ Rainfall Data Provided by PAGASA

		Approximate Expression of a Scatter Plot			Correlation with PAGASA Data		
		ERA5/PAGASA	GSMaP/PAGASA	CHIRPS/PAGASA	ERA5	GSMaP	CHIRPS
Province	PAGASA Sta. Name	Slope of an Approximate Expression			Correl. Coef.: **R**		
Pampanga	Clark	0.75	1.10	1.34	0.87	0.96	0.92
Maguindanao	Cotabato	0.90	0.82	0.83	0.57	0.91	0.76
Davao_del_Sur	Davao City	0.80	1.04	1.09	0.45	0.91	0.58
Misamis_Oriental	Lumbia	1.00	1.06	0.95	0.54	0.90	0.74
Sorsogon	Juban	0.46	0.80	0.73	0.56	0.93	0.89
Ilocos_Norte	Laoag	0.82	1.00	0.84	0.89	0.93	0.98
Cebu	Mactan	0.94	1.06	0.88	0.65	0.75	0.80
Metropolitan_Manila	Port Area	0.61	0.92	0.95	0.86	0.94	0.95
Palawan	Puerto Princesa	1.15	1.03	0.90	0.77	0.83	0.97
Capiz	Roxas City	1.10	0.91	0.95	0.60	0.94	0.78
Occidental_Mindoro	San Jose	0.95	1.07	1.23	0.90	0.93	0.90
Leyte	Tacloban	0.63	1.12	1.02	0.70	0.93	0.89
Cagayan	Tuguegarao	0.99	1.01	1.05	0.71	0.94	0.79
Zamboanga_del_Sur	Zamboanga	1.28	1.24	0.86	0.66	0.89	0.87
Mean Slope	Average=	0.88	1.01	0.97	0.69	0.91	0.84

Source: JICA Survey Team

<u>Spatial Distribution</u>

Iso-hyetal maps of the mean annual rainfall of ERA5, GSMaP and CHIRPS are compared to the iso-hyetal map cited from the previous project: "Master Plan Study on Water Resources Management in the Republic of the Philippines" (hereinafter referred to as "the 1998 Master Plan"). See Annex-D for the contour map and iso-hyetal maps of CHIRPS and GSMaP. Since the iso-hyetal map of the 1998 Master Plan is based on the in-situ rainfall observed from 1961 to 1995, the maps of ERA5, CHIRPS and GSMaP are created based on rainfall data from a similar period as possible. It should be noted that ERA5, CHIRPS and GSMaP data are available from 1979, 1981 and March 2000, respectively, and that there are no data available before that.

The iso-hyetal line of ERA5 represents good topographical dependency. In other words, rainfall is closely correlated with the elevation. CHIRPS, also shows good topographical dependency; rainfall amount increases as the elevation goes up. In GSMaP, as in Annex-D, the iso-hyetal line looks sparse and shows less topographical dependency compared to ERA5 and CHIRPS. This can be explained by resolution of the rain gauge that is used in GSMaP for correcting rainfall amount; the rain gauge's spatial/temporal resolution is 50 km/day, which is not enough to fully represent local precipitation such as squalls. This could have led to underestimation of rainfall in mountainous areas and hence the iso-hyetal map of GSMaP shows least topographical dependency of the three datasets.

3) Conclusion

As in Table 2.3-2, CHIRPS is considered as the most suitable dataset for the survey. Therefore, ERA5 is used for the first two years (1979 and 1980) of the analysis period (1979 to 2020), as explained above, and CHIRPS is adopted for the rest: 1981 to 2020.

Table 2.3-2 Evaluation of Re-analysis and Satellite Data

	ERA5	GSMaP	CHIRPS
Availability	Good	Poor	Good
Resolution	Poor	Fair	Good
Correlation	Poor	Good	Fair
Spatial Distribution	Fair	Poor	Fair
Overall	**Fair**	**Fair**	**Good**

Source: JICA Survey Team

(3) National Level Hydrological Analysis (Surface Water)

1) Tank Model

Concept of Tank Model

The preparation of the Tank Model is carried out to complete the missing data period and to conduct climate change simulation. The basic component of the Tank Model (*Sugawara*, 1967) is a simple tank with holes to pass the water content.

In this study, the Tank Model is applied with four storage tanks consisting of a surface tank, a sub-surface tank, an intermediate tank, and a base tank. The two side outflows from the surface tank are regarded as the surface runoff and the sub-surface runoff, the side outflow from the intermediate tank is regarded as the intermediate runoff and the outflow from the third and fourth tank is regarded as the base runoff. The total outflow from the side outlet (Q) from each tank is regarded as the accumulation of the outflows from a system in the watershed.

The outflow (seepage) parameter from the bottom tank (4th Tank) of the Tank Model was set by calibration of the observed and calculated river discharges and the groundwater level fluctuation of the groundwater model.

Paddy Model

The irrigated area of paddy fields is vast in the Philippines, and the function of paddy fields cannot be ignored in runoff analysis. Paddy irrigation has a special water cycle mechanism, with abundant water supply (entered as rainfall) on the surface soil of the paddy, thus overflow and infiltration from the paddy must also be considered. Paddy fields can be thought of as a kind of vast artificial infiltration pond. Therefore, in this survey, the paddy field model was incorporated into the normal Tank Model and analysed.

The height of the paddy field (overflow height) was assumed to be 50 mm, and the infiltration amount from the paddy field was assumed at 2 mm/day. The potential evapotranspiration from paddy fields during the irrigation period was the value of ETo by *FAO-Penman-Monteith*, and the potential evapotranspiration outside the irrigation period was the value of the *Hamon* equation. The irrigation area for the paddy model is the ten-day average area by rainy season and dry season, and likewise, the amount of irrigation water is the ten-day average water volume required.

Irrigation Water Demand

For details on how to calculate the amount of irrigation water requirement, refer to the next section. In the calibration of the Tank Model, the diversion water requirement considering the waterway loss was subtracted from the rivers in each sub-basin to the irrigation requirement (ten-day average water volume) by province, and the water volume was supplied to the paddy fields as rainfall. The loss of the irrigation canal was also supplied as rainfall to the land other than the paddy field. Diversion water requirement was calculated by using the irrigation water requirement and assumed irrigation efficiency at 54%, which is commonly used in the Philippines, was used, as follows:

(Diversion Water requirement) = (Irrigation Water requirement) / 0.54

In the calibration of the Tank Model, the irrigation requirement was calculated by changing the irrigation area by province (ten-day average area by rainy season and dry season) for each year from 1979 to 2020.

Domestic, Industrial and Other Water Demand

For details on the calculation method of domestic, industrial, and other water demand, refer to the next section. In the calibration of the Tank Model, the required water volume for each year from 1979 to 2020 for domestic, industrial, and other water demand was calculated for each province, and the required water volume for each province is multiplied by the area ratio of each sub-basin. The required amount of the domestic, industrial, and other water demand was subtracted from the rivers in each sub-basin. In this survey, it was assumed that 60% of the water returned to the rivers as return flow by sewage, etc., which is commonly used in water cycle analysis in Japan.

Evapotranspiration

As mentioned above, the potential evapotranspiration of ETo by the *FAO-Penman-Monteith* method was used during the irrigation period of the paddy field. The potential evapotranspiration by the *Hamon* equation was used for evapotranspiration from land other than paddy fields and the non-irrigation period of paddy fields. In the Tank Model, when the water retention capacity of the first uppermost tank becomes zero (0), the evapotranspiration amount is subtracted from the second tank.

Infiltration

Infiltration from each tank in the Tank Model is simply calculated by multiplying the amount of storage in each tank by the infiltration rate multiplier. In the Stage-II survey, the infiltration amount is calculated by performing "saturated-unsaturated infiltration analysis" using a physical model in the selected priority area.

Maintenance Flow

During the dry season, all the demand for irrigation and urban water cannot be taken from rivers. In such a case, if all the required amount of water is taken from the river, the river flow becomes zero (0). Therefore, in this survey, it was assumed that 60% of the river flow in the dry season would be used as the maintenance flow to the downstream, and that the remaining 40% could be taken from river.

Reservoir Operation Model of Major Dams

There are many dams in the Philippines; in this survey however, the following four large-scale dams with irrigation purposes included were considered in the Tank Model calibration and future prediction simulation.

- Magat Dam : WRR-II, Cagayan River Basin
- San Roque Dam : WRR-III, Agno River Basin
- Angat Dam : WRR-III, Pampanga River Basin
- Pantabangan Dam : WRR-III, Pampanga River Basin

The details of the above dam/reservoir operation calculation model are attached in Annex-D Hydrology.

(4) Verification of Observed River Discharge Data

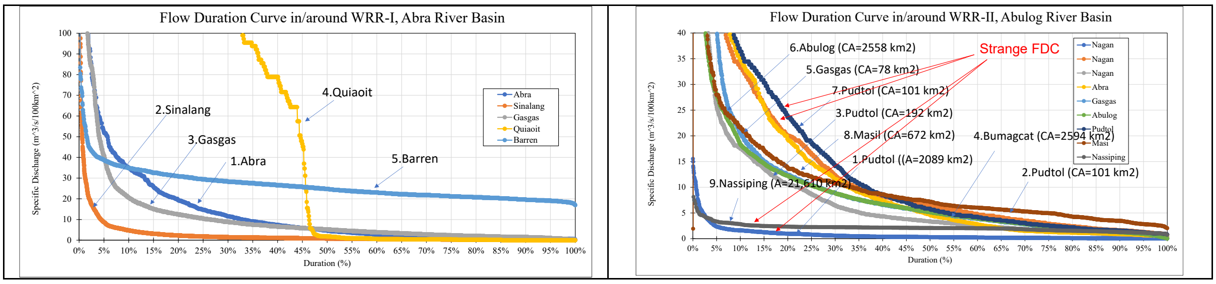
The observed discharge of each observation station was used as the verification discharge for the calibration of the Tank Model parameters of each sus-basin based on the catchment area ratio. First, the accuracy of the observed discharge was evaluated by the runoff coefficient and the flow duration curve. Unfortunately, many of the observed discharges had a runoff coefficient of more than 1 (larger than precipitation), and there were many points where the flow duration curve (FDC) due to the specific discharge was questionable. Therefore, in this survey, it was decided to only use the observed runoff coefficient in the year when the coefficient is 0.25 to 0.7 as the verification discharge for the Tank Model calibration. There are issues with improving data quality (such as updating rating curves).

1) Runoff Coefficient

There are many observation stations where the annual runoff rate exceeds 1.0 and the runoff is larger than the amount of precipitation. The cells in yellow in the Table in Annex-D, Hydrology indicate the years when the runoff coefficient exceeds 1.0.

2) Flow Duration Curve (FDC) of Observed Discharge

Figure 2.3-5 shows an example of the FDC of the observed discharge. The discharges of some stations were questionable in reliability.



Source: JICA Survey Team based on observed discharge data of DPWH, etc.

Figure 2.3-5 Example of Flow Duration Curves (FDC) of Specific Discharge ($m^3/sec/km^2$)

2.3.3 Hydrological Analysis (Groundwater)

(1) Groundwater Model

1) Concept of Groundwater Analysis Model (Darcy's Law Model)

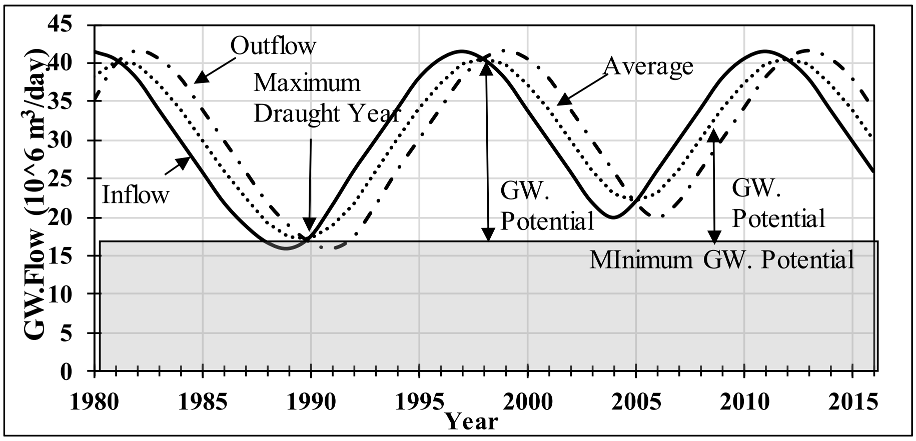
Using the recharge results from topsoil to groundwater aquifer by Tank Model, the Darcy's Law model for groundwater was constructed for evaluation of groundwater potentials.

The parameters of the Groundwater Model were decided with reference to the topographic map, geological map, hydrogeological map, borehole log data and observed groundwater level data, etc. The model was built by sub-basin block based on the Darcy's Law.

In this survey, the safety groundwater availability was defined as shown in Figure 2.3-6. The safety factor[1] of 0.7 was decided based on the consideration of aquifer characteristics, status of groundwater exploitation, and requirement of groundwater management of the area. After calibration of the model with the estimated parameters, naturalized safety groundwater availability was estimated by not considering artificial groundwater intake.

[1] Source: Summary of Western Area Groundwater Endowment Survey Results, Shizuoka Prefecture, Japan, 2015,

(https://www.pref.shizuoka.jp/kankyou/ka-060/tikasui_fuzon_kekka.html)



Source: JICA Survey Team

Figure 2.3-6 Conceptual Diagram of Groundwater Potential

2) Model Input Data

As the input data of the Groundwater Model, the amount of infiltration into the shallow groundwater aquifer from bottom of the Tank Model is the input value as described before. In addition, as shown in Table 2.3-3, the catchment area of each sub-basin, the average elevation of the block, the initial groundwater level, the thickness (height) of the aquifer, the connection width with the downstream block, the distance to the downstream block, and the average altitude (height) of the downstream block are also input data for the Groundwater Model. The altitude, the saturated hydraulic conductivity (*Ko*) of the aquifer, and the porosity of the aquifer are also input data. The initial groundwater level, aquifer thickness, connection width, saturated hydraulic conductivity (*Ko*) of the aquifer, and porosity are the model parameters.

Table 2.3-3 Example of Input Data and Parameters for Groundwater Model

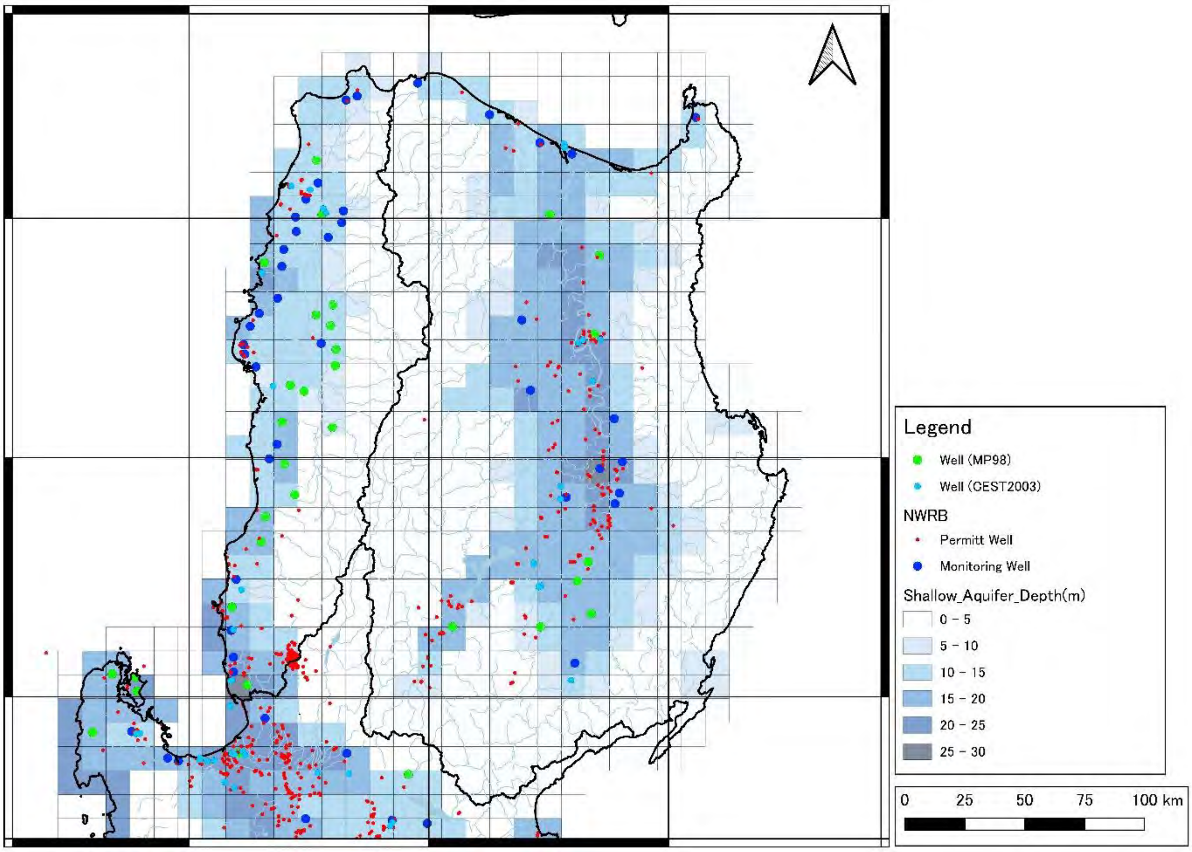
C.A.[km^2]=	206.7		
Area of This Block [km2]=	206.7	Width to D/S Block [m]=	1,000.0
Average Elevation of This Block [El.m]=	809.3	Thickness (Depth) of GW Aquifer [m]=	25.0
Initial GWL [El.m]=	804.3	Distance to D/S Block [m]=	22,417
Elevation of Base Lock [El.m]=	468.4	Elevation of D/S Block [El.m]=	177.4

Saturated Hydraulic Conductivity *K* [cm/sec]=	3.8901E-04	*K* =5.0E-01 ~ 1.0E-07
Porosity of Aquifer [%]=	0.01	*P* =0.05~0.4

Source: JICA Survey Team

The aquifer thickness was estimated based on the aquifer distribution and well data shown in Section 2.2.5. The depth of the wells was assumed to be the aquifer depth, and the wells were divided into shallow groundwater and deep groundwater with 30 m as the boundary. The aquifer depths were organized as 10 km mesh grid data.

Figure 2.3-7 shows the example of aquifer depth distribution in WRR-I and II. The average shallow aquifer thickness of 25 m, which was clarified in this estimation, was applied to the Groundwater Model.



Source: JICA Survey Team

Figure 2.3-7 Example of Shallow Aquifer Depth Distribution (Region I and II)

Hydraulic conductivity and porosity required for the Groundwater Model input were selected based on the existing groundwater flow analysis reports in Metro Manila and Metro Cebu and the results of the pumping test in Pinatubo area. The physical properties are distributed to each classification of the Groundwater Availability Map (see Figure 2.2-9) as shown in Table 2.3-4.

Table 2.3-4 Physical Properties

Category of Groundwater Availability Map	Permeability (cm/sec)	Porosity (%)	Storage Coefficient
Rocks in which flow is dominantly intergranular			
Extensive and highly productive aquifer	1.0×10^{-0}~ 3.0×10^{-1}	34	0.05
Fairly extensive to productive aquifer	1.0×10^{-1}~ 1.0×10^{-3}	31	0.05
Local and less productive aquifer	1.0×10^{-3}~ 2.0×10^{-5}	24	0.05
Rocks in which flow is dominantly through fractures and/or solution openings			
Fairly extensive and productive aquifer	1.5×10^{-2} ~ 3.0×10^{-4}	17.5	0.05
Fairly to less extensive and productive aquifer	3.0×10^{-4}	5	0.05
Local groundwater regions underlain by impermeable rocks			
Rocks with limited potential	2.5×10^{-7}	2.5	0.03
Rocks without any known significant groundwater obtainable thorough drilled wells	1.0×10^{-8}	0	-

Source: JICA Survey Team

3) Irrigation Water Demand

For details on how to calculate the amount of irrigation water requirement, refer to the next section. In the calibration of the Groundwater Model, the diversion water requirement considering the waterway loss was subtracted from the groundwater aquifer in each sub-basin to the irrigation requirement (ten-day average water volume) by province. Diversion water requirement was calculated by using the irrigation water requirement and assumed irrigation efficiency at 54% that is commonly used in the Philippines as follows:

(Diversion Water requirement) = (Irrigation Water requirement) / 0.54

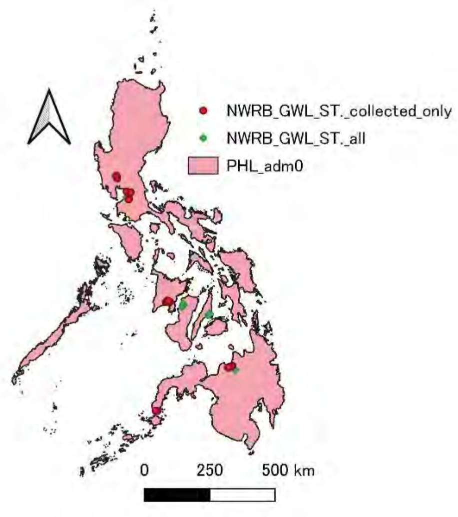
In the calibration of the Groundwater Model, the irrigation requirement was calculated by changing the irrigation area by province (ten-day average area by rainy season and dry season) for each year from 1979 to 2020.

4) Domestic, Industrial and Other Water Demand

For details on the calculation method of domestic, industrial, and other water demand, refer to the next section. In the calibration of the Groundwater Model, the required water volume for each year from 1979 to 2020 for domestic, industrial, and other water demand was calculated for each province, and the required water volume for each province is multiplied by the area ratio of each sub-basin. The required amount of the domestic, industrial, and other water demand was subtracted from the groundwater in each sub-basin.

(2) Verification of Observed Groundwater Level

The list of groundwater level monitoring stations by NWRB is shown in Table 2.3-5, and the location map is shown in Figure 2.3-8. Of the 47 groundwater level stations in total, 22 groundwater level data were obtained from NWRB. As shown in the location map, the groundwater level observation stations are unevenly distributed, and it can be seen that the number of monitoring is not sufficient for national level groundwater level verification.



Source: NWRB

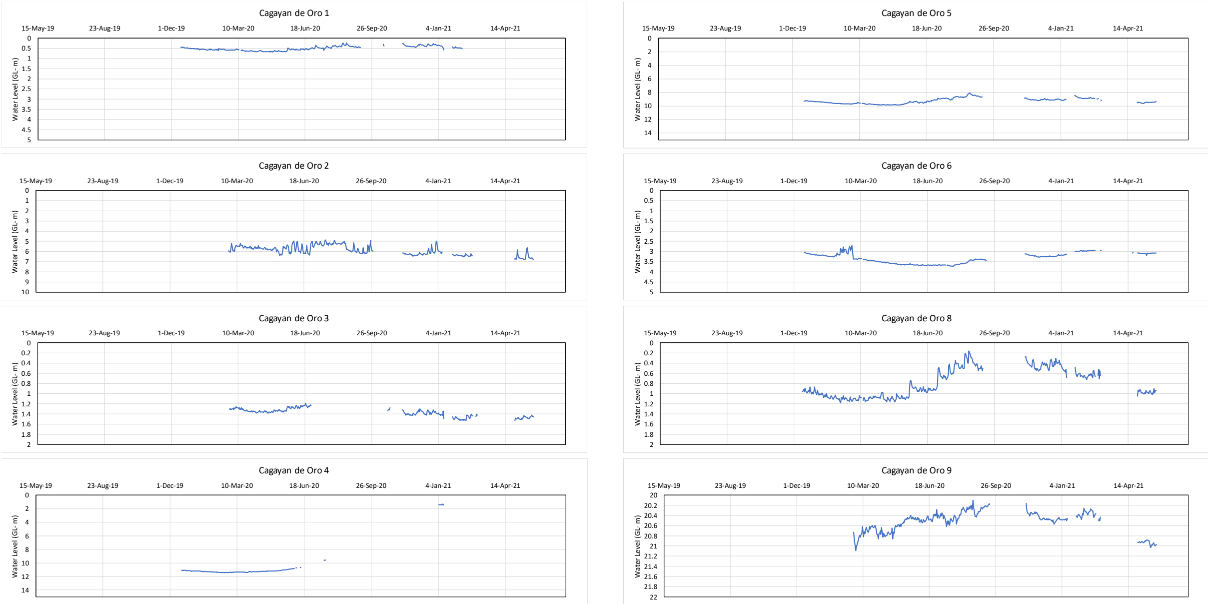
Figure 2.3-8 Location Map of Groundwater Monitoring Wells by NWRB

The following figures show the fluctuations in the groundwater level data collected at 22 locations: in Cagayan (Figure 2.3-9), Iloilo (Figure 2.3-10), Metro Manila (Figure 2.3-11), Pampanga (Figure 2.3-12), and Zamboanga (Figure 2.3-13). The obtained groundwater level data is only for after 2019, and thus is short-term data. In addition, there are many missing data and many points show extreme fluctuations.

Table 2.3-5 Groundwater Monitoring Wells by NWRB

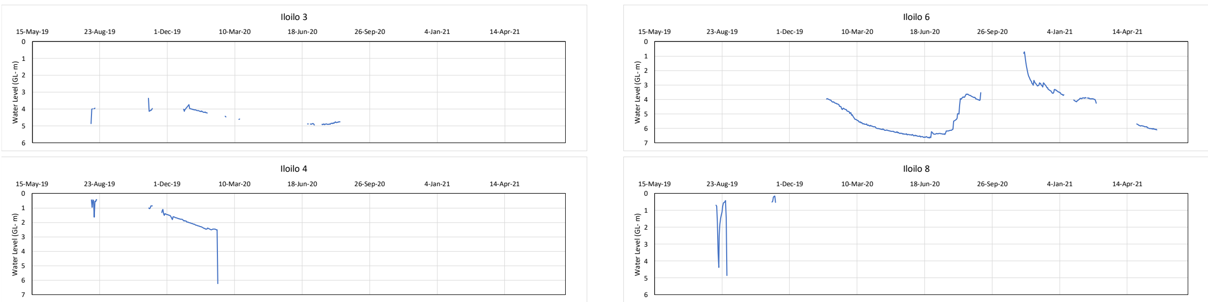
No.	Collected	Zone	No. (2)	Well Name	Location	Latitude	Longitude	Elevation (m)	Depth (m)	Casing (mm)	SWL (m)	Date Completed
1		Iloilo	1	Cambito National High School, Oton	Cabalo-an Sur, Oton, Iloilo	10.743	122.481		102.00	75	13.7	February 16, 2014
2		Iloilo	2	Cambito National High School, Oton	Cabalo-an Sur, Oton, Iloilo	10.762	122.497		45.00	75	4.4	March 4, 2014
3	*	Iloilo	3	Pavia National High School, Pavia	Poblacion, Pavia, Iloilo	10.781	122.540		100.00	75	4.3	June 2, 2014
4	*	Iloilo	4	Pavia Elementary, Pavia	Pagsanga-an, Pavia, Iloilo	10.766	122.386		50.00	75	2.0	June 22, 2014
5		Iloilo	5	Felix Amparado Memorial School, Alimodian	Ubudan, Alimodian, Iloilo	10.838	122.425		100.00	75	GL	August 28, 2014
6	*	Iloilo	6	Gelacio Allones Memorial Elem. Sch. Alimodian	Balabag, Alimodian, Iloilo	10.803	122.429		50.00	75	GL	Sept. 23, 2014
7		Iloilo	7	Barangay San Jose, San Miguel	San Jose, San Miguel, Iloilo	10.761	122.497		49.00	75	GL	Oct. 20, 2014
8	*	Iloilo	8	Barangay Consolacion, San Miguel	Consolacion, San Miguel, Iloilo	10.811	122.476		95.00	75	GL	Nov. 19, 2014
9		Pampanga	1	Tacondo Elementary School	Margot, Angeles City	15.171	120.538	176	176.00	75	28.7	April 10, 2017
10		Pampanga	2	Sitio Pader Elementary School	Pulung Maragul, Angeles City	15.160	120.598	90	154.50	75	9.6	
11	*	Pampanga	3	Gueco Balibago Elementary School	Balibago, Angeles City	15.169	120.596	97	147.30	75	7.2	
12		Pampanga	4	Dr. Clemente Dayrit Elementary School	Lourdes Sur East, Angeles City	15.144	120.594	95	171.00	75	10.7	
13	*	Pampanga	5	Sto. Domingo Integrated School	Sto. Domingo, Angeles City	15.127	120.601	89	108.00	75	7.2	May 29, 2017
14	*	Pampanga	6	Angeles Elementary School	Pulungbulu, Angeles City	15.136	120.595	100	186.00	75	12.0	May 16, 2017
15	*	Pampanga	7	Mabalacat Central Elementary School	Poblacion, Mabalacat	15.226	120.572	110	156.40		24.6	May 15, 2018
16		Pampanga	8	Mabiga Elementary School	Mabiga, Mabalacat	15.212	120.580	90	151.50	100	2.5	May 15, 2018
17		Pampanga	9	Mauaque Ressettlement Elem. School	Mauaque, Mabalacat	15.206	120.608	80	150.50	100	4.2	
18		Negros Occidental	1	Vista Alegre Elementary School	Purok Katiligban, Bacolod City	10.642	123.008	90	150.00	100	17.2	February 10, 2018
19		Negros Occidental	2	Antonio Jayme Elementary School	Mansilingan, Bacolod City	10.630	122.976	70	144.50	100	33.3	Nov. 23, 2018
20		Negros Occidental	3	Emilio Lizares National High School	Granada, Bacolod City	10.666	123.033	20	132.23	100	16.3	April 5, 2018
21		Negros Occidental	4	Jovito Sayson National High School	Brgy. Felisa, Bacolod City	10.589	122.972	50	150.00	100	33.8	February 10, 2018
22		Negros Occidental	5	Old Municipal Bldg. Police Station	Bonifacio St., Talisay City	10.720	123.008		86.50	100	3.4	December 5, 2018
23	*	Cagayan de Oro & Manodo Fortich	1	Bugo Central School	Bugo, Cagayan de Oro City	8.503	124.753					
24	*	Cagayan de Oro & Manodo Fortich	2	Cagayan de Oro Bugo School of Arts and Trade	Bugo, Cagayan de Oro City	8.507	124.761		60.00	75	5.1	Oct. 31, 2015
25	*	Cagayan de Oro & Manodo Fortich	3	Bugo Barangay Hall	Bugo, Cagayan de Oro City	8.508	124.755		30.00	75	1.0	Nov. 14, 2015
26	*	Cagayan de Oro & Manodo Fortich	4	Pedro N. Roa Sr. Elementary School	Sitio Calaanan, Canitoan	8.460	124.607		100.00	75	12.0	Nov. 23, 2015
27	*	Cagayan de Oro & Manodo Fortich	5	Balulang Elementary School	Balulang, Cagayan de Oro City	8.443	124.635		52.00	75	8.4	Dec. 12, 2015
28	*	Cagayan de Oro & Manodo Fortich	6	Balulang National High School	Balulang, Cagayan de Oro City	8.438	124.632		50.33	75	1.9	Dec. 13, 2015
29		Cagayan de Oro & Manodo Fortich	7	Northern Bukidnon Community College Cmpd	Kihare, Tankulan, Manolo Fortich	8.361	124.868		60.87	75	6.2	Feb. 20, 2016
30	*	Cagayan de Oro & Manodo Fortich	8	Agusan Elementary School	Agusan, Cagayan de Oro City	8.491	124.742		60.00	75	5.2	March 12, 2016
31	*	Cagayan de Oro & Manodo Fortich	9	Macasandig Elementary School	Macasandig, Cagayan de Oro City	8.464	124.644		150.00	75	20.8	Sept. 20, 2016
32		Cagayan de Oro & Manodo Fortich	10	Carmen Macanhan National High School	Brgy Carmen, Ilaya, Cagayan de Oro City	8.470	124.632		170.00	75	10.0	Sept. 22, 2016
33		Cebu	1	Barrio Luz Elementary School	Banilad, Cebu City	10.324	123.907		80.00	100	36.8	Feb. 6, 2019
34		Cebu	2	Abellana National High School	Osmena Blvd, Cebu City	10.301	123.896		60.00	100	14.9	April 30, 2019
35		Cebu	3	Jagobiao National High School	Brgy. Jagobiao, Mandaue City	10.368	123.954		80.00	100	19.2	Jan. 6, 2019
36		Cebu	4	Jagobiao Barangay Hall	Brgy. Jagobiao, Mandaue City	10.367	123.952		80.00	100	23.9	March 26, 2019
37		Cebu	5	Lawaan Elementary School	Brgy. Lawaan, Talisay City Cebu							
38		Cebu	6	Tabunok Elementary School	Brgy. Tabunok, Talisay City Cebu							
39	*	Metro Manila	1	Santiago Syjuco Memorial School	Malabon City	14.665	120.951		275.00	100	3.0	Sept. 22, 2017
40	*	Metro Manila	2	Alabang Elementary School	Brgy. Alabang, Munitinlupa City	14.421	121.049		244.69		17.3	
41	*	Metro Manila	3	Muntinlupa National High School	Muntinlupa City	14.388	121.028		147.62	100	33.8	
42	*	Metro Manila	4	City Environmental Management Office	CEMO Cmpd, Sto. Nino, Marikina City	14.640	121.104		201.42	100	0.1	April 10, 2017
43		Bacoor, Cavite	1	Queensrow Elementary School	Brgy. Molino, Bacoor City	14.398	120.990		180.00	100	47.5	Oct. 17, 2017
44		Bacoor, Cavite	2	Bacoor Elementary School	Brgy. Alima, Bacoor City, Cavite	14.458	120.938		183.00	100	2.3	Nov. 30, 2017
45		Bacoor, Cavite	3	Bacoor City Government Center	Bacoor City	14.435	120.967		156.00	100	8.5	Sept. 5, 2018
46	*	Zamboanga	1	Tugbungan Barangay Hall	Tugbungan, Zamboanga	6.919	122.105				2.4	
47	*	Zamboanga	2	Calarian Barangay Hall	Calarian, Zamboanga	6.924	122.030				16.8	
	22											

Source: NWRB



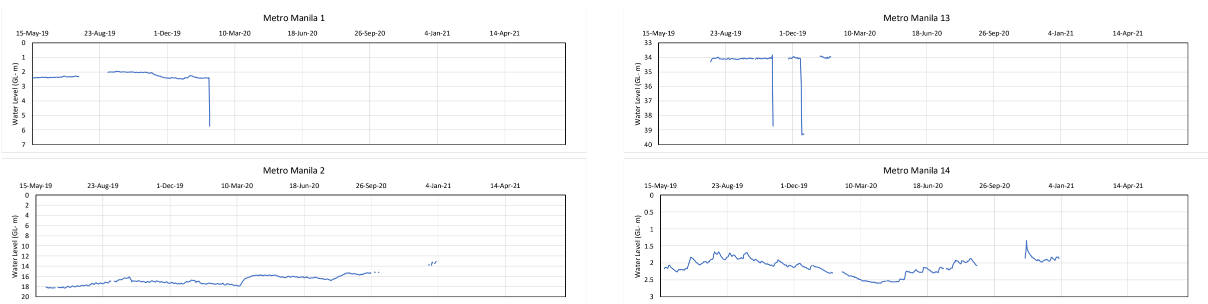
Source: NWRB

Figure 2.3-9 Groundwater Level Monitoring Data by NWRB in Cagayan



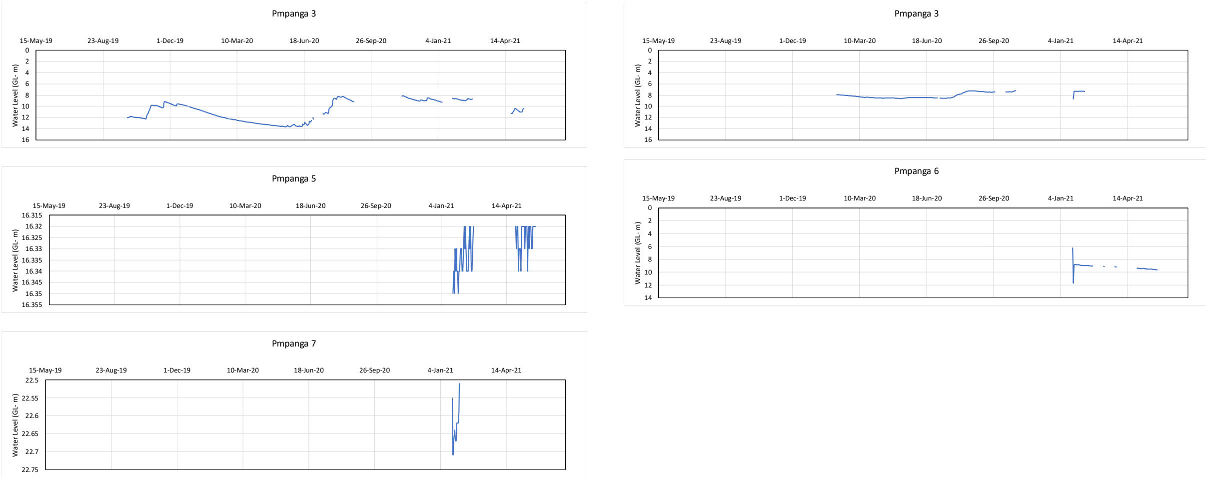
Source: NWRB

Figure 2.3-10 Groundwater Level Monitoring Data by NWRB in Iloilo



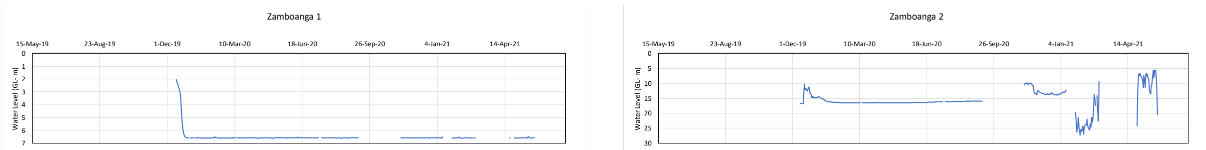
Source: NWRB

Figure 2.3-11 Groundwater Level Monitoring Data by NWRB in Metro Manila



Source: NWRB

Figure 2.3-12 Groundwater Level Monitoring Data by NWRB in Pampanga



Source: NWRB

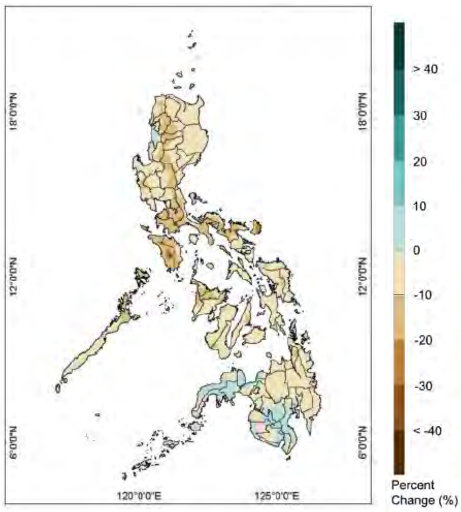
Figure 2.3-13 Groundwater Level Monitoring Data by NWRB in Zamboanga

2.3.4 Climate Change Impact Assessment

(1) General Information

The climate change impact forecast of this survey was carried out by the following method in consideration of accuracy and data collection time.

Detailed information on climate change forecast data for the Philippines has already been organized in the Department of Science and Technology (DOST)-PAGASA's "Observed Climate Trend and Projected Climate Change in the Philippines" report (2018). The report includes the upper, middle, and lower three cases of two scenarios, RCP4.5 (medium) and RCP8.5 (high), by water resources region and state in the middle of the 21st century (2036-2065). The predicted changes in precipitation and temperature every three months are given (example graph is shown in Figure 2.3-14). This data in the report was effectively utilized in this survey, for confirming the latest trends in climate change forecasts, and



Source: DOST-PAGASA (2018)

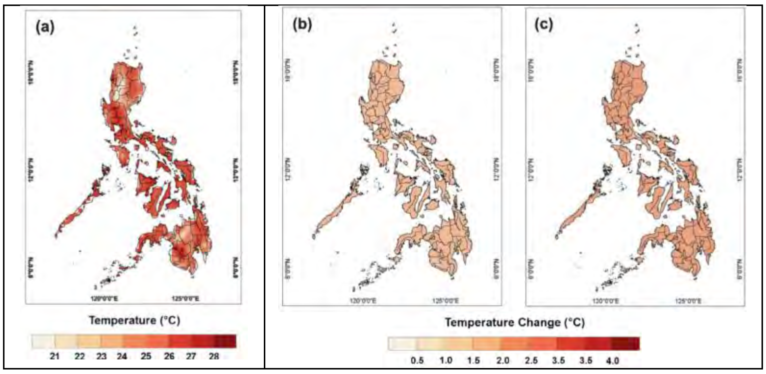
Figure 2.3-14 Mid-21st Century (2036-2065) July-September Average Precipitation Change Prediction (RCP8.5 Scenario Average)

calculating future water resource potentials in consideration of the effects of climate change. For example, future precipitation and temperature (and evapotranspiration) are calculated by multiplying the precipitation and temperature, which are the input data of the surface water analysis model, by the rate of increase/decrease from the current weather due to climate change. Then, future changes in water resource potentials (surface water and groundwater) were calculated. The impact of climate change on the water balance is an assessment of future uncertainty (variability). In this study, it was evaluated that RCP8.5 has a large degree of uncertainty. Key findings of this report are described below.

(2) Temperature

Observed temperature in the Philippines is warming at an average rate of 0.1°C per decade. Climate projections suggest continuous warming in the future. It is projected that the country-averaged mean temperature could increase by as much as 0.9°C-1.9°C (assuming a moderate emission scenario, RCP4.5) and by 1.2°C-2.3°C (considering a high emission scenario, RCP8.5) in the mid-21st century (2036-2065). Warmer conditions are further expected by the end of the 21st century (2070-2099), which could range from 1.3°C-2.5°C (based on the RCP4.5) to 2.5°C-4.1°C (based on RCP8.5) increase in mean temperature relative to the baseline climate.

The spatial distribution of observed annual mean temperature from 1971 to 2000 is shown in Figure 2.3-15(a); It is observed that most areas in the country have experienced air temperatures exceeding 26°C, while, as expected, slightly cooler areas are found in mountainous regions. These temperatures are projected to increase uniformly and minimally across the country in both the moderate-emission (RCP 4.5) and the high-emission (RCP 8.5) scenarios (Figure 2.3-15 (b) and Figure 2.3-15 (c), respectively).



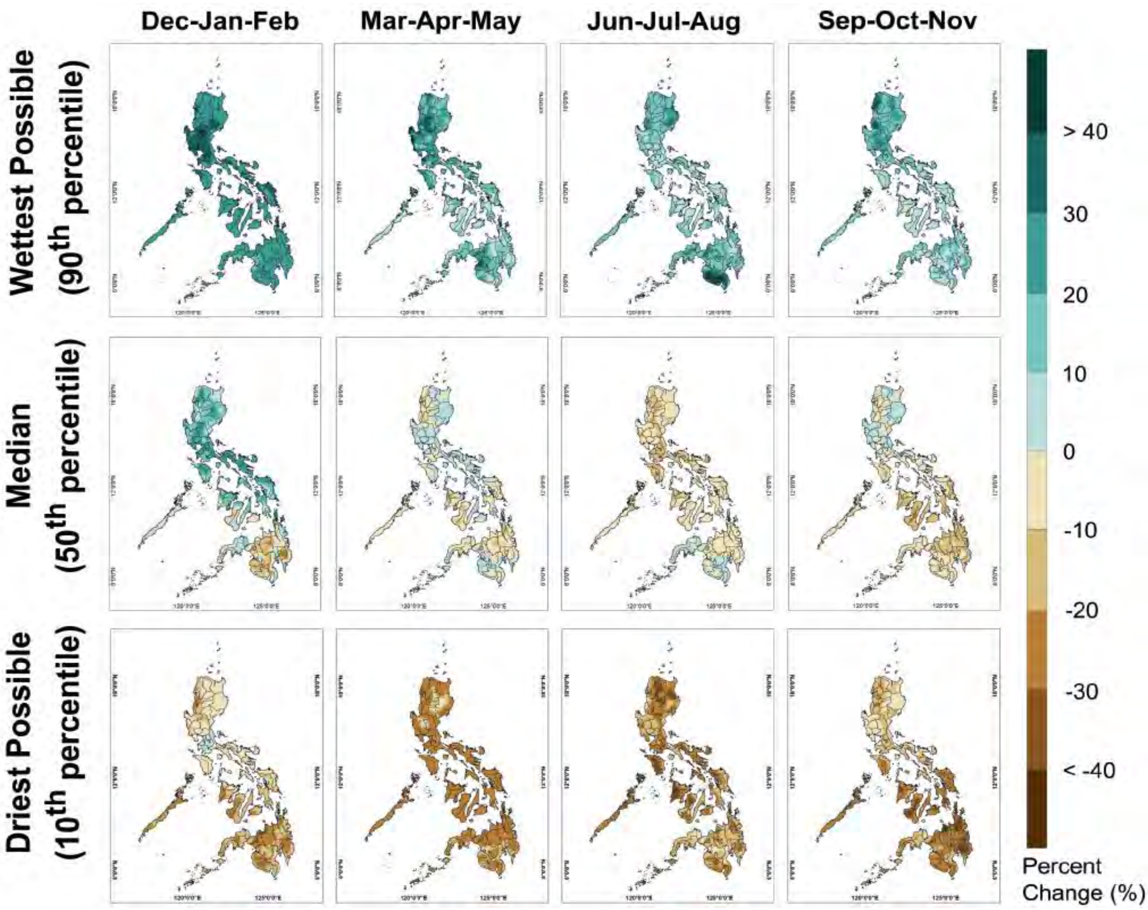
Source: DOST-PAGASA (2019)

Figure 2.3-15 Spatial Distribution of (a) Observed Annual Average Temperature for 1971-2000 and Projected Temperature Changes for the mid-21st Century (2036-2065) at (b) RCP 4.5 and (c) RCP 8.5

(3) Rainfall

Increasing trends in annual and seasonal rainfall were observed in many parts of the country. Such trends were found to be associated with extreme rainfall events. Multi-model projections suggest a range of increase and decrease in seasonal-mean rainfall exceeding 40% of its historical values. Nevertheless, the multi-model central estimate of projected changes in rainfall could be within the natural rainfall variations, except for the projected rainfall reduction over central sections of Mindanao that are beyond the observed rainfall variations in the past.

The models used in the DOST-PAGASA report are suggesting a wide range of future changes in the Philippine rainfall of RCP8.5-Median Case (Figure 2.3-16). Considering the models' assumptions underlying the RCP8.5 scenario, the driest possible rainfall change (i.e., the 10th percentile of the models' projections) could reach beyond 40% reduction in many areas, particularly over Mindanao by the mid-21st century. The wettest possible change (i.e., the 90th percentile of the models' projections), on the other hand, could exceed a 40% increase in rainfall, particularly over Luzon, the western sections of Visayas, and some parts of Mindanao. The multi-model central estimate (i.e., the 50th percentile or the median) future rainfall conditions is well within its natural variability, i.e., <1 standard deviation of observed rainfall; except for the drier future over central sections of Mindanao, particularly in September-October-November and the December-January-February seasons, which might require actionable climate change adaptation plans.



Source: DOST-PAGASA (2019)

Figure 2.3-16 Projected Changes in Seasonal Mean Rainfall in the Philippines for the mid-21st Century (2036-2065) relative to the Baseline Period of 1971-2000 (RCP8.5-Median Case)

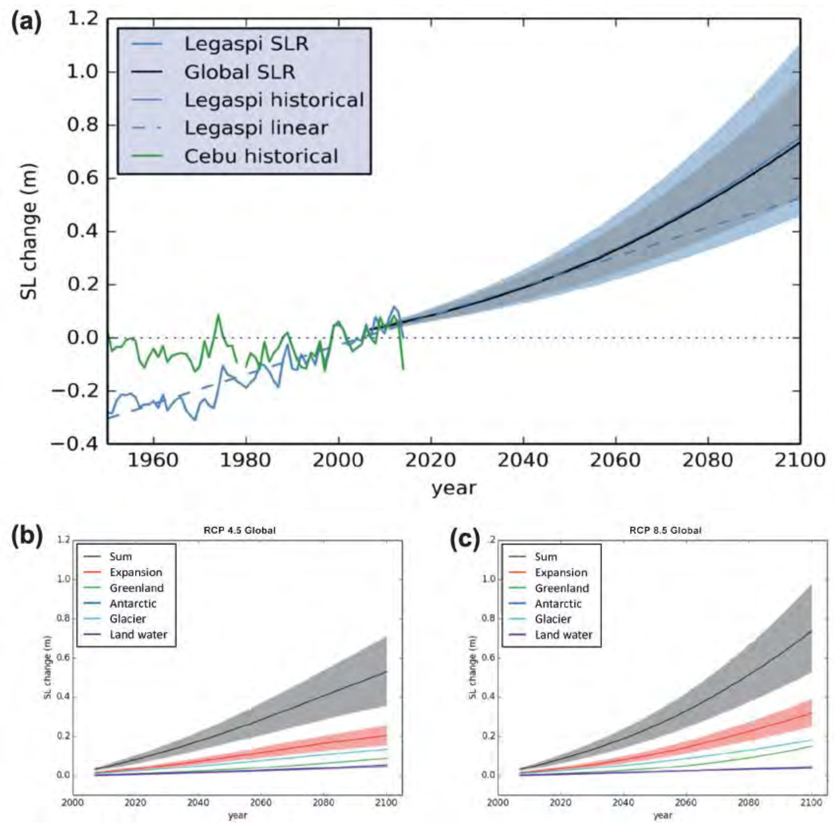
The wettest possible change represents the 90th percentile of the projections, 50th percentile or the median, and 10th percentile is driest possible change; these were computed from the 12-member high emission scenario (RCP8.5) RCM ensemble. Dotted areas denote that the change is beyond the natural variability (i.e. ±1 standard deviation of the baseline period).

The impact of climate change on rainfall is expected to increase at the extreme values (floods and droughts), but this study focuses on annual and monthly water balance assessments. Evaluation is based only on the amount of change in rainfall and temperature. Therefore, although an increase in the extreme values cannot be expressed, the level of annual or monthly water balance analysis for surface water and groundwater can be evaluated.

(4) Sea Level Rise

The sea level has risen by nearly double the global average rate of sea level rise over certain parts of the Philippines from 1993 to 2015. The projections revealed that the sea level in the country was expected to increase by approximately 20 cm by the end of the 21st century under the RCP8.5 scenario. Such projected increase of the sea level might worsen storm surge hazards, particularly on coastal communities.

As shown in Figure 2.3-17, the sea level rise in the Philippines will continue to be slightly larger than the global average. In both the moderate (RCP4.5) and high (RCP8.5) emission scenarios, the increase is expected to be almost the same by the mid-21st century. The trend for RCP4.5 will continue to be linear up to the end of the 21st century, while the trend for RCP8.5 will follow a rather exponential increase as shown in Figure 2.3-17 (b) and (c), which requires climate change adaptation action plans.



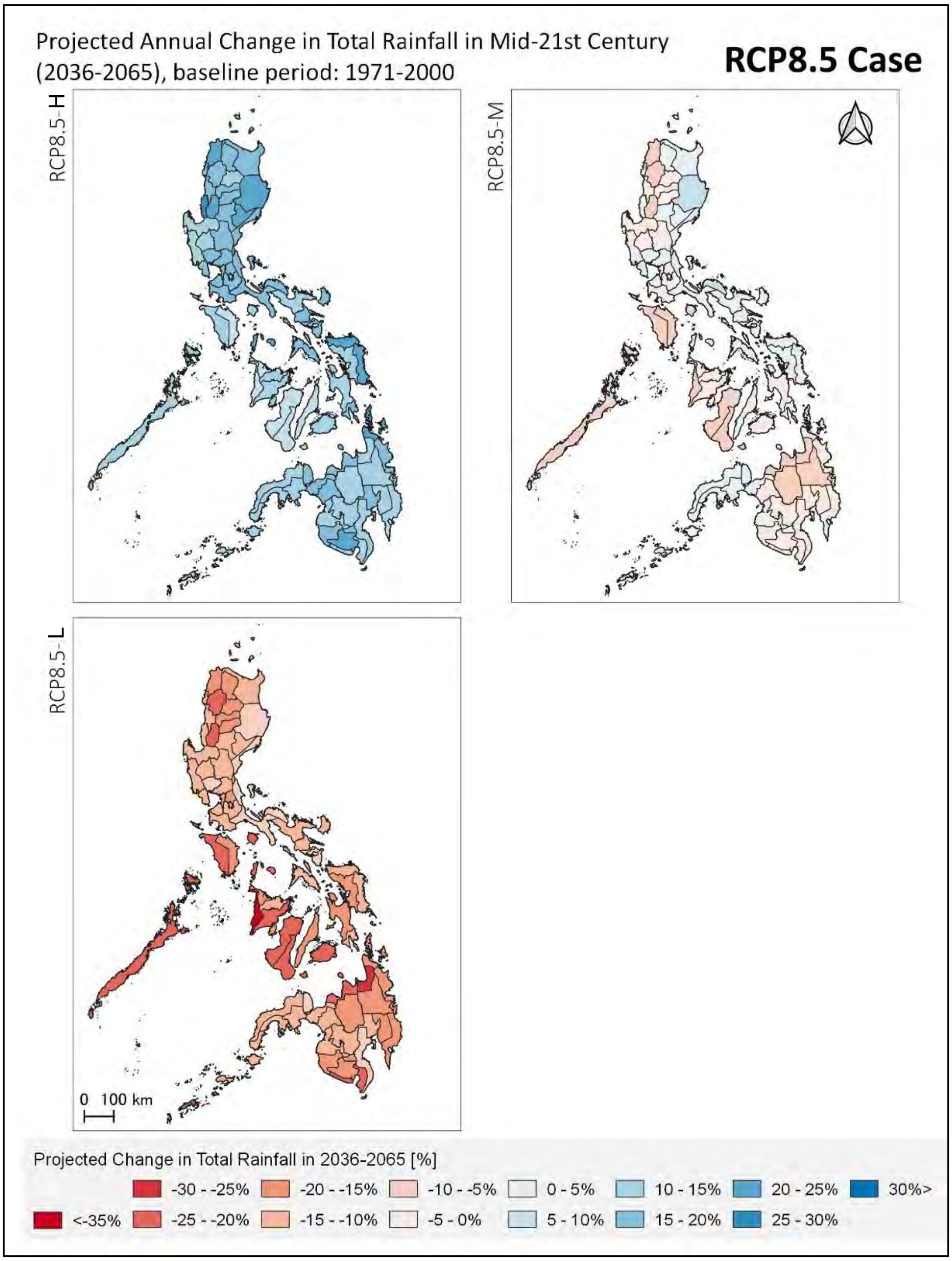
Source: DOST-PAGASA (2019)

Figure 2.3-17 Historical Sea Level Change (SLC) and Future Projections

Figure 2.3-17 (a) shows the historical sea level change (SLC) from tide gauge observations and future projections; (b) and (c) contain time series plots of the global mean sea level change projections under RCP4.5 and RCP8.5. The plot in (a) shows the sum of SLC components for the global ocean (black line, with uncertainty range in grey) and for the coastal region of Legaspi City, Philippines (blue line, with uncertainty), under the RCP8.5 future scenario. Annual mean tide gauge measurements from Legaspi (blue line) and Cebu (green line) are also presented and a linear trend is added to the observations from Legaspi. The solid black line in (a), (b), and (c) represents the central estimate and the shaded area represents the uncertainty of the likely range.

(5) Annual Precipitation Changes

Figure 2.3-18 shows the estimated annual precipitation changes nationwide. In this survey, the RCP8.5 scenario of the DOST-PAGASA report was used as the future climate change forecast value. The report shows three cases of changes in the RCP8.5 scenario in the mid-21st century (2036-2065): upper bound (high, RCP8.5-H case), median, and lower bound (RCP8.5-L case). As shown in Figure 2.3-18, the change in median precipitation is not much different from the current situation, but it is expected to decrease slightly in the WRR-I, VII, X, and XI regions. On the other hand, RCP8.5-L scenario showed that precipitation was higher than the current situation in all regions. In RCP8.5-H scenario, precipitation decreased in all regions compared to the current situation. Seasonal projected annual changes in total rainfall, as well as RCP4.5 case scenarios can be found in Annex-D: Hydrology.



Source: JICA Survey Team based on the report and data of DOST-PAGASA (2019)

Figure 2.3-18 Projected Annual Precipitation Changes Nationwide for RCP8.5 Case

(6) Annual Evapotranspiration Changes in WRRs

In many regions, evapotranspiration increases with increasing temperatures due to future climate change effects. However, in the lower bound case of the RCP8.5 scenario, evapotranspiration in WRR-II, III, VI, X, and XI regions will decrease compared with the current situation. It is considered that this is because the actual evapotranspiration decreases are caused by the soil moisture drying up due to the decrease in precipitation in the lower bound case, rather than the increase in potential evapotranspiration due to the rise in temperature.

2.3.5 Results of Hydrological Analysis

(1) Results of Tank Model Parameter Calibration

The results of Tank Model parameter calibration by hydrographs are shown in Figures in Annex-D, Hydrology. Blue line of hydrograph shows observed discharge and red line of hydrograph shows calculated discharge. The calibrations of the Tank Model parameters are conducted by using the observed discharge within or nearby stations of the sub-basins. Also, for calibration, the most reliable year was used when the annual runoff coefficient of the observed discharge was 0.25 to 0.7. Furthermore, since the main purpose of this analysis is to fit low flow discharge, calibration was performed at a specific discharge of less than 10 $m^3/s/100\text{-}km^2$. The calibration result was also evaluated by the Nash–Sutcliffe model efficiency coefficient (NSE). At many points, the Nash-Sutcliffe coefficient was 0.4 to 0.7 or more, and it was judged that the model was reproducible, which was a sufficient result considering the accuracy of the observed discharge.

(2) Flow Duration Curve of Simulated Specific Discharge by Tank Model

Flow duration curves of simulated specific discharge by Tank Model are shown in Figures in Annex-D, Hydrology.

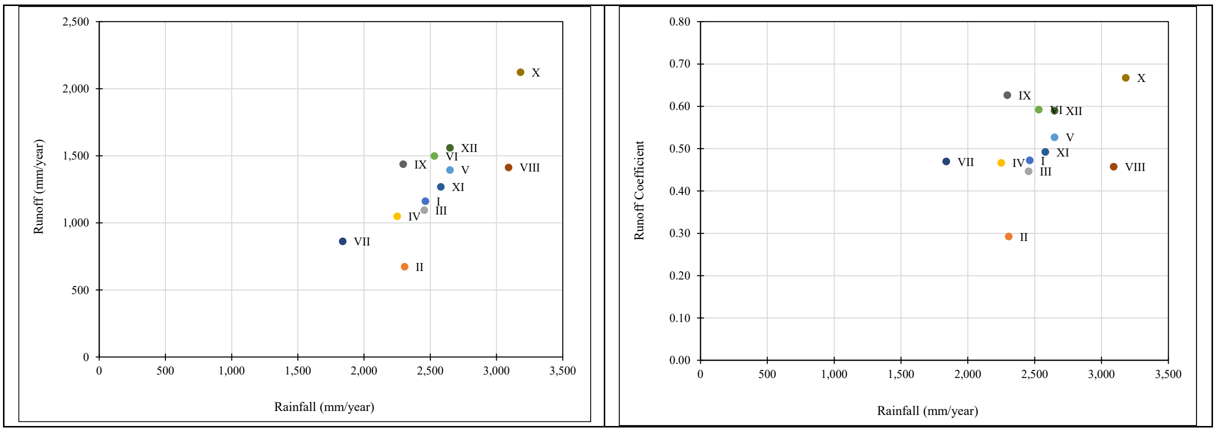
(3) Results of Simulated Runoff by Tank Model

The results of simulated annual runoff by Tank Model are shown in Table 2.3-6 and Figure 2.3-19. The runoff height is almost linear, and the Tank Model calculation results are considered to be within the normal range.

Table 2.3-6 Results of Simulated Mean Annual Rainfall and Runoff by Tank Model

WRR	Annual Rainfall mm/year	Annual Runoff mm/year	Runoff Coefficient -	Area km^2	Specific Q $m^3/s/100\text{-}km^2$
I	2,463	1,163	0.47	12,717	4.69
II	2,306	674	0.29	38,290	8.18
III	2,455	1,095	0.45	27,131	9.42
IV	2,250	1,049	0.47	44,034	14.65
V	2,649	1,395	0.53	17,821	7.88
VI	2,531	1,499	0.59	20,733	9.85
VII	1,839	864	0.47	13,606	3.73
VIII	3,091	1,413	0.46	20,768	9.31
IX	2,296	1,438	0.63	20,395	9.30
X	3,182	2,123	0.67	23,395	15.75
XI	2,580	1,270	0.49	26,486	10.66
XII	2,649	1,561	0.59	30,461	15.08
Average	2,524	1,295	0.51		9.88

Source: JICA Survey Team

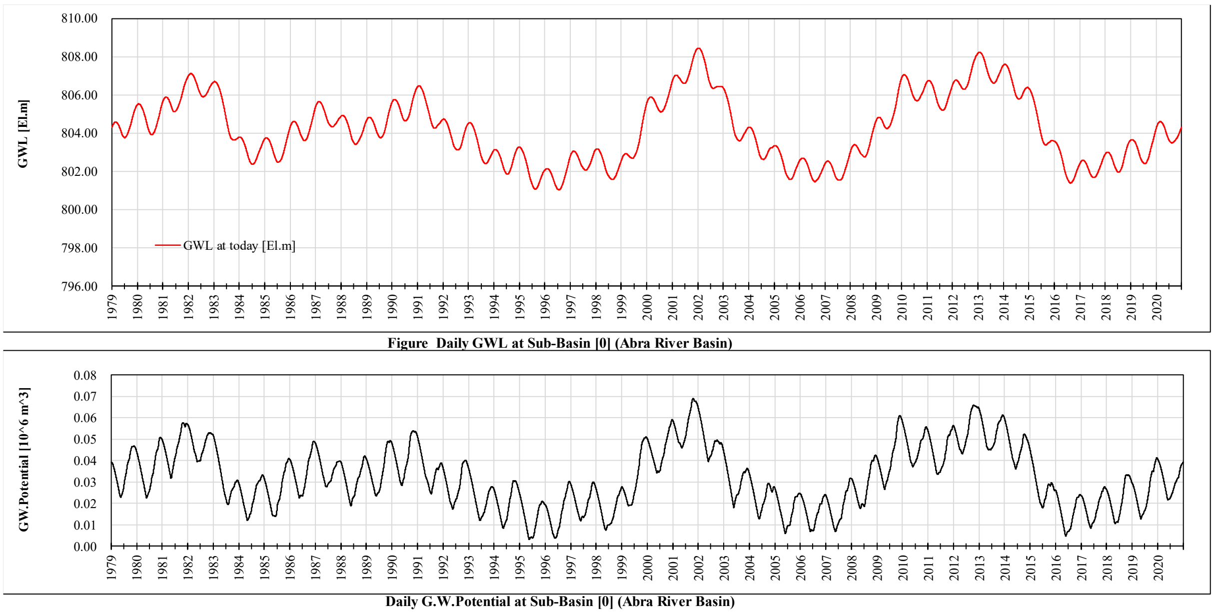


Source: JICA Survey Team

Figure 2.3-19 Results of Simulated Mean Annual Rainfall and Runoff by Tank Model

(4) Results of Groundwater Model Parameter Calibration

As an example of the simulation results by the Groundwater Model, the results of the simulated groundwater level and the calculated groundwater potential of Sub-Basin-0 of WRR-I are shown in Figure 2.3-20.



Source: JICA Survey Team

Figure 2.3-20 Example of Results of Simulated Daily Groundwater Level and Safety Groundwater Potential by Groundwater Model at C00 in WRR-I

The results of Groundwater Model parameter calibration by groundwater level graphs are shown in Figures in Annex-D, Hydrology. The blue dot of the graph shows observed groundwater level and red line of graph shows simulated groundwater level. The calibrations of the Groundwater Model parameters are conducted by using the observed groundwater level within or nearby stations of the sub-basins. However, since the observation data is very limited in terms of spatial distribution, the reference groundwater level data of each sub-basin was selected similar to elevations in the neighbouring areas as points that are topographically similar.

The saturated hydraulic conductivity of aquifer was calibrated that the initial groundwater level and the final groundwater level were the same. Porosity was set to be 0.03 or higher, which is a general value of aquifer. The thickness of the aquifer was set to 25 m, which is the average aquifer thickness in the Philippines. The width of the water flow cross section with the downstream block was set to about 100 m to 10,000 m by considering the block area, and finally calibrated from the fluctuation range of the groundwater level. The groundwater potential was estimated by using calculated groundwater flow by sub-basins and applying safety factor of 0.7.

2.4 Water Resources Potentials

2.4.1 Surface Water Potentials

(1) Study Cases

Using a calibrated Tank Model, surface water potential was calculated in the case where the water demand was zero (0). In addition, the following cases shown in Table 2.4-1 were implemented to assess the impact of climate change on the water resources potential. To calculate the groundwater potential, it was assumed that the current paddy field area would not decrease from the current level, and the groundwater potential was calculated in the case where the current water demand was used.

Table 2.4-1 Case Study on Surface Water Potential by Tank Model

Case No.	Case Name	Weather Condition	Water Demand	Note	used Model
0	Calibration	Present Condition	Present Condition	Water Demand from 1979-2020	-
1	Potential	Present Condition	0	Water Demand = 0	Water Balance Model
2	Present Condition	Present Condition	2020	Water Demand = 2020 fixed	for GW Model
3	RCP8.5-Low_WD=2020	RCP8.5-Low	2020	Water Demand = 2020 fixed	for GW Model
4	RCP8.5-Mid_WD=2020	RCP8.5-Mid	2020	Water Demand = 2020 fixed	for GW Model
5	RCP8.5-High_WD=2020	RCP8.5-High	2020	Water Demand = 2020 fixed	for GW Model
6	RCP8.5-Low_WD=0	RCP8.5-Low	0	Water Demand = 0	Water Balance Model
7	RCP8.5-Mid_WD=0	RCP8.5-Mid	0	Water Demand = 0	Water Balance Model
8	RCP8.5-High_WD=0	RCP8.5-High	0	Water Demand = 0	Water Balance Model

Source: JICA Survey Team

(2) Surface Water Potentials by WRR

The results of the calculation of surface water potentials are shown in Annex-D, Hydrology. For the surface water potential, the total value of the annual discharge including the flood discharge in the 1/5 drought year was taken as the potential according to the irrigation plan. The water resources potential of each sub-basin was weighted and averaged by the area ratio of each sub-basin, and the potential per unit area was used to multiply the area of the entire WRR to calculate the water resource potential of all areas of the WRR.

The impact of climate change on the surface water potential of each WRR is different for each WRR but tends to decrease in the lower bound case of the RCP8.5 scenario and tends to increase in the upper bound case of the RCP8.5 scenario.

2.4.2 Groundwater Potentials

Results of the calculation of groundwater potentials are shown in Annex-D, Hydrology. The impact of climate change on the groundwater potential of each WRR is different for each WRR but tends to decrease in the lower bound case of the RCP8.5 scenario and tends to increase in the upper bound case of the RCP8.5 scenario.

2.5 Water Demand Prediction

2.5.1 Outline of Water Demand Prediction and Basic Approach

Based on the results of collecting and organizing the data of the economic framework in following Section 2.5.2, the demands for agriculture, domestic water, and industrial water are calculated, and the future water demand in each water resources region was predicted.

(1) Setting the Target Year:

The target year for a national level water demand forecast is set at 2050.

(2) Confirmation of Measured Values:

The following measurement values and water rights data were collected to confirm the current water demand, which is the basic value for future forecasts.

i) The effective storage capacity (by purpose) and operation rule of existing major dams located in each water resources region,
ii) Existing groundwater well inventory (location, number, pumping volume),
iii) Water intake volume of existing irrigation, facilities, and
iv) Water permit data prepared by NWRB.

The "water permit data" of NWRB is only permitted data and also, the amount of permitted water intake value is the requested amount and may not be the actual amount of water intake. For this reason, it is not sufficient to be a true basis for water demand estimation. However, in this survey, the calculating of the water demand for each sub-basin were calculated by using the water demand at the province or municipality level, and the location/coordinates of the intake sites and the ratio of permitted water intake by purpose. Therefore, it is considered that this method is rational and can ensure a certain degree of accuracy.

2.5.2 Socio-Economic Framework

The following socio-economic framework was set to project water demand in the Philippines:

i) Population by Region, Province, City and Municipality

ii) GDP and GRDP

(1) Methodology of Projection of Population

Data of population and AAGR is collected based on the latest census data (2010, 2015 and 2020) publicized by the PSA. Regional development plans are used as a reference.

i) The population projection by region and province is based on the medium of the population projection from 2015 to 2045 publicized by the PSA in 2010.

ii) Since the population projection from 2015 to 2025 was updated in 2015, the above projection was revised based on the updated projection.

iii) The population by region and province from 2045 to 2050 was projected based on the trend of population growth rate from 2021 to 2045 by JICA Study Team.

iv) The population projection by city and municipality is not publicized by the PSA. Therefore, the population was distributed based on the regional population share in province of the census 2015.

v) Since population in 2020 was published, it was updated by JICA Study Team in 2022.

(2) Projection of Population by Nation and Region

The national population of the Philippines was projected to increase from 109,035,343 in 2020 to 143,286,211 in 2050 as shown in Table 2.5-1. It increases by 1.3 times.

The results of regional population projection is also shown in Table 2.5-1. The highest AAGR of 2.2% is expected in BARMM from 2020 to 2025, followed by Calabarzon (Region IV-A) of 1.8%, Central Luzon (Region III) of 1.5% and Davao (Region XI) of 1.5% as shown in Table 2.5-1. On the contrary, Ilocos (Region I), Zamboanga Peninsula (Region IX), Northern Mindanao (Region X) has the lowest AAGR of 0.7% from 2020 to 2025, followed by Western Visayas (Region VI) of 0.8%.

Additionally, BARMM has the highest AAGR of 1.4% from 2045 to 2050, followed by Caraga (Region XIII) of 1.1% and Bicol (Region V) of 1.0%. NCR has the lowest AAGR of -0.2% from 2045 to 2050, followed by Ilocos (Region I) of 0.0% and Cagayan Valley (Region II) of 0.1%.

(3) Projection of Population by Province

The results of the population projection by province (Medium/Low/High Cases) are shown in Annex-B.

Table 2.5-1 National and Regional Population Projection in Philippines

Administrative Region	Census Results			Population Projection						Average Annual Growth Rate							
	2010	2015	2020	2025	2030	2035	2040	2045	2050	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
PHILIPPINES*	92,337,852	100,981,437	109,035,343	115,891,083	123,284,404	129,782,360	135,357,291	139,886,989	143,286,211	1.7%	1.5%	1.2%	1.2%	1.0%	0.8%	0.7%	0.5%
National Capital Region (NCR)	11,855,975	12,877,253	13,484,462	14,207,245	14,587,873	14,859,435	15,017,450	15,029,180	14,887,900	1.6%	0.9%	1.0%	0.5%	0.4%	0.2%	0.0%	-0.2%
Cordillera Administrative Region (CAR)	1,616,867	1,722,006	1,797,660	1,866,097	1,996,430	2,114,795	2,224,591	2,321,125	2,400,540	1.2%	0.9%	0.8%	1.4%	1.2%	1.0%	0.9%	0.7%
REGION I - ILOCOS	4,748,372	5,026,128	5,301,139	5,499,777	5,709,141	5,862,918	5,956,142	5,997,256	5,983,724	1.1%	1.1%	0.7%	0.8%	0.5%	0.3%	0.1%	0.0%
REGION II - CAGAYAN VALLEY	3,229,163	3,451,410	3,685,744	3,854,955	4,026,094	4,157,739	4,247,023	4,297,223	4,308,575	1.3%	1.3%	0.9%	0.9%	0.6%	0.4%	0.2%	0.1%
REGION III - CENTRAL LUZON	10,137,737	11,218,177	12,422,172	13,399,160	14,073,281	14,653,646	15,113,325	15,431,228	15,614,161	2.0%	2.1%	1.5%	1.0%	0.8%	0.6%	0.4%	0.2%
REGION IV-A - CALABARZON	12,609,803	14,414,774	16,195,042	17,691,929	18,874,221	19,895,721	20,765,860	21,443,785	21,882,557	2.6%	2.4%	1.8%	1.3%	1.1%	0.9%	0.6%	0.4%
REGION IV-B - MIMAROPA REGION	2,744,671	2,963,360	3,228,558	3,409,486	3,690,765	3,954,840	4,196,820	4,411,154	4,591,413	1.5%	1.7%	1.1%	1.6%	1.4%	1.2%	1.0%	0.8%
REGION V - BICOL	5,420,411	5,796,989	6,082,165	6,354,276	6,936,643	7,498,680	8,025,192	8,507,834	8,932,767	1.3%	1.0%	0.9%	1.8%	1.6%	1.4%	1.2%	1.0%
REGION VI - WESTERN VISAYAS	7,102,438	7,536,383	7,954,723	8,268,138	8,743,545	9,167,741	9,524,308	9,823,255	10,071,033	1.3%	1.1%	0.8%	1.1%	1.0%	0.8%	0.6%	0.5%
REGION VII - CENTRAL VISAYAS	6,800,180	7,396,898	8,081,988	8,548,393	9,090,007	9,570,437	9,976,015	10,316,159	10,604,195	1.8%	1.8%	1.1%	1.2%	1.0%	0.8%	0.7%	0.6%
REGION VIII - EASTERN VISAYAS	4,101,322	4,440,150	4,547,150	4,844,856	5,254,252	5,642,330	6,000,130	6,323,399	6,605,989	1.5%	0.5%	1.3%	1.6%	1.4%	1.2%	1.1%	0.9%
REGION IX - ZAMBOANGA PENINSULA	3,407,353	3,629,783	3,875,576	4,005,196	4,303,284	4,578,493	4,820,916	5,026,421	5,194,662	1.2%	1.3%	0.7%	1.4%	1.2%	1.0%	0.8%	0.7%
REGION X - NORTHERN MINDANAO	4,297,323	4,689,302	5,022,768	5,191,954	5,601,859	5,853,584	6,042,047	6,166,770	6,224,978	1.7%	1.4%	0.7%	1.5%	0.9%	0.6%	0.4%	0.2%
REGION XI - DAVAO	4,468,563	4,893,318	5,243,536	5,649,098	6,059,239	6,435,269	6,767,827	7,048,176	7,275,507	1.7%	1.4%	1.5%	1.4%	1.2%	1.0%	0.8%	0.6%
REGION XII - SOCCSKSARGEN	4,109,571	4,545,276	4,360,974	4,633,766	4,987,767	5,312,226	5,599,572	5,839,756	6,024,644	1.9%	-0.8%	1.2%	1.5%	1.3%	1.1%	0.8%	0.6%
REGION XIII - CARAGA	2,429,224	2,596,709	2,804,788	2,951,611	3,219,308	3,483,531	3,741,516	3,986,790	4,215,471	1.3%	1.6%	1.0%	1.8%	1.6%	1.4%	1.3%	1.1%
Bangsamoro Autonomous Region in Muslim Mindanao (BARMM)	3,256,140	3,781,387	4,944,800	5,515,146	6,130,695	6,740,975	7,338,557	7,917,478	8,468,095	2.9%	5.5%	2.2%	2.1%	1.9%	1.7%	1.5%	1.4%

Source: 1. Philippine Statistics Authority, “2010 Census of Population and Housing”, 2. Philippine Statistics Authority, “2015 Census of Population", 3. Philippine Statistics Authority, “2020 Census of Population", 4. Population projection by JICA Study Team based on PSA "2010 Census-based Population Projections in collaboration with the Inter-Agency Working Group on Population Projections" and "Updated Projected Mid-Year Population Based on 2015 POPCEN by Five-Year Age Group, Sex, Single-Calendar Year and by Province: 2015 - 2025"

(4) Methodology of Projection of GDP and GRDP

GDP and GRDP from 2021 to 2050 is projected based on the data of GDP and GRDP growth rate of "Updated Philippine Development Plan 2017-2022 (PDP)", "Regional Development Plan 2017-2022 (RDP)", International Monetary Fund (IMF) "World Economic Outlook" and the past trend of them. Although the PDP 2023-2028 was published in January 2023, the PDP 2017-2022 was used to estimate the GDP in 2021 and 2022. Therefore, there is no impact on the projections of GDP and GRDP by the PDP 2023-2028.

1) GDP

i) GDP (Medium) from 2021 to 2026 was projected based on NEDA (2021) "PDP" and IMF (2021) "World Economic Outlook Database".
ii) GDP (Medium) from 2027 to 2050 was projected based on the GDP annual growth trend of other countries in Asia which have GDP per capita which is similar to that of the Philippines.
iii) GDP (Low) was projected based on ADB's projections which are -0.5% of GDP annual growth rate of medium case. GDP (High) is projected based on +0.5% of GDP annual growth rate of medium case.

2) GRDP

i) GRDP (Medium) in 2021 and 2022 was estimated based on forecast of NEDA (2017) "RDP" Data. GRDP of some regions which do not have forecast of RDP data was projected based on the past trend.
ii) GRDP (Medium) from 2023 to 2036 was projected based on the GDP projection in 2022 by NEDA and the regional gap of growth rate was projected to be gradually reduced. From 2037 to 2050, the growth rates were projected to increase in corporation to the population growth rate of each region.
iii) GRDP (High and Low) was projected based on the GDP projection (High and Low) and share of each region of medium case.

3) GDP by Major industries

i) GDP by major industries (Medium) was estimated based on the past trend of share of major industries in the Philippines from 2000 to 2020 and the GDP projection (Medium).
ii) GDP by major industry (High and Low) was projected based on the GDP projections (High and Low) and the share of major industry of medium case.

(5) Projection of GDP

GDP (Medium, Low and High) from 2021 to 2050 was projected as shown in Table 2.5-2 and Figure 2.5-1. The total GDP was projected to increase from 19,194,283 million pesos in 2021 to 212,208,301 million pesos in 2050 in medium case. After the GDP growth rate was estimated to be 7.0% in 2021 and 2022, it will increase to 9.7% from 2023 to 2026. It was projected to decrease to 7.7% in 2047.

Additionally, the total GDP (Low) is projected to increase from 19,104,590 million pesos in 2021 to 184,768,551 million pesos in 2050 in low case. After the GDP growth rate is estimated to be 6.5% in 2021 and 2022, it will increase to 9.2% from 2023 to 2026. It is projected to decrease to 7.2% in 2047.

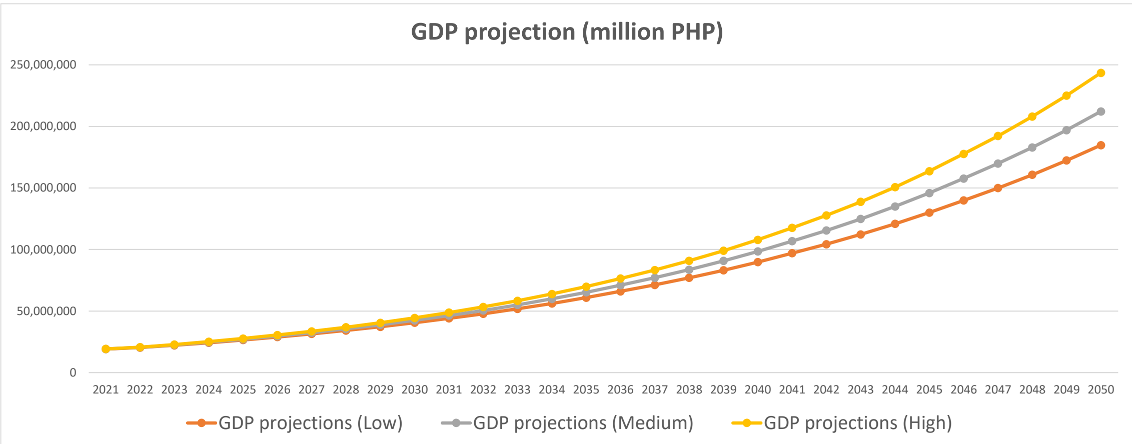
Furthermore, the total GDP (High) is projected to increase from 19,283,976 million pesos in 2021 to 243,568,093 million pesos in 2050 in high case. After the GDP growth rate is estimated to be 7.5% in 2021 and 2022, it will increase to 10.2% from 2023 to 2026. It is projected to decrease to 8.2% in 2047.

Table 2.5-2 GDP Projection (High/Medium/Low)

At Current Prices (Unit: Mil. PHP)

Item	2021	2030	2040	2050
GDP Projection (Medium)	19,194,283	42,448,547	98,478,482	212,208,301
GDP Growth Rate (%)	7.0%	9.3%	8.5%	7.7%
Item	2021	2030	2040	2050
GDP Projection (Low)	19,104,590	40,540,908	89,818,087	184,768,551
GDP Growth Rate (%)	6.5%	8.8%	8.0%	7.2%
Item	2021	2030	2040	2050
GDP Projection (High)	19,283,976	44,436,596	107,928,398	243,568,093
GDP Growth Rate (%)	7.5%	9.8%	9.0%	8.2%

Source: 1. NEDA (2021) "Updated Philippine Development Plan 2017-2022" for data in 2021 and 2022, 2. International Monetary Fund (2021) "World Economic Outlook Database" for data from 2023 to 2026, 3. JICA Study Team's projection from 2027 to 2050



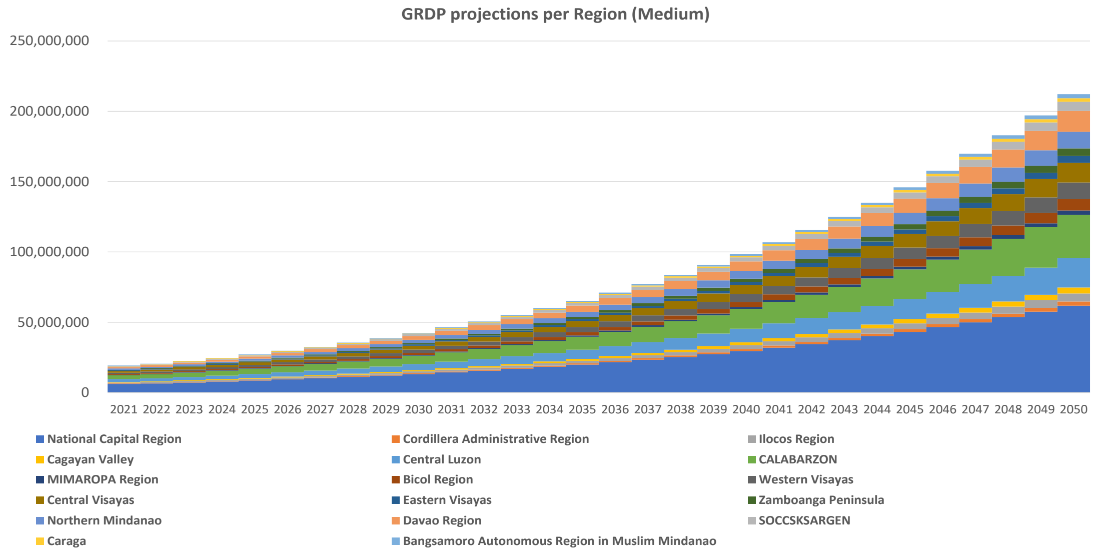
At Current Prices (Unit: Mil. PHP)

Source: 1. NEDA (2021) "Updated Philippine Development Plan 2017-2022" for data in 2021 and 2022, 2. International Monetary Fund (2021) "World Economic Outlook Database" for data from 2023 to 2026, 3. JICA Study Team's projection from 2027 to 2050

Figure 2.5-1 GDP Projection (High/Medium/Low)

(6) Projection of GRDP

GRDP (Medium, Low and High) from 2021 to 2050 is projected as shown in Figure 2.5-2 and Annex-B. The GRDP of Davao Region (Region XI) is expected to increase from 987,298 million pesos in 2021 to 14,869,958 million pesos in 2050 at the highest average GRDP growth rate of 9.8% in medium case. On the contrary, the GRDP of Caraga (Region XIII) is expected to increase from 303,332 million pesos in 2021 to 2,493,346 million pesos in 2050 at the lowest average GRDP growth rate of 7.5% in medium case.



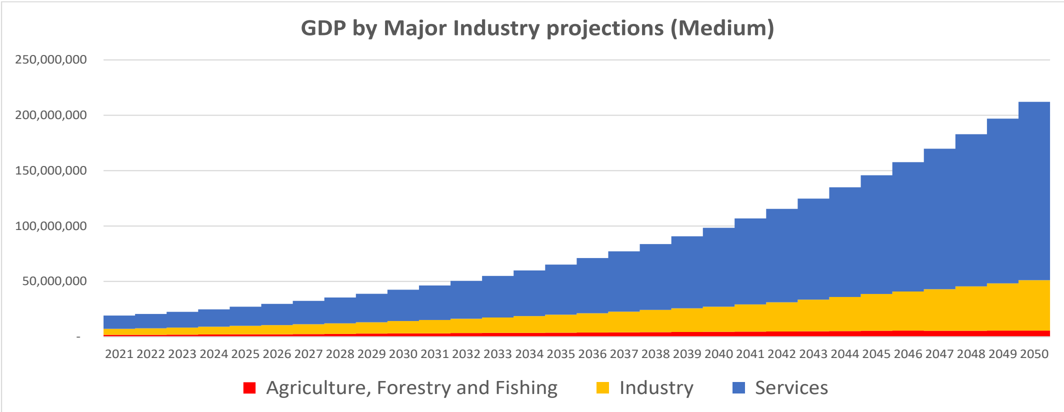
at Current Prices (Unit: Mil. PHP)

Source: 1. PSA (2021) "Regional Accounts of the Philippines" for data from 2017 to 2020, 2. Regional Development Plan (2017) for Data in 2021 and 2022, 3. JICA Study Team's projection from 2023 to 2050

Figure 2.5-2 GRDP Projection (Medium)

(7) Projection of GDP by Major Industries

GDP by major industries (Medium, Low and High) from 2021 to 2050 is projected as shown in Figure 2.5-3 and Annex-B. The share of "Agriculture, Forestry and Fishing" in the total GDP is expected to decrease from 9.2% in 2021 to 2.6% in 2050 in medium case while that of "Industry" in the total GDP is projected to decrease from 28.5% in 2021 to 21.5% in 2050. On the other hand, that of "Services" is expected to increase from 62.3% in 2021 to 75.9% in 2050. Additionally, the total GDP in low and high cases are based on the projection in "(5) Projection of GDP", and the share of three major industries in low and high cases are same as that in medium cases.



At Current Prices (Unit: Mil. PHP)

Source: JICA Study Team

Figure 2.5-3 GDP by Major Industries Projection (Medium)

2.5.3 Water Demand Forecast (Agricultural Use)

(1) Future Irrigation Area

In order to assess the water resources in the year of 2030, 2040, and 2050, the respective irrigation water demands were estimated. For the purpose, future ISA, FUSA and irrigated area were projected based on the two programs, (i) National Irrigation Master Plan (NIMP) 2020-2030, and (ii) NIA Annual Irrigation Programs from 2011 to 2020.

The future firm-up irrigation service areas in 2030, 2040 and 2050 based on NIMP 2020-2030 are estimated at 2,602,273 ha, 2,995,392 ha and 3,180,147 ha, respectively. The required increase in the area from 2020 to 2030, 2030 to 2040 and 2040 to 2050 are 823,634 ha, 393, 119 ha and 184, 755 ha, respectively. There are 57 identified priority provinces for paddy production with newly estimated potential irrigable area of 4,620,387 ha in the NIMP. Based on above FUSA in 2030, 2040, and 2050 and the potential service areas in 57 provinces, the irrigated areas in 2030, 2040, and 2050 are calculated by each province (refer to Table F-14 in Annex-F).

JICA Survey Team also studied the possible irrigation development plan based on NIA's past financial programs from 2011 to 2010. Based on the average of these 10 years irrigation development areas, annual increased area of ISA is assumed at 38,000 ha. The future ISAs in 2030, 2040 and 2050 are estimated at about 2,355,000 ha, 2,735,000 ha and 3,115,000 ha, respectively. The potential irrigable area was reported at 3,128,632 ha in NIA Status of Irrigation Development as of December 31, 2019. The remaining irrigable area for future development is 1,153,352 ha as of December 31, 2020. The future ISAs and FUSAs by province are estimated based on the ratio of remaining potential area by province to the total remaining area. The irrigated areas by province are also calculated based on the NIMP targeted cropping intensity of 170% (refer to Table F-15 in Annex-F).

(2) Irrigation Water Requirements

The Philippines has imported rice every year since the middle of the 1990s. Under this situation, irrigation water demands was estimated based on the paddy-paddy cropping pattern. The double cropping of paddy requires the maximum water demand in the irrigated farming for all crops.

The irrigation water requirements are estimated for the two cases. One is the requirements based on NIA's present operation with JICA Survey Team's modifications. Other is the requirements based on proposed future operations considering the improved irrigation water management. Calculation sheets for irrigation water requirements of each province are shown in Attachment-A of Annex-F for present operation and Attachment-B of Annex-F for future operation.

(3) Present Irrigation Water Demands

Based on the 2020 irrigation area, the irrigation water demands (IWD) by provinces in 2020 are calculated (refer to Table F-18 of Annex-F). Annual total demand is estimated at 31,524 MCM (Table 2.5-3).

Table 2.5-3 Estimated Present Irrigation Water Demands

ISA (ha)	FUSA (ha)	Irrigated Area (ha)		Cropping Intensity (%)	IWD (MCM)
		Wet	Dry		
1,975,280	1,778,181	1,424,239	1,308,417	153.7	31,527

Source: JICA Survey Team

(4) Future Irrigation Water Demands

Future water demands are calculated for two cases of irrigation areas, based on the NIMP 2020-2030 and based on the past NIA financial programs. Annual total demands for each case are summarized in Table 2.5-4.

Table 2.5-4 Estimated Future Irrigation Water Demands

Year	ISA (ha)	FUSA (ha)	Irrigated Area (ha)		Cropping Intensity (%)	IWD (MCM)
			Wet	Dry		
Based on NIMP 2020-2030						
2030	2,799,014	2,602,815	2,313,988	2,110,798	170	49,901
2040	3,193,033	2,995,934	2,662,389	2,430,698	170	57,283
2050	3,377,788	3,180,689	2,826,128	2,581,043	170	60,753
Based on NIA Past Financial Programs						
2030	2,355,280	2,158,181	1,918,116	1,750,791	170	41,300
2040	2,735,280	2,538,181	2,253,076	2,061,832	170	48,186
2050	3,115,280	2,918,181	2,588,035	2,372,872	170	55,069

Source: JICA Survey Team

(5) Irrigation Water Demands by Water Resources Regions

Based on the area rate of each provincial area in water resources region (WRR), irrigation areas by provinces of each WRR and these water demands are calculated. The monthly irrigation water demands for all irrigation systems by WRR in 2020 are summarized in Table 2.5-5.

Table 2.5-5 Monthly Irrigation Water Demands for All Systems by WRR in 2020

(Unit: MCM)

WRR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
I	243.65	198.93	43.22	0.96	13.61	122.97	172.23	143.48	107.15	26.17	190.52	185.52	1,448.41
II	1,147.19	1,175.41	587.54	53.70	37.63	872.41	809.94	648.39	522.55	67.58	606.75	661.06	7,190.16
III	1,282.51	1,246.19	734.86	89.54	29.61	288.87	625.67	641.20	509.07	408.30	898.86	1,200.41	7,955.08
IV	400.75	405.21	275.09	46.03	305.68	213.35	281.92	176.01	33.02	31.72	89.89	338.31	2,596.97
V	279.67	334.49	305.80	10.06	268.52	271.96	143.01	149.78	8.19	0.00	0.87	191.75	1,964.11
VI	294.84	106.20	3.55	0.00	232.16	180.11	200.23	198.25	15.58	97.59	208.14	297.36	1,834.01
VII	110.46	46.06	10.24	0.00	47.04	85.01	98.67	102.19	32.15	41.26	111.90	109.53	794.51
VIII	192.69	108.00	15.55	67.91	69.27	165.25	108.40	117.28	70.64	0.00	89.40	119.33	1,123.72
IX	190.68	113.23	21.63	97.67	118.04	78.99	54.48	25.24	12.12	21.07	63.23	84.22	880.61
X	196.33	173.86	78.50	0.86	17.59	140.14	77.49	118.22	54.51	0.00	57.10	80.09	994.69
XI	243.98	180.57	130.35	78.93	82.41	177.79	117.42	141.51	83.14	47.08	159.47	243.83	1,686.48
XII	252.06	59.93	224.37	499.59	407.74	268.83	59.18	57.30	115.39	264.18	385.43	463.45	3,057.44
Total	4,834.80	4,148.07	2,430.69	945.26	1,629.32	2,865.68	2,748.65	2,518.88	1,563.50	1,004.95	2,861.57	3,974.84	31,526.20

Source: JICA Survey Team

The future irrigation areas of 2030, 2040 and 2050 by WRR are also estimated based on the area rate of each provincial area in WRR. The future irrigation water demands are estimated for the future irrigation areas based on NIMP 2020-2030 and the areas based on NIA's 2011-2020 financial program. The monthly irrigation water demands for the future irrigation areas based on NIA's 2011-2020 financial program are summarized in Table 2.5-6 to Table 2.5-8.

Table 2.5-6 Monthly Irrigation Water Demands by WRR in 2030 (All Systems under NIA Financial Programs)

(Unit: MCM)

WRR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
I	308.47	258.59	71.22	0.00	19.41	150.61	227.56	197.01	146.46	37.07	225.27	239.04	1,880.72
II	1,339.35	1,386.71	733.84	93.11	65.29	971.62	943.42	775.70	608.74	95.13	679.83	785.55	8,478.29
III	1,609.01	1,526.17	880.33	90.46	35.20	363.06	826.20	838.08	654.70	518.74	1,123.70	1,474.71	9,940.36
IV	558.95	575.65	415.44	98.07	315.32	239.12	275.31	221.21	50.28	40.52	127.77	360.28	3,277.94
V	417.49	514.64	562.33	83.44	436.05	422.43	293.75	302.33	12.53	0.00	1.43	261.72	3,308.13
VI	403.35	152.74	5.74	0.00	347.02	240.77	225.04	240.13	7.67	141.88	271.46	385.60	2,421.41
VII	149.78	71.69	16.07	0.00	71.41	98.97	129.44	128.79	48.46	49.75	137.18	147.35	1,048.90
VIII	242.68	158.15	29.13	113.39	108.45	214.78	136.52	136.32	81.85	0.00	113.85	150.01	1,485.13
IX	245.55	152.80	31.56	133.07	174.56	128.22	94.63	34.40	13.67	22.61	83.68	119.07	1,233.83
X	375.91	329.64	116.94	1.80	17.77	280.53	149.21	235.94	121.24	0.00	111.73	159.15	1,899.87
XI	301.33	250.00	158.55	111.39	95.77	288.82	210.64	252.93	147.95	50.20	217.29	291.56	2,376.43
XII	377.36	100.06	283.89	628.33	452.01	291.33	56.17	89.79	173.78	352.69	502.06	641.33	3,948.78
Total	6,329.22	5,476.84	3,305.04	1,353.06	2,138.26	3,690.27	3,567.90	3,452.64	2,067.34	1,308.59	3,595.23	5,015.37	41,299.77

Source: JICA Survey Team

Table 2.5-7 Monthly Irrigation Water Demands by WRR in 2040 (All Systems under NIA Financial Programs)

(Unit: MCM)

WRR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
I	312.79	262.11	71.93	0.00	19.41	151.91	230.53	201.50	149.75	37.92	228.55	243.06	1,909.46
II	1,527.26	1,582.60	838.26	103.44	67.98	1,101.70	1,075.28	884.30	688.22	101.82	763.71	893.77	9,628.34
III	1,795.65	1,701.68	977.68	99.02	36.76	408.88	933.18	942.11	731.63	576.86	1,259.13	1,643.01	11,105.61
IV	626.23	643.41	457.62	105.51	344.63	265.55	310.20	244.94	58.48	47.58	147.11	404.38	3,655.64
V	506.07	623.50	679.13	100.58	528.12	509.19	355.60	365.10	15.03	0.00	1.55	315.31	3,999.18
VI	465.50	176.07	6.78	0.00	399.50	281.61	263.21	280.15	8.30	163.00	316.91	447.80	2,808.83
VII	157.03	74.91	16.89	0.00	75.84	103.58	135.91	134.90	50.36	52.24	143.68	155.30	1,100.64
VIII	263.38	172.62	32.16	123.76	119.36	234.60	146.49	148.72	89.35	0.00	122.43	162.33	1,615.19
IX	294.52	180.36	34.51	167.79	220.72	158.97	118.89	40.11	13.96	28.31	100.45	147.35	1,505.94
X	508.99	441.56	155.02	2.31	22.98	387.51	200.97	318.93	170.72	0.00	152.69	219.84	2,581.52
XI	391.23	307.85	191.98	144.46	122.09	376.76	262.59	318.08	198.98	63.56	279.96	373.05	3,030.57
XII	502.31	123.20	366.02	838.36	593.64	379.13	70.16	104.53	240.90	479.73	681.48	865.19	5,244.63
Total	7,350.95	6,289.87	3,827.99	1,685.21	2,551.04	4,359.39	4,102.99	3,983.36	2,415.69	1,551.03	4,197.66	5,870.38	48,185.55

Source: JICA Survey Team

Table 2.5-8 Monthly Irrigation Water Demands by WRR in 2050 (All Systems under NIA Financial Programs)

(Unit: MCM)

WRR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
I	317.11	265.62	72.64	0.00	19.41	153.22	233.49	205.99	153.05	38.78	231.83	247.07	1,938.21
II	1,715.18	1,778.50	942.69	113.76	70.67	1,231.78	1,207.14	992.89	767.69	108.50	847.60	1,002.00	10,778.40
III	1,982.30	1,877.19	1,075.03	107.58	38.33	454.70	1,040.16	1,046.15	808.56	634.98	1,394.57	1,811.32	12,270.86
IV	693.51	711.18	499.80	112.94	373.94	291.98	345.08	268.67	66.67	54.64	166.46	448.47	4,033.34
V	594.64	732.37	795.94	117.72	620.19	595.94	417.45	427.86	17.53	0.00	1.68	368.90	4,690.22
VI	527.65	199.39	7.82	0.00	451.98	322.45	301.37	320.16	8.94	184.13	362.37	509.99	3,196.26
VII	164.27	78.13	17.71	0.00	80.26	108.18	142.38	141.01	52.26	54.73	150.19	163.25	1,152.38
VIII	284.07	187.09	35.19	134.12	130.26	254.42	156.46	158.43	96.86	0.00	131.01	174.65	1,742.57
IX	343.50	207.91	37.45	202.50	266.89	189.72	143.14	45.81	14.24	34.02	117.22	175.63	1,778.04
X	642.07	553.48	193.10	2.82	28.19	494.49	252.73	401.92	220.21	0.00	193.64	280.52	3,263.17
XI	481.12	365.69	225.41	177.52	148.42	464.70	314.54	383.23	250.00	76.92	342.63	454.54	3,684.71
XII	627.25	146.35	448.14	1,048.39	735.26	466.93	84.14	119.28	308.02	606.76	860.91	1,089.05	6,540.48
Total	8,372.68	7,102.89	4,350.94	2,017.35	2,963.81	5,028.52	4,638.09	4,511.40	2,764.03	1,793.47	4,800.09	6,725.39	55,068.65

Source: JICA Survey Team

(6) Water Demands for Fishery Sub-Sector

The unit water requirement of 0.9259 lit/sec/ha (80 cum/day/ha) for tilapia under freshwater fishpond is adopted for the estimation of water demands, whose criteria were used as basis in granting water right for fishery purpose by NWRB. The water demands for freshwater aquafarms are estimated based on the unit water requirement and the area (18,851 ha) of aquafarms in 2020, explained above. The annual water demands in 2030, 2040 and 2050 are also estimated as shown in Table 2.5-9 with adopting the annual increase rate of 1.6% for the quantity of fish production in freshwater fishpond.

Table 2.5-9 Annual Water Demands for Fresh Water Aquafarms

Year	Area of Fresh Water Aquafarms*1	Annual Water Demands for Fishery (FWD)	Annual Water Demands for Irrigation (IWD)	(FWD)/(IWD)
2020	18,851 ha	**550 MCM**	31,529 MCM	**1.74%**
2030	(18,851 ha) x $(1.016)^{10}$= 22,094 ha	**645 MCM**	41,300 MCM*2	**1.56%**
2040	(18,851 ha) x $(1.016)^{20}$= 25,895 ha	**756 MCM**	48,186 MCM*2	**1.57%**
2050	(18,851 ha) x $(1.016)^{30}$= 30,349 ha	**886 MCM**	55,069 MCM*2	**1.61%**

Source: JICA Survey Team
Remarks: *1=Include fishpond, fish pen, fish cage, fish tank, hatchery, etc.
*2=IWD estimated in consideration of NIA Financial Programs

(7) Water Demands for Livestock/Poultry Sub-Sector

The unit water requirements of 2.4 lit/sec/10,000 heads (21 cum/day/1,000 heads) for livestock and 1.46 lit/sec/1 million heads (130 cum/day/1 million heads) for poultry are adopted for the estimation of water demands, whose criteria were used as basis in granting water right for livestock/poultry by NWRB. As explained above, total heads of livestock and poultry in 2020 are counted at 16,203 thousand heads (TH) (Carabao=2,865 TH, Cattle = 2,542 TH and Hog = 12,796 TH) and 178,265 TH of chicken. Assuming the heads of livestock/poultry would be increased with following the population increase ratio, annual water demands for livestock/poultry would be also calculated as showing in Table 2.5-10.

Table 2.5-10 Annual Water Demands for Livestock and Poultry

Year	Total Heads (Thousand)		Annual Water Demands for Livestock/ Poultry (LPWD)	Annual Water Demands for Irrigation (IWD)	(LPWD) /(IWD)
	Livestock	Poultry			
2020	16,203	178,265	**133 MCM**	31,529 MCM	**0.42%**
2030	(16,203) x (1.133)*1= 18,358	(178, 265) x (1.133) *1= 201,973	**150 MCM**	41,300 MCM*4	**0.36%**
2040	(16,203) x (1.243) *2= 20,140	(178, 265) x (1.243) *2= 221,583	**165 MCM**	48,186 MCM*4	**0.34%**
2050	(16,203) x (1.315) *3= 21,307	(178, 265) x (1.315) *3= 234,418	**174 MCM**	55,069 MCM*4	**0.32%**

Source: JICA Survey Team

Remarks: *1=Population: (123,833,055 in 2030) / (109,292,453 in 2020)=1.133
*2=Population: (135,881,380 in 2040) / (109,292,453 in 2020)=1.243
*3=Population: (143,758,859 in 2050) / (109,292,453 in 2020)=1.315
*4=IWD estimated in consideration of NIA Financial Programs

2.5.4 Water Demand Forecast for Municipal and Industrial Sector

(1) Methodology and Conditions

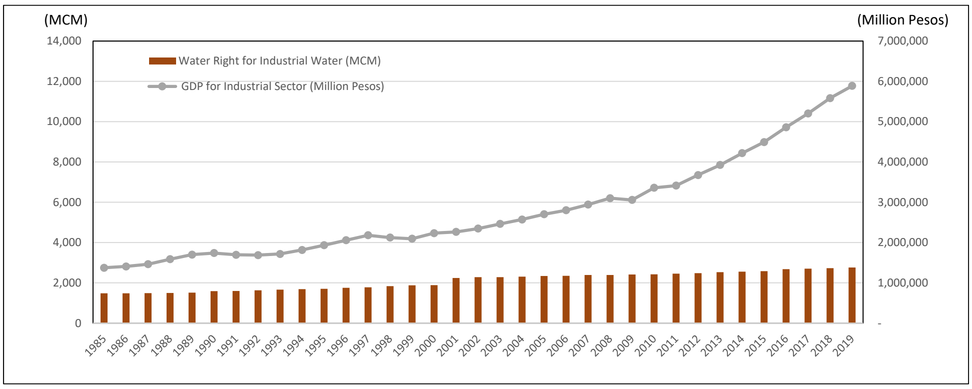
In this survey, the objective area is set to WRR, and the target year is set to 2050. The water demand for municipal sector was estimated by increasing the present water demand in proportion to the population projection from 2015 to 2050 as follows:

Table 2.5-11 Population Projection from 2015 to 2050

Water Resource Region	Census Results	Population Projection (Medium)						
	2015	2020	2025	2030	2035	2040	2045	2050
PHILIPPINES*	100,981,437	108,771,978	115,377,992	122,594,631	129,017,332	134,522,463	138,985,510	142,321,162
WRR I - ILOCOS	3,415,049	3,581,919	3,709,847	3,868,527	3,991,763	4,077,770	4,129,970	4,145,565
WRR II - CAGAYAN VALLEY	5,139,790	5,461,617	5,714,921	6,002,318	6,237,925	6,419,697	6,546,926	6,617,309
WRR III - CENTRAL LUZON	13,933,561	15,152,985	16,168,616	16,924,663	17,558,009	18,044,327	18,362,794	18,517,805
WRR IV - SOUTHERN TAGALOG	28,806,796	31,469,488	33,679,558	35,445,792	36,937,974	38,155,460	39,023,100	39,483,925
WRR V - BICOL	6,174,918	6,554,821	6,855,893	7,472,630	8,064,672	8,616,972	9,120,126	9,558,853
WRR VI - WESTERN VISAYAS	7,918,932	8,322,287	8,645,904	9,146,558	9,593,163	9,968,763	10,283,529	10,544,767
WRR VII - CENTRAL VISAYAS	7,014,367	7,539,645	7,947,513	8,449,378	8,894,446	9,269,875	9,584,667	9,850,727
WRR VIII - EASTERN VISAYAS	4,440,226	4,742,402	5,049,148	5,475,310	5,879,250	6,251,415	6,587,235	6,880,897
WRR IX - SOUTHWESTERN MINDANAO	5,319,550	5,633,415	5,921,215	6,409,634	6,868,620	7,286,103	7,656,681	7,976,959
WRR X - NORTHERN MINDANAO	4,445,080	4,744,545	5,001,317	5,373,755	5,716,176	6,023,286	6,288,825	6,508,840
WRR XI - SOUTHEASTERN MINDANAO	6,199,047	6,688,626	7,153,082	7,691,244	8,189,498	8,636,592	9,020,268	9,335,945
WRR XII - SOUHTERN MINDANAO	8,172,122	8,880,307	9,530,859	10,334,458	11,085,720	11,771,970	12,381,554	12,899,857

Source: JICA Survey Team

The water demand for industrial sector was estimated by the past trend of water volume of the water permits for industrial sector and GDP for industrial sector.



Source: NWRB water permit list, JICA Survey Team

Figure 2.5-4 Image of National Level Surface Water and Groundwater Balance Calculation

The following regression formula obtained through the correlation analysis between water volume of the water permits for the industrial sector and GDP for the industrial sector was applied to the estimation of the industrial water demand.

$$WD = 0.0001 \times GDP + 2001.1$$

WD: Water Demand for Industrial Sector (MCM/Year)

GDP: GDP for industrial sector (Million Pesos)

(2) Water Demand Forecast for Municipal Sector

The water demand forecast for the municipal sector is shown as follows.

Table 2.5-12 Water Demand Projection for Municipal Sector from 2015 to 2050

Water Resource Region	Municipal Water Demand Projection (MCM/Year)								
	2015	2017	2020	2025	2030	2035	2040	2045	2050
PHILIPPINES*	**5,063**	**5,216**	**5,454**	**5,785**	**6,147**	**6,469**	**6,745**	**6,969**	**7,136**
WRR I - ILOCOS	133	135	139	144	150	155	158	160	161
WRR II - CAGAYAN VALLEY	209	214	222	232	244	254	261	266	269
WRR III - CENTRAL LUZON	696	719	757	807	845	877	901	917	925
WRR IV - SOUTHERN TAGALOG	1,779	1,844	1,944	2,081	2,190	2,282	2,357	2,411	2,439
WRR V - BICOL	241	247	256	268	292	315	337	356	374
WRR VI - WESTERN VISAYAS	363	370	381	396	419	439	457	471	483
WRR VII - CENTRAL VISAYAS	320	330	344	363	386	406	423	438	450
WRR VIII - EASTERN VISAYAS	169	173	180	192	208	224	238	251	262
WRR IX - SOUTHWESTERN MINDANAO	242	248	256	269	291	312	331	348	363
WRR X - NORTHERN MINDANAO	212	217	226	238	256	272	287	300	310
WRR XI - SOUTHEASTERN MINDANAO	329	339	355	379	408	434	458	478	495
WRR XII - SOUHTERN MINDANAO	371	384	403	433	469	503	534	562	586

Source: JICA Survey Team

(3) Water Demand Forecast for Industrial Sector

The water demand forecast for the industrial sector is shown as follows.

Table 2.5-13 Water Demand Projection for Industrial Sector from 2017 to 2050

Water Resource Region	Industrial Water Demand Projection (MCM/Year)							
	2017	2020	2025	2030	2035	2040	2045	2050
PHILIPPINES*	**2,703**	**2,415**	**2,536**	**2,604**	**2,676**	**2,731**	**2,826**	**2,875**
WRR I - ILOCOS	64	58	59	56	56	56	57	57
WRR II - CAGAYAN VALLEY	104	88	91	92	93	94	97	98
WRR III - CENTRAL LUZON	402	342	350	353	357	361	371	374
WRR IV - SOUTHERN TAGALOG	1,232	1,095	1,120	1,134	1,151	1,166	1,200	1,213
WRR V - BICOL	86	79	90	97	104	109	115	120
WRR VI - WESTERN VISAYAS	140	124	141	151	159	163	169	172
WRR VII - CENTRAL VISAYAS	164	147	157	160	164	168	175	179
WRR VIII - EASTERN VISAYAS	65	56	57	57	58	60	64	66
WRR IX - SOUTHWESTERN MINDANAO	80	77	83	88	92	95	100	102
WRR X - NORTHERN MINDANAO	97	91	96	101	106	109	113	116
WRR XI - SOUTHEASTERN MINDANAO	138	133	156	173	186	194	203	210
WRR XII - SOUHTERN MINDANAO	131	125	135	143	151	156	163	168

Source: JICA Survey Team

(4) Water Demand Forecast for Municipal and Industrial Sector

The water demand forecast for municipal and industrial sectors is shown as follows.

Table 2.5-14 Water Demand Projection for Municipal and Industrial Sector from 2017 to 2050

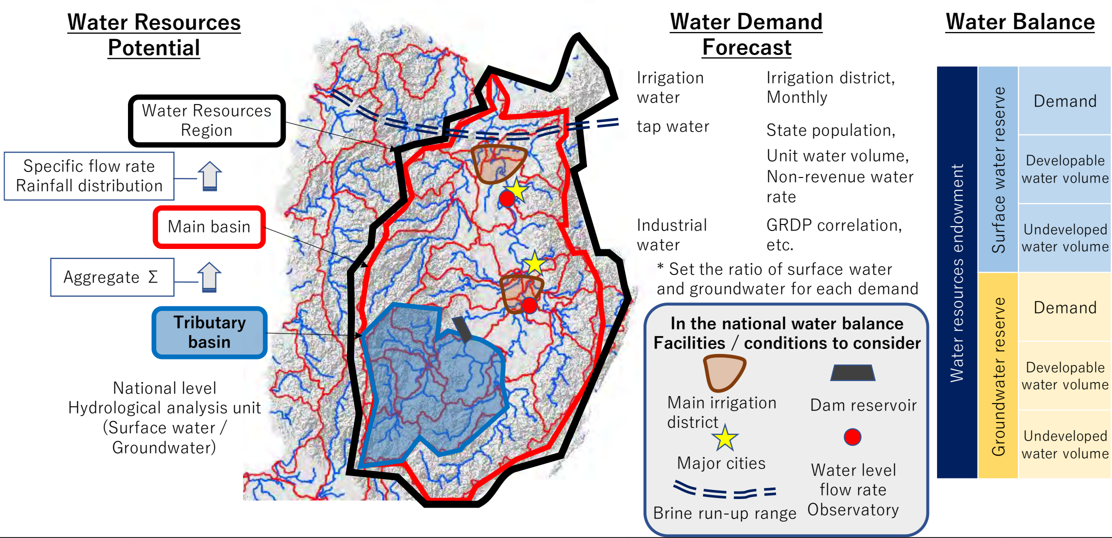
Water Resource Region	Municipal & Industrial Water Demand Projection (MCM/Year)							
	2017	2020	2025	2030	2035	2040	2045	2050
PHILIPPINES*	**7,919**	**7,869**	**8,321**	**8,751**	**9,146**	**9,477**	**9,795**	**10,011**
WRR I - ILOCOS	199	197	203	207	210	214	217	218
WRR II - CAGAYAN VALLEY	318	311	323	336	347	355	363	367
WRR III - CENTRAL LUZON	1,121	1,098	1,158	1,198	1,234	1,262	1,288	1,299
WRR IV - SOUTHERN TAGALOG	3,076	3,039	3,200	3,323	3,432	3,523	3,610	3,652
WRR V - BICOL	334	335	358	389	419	446	472	493
WRR VI - WESTERN VISAYAS	510	505	537	570	598	620	640	655
WRR VII - CENTRAL VISAYAS	494	492	520	546	571	592	613	629
WRR VIII - EASTERN VISAYAS	238	236	249	265	282	298	314	328
WRR IX - SOUTHWESTERN MINDANAO	328	333	352	379	404	427	448	465
WRR X - NORTHERN MINDANAO	315	317	335	357	378	395	413	426
WRR XI - SOUTHEASTERN MINDANAO	477	488	535	580	620	652	682	705
WRR XII - SOUHTERN MINDANAO	515	528	568	613	654	690	725	753

Source: JICA Survey Team

2.6 Water Balance

2.6.1 Calculation of Water Balance

The water balance was calculated for each water resources region based on the results of Stage I. In this survey, the water resource potential was calculated by dividing it into surface water and groundwater as shown in Figure 2.6-1 (water balance). The amount of water that can be developed was defined as the amount obtained by subtracting each water demand (agriculture, domestic water, industrial water, etc.) from the amount of undeveloped water (without contaminated water, salinity water, etc.). The water resource potential of the major river basins entire water resources region were calculated based on each tributary sub-basin using the calibrated runoff model by discharge observation stations as shown in Figure 2.6-1 (water resource potential). After totaling the run-offs from each sub-basin by runoff model, water potential in other areas were converted to the data for the water resources region in consideration of the specific discharge by runoff model and rainfall distribution. The data related to the water balance calculation was summarized in the annual and monthly water balance tables for each water resources region. Lastly, the tightness of the water balance can be evaluated as P-D and P/D using the amount of water potential (P) that can be developed and total demand (D).



Water Resources Region		Water resources endowment (P)						Water demand (D)					Water balance	
		Precipitation	Evapo-transpiration	Groundwater Recharge	Water Resources Potential	Storage Facility	Salt Water Area (Deduction)	Agriculture	Domestic Water	Industrial Water	Other	Total Water Demand	P-D	P/D
I	Surface Water													
	Groundwater	-	-			-								
	Total													

XII														

Source: JICA Survey Team

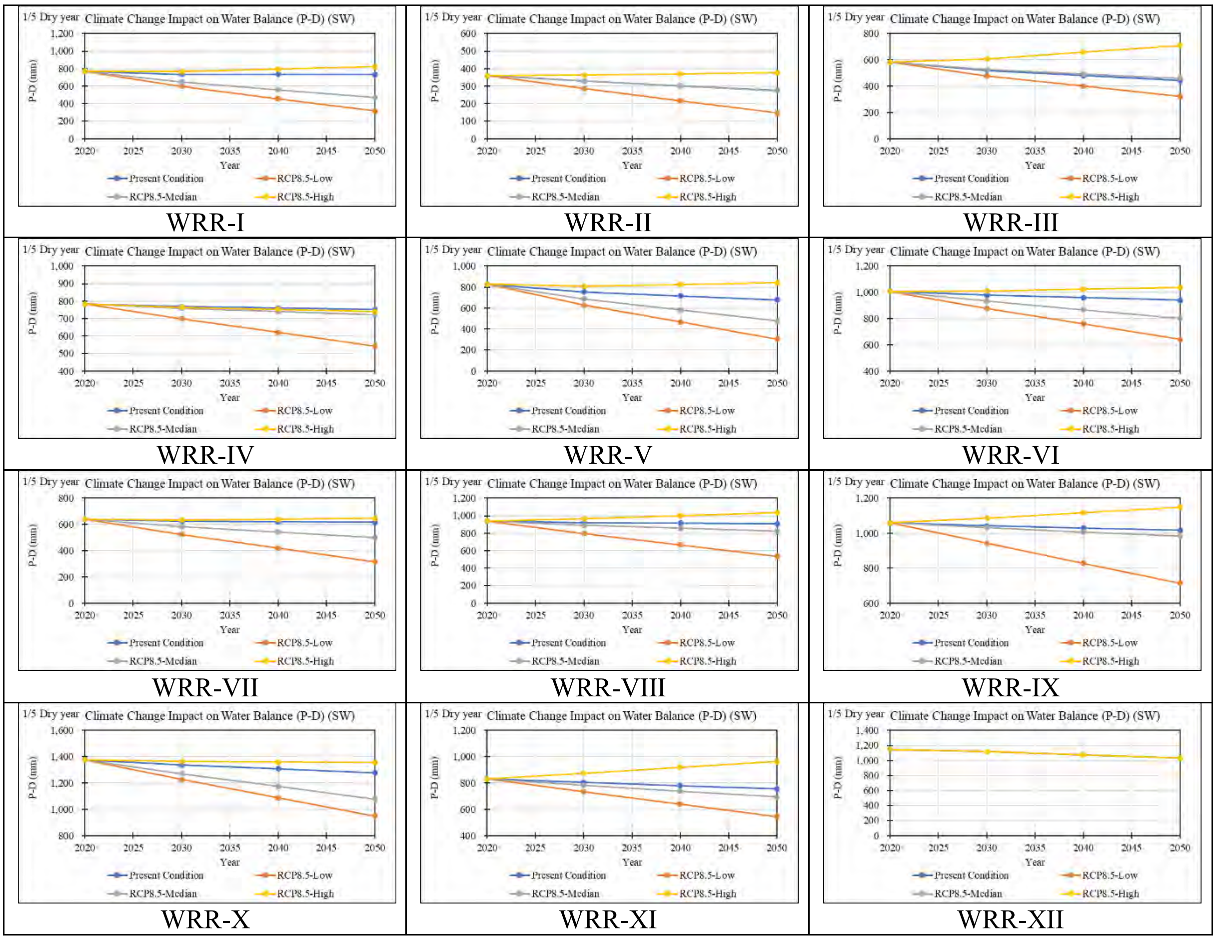
Figure 2.6-1 Image of National Level Surface Water and Groundwater Balance Calculation

2.6.2 Results of Annual Water Balance (P-D) by WRRs

The water balance of irrigation water demand was examined using the case of the National Irrigation Master Plan (NIMP) and the case proposed by the JICA Survey Team. The water resource (surface water and groundwater) potentials were calculated using the Tank Model and Groundwater Model. It was subtracted from the water resource potential assuming that the amount could not be used due to saltwater intrusion was assumed at 5%. In addition, the water resources potentials of 2030 and 2040 were estimated by linear regression from the predicted values of 2020 and 2050. The results of water balance analysis on surface water and groundwater in 2020, 2030, 2040, and 2050 by WRRs of NIMP and JICA Survey Team proposed irrigation water demand is shown in Figure 2.6-2 and Figure 2.6-3. In WRR-II, III, VII, and X, the water balance of water potential minus water demand (P-D) will have little margin for water resource potential, compared to other regions.

In the climate change impact assessment, the P-D tended to be smaller in the lower bound case of the RCP8.5 scenario, and the P-D tended to be higher than the current weather in the upper bound (high) case. In the median case of the RCP8.5 scenario, P-D tends to decrease slightly compared to the current weather.

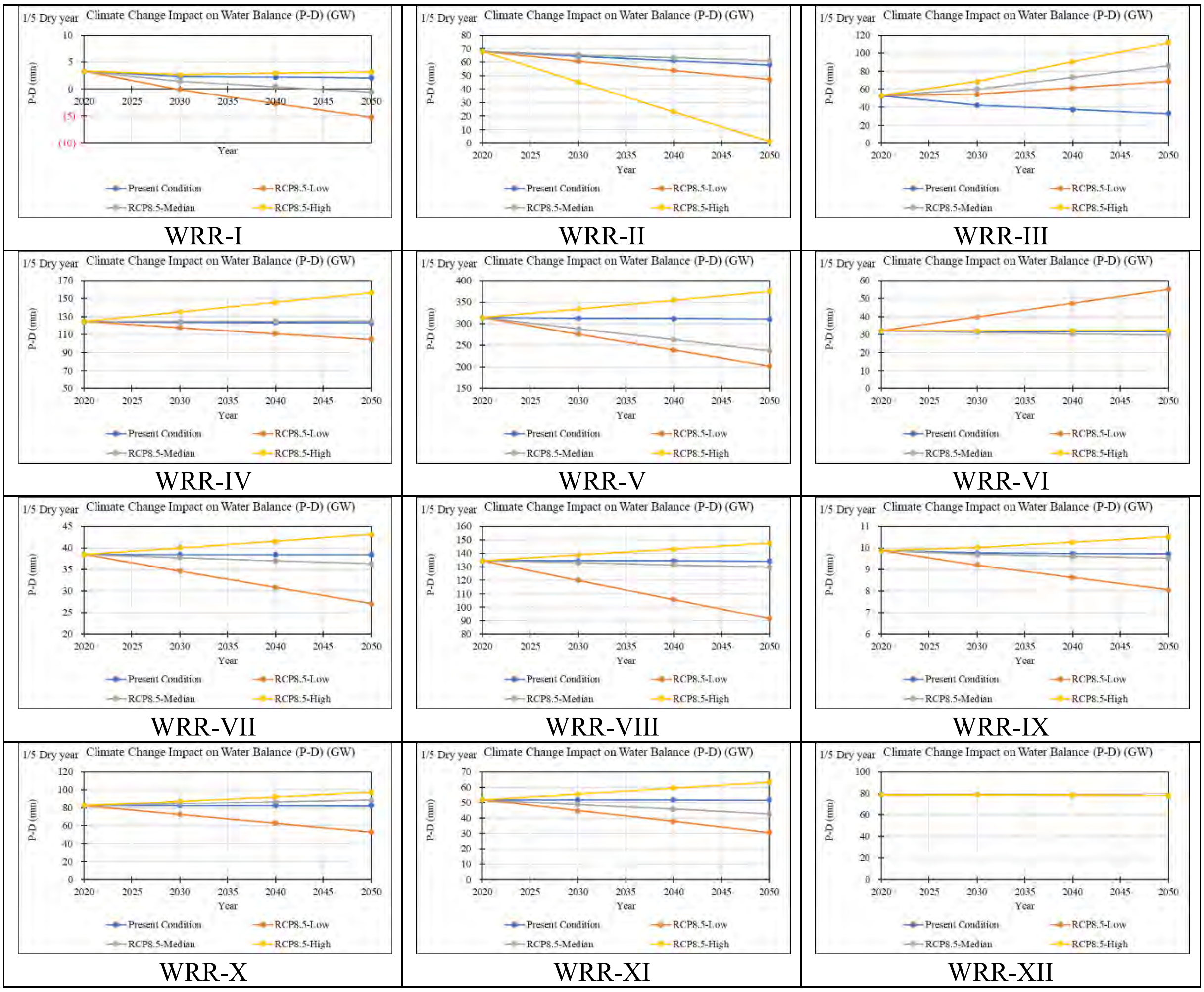
Looking at the annual water balance, it was calculated that the water balance would not be negative until 2050 for all WRRs.



Source: JICA Survey Team

Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

Figure 2.6-2 Results of Annual Water Balance of Surface Water by WRR (1/5-Dry Year) [JICA]



Source: JICA Survey Team

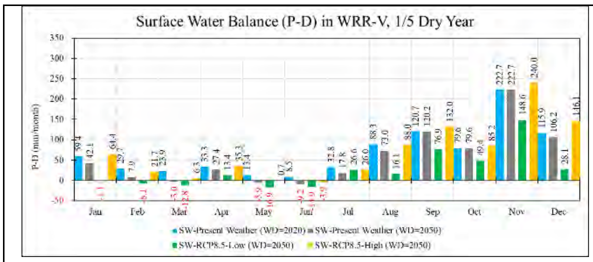
Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

Figure 2.6-3 Results of Annual Water Balance of Groundwater by WRR (1/5-Dry Year) [JICA]

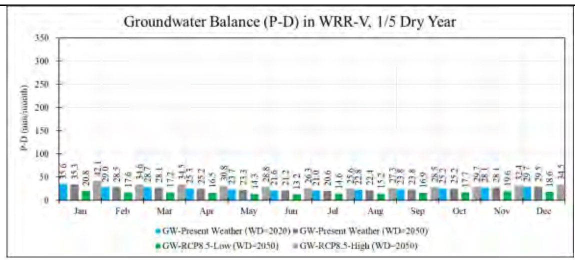
2.6.3 Results of Monthly Water Balance (P-D) by WRRs

The results of monthly water balance (P-D) by WRR are shown in table in Annex-D Chapter 7. Although the annual water balance did not become negative in all WRRs, the monthly surface water use will cause water shortages in the dry season in many areas, and mainly groundwater use will cause water shortages in future dry seasons.

The water balance of surface water and groundwater is expected to be tight in WRR-VII and XI. In addition, the water balance of surface water in the dry season is expected to become tight in the future in WRR-I, II, III, V, and VI. Regarding the water balance of groundwater, it is expected that there will be a shortage of groundwater mainly in dry season in WRR-IV, VI, and VII.



Monthly Water Balance of Surface Water [JST]



Monthly Water Balance of Groundwater [JST]

Source: JICA Survey Team

Figure 2.6-4 Monthly Water Balance (P-D) in WRR-V (1/5-Dry Year)

2.6.4 Comparison of Water Balance of Surface Water in 2050 by WRR

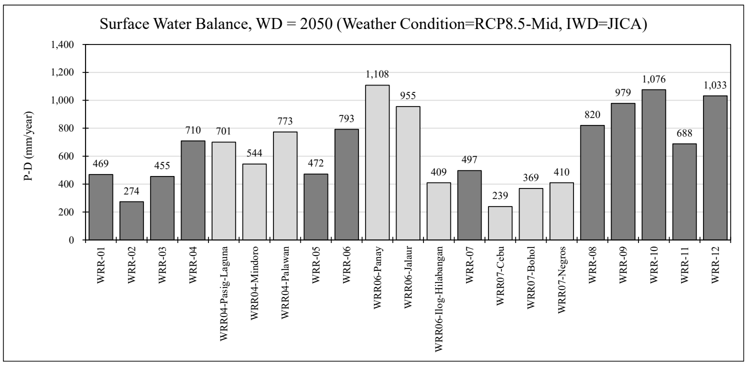
The comparison of the results of water balance analysis on surface water in 2050 by WRR are shown in Table 2.6-1 and Figure 2.6-5 and Annex-D, Hydrology. In these tables and figures, detailed zones of WRR IV, VI and VII are added for more thorough understanding. The WRR III, II, VI-Ilog-Hilabangan, V, and I are ranked as a critical area of water balance in 2050.

Table 2.6-1 Comparison of Water Balance of Surface Water in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

Unit: mm/year

Calculation Condition							Water Balance									
No.	Water Resources Region	Area	Population (2050)	Water Demand Condition	Water Source	Year	Water Potential (P)	Ittigation Water Demand	Domestic+Industrial+Other Water Demand	Total Water Demand (D)	P-D	P-D (per Capita)	P/D	Rank of P/D (5)	P - (P-D) (6)=(1)-(3)	(P-D)/P (7)=(3)/(1)
		km^2	Capita				mm/year	mm/year	mm/year	mm/year	mm/year	m3/yr/capita	-	-	MCM/year	%
1	I - ILOCOS	12,717	4,145,565	Present Condition	Surface Water	2050	624.7	146.0	9.6	155.6	469.2	1,439	4.0	**5**	621	75%
2	II - CAGAYAN VALLEY	38,290	6,617,309	Present Condition	Surface Water	2050	522.2	244.4	3.9	248.4	273.8	1,585	2.1	**2**	520	52%
3	III - CENTRAL LUZON	27,131	18,517,805	Present Condition	Surface Water	2050	901.8	408.3	38.8	447.1	454.7	666	2.0	**1**	900	50%
4	IV - SOUTHERN TAGALOG	44,034	39,483,925	Present Condition	Surface Water	2050	865.7	86.3	69.6	155.9	709.8	792	5.6	**12**	860	82%
4-(1)	WRR04-Pasig-Laguna de Bay	17,012	21,790,744	Present Condition	Surface Water	2050	324.9	23.5	64.4	79.2	245.6	192	4.1	**6**	321	76%
4-(2)	WRR04-Mindoro	12,413	15,900,097	Present Condition	Surface Water	2050	249.3	48.7	2.8	58.5	190.8	149	4.3	**8**	245	77%
4-(3)	WRR04-Palawan	14,608	1,793,084	Present Condition	Surface Water	2050	291.6	14.1	2.4	18.1	273.5	2,228	16.1	**20**	276	94%
5	V- BICOL	17,821	9,558,853	Present Condition	Surface Water	2050	745.2	257.7	15.5	273.2	472.0	880	2.7	**4**	742	63%
6	VI - WESTERN VISAYAS	20,733	10,544,767	Present Condition	Surface Water	2050	990.8	152.9	45.2	198.1	792.7	1,559	5.0	**10**	986	80%
6-(1)	WRR06-Panay	2,649	1,612,198	Present Condition	Surface Water	2050	384.5	21.5	1.7	22.4	362.1	595	17.2	**21**	367	94%
6-(2)	WRR06-Jalaur	9,713	5,911,138	Present Condition	Surface Water	2050	399.0	53.1	37.6	94.6	304.4	500	4.2	**7**	395	76%
6-(3)	WRR06-Ilog-Hilabangan	8,371	3,021,431	Present Condition	Surface Water	2050	207.3	78.3	5.9	81.1	126.2	350	2.6	**3**	205	61%
7	VII - CENTRAL VISAYAS	13,606	9,850,727	Present Condition	Surface Water	2050	599.5	83.1	19.8	102.9	496.6	686	5.8	**14**	594	83%
7-(1)	WRR07-Cebu	4,879	6,429,612	Present Condition	Surface Water	2050	136.0	9.6	11.9	20.8	115.3	87	6.6	**15**	129	85%
7-(2)	WRR07-Bohol	3,977	2,035,348	Present Condition	Surface Water	2050	233.3	45.0	3.4	48.9	184.5	360	4.8	**9**	229	79%
7-(3)	WRR07-Negros	4,750	1,385,767	Present Condition	Surface Water	2050	230.2	28.5	4.6	33.3	196.9	675	6.9	**16**	223	86%
8	VIII - EASTERN VISAYAS	20,768	6,880,897	Present Condition	Surface Water	2050	910.4	83.9	6.1	90.0	820.5	2,476	10.1	**18**	900	90%
9	IX - SOUTHWESTERN MINDANAO	20,395	7,976,959	Present Condition	Surface Water	2050	1,079.9	86.9	14.3	101.2	978.8	2,503	10.7	**19**	1,069	91%
10	X - NORTHERN MINDANAO	23,395	6,508,840	Present Condition	Surface Water	2050	1,228.1	139.2	12.9	152.1	1,076.0	3,868	8.1	**17**	1,220	88%
11	XI - SOUTHEASTERN MINDANAO	26,486	9,335,945	Present Condition	Surface Water	2050	846.0	139.0	18.5	157.5	688.5	1,953	5.4	**11**	841	81%
12	XII - SOUTHERN MINDANAO	30,461	12,899,857	Present Condition	Surface Water	2050	1,252.7	213.4	6.8	220.1	1,032.6	2,438	5.7	**13**	1,247	82%
	All Philippines Total	299,404	########	Present Condition	Surface Water	2050	10,567	2,041	261	2,302	8,265	17,388	**4.6**	-	10,563	78%

Source: JICA Survey Team



Source: JICA Survey Team

Figure 2.6-5 Comparison of Water Balance of Surface Water in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

2.6.5 Comparison of Water Balance of Groundwater in 2050 by WRR

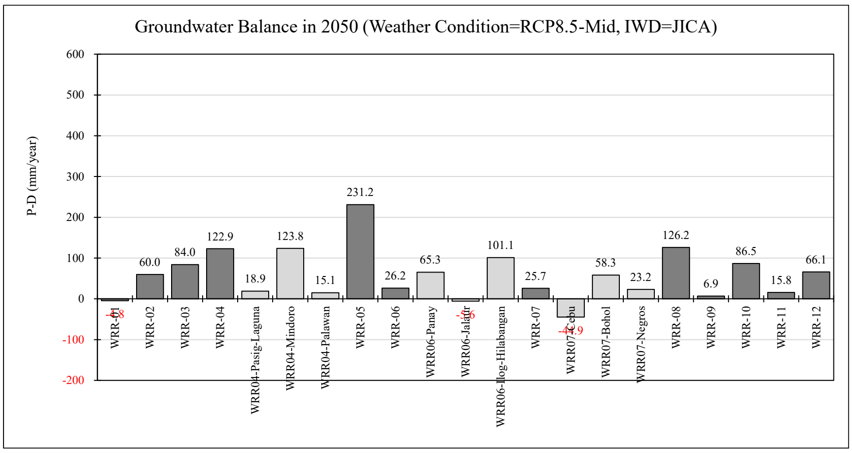
The comparison of the results of water balance analysis on Groundwater in 2050 by WRR are shown in Table 2.6-2, Figure 2.6-6 and in Annex-D, Hydrology. In these tables and figures, detailed zones of WRR IV, VI, and VII are added for more thorough understanding. The WRR VII-Cebu, VI-Jalaur, I, XI, and VII, are ranked as a critical area of water balance in 2050.

Table 2.6-2 Comparison of Water Balance of Groundwater in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

Unit: mm/year

Calculation Condition							Water Balance									
No.	Water Resources Region	Area	Population (2050)	Water Demand Condition	Water Source	Year	Water Potential (P)	Ittigation Water Demand	Domestic+Industrial+Other Water Demand	Total Water Demand (D)	P-D	P-D (per Capita)	P/D	**Rank of P/D (5)**	P - (P-D) (6)=(1)-(3)	(P-D)/P (7)=(3)/(1)
		km^2	Capita				mm/year	mm/year	mm/year	mm/year	mm/year	m3/yr/capita	-	-	MCM/year	%
1	I - ILOCOS	12,717	4,145,565	Present Condition	Groundwater	2050	27.5	6.4	25.9	32.3	-4.8	-15	0.9	**3**	27	-17%
2	II - CAGAYAN VALLEY	38,290	6,617,309	Present Condition	Groundwater	2050	102.9	37.0	5.9	42.9	60.0	347	2.4	**7**	100	58%
3	III - CENTRAL LUZON	27,131	18,517,805	Present Condition	Groundwater	2050	138.4	44.1	10.2	54.3	84.0	123	2.5	**8**	136	61%
4	IV - SOUTHERN TAGALOG	44,034	39,483,925	Present Condition	Groundwater	2050	149.2	5.1	21.2	26.3	122.9	137	5.7	**15**	144	82%
4-(1)	WRR04-Pasig-Laguna de Bay	17,012	21,790,744	Present Condition	Groundwater	2050	59.0	0.8	19.0	20.6	38.4	30	2.9	**10**	56	65%
4-(2)	WRR04-Mindoro	12,413	15,900,097	Present Condition	Groundwater	2050	80.7	4.0	2.0	5.2	75.5	59	15.5	**20**	65	94%
4-(3)	WRR04-Palawan	14,608	1,793,084	Present Condition	Groundwater	2050	9.6	0.4	0.2	0.5	9.1	74	17.8	**21**	-8	94%
5	V- BICOL	17,821	9,558,853	Present Condition	Groundwater	2050	256.5	5.5	19.7	25.2	231.2	431	10.2	**17**	246	90%
6	VI - WESTERN VISAYAS	20,733	10,544,767	Present Condition	Groundwater	2050	42.2	1.3	14.7	16.0	26.2	52	2.6	**9**	40	62%
6-(1)	WRR06-Panay	2,649	1,612,198	Present Condition	Groundwater	2050	16.0	1.0	4.0	5.1	10.9	18	3.1	**13**	13	68%
6-(2)	WRR06-Jalaur	9,713	5,911,138	Present Condition	Groundwater	2050	5.1	0.3	7.5	7.8	-2.6	-4	0.7	**2**	4	-51%
6-(3)	WRR06-Ilog-Hilabangan	8,371	3,021,431	Present Condition	Groundwater	2050	21.0	0.0	3.1	3.1	17.9	50	6.8	**16**	14	85%
7	VII - CENTRAL VISAYAS	13,606	9,850,727	Present Condition	Groundwater	2050	66.2	1.6	38.9	40.5	25.7	35	1.6	**5**	65	39%
7-(1)	WRR07-Cebu	4,879	6,429,612	Present Condition	Groundwater	2050	13.9	1.6	25.1	26.6	-12.7	-10	0.5	**1**	13	-92%
7-(2)	WRR07-Bohol	3,977	2,035,348	Present Condition	Groundwater	2050	35.2	0.0	8.1	8.1	27.0	53	4.3	**14**	31	77%
7-(3)	WRR07-Negros	4,750	1,385,767	Present Condition	Groundwater	2050	17.2	0.0	5.8	5.8	11.4	39	3.0	**12**	14	66%
8	VIII - EASTERN VISAYAS	20,768	6,880,897	Present Condition	Groundwater	2050	136.3	0.1	10.0	10.1	126.2	381	13.5	**19**	123	93%
9	IX - SOUTHWESTERN MINDANAO	20,395	7,976,959	Present Condition	Groundwater	2050	16.1	0.3	8.9	9.2	6.9	18	1.8	**6**	14	43%
10	X - NORTHERN MINDANAO	23,395	6,508,840	Present Condition	Groundwater	2050	94.0	0.3	7.1	7.4	86.5	311	12.7	**18**	81	92%
11	XI - SOUTHEASTERN MINDANAO	26,486	9,335,945	Present Condition	Groundwater	2050	100.8	0.2	84.9	85.1	15.8	45	1.2	**4**	100	16%
12	XII - SOUTHERN MINDANAO	30,461	12,899,857	Present Condition	Groundwater	2050	101.4	1.4	34.0	35.4	66.1	156	2.9	**11**	99	65%
	All Philippines Total	299,404	########	Present Condition	Groundwater	2050	1,231	103	281	385	847	1,781	**3.2**	-	1,228	69%

Source: JICA Survey Team



Source: JICA Survey Team

Figure 2.6-6 Comparison of Water Balance of Groundwater in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

2.6.6 Comparison of Total (SW+GW) Water Balance by WRR in 2050

The comparison of the results of total (surface water + groundwater) water balance analysis in 2050 by WRR are shown in Table 2.6-4, Figure 2.6-7, and Annex-D, Hydrology. The WRR-III, II, VI-Ilog-Hilabangan, WRR-I and WRR-VII-Cebu are ranked as a critical area of water balance (surface water + groundwater) in 2050. For the reference, the results of water balance analysis by JICA 1998 MP are shown in Table 2.6-3 below. The surface water potentials in this survey are based on the calculated annual runoff by the Tank Model.

Table 2.6-3 Comparison of Water Balance Analysis by JICA 1998 MP and This Survey

WRR		Water Balance of JICA 1998 M/P							Water Balance of This Survey			
No.	Water Resources Region (WRR)	Water Potential (SW+GW) (1)	Total Water Demand in 2025 Case-1	Total Water Demand in 2025 Case-2	P/D of Case-1 (4)=(1)/(2)	P/D of Case-2 (5)=(1)/(3)	**Rank of P/D of Case-1 (6)**	**Rank of P/D of Case-2 (7)**	Water Potential (SW+GW) (8)	Total Water Demand in 2050 (9)	P/D of 2050 (10)=(8)/(9)	**Rank of P/D of Case-1 (6)**
		MCM/year	MCM/year	MCM/year	-	-	-	-	MCM/year	MCM/year	-	-
1	I - ILOCOS	11,348	3,041	2,874	3.7	3.9	**8**	**8**	11,666	2,389	4.9	**5**
2	II - CAGAYAN VALLEY	19,625	12,466	7,618	1.6	2.6	**2**	**3**	23,883	11,154	2.1	**2**
3	III - CENTRAL LUZON	12,521	18,168	14,618	0.7	0.9	**1**	**1**	26,319	13,603	1.9	**1**
4	IV - SOUTHERN TAGALOG	21,110	10,052	7,368	2.1	2.9	**5**	**4**	45,896	8,023	5.7	**9**
5	V- BICOL	11,045	4,167	2,841	2.7	3.9	**6**	**7**	22,747	5,318	4.3	**4**
6	VI - WESTERN VISAYAS	20,644	7,595	6,206	2.7	3.3	**7**	**5**	24,342	4,439	5.5	**8**
7	VII - CENTRAL VISAYAS	4,649	2,729	2,226	1.7	2.1	**3**	**2**	10,669	1,951	5.5	**7**
8	VIII - EASTERN VISAYAS	18,457	1,956	1,644	9.4	11.2	**11**	**11**	23,654	2,077	11.4	**12**
9	IX - SOUTHWESTERN MINDANAO	17,282	4,598	3,616	3.8	4.8	**9**	**9**	23,039	2,250	10.2	**11**
10	X - NORTHERN MINDANAO	44,216	3,682	2,253	12.0	19.6	**12**	**12**	35,478	3,732	9.5	**10**
11	XI - SOUTHEASTERN MINDANAO	18,675	4,141	2,390	4.5	7.8	**10**	**10**	26,944	6,425	4.2	**3**
12	XII - SOUTHERN MINDANAO	26,858	12,806	6,946	2.1	3.9	**4**	**6**	41,249	7,782	5.3	**6**
	All Philippines Total	226,430	85,401	60,600	2.7	3.7	**-**	**-**	396,795	83,557	4.7	**-**

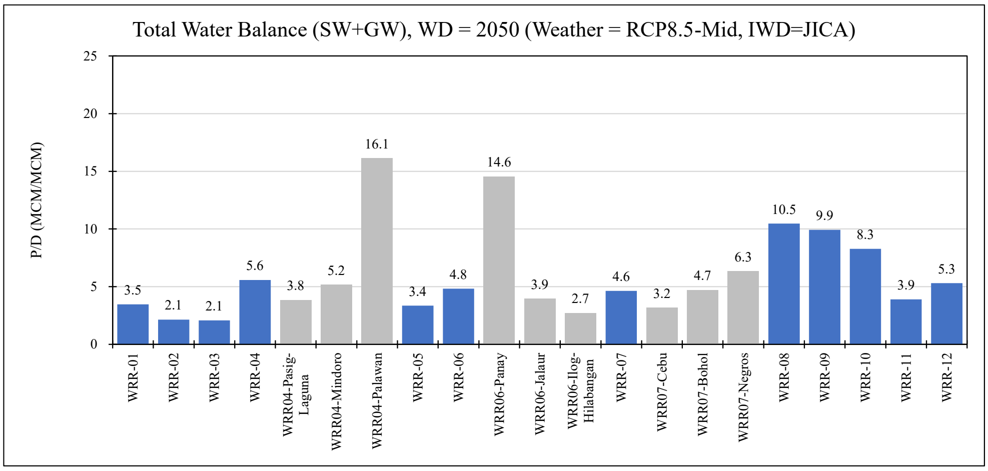
Source: JICA 1998 MP

Table 2.6-4 Comparison of Water Balance of Total (SW+GW) in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

Unit: MCM/year

Calculation Condition							Water Balance of This Survey (1/5-dry Year)									
No.	Water Resources Region	Area	Population (2050)	Water Demand Condition	Water Source	Year	Water Potential (SW+GW) (1)	Ittigation Water Demand	Domestic+Industrial+Other Water Demand	Total Water Demand (2)	P-D (3)=(1)-(2)	P-D (per Capita)	**P/D (4)=(1)/(2)**	**Rank of P/D (5)**	P - (P-D) (6)=(1)-(3)	(P-D)/P (7)=(3)/(1)
		km^2	Capita				MCM/year	MCM/year	MCM/year	MCM/year	MCM/year	m3/yr/capita	-	-	MCM/year	%
1	I - ILOCOS	12,717	4,145,565	RCP8.5-Median	SW+GW	2050	8,295	1,938	451	2,389	5,906	18,117	**3.5**	**6**	8,292	71%
2	II - CAGAYAN VALLEY	38,290	6,617,309	RCP8.5-Median	SW+GW	2050	23,935	10,777	377	11,154	12,781	73,957	**2.1**	**2**	23,933	53%
3	III - CENTRAL LUZON	27,131	18,517,805	RCP8.5-Median	SW+GW	2050	28,222	12,274	1,330	13,603	14,618	21,418	**2.1**	**1**	28,220	52%
4	IV - SOUTHERN TAGALOG	44,034	39,483,925	RCP8.5-Median	SW+GW	2050	44,691	4,026	3,997	8,023	36,668	40,893	**5.6**	**15**	44,685	82%
4-(1)	WRR04-Pasig-Laguna de Bay	17,012	21,790,744	RCP8.5-Median	SW+GW	2050	16,901	1,071	3,670	4,396	12,505	9,763	**3.8**	**7**	16,897	74%
4-(2)	WRR04-Mindoro	12,413	15,900,097	RCP8.5-Median	SW+GW	2050	14,527	2,319	213	2,805	11,722	9,152	**5.2**	**13**	14,522	81%
4-(3)	WRR04-Palawan	14,608	1,793,084	RCP8.5-Median	SW+GW	2050	13,263	636	114	822	12,440	101,350	**16.1**	**21**	13,247	94%
5	V- BICOL	17,821	9,558,853	RCP8.5-Median	SW+GW	2050	17,851	4,690	628	5,318	12,533	23,365	**3.4**	**5**	17,847	70%
6	VI - WESTERN VISAYAS	20,733	10,544,767	RCP8.5-Median	SW+GW	2050	21,417	3,197	1,242	4,439	16,978	33,382	**4.8**	**12**	21,412	79%
6-(1)	WRR06-Panay	2,649	1,612,198	RCP8.5-Median	SW+GW	2050	8,304	467	119	570	7,734	12,708	**14.6**	**20**	8,290	93%
6-(2)	WRR06-Jalaur	9,713	5,911,138	RCP8.5-Median	SW+GW	2050	8,379	1,106	936	2,123	6,256	10,280	**3.9**	**9**	8,375	75%
6-(3)	WRR06-Ilog-Hilabangan	8,371	3,021,431	RCP8.5-Median	SW+GW	2050	4,734	1,624	187	1,746	2,988	8,278	**2.7**	**3**	4,731	63%
7	VII - CENTRAL VISAYAS	13,606	9,850,727	RCP8.5-Median	SW+GW	2050	9,057	1,152	799	1,951	7,106	9,815	**4.6**	**10**	9,053	78%
7-(1)	WRR07-Cebu	4,879	6,429,612	RCP8.5-Median	SW+GW	2050	2,040	152	502	645	1,395	1,058	**3.2**	**4**	2,036	68%
7-(2)	WRR07-Bohol	3,977	2,035,348	RCP8.5-Median	SW+GW	2050	3,653	612	156	775	2,878	5,622	**4.7**	**11**	3,648	79%
7-(3)	WRR07-Negros	4,750	1,385,767	RCP8.5-Median	SW+GW	2050	3,365	388	141	531	2,834	9,714	**6.3**	**16**	3,359	84%
8	VIII - EASTERN VISAYAS	20,768	6,880,897	RCP8.5-Median	SW+GW	2050	21,738	1,743	335	2,077	19,661	59,341	**10.5**	**19**	21,728	90%
9	IX - SOUTHWESTERN MINDANAO	20,395	7,976,959	RCP8.5-Median	SW+GW	2050	22,353	1,778	472	2,250	20,103	51,399	**9.9**	**18**	22,343	90%
10	X - NORTHERN MINDANAO	23,395	6,508,840	RCP8.5-Median	SW+GW	2050	30,930	3,263	470	3,732	27,198	97,759	**8.3**	**17**	30,922	88%
11	XI - SOUTHEASTERN MINDANAO	26,486	9,335,945	RCP8.5-Median	SW+GW	2050	25,077	3,685	2,740	6,425	18,652	52,916	**3.9**	**8**	25,073	74%
12	XII - SOUTHERN MINDANAO	30,461	12,899,857	RCP8.5-Median	SW+GW	2050	41,249	6,541	1,242	7,782	33,466	79,025	**5.3**	**14**	41,244	81%
	All Philippines Total	299,404	########	RCP8.5-Median	SW+GW	2050	294,816	55,063	14,082	69,145	225,671	474,748	**4.3**	-	294,811	77%

Source: JICA Survey Team



Source: JICA Survey Team

Figure 2.6-7 Comparison of Water Balance of Total (SW+GW) in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

2.6.7 Monthly Water Balance of Dry Season by WRRs

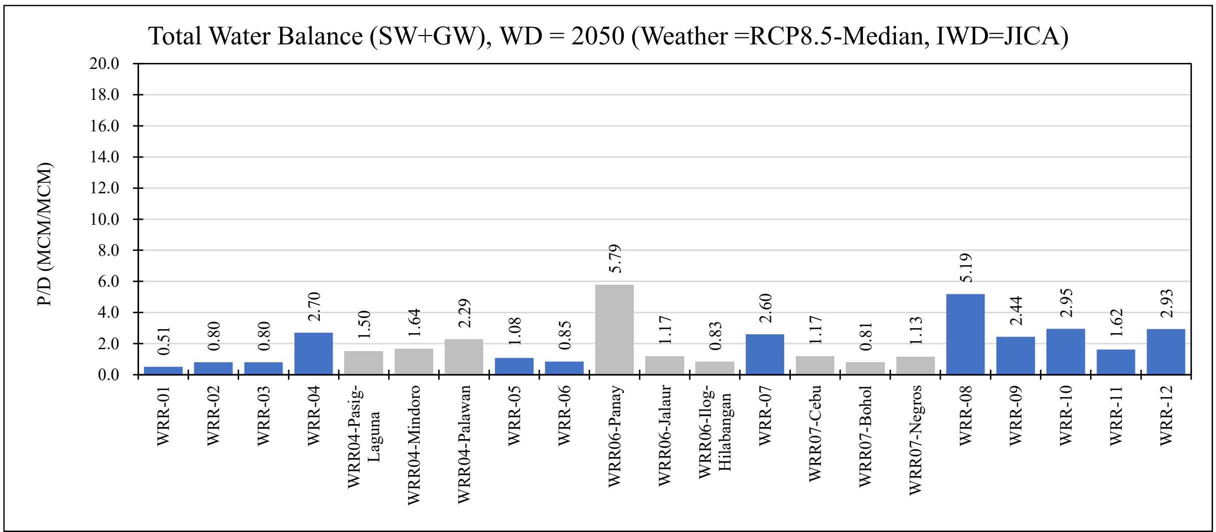
Table 2.6-5 and Figure 2.6-8 below shows the monthly water balance calculation results in 2050 for the month when the water balance is the tightest in the year (dry season). The demand for irrigation water is proposed by the JICA Survey Team.

Table 2.6-5 Monthly Water Balance of Total (SW+GW) in Dry Season in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR=JST]

Unit: MCM/month

Calculation Condition							Water Balance of This Survey (RCP8.5-M)										
No.	Water Resources Region	Area	Population (2050)	Water Demand Condition	Water Source	Year	Water Potential (SW+GW) (1)	Ittigation Water Demand	Domestic+Industrial+Other Water Demand	Total Water Demand (2)	P-D (3)=(1)-(2)	P-D (per Capita)	**P/D (4)=(1)/(2)**	**Rank of P/D (5)**	P - (P-D) (6)=(1)-(3)	(P-D)/P (7)=(3)/(1)
		km^2	Capita				MCM/month	MCM/month	MCM/month	MCM/month	MCM/month	m3/yr/capita	-	-	MCM/month	%
1	I - ILOCOS	12,717	4,145,565	RCP8.5-Median	SW+GW	2020	178.50	317.14	33.40	350.39	-171.89	-527.32	**0.51**	**1**	177.99	-96%
2	II - CAGAYAN VALLEY	38,290	6,617,309	RCP8.5-Median	SW+GW	2020	1,042.53	1,231.76	26.43	1,303.39	-260.86	-1,509.40	**0.80**	**2**	1,041.73	-25%
3	III - CENTRAL LUZON	27,131	18,517,805	RCP8.5-Median	SW+GW	2020	1,672.88	1,982.76	96.56	2,089.68	-416.80	-610.67	**0.80**	**3**	1,672.08	-25%
4	IV - SOUTHERN TAGALOG	44,034	39,483,925	RCP8.5-Median	SW+GW	2020	1,794.00	371.99	283.72	664.87	1,129.14	1,259.24	**2.70**	**17**	1,791.31	63%
4-(1)	WRR04-Pasig-Laguna de Bay	17,012	21,790,744	RCP8.5-Median	SW+GW	2020	728.54	153.89	327.85	487.19	241.35	188.4	**1.50**	**11**	727.05	33%
4-(2)	WRR04-Mindoro	12,413	15,900,097	RCP8.5-Median	SW+GW	2020	473.24	278.96	16.10	287.96	185.28	144.6	**1.64**	**13**	471.59	39%
4-(3)	WRR04-Palawan	14,608	1,793,084	RCP8.5-Median	SW+GW	2020	303.05	125.39	7.68	132.58	170.47	1,388.8	**2.29**	**14**	300.76	56%
5	V- BICOL	17,821	9,558,853	RCP8.5-Median	SW+GW	2020	726.36	620.17	35.62	669.52	56.83	105.96	**1.08**	**7**	725.27	8%
6	VI - WESTERN VISAYAS	20,733	10,544,767	RCP8.5-Median	SW+GW	2020	516.40	527.75	81.78	605.32	-88.92	-174.82	**0.85**	**6**	515.55	-17%
6-(1)	WRR06-Panay	2,649	1,612,198	RCP8.5-Median	SW+GW	2020	90.15	11.73	4.65	15.57	74.57	122.5	**5.79**	**21**	84.36	83%
6-(2)	WRR06-Jalaur	9,713	5,911,138	RCP8.5-Median	SW+GW	2020	143.26	0.00	122.32	122.32	20.95	34.4	**1.17**	**10**	142.09	15%
6-(3)	WRR06-Ilog-Hilabangan	8,371	3,021,431	RCP8.5-Median	SW+GW	2020	239.88	257.87	23.02	289.84	-49.96	-138.4	**0.83**	**5**	239.05	-21%
7	VII - CENTRAL VISAYAS	13,606	9,850,727	RCP8.5-Median	SW+GW	2020	522.46	150.10	50.33	201.31	321.15	443.58	**2.60**	**16**	519.87	61%
7-(1)	WRR07-Cebu	4,879	6,429,612	RCP8.5-Median	SW+GW	2020	77.51	24.06	42.75	66.46	11.05	8.4	**1.17**	**9**	76.34	14%
7-(2)	WRR07-Bohol	3,977	2,035,348	RCP8.5-Median	SW+GW	2020	89.16	98.37	11.21	110.66	-21.50	-42.0	**0.81**	**4**	88.36	-24%
7-(3)	WRR07-Negros	4,750	1,385,767	RCP8.5-Median	SW+GW	2020	90.17	65.28	12.03	79.46	10.71	36.7	**1.13**	**8**	89.04	12%
8	VIII - EASTERN VISAYAS	20,768	6,880,897	RCP8.5-Median	SW+GW	2020	811.94	134.12	19.63	156.59	655.35	1,978.00	**5.19**	**20**	806.76	81%
9	IX - SOUTHWESTERN MINDANAO	20,395	7,976,959	RCP8.5-Median	SW+GW	2020	567.81	202.50	27.14	232.58	335.23	857.12	**2.44**	**15**	565.37	59%
10	X - NORTHERN MINDANAO	23,395	6,508,840	RCP8.5-Median	SW+GW	2020	1,993.72	642.03	29.18	675.61	1,318.11	4,737.73	**2.95**	**19**	1,990.77	66%
11	XI - SOUTHEASTERN MINDANAO	26,486	9,335,945	RCP8.5-Median	SW+GW	2020	544.72	177.44	153.15	335.49	209.23	593.58	**1.62**	**12**	543.09	38%
12	XII - SOUTHERN MINDANAO	30,461	12,899,857	RCP8.5-Median	SW+GW	2020	1,938.43	627.21	69.82	661.09	1,277.34	3,016.18	**2.93**	**18**	1,935.50	66%
	All Philippines Total	299,404	#########	RCP8.5-Median	SW+GW	2020	12,309.75	6,984.98	906.76	7,945.83	4,363.91	9,180.46	**1.55**	-	12,308.20	35%

Source: JICA Survey Team



Source: JICA Survey Team

Figure 2.6-8 Monthly Water Balance of Total (SW+GW) in Dry Season in 2050 by WRR (Weather Condition=RCP8.5 Median Case) [Irrigation WR= JST]

2.6.8 Conclusion

The summary comparison of the results of total (surface water + groundwater) water balance analysis in 2050 by WRR are shown in Table 2.6-6 and Table 2.6-7 below.

The median case was selected because the high and low cases are shown in Annex-D, but in this main report, showing the median case is the average and most appropriate. In addition, RCP8.5 was adopted because it represents the most serious impact in the future from the current weather, compared with RCP2.6 which only shows a small change. The impact of climate change on the water balance is an assessment of future uncertainty (variability). In this study, it was evaluated RCP8.5, which has a large degree of uncertainty.

Table 2.6-6 Comparison of Annual Water Balance in 2050 [SW+GW] by WRR [Irrigation WR=JST]

WRR					Water Balance of This Survey (1/5-dry Year) at 2050							
No.	Water Resources Region (WRR)	Area km^2	Water Source	Year	Present Weather		RCP8.5-Low		RCP8.5-Median		RCP8.5-High	
					P/D	Rank of P/D	P/D	Rank of P/D	P/D	Rank of P/D	P/D	Rank of P/D
1	I - ILOCOS	12,717	SW+GW	2050	4.9	5	2.6	3	**3.5**	**4**	5.4	6
2	II - CAGAYAN VALLEY	38,290	SW+GW	2050	2.1	2	1.7	1	**2.1**	**2**	2.3	1
3	III - CENTRAL LUZON	27,131	SW+GW	2050	1.9	1	1.8	2	**2.1**	**1**	2.6	2
4	IV - SOUTHERN TAGALOG	44,034	SW+GW	2050	5.7	9	4.5	8	**5.6**	**9**	5.8	8
5	V- BICOL	17,821	SW+GW	2050	4.3	4	2.7	4	**3.4**	**3**	5.0	3
6	VI - WESTERN VISAYAS	20,733	SW+GW	2050	5.5	8	4.2	7	**4.8**	**7**	5.9	9
7	VII - CENTRAL VISAYAS	13,606	SW+GW	2050	5.5	7	3.3	6	**4.6**	**6**	5.7	7
8	VIII - EASTERN VISAYAS	20,768	SW+GW	2050	11.4	12	7.2	10	**10.5**	**12**	12.8	12
9	IX - SOUTHWESTERN MINDANAO	20,395	SW+GW	2050	10.2	11	7.5	12	**9.9**	**11**	11.4	11
10	X - NORTHERN MINDANAO	23,395	SW+GW	2050	9.5	10	7.2	11	**8.3**	**10**	10.1	10
11	XI - SOUTHEASTERN MINDANAO	26,486	SW+GW	2050	4.2	3	3.2	5	**3.9**	**5**	5.1	4
12	XII - SOUTHERN MINDANAO	30,461	SW+GW	2050	5.3	6	5.3	9	**5.3**	**8**	5.3	5
	All Philippines Total	299,404	SW+GW	2050	4.6	-	3.5	-	**4.3**	-	5.1	-

Source: JICA Survey Team

Table 2.6-7 Detailed Comparison of Annual Water Balance in 2050 [SW+GW] by WRR [Irrigation WR=JST]

WRR					Water Balance of This Survey (1/5-dry Year)							
					Present Weather		RCP8.5-Low		RCP8.5-Median		RCP8.5-High	
No.	Water Resources Region (WRR)	Area km^2	Water Source	Year	P/D	Rank of P/D	P/D	Rank of P/D	P/D	Rank of P/D	P/D	Rank of P/D
1	I - ILOCOS	12,717	SW+GW	2050	4.88	9	2.64	5	3.47	6	5.37	11
2	II - CAGAYAN VALLEY	38,290	SW+GW	2050	2.14	2	1.66	1	2.15	2	2.29	1
3	III - CENTRAL LUZON	27,131	SW+GW	2050	1.93	1	1.77	2	2.07	1	2.62	2
4	IV - SOUTHERN TAGALOG	44,034	SW+GW	2050	5.72	15	4.47	15	5.57	15	5.84	13
4-(1)	WRR04-Pasig-Laguna de Bay	17,012	SW+GW	2050	3.86	5	3.28	9	3.84	7	4.29	5
4-(2)	WRR04-Mindoro	12,413	SW+GW	2050	5.21	11	3.90	12	5.18	13	5.13	9
4-(3)	WRR04-Palawan	14,608	SW+GW	2050	17.45	21	12.79	20	16.13	21	16.58	20
5	V- BICOL	17,821	SW+GW	2050	4.28	7	2.66	6	3.36	5	5.04	7
6	VI - WESTERN VISAYAS	20,733	SW+GW	2050	5.48	14	4.20	13	4.83	12	5.93	15
6-(1)	WRR06-Panay	2,649	SW+GW	2050	16.34	20	14.76	21	14.57	20	17.81	21
6-(2)	WRR06-Jalaur	9,713	SW+GW	2050	4.42	8	3.22	7	3.95	9	4.84	6
6-(3)	WRR06-Ilog-Hilabangan	8,371	SW+GW	2050	3.23	3	1.94	3	2.71	3	3.38	3
7	VII - CENTRAL VISAYAS	13,606	SW+GW	2050	5.47	13	3.30	10	4.64	10	5.71	12
7-(1)	WRR07-Cebu	4,879	SW+GW	2050	3.76	4	2.32	4	3.16	4	3.91	4
7-(2)	WRR07-Bohol	3,977	SW+GW	2050	5.15	10	3.41	11	4.71	11	5.87	14
7-(3)	WRR07-Negros	4,750	SW+GW	2050	8.00	16	4.33	14	6.34	16	7.68	16
8	VIII - EASTERN VISAYAS	20,768	SW+GW	2050	11.39	19	7.22	17	10.46	19	12.80	19
9	IX - SOUTHWESTERN MINDANAO	20,395	SW+GW	2050	10.24	18	7.49	19	9.93	18	11.44	18
10	X - NORTHERN MINDANAO	23,395	SW+GW	2050	9.51	17	7.25	18	8.29	17	10.08	17
11	XI - SOUTHEASTERN MINDANAO	26,486	SW+GW	2050	4.19	6	3.24	8	3.90	8	5.10	8
12	XII - SOUTHERN MINDANAO	30,461	SW+GW	2050	5.30	12	5.30	16	5.30	14	5.30	10
	All Philippines Total	299,404	SW+GW	2050	4.75	-	3.66	-	4.43	-	5.19	-

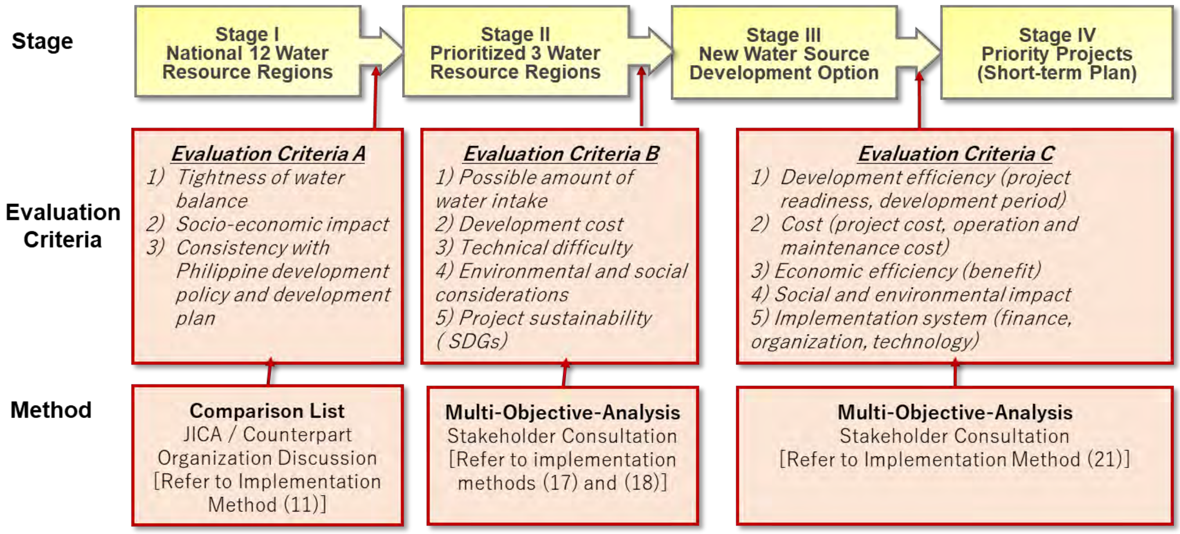
Source: JICA Survey Team

2.7 Selection of Priority Water Resources Regions

2.7.1 Approach for Evaluation and Selection of Optimal Plans based on Multifaceted Evaluation Criteria

As shown in Figure 2.7-1 below, three priority water resources regions were identified among the national 12 water resources regions in this survey, and new water resources development options and effective priority project concepts in these regions were formulated through a “three-stage” comparison study. The evaluation criteria and methods for the comparison study at each stage are also presented in Figure 2.7-1. These evaluation criteria and methods were determined through consultation with JICA and the Philippine counterpart organization(s).

The most feasible and optimal project concept were selected through the evaluation of multifaceted criteria and from stakeholder consultations in the priority water resources regions.



Source: JICA Survey Team

Figure 2.7-1 Evaluation Criteria and Evaluation Method for Comparing Alternatives at Each Survey Stage

It is noted that this survey focuses mainly on the development and management of water resources in local cities and does not include the water resources region (IV) of Metro Manila as a priority area.

2.7.2 Selection Policy (Evaluation Criteria and Method)

(1) Criteria for Selection of 3 Priority WRRs

Out of 12 water resources regions, three priority water resources regions were selected based on the following criteria for the subsequent detailed investigation:

i) Water balance tightness: based on the result of water balance calculation

ii) Socio-economic impact: affected population, magnitude of GRDP in affected areas, etc.

iii) Consistency with the Philippine development policies and development plans:

These criteria were further divided into sub-criteria considering the results of data collection and water balance study.

1) Tightness of Water Balance

The balance and the ratio of total water resources potential (P) and total water demand (D) in each water resources region are applied as evaluation criteria for tightness of water balance. In addition, water balance per capita ((P-D)/capita) is applied considering water availability per person.

<Criteria for Tightness of Water Balance>

1-1) P-D

1-2) P/D

1-3) (P-D)/capita

Where, P: Water resources potential, D: Water demand

2) Socio-economic impact

The population density and GRDP in each water resources region are applied as evaluation criteria for socio-economic impact. In addition, water demand for municipal, industrial and other uses is applied taking into account necessity and importance of attaining water security in line with the socio-economic developments.

<Criteria for Socio-Economic Impact>

2-1) Population density

2-2) GRDP

2-3) Water demands for municipal, industrial and others (recreation, etc.)

3) Consistency with Development Policy

Regarding the evaluation criteria for the consistency with the development policy, availability and degree of maturity of the water resources master plan and sectoral development plan were applied considering the realization and facilitation of the plans and programs in each water resources region.

<Criteria for Consistency with Development Policy>

3-1) Consistency with Water Resources M/P

3-2) Consistency with Special development plans

(2) Selection Method

Following two methods were adopted for selection of priority region.

1) Ranking method

Each water resources region was ranked according to the evaluation criteria, then the ranking was comprehensively evaluated, and the priority regions were selected.

2) Point allocation method

As shown in Table 2.7-1, each criterion has a maximum of 5 allocation points, and the points were allocated considering the range (from minimum to maximum value) and balance of each evaluation item and determined through discussion with NEDA and NWRB. For the final evaluation, the points were totaled, and the top three were selected as the priority regions.

Table 2.7-1 Point Allocation Table of Each Criteria for Selection of Priority Regions

	Item	Parameter	Max. Point	Point				
				1	2	3	4	5
Criteia	Water Deficit	P-D	**5**	30,000<x	20,000<x≦30,000	10,000<x≦20,000	0<x≦10,000	x≦0
		P/D	**5**	8<x	6<x<=8	4<x<=6	1<=x<=4	x<1
		(P-D) per capita	**5**	4,000<x	3,000<x≦4,000	2,000<x<=3,000	1,000<x≦2,000	x≦1,000
	Social Economic Impacts	Population Density	**5**	0<x≦100	100<x≦300	300<x≦500	500<x≦800	800<x
		GRDP	**5**	0<x≦5,000	5,000<x<=10,000	10,000<x<=15,000	15,000<x<=20,000	20,000<x
		Domestic+Industrial+Other Water Demand	**5**	0<x≦1,000	1,000<x≦2,000	2,000<x≦3,000	3,000<x≦4,000	4000<x
	Consistency of Development Policy	Water Resources M/P	**5**	n/a	1998 M/P priority cities	available (after 2000)	available (after 2010)	available (recently)
		Special Development Plan	**5**	n/a	RDP	available (after 2000)	available (after 2010)	available (recently)
TOTAL POINT			**40**					

Note: P: Water Potential, D:: Water Demands

Source: JICA Survey Team

(3) Evaluation by Ranking Method and Point Allocation Method

1) Ranking method

The result of evaluation by the ranking method is presented below. Based on comprehensive evaluation of each rank, the highest ranked regions are WRR III, IV, and VII, and the next group are WRR I, II, V and XI.

Table 2.7-2 Evaluation Result by Ranking Method

Items	1	2	3	4	5	6	7	8	9	10	11	12
	I - ILOCOS	II - CAGAYAN VALLEY	III - CENTRAL LUZON	IV - SOUTHERN TAGALOG	V- BICOL	VI - WESTERN VISAYAS	VII - CENTRAL VISAYAS	VIII - EASTERN VISAYAS	IX - SOUTHWESTERN MINDANAO	X - NORTHERN MINDANAO	XI - SOUTHEASTERN MINDANAO	XII - SOUTHERN MINDANAO
Rank of P-D	1	4	5	12	3	6	2	8	9	10	7	11
Rank of P/D	4	2	1	9	3	7	6	11	12	10	5	8
Rank (P-D)/capita	5	7	2	3	4	6	1	11	9	12	8	10
Rank of Population Density	10	12	3	1	4	5	2	9	7	11	8	6
Rank of GRDP	12	10	2	1	7	5	4	11	9	8	3	6
Rank of Domestic-Industrial Water Demand	11	12	3	1	7	4	6	8	9	10	2	5
Water Resources Development Plan	1998 (Baguio)	Cagayan WRMP (2002)	Pampanga IWRMP (2011)	Metro Manila (2003/ 2013)	Bicol (2003)	1998 (Iloilo/Bacolod)	Metro Cebu (2006)		1998 (Zamboanga)	1998 (Cagayan de Oro)	1998 (Davao)	
Special Urban Development Plan (Major City)	Baguio	Tuguegarao	Clark (2020)	Metro Manila		Iloilo, Bacolot	Metro Cebu (1995/ 2016)		Zamboanga	Cagayan de Oro	Davao	

Source: JICA Survey Team

2) Point allocation method

The result of evaluation by the point allocation method is presented in Table 2.7-3. Based on the total points, the highest is WRR-III (Central Luzon) and WRR-IV (Southern Tagalog) with 34 points. The third highest is WRR-VII (Western Visayas) with 31 points, followed by WRR-XI (South-eastern Mindanao) with 30 points.

Table 2.7-3 Evaluation Result by Point Allocation Method

No.	Water Resources Region	Water Deficit							Social Economic Impacts							Consistency of Development Policy			TOTAL	RANK
		P-D		P/D		(P-D) per capita		Sub Total	Population Density (2050)		GRDP (2050)		Domestic+Industrial Water Demand		Sub Total	WRMP	SUDP	Sub Total		
		MCM/Year	point	-	point	m3/year/person	point	point	person/km^2	point	Bil. PHP	point	MCM/Year	point	point	point	point	point	point	-
1	I - ILOCOS	5,906	4	3.5	3	1,425	4	11	326	3	4,215	1	451	1	5	3	2	5	21	8
2	II - CAGAYAN VALLEY	12,781	3	2.1	4	1,932	4	11	173	2	7,229	2	377	1	5	4	2	6	22	7
3	III - CENTRAL LUZON	14,618	3	2.1	4	789	5	12	683	4	27,635	5	1,330	3	12	5	5	10	34	1
4	IV - SOUTHERN TAGALOG	36,668	1	5.6	3	929	5	9	897	5	89,556	5	3,997	5	15	5	5	10	34	1
5	V- BICOL	12,533	3	3.4	4	1,311	4	11	536	4	8,842	2	628	2	8	3	2	5	24	6
6	VI - WESTERN VISAYAS	16,978	3	4.8	3	1,610	4	10	509	4	12,671	3	1,242	3	10	3	2	5	25	5
7	VII - CENTRAL VISAYAS	7,106	4	4.6	3	721	5	12	724	4	13,208	3	799	2	9	5	5	10	31	3
8	VIII - EASTERN VISAYAS	19,661	3	10.5	1	2,857	3	7	331	3	4,895	1	335	1	5	1	2	3	15	11
9	IX - SOUTHWESTERN MINDANAO	20,103	2	9.9	1	2,520	3	6	391	3	7,560	2	472	1	6	3	2	5	17	10
10	X - NORTHERN MINDANAO	27,198	2	8.3	1	4,179	1	4	278	2	8,544	2	470	1	5	3	2	5	14	12
11	XI - SOUTHEASTERN MINDANAO	18,652	3	3.9	4	1,998	4	11	352	3	15,490	4	2,740	5	12	3	4	7	30	4
12	XII - SOUTHERN MINDANAO	33,466	1	5.3	3	2,594	3	7	423	3	12,364	3	1,242	3	9	1	2	3	19	9

Source: JICA Survey Team

(4) Final Selection through Discussions with Philippines Counterparts

At the 5th joint progress meeting on September 6, 2021, the Survey Team explained the above evaluation results to NEDA and NWRB. After that, the evaluation results including the evaluation criteria, selection methods, and selection policies were discussed with related organizations of the Philippine side and JICA at the 6th joint meeting on September 27, 2021, the stakeholder meeting of NEDA-INFRACOM Sub Committee of Water Resources (SCWR) on October 12, 2021, and the 7th joint meeting on October 19, 2021.

After the series of discussions, NEDA and NWRB made the following proposals regarding the final selection of priority water resources region at the 8th joint meeting on October 26, 2021:

- NEDA and NWRB basically agreed to use the point allocation method, but giving a unique scoring system that is partially different from the selection criteria of the Survey Team. This gives priority to water deficit criteria, followed by socio-economic impacts.
- At first, it was agreed to exclude WRR-III because of the existing on-going KOICA study and WRR-IV as exemption in the TOR.
- Based on the first criteria which is water deficit, the highest would be WRR-VII (Central Visayas) with 13 points. This would be automatically chosen as Priority 1.
- The next in rank are WRR-I (Ilocos), WRR-II (Cagayan Valley), WRR-V (Bicol) and WRR-XI (Southeastern Mindanao) with 11 points. To choose the priority among the four, the second criteria (socio-economic impacts) is compared. The highest two would be WRR-XI (Southeastern Mindanao) with 12 points and WRR-V (Bicol) with 10 points. Thus, the

suggested three priority regions would be WRR-VII (Central Visayas), WRR-XI (Southeastern Mindanao) and WRR-V (Bicol).

- The third criteria for consistency of development policy is only measured as either a *Yes* or *No*. This could be argued in two ways. Firstly, if there are prior existing plans, it can be enhanced through policy convergence. Secondly, if there is none, there will be a need. Therefore, this criterion is not adopted for the selection of the priority region.

The above proposal can be justified considering the following approach for selecting the priority regions:

i) Rather than treating the three criteria equally, most important criteria is “water deficit” that has more weight than “socio-economic impacts”.

ii) The criteria for “consistency of development policy” is not adopted for the selection of the priority region because there is a double-sided evaluation.

iii) The policy reasons such as the importance of the selected area for the Philippines, and/or considering studies/projects that have already been started are taking into consideration.

iv) Based on the above, the priority regions can be ranked among the 12 WRRs.

v) In addition, it is necessary to avoid overlapping of the scope of the works with other studies and projects. At present, there is an on-going water balance study undertaken by KOICA in WRR-III. For WRR-VII, the water balance study was only done in Cebu City but not for the whole Cebu Island, Bohol and Dumaguete; therefore there is no large scope duplication.

vi) NEDA and NWRB will initiate the study for other remaining regions considering “equality” of the regional development in the Philippines.

Based on the above, it was agreed among the parties to proceed with the work after Stage II on the premise of priority WRR VII, V, and XI.

(5) Evaluation of "Water Demand Sufficiency Fill-Rate"

1) Definition of Water Demand Sufficiency Fill-Rate”

The "Sufficiency Fill-Rate" is a numerical value indicating how much a need can be satisfied. For the "Water Demand Sufficiency Fill-Rate ", it is defined as a numerical value indicating the degree of supply to water demand.

So far, in this survey, the "Water Balance Tightness" was set as one of the three main evaluation criteria, and it was evaluated using subdivided into three criteria, a) P-D, b) P/D, c) (PD)/capita (P: water resource reserve, D: water demand). Of these, P/D is considered the "Sufficiency Fill-Rate" evaluated for the entire water resources regions.

The evaluation result of the P/D by each region is shown in the figure below:

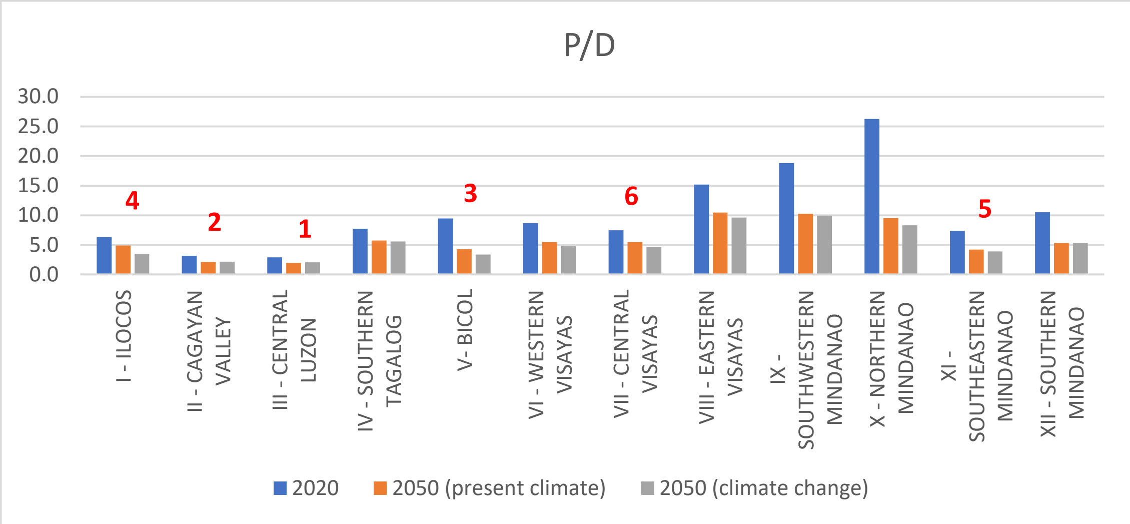


Figure 2.7-2 P/D by Each Water Resources Region under National Level Evaluation (RCP8.5-Median Case)

As this is an evaluation from a macro perspective, in order to evaluate the "Sufficiency Fill-Rate" from a more detailed perspective, water demand is further subdivided by region, purpose, or period (monthly), and would be further analysed.

2) Subdivision of "Sufficiency Fill-Rate" Evaluation

The data of water balance calculation result can be subdivided as follows:

a) By Region: The data and results of Water Resources Regions (WRR) can be subdivided into basin categories as follows:

- WRR-III (Pampanga / Agno)
- WRR-IV (Pasig-Laguna / Mindoro / Palawan)
- WRR-VI (Panay / Jalaur / Ilog-Hirabangan)
- WRR-VII (Cebu / Bohol / Negros)

b) By Purpose: The sources of water are classified into surface water and groundwater. The water usage patterns are classified into cases where total water demand and cases where only domestic and industrial water demand are considered.

c) By Period: The water balance data is subdivided by monthly data.

3) Examination Result of Subdivided "Water Sufficiency Fill-Rate"

Table 2.7-4 shows the results of the WRR-I study as of 2050 as a reference example of the study results of the subdivided "Water Sufficiency Fill-Rate". The procedure for calculating the Water Sufficiency Fill-Rate is as follows.

a) Organize the water resource potentials and water demands in the target area by month and by water source (surface water, groundwater). (Green and blue shaded cells in the table)

b) Based on the data in 1) above, evaluate the ratio P/D of surface water, groundwater, total (surface water + groundwater) by a monthly basis

c) The month when the P/D value is 1.0 or less is the month when the water potential is insufficient for water demand. (Yellow shaded cell in the table)

d) Here, the "Water Sufficiency Fill-Rate" is defined as "the ratio of the number of shortage months in a year ((the number of months in which the shortage occurred)/12)". The values are calculated separately for surface water, groundwater, and total (surface water + groundwater). The adopted cases of water demand are for all demand and for domestic and industrial water demand.

e) As a result of the above analysis in this reference, Water Sufficiency Fill-Rate will be at 83.3% for the water balance of surface water, at 58.3% for the water balance of groundwater, and at 83.3% for the water balance of total (surface water and groundwater). In addition, when evaluated in the case of only the demand for domestic and industrial water, the Water Sufficiency Fill-Rate will be 100% in all cases.

Table 2.7-4 Evaluation Results of P/D and Water Sufficiency Fill-Rate based on Water Balance Analysis at The National Level (Analysis Example In WRR-I)

Monthly Water Balance of 1/5-Dry Year in 2050 (mm/month) [Weather=RCP8.5-Median] (Irrigation Water Demand=JPT Proposed Demand)

Unit: mm/month

Calculation Condition						Surface Water Demand (D)					Total Water Balance			Water Balance (Domestic Water)		
Water Resources Region	Weather Condition	Water Demand Condition	Water Source	Month	Water Potential w/o Salt Water Area	Irrigation Water Demand	Domestic Water Demand	Industrial Water Demand	Other Water Demand (w/o Power)	Total Water Demand	P-D	P/D	Demand Sufficiency Fill-Rate	P-D	P/D	Demand Sufficiency Fill-Rate
					mm/Month	mm/Month	mm/Month	mm/Month	mm/Month	mm/Month	mm/Month	-	-	mm/Month	-	-
I - ILOCOS	RCP8.5-Median	WD=2050	Surface Water	Jan	10.2	23.9	0.3	0.4	0.0	24.7	-14.5	0.41	83.3%	9.9	30.99	100.0%
				Feb	8.9	20.0	0.3	0.4	0.0	16.8	-7.9	0.53		8.6	30.08	
				Mar	9.6	5.5	0.3	0.4	0.0	5.9	3.7	1.62		9.3	29.19	
				Apr	9.2	0.0	0.3	0.4	0.0	0.8	8.4	12.06		8.9	28.90	
				May	48.4	1.5	0.3	0.4	0.0	2.3	46.1	21.13		48.1	147.25	
				Jun	65.8	11.8	0.3	0.4	0.0	13.2	52.5	4.97		65.4	206.69	
				Jul	22.7	17.6	0.3	0.4	0.0	18.1	4.6	1.25		22.3	68.98	
				Aug	48.7	15.5	0.3	0.4	0.0	16.6	32.1	2.94		48.4	148.23	
				Sep	121.8	11.5	0.3	0.4	0.0	12.4	109.3	9.79		121.4	382.73	
				Oct	170.9	2.8	0.3	0.4	0.0	3.4	167.5	49.55		170.6	519.92	
				Nov	58.8	17.3	0.3	0.4	0.0	18.5	40.4	3.19		58.5	184.85	
				Dec	49.8	18.5	0.3	0.4	0.0	19.2	30.6	2.60		49.5	151.51	
			Groundwater	Jan	3.8	1.0	0.6	0.0	1.3	2.9	1.0	1.34	58.3%	3.3	6.84	100.0%
				Feb	3.0	0.9	0.5	0.0	1.1	2.4	0.6	1.27		2.5	5.87	
				Mar	2.7	0.2	0.6	0.0	1.3	2.0	0.7	1.33		2.1	4.73	
				Apr	1.9	0.0	0.5	0.0	1.2	1.8	0.1	1.05		1.3	3.42	
				May	1.3	0.0	0.6	0.0	1.3	1.8	-0.5	0.72		0.8	2.37	
				Jun	1.4	0.2	0.5	0.0	1.2	2.0	-0.7	0.67		0.8	2.53	
				Jul	1.4	0.7	0.6	0.0	1.3	2.6	-1.2	0.54		0.8	2.45	
				Aug	1.4	0.7	0.6	0.0	1.3	2.5	-1.1	0.56		0.8	2.49	
				Sep	1.8	0.6	0.5	0.0	1.2	2.4	-0.6	0.75		1.2	3.24	
				Oct	2.5	0.3	0.6	0.0	1.3	2.1	0.4	1.19		1.9	4.40	
				Nov	3.0	0.9	0.5	0.0	1.2	2.7	0.2	1.08		2.4	5.44	
				Dec	3.5	1.0	0.6	0.0	1.3	2.8	0.7	1.25		2.9	6.21	
			SW+GW	Jan	14.0	24.9	0.9	0.4	1.3	27.6	-13.5	0.51	83.3%	13.1	15.75	100.0%
				Feb	11.9	20.9	0.8	0.4	1.2	19.2	-7.3	0.62		11.0	13.37	
				Mar	12.3	5.7	0.9	0.4	1.3	7.9	4.3	1.55		11.4	13.75	
				Apr	11.1	0.0	0.9	0.4	1.3	2.5	8.5	4.35		10.2	12.40	
				May	49.7	1.5	0.9	0.4	1.3	4.1	45.6	12.01		48.8	55.80	
				Jun	67.1	12.0	0.9	0.4	1.3	15.3	51.8	4.39		66.2	75.31	
				Jul	24.1	18.4	0.9	0.4	1.3	20.7	3.4	1.16		23.2	26.98	
				Aug	50.1	16.2	0.9	0.4	1.3	19.1	31.0	2.62		49.2	56.24	
				Sep	123.5	12.0	0.9	0.4	1.3	14.8	108.7	8.36		122.6	138.57	
				Oct	173.4	3.0	0.9	0.4	1.3	5.5	167.9	31.36		172.5	194.52	
				Nov	61.8	18.2	0.9	0.4	1.3	21.2	40.6	2.92		60.9	69.30	
				Dec	53.3	19.4	0.9	0.4	1.3	22.0	31.3	2.43		52.4	59.79	

Source: JICA Survey Team

The results adopting the above procedure for each water resources region are tabulated and summarized as shown in Table 2.7-5.

Table 2.7-5 Evaluation Results of P/D and Water Sufficiency Fill-Rate based on National Water Balance Analysis (2050)

Calculation Condition						Demand Sufficiency Fill-Rate			
No.	Water Resources Region	Area	Water Demand Condition	Water Source	Year	Total Water Demand (P/D)	Domestic Water Demand (P/D)	Total Water Demand (P/D) (SW+GW)	Total Water Demand (P/D) (SW+GW) Domestic
		km^2				%	%	%	%
1	I - ILOCOS	12,717	RCP8.5-Median	Surface Water	2050	83%	100%	83%	100%
				Groundwater		58%	100%		
2	II - CAGAYAN VALLEY	38,290	RCP8.5-Median	Surface Water	2050	83%	100%	83%	100%
				Groundwater		100%	100%		
3	III - CENTRAL LUZON	27,131	RCP8.5-Median	Surface Water	2050	75%	100%	83%	100%
				Groundwater		100%	100%		
4	IV - SOUTHERN TAGALOG	44,034	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
4-(1)	WRR04-Pasig-Laguna de Bay	17,012	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		75%	100%		
4-(2)	WRR04-Mindoro	12,413	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
4-(3)	WRR04-Palawan	14,608	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
5	V- BICOL	17,821	RCP8.5-Median	Surface Water	2050	75%	100%	100%	100%
				Groundwater		100%	100%		
6	VI - WESTERN VISAYAS	20,733	RCP8.5-Median	Surface Water	2050	92%	100%	92%	100%
				Groundwater		100%	100%		
6-(1)	WRR06-Panay	2,649	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
6-(2)	WRR06-Jalaur	9,713	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		42%	83%		
6-(3)	WRR06-Ilog-Hilabangan	8,371	RCP8.5-Median	Surface Water	2050	92%	100%	92%	100%
				Groundwater		100%	100%		
7	VII - CENTRAL VISAYAS	13,606	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
7-(1)	WRR07-Cebu	4,879	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		0%	0%		
7-(2)	WRR07-Bohol	3,977	RCP8.5-Median	Surface Water	2050	83%	100%	92%	100%
				Groundwater		100%	100%		
7-(3)	WRR07-Negros	4,750	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		92%	100%		
8	VIII - EASTERN VISAYAS	20,768	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
9	IX - SOUTHWESTERN MINDANAO	20,395	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
10	X - NORTHERN MINDANAO	23,395	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		
11	XI - SOUTHEASTERN MINDANAO	26,486	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		83%	100%		
12	XII - SOUTHERN MINDANAO	30,461	RCP8.5-Median	Surface Water	2050	100%	100%	100%	100%
				Groundwater		100%	100%		

Source: JICA Survey Team

4) Consideration of the Examination Result of the Subdivided "Water Sufficiency Fill-Rate"

As shown in Table 2.7-5, the areas with low "Water Sufficiency Fill-Rate" by surface water and groundwater are as follows:

Surface water : WRR-I, II, III, V, VI (Ilog Hirabigan), VII (Bohol)

Groundwater : WRR-I, IV (Pasig-Laguna), VI (Jalaur), VII (Cebu / Negros), XI

The evaluation results from the viewpoint of the "Water Sufficiency Fill-Rate" show almost the same tendency as the priority evaluation based on the evaluation criteria of "Tightness of Water Balance".

In addition, the analysis results for candidates of the priority water resources regions show the following trends for each area. It was confirmed that the water sufficiency fill-rate was below 100% by monthly evaluations in all areas. It means that there would be a monthly water shortage in each region.

- WRR-V (Bicol): The water sufficiency fill-rate of surface water is 75%, and there is a monthly water shortage in surface water.
- WRR-VII (Central Visayas): The surface water sufficiency fill-rate is 83% in the Bohol area, causing water shortages on a monthly basis. In addition, the groundwater sufficiency rate is 0% in Cebu and 92% in Negros, and the degree of groundwater shortage is particularly large in Cebu.
- WRR-XI (South-eastern Mindanao): The groundwater sufficiency fill-rate is 83%, causing monthly water shortages in groundwater.

Based on the above, the priority water resources region V, VII, and XI selected in consultation with the Philippine side as mentioned in Section 2.7.2(4) are considered reasonable in terms of water sufficiency fill-rate.

2.8 Organizations and Legal Frameworks

2.8.1 Introduction

In this section, current status of organizations, legal frameworks and plans related to water resources in the Philippines are explained. In the Philippines, organizations and legal frameworks related to water resources have existed in a complicated form. JICA Survey Team recognizes this matter, and the following items are researched accordingly in order to clarify the current situation:

i) List of Organizations, Legal Frameworks and Plans on Water Resources
ii) Analysis on Previous Recommendations and Current Situations
iii) Major Issues on Organizations and Legal Frameworks Related to Water Resources in the Philippines
iv) Current Actions for Improving the Issues in the Philippines
v) Project Implementation Systems to consider towards Stage III and IV

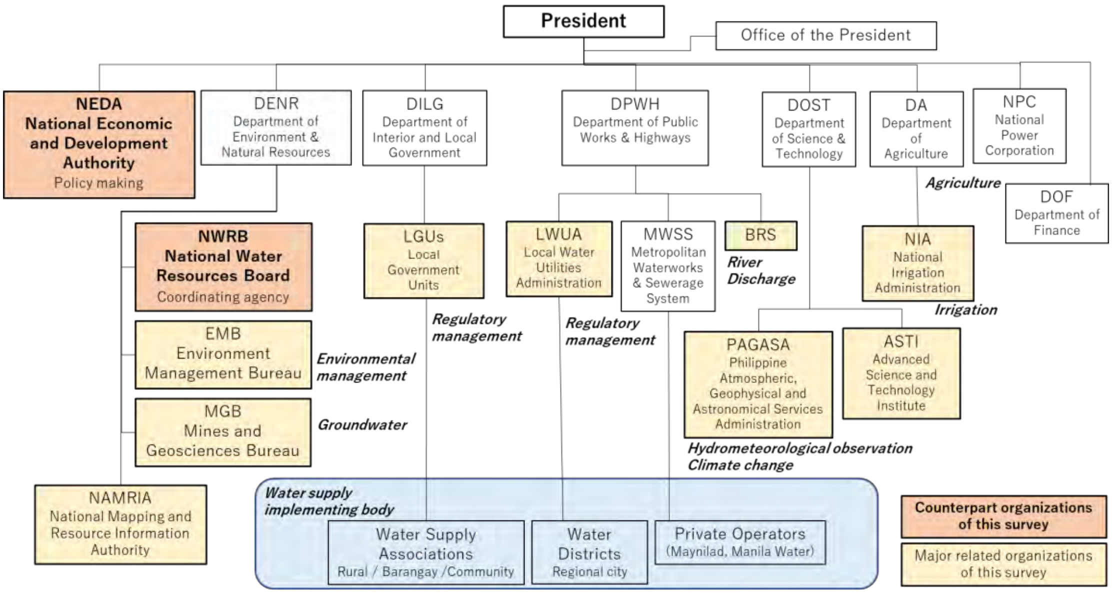
The outline of the survey results and the details of the survey are organized in the supporting report (Annex-C).

2.8.2 Organizations

The current status of organizations in the Philippines related to (1) water resources development, management and utilization, and (2) Public-Private Partnership (PPP) are listed in the tables in the supporting report (Annex-C-1). The outlines are given below.

(1) Water Resources related Agencies

As of 2021, there are over 30 water-related agencies with overlapping and at times conflicting mandates or functions over the country's water resources (The Philippine Development Plan 2023-2028). The conceptual chart on the organizations related to water resources in the Philippines is shown in Figure 2.8-1.



Source: JICA Survey Team

Figure 2.8-1 Conceptual Chart on the Organizations Related to Water Resources

(2) Organizations related to PPP (Public Private Partnership)

In this survey, it is expected that project implementation schemes based on PPP will be proposed proactively from the viewpoint of mitigating the financial burden of project implementation body. Thus, JICA Survey Team investigated about the organizations and legal frameworks related to PPP. Various organizations are involved with PPP in the Philippines, and the main findings are as follows:

i) The organization that oversees PPP is NEDA, and the PPP Center is placed under NEDA as the body for facilitating PPP programs and projects,

ii) When starting PPP projects, it is necessary to obtain the approval from the Investment Coordination Committee (under NEDA), which consists of the representatives from the related government organizations,

iii) DOF (Department of Finance) and DBM (Department of Budget and Management) are involved with PPP from the viewpoint of the financial aspect and budgetary aspect respectively.

2.8.3 Legal Frameworks

In this survey, JST summarized the legal frameworks related to PPP as well as those related to water resources development, management and utilization in the supporting report (Annex-C). The outline is as follows:

(1) Water Resources Development, Management and Utilization

1) Water Resources Development and Management

The main legal frameworks related to water resources development and management are Water Code (Presidential Decree No.1067) and its Implementing Rules and Regulations (IRR). In addition, the important legal frameworks related to water resources include Executive Order No.123, 2002, which stipulates the jurisdiction on NWRB (Transferred from DPWH to DENR), and Executive Order No.860, 2010, which stipulates the reorganizing of the NWRB board members and the jurisdiction on tariff regulation (transferred from NWRB to LWUA).

2) Water Supply

The representative legal frameworks related to water supply include Republic Act No.6234 (1971), the legal basis for establishment of the MWSS which has jurisdiction over the water supply in Metro Manila; Provincial Water Utility Act (Presidential Decree No.198 (1973)), the legal basis for establishment of LWUA; and Local Government Code (Republic Act No.7180 (1991)), which stipulates the authority for LGU-run water supply. In addition, the important legal frameworks include Executive Order No.311, 1996, the legal basis for private sector participation in the water supply in Metro Manila; and Executive Order No.62, which stipulates the jurisdiction on the LWUA (transferred from DOH to DPWH).

3) Irrigation

The representative legal frameworks related to irrigation include Free Irrigation Service Act (Republic Act No.10969 (2018)) which stipulates the exemption of irrigation service fee for farmers with landholdings of eight hectares and below; and the Agriculture and Fisheries Modernization Act (Republic Act No.8435 (1997)) which aims to modernize the agriculture and fishery sectors to technology-based, advanced and competitive industry.

4) Flood Management

The legal frameworks specialized for flood management cannot be confirmed in the Philippines. However, legal frameworks related to flood management include Water Code (Presidential Decree No.1067) and its Implementing Rules and Regulations (IRR), Local Government Code (Republic Act No.7180 (1991)). Also, Philippines Disaster Risk Reduction and Management Act (Republic Act No.10121) and Climate Change Act (Republic Act No.9729 (2009)) can be listed from the viewpoint of disaster risk reduction and climate change adaptation respectively.

(2) PPP

The basic legal framework related to PPP is BOT Law (Republic Act No.7718) and Revised Implementing Rules and Regulations, which stipulates the procedure of approval, bidding and contract related to PPP projects. In addition, the Philippines have the framework of joint venture between the government organizations or LGUs and private companies as one of the ways of PPP, which is not based on BOT Law. In this regard, the guidelines for such joint venture schemes prescribed by NEDA are also important.

2.8.4 Plans

The major administrative plans related to water resources are listed as follows at present:

i) The Philippine Development Plan (PDP), which is developed on the basis of six years of the presidential term, is the national comprehensive plan. PDP 2023-2028 takes up the water resources affair in the Chapter 12 “Expand and Upgrade Infrastructure”.

ii) The Philippine Water Supply and Sanitation Master Plan (PWSSMP) 2019-2030 is the guiding plan for the water supply and sanitation sector.

iii) The Irrigation Master Plan (NIMP) 2020-2030 is the guiding plan for the irrigation sector.

iv) The Disaster Risk Reduction and Management Plan established both at national and local level is the administrative plan related to the flood management.

v) The Integrated Water Resources Development and Management Master Plan established at the 18 basins and other areas in the Philippines is the administrative plan related to IWRM.

2.8.5 Previous Recommendations and Current Situation on Sector Reform

JST has reviewed the previous reports/documents related to water resources in the Philippines, and confirmed the recommendations related to organizations and legal frameworks and the situation on the actions taken for improving the issues corresponding to the recommendations. Table 2.8-1 summarizes the recommendations and current situation.

Table 2.8-1 Recommendations and Current Situation (Action for Improvement Taken)

<table>
<tr><th>Recommendation</th><th>Current Situation</th></tr>
<tr><td>Creation of the Water Resources Authority of the Philippines (WRAP) (1998 M/P JICA)</td><td rowspan="4">- President Mr. Marcos Jr. declared that the establishment of the Department of Water Resources (DWR) is one of the priorities in his first State of Nation Address (SONA) on July 25 2022.
- Bills for Creating the Department of Water Resources (DWR) and the Water Regulatory Commission (WRC) have been filed in Congress. Also, the bills have been deliberated, but not approved as of April 2023.
- If the act is enacted,
DWR shall function as the overall apex body.
WRC shall function as an independent and quasi-judicial regulatory body for the water supply and sanitation sub-sector.
- The Executive Order No.22 2023 was issued for creating the Water Resources Management Office under the DENR on 27th April 2023.</td></tr>
<tr><td>Implement new institutional arrangement including an expanded role of NWRB as the sector regulator and its translation to National Water Resources Management Office … (2016 World Bank)</td></tr>
<tr><td>Enactment of a Law Creating an Apex Body for the Water Resources Sub sector (PDP 2017-2022)</td></tr>
<tr><td>Enactment of a Law Creating an Independent Economic or Financial Regulator for Water Supply and Sanitation (PDP 2017-2022)</td></tr>
<tr><td>Establish regional offices to effectively regulate and monitor the water resources activities on site rather from a distant central office … (1998 M/P JICA)</td><td>NWRB extension offices have been established in the Visayas and Mindanao in 2018, specifically in Cebu City and Davao City.</td></tr>
<tr><td>Revenue from water charge or fine to be allocated for research activity and data collection on water resources… (1998 M/P JICA)</td><td>House Bill of An Act for Creating the Department of Water Resources (DWR) and the Water Regulatory Commission (WRC) includes an article of creating a “Water Trust Fund” from water charge and others, utilized for water development and water sustainability programs.</td></tr>
</table>

Source: JICA Survey Team

2.8.6 Major Issues on Organizations and Legal Frameworks in Water Resources Sector

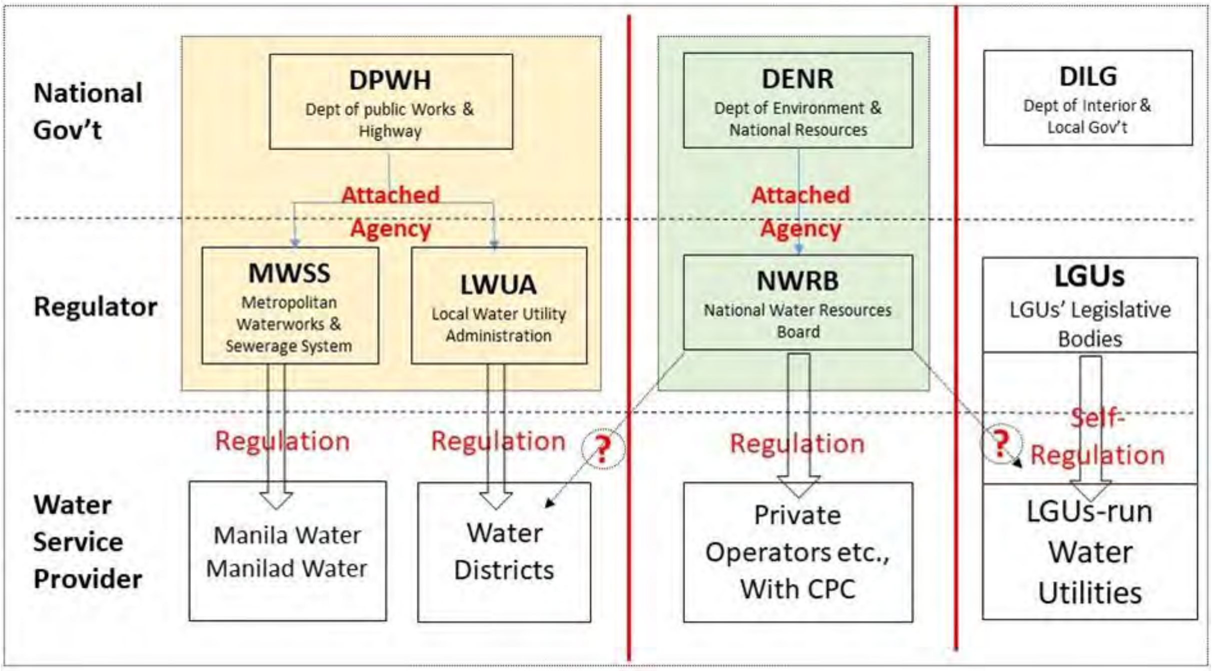
(1) General

According to the previous reports/documents, two major issues have been pointed out with regard to organizations and legal frameworks related to water resources sector in the Philippines: 1) institutional fragmentation/lack of coordination and 2) necessity to strengthen the regulatory functions. These issues are indicated in the Philippine Development Plan (PDP) 2017-2022, which implies the common understandings that the two issues exist in the Philippines.

(2) Institutional Fragmentation/Lack of Coordination

The issue on institutional fragmentation/lack of coordination is significant in the water supply sub-sector. In the Philippines, there are many water service providers including water districts, private companies, LGU-run utilities etc., and they operate their water services under other regulatory organizations. Their standards for technical operation and water rate setting are developed by their respective regulatory organization, hence the standards are different from each other. Figure 2.8-2 shows the situation.

In addition, JST confirmed a situation where multiple water service providers under the jurisdiction of different regulatory organizations are implementing their operations in the same area.



Source: JICA Survey Team

Figure 2.8-2 Fragmentation on Regulatory Function for Water Utilities

(3) Weak Regulatory Functions for Water Resources

1) Resource Regulation

The representative organization for water resources regulation in the Philippines is NWRB, which is in charge of regulatory affairs including issuing water permit, adjudication for water use conflicts, and also monitoring and execution of illegal water intake. The NWRB Annual Reports indicate the situation on processing of the water permit application and adjudication of water use conflicts, and it was found that the numbers of water permit applications and water use conflict cases have been accumulating every year in spite of NWRB's efforts to process their applications/cases.

Also, the NWRB Annual Reports indicate that there remain the issues on illegal surface water and groundwater intake in spite of NWRB's efforts for regulatory works (monitoring and execution). As recommended previously, it is necessary for NWRB to strengthen their organizational structure, human resources, and financial basis continuously.

2) Economic Regulation

Here, economic regulation means the regulatory framework on water rates collected by the water service providers. According to PWSSMP 2019-2030, the inadequate situation on economic regulation can be recognized as follows:

i) Only 27% of piped water service providers, mostly WDs and private WSPs, are subject to economic regulation (leaving 73% without any standard guidelines for tariff setting or oversight on performance).
ii) There is no lead agency for the water supply sub-sector that grants and revokes licenses and sets standards for public and private WSPs. Several agencies act as economic regulators for water in the absence of a lead regulatory agency.
iii) Some LGU-run water utilities cannot earn adequate income for their operation and maintenance because of low level of cost recovery.

2.8.7 Current Actions for Improving the Issues in Water Resources Sector

(1) Creation of the Water Resources Management Office (WRMO)

The Executive Order No.22 2023 for creating the Water Resources Management Office (WRMO) was issued on 27th April 2023. WRMO is placed under the DENR, and in coordination with all stakeholders, shall primarily be responsible for the integration and harmonization of all government efforts and regulatory activities to ensure availability and sustainable management of water resources in the whole country of the Philippines.

It is mandated to "ensure the immediate implementation of the IWRM in line with the United Nations Sustainable Development Goals, and formulate a corresponding Water Resources Master Plan." It is also directed to integrate into the master plan the various programs of agencies, which include the Philippine Development Plan, the Philippine Water Supply and Sanitation Master Plan, and the National Water Resources Board Security Master Plan. It is also tasked to "shepherd and champion, together with the Presidential Legislative Liaison Office, the passage of a law creating an apex body such as the proposed Department of Water and/or a regulatory commission on water." In this regard, WRMO is the transitory body until the Department of Water Resources is established. The outline of the E.O. is summarized in the Annex C-1.

(2) Creation of Apex Body and Independent Economic Regulatory Body

1) Movement towards Creation of the Department of Water Resources as an "Apex Body"

Creation of the Department of Water Resources (DWR) as an "Apex Body" was deliberated in the former President Duterte Administration, and the present President Marcos Jr. declared in the first State of Nations on 25th July 2022 that creation of DWR is one of the priorities. Also, the creation of DWR is included in the new PDP 2023-2028 as one of the items of the legislative agenda (Responsible Agency: NEDA).

Through the creation of the DWR by enacting the bill, it is directed to integrate various water-related organizations/bureaus/divisions belonging to different departments into one organization. However, though currently several congressmen/women have prepared the bills for creation of DWR and submitted them to the Congress, but it has not been enacted yet.

2) Movement towards Creation of Independent Economic Regulatory Body (Water Regulatory Commission)-

In line with the creation of DWR, it is proposed to create the independent regulatory body with quasi-judicial functions (The Water Regulatory Commission (WRC)) under DWR. Same as DWR, it is directed to integrate various organizations/bureaus/divisions in charge of regulatory functions into the WRC. Also, the creation of WRC is included in the new PDP 2023-2028 as one of the items of the legislative agenda (Responsible Agency: NEDA). Creation of WRC is included in the bills for creation of DWR, however not yet been enacted.

Meanwhile, the outline of the House Bill No.9948, filed to the Congress on August 2021, is introduced in the supporting report (Annex-C-1) in order to clarify the idea of DWR and WRC as one of the examples. It should be noticed that the House Bill was filed but not enacted by the Congress, so the contents of the House Bill will not be realized.

(3) Other Actions

According to the NWRB Annual Reports, the following actions for improving the issues on organizations and legal frameworks can be confirmed:

1) Listahang Tubig Database:

Listahang Tubig is a program to register the information on water providers covering all service levels in the Philippines and formulate the database, which is administered by NWRB in partnership with DILG and LWUA from 2014.

2) Development of Groundwater Management Plan and Establishment of Monitoring Wells

NWRB is working on the development of Groundwater Management Plan in groundwater constraint areas or highly urbanized water constraint cities, in collaboration with LGUs, national government agencies, and private and academic institutions. LGUs are involved in the identification of monitoring well sites and provision of land area to NWRB for the installation of wells.

CHAPTER 3 STAGE II: DETAILED WATER BALANCE ANALYSIS IN THE PRIORITY WATER RESOURCES REGIONS

3.1 Outline

In this chapter, (14) Detailed Hydrological Analysis and Water Resources Potential Assessment, (15) Detailed Water Demand Forecast, and (16) Calculation of Water Balance are described by each priority Water Resources Region (WRR).

In the hydrological analysis of the priority water resources regions in Stage II, the analysis was conducted while assuming the subsequent water resource development options. The main purpose of this analysis is to contribute to the evaluation of the effects of the proposed options.

Water demand forecast for priority WRRs was conducted by adopting similar methods as in Stage I, but was differentiated in the following points: i) Target Year: short term (2030), medium term (2040), and long term (2050); ii) Detailed Irrigation Water Demand: clarified by all irrigation systems and potential irrigation development area with main features of the location, irrigation service area, water source, water intake site and so on. For these irrigation systems/projects, monthly irrigation water requirements were estimated based on the influences of the climate change phenomena; and iii) Detailed Water Demand for Domestic and Industrial Use: predicted with the utilization of preceding outline water demand forecast data in the priority area. Data accuracy was increased by using water usage record data, water charge collection data, and the latest industrial development plan collected by site survey.

3.2 Socio-economic Framework in Priority Water Resources Regions

3.2.1 Socio-economic Situation

(1) Population for the Priority WRRs

The population by province for the priority WRRs is shown in Table 3.2.1-1. The population of WRR V was 22,277,207 in 2020 while that of WRR VII was 16,036,711 and that of XI was 17,432,066 in 2020.

Table 3.2.1-1 Population by Province for the Priority WRRs

WRR	Region/Year	Province	Population		
			2010	2015	2020 (updated by 2020 census)
WRR V (Bicol)	Region IV-A - Calabarzon	Batangas	2,377,395	2,694,335	2,908,494
		Cavite	3,090,691	3,678,301	4,344,829
		Laguna	2,669,847	3,035,081	3,382,193
		Quezon	1,987,030	2,122,830	2,229,383
		Rizal	2,484,840	2,884,227	3,330,143
		Sub-total	**12,609,803**	**14,414,774**	**16,195,042**
	Region V - Bicol Region	Albay	1,233,432	1,314,826	1,374,768
		Camarines Norte	542,915	583,313	629,699
		Camarines Sur	1,822,371	1,952,544	2,068,244
		Catanduanes	246,300	260,964	271,879
		Masbate	834,650	892,393	908,920
		Sorsogon	740,743	792,949	828,655
		Sub-total	**5,420,411**	**5,796,989**	**6,082,165**
WRR VII (Central Visayas)	Region VI - Western Visayas	Aklan	535,725	574,823	615,475
		Antique	546,031	582,012	612,974
		Capiz	719,685	761,384	804,952
		Guimaras	162,943	174,613	187,842
		Iloilo	2,230,195	2,384,415	2,509,525
		Negros Occidental	2,907,859	3,059,136	3,223,955
		Sub-total	**7,102,438**	**7,536,383**	**7,954,723**
	Region VII - Central Visayas	Bohol	1,255,128	1,313,560	1,394,329
		Cebu	4,167,320	4,632,359	5,151,274
		Negros Oriental	1,286,666	1,354,995	1,432,990
		Siquijor	91,066	95,984	103,395
		Sub-total	**6,800,180**	**7,396,898**	**8,081,988**

WRR	Region/Year	Province	Population		
			2010	2015	2020 (updated by 2020 census)
WRR XI (Southeastern Mindanao)	Region X - Northern Mindanao	Bukidnon	1,299,192	1,415,226	1,541,308
		Camiguin	83,807	88,478	92,808
		Lanao del Norte	930,738	1,019,013	1,086,017
		Misamis Occidental	567,642	602,126	617,333
		Misamis Oriental	1,415,944	1,564,459	1,685,302
		Sub-total	**4,297,323**	**4,689,302**	**5,022,768**
	Region XI - Davao Region	Davao de Oro	687,195	736,107	767,547
		Davao del Norte	945,764	1,016,332	1,125,057
		Davao del Sur	2,024,206	2,265,579	2,457,430
		Davao Occidental	293,780	316,342	317,159
		Davao Oriental	517,618	558,958	576,343
		Sub-total	**4,468,563**	**4,893,318**	**5,243,536**
	Region XII - SOCCSKSARGEN	Cotabato (North Cotabato)	1,226,508	1,379,747	1,275,185
		Cotabato City	271,786	299,438	-
		Sarangani	498,904	544,261	558,946
		South Cotabato	1,365,286	1,509,735	1,672,791
		Sultan Kudarat	747,087	812,095	854,052
		Sub-total	**4,109,571**	**4,545,276**	**4,360,974**
	Region XIII - Caraga	Agusan del Norte	642,196	691,566	760,413
		Agusan del Sur	656,418	700,653	739,367
		Dinagat Islands	126,803	127,152	128,117
		Surigao del Norte	442,588	485,088	534,636
		Surigao del Sur	561,219	592,250	642,255
		Sub-total	**2,429,224**	**2,596,709**	**2,804,788**

Source: Philippine Statistics Authority (PSA), “2010 Census of Population and Housing”, “2015 Census of Population”, “2020 Census of Population”, Population projection by JICA Survey Team based on PSA "2010 Census-based Population Projections in collaboration with the Inter-Agency Working Group on Population Projections" and "Updated Projected Mid-Year Population Based on 2015 POPCEN by Five- Year Age Group, Sex, Single-Calendar Year and by Province: 2015 - 2025"

(2) GRDP of the Priority WRRs

The Gross Regional Domestic Product (GRDP) of the priority WRRs is shown in Table 3.2.1-2. The GRDP of WRR V was PHP 3,080,918 million while that of WRR VII was PHP 2,015,466 million and that of XI was PHP 2,510,535 million in 2020.

Table 3.2.1-2 GRDP of the Priority WRRs

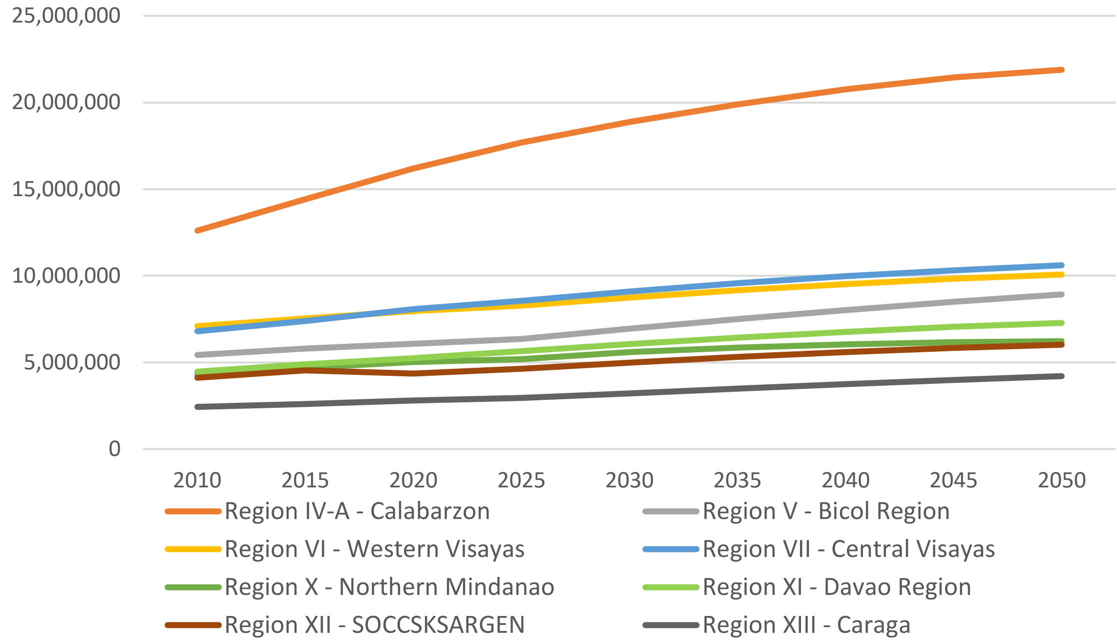
Unit: million PHP

The Priority WRRS	GRDP	2017	2018	2019	2020
WRR V (Bicol)	Region IV-A (Calabarzon)	2,423,069	2,706,995	2,865,793	2,565,124
	Region V (Bicol)	465,966	522,015	560,835	515,794
WRR VII (Central Visayas)	Region VI (Western Visayas)	791,282	860,108	919,163	850,747
	Region VII (Central Visayas)	1,067,273	1,180,946	1,270,612	1,164,719
WRR XI (Southeastern Mindanao)	Region X (Northern Mindanao)	737,898	821,122	885,224	861,506
	Region XI (Davao)	748,539	841,429	922,614	889,458
	Region XII (Soccsksargen)	420,128	454,305	474,893	467,906
	Region XIII (Caraga)	273,088	290,562	302,930	291,665

Source: JICA Survey Team

3.2.2 Population Projection for the Priority WRRs

The results of the population projection for the priority WRRs (V, VII and XI) are shown in Figure 3.2.2-1 and Table 3.2.1-1. The population projection is based on the projection of PSA (issued in 2010 and 2015) and it was updated based on census data in 2020 by JICA Survey Team.



Source: JICA Survey Team

Figure 3.2.2-1 Population Projection for the Priority WRRs

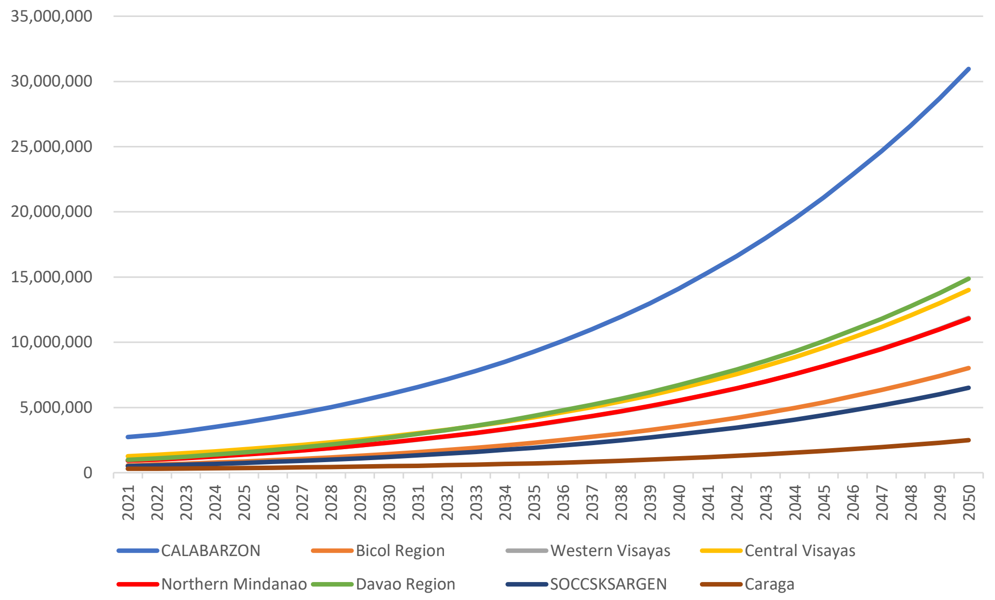
Table 3.2.2-1 Population Projection for the Priority WRRS

Region	2010	2015	2020	2025	2030	2035	2040	2045	2050
Region IV-A - Calabarzon	12,609,803	14,414,774	16,195,042	17,691,929	18,874,221	19,895,721	20,765,860	21,443,785	21,882,557
Region V - Bicol Region	5,420,411	5,796,989	6,082,165	6,354,276	6,936,643	7,498,680	8,025,192	8,507,834	8,932,767
Region VI - Western Visayas	7,102,438	7,536,383	7,954,723	8,268,138	8,743,545	9,167,741	9,524,308	9,823,255	10,071,033
Region VII - Central Visayas	6,800,180	7,396,898	8,081,988	8,548,393	9,090,007	9,570,437	9,976,015	10,316,159	10,604,195
Region X - Northern Mindanao	4,297,323	4,689,302	5,022,768	5,191,954	5,601,859	5,853,584	6,042,047	6,166,770	6,224,978
Region XI - Davao Region	4,468,563	4,893,318	5,243,536	5,649,098	6,059,239	6,435,269	6,767,827	7,048,176	7,275,507
Region XII - SOCCSKSARGEN	4,109,571	4,545,276	4,360,974	4,633,766	4,987,767	5,312,226	5,599,572	5,839,756	6,024,644
Region XIII - Caraga	2,429,224	2,596,709	2,804,788	2,951,611	3,219,308	3,483,531	3,741,516	3,986,790	4,215,471

Source: JICA Survey Team

3.2.3 GRDP Projection for the Priority WRRs

The results of the GRDP projection for the priority WRRs (V, VII and XI) are shown in Figure 3.2.3-1 and Table 3.2.3-1. The projection in 2021 and 2022 is based on “PDP 2017-2022”, and that from 2023 to 2026 is based on IMF “World Economic Outlook”. The projection from 2027 to 2050 was conducted based on the GDP annual growth trend of other countries in Asia which have GDP per capita which is similar to that of the Philippines.



At Current Prices (Unit: Mil. PHP)

Source: JICA Survey Team

Figure 3.2.3-1 GRDP Projection for the Priority WRRs

Table 3.2.3-1 GRDP Projection for the Priority WRRS

At Current Prices (Unit: Mil. PHP)

The Priority WRRS	Administrative Regions	2025	2030	2035	2040	2045	2050
WRR V (Bicol)	Region IV-A (Calabarzon)	3,841,154	6,008,318	9,269,986	14,106,645	21,094,397	30,965,731
	Region V (Bicol)	862,161	1,429,362	2,295,693	3,558,133	5,394,708	8,029,838
WRR VII (Central Visayas)	Region VI (Western Visayas)	1,406,863	2,303,038	3,635,398	5,511,734	8,166,214	11,877,069
	Region VII (Central Visayas)	1,788,710	2,769,869	4,250,064	6,437,876	9,582,559	14,001,797
WRR XI (Southeastern Mindanao)	Region X (Northern Mindanao)	1,386,486	2,304,832	3,661,492	5,535,914	8,164,200	11,819,157
	Region XI (Davao)	1,556,217	2,674,580	4,354,428	6,711,806	10,082,900	14,869,958
	Region XII (Soccsksargen)	750,717	1,215,631	1,915,419	2,936,275	4,411,058	6,505,297
	Region XIII (Caraga)	365,828	497,905	716,768	1,094,703	1,667,398	2,493,346

Source: JICA Survey Team

3.3 Priority Water Resources Region (WRR VII)

3.3 Priority Water Resources Region (WRR VII)

3.3.1 Outline of WRR VII

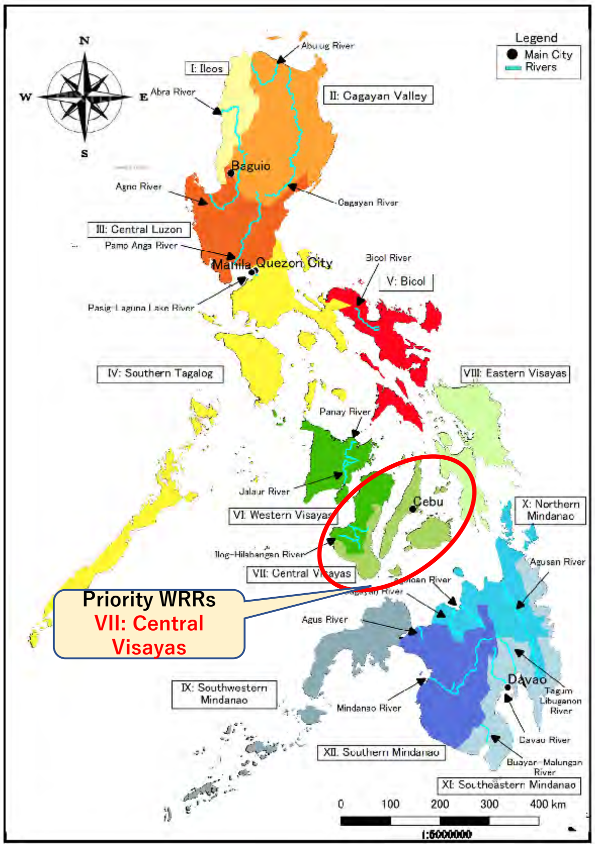
WRR VII is located in Central Visayas consisting of Cebu Island, Bohol Island, Negros Oriental, and Siquijor Island. The administrative district includes parts of Regions VII and VI. The provincial division consists of these four provinces.

From the perspective of water resources, especially in Cebu Island, problems such as the lowering of dam water levels during droughts and the infiltration of saltwater into groundwater have become apparent, making water resource problems an urgent issue.

Table 3.3.1-1 General Information on WRR VII

Water Resources Regions	Major 18 Rivers (Catchment Area)	Major Cities	Climate Classification	Island Name
WRR VII Central Visayas	—	Metro Cebu	Type-III & IV	Cebu, Bohol Island, Negros Island

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.3.1-1 Location Map of Priority WRR (WRR VII)

3.3.2 Socio-Economic Situation and Organization and Legal Framework in WRR VII

3.3.2.1 Socio-Economic Situation

This is described in Section 3.2.

3.3.2.2 Organization and Legal Framework in the WRR VII

In this section, the outline of the organizations related to water resources in WRR VII is summarized, and after that, the organizations that JST visited during the site survey periods are introduced and sorted into: (1) National government organizations, (2) LGUs, and (3) Water Service Providers (WSPs). Although a small part of administrative area of Region VI (Western Visayas) is covered by WRR VII, most of the area belongs to Region VII (Central Visayas). Thus, JST visited organizations mainly within Region VII.

(1) Organizations

1) National Government Organizations

In the Philippines, "Regions" are set as administrative divisions that primarily serve to coordinate planning and organize national government services across multiple LGUs. Also, most national government organizations provide their regional branch offices, which have jurisdiction over the services of the national government and oversee the LGUs. Organizations related to the planning and implementation of water resources projects are introduced below.

- NEDA Region VII

  NEDA Region VII, located in Cebu City, monitors regional and inter-regional development policies, plans and programs; prepares integrated reports on regional planning; conducts studies on regional development policies; and performs such other planning tasks as may be assigned by the Director-General in its region (Sec.14, Title II, Book V, Administrative Code of 1987). It also serves as the secretariat of the Regional Development Council Region VII, which is deeply involved in the preparation of the Regional Development Plan and other investment programs.

- DPWH Region VII

  DPWH Region VII, located in Cebu City, is responsible for highways, flood control and water resources development and management, and other public works with its region (Sec.20, Title V, Administrative Code of 1987). It also provides some engineering offices within its region for implementing construction works or other duties.

- NIA Region VII

  NIA Region VII, located in Dao District, city of Tagbilaran, in the province of Bohol, is composed of one interim irrigation management office (IMO), the Bohol-Cebu IMO and one satellite office, the Negros Oriental-Siquijor Satellite Office. Its objective is to develop and maintain irrigation systems in support of the agricultural program of the government; to provide an adequate level of irrigation service on a sustainable basis in partnership with the farmers and local government units; to provide technical assistance to institutions in the development of water resources for irrigation; and to improve and sustain the operation of NIA as a viable corporation and service-oriented agency.

2) LGUs

According to PhilAtlas website, Region VII, which occupies most of the area of WRR VII, has four provinces (Bohol, Cebu, Negros Oriental, and Siquijor), 16 cities including three highly urbanized cities (Cebu City, Lapu-Lapu City, and Mandaue City), and 116 municipalities. JST visited the municipality of Inabanga in the province of Bohol for information collection, as it is a strong candidate as a source area for the Bohol water conveyance to the Metro Cebu Water District (MCWD) area in the MCWD's water resources development plan.

3) WSPs

According to the Central Visayas Water Supply and Sanitation Databook and Regional Roadmap attached to the PWSSMP, the overview of the WSPs within Region VII is as follows:

- As of 2015, of the 33 operational WDs serving Central Visayas, 20 were operational and 13 were non-functional.
- There are 304 LGU-run water utilities within the region.
- There are 646 BWSA utilities within the region.
- There are 70 RWSA utilities within the region.
- There are 981 private or other types of water service providers within the region.

The water service providers that JST has visited are as follows. Meanwhile, the information on water districts is obtained from the interview session with each WSP as well as the annual audit report of 2021 prepared by the Commission of Audit (COA).

- Metro Cebu Water District (MCWD)

  MCWD, created in May 1974, is the water district providing water to the cities of Cebu, Lapu-Lapu, Mandaue and Talisay, and the municipalities of Compostela, Consolacion, Cordova, and Liloan. It had a total workforce of 789 employees composed of 539 regular personnel, 227 job order/contractual employees, and 23 casual employees. It is categorized as a "Category A" water district.

- Metro Siquijor Water District (MSWD)

  MSWD, created in May 1980, is the water district providing water to the municipalities of Siquijor, San Juan, Lazi and Maria in the province of Siquijor. It has 47 personnel composed of 18 regular employees and 29 job order positions. It is categorized as a "Category D" water district.

- Bohol Water Utility Incorporated (BWUI)

  BWUI is the joint venture company, established in 2000, between the Provincial Government of Bohol, owning 30% of the shares (mostly through the handover of existing assets), and the Salcom Consortium, owning 70% of the shares. Meanwhile, the city of Tagbilaran, the capital of the province of Bohol, has three major water service providers, namely, BWUI, Tagbilaran City Waterworks (LGU-run), and the Richli Corporation (private utility). The duplication of the service areas covered by these providers is recognized one of the issues related to water resources management in this region.

- Dumaguete City Water District (DCWD)

  DCWD, created in 1977, is the water district providing water to the city of Dumaguete. It had 32 personnel composed of 14 regular employees, 15 casual employees and three job order employees. It is categorized as a "Category B" water district. DCWD has established a joint venture company, Metro Dumaguete Water, with Metro Pacific Water in 2019.

- Sibulan Water District (SIWAD)

  SIWAD, created in November 1982, is the water district providing water to the municipality of Sibulan and one barangay in the municipality of San Jose in the province of Negros Oriental. It has 53 personnel composed of 13 regular employees, 37 casual and three job order positions. It is categorized as a "Category C" water district.

The categorization of water districts (Category A, B, C and D) is explained in Annex C-5.

(2) Plans

The following items are the representative regional plans related to water resources in WRR VII:

- Regional Development Plan of Region VII 2017-2022

  This is the mid-term development plan between 2017 and 2022 prepared for Region VII. The items related to water resources are described in "Chapter 19 Accelerating Infrastructure Development" with some proposed dam projects for water supply in Central Visayas.

- Central Visayas Water Supply and Sanitation Databook and Regional Roadmap

  The Water Supply and Sanitation Databook and Regional Roadmap is an attached document to the PWSSMP. It supplements the PWSSMP with maps, datasets and charts, and presents the framework, vision, goals and strategies, which are contemplated to achieve the planned targets in Region VII.

- Climate Change Responsive Integrated River Basin Management and Development Master Plan for the Central Cebu River Basins

  This is the basic management plan for six watersheds (Kotkot, Mananga, Lusaran-Combado, Cansaga, Butuanon, and Cebu City watersheds) in the Central Cebu River basins, encompassing four cities (Cebu, Danao, Mandaue and Talisay), and six municipalities (Asturias, Balamban, Compostela, Consolacion, Liloan and Minglanilla).

In addition, plans related to flood control at regional level are summarized in Table 2.2-20 of Section 2.2.11.

3.3.3 Natural Condition in WRR VII

3.3.3.1 Land and General Topography, Geology in WRR VII

(1) Land Area

Central Visayas is an administrative region in the Philippines, numerically designated as Region VII. It consists of four provinces, Cebu, Bohol, Negros Oriental, and Siquijor, and three highly urbanized cities: Cebu City, Lapu-Lapu, and Mandaue.

Major islands are Cebu, Bohol, and Siquijor, together with the eastern part of Negros. The regional center with the largest scale is Cebu City. The land area of the region is 15,895.66 km^2, and with a population of 8,081,988 inhabitants, it is the second most populous region in Visayas[1].

(2) General Topography and Geology

Central Visayas consists of the two major island provinces of Cebu and Bohol, as well as the smaller island of Siquijor and several outlying islands. It also includes the eastern half of the larger island of Negros. The straits of Cebu and Tañon are also part of the region. The region is bordered in the north by the Visayan Sea, in the west by the province of Negros Occidental in Western Visayas, in the south by the Bohol Sea, and in the east by the Camotes Sea and the island of Leyte in Eastern Visayas.

The terrain of Cebu Island is characterized by highlands with narrow coastal strips. Bohol Island does not have very high mountains and the terrain is rather flat. It is characterized by hills such as the Chocolate Hills. The southern part of Negros Island has volcanic topography and is highly permeable. In the eastern and northern parts of Negros Island, rolling plains extend from the hills to the coastline, and sugar cane fields and paddy fields are spread out. Siquijor Island has extensive limestone geology, abundant limestone caves and springs, and a gentle topography with no relatively high mountains.

[1] https://rsso07.psa.gov.ph/population

3.3.3.2 Meteorology and Hydrology in WRR VII

(1) Climate and Climate Regions of the Study Area

Four climatological types exist in the Philippines as shown in Figure 3.3.3-1.

Cebu, Negros Oriental and Siquijor provinces are located in Type-III climatological type and Bohol Province is located in Type-IV climatological type.

Source: PAGASA (http://bagong.pagasa.dost.gov.ph/information/climate-philippines)

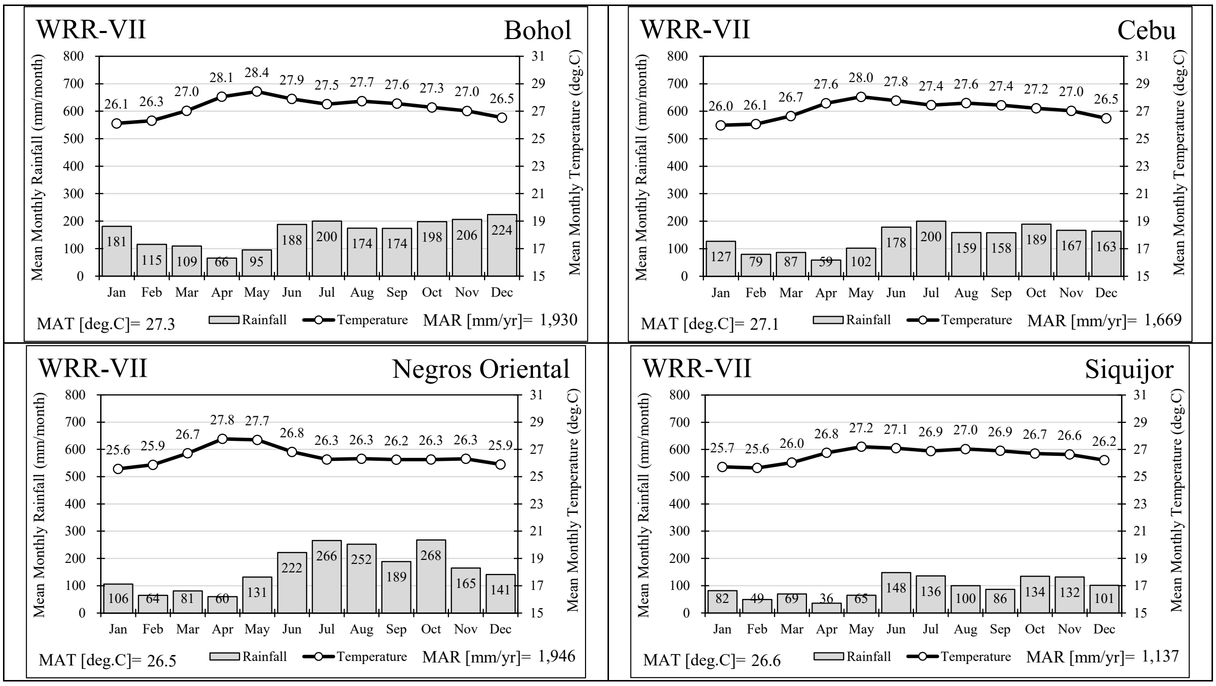
Figure 3.3.3-1 Climate Regions in the Philippines

In WRR-VII, climate is classified as dry season from February to May with little rainfall, and rainy season from June to January. Eastern Negros has relatively high rainfall during the wet season, while Siquijor has low rainfall throughout the year.

(2) Temperature and Rainfall

The average annual temperature in Bohol and Cebu exceeds 27 °C, while it is around 26.5 °C in eastern Negros and Siquijor. The temperature is stable throughout the year, but the highest temperature is around April to May at the end of the dry season.

Daily mean temperatures from 1979 to 2020 of ERA5 (0.25-degree grid; approximately 31 km mesh) were collected from the ECMWF reanalysis data sets. Provincial mean monthly rainfall and mean monthly temperature from 1979 to 2020 (42 years) in each water resources region are shown in Figure 3.3.3-2 below:



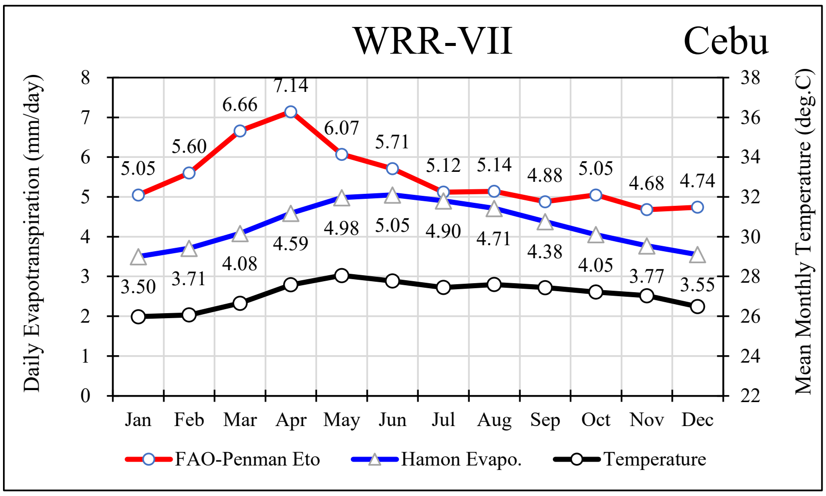
Source: JICA Survey Team, based on ERA5 and CHIRPS data

Figure 3.3.3-2 Provincial Mean Monthly Rainfall and Mean Monthly Temperature from 1979 to 2020 (42 Years) in Each Province in WRR-VII

(3) Evapotranspiration

Estimated daily potential evapotranspiration (reference crop evapotranspiration) (ETo), averaged by each province using FAO-Penman-Monteith equation, was used for paddy fields and the estimated daily average potential evapotranspiration by province using Hamon's equation, was used for other land use fields. The ten-day reference crop evapotranspiration (ETo) was also used for the estimation of the crop water requirement of paddy by province.

The estimated daily evapotranspiration by FAO-ETo and Hamon methods averaged by province, is shown in Figure 3.3.3-3 below:



Source: JICA Survey Team, based on ERA5 and FAO-ClimWat data

Figure 3.3.3-3 Estimated Daily Potential Evapotranspiration of FAO-ETo and Hamon Method

(4) Precipitation/Weather Data

1) Data Set

In this study, satellite rainfall data (CHIRPS) and re-analysis rainfall data (ERA5) were used due to the low density of observed rainfall stations within the priority WRR. For precipitation/weather data, ERA5, GSMaP, and CHIRPS data were used from each provider as listed in the IT/R (see Table 2.3-1 for data specifications). The summary of each data is as follows:

- ERA5: Numerical forecasting system analysis using observed data as input to reproduce past weather events with homogeneous quality. Spatial resolution is 0.25° × 0.25° grids and temporal resolution is hourly. The data are available from January 1979. The provider is the European Centre for Medium-Range Weather Forecasts (hereinafter “ECMWF”).
- GSMaP: Precipitation estimated from microwave radiometers/sounders is supplemented by cloud moving vectors obtained from thermal infrared bands of geostationary satellites and corrected by ground rain gauges. Spatial resolution is 0.1° × 0.1° grids and temporal resolution is hourly. The data are available from March 2000. The provider is the Japan Aerospace Exploration Agency (hereinafter “JAXA”).
- CHIRPS: Rain gauges are used to correct for precipitation estimated from the thermal infrared bands of geostationary satellites. Since 2000, Tropical Precipitation Measuring Mission Multi-satellite Precipitation Analysis (NASA's version of GSMaP) has been included. Spatial resolution is 0.05° × 0.05° grids and temporal resolution is daily or monthly. The data are available from January 1981. The provider is the United States Geological Survey / Climate Hazards Center (hereinafter "USGS/CHC").

ERA5 and GSMaP, which are provided in hourly precipitation, are converted to daily precipitation according to the Philippine local time. It should be noted that CHIRPS, which is provided in daily or monthly precipitation, is based on the Universal Time.

Total monthly precipitation data provided by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) for 17 stations are available. Also, since the total daily precipitation data for 7 stations are available from 1961 to 2021, the equivalent total monthly precipitation data are created by accumulating the daily precipitation data. In total, monthly precipitation data at 24 stations are used for this study.

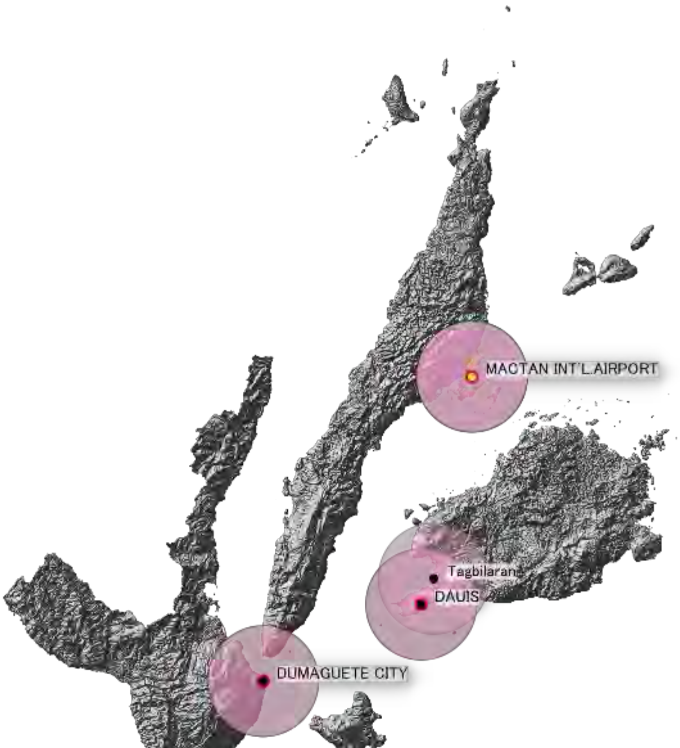
2) Methods

To validate the reanalysis/satellite precipitation datasets with the total monthly precipitation datasets observed by ground stations, the reanalysis/satellite daily or hourly precipitation datasets were accumulated for equivalent total monthly precipitation, and pixels over rain gauge locations were extracted. Also, since anomalous precipitation values should be removed for robust statistical analysis, the Smirnoff-Grubbs tests (Grubbs, 1950) were performed for the annual trends of each month over each station; then, data determined to be outliers at the 95% confidence level were excluded. In order to correct the reanalysis/satellite precipitation datasets, a cumulative precipitation amount was compared with rain gauges.

Although there is some bias in the CHIRPS and PAGASA observation data, CHIRPS data was selected for the hydrological analysis without correction in this study considering the limited number of the PAGASA stations.

3) Results for WRR-VII

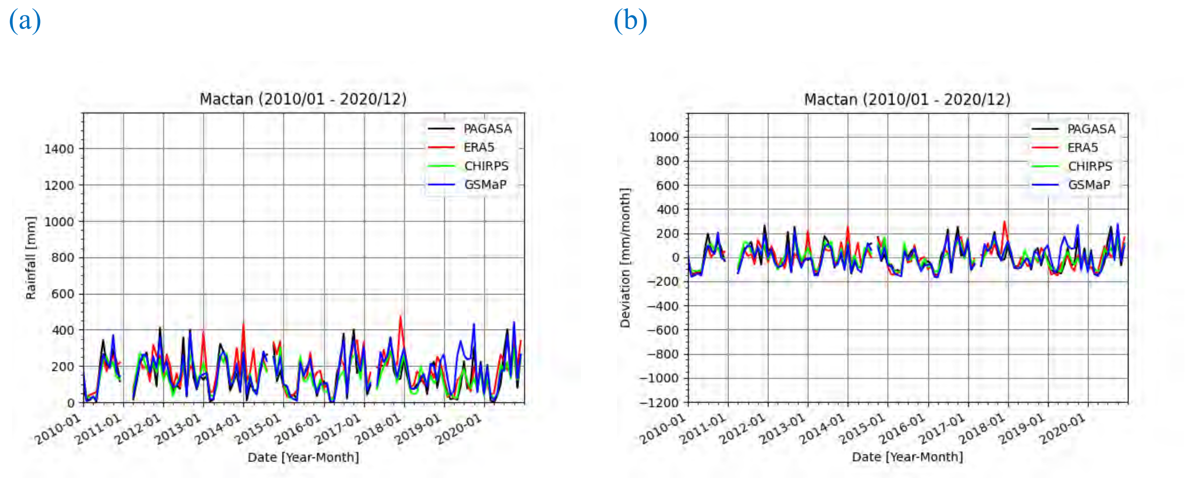
In WRR-VII, datasets at the four PAGASA's stations, namely: MACTAN INT'L AIRPORT, DAUIS, DUMAGUETE CITY, and TAGBILARAN, are available. Figure 3.3.3-4 shows the location of the stations. In this section, the results of the MACTAN INT'L AIRPORT are described. Annual trends of the monthly precipitation and the biases from the average are shown in Figure 3.3.3-5. Inter-annual trends of each precipitation dataset are almost the same among the three datasets except for an overestimation around December in the ERA5 trend. CHIRPS's cumulative precipitation amount comparing with the PAGASA's rain gauge shows 7.1% underestimation as shown in Figure 3.3.3-5.



Note: Dots indicate location at the PAGASA station which provides daily dataset (black) and monthly dataset (yellow).

Source: JICA Survey Team

Figure 3.3.3-4 Location at Station in WRR VII



Note: Lines indicate PAGASA station (black), ERA5 (red), CHIRPS (green) and GSMaP (blue).

Source: JICA Survey Team

Figure 3.3.3-5 Annual Trends of the Precipitation at Mactan Int'l Airport Station

(a) Total monthly precipitation (b) Biases from the average

3.3.3.3 River and Water Resources

(1) River

There are no major river basins in WRR VII, but there are several principal river basins as shown in Figure 3.3.3-6 below:

Source: National Water Resources Council (1976) "Principal River Basins of the Philippines"

Figure 3.3.3-6 Location Map of Principal Rivers in WRR VII

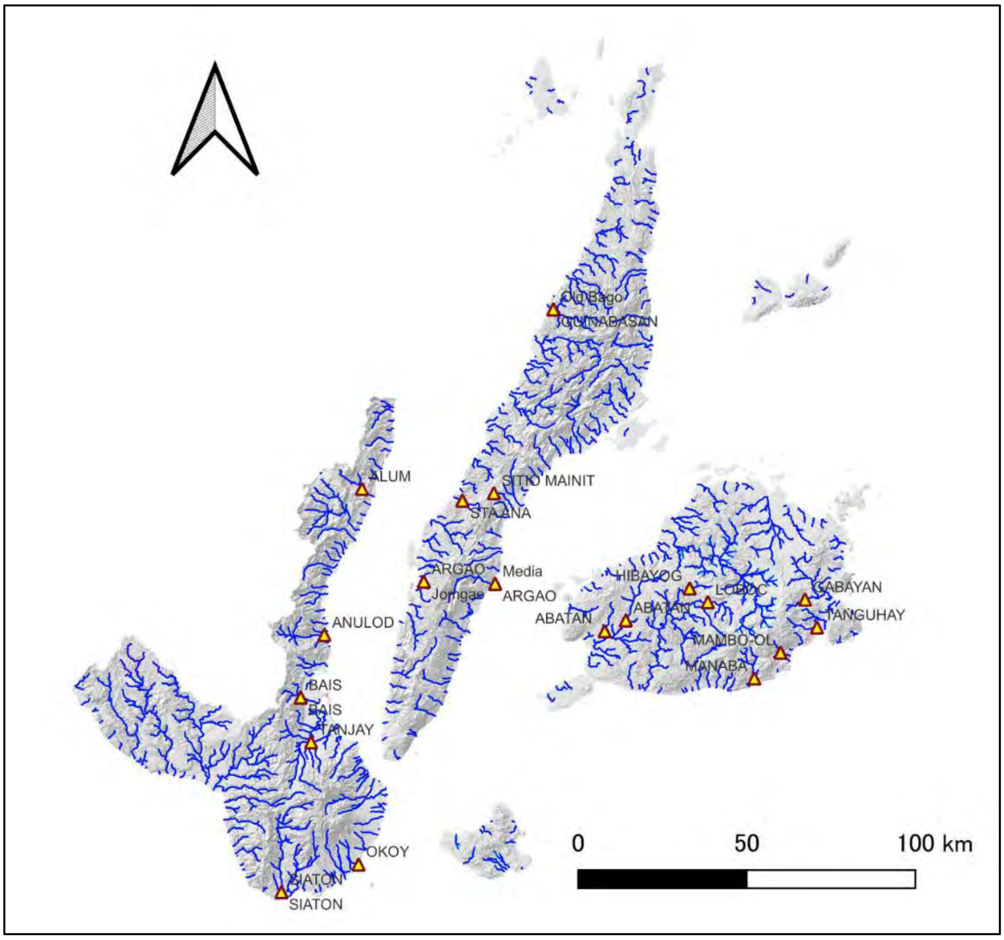
(2) Streamflow Data

Streamflow data were gathered for many of the stations within the survey area. Streamflow records were obtained from DPWH. A total of 25 daily average discharge data shown in Figure 3.3.3-7 and Table 3.3.3-1 were collected and used for the low flow analysis of WRR VII.

Table 3.3.3-1 Number of Discharge Observation Stations by WRRs

N	N	Station	River	Basin	Agenc	WRF	Province	Town, Village	Latitud	Longitu	Elevatioi	C.A.(km	Period
394	1	ABATAN	ABATAN	ABATAN	DPWH	VII	BOHOL	SAN ISIDRO, BALILIHAN, BOHOL	9.7890	123.9570	48.7	140.0	1984-2000
396	2	ABATAN	ABATAN	ANTEQUERA	DPWH	VII	BOHOL	STO. ROSARIO, ANTEQUERA, BOHOL	9.7600	123.9000	44.2	45.0	1984-2016
402	3	LOBOC	LOBOC	CANTIMOC	DPWH	VII	BOHOL	VILLARCAYO, CARMEN, BOHOL	9.8370	124.1790	197.2	91.0	1985-2006
403	4	GABAYAN	GABAYAN	GABAYAN	DPWH	VII	BOHOL	CANAWA, CANDIJAY, BOHOL	9.8430	124.4420	26.1	28.0	1985-2003
405	5	HIBAYOG	HIBAYOG	HIBAYOG	DPWH	VII	BOHOL	LA VICTORIA, CARMEN, BOHOL	9.8740	124.1300	170.7	41.0	1986-2003
406	6	MAMBO-OL	MAMBO-OL	MAMBO-OL	DPWH	VII	BOHOL	MAMBO-OL, DUERO, BOHOL	9.7010	124.3750	10.0	22.0	1987-2011
407	7	MANABA	MANABA	MANABA	DPWH	VII	BOHOL	CANDULAO, G. HERNANDEZ, BOHOL	9.6320	124.3040	68.1	93.0	1984-2016
412	8	TANGUHAY	TANGUHAY	TANGUHAY	DPWH	VII	BOHOL	BULAWAN, GUINDULMAN, BOHOL	9.7680	124.4740	46.8	21.0	1986-2004
304	9	Jomgao	Argao	ARGAO RIVER BASIN	DPWH	VII	Cebu	Jomgao, Argao, Cebu	9.8940	123.4110		71.0	2010-2013
305	10	Media	Argao	ARGAO RIVER BASIN	DPWH	VII	Cebu	Media, Argao, Cebu	9.8880	123.6040		80.0	1985-2009
306	11	Old Bago	Guinabasan	GUINABASAN RIVER BASIN	DPWH	VII	Cebu	Old Bago, Asturias, Cebu	10.6240	123.7630		153.0	1984-2005
307	12	STA ANA	STA ANA	STA ANA RIVER BASIN	DPWH	VII	Cebu	STA ANA, BARILI, CEBU	10.1110	123.5160		45.0	1984-2016
398	13	ARGAO	ARGAO	ARGAO	DPWH	VII	CEBU	MEDIA, ARGAO, CEBU	9.8880	123.6040	11.9	80.0	1985-2002
399	14	ARGAO	ARGAO	ARGAO	DPWH	VII	CEBU	JOMGAO, ARGAO, CEBU	9.8940	123.4110		71.0	2003-2013
404	15	GUINABASAN	GUINABASAN	GUINABASAN	DPWH	VII	CEBU	NEW BAGO, ASTURIAS, CEBU	10.6240	123.7630	18.9	153.0	1984-2005
411	16	STA ANA	STA ANA	STA ANA	DPWH	VII	CEBU	STA ANA, BARILI, CEBU	10.1110	123.5160	43.5	45.0	1984-2016
448	17	SITIO MAINIT	CARCAR	CARCAR	DPWH	VII	CEBU	SITIO MAINIT, GUADALUPE, CARCAR	10.1310	123.6010	94.9	16.0	1984-1989, 1991-2012
395	18	ALUM	ALUM	ALUM	DPWH	VII	NEGROS ORIENTAL	BUENAVISTA, GUIHULNGAN, NEGROS ORIENT	10.1430	123.2440	96.5	61.0	1985-1999
397	19	ANULOD	ANULOD	ANULOD	DPWH	VII	NEGROS ORIENTAL	CABUGAN, BINDOY, NEGROS ORIENTAL	9.7510	123.1420		122.0	2011-2015
400	20	BAIS	BAIS	BAIS	DPWH	VII	NEGROS ORIENTAL	CABANLUTAN, BAIS CITY, NEGROS ORIENTAL	9.5830	123.0780	48.7	56.0	1984-2009
401	21	BAIS	BAIS	BAIS	DPWH	VII	NEGROS ORIENTAL	CABANLUTAN, BAIS CITY, NEGROS ORIENTAL	9.5830	123.0780	48.7	50.0	2010-2015
408	22	OKOY	OKOY	OKOY	DPWH	VII	NEGROS ORIENTAL	PALINPINON, VALENCIA, NEGROS ORIENTAL	9.1350	123.2340	48.2	100.0	1984-2015
409	23	SIATON	SIATON	SIATON	DPWH	VII	NEGROS ORIENTAL	POBLACION, SIATON, NEGROS ORIENTAL	9.0610	123.0260	1.2	220.0	1984-2010
410	24	SIATON	SIATON	SIATON	DPWH	VII	NEGROS ORIENTAL	POBLACION, SIATON, NEGROS ORIENTAL	9.0610	123.0260		220.0	2011-2015
413	25	TANJAY	TANJAY	TANJAY	DPWH	VII	NEGROS ORIENTAL	PINANLAYAAN, PAMPLONA, NEGROS ORIENT	9.4630	123.1060	45.1	163.0	1986-2015

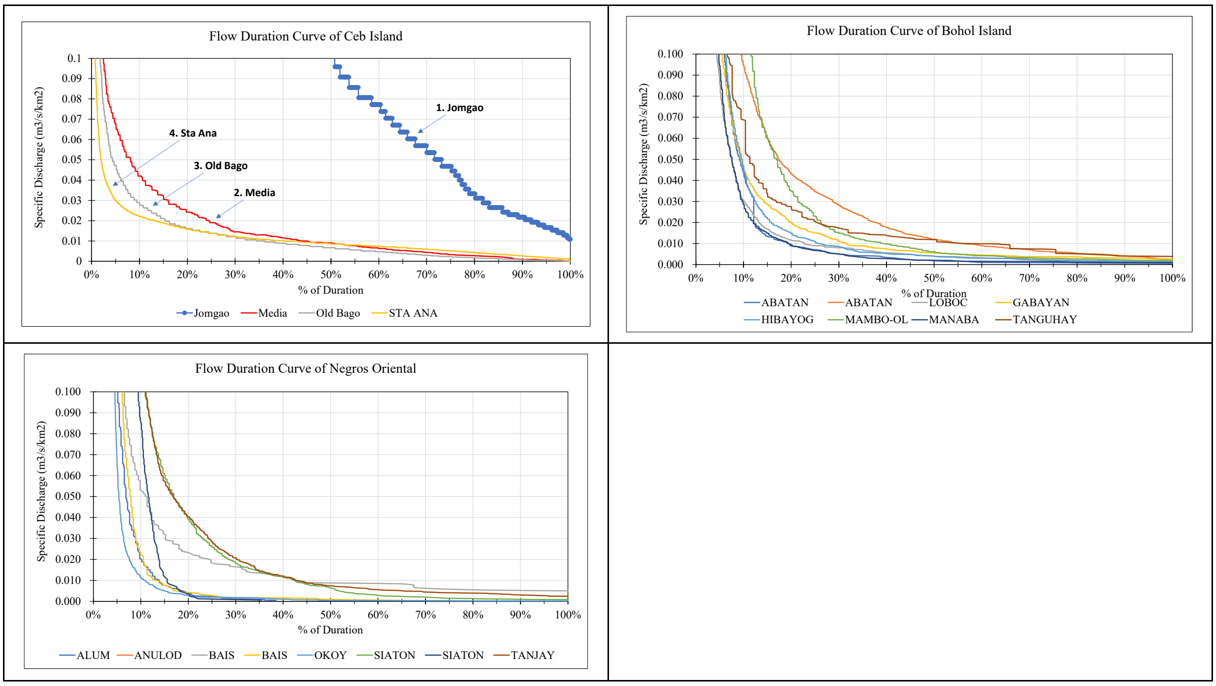
Source: DPWH



Source: JICA Survey Team based on the data of DPWH

Figure 3.3.3-7 Location Map of Daily Discharge Observation Stations used for Low Flow Analysis (Total 25 Stations)

Unfortunately, these streamflow data were often missing as shown in Annex-D: Hydrology. In addition, there are limits to the frequency of discharge observations and the accuracy of the water level-discharge rating curves (H-Q curves), as there are many flows in which the value of the flood discharge is questionable. There are many data at observatories where the flow duration curves (FDCs) using the specific discharge are unreliable as shown in Figure 3.3.3-8 below:



Source: JICA Survey Team

Figure 3.3.3-8 Flow Duration Curve (FDC) of Observed Daily Discharge in WRR VII

3.3.3.4 Geology and Hydrogeology

(1) Geology

The geological map of WRR VII is shown in Figure 3.3.3-9. A geological overview of Cebu island, Bohol island, Negros Oriental, and Siquijor islands, is also separately described below.

1) Cebu Island

The larger portions of the Cebu Island are dominated by sedimentary rocks while the rest are distributed with metamorphic and igneous rocks. The central highland is underlain chiefly by Tertiary and Pre-Tertiary sedimentary rocks such as extensive, transgressive graywacke-shale sequence intercalated with spilites associated with limestone lenses and sometimes metamorphic rock consisting of greenschist facies.

Distributed in the circumference of South Cebu at an elevation ranging from 150 m to 600 m are Upper Miocene Pleistocene sedimentary rocks which are made up of marine elastics (molasse) overlain by extensive, locally transgressive pyroclastics and tuffaceous sediments.

2) Bohol Island

Bohol island was believed to be developed as a product of tectonic and magmatic action from the subduction of the Pacific Crustal Plate east of Samar and Surigao. The oldest rocks occur in the northern and northeastern parts of the island. These consist of pre-tertiary schist, metavolcanics and some patches of ultramafic rocks. It is assumed to be a part of the Bohol crustal rocks before plate action began. All the succeeding igneous extrusive and intrusive in Bohol are the results of plate action. The rest of the island is underlain by tertiary sedimentary rocks consisting mainly of limestone and limy sedimentary clastic.

All structures developed over the Bohol crustal area are inferred to have resulted from the tectonic and magmatic action of the Philippine Island Arc System. The underlying crustal basement is believed to have exerted influence in the present northeast disposition of the rock formation of the island. The original topography of the underlying basement rocks upon which the beds were deposited is believed to be heavily influential in the development of structures in the latter. Except for the general northeast disposition of the rock formations, there is no abundant presence of major structural features such as faults and fissures on the island.

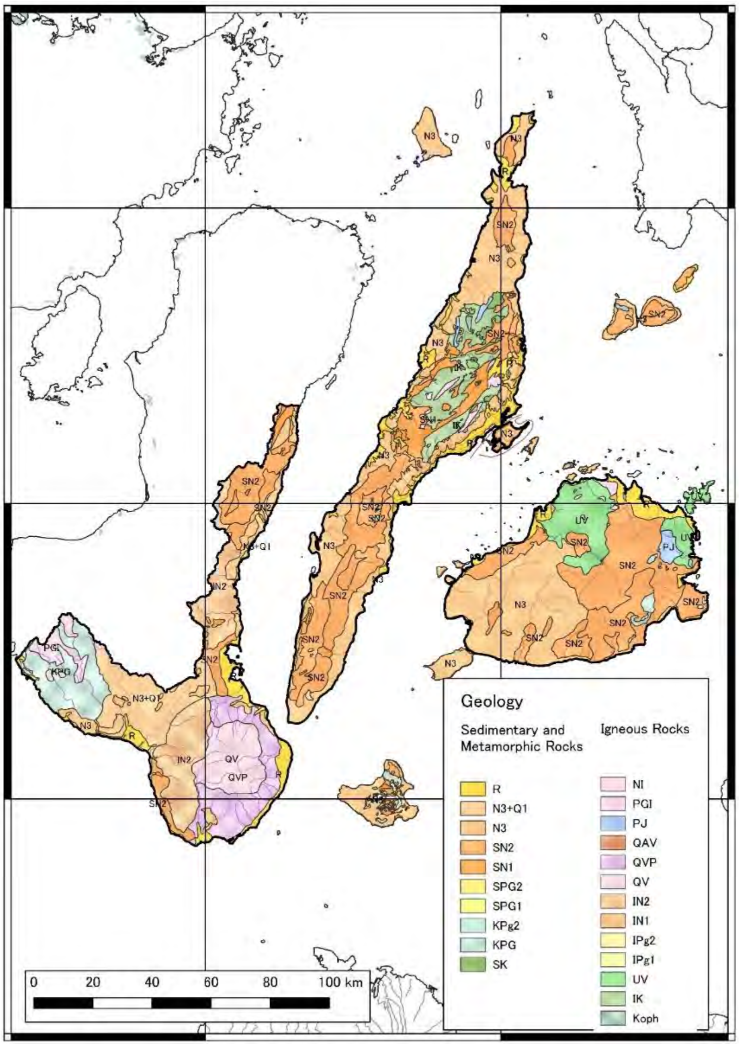
3) Negros Oriental

Tertiary sedimentary rocks, possibly from the Pliocene age, predominate most parts of Negros Oriental. Running as a narrow coastal belt are coralline limestone formations from the upper most part of Vallehermoso down to Dumaguete and other portions in Tolong in the south. Extensive areas of coralline limestone are also found in the interior of Bagtic. The whole of the southern peninsula is of andesitic to basaltic lava flow of the Late Tertiary and Quaternary age.

During the time of mountain-making movements, intrusions of igneous rocks came about. The high fertility of the soils in the eastern coastal plains may be attributed to the leaching of lime rich in phosphorous from the upper hills.

4) Siquijor

Siquijor island is mainly of coralline limestone formation except for some areas which are of calcareous shale. It can be said that the present landform of the island is accentuated from the Pliocene to Pleistocene uplift and continues to rise above sea level to the present time, as exemplified by steep and precipitous cliffs of coralline limestone along coastal areas. This limestone which coves almost 2/3 of the island fringes the coastal portion and underlines the relatively flat and isolated intermontane hills at the foot of the mountain. Underlying this rock is the Upper Miocene sandstone-shale sequence. Early to Middle Miocene limestone, and the Cretaceous Paleogene stratified sedimentary rocks with local interbeds of basalt and agglomerate flows in some places.



Source: MGB

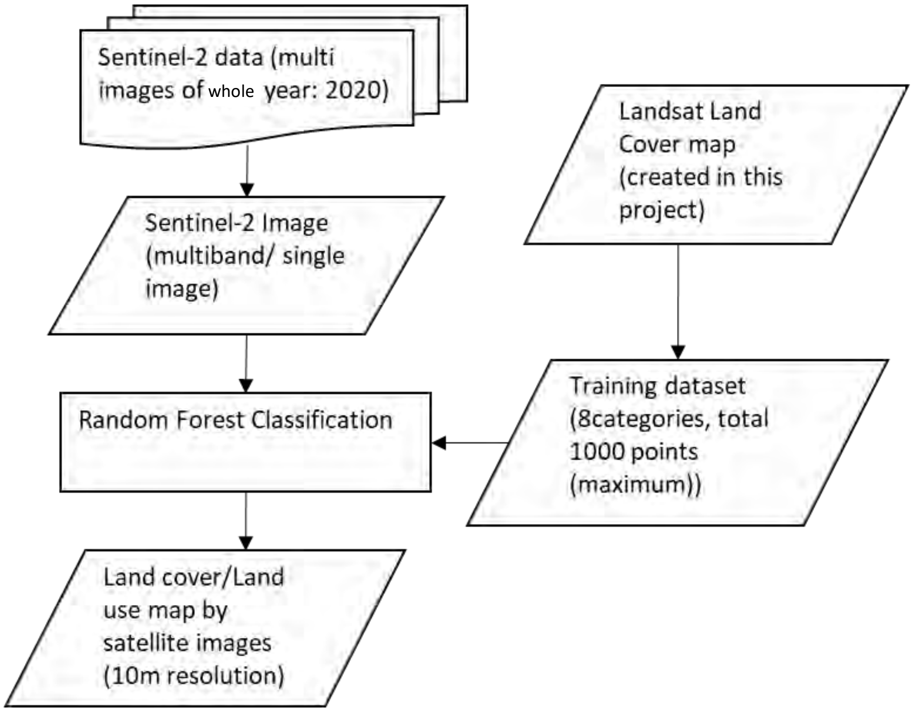
Figure 3.3.3-9 Geological Map of WRR VII

3.3.3.5 Creation of Land Cover/Land Use Using Satellite Data

(1) 10 m land cover/land use map creation for WRR VII using Sentinel-2

Land cover/land use map was created for the 3 priority WRRs. Satellite data were used to create 2020 land cover maps. For satellite data, JST used the optical images of Sentinel-2. The ground resolution is about 10 m which is higher than the Landsat dataset (30 m), and the visible band, near infrared band, and short wavelength infrared band of optics can be used. This near infrared band and short wavelength infrared band are effective for analysis.

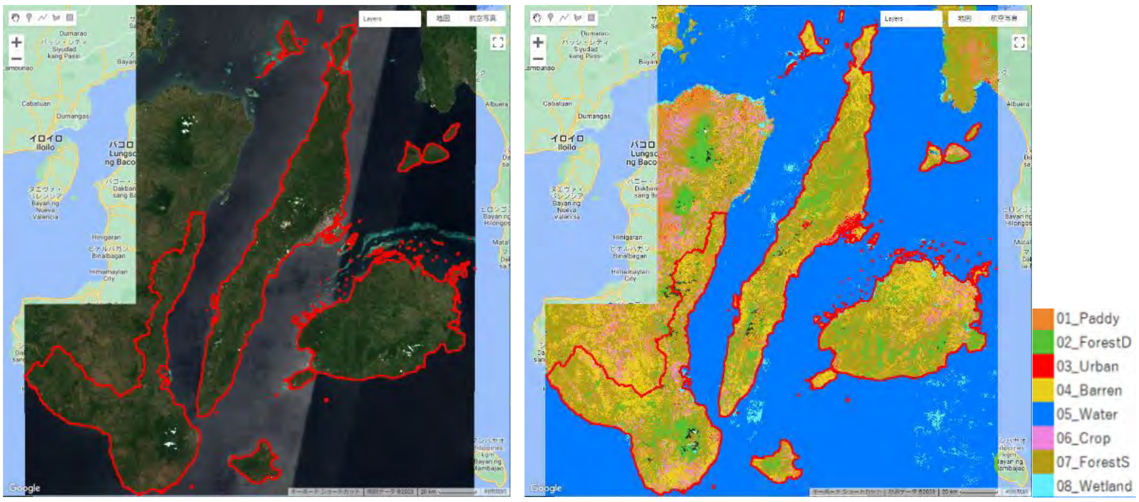
Sentinel-2 images were classified by Random Forest methodology to create a land cover map. Training points for Random Forest classification were obtained by referring to the Landsat land cover map that was created in this survey (refer to section 2.2.6). The classification category is that of Table 3.3.3-2. For the input Sentinel-2 images, JST used a mosaic image that connects the cloudless parts from the image of the target year. All of this was done on Google Earth Engine. The processing flow is shown in Figure 3.3.3-10.



Source: JICA Survey Team

Figure 3.3.3-10 Flow of classification processing using satellite data

The land cover/land use map for WRR VII is shown in Figure 3.3.3-11. When the classification results were visually interpreted, it was confirmed that the paddy field area could be detected well.



Note: Left: Sentinel-2 mosaic image, right: Land cover map

Source: JICA Survey Team

Figure 3.3.3-11 Flow of classification processing using satellite data (WRR VII)

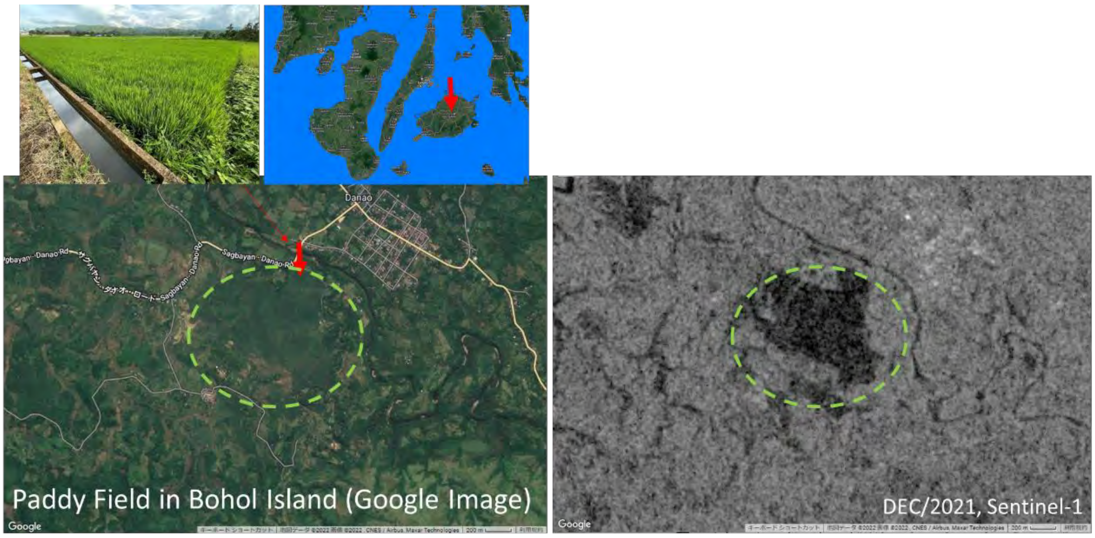
Table 3.3.3-2 List of land cover/land use map category

Classification Category
Paddy
Forest (Dense)
Urban
Barren
Water
Crop (not paddy)
Forest (Sparse)
Wetland

Source: JICA Survey Team

(2) Seasonal change understanding on paddy field using Sentinel-1

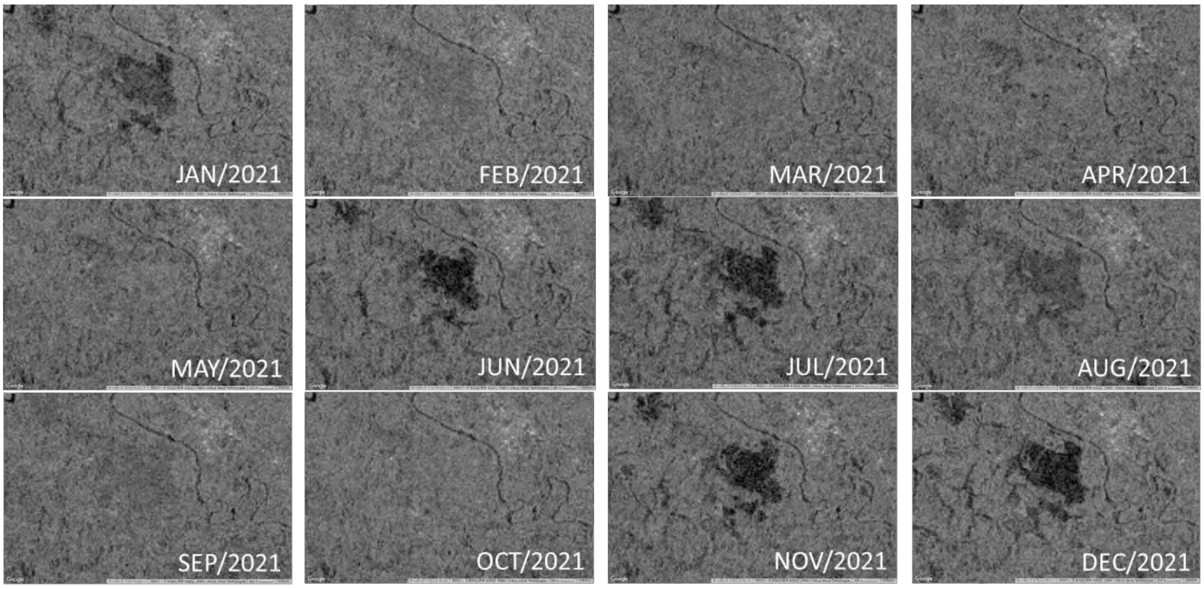
As a method for monitoring seasonal changes in paddy fields and cropping conditions, optical satellites are affected by clouds, so it is difficult to monitor the crop conditions season by season. Radar satellites are not affected by clouds and can monitor the flood area of paddy fields (Figure 3.3.3-12). Therefore, it is possible to monitor seasonal changes in paddy fields from flooded areas. An example is the monthly change image of a paddy field in Bohol island using Sentinel-1. It can be seen that the paddy fields are flooded twice a year, in June-August and November-January (Figure 3.3.3-13).



Note: Paddy field looks dark on Sentinel-1 image during the flooded season. The surface of the water looks dark on Radar image.

Source: JICA Survey Team

Figure 3.3.3-12 Comparison of Sentinel-2 image (left) and Sentinel-1 image (right) on paddy field in Bohol island



Note: By observing seasonal changes using Sentinel-1 image, it is possible to understand the season and area of flooding of paddy fields.

Source: JICA Survey Team

Figure 3.3.3-13 Monthly monitoring of paddy fields using Sentinel-1 (Bohol island)

3.3.3.6 Current Status of Agricultural Water Use in WRR VII

(1) Irrigation Areas

The irrigation areas covered by WRR VII in 2020 are summarized in Table 3.3.3-3.

Table 3.3.3-3 Irrigation Areas of WRR-VII in 2020

Province	Area Rate	All Systems				By Surface Water				By Ground Water			
		ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry
Negros Occidental	0.076	3,004	2,887	1,773	1,252	2,999	2,881	1,773	1,252	5	5	0	0
Bohol	1	25,254	23,904	18,677	16,736	25,234	23,904	18,677	16,736	20	0	0	0
Cebu	1	9,504	7,634	6,742	5,850	8,392	6,657	5,799	5,155	1,112	977	943	695
Negros Oriental	0.769	11,431	9,197	7,812	7,808	11,431	9,197	7,812	7,808	0	0	0	0
Siquijor	1	734	580	329	159	734	580	329	159	0	0	0	0
Total		49,927	44,202	35,332	31,805	48,790	43,219	34,389	31,110	1,137	982	943	695

Source: NIA Inventry Dat modified by JICA Survey Team

(2) Heads of Livestock and Poultry

The heads of livestock and poultry in WRR VII in 2020 are summarized in Table 3.3.3-4.

Table 3.3.3-4 Heads of Livestock & Poultry by Province in WRR-VII (2020)

Region	Province	Area Rate	Heads of Livestock & Poultry				
			Carabao	Cattle	Hog	(Sub-total)	Chicken
VI	Negros Occidental	0.076	7,617	3,900	35,794	47,312	643,383
VII	Bohol	1	74,404	77,626	329,377	481,407	4,228,731
	Cebu	1	53,404	119,408	459,715	632,527	10,482,111
	Negros Oriental	0.769	50,929	49,374	207,320	307,622	2,220,729
	Siquijor	1	1,084	20,104	49,200	70,388	590,425
	Total		187,437	270,412	1,081,406	1,539,256	18,165,379

Source:Philippine Statistics Authority modified by JICA Survey Team

(3) Freshwater Fishpond Areas

The freshwater fishpond areas in WRR VII in 2022 are shown in Table 3.3.3-5.

Table 3.3.3-5 Freshwater Fishpond Areas by Province in WRR VII (2022)

Region	Province	Area Rate	Fishpond Area (ha) in		Water Sources
			Province	WRR	
VI	Negros Occidental	0.076	No data		
VII	Bohol	1	54.25	54.25	Spring, NIA/BSWM Irrigation Canal
	Cebu	1	1.68	1.68	River, Spring
	Negros Oriental	0.769	29.67	22.82	NIA Irrigation Canal, Ground water
	Siquijor	1	1.12	1.12	Creek/River, Ground water
	Total		**86.72**	**79.87**	

Source: DA-BFAR modified by JICA Survey Team

3.3.3.7 Current Status of Municipal and Industrial Water Use in WRR VII

Basic information for all area was confirmed based on the PWSSMP 2018. In addition, the detailed current status and future plans were confirmed through site surveys in large population cities with huge water demands in WRR VII (Central Visayas) as shown in Table 3.3.3-6 below:

Table 3.3.3-6 Large Population Cities in WRR VII

WRR	Region		WD	Population (2020)	Note
WRR VII (Central Visayas)	Region VI	Western Visayas	-	-	Region VI is mostly out of range of WRR VII
	Region VII	Central Visayas	Metro Cebu	2,524,955	The most populous metropolitan area in WRR VII; Cebu City is HUC. MCWD covers surrounding large cities Lapu-Lapu, Mandaue, Talisay, Sibulan, etc.
			Bohol	189,746	Although the population is relatively small, it has the largest population size in the Bohol Island watershed.
			Dumaguete	278,954	Although the population is relatively small, it has the largest population size in the Negros Island watershed.
			Siquijor	103,655	Although the population is relatively small, it has the largest population size in the Siquijor Island watershed.

Source: JICA Survey Team

Current municipal and industrial water demand and existing water supply production in large population cities are shown as Table 3.3.3-7 below.

Table 3.3.3-7 Current Status of Municipal and Industrial Water Use in Large Population Cities

	WRR VII (Central Visayas)			
	Metro Cebu	**BWUI**	**Dumaguete**	**Siquijor**
Covered Municipality	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	Tagbilaran, Dauis, Baclayon, Corella	Dumaguete, Sibulan, Valencia, Bacong	Siquijor, San Juan, Lazi, Maria
Total Water Demand (MCM/Year)	**238.0**	**18.6**	**32.2**	**6.4**
Municipal Water Demand (MCM/Year)	185.9	14.7	26.4	4.7
Industrial Water Demand (MCM/Year)	52.1	3.9	5.8	1.7
Total Production Capacity (MCM/Year)	**99.6**	**8.0**	**15.2**	**2.5**
Production Source (MCM/Year)	Wells: 63.1 River: 12.4 Desalination: 2.2 Bulk purchase: 21.9	Wells:8.0	Wells: 15.2	Wells: 1.0 Springs: 1.5

Source: JICA Survey Team

3.3.3.8 Current Status of Water Use Facilities in WRR VII

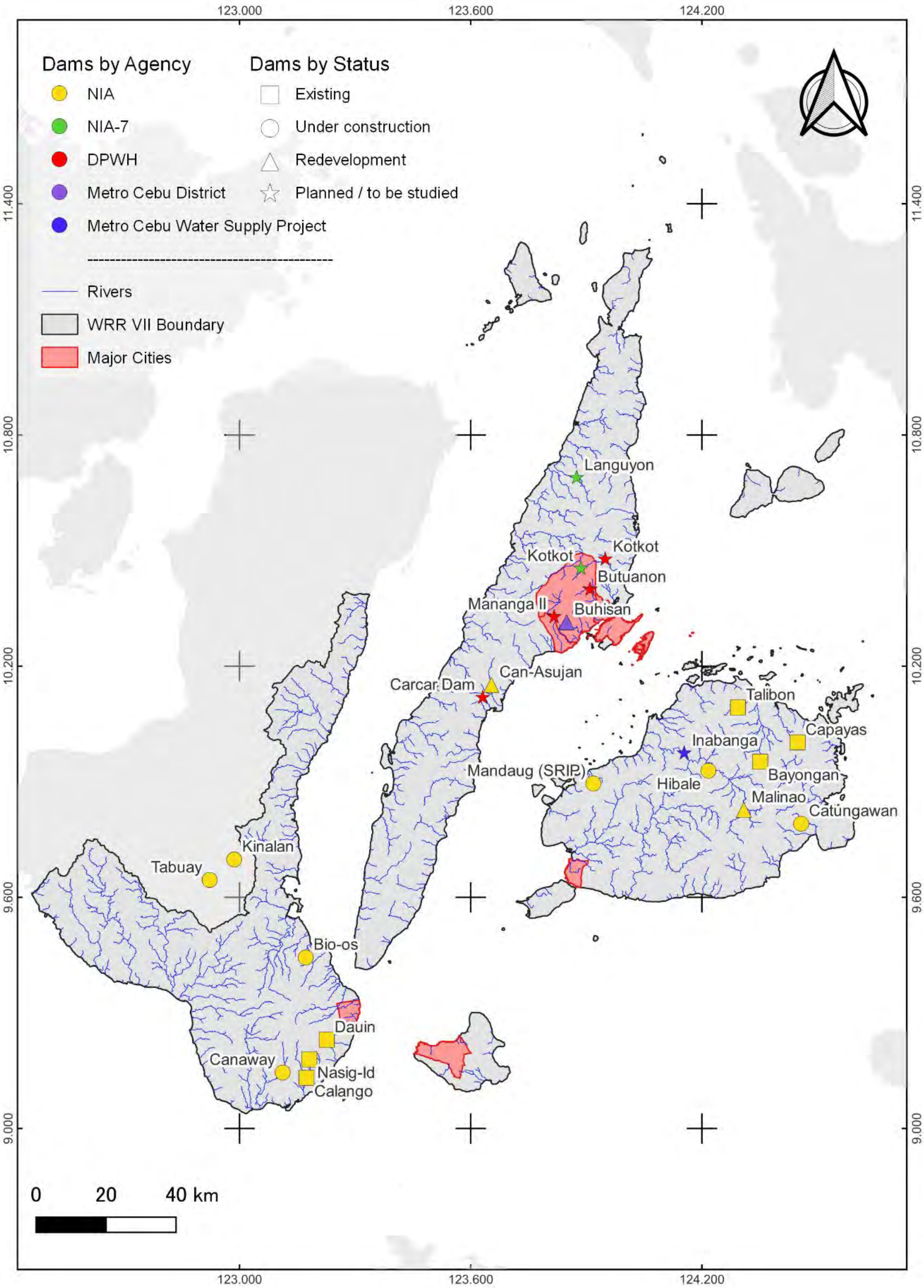
(1) Existing dams and dam construction plans confirmed before the field survey

Table 3.3.3-8 below shows the list of existing dams and dam construction plans organized from past reports and information provided from related implementing agencies. In addition, each dam location map is shown in Figure 3.3.3-14.

Table 3.3.3-8 List of Existing and Proposed Dams (WRR VII)

Region	Name of Dam	Construction Year /Current Status of Plan	Owner of Dam/ Implementing Agency	Purpose of Dam	Location		Dam Specification							Data Source
					Island	River	Type of Dam	Height (m)	Crest Length (m)	Coordinates: Latitude of Dam Center (° ' "")	Coordinates: Longitude of Dam Center (° ' "")	Reservoir Gross Storage (MCM) Design	Reservoir Usable Storage (MCM) Design	
WRR VII	Dauin（Existing）	Existing	NIA	Irrigation (SRIP)	Negros	-	-	29.00	-	1020272.00 m N	524839.00 m E	-	-	METI(2019) ,This Field Survey
	Nasig-Id（Existing）	Existing	NIA	Irrigation (SRIP)	Negros	-	-	32.00	-	1014626.00 m N	519865.00 m E	-	-	METI(2019),This Field Survey
	Calango Dam（Existing）	Existing	NIA	Irrigation (SRIP)	Negros	-	-	-	-	1009360.00 m N	519073.00 m E	-	-	This Field Survey
	Construction of Kinalan Dam	(DE completed)	NIA	Irrigation (SRIP)	Negros	-	-	-	-	9°41'52.00"N	122°59'8.99"E	-	-	This Field Survey
	Construction of Tabuay Dam	For Pre-FS in CY 2022	NIA	Irrigation (SRIP)	Negros	Tabuay River in Mabinai	earthfill dam	-	-	9°38'41.12"N	122°55'20.05"E	-	-	NIA-7 Dumaguete
	Construction of Canaway Dam	For Pre-FS in CY 2022	NIA	Irrigation (SRIP)	Negros	Canaway River	earthfill dam	-	-	9° 8'40.73"N	123° 6'42.04"E	-	-	NIA-7 Dumaguete
	Construction of Bio-os Dam	Pre-FS stage /July 9, 2021	NIA	Irrigation (SRIP)	Negros	Bio-os River and Naupas Creek	earthfill dam	-	-	Lat: 9°26'36.08"N	Long: 123° 10'17.96"E	-	-	NIA-7 Dumaguete
	Amlan	Existing	NPC	Power	Negros	Amlan	Overflow concrete	-	-	-	-	-	-	METI(2019)
	Calango	Existing	NIA	Irrigation (SRIP)	Negros	-	-	-	-	-	-	-	-	METI(2019)
	Nasig-Id	Existing	NIA	Irrigation (SRIP)	Negros	-	-	-	-	-	-	-	-	METI(2019)
	Dauin	Existing	NIA	Irrigation (SRIP)	Negros	-	-	-	-	-	-	-	-	METI(2019)
	Can-Asujan	Redevelopment plan in progress	NIA	Irrigation (SRIP)	Cebu	Can-Asujan	-	25.00	-	10.15093°N	123.65351°E	-	2.45	METI(2019), NIA Resettlement Plan
	Buhisan dam	around 1912, Redevelopment plan in progress	Metro Cebu District	Water Supply	Cebu	Kinalumsan	Concrete Arch Dam	29.95	-	10.31353°N	123.84852°E	-	0.23	METI(2019), LWUA(1976), JICA(2015)
	Buhisan dam	Redevelopment plan in progress	DPWH	Flood Control	Cebu	Kinalumsan	-	31	65	(Same as above)	(Same as above)	-	0.1	Metro Cebu Integrated Flood and Drainage System Master Plan (DPWH, 2018)
	Kotkot Dam	Pre-FS	NIA-7	Irrigation (SRIP)	Cebu	Kotkot	Zone-Earthfill Dam	34.00	139.00	10°27'11.53" N	123°53' 8.52" E	0.83	0.39	NIA-7(Aug. 2022)
	Kotkot Dam	-	DPWH	Flood Control	Cebu	Kotkot	-	29.5	110	10°28' 37.37" N	123°56' 55.69" E	-	-	Metro Cebu Integrated Flood and Drainage System Master Plan (DPWH, 2018)
	Butuanon Dam	-	DPWH	Flood Control	Cebu	Butuanon	-	18.0	320	10°23' 55.61" N	123°54' 33.44" E	-	-	Metro Cebu Integrated Flood and Drainage System Master Plan (DPWH, 2018)
	Languyon Dam	Pre-FS	NIA-7	Irrigation (SRIP)	Cebu	Languyon	Zone-Earthfill Dam	52.00	296.00	10°41'19.56" N	123°52'29.43" E	83.87	63.31	NIA-7(July 2022)
	Mananga II Dam	To be studied by DPWH	-	Water supply	Cebu	Mananga	Rockfill	70	-	10°19'33.816" N	123°49' 6.534" E	-	-	JICA(2015),and This survey
	Mananga II Dam	-	DPWH	Flood Control	Cebu	Mananga	-	70	370	10°19' 39.41" N	123°48' 58.5" E	-	3.0	Metro Cebu Integrated Flood and Drainage System Master Plan (DPWH, 2018)
	Carcar Dam	-	DPWH	Flood Control	Cebu	Carcar	-	30	195	10°7' 4.72" N	123°37' 51.59" E	-	-	Metro Cebu Integrated Flood and Drainage System Master Plan (DPWH, 2018)
	Loboc	Existing	NPC	Power	Bohol	Loboc	Overflow concrete	11.1	-	-	-			METI(2019)
	Capayas	Existing	NIA	Irrigation (SRIP)	Bohol	-	-	17.00	-	10.001843°	124.448286°	-	-	METI(2019)
	Ilaya	Existing	NIA	Irrigation (SRIP)	Bohol	Inabanga	-	25.00	-	-	-	-	-	METI(2019)
	Inabanga Dam	Pre-FS	Metro Cebu Water Supply Project	Water supply	Bohol	Inabanga	Concrete Dam	60~70	-	9.97378° N	124.15386° E	-	-	Japanese Ministry of Construction(H6.3) and This survey
	Malinao (Bohol I)	1998 Redevelopment plan in progress	NIA	Irrigation	Bohol	Wahing	Dam Filltype	20.40	845.00	9.82672°N	124.30839	6.00	5.00	METI(2019)
	Talibon	Existing	NIA	Irrigation (SRIP)	Bohol	-	-	21.50	-	10.092472°	124.293335°	-	-	METI(2019)
	Bayongan (Bohol II)	Existing	NIA	Irrigation	Bohol	-	Zone-Earthfill Dam	31.00	855	9.951761°	124.350901°	-	-	METI(2019)
	Wahig Impounding Dam	-	NIA	Multi Purpose	Bohol	Wahing	-	33	160	9.923664°	124.248790°	8.75	-	NIA, 2019
	Construction of Hibale Dam	-	NIA	Irrigation (SRIP)	Bohol	-	-	-	-	9.92815°N	124.21655°E	-	-	On-going Construction This field survey
	Construction of Mandaug Dam (SRIP)	-	NIA	Irrigation (SRIP)	Bohol	-	-	-	-	9.89502°N	123.91800°E	-	-	(DE completed) This field survey
	Construction of Catungawan Dam	-	NIA	Irrigation (SRIP)	Bohol	-	-	-	-	9.79063°N	124.45747°E	-	-	(DE completed) This field survey
	Constrictuon of San Isidro Banlasan (SRIP)	-	NIA	Irrigation (SRIP)	Bohol	-	-	-	-	-	-	-	-	This survey by our irrigation engineer.
	Constrictuon of Bagasico (SRIP)	-	NIA	Irrigation (SRIP)	Bohol	-	-	-	-	-	-	-	-	This survey by our irrigation engineer.
	Constrictuon of Cabatang (SRIP)	-	NIA	Irrigation (SRIP)	Bohol	-	-	-	-	-	-	-	-	This survey by our irrigation engineer.

Source: JICA Survey Team



Note: Buhisan Dam is planned for redeveloped by both DPWH & Metro Cebu District.

Source: JICA Survey Team

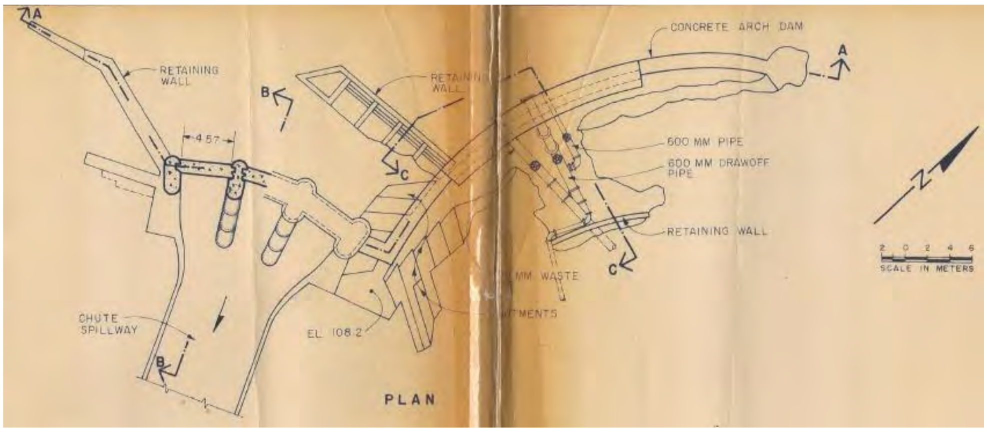
Figure 3.3.3-14 Location Map of Existing & Proposed Dams (WRR VII)

(2) Existing Surface Water Resources Development Facilities

1) Buhisan Dam

Cebu City and Mandaue are served by a common waterworks system originally constructed in 1911. It underwent three major stages of source development: Buhisan River in 1911, Hagubial Spring in 1934, and 26 deep wells in 1958 and 1964. Buhisan Dam is a concrete arch structure with a present reservoir volume of 0.23 million m^3. This capacity has been severely reduced over the years by siltation. The plan of Buhisan Dam is shown in Figure 3.3.3-15 (LWUA, 1976).

Surface water is supplied by the Buhisan Dam which is processed by the Tisa Water Treatment Plant. The dam was constructed more than 100 years ago and 60% of its capacity is silted. It is currently supplying 3,080 m^3/day to MCWD, but it is closed three months a year for maintenance dredging. In 1997, the development and operation of the Jaclupan Weir Dam (Mananga I Dam) in Talisay City augmented the supply by another 30,000 to 36,000 m^3 per day. This surface water source (now categorized as groundwater) recharges the well gallery in Jaclupan Valley, which is then extracted to supply water to the system. In the MCWD data-book, Jaclupan is considered a groundwater source and only the Buhisan Dam is considered to be a surface water source (Roadmap Study, JICA, 2015).



Source: LWUA, 1976

Figure 3.3.3-15 Plan of Buhisan Dam

2) Desalination Plant

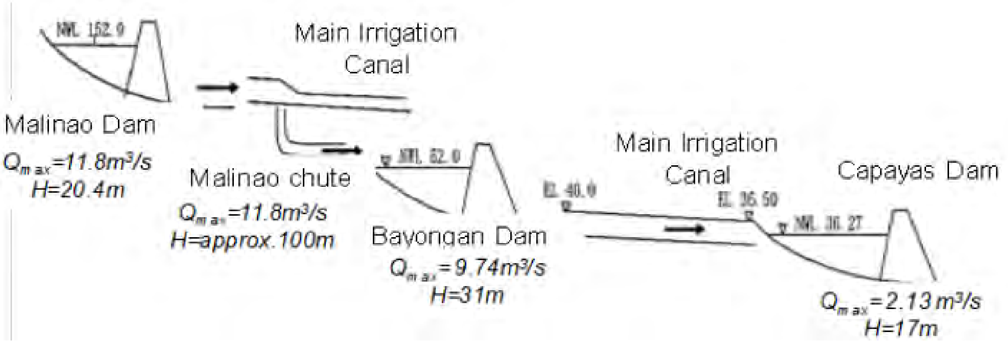
Mactan Rocks Industries (MRI) operates the desalination plant in Lapu-Lapu City as a bulk water supplier at 4,881 m^3/day to MCWD and at 12,700 m^3/day to the direct consumers (Roadmap Study, JICA, 2015).

Source: Mactan Rock Industries, Inc.

Figure 3.3.3-16 Desalination Plant of Mactan Rock Industries

3) Malinao, Bayongan, and Capayas Dam

There are 3 irrigation dams in eastern Bohol Island, namely Malinao Dam, Bayongan Dam and Capayas Dam, which were constructed by Japanese ODA. These dams are interconnected through the Malinao main canal, Malinao diversion chute and Bayongan main canal as shown in Figure 3.3.3-17. Malinao Dam has a bigger inflow but smaller storage while Bayongan Dam has smaller inflow but bigger storage. The basic irrigation development plan is an integrated water management considering how to regulate the Malinao inflow and to divert flow to the downstream Bayongan Reservoir and the further downstream Capayas Reservoir (METI, 2019).



Source: METI, 2019

Figure 3.3.3-17 Diagram of Malinao, Bayongan, and Capayas Dam

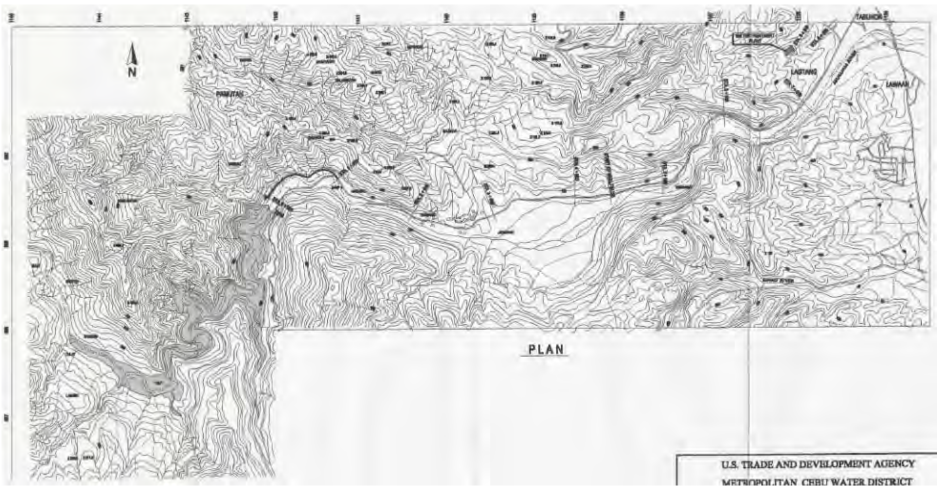
(3) Surface Water Resources Development Projects Proposed in Past Studies

1) Construction of Mananga II Dam

The development of the Mananga River for municipal water supply has been studied over the last 30 years. The expected volume of water produced by a 76 m high Mananga II Dam of 68,000 m^3/day is applied for this proposed project. The location of Mananga II Dam is upstream of the Mananga River in Barangay Bou Taup in Cebu. The proposed dam construction method is the roller compacted concrete method. This project consists of water intake, conveyance tunnel/transmission pipeline, water treatment plant, pumping station, and transmitting pipelines beside a high dam. It is recommended to acquire a property for the water treatment plant because there is no existing land for the plant until now. The inundated area will be approximately 140 ha (Roadmap Study, JICA, 2015).

The Mananga II Bulk Water Supply Project will be controlled by a 76 m high dam. The dam will capture and regulate the Mananga River inflows to insure a firm reservoir of 56,500 m^3/day. Of this amount, 20,000 m^3/day will be dedicated to maintaining the minimum Mananga River flows downstream of the dam including the required level to maintain the current Jaclupan well field production. The remaining 36,500 m^3/day will provide a new firm water supply for the Metropolitan Cebu area. The proposed location of Mananga II Dam is shown in Figure 3.3.3-18 (USTDA, 2001).

The feasibility study of Mananga II Dam is to be conducted by DPWH, as of 2022 February.



Source: USTDA, 2001

Figure 3.3.3-18 Proposed Location of Mananga II Dam

2) Construction of Kotkot Dam

With a height of 25 m, Kotkot Dam is expected to produce 54,000 m^3/day of water. The construction method for this dam is the roller compacted concrete method, the same as for Mananga II Dam. Similarly, land for the Kotkot Dam's water treatment plant will need to be secured. Construction of the dam will submerge 210 ha of land due to the flat geographical feature (Roadmap Study, JICA, 2015).

The Kotkot Dam proposal, known as Paril Weir, involves a construction of a single medium-height dam in the Upper Kotkot River, storing water for surface water abstraction. A 22 m high dam in the Kotkot watershed would have a yield of approximately 20 MCM/year. Previous investigations have estimated quite high rates of siltation (ADB, 2008).

The construction of Kotkot Dam is under pre-feasibility study, as of 2022 February.

3) Construction of Lusaran Dam

The volume of expected development water production by Lusaran Dam, with a height of 63 m, is 109,000 m^3/day. Construction of this dam is expected to involve a rock fill dam construction method. The same as in the other dams, land for the water treatment plant for the Lusaran Dam will need to be secured. Construction is expected to affect around 200 ha of land. There is an alternative proposed idea that Kotkot Dam and Lusaran Dam may be connected by tunnel, which would allow the dam height to be lower, but the water supply volume will decrease to 110,000 m^3/day (Roadmap Study, JICA, 2015).

The construction of Lusaran Dam is under pre-feasibility study, as of 2022 February.

4) Development of Surface Water at Northern and Southern Areas of Metro Cebu

The development of surface water at the northern and southern areas of Metro Cebu is expected to produce 50,000 m^3/day (Roadmap Study, JICA, 2015).

5) Construction of Reverse Osmosis Desalination Plant

The development of 20,000 m^3/day of water is planned through a desalination plant. Considering, however, the unit price of water by desalination is more expensive, the capacity of the proposed desalination plant will be smaller (Roadmap Study, JICA, 2015).

In 2015, the desalination plant in Mactan Island should produce and supply 9,600 m^3/day of membrane filtered water. The Punta Engano area as shown in Figure 3.3.3-19, was nominated as the construction site of the desalination plant. Available land area is sufficient for the plant capacity, and it could be expanded when the water source supply from Cebu is insufficient. This plant will intake seawater from Hilutungan Channel and discharge condensed seawater to Magellan Bay. Site selection, intake and discharge method, and treatment process were determined with the reference materials of the JBIC Study 2005 (Feasibility Study of Seawater Desalination Facility for Water Supply in Metro Cebu) and JICA study 2009 (Preparatory Survey on the Programme Grant Aid for Environment and Climate Change; Water Technology) (JICA, 2010).

Source: JICA, 2010

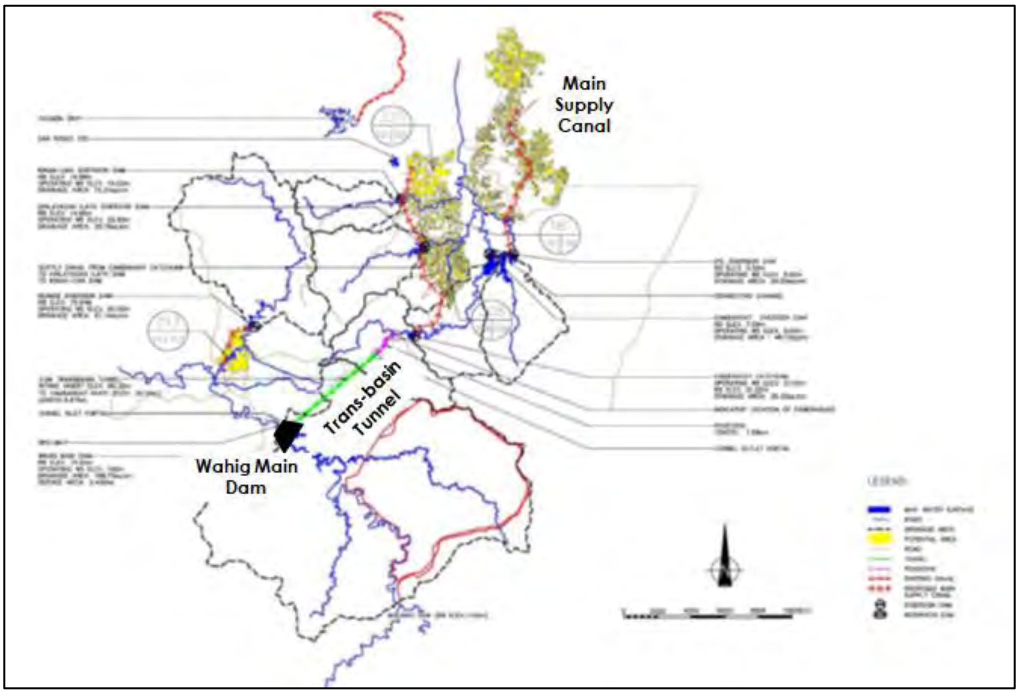
Figure 3.3.3-19 Proposed Location of Desalination Plant in Punta Engano, Mactan Island

6) Use of Recycled Water

Recycling of treated wastewater is expected to add 10,000 m^3/day of water supply (Roadmap Study, JICA, 2015).

7) Bohol Northeast Basin Multipurpose Dam Project (Wahig Impounding Dam)

The proposed dam project is located in the Province of Bohol, with its key structures and service areas situated in the municipalities of Danao, Trinidad, San Miguel, Dagohoy and Bien Unido. The purpose of the project is irrigation for the service area of 2,133 ha, raw water for domestic water supply of 48.295 MCM/year, and hydropower output of 2.08 MW. The project components are Wahig Impounding Dam, a 6.575 km long trans-basin tunnel, 4 concrete diversion dams, and 2 rubber diversion dams. The proposed Wahig Impounding Dam will have a height of about 33 m above the riverbed and a crest length of about 160 m. It will inundate an area of about 180.27 ha with a storage capacity of 8.75 million m^3 at normal water surface level. The location map of the Bohol Northeast Basin Multipurpose Dam Project is shown in Figure 3.3.3-20 (NIA, 2019).



Source: NIA, 2019

Figure 3.3.3-20 Location Map of Bohol Northeast Basin Multipurpose Dam Project

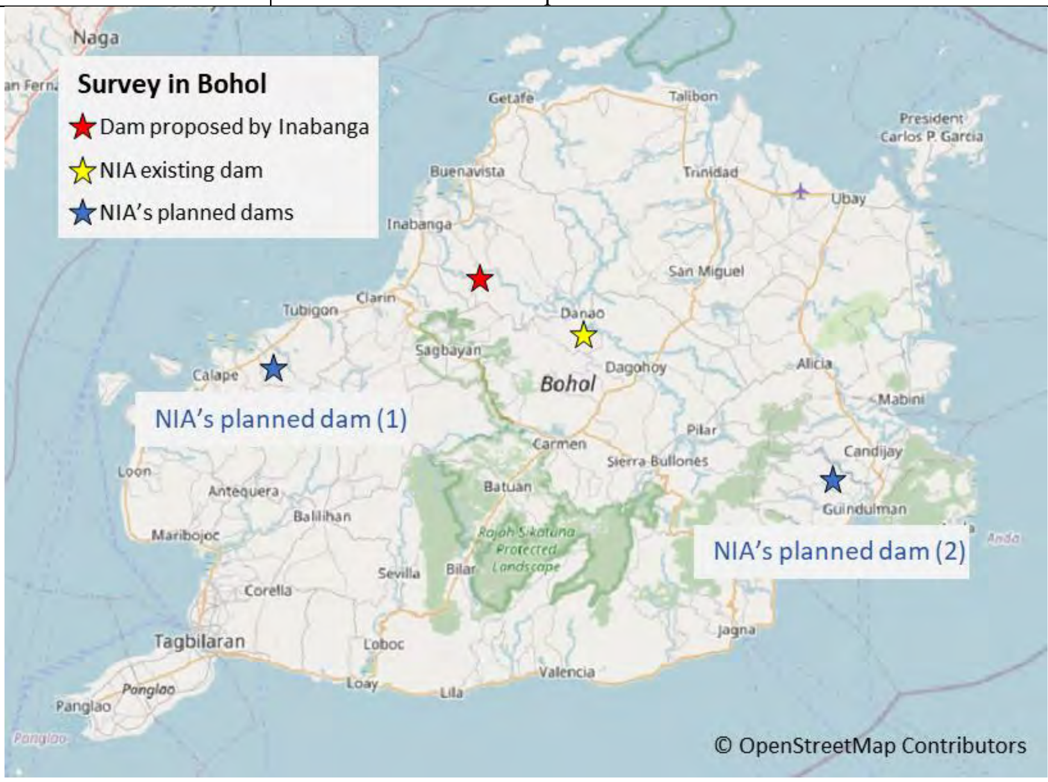
(4) Field Survey Reports

The field survey report prepared by the JICA Survey Team for each dam site is shown in Table 3.3.3-9 below.

Table 3.3.3-9 Field Survey Report of Dam Sites in WRR VII

WRR VII (Bohol): Sep. 9 - 10, 2022

Dam site	Information during Site Inspection
1) Dam site proposed in Inabanga River	A detailed study is needed for feasibility of construction of the proposed dam in Inabanga River.
2) NIA's planning dam (1)	Survey of proposed sites for proposed zoned earth-fill dam (H30m) construction by NIA in western Bohol Island. It is considered to be a reasonable construction plan.
3) NIA's planning dam (2)	Survey of proposed sites for proposed zoned earth-fill dam (H30m) construction by NIA in east-south Bohol Island. It is considered to be a reasonable construction plan.



Source: JICA Survey Team, Map data © OpenStreetMap contributors

Figure 3.3.3-21 Field Survey Sites in WRR VII

WRR VII (Cebu): Dec 10, 2022

Dam site	Information during Site Inspection
1) Mananga II Dam	(1) It is one of the priority proposed dams on the upper Mananga River. There is Jaclupan Dam (Mananga-I) by MCDW at 3.5 km downstream from here. (2) The riverbed had good sedimentary rock outcrops. (3) The main road running parallel to the right bank of the river would be submerged in case of construction of the dam with a height of 40 meters. Therefore, Dam height of 40m or less is desirable. (4) It would be effective to install gated weir at this dam as a sediment control measure. And some fence dams will be installed upstream of the main dam as a measure to protect the gate from boulders. (5) Dump trucks were accessing the site directly from the dam site downstream.

Source: JICA Survey Team

Figure 3.3.3-22 Field Survey (Mananga II Dam)

WRR VII (Cebu): Dec. 10, 2022

Dam site	Information during Site Inspection
2) Kotkot Dam	(1) It is one of the priority proposed dams on the upper Kotkot River. (2) The riverbed had good sedimentary rock outcrops. (3) Transportation costs of water would be greater due to the distance from Metro Cebu.

Upstream

Downstream

Source: JICA Survey Team

Figure 3.3.3-23 Field Survey (Kotkot Dam)

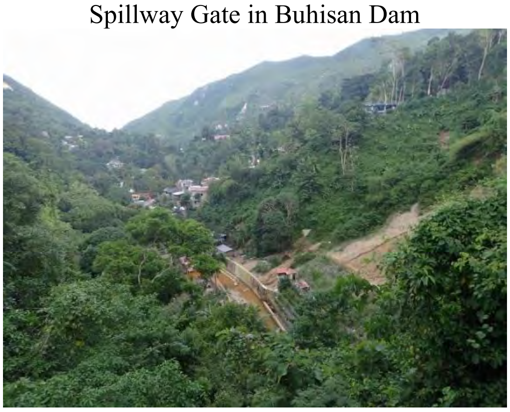
WRR VII (Cebu): Sep 2, 2022

Dam Site	Information during Site Inspection
3) Existing Buhisan Dam	(1) The main road runs on the right bank side. (2) Main facilities are: i) Dam body (arch concrete type) ii) Reservoir iii) Spillway iv) Water intake/discharge pipe (valve) (3) Local interview - The dam was built in 1910, and sedimentation is progressing. - The water depth is 27m. - The reservoir was emptied in 2019 due to drought. - Water intake capacity is 4,000m^3/day. - Driftwood has flowed in and been removed.

Buhisan Dam

Spillway Gate in Buhisan Dam

Ogee crest spillway in Buhisan Dam



Downstream view of Buhisan Dam

Removed drifted woods in Buhisan Dam

Photo of Buhisandam Lake (left: full water, right: dry)

Source: JICA Survey Team

Figure 3.3.3-24 Field Survey (Buhisan Dam Lake)

Source: JICA Survey Team

(5) Considerations for Dam Construction

Water demand in WRR VII is increasing due to population growth and economic development and other factors, particularly in the Metro Cebu area. There is great concern about water shortages in the Cebu Metropolitan area, so there is a great need to build dams to supplement the water demand.

Large dam installations for the Metro Cebu area and upgrading of existing Buhisan Dam (MCWD/DPWH) and Can-asujan Dam (NIA) can be considered as surface water development projects.

In addition, there is a private water supply project (Carmen Weir), and a new private water supply facility is currently under construction (Lusaran Weir near the lower reaches of Kotkot River).

In Bohol Island, many of the NIA's irrigation dams are functioning well, but there is information that in recent years there has been a lot of flood damages in Inabanga City, which is located downstream of Inabanga River. Flood control is necessary, and there is also a water shortage. There are also plans to supply surplus water resources to Metro Cebu in conjunction with the construction of Inabanga Dam.

Mananga 2 Dam and Kotkot Dam, which are adjacent to Cebu Metropolitan area, and Languyon Dam, which is a little further away but can hold a large amount of water, are studied further as alternatives of surface water development projects in the WRR VII area.

3.3.3.9 Current Status of Groundwater Use in WRR VII

Based on the NWRB’s water permit records, a total of 753 water permit wells and 227 springs have been issued within WRR VII. This record does not include small domestic wells, and the actual number of well and spring is assumed to be much higher. The number of wells and springs for each Province is shown in Table 3.3.3-10.

Table 3.3.3-10 Water Permit Wells and Springs in WRR VII

Province	Permit Water Source		Major water source owners
	Groundwater Well	Spring	
Cebu	611	84	MCWD, BP Waterworks
Bohol	67	102	BWUI, TCWS
Negros Oriental	64	39	DCWD, SIWAD, BCWD
Siquijor	11	2	MSWD
Total	753	227	

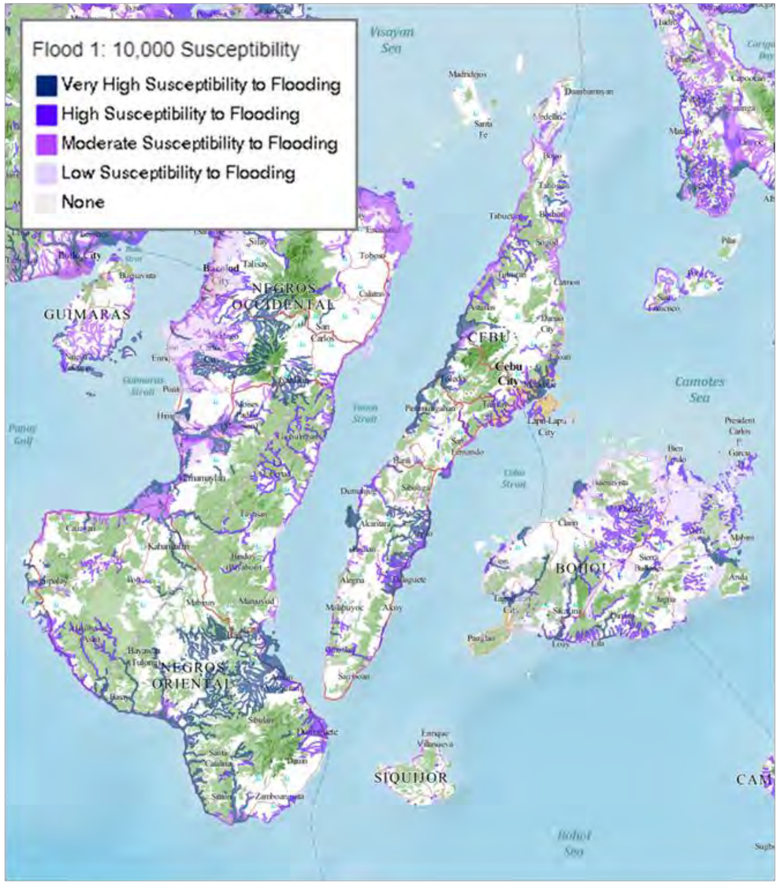
Source: JICA Survey Team

3.3.3.10 Flood Risk Management (FRM) in WRR VII

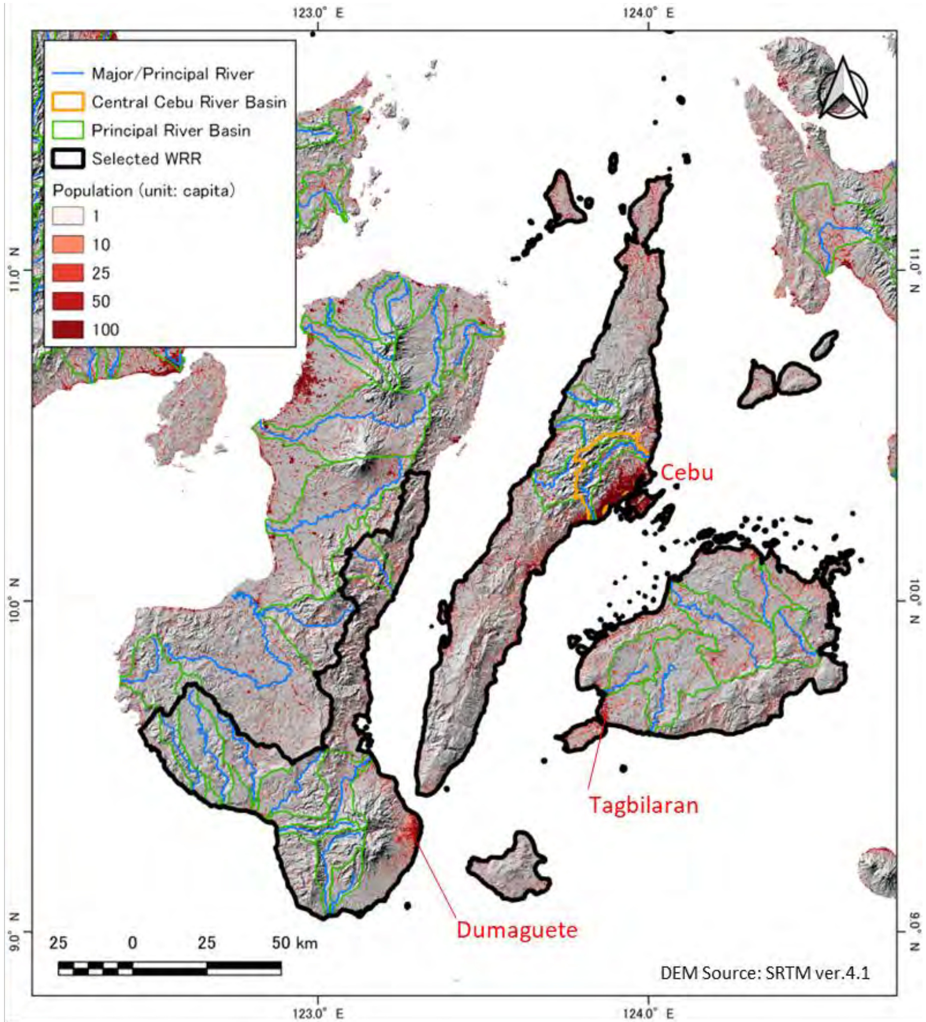
(1) Overview of Flood Risk in WRR VII

To overview the flood risks in WRR VII, the flood susceptibility map and population distribution map are compared as shown in Figure 3.3.3-25. Since there is no major river whose drainage area is over 1,400 km^2 in WRR VII, the flood susceptibility map shows that flood-prone areas spread in relatively narrow area along rivers. High-risk flood area is concentrated in the Metro Cebu area due to the high population density of the area. There are 19 principal river basins in the WRR VII. Two of them, the Kot-kot River and the Mananga River, flow through Metro Cebu.

The two principal rivers and other rivers in Metro Cebu are significantly important in terms of both flood risk management and water resources management. Correspondingly, the River Basin Control Office (RBCO) under DENR manages the areas such as Central Cebu River basin. Therefore, the Central Cebu River basin was focused on to study its flood risk management.



Source of flood susceptibility map: Geoportal PH (https://www.geoportal.gov.ph/#)



Source of population 30m mesh data: Facebook Connectivity Lab and Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. High Resolution Settlement Layer (HRSL). Source imagery for HRSL © 2016 DigitalGlobe.

Figure 3.3.3-25 Flood Susceptibility Map (Left) and Population Distribution Map (Right) in WRR VII

(2) Summary of Current FRM Plan

Since flood risk management (FRM) structural measures such as dams, shortcuts, flood diversion channels, etc. affect river flows and the furthermore water cycle in the region as mentioned in Chapter 2.2.11 (1), the current FRM plan of the Central Cebu River basin was collected and reviewed. The FRM master plan (FRMMP) is summarized in Table 3.3.3-11. The target safety level is set as a 50-year or 100-year flood depending on the scale of the river basin catchment area based on the DPWH's Design Guidelines, Criteria and Standards (DGCS, 2015). Proposed structural measures in the FRMMP include river and drainage improvement works and flood diversion channel. There is no existing flood control dam in the region, but new flood control dams were roughly studied as one of alternative solutions. Although the studied dams were not adopted in the FRMMP, there remains the possibility that a new flood control dam will be needed in the context of increasing flood risk in the future by city development or climate change impacts.

Table 3.3.3-11 Summary of the Current FRMMP for Central Cebu River Basin

River Basin Name	Central Cebu River Basin
Drainage Area (km^2)	679 *1
Estimated Population (thousand people) and Estimated Year	1,780 (2018) *1
Latest M/P	DPWH (2018) *2
Target Year	Next 10 years
Target Flood Level	50 or 100-year flood depending on the size of drainage area *3
Design Flood Discharge	Kotkot River: 450 m^3/s (100 year), Butuanon River: 740 m^3/s (100 year), Mananga River: 1,120 m^3/s (100 year), etc.
Consideration of CCI *4 on rainfall	Incorporate a 10% increase in rainfall intensity in the design
Consideration of CCI *4 on sea level rise	Not specifically described
No. of Existing Flood Control Dam	0
No. of Potential Flood Control Dam	4 *5

*1) The values of "Drainage Area" and "Estimated Population" are quoted from the website of River Basin Control Office (https://riverbasin.denr.gov.ph/main/index)

*2) DPWH, 2018, "Comprehensive Study for a Metro Cebu Integrated Flood and Drainage System Master Plan"

*3) If the drainage area is less than 40 km^2, the target flood level is 50-year flood. Otherwise, it is 100-year flood.

*4) CCI: Climate Change Impacts

*5) Dams were studied as an alternative countermeasure, but they were not adopted in the FRMMP.

Source: JICA Survey Team

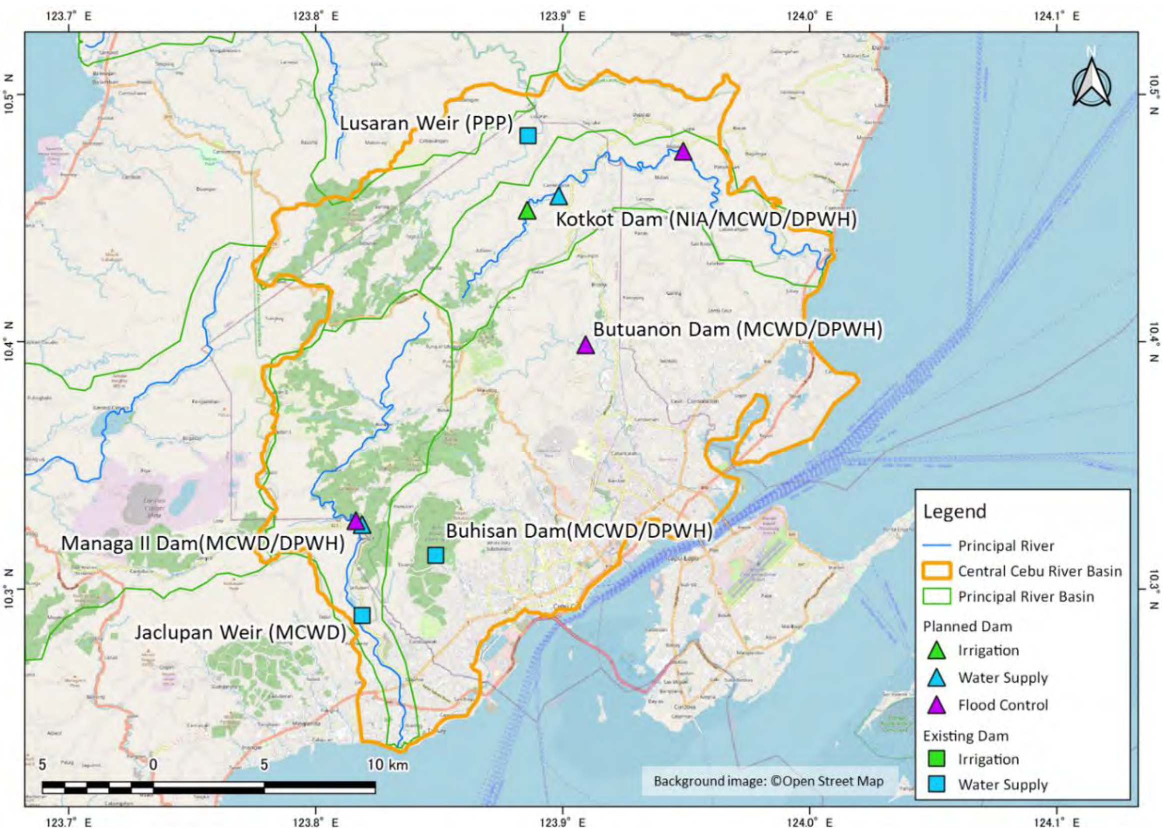
The potential dams studied in the FRMMP are summarized in Table 3.3.3-12, and their locations are illustrated in Figure 3.3.3-26. More details are described in Annex-H.

Table 3.3.3-12 Summary of Potential Flood Control Dams in Central Cebu River Basin

Dam Name	Dam Height	Crest Length	Storage Volume	Remarks
Kot-kot Dam	29.5 m	110 m	6 MCM	• New dams are also proposed along the same river from NIA and MCWD, separately.
Butuanon Dam	18 m	320 m	2 MCM	• MCWD also has a plan for water supply dam along the Butuanon River.
Buhisan Dam (upgrading of existing dam)	31 m	65 m	0.1 MCM	• Upgrading of the existing Buhisan Dam is proposed to add flood control function. • Existing dam was constructed with the storage volume of 500,000 m^3, but the current volume is only up to 12,000 m^3 due to sedimentation. • Existing access road to the dam is too narrow to transport heavy machinery.
Mananga II Dam	70 m	370 m	31 MCM	• This dam was originally concepted in 1991 under ADB project as a water supply dam for Metro Cebu, but still not realized. • Location of dam body is slightly different between the proposed dam by MCWD and DPWH.

*NIA: National Irrigation Agency, MCWD: Metro Cebu Water District

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.3.3-26 Location of Existing/Potential Dams in the Central Cebu River Basin

3.3.3.11 Water Quality in WRR VII

The water bodies in WRR VII that are monitored by EMB in 2021 are the Bulacao River, Butuanon River, Guadalupe River and Mananga River. Currently, EMB is not monitoring the water body in the Municipality of Tuburan, Municipality of Danao and Municipality of Inabanga. The outline of the water quality monitoring for each water body is shown in Table 3.3.3-13.

Table 3.3.3-13 Outline of Water Quality Monitoring in WRR VII

Water Body	Monitoring Station	Parameter	Summary of the Result
Butuanon River	- 12 stations - 5 stations are in the Cebu City	- Primary parameters: DO, BOD5, TSS, pH, temperature, nitrates, phosphates, chlorides, color - Secondary parameters: ammonia, oil, grease, and heavy metals	- Phosphate in five monitoring stations exceeded the water quality guideline value for a Class D water body. - TSS in stations 8 and 9 also exceeded the limit. - Fecal coliform levels are high in five monitoring stations.
Bulacao River	- 5 stations - 3 stations are in Cebu City	- pH, temperature, DO, BOD5, TSS, nitrate, phosphate, chloride, color, and fecal coliform	- BOD and phosphate in three monitoring stations exceeded the water quality guideline value for a Class D water body. - DO in stations 1 and 3 also exceeded the limit. - Fecal coliform levels are high in three monitoring stations.
Guadalupe River	- 4stations - 4 stations are in Cebu City	- DO, BOD5, TSS, pH, temperature, nitrate, phosphate, chloride, color, and fecal coliform	- BOD and phosphate in four monitoring stations exceeded the water quality guideline value. - DO in stations 1 to 3 also exceeded the limit. - Fecal coliform levels are high in four monitoring stations.
Mananga River	- 4 stations - 4 stations are in Talisay City	- DO, BOD5, TSS, pH, temperature, nitrate, phosphate, chloride, color, and fecal coliform	- Phosphate in all monitoring stations exceeded the water quality guideline value for the Class A water body. - Only station 4 has BOD and TSS concentration within the limit. - Fecal coliform levels are high in all monitoring stations.

Source: JICA Survey Team

3.3.3.12 Natural and Social Environment in WRR VII

(1) Natural Environment

1) Flora, Fauna, and Ecosystem

Bohol has a high biodiversity level of plant species categorized as: upland, mangrove, coastal areas, cave entrances, cultivated cropland and intensively used lands. Several plant species noted to be abundant before are already extinct, and others are becoming rare. Data about Bohol's terrestrial and freshwater flora and fauna is scarce except for a study in Rajah Sikatuna Protected Landscape.

2) Protected Area

The list and distribution of protected areas in WRR VII are summarized in Table 3.3.3-14 below:

Table 3.3.3-14 List of Protected Areas in WRR VII

Province	Protected Area	Category
Cebu Province	Central Cebu Protected Landscape (CCPL) – RA 9486	Legislated
	Guadalupe Mabugnao-Mainit Hot Spring National Park (GMMHSNP) – RA 6429	Legislated
	Olango Island Wildlife Sanctuary (OIWS)	E-NIPAS
	Camotes Island Protected Landscape/Seascape (CIPLS)	E-NIPAS
	Tanon Strait Protected Seascape	E-NIPAS
	Bantayan Island Wilderness Area (BIWA)	Initial Component
Bohol Province	Rajah Sikatuna Protected Landscape (RSPL)	E-NIPAS
	Talibon Group of Islands Protected Landscape/Seascape (TGIPLS)	E-NIPAS
	Alburquerque-Loay-Loboc Protected Landscape/Seascape (ALLPLS)	E-NIPAS
	Panglao Island Protected Seascape (PIPS)	E-NIPAS
	Chocolate Hills Natural Monument (CHNM)	E-NIPAS
	Calape Group of Islands Wilderness Area and MSFR	Initial Component
	Cabilao-Sandingan Islands MSFR	Initial Component
	Inabanga-Buenavista MSFR & Inabanga Group of Islands WA	Initial Component
	Loboc Watershed Forest Reserve	Initial Component
	Alijawan-Cansuhay-Anibongan River Watershed Forest Reserve	Initial Component
	Tubigon Group of Islands Wilderness Area and MSFR	Initial Component
	Clarin Group of Islands Wilderness Area	Initial Component
	Candijay-Anda-Mabini MSFR & Candijay Group of Islands WA	Initial Component
	Pres. Carlos P. Garcia MSFR & Pres. Carlos P. Garcia Group of Islands MSFR	Initial Component
	Getafe Group of Islands MSFR and WA	Initial Component
	Ubay MSFR (Areas 1 & 2) & WA	Initial Component

Source: DENR Region VII

3) Air Quality

Based on available DENR-EMB data on annual ambient air quality monitoring in urban areas, there are 4 monitoring stations in Cebu City for total suspended particulates (TSP). From 2011 to 2021, the average TSP concentration recorded was 44.50 ug/Ncm, which was within the annual guideline value (90 ug/Ncm).

There is no established DENR-EMB ambient air quality monitoring station in the municipality of Tuburan, Talisay City and Municipality of Danao at present.

(2) Social Environment

1) Ethnicity

Cebu City, Tuburan, Talisay City, Danao and Inabaga do not have any known indigenous people communities nor ancestral domains recognized by the National Commission on Indigenous Peoples (NCIP).

2) Local Economy

Cebu Province

Serving as the center of economic activities in the province is Metro Cebu, where majority of the population is also concentrated. It is designated as the premier industrial, commercial, and service center in Central Visayas, with service-oriented institutions that cater to the needs of the people in the region as well as other provinces in Southern Philippines. Five of the eight proclaimed Special Economic Zones (SEZs) in WRR VII are located in Metro Cebu.

Bohol Province

Predominantly an agricultural province. The economy is also supported by home-based industries, which consist of micro and cottage types of industries. Tourism is another industry, which has steadily gained influence on the province's economy due to its famous tourist attractions. Bohol also serves as the food source of Central Visayas, with 45% of its land area allocated to agriculture. Primary agriculture products such as rice and coconut are grown in the province.

The central business district of Bohol is Tagbilaran City, which also serves as the center of education of the province.

3) Historic Site / Culture Heritage

Table 3.3.3-15 highlights some of the declared marked structures and important cultural property in WRR VII. There were no records of these historical, tangible, and intangible cultural properties in the municipality of Tuburan, Municipality of Danao and municipality of Inabaga.

Table 3.3.3-15 List of Marked Structures & Important Cultural Properties in WRR VII

Area	Official Name	Declaration/Classification	Type
Cebu City	The Cross of Magellan	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Antonio Pigafetta Monument | Antonio Pigafetta (1496–1535) Marker	Marked Structure, NHCP; Work of National Artist for Visual Arts Abdulmari Asia Imao; Registered Property, Cebu City	Tangible-Immovable

Area	Official Name	Declaration/Classification	Type
	Minor Basilica of the Holy Child of Cebu	Church and Convent of Santo Niño Marker	National Historical Landmark, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Colon Street	Daang Colon Marker	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Magsaysay Monument	Inscription on the Magsaysay Monument Dedication	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Metropolitan Cathedral and Parish Church of Saint Vitalis and of the Guardian Angels of Cebu	Katedral ng Cebu Marker	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Casa Gorordo Historical Landmark	National Historical Landmark, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Matilde Bradford Memorial Church Historical Landmark	National Historical Landmark, NHCP; Registered Property, Cebu City	Tangible-Immovable
	University of San Carlos	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Parish Church of Santo Tomas de Villanueva of Pardo	Simbahan ng Pardo Marker	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
	Fort San Pedro	Unang Kasunduan ng Kapayapaan sa Pilipinas Marker	Marked Structure, NHCP; Registered Property, Cebu City	Tangible-Immovable
Talisay City	Talisay Landing Marker	Marked Structure, NHCP; Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable
	Parish Church of Santa Teresa de Avila of Talisay	Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable
	Talisay City College	Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable
	Tres Aliños Monument	Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable
	Canton Museum	Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable
	MCWD Reservoir	Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable
	MCWD Dam	Local Cultural Property - Heritage Monuments, Sites and Zones of the City of Talisay, Cebu (per 3rd SP Ordinance No. 2009-14)	Tangible-Immovable

Source: National Commission for Culture and the Arts (NCCA) TALAPAMANA Visayas (2022)

3.3.4 Hydrological Analysis in WRR VII

3.3.4.1 Hydrological Analysis (Surface Water)

(1) Selection of Hydrological Model

In this survey, the physically based runoff model, the SHER Model was selected for detailed hydrological analysis for priority WRRs. The selection criteria and comparison of major hydrological (surface water) analysis models are shown in Table 3.3.4-1 below. The selected hydrological analysis models are the SWAT Model (USDA), the SHER Model (MLIT&ARSIT/Nippon Koei), and the Tank Model (Sugawara) in consideration of versatility, ease of calibration, the accuracy of daily low-water analysis, and free license.

Table 3.3.4-1 Comparison of Major Surface Water Models

Evaluation Items	SWAT Model (Soil & Water Assessment Tool)	Physical Water Cycle Analysis Model "SHER Model" (ARSIT Model)	Physical Water Cycle Analysis Model "SHER Model" (NK Model)	Tank Model (Conceptual Model)
Created / Publisher	USDA/Texas A&M	MLIT, Japan/ARSIT/ University of Tokyo / United Nations University / Nippon Koei Co., Ltd.	Nippon Koei Co., Ltd. (NK Central Research Institute)	Sugawara (1972)/ Nippon Koei Co., Ltd.
Copyright	● Free Software (Source code private)	○ Web publishing (Source code private)	× (Not Open)	● (Excel・Open)
Versatility / Transfer	● (Used in many countries)	△(Japanese Manual Only)	× (Non-transferable)	● Transferable (No manual)
Analysis Time Unit	Daily	Daily	Hourly/Daily	Daily
Land Use Change	●	● (Impervious area/Paddy)	● (Impervious area/Paddy)	△ (Paddy Model)
Topography/Geology	○ (Linked with QGIS)	● (Linked with NK-GIAS)	● (Linked with NK-GIAS)	×
Soil Classification	● (Linked with USGS data)	● (FAO Soil Map)	● (FAO Soil Map)	×
Paddy/Irrigation	●	●	○	●
Infiltration Analysis	○	●	●	△ (Soil Moisture Tank Model)
Groundwater Analysis	△(There is a Tool for linking to MODFLOW)	● (Analysis by Darcy's law)	◎(Analysis by Darcy's law)	△ (Separate GW Model is required)
Dam/Reservoir	○ (With Tools)	● (Created Separately)	△	● (Separate Model)
(Water Quality)	Possible	Not Available	Not Available	Not Available
Areas without Obs.Q	● (Estimable)	● (Estimable)	● (Estimable)	△ (Estimated by Specific Q)
Calibration Convenience/Time	△(+2 Point) Large amount of Manuals	○ (+6 Points) Relatively Easy	×(—10 Points) Very Difficult	● (+10Points) Very Easy
Overall Evaluation	○ (42 Points)	● (50 Points)	×(14 Points)	△ (23 Points)

Note) Legend : ●:Very Good (5 points), ○: Good (3 points), △: Fair (1 point), ×: Not Good (-5 points), However, "calibration convenience" was doubled.

Source: Nippon Koei Co., Ltd.

As a result of the examination in the comparison table on Table 3.3.4-1 above, it was decided to use the physical water cycle analysis model "SHER Model" (ARSIT Model) as the surface water model in the three priority WRRs.

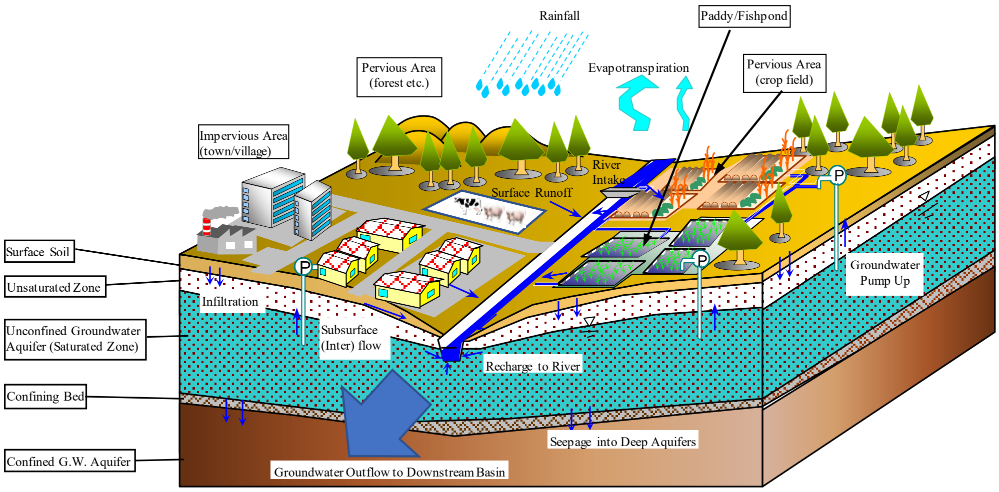
As a result of the comparative examination, the "SWAT Model" of the USDA is a free software, has a track record of application in the Philippines, and is highly versatile. However, it is not selected because it takes time to calibrate the model parameters. It is also noted that the SWAT model does not physically/logically solve for groundwater flow.

The Tank Model used for water balance analysis at the national level is very easy to calibrate. However, it is not selected because it is difficult to predict the discharge in areas where there is no observed discharge.

(2) SHER Model

The SHER (Similar Hydrologic Element Response) Model was developed based on the study done by Dr. Herath et al. The modeling concept of the SHER Model is shown in Figure 3.3.4-1.

The model was developed by the Ministry of Land, Infrastructure and Transport (MLIT), Japan, Association for Rainwater Storage and Infiltration Technology (ARSIT) and Nippon Koei Co., Ltd. The model is applicable to a river basin where hydrological characteristics are subject to change by deforestation, water resources development and urbanization.



Source: Nippon Koei Co., Ltd.

Figure 3.3.4-1 Conceptual Diagram of the SHER Model

The hydrological cycle is conceptually organized into surface flow, sub-surface flow and unconfined groundwater flow. There is no recharge to the river flow from the confined aquifer when the aquifer water level (unconfined groundwater level) is lower than the riverbed elevation.

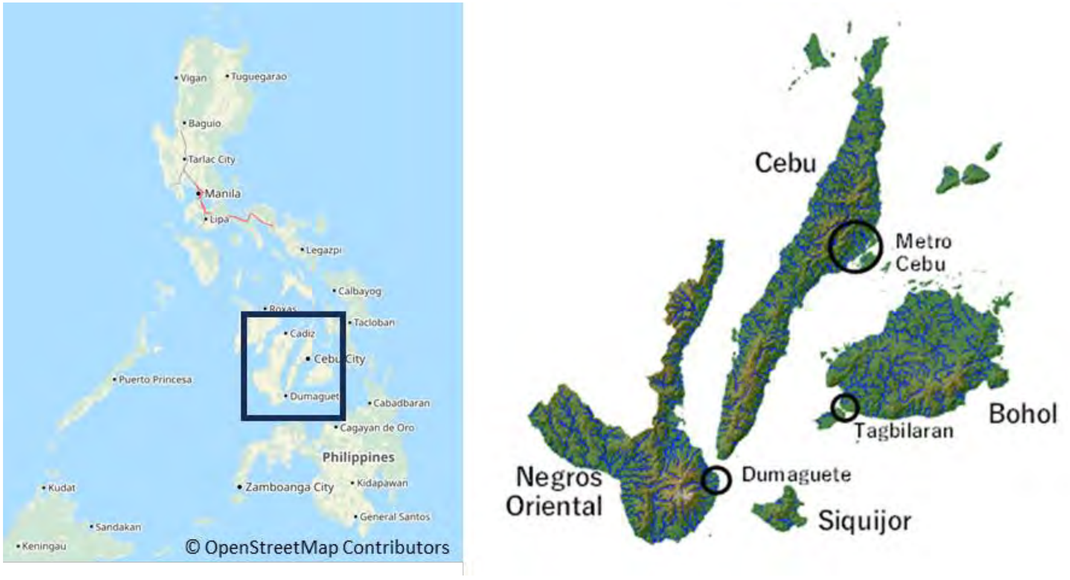
The hydrological cycle in a catchment shown above is schematically simplified for modeling; namely, the upper soil layer (soil moisture storage) and the underlying aquifer (groundwater). The upper soil moisture storage mainly contributes to the hydrological changes when the moisture content of the upper soil layer is transferred to the underlying aquifer where groundwater level is sufficiently low.

With this assumption, a catchment is represented by a number of interacting layers in the vertical direction for the purpose of hydrological simulation. These layers represent the surface layer, the sub-surface layer, the unconfined groundwater, and the confined groundwater.

A catchment is divided into a number of sub-basin blocks based on the hydrological properties of soil, topography and geological properties. The lumped hydrological responses are modeled for each sub-basin based on various hydrological equations. If the catchment can be further sub-divided into many sub-basins more spatial hydrological information could be analyzed in the catchment.

(3) Modeled Sub-basins

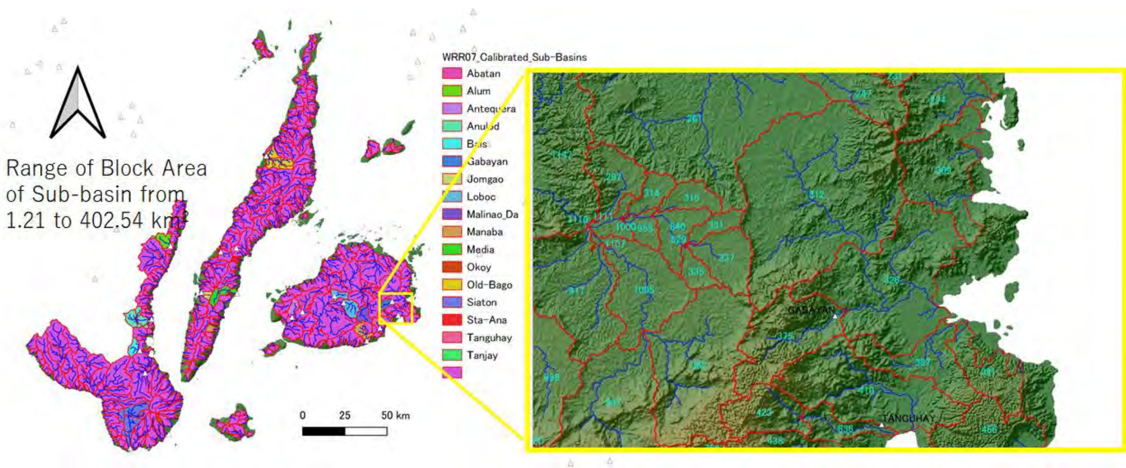
Figure 3.3.4-2 shows the location of WRR VII (left) and the major cities (right).



Source: JICA Survey Team

Figure 3.3.4-2 Location of WRR-VII and the Major Cities

In WRR VII, the sub-basins were divided into 408 sub-basins as shown in Figure 3.3.4-3. The range of sub-basin block area is from 1.21 km^2 to 402.5 km^2. The right figure shows the zoomed- up figure of the sub-basins in the east of Bohol. The topography of the Digital Elevation Model (DEM) used SRTM-30m.



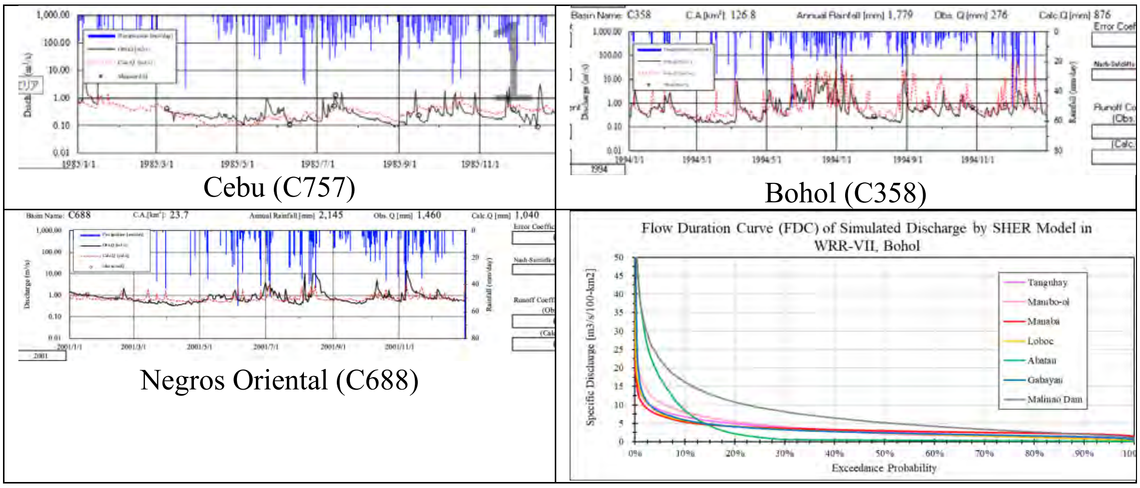
Source: JICA Survey Team

Figure 3.3.4-3 Sub-Basins for SHER Model in WRR-VII

(4) Calibration of SHER Model Parameters

The model parameters are calibrated by using the observed daily mean discharge converted by daily mean river water level and gauge height- discharge (H-Q) rating curves and measured monthly discharge by DPWH. The precipitation data used are the ERA5 (ECMW) from 1979 to 1980 and CHIRPS from 1981 to 2020 for each sub-basin mean rainfall. Evapotranspiration data for the basin is calculated using the evapotranspiration rate by Hamon's equation and FAO Penman-Monteith equation for the paddy areas. The Soil map of FAO was also used as a reference to calibrate of soil parameters. The groundwater parameters were used as a reference for the geological map.

The results of hydrographs of simulated and observed discharge are attached in Annex-D: Hydrology. Example of calibrated hydrographs are shown in Figure 3.3.4-4. Calibration was evaluated using the hydrograph shape, error coefficient, the Nash–Sutcliffe (NS) model efficiency coefficient and the flow-duration curves (FDCs). The calibration was carried out by selecting the year in which the observed and the calculated discharge are the best fit.

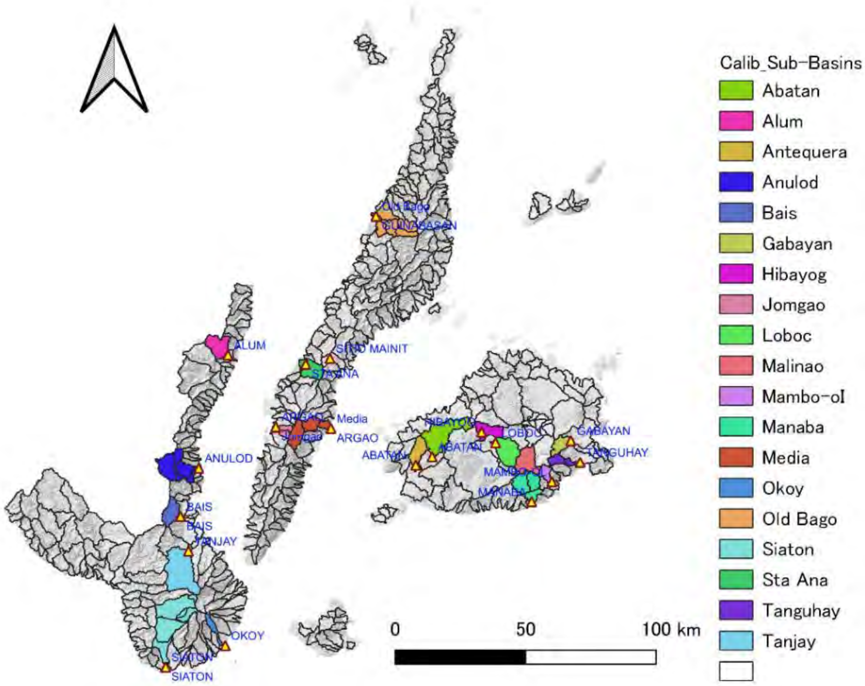


Source: JICA Survey Team

Figure 3.3.4-4 Example of Results of Simulated and Observed Discharge Hydrograph and FDC

(5) Expansion of SHER Model Parameters for Ungauged Sub-basin

Using the calibrated parameters of the SHER Model for sub-basins with the DPWH observed discharges, river discharges for sub-basins without observed discharges were estimated. Figure 3.3.4-5 shows the sub-basins where the DPWH observed discharges are located.



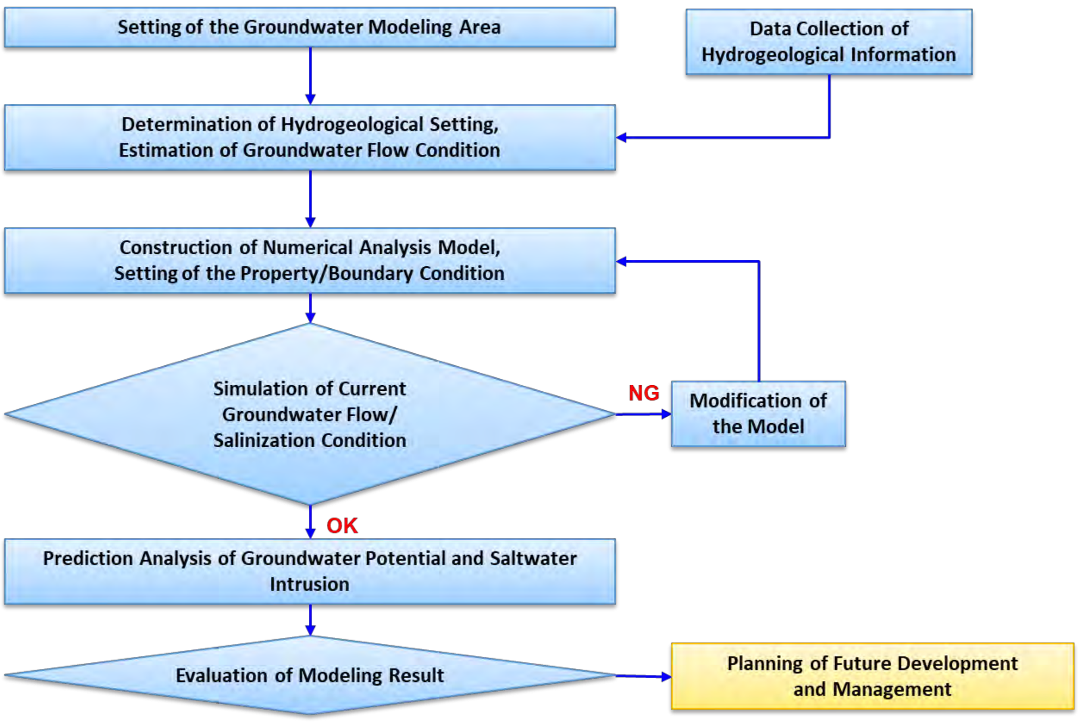
Source: JICA Survey Team

Figure 3.3.4-5 Calibrated Sub-Basins in WRR VII

3.3.4.2 Hydrological Analysis (Groundwater)

(1) Workflow of Groundwater Analysis

The groundwater analysis procedure is described below in Figure 3.3.4-6.



Source: JICA Survey Team

Figure 3.3.4-6 Procedure of Groundwater Analysis

(2) Groundwater Model Setting

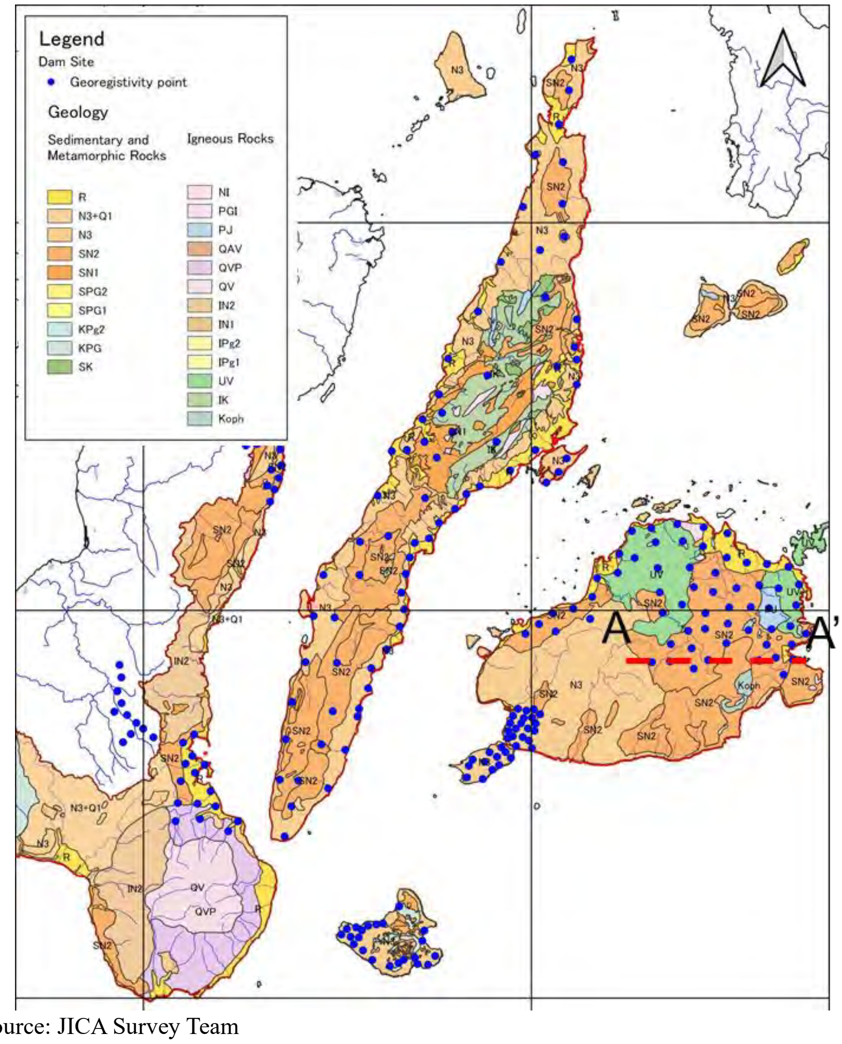
1) Hydrogeological Boundary

The modeling area was set at the boundary of the water resources region.

Since WRR VII has several independent islands, the modeling area was divided into four parts: Cebu, Bohol, Negros Oriental, and Siquijor Island (Figure 3.3.4-7).

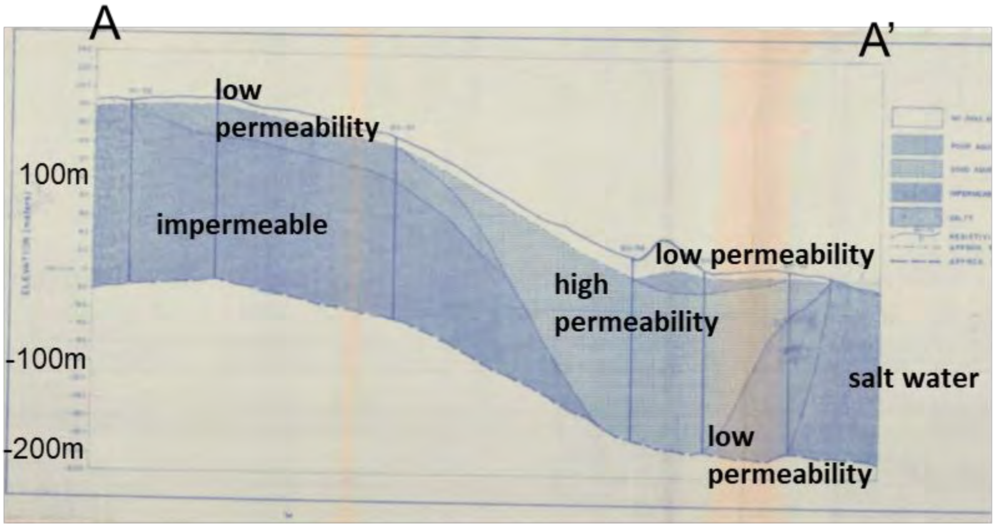
Boundary depths of aquifers and hydrogeological bedrock are estimated based on subsurface resistivity structures from GW Resources Investigation's (NWRB) Geo-resistivity Survey. This report presents the results of a geo-resistivity survey of 69 sites in Cebu, 92 sites in Bohol, 39 sites in Negros Oriental, and 22 sites in Siquijor. The survey sites cover almost the entire area of the three islands except for Negros Oriental.

In NWRB's report, the hydrogeologic structure is classified into three layers: high permeable zone, low permeable zone, and impermeable zone (see Figure 3.3.4-7). In this study, this classification was followed, and a three-layer model was created.



Source: JICA Survey Team

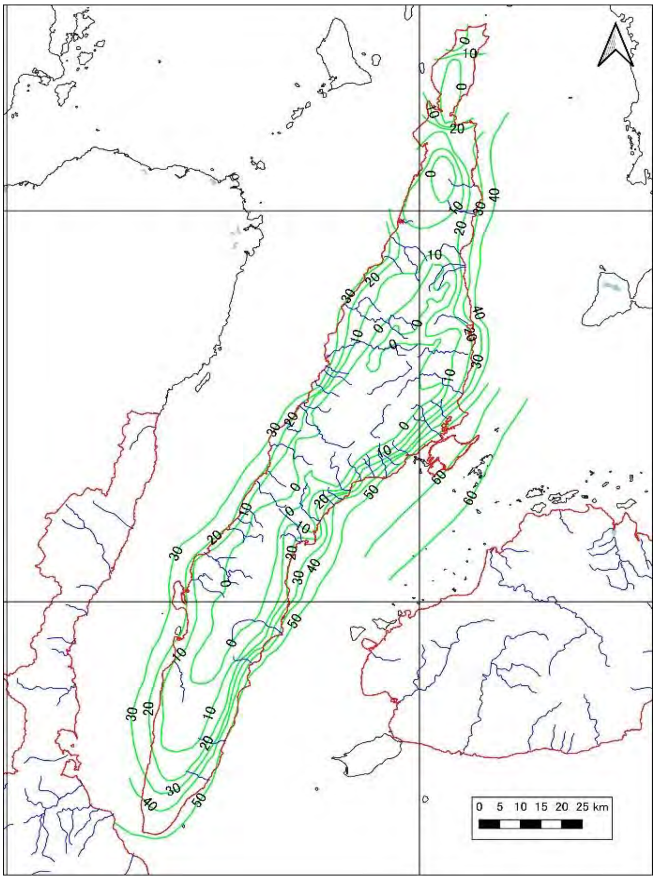
Figure 3.3.4-7 Groundwater Model Area of WRR VII

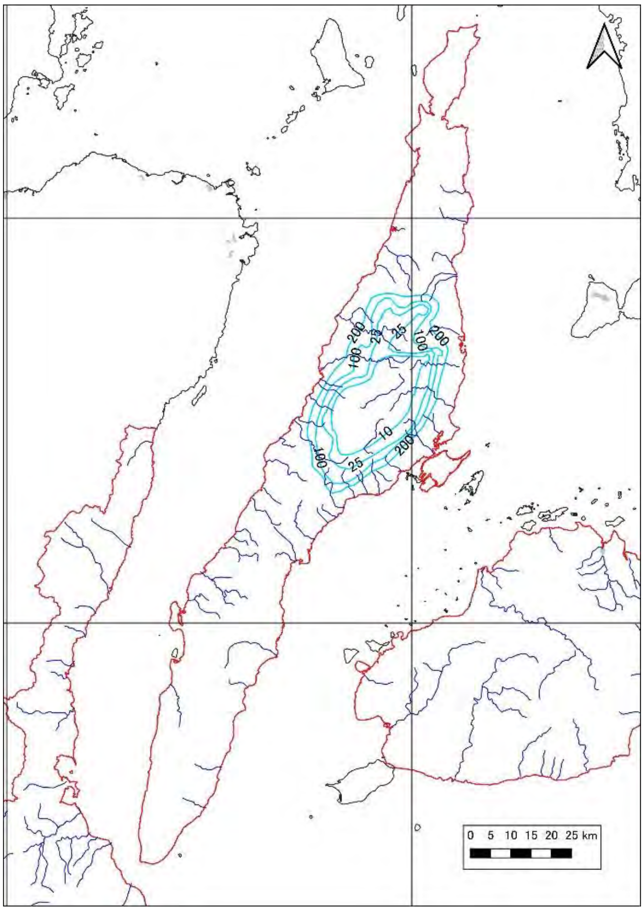


Source: Groundwater Resources Investigation Report (NWRB)

Figure 3.3.4-8 Example of Hydrogeological Structure estimated by Geo-resistivity Survey (The Cross-Section Line A-A' is shown in Figure 3.3.4-7)

Figure 3.3.4-9 shows the contour of the high-low permeable layer boundary and the low-impermeable layer boundary. In Cebu Island, the coastal area is covered by a thick layer of highly permeable aquifers corresponding to alluvium and limestone formations. In the central mountainous areas, impermeable sandstone and volcanic rocks are exposed to the ground.





Source: JICA Survey Team

Figure 3.3.4-9 Hydrogeological Boundary Contour of Cebu Island

2) Numerical Model Setting

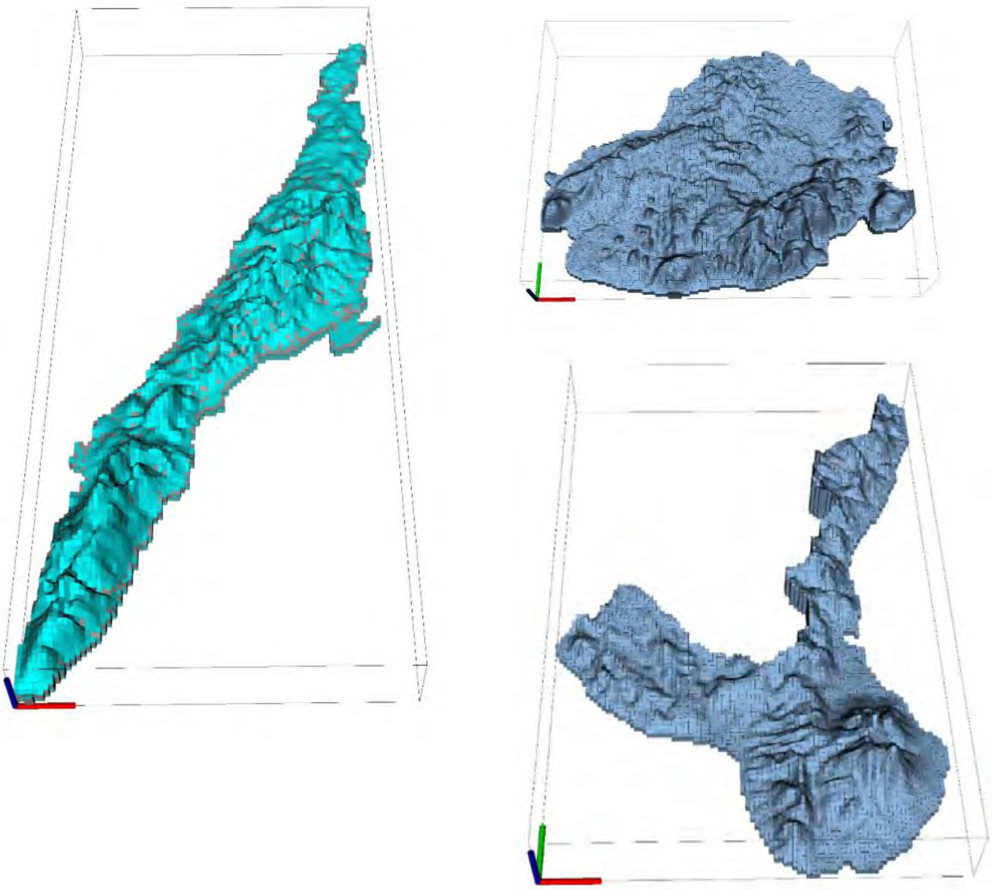
Based on the hydrogeologic structures established above, an analytical mesh was created for input into MODFLOW. Figure 3.3.4-10 shows a model diagram for each basin. In Negros Oriental, the mesh size was set larger than in other areas because there is little evidence for hydrogeological structure estimation and no groundwater observation data to be tested.

Table 3.3.4-2 summarizes the mesh size, number of layers, and number of meshes in each modeling area.

Table 3.3.4-2 Numerical Model Settings

Model Area	Cebu Island	Bohol Island	Negros Oriental	Siquijor Island
Grid Size	500m	500m	1,000m	500m
Cell Number of each Layer	19,012	15,570	4,750	1,410
Layer Number	4	4	4	4
Total Cell Number	76,048	62,280	19,000	5,640

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.3.4-10 Model Diagram of Each Modeling Area

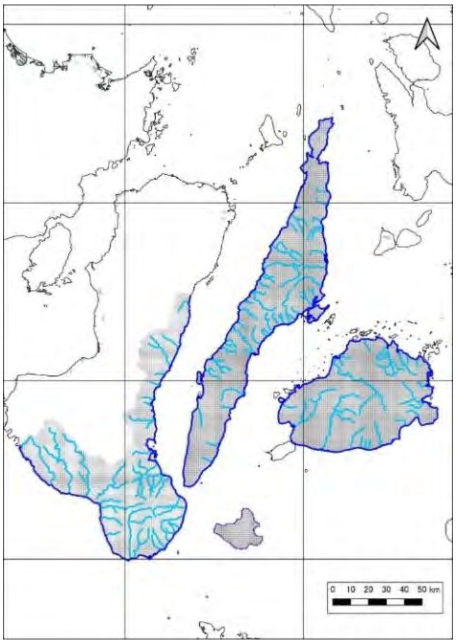
3) Groundwater Recharge

Groundwater recharge is the supply from surface water to an aquifer by infiltration. In this study, recharge rates estimated by the SHER model for each sub-basin are set as input parameters from the top of the model within each sub-basin. The period of input data is 1/1/1980 - 12/31/2020.

4) Boundary Condition

For groundwater analysis, at least, one boundary condition must always be set in order to converge the calculation.

In this study, rivers and oceans are used as boundary conditions. Since the flow rate between these boundaries and groundwater is unknown, they are set as known hydraulic head boundaries (Figure 00). The hydraulic head value for the sea was set to 0, and the hydraulic head value for the river was set to the ground surface elevation of the corresponding model mesh. In addition, semi-permeable boundary was set across the entire ground surface to check for groundwater outflow (groundwater leakage at the ground surface) at the surface.



Source: JICA Survey Team

Figure 3.3.4-11 Boundary Condition of WRRVII (Blue line: Sea, Sky Blue: River)

5) Hydrogeological Parameter

Hydraulic conductivity, a parameter that describes the ease of water flow, must be established for each hydrogeologic formation. This parameter should be set based on the field permeability test results of production wells and literature values. To improve the reproducibility of the model result, it is common practice to modify the hydraulic conductivity to an optimal value through calibration with observed groundwater data.

Based on the literature, the hydraulic conductivity shown in Table 3.3.4-3 was given as the initial set value for each layer.

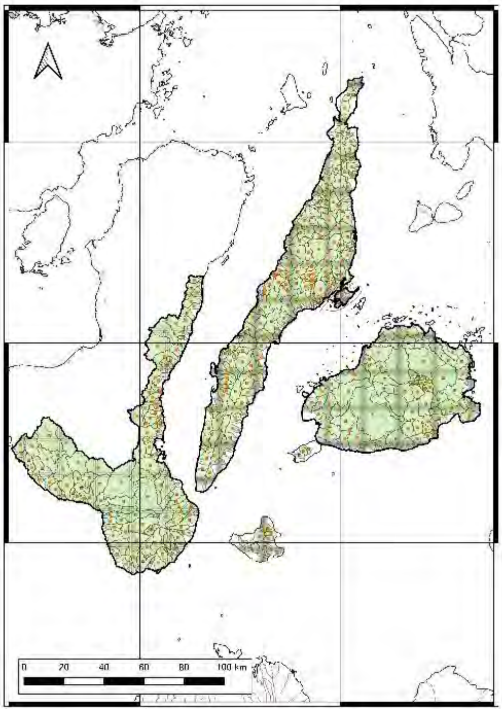
Table 3.3.4-3 Initial Model Setting of Hydraulic Conductivity

Model Area	Layer	Hydraulic Conductivity (m/s)	Assumed Geology
Cebu	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Limestone, Sand
	3,4	1×10^{-8}	Sandstone, Shale, Silt, Tuff
Bohol	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Limestone, Sand
	3,4	1×10^{-8}	Sandstone, Shale, Silt, Tuff
Negros Oriental	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Volcanic Ash,
	3,4	1×10^{-8}	Volcanic Rock, Sandstone, Shale, Tuff
Siquijor	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Limestone, Sand
	3,4	1×10^{-8}	Sandstone, Shale, Silt, Tuff

Source: JICA Survey Team

6) Pumping Well Setting

Pumping from wells is one of the major factors that affect groundwater level fluctuations and groundwater abundance. In this study, the amount of groundwater used for agricultural and water supply purposes was estimated by sub-basin. On the other hand, the location and quantity of pumping wells are not completely known. Therefore, in this groundwater analysis, a hypothetical pumping well was established at the center of each sub-basin (Figure 3.3.4-12), and the amount of water used in each sub-basin was set there. Since the depth of many of the pumping wells is also unknown, the depth of the virtual well was set to the underside of the model (the boundary with the basement), and the screen depth (the depth at which groundwater is drawn) was set to the full depth.



Source: JICA Survey Team

Figure 3.3.4-12 Location of Pumping Wells in the Numerical Model (Orange Square)

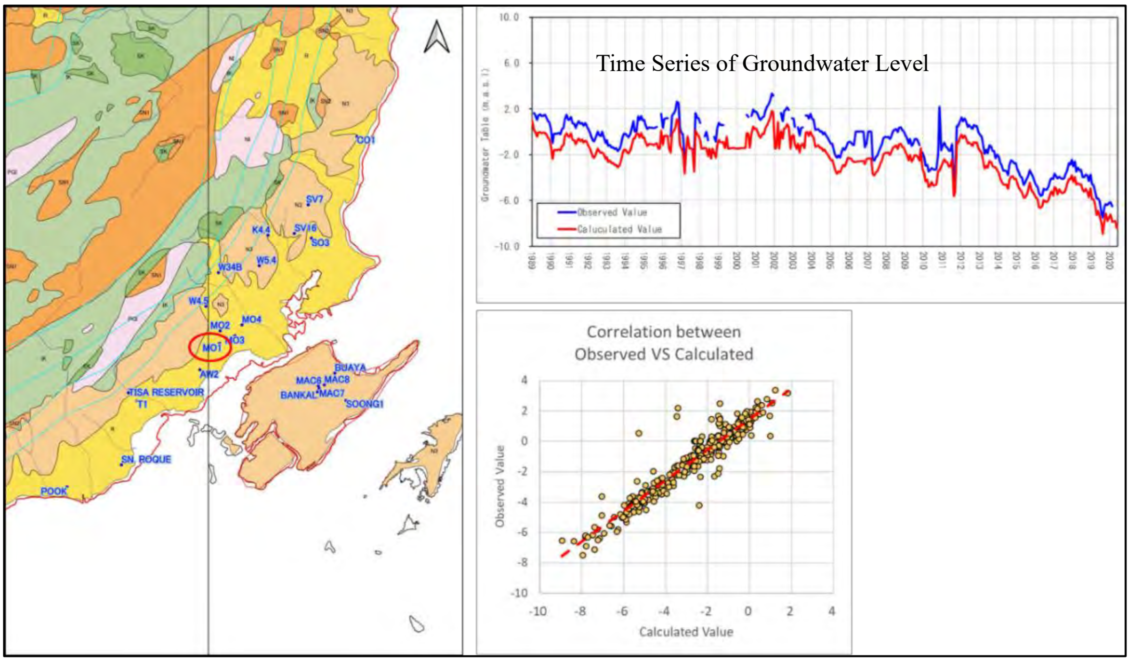
(3) Calibration of Groundwater Model Parameter

1) Groundwater Level Calibration

Calibration of model parameters (hydraulic conductivity) was performed by comparing the groundwater levels calculated by MODFLOW with the measured groundwater levels.

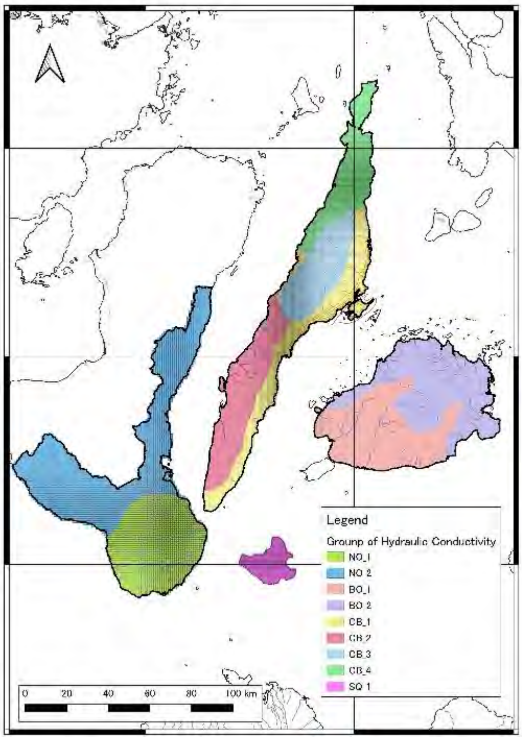
The only measured groundwater levels that can be used for calibration are the groundwater observation wells in Metro Cebu managed by MCWD, and very little calibration is possible for other areas. Therefore, the hydraulic conductivity in areas without calibration targets was adjusted based on the values set by the SHER model.

The results of groundwater level calibration within Metro Cebu are shown in Figure 3.3.4-13. The trend of groundwater level fluctuation is generally reproduced and the correlation is high. Figure 3.3.4-14 and Table 3.3.4-4 shows the hydraulic conductivity settings after calibration.



Source: JICA Survey Team

Figure 3.3.4-13　Example of the Calibration by Groundwater Level



Source: JICA Survey Team

Figure 3.3.4-14　Setting of Hydraulic Conductivity after Calibration

Table 3.3.4-4 Setting of Hydraulic Conductivity after Calibration

Model Area	Group	Layer	Hydraulic Conductivity (m/s)	Model Area	Group	Layer	Hydraulic Conductivity (m/s)
Cebu	CB_1	1	1×10^{-3}	Bohol	BO_1	1	1×10^{-3}
		2	1×10^{-4}			2	1×10^{-4}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	CB_2	1	1×10^{-6}		BO_2	1	1×10^{-6}
		2	1×10^{-7}			2	1×10^{-7}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	CB_3	1	1×10^{-7}	Negros Oriental	NO_1	1	1×10^{-3}
		2	1×10^{-7}			2	1×10^{-3}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	CB_4	1	1×10^{-6}		NO_2	1	1×10^{-6}
		2	1×10^{-7}			2	1×10^{-6}
		3,4	1×10^{-9}			3,4	1×10^{-9}
Siquijor	SQ_1	1	1×10^{-3}				
		2	1×10^{-4}				
		3,4	1×10^{-9}				

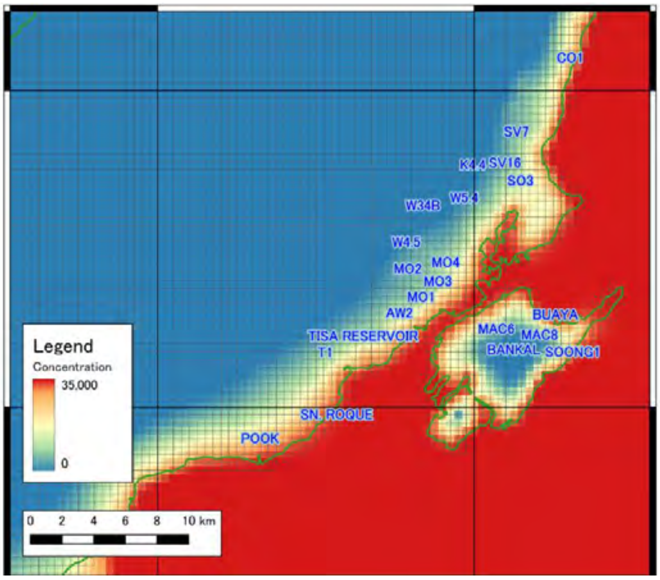
Source: JICA Survey Team

2) Saltwater Intrusion

Using the parameters determined by calibration, a saltwater intrusion analysis was conducted by SEAWAT. The target areas are Cebu and Bohol, where salinization is a problem.

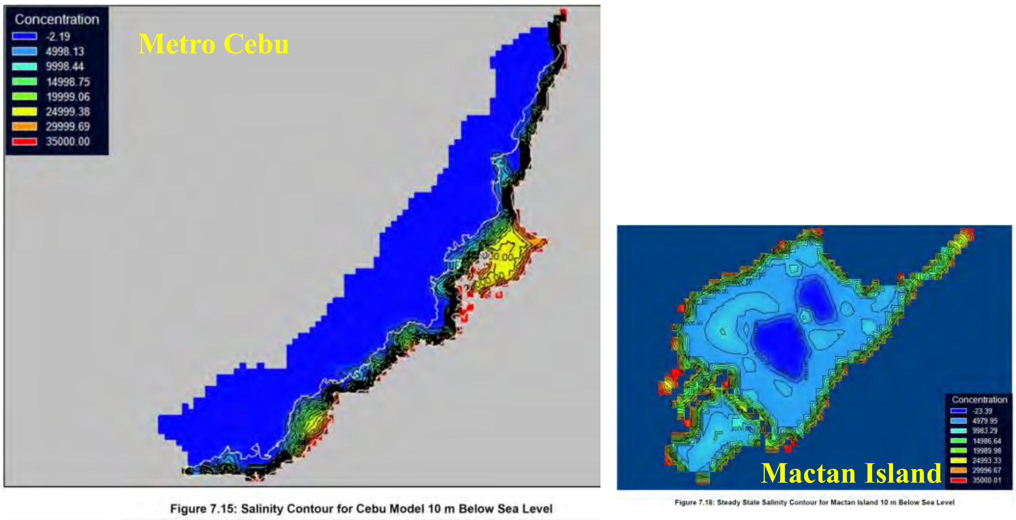
In order to input the salinity distribution before the start of pumping as an initial condition, the salinity of seawater (35,000 mg/L) was set as the constant boundary in the coastline and the salinity of land area was set as 0 mg/L. The model was calculated for 1,000 years excluding the pumping wells. And then, the analysis was performed with pumping data input for the period of 1980 to 2020, and the salinity distribution for 2020 was calculated.

Figure 3.3.4-15 shows the results of the salinity analysis at -10 m above sea level in Metro Cebu; the distribution is roughly equivalent to the results of the NWRB's study conducted in 2018.



Source: JICA Survey Team

Figure 3.3.4-15 Salinity Distribution at 10m below sea level



Source: Development of Groundwater Management Plan for Highly Urbanized Water Constraint Cities (NWRB, 2018)

Figure 3.3.4-16 Salinity Distribution Calculated by NWRB

3.3.4.3 Climate Change Impact Assessment

(1) Cases of Water Balance Calculations

Cases of water balance calculations are shown in Table 3.3.4-5. For future cases, because the infiltration (groundwater recharge) of irrigation water at the paddy is currently large, the irrigation water demands, paddy areas and urban areas are set for the year 2020. However, municipal and industrial water demands are set at zero, because the effect of infiltration from municipal and industrial water is not substantial. The impact of climate change on the water balance is an assessment of future uncertainty (variability). In this study, it was evaluated RCP8.5, which has a large degree of uncertainty. The impact assessment of climate change was estimated by inputting values after changes in future climate change (precipitation and temperature = evapotranspiration) into the input values of the calibrated runoff analysis model. Spatial province-level and temporal quarter-level PAGASA climate change impact data were used.

Table 3.3.4-5 Cases of Water Balance Calculations

Case No.	Case-Name	Weather (Rain & Evapo)	Paddy Area [ha]	Irrigation WD	Urban Area	Domestic & Industrial WD	Urban Area
0	Calibration	1979-2020	1979-2020	1979-2020	1979-2020	1979-2020	1979-2020
1	Present Condition	1979-2020	2020	2020	2020	0	2020
2	RCP8.5-Low_WD=2020	RCP8.5-Low	2020	2020	2020	0	2020
3	RCP8.5-Mid_WD=2020	RCP8.5-Mid	2020	2020	2020	0	2020
4	RCP8.5-High_WD=2020	RCP8.5-High	2020	2020	2020	0	2020

Source: JICA Survey Team

(2) PAGASA's Climate Change Report

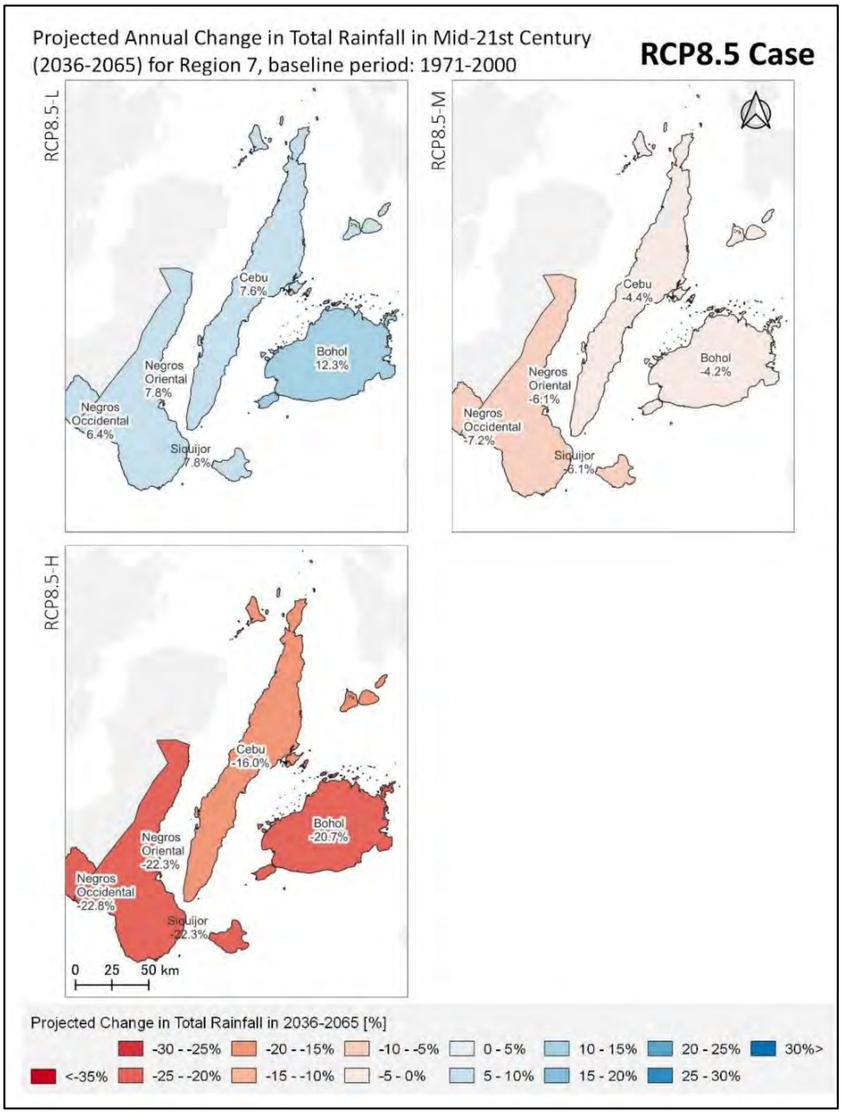
Cases of climate change used the data of the DOST-PAGASA's report. The data of PAGASA's report is a provincial-wise change of rainfall and temperature by four seasons. The CLIRAM of the projected seasonal change in mean temperature and precipitation in the mid-21s century (2036-2065) for all provinces (baseline period: 1971-2000) is shown in PAGASA's Report. High global emission scenario of RCP8.5 (Representative Concentration Pathways) of lower bound (L), median (M) and upper bound (H) were used for this study. This scenario indicates global average warming levels of 3.2 to 5.4 ºC by 2090. The changes in rainfall and temperature are different by province. The changes of evapotranspiration by Hamon's equation and FAO Penman-Monteith method were calculated using temperature changes data.

Table 3.3.4-6 CLIRAM of the Projected Seasonal Change in Annual Total Precipitation (mm/year) in the Mid-21st Century (2036-2065) for all Provinces (baseline period: 1971-2000)

Region	Province	Observed (1971-2000)				Projected (2036-2065)									
								DJF (Dec-Jan-Feb)		MAM (Mar-Apr-May)		JJA (Jun-Jul-Aug)		SON (Sep-Oct-Nov)	
		DJF	MAM	JJA	SON	Scenario	Range*	Percent change	Projected value	Percent change	Projected value	Percent change	Projected value	Percent change	Projected value
Region 7	Bohol	376.1	209.6	412.9	514.5	Moderate Emission (RCP4.5)	Lower Bound	-13.5	325.3	-2.4	204.5	-16.8	343.5	-21.2	405.7
							Median	3.0	387.5	3.9	217.7	-6.5	386.1	-12.2	451.9
							Upper Bound	29.7	487.8	11.9	234.5	13.8	470.1	4.8	539.1
						High Emission (RCP8.5)	Lower Bound	-17.1	311.9	-6.7	195.5	-22.1	321.7	-27.9	370.8
							Median	1.5	381.8	1.8	213.3	-2.3	403.3	-12.3	451.4
							Upper Bound	21.5	457.1	8.5	227.5	13.4	468.2	6.3	546.8
	Cebu	324.0	228.3	595.1	607.4	Moderate Emission (RCP4.5)	Lower Bound	-7.1	301.1	-3.7	219.8	-12.4	521.3	-17.7	499.9
							Median	3.9	336.6	6.6	243.4	-4.9	565.7	-6.0	570.7
							Upper Bound	31.7	426.9	9.2	249.4	1.0	601.2	1.5	616.4
						High Emission (RCP8.5)	Lower Bound	-15.4	274.1	-3.2	221.1	-15.8	501.1	-21.3	478.0
							Median	6.2	344.1	2.1	233.1	-5.4	562.8	-11.5	537.5
							Upper Bound	22.4	396.7	10.2	251.5	3.6	616.6	2.7	623.5

Source: DOST-PAGASA

Figure 3.3.4-17 shows the projected annual change in total rainfall in Mid-21st Century (2036-2065) for administrative region VII and part of Negros Occidental province for RCP8.5 cases. Figures for RCP4.5 as well as seasonal changes in total rainfall are given in Annex-D.



Source: JICA Survey Team

Figure 3.3.4-17 Projected annual change in total rainfall in Mid-21st Century (2036-2065) for Region VII

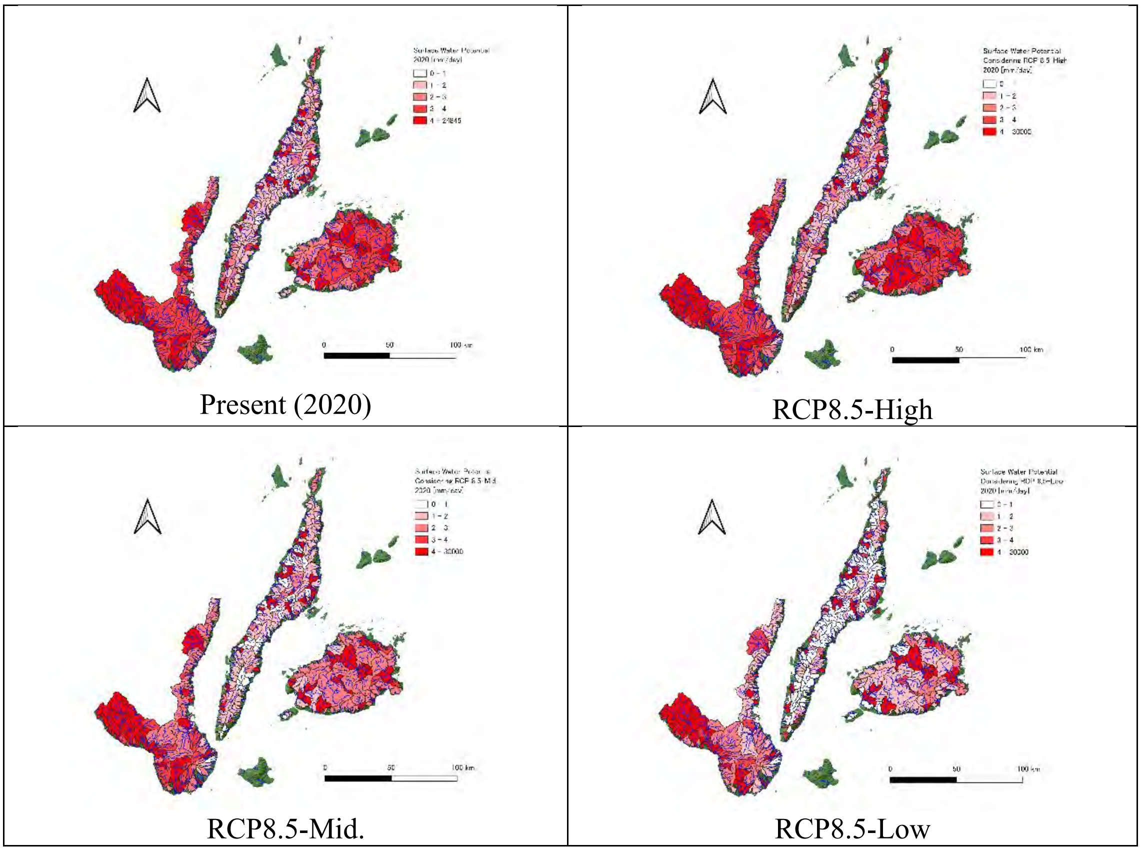
3.3.4.4 Results of Hydrological Analysis

In the detailed hydrological analysis in priority water resources regions, a physically based water cycle model was used to logically calculate river discharge, groundwater recharge and groundwater flow. It could be estimated using physical parameters calibrated in sub-basins with discharge gauging stations, and even in sub-basins where there are no discharge gauging stations. Calibration results were generally good as shown in Annex-D. As a result of reducing the sub-basin division, it was possible to determine the regional water potential (surface water and groundwater) of the target water resources regions in detail. The results of the water balance analysis with water resources potential and water demand for each sub-basin are described in the following sections.

3.3.5 Water Potential in WRR VII

(1) Surface Water Potential

The surface water potential (river flow) of each sub-basin in WRR VII was calculated by the SHER Model as shown in Figure 3.3.5-1. The surface water potential is abundant in the western part of Bohol Island and the whole area of Negros Oriental because of irrigation dams and volcanic mountains soils, respectively.



Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

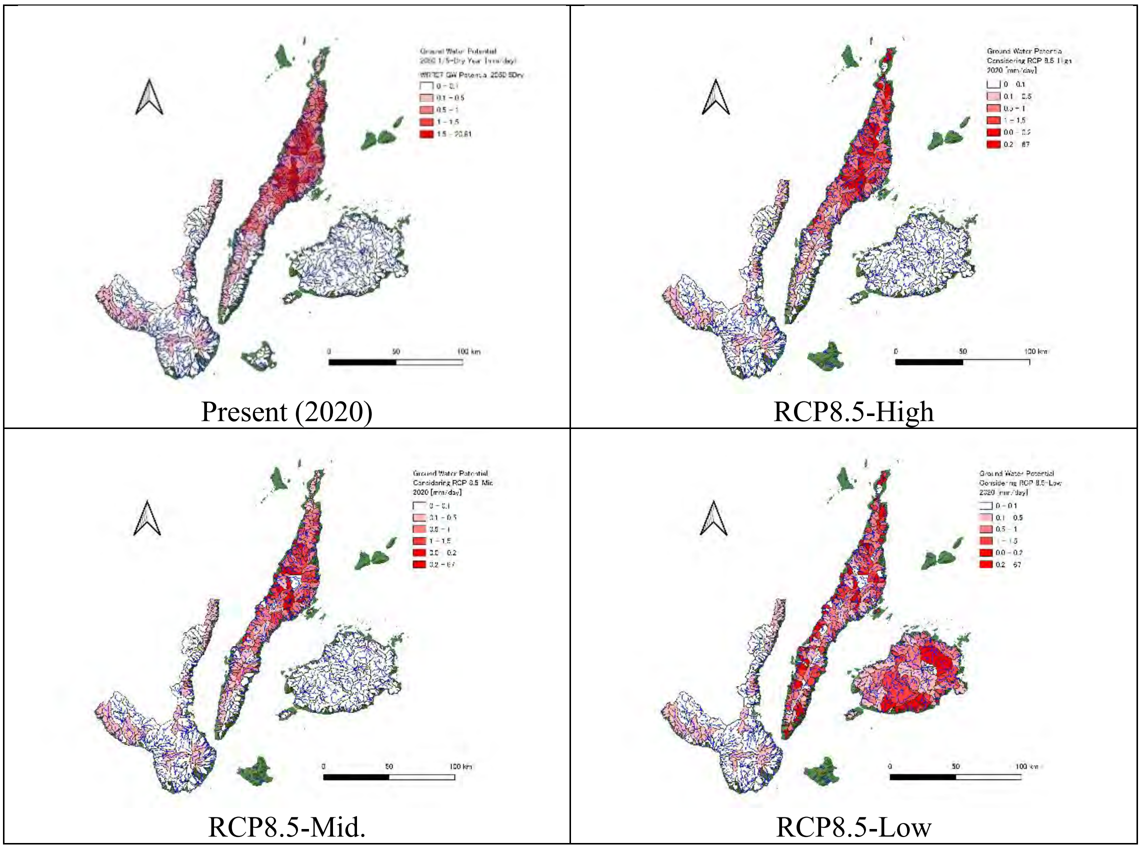
Source: JICA Survey Team

Figure 3.3.5-1 Surface Water Potentials (Average) in WRR-VII (Unit: mm/day)

(2) Groundwater Potential

The results of groundwater potentials (groundwater flow) at each block were also calculated by the SHER Model. The groundwater potentials used by the MODFLOW Model is described in the next section of "Hydrological Analysis (Groundwater)".

As shown in Figure 3.3.5-2, the groundwater potential is relatively abundant in the northern part to the central part of Cebu Island due to the geology of the limestone rocks and steep slope of the groundwater flow. Groundwater potential was calculated by multiplying the groundwater flow of each block by the safe groundwater pumping rate of 0.7. "Safety GW Availability" is 70% of groundwater flow (groundwater potential). This safety factor of 70% is the value used in the groundwater potential survey report for Shizuoka Prefecture, Japan[2].



Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

Source: JICA Survey Team

Figure 3.3.5-2 Groundwater Potentials (Average) in WRR-VII (Unit: mm/day)

3.3.6 Water Demand Forecast in WRR VII

3.3.6.1 Socio-Economic Framework

Results of the population projection and GRDP projection of the priority WRRs (V, VII and XI) are shown in Section 3.2.1.

3.3.6.2 Water Demand Forecast (Agricultural Use) in WRR VII

1) Irrigation Water Demands

The annual irrigation water demands (AWDs) in WRR VII are summarized in Table 3.3.6-1 for 2020, Table 3.3.6-2 for 2030, Table 3.3.6-3 for 2040, and Table 3.3.6-4 for 2050. The future AWDs are only presented in the case of the irrigation areas estimated based on NIA's past financial programs. The future AWDs in the case of the irrigation areas based on NIMP 2020-2030 are explained in Annex-F.

[2] Source: The groundwater potential survey report for Shizuoka Prefecture, Japan.
(https://www.pref.shizuoka.jp/_res/projects/default_project/_page_/001/018/048/toubu_hp_kouhyou.pdf)

Table 3.3.6-1 Annual Irrigation Water Demands of 2020 in WRR VII

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Negros Occidental	0.076	2,999	2,881	1,773	1,252	60.34	5	5	0	0	0.00	60.34
Bohol	1.000	25,234	23,904	18,677	16,736	320.24	20	0	0	0	0.00	320.24
Cebu	1.000	8,392	6,657	5,799	5,155	141.98	1,112	977	943	695	21.02	163.00
Negros Oriental	0.769	11,431	9,197	7,812	7,808	244.27	0	0	0	0	0.00	244.27
Siquijor	1.000	734	580	329	159	6.65	0	0	0	0	0.00	6.65
Total		48,790	43,219	34,389	31,110	773.49	1,137	982	943	695	21.02	794.51

Source: JICA Survey Team

Table 3.3.6-2 Annual Irrigation Water Demands of 2030 in WRR VII

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Negros Occidental	0.076	3,810	3,692	3,686	2,603	91.89	7	7	0	0	0.00	91.89
Bohol	1.000	26,526	25,197	22,591	20,243	507.50	21	0	0	0	0.00	507.50
Cebu	1.000	8,392	6,657	5,977	5,313	146.33	1,112	977	972	716	21.66	167.99
Negros Oriental	0.769	11,624	9,390	7,984	7,980	268.07	0	0	0	0	0.00	268.07
Siquijor	1.000	734	580	665	321	13.44	0	0	0	0	0.00	13.44
Total		51,086	45,517	40,902	36,460	1,027.24	1,140	984	972	716	21.66	1,048.90

Source: JICA Survey Team

Table 3.3.6-3 Annual Irrigation Water Demands of 2040 in WRR VII

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Negros Occidental	0.076	4,621	4,503	4,496	3,175	112.07	8	9	0	0	0.00	112.07
Bohol	1.000	27,818	26,490	23,750	21,282	533.54	22	0	0	0	0.00	533.54
Cebu	1.000	8,392	6,657	5,977	5,313	146.33	1,112	977	972	716	21.66	167.99
Negros Oriental	0.769	11,818	9,584	8,148	8,144	273.59	0	0	0	0	0.00	273.59
Siquijor	1.000	734	580	665	321	13.44	0	0	0	0	0.00	13.44
Total		53,382	47,814	43,036	38,235	1,078.98	1,142	986	972	716	21.66	1,100.64

Source: JICA Survey Team

Table 3.3.6-4 Annual Irrigation Water Demands of 2050 in WRR VII

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Negros Occidental	0.076	5,432	5,314	5,305	3,746	132.26	10	10	0	0	0.00	132.26
Bohol	1.000	29,110	27,783	24,910	22,321	559.58	23	0	0	0	0.00	559.58
Cebu	1.000	8,392	6,657	5,977	5,313	146.33	1,112	977	972	716	21.66	167.99
Negros Oriental	0.769	12,011	9,777	8,312	8,308	279.11	0	0	0	0	0.00	279.11
Siquijor	1.000	734	580	665	321	13.44	0	0	0	0	0.00	13.44
Total		55,679	50,111	45,169	40,010	1,130.72	1,145	987	972	716	21.66	1,152.38

Source: JICA Survey Team

2) Livestock and Poultry Water Demands

The AWDs of livestock and poultry in WRR VII are calculated as shown in Table 3.3.6-5.

Table 3.3.6-5 Annual Water Demands for Livestock/Poultry in WRR VII

Region	Province	Area	Heads in 2020		AWD (MCM) in 2020			AWD (MCM)		
		Rate	Livestock	Poultry	Livestock	Poultry	Total	2,030	2,040	2050
VI	Negros Occidental	0.076	47,312	643,383	0.363	0.031	0.393	0.445	0.489	0.517
VII	Bohol	1.000	481,407	4,228,731	3.690	0.201	3.891	4.408	4.836	5.116
	Cebu	1.000	632,527	10,482,111	4.848	0.497	5.346	6.057	6.645	7.030
	Negros Oriental	0.769	307,622	2,220,729	2.358	0.105	2.463	2.791	3.062	3.239
	Siquijor	1.000	70,388	590,425	0.540	0.028	0.568	0.643	0.705	0.746
	Total		1,539,256	18,165,379	11.798	0.862	12.660	14.344	15.737	16.648

Source: JICA Survey Team

3) Freshwater Fishpond Water Demands

The AWDs for the freshwater fishponds in WRR VII are estimated as shown in Table 3.3.6-6.

Table 3.3.6-6 Water Demands for Freshwater Fishponds in WRR VII

Region	Province	Area	Fishpond Area (ha) in		Annual Water Demands for Fishpond (MCM)			
		Rate	Province	WRR	2022	2030	2040	2050
VI	Negros Occidental	0.076	No data					
VII	Bohol	1	54.25	54.25	1.58	1.80	2.11	2.47
	Cebu	1	1.68	1.68	0.05	0.06	0.07	0.08
	Negros Oriental	0.769	29.67	22.82	0.67	0.76	0.89	1.04
	Siquijor	1	1.12	1.12	0.03	0.04	0.04	0.05
	Total		**86.72**	**79.87**	**2.33**	**2.65**	**3.11**	**3.64**

Source: JICA Survey Team

3.3.6.3 Water Demand Forecast for Municipal and Industrial Sector WRR VII

(1) Water Demand Forecast Methodology

1) Target Year

To assess the water resources in 2030, 2040, and 2050, the respective municipal and industrial water demands were estimated.

2) Population Projection

Population projection was based on population projection (medium) in latest census data (2020) publicized by PSA.

3) Unit Water Consumption

Unit water consumption was based on the conditional value of PWSSMP 2018. In addition, the values confirmed in the site survey were applied as shown in Table 3.3.6-7.

Table 3.3.6-7 Unit Water Consumption (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	151	159	159	159	159	159	159	MCWD hearing survey
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	180	180	190	190	200	200	200	BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	155	**155**	**155**	**155**	**155**	**155**	**155**	DCWD hearing survey
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	118	122	125	128	130	135	135	MSWD hearing survey
Other cities in Urban Area			120	120	120	120	120	120	120	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	60	60	60	60	60	60	Domestic demand (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

4) Non-Revenue Water Ratio

Non-revenue water ratio was based on the conditional value of PWSSMP 2018. In addition, the values confirmed in the site survey were applied as shown in Table 3.3.6-8.

Table 3.3.6-8 Non-Revenue Water Ratio

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	25%	25%	20%	20%	20%	20%	20%	MCWD hearing survey
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	15%	15%	15%	15%	15%	15%	15%	BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	40%	25%	23%	20%	20%	20%	**20%**	DCWD hearing survey
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	24%	22%	20%	20%	20%	20%	20%	MSWD hearing survey

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

5) Allocation for Municipal Water Demand

Allocation for each category was based on the current consumption result confirmed in PWSSMP 2018 and the site survey as shown in Table 3.3.6-9.

Table 3.3.6-9 Allocation for Municipal Water Demand

	Water District	Municipality	Domestic (%)	Commercial (%)	Institutional (%)	Total (%)	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	63%	32%	5%	100%	Actual consumption result as of April 2022 by MCWD
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	79%	15%	6%	100%	Actual consumption result as of May 2022 by BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	**79%**	**15%**	**6%**	**100%**	Refer to Bohol data
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	83%	11%	6%	100%	Actual consumption result as of May 2022 by BWUI hearing survey
Other cities in Urban Area			93%	6%	1%	100%	Current Allocation (urban) in PWSSMP2018
Other cities in Rural Area			90%	8%	2%	100%	Current Allocation (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

6) Correlation Formula between GRDP and Industrial Water Demand

In the estimation of the future industrial water demand, the past trend of industrial GRDP was calculated based on the GRDP record and percentage of the industry to GDP on PSA "Regional Accounts of the Philippines" 2021 as shown in Table 3.3.6-10.

Table 3.3.6-10 Past Trend of Industrial GRDP

Water Resource Region		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
WRR VII	REGION VI (WESTERN VISAYAS)	159,573	165,872	179,135	187,026	199,058	214,463	229,420	248,611	262,881	264,729
	REGION VII (CENTRAL VISAYAS)	200,077	209,609	230,736	249,135	270,489	287,319	311,619	334,025	360,941	365,950

Source: JICA Survey Team

Also, the past trend of industrial water use was calculated by dividing the NWRB national industrial water rights grant record by the above past trend of industrial GRDP as shown in Table 3.3.6-11.

Table 3.3.6-11 Past Trend of Industrial Water Use

Unit:MCM

Water Resource Region		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
WRR VII	REGION VI (WESTERN VISAYAS)	115	120	121	120	121	123	126	129	129	130
	REGION VII (CENTRAL VISAYAS)	145	151	156	160	164	165	172	174	177	180

Source: JICA Survey Team

Based on the above past trend of industrial GRDP and industrial water use, correlation formula between industrial GRDP and industrial water use is calculated using the formula below. Results are shown in Table 3.3.6-12.

Industrial Water Use (MCM/Year) = SLOPE × Industrial GRDP (Million Pesos) + INTERCEPT

Table 3.3.6-12 Correlation Formula Factor Between Industrial GRDP and Industrial Water Use

Water Resource Region		SLOPE	INTERCEPT
WRR VII	REGION VI (WESTERN VISAYAS)	0.00012	98
	REGION VII (CENTRAL VISAYAS)	0.00019	112

Source: JICA Survey Team

7) Industrial GRDP Projection

Industrial GRDP projection is calculated by GRDP projection (medium) and percentage of the industry to GDP on PSA "Regional Accounts of the Philippines" 2021 as shown in Table 3.3.6-13.

Table 3.3.6-13 Industrial GRDP Projection

Water Resource Region		2020	2025	2,030	2035	2040	2045	2050
WRR VII	REGION VI (WESTERN VISAYAS)	217,888	277,357	327,163	376,244	408,767	461,732	489,148
	REGION VII (CENTRAL VISAYAS)	298,301	352,637	393,480	439,858	477,453	541,814	576,653

Source: JICA Survey Team

(2) Water Demand Forecast Result

1) Water Demand Forecast Result for Municipal Sector

Based on the above population projection and prediction condition for the municipal water demand forecast, the municipal water demand forecast is calculated as shown in Table 3.3.6-14. The detailed water demand forecast result is shown in Appendix A.

Table 3.3.6-14 Result of Municipal Water Demand Forecast for Priority WRRs

Water Resource Region	Municipal Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR VII - CENTRAL VISAYAS	409	437	438	459	479	494	506

Source: JICA Survey Team

2) Water Demand Forecast Result for Industrial Sector

Based on the above correlation formula and industrial GRDP projection, the industrial water demand forecast is calculated as shown in Table 3.3.6-15. The detailed water demand forecast result is shown in Appendix B.

Table 3.3.6-15 Result of Industrial Water Demand Forecast for Priority WRRs

Water Resource Region	Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR VII - CENTRAL VISAYAS	170	180	188	196	203	215	222

Source: JICA Survey Team

3.3.6.4 Water Resources Facility Plan (Hydropower Plant, Dam)

Plan of the irrigation dams and flood control dams are presented in Section 3.3.3.7 Current Status of Municipal and Industrial Water Use in WRR VII and Section 3.3.3.10 Flood Risk Management (FRM) in WRR VII, respectively.

3.3.6.5 River Maintenance Flow (Environmental Flow)

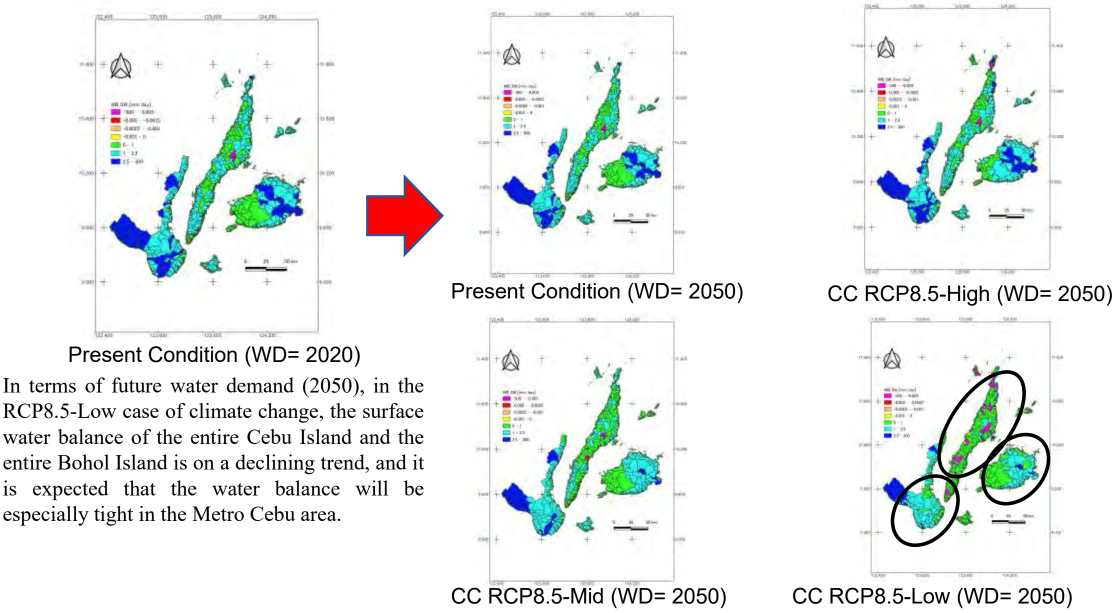
10% of dependable flow (80% of flow duration curve) is applied in the study based on DENR-NWRB resolution No. 030613. For estimation of the river environmental maintenance flow, the flow duration curve (FDC) must be calculated for each sus-basin, which is a huge amount of work. For this reason, in this survey, the water balance calculation and the surface water potential was used the annual runoff of the model. The river environmental maintenance flow was taken into account in the reservoir operation calculations for the dam plan.

3.3.7 Water Balance Analysis in WRR VII

(1) Sub-basin-wise Surface Water Balance

Sub-basin-wise surface water balance at present condition, future (2050) and climate change condition are shown in Figure 3.3.7-1. The monthly water balance is shown in Sections 11.3 and 11.4 of Annex-D-Hydrology. Even in areas where there is no water shortage in the annual water balance, there are many areas where the water balance is negative in the dry season, which is the most severe, when looking at the monthly water balance.

In terms of future water demand (2050), although it is a severe case that does not take any measures in RCP8.5, in the RCP8.5-Low case of climate change, the surface water balance of the entire Cebu Island and the entire Bohol Island is on a declining trend, and it is expected that the water balance will be especially tight in the Metro Cebu area.



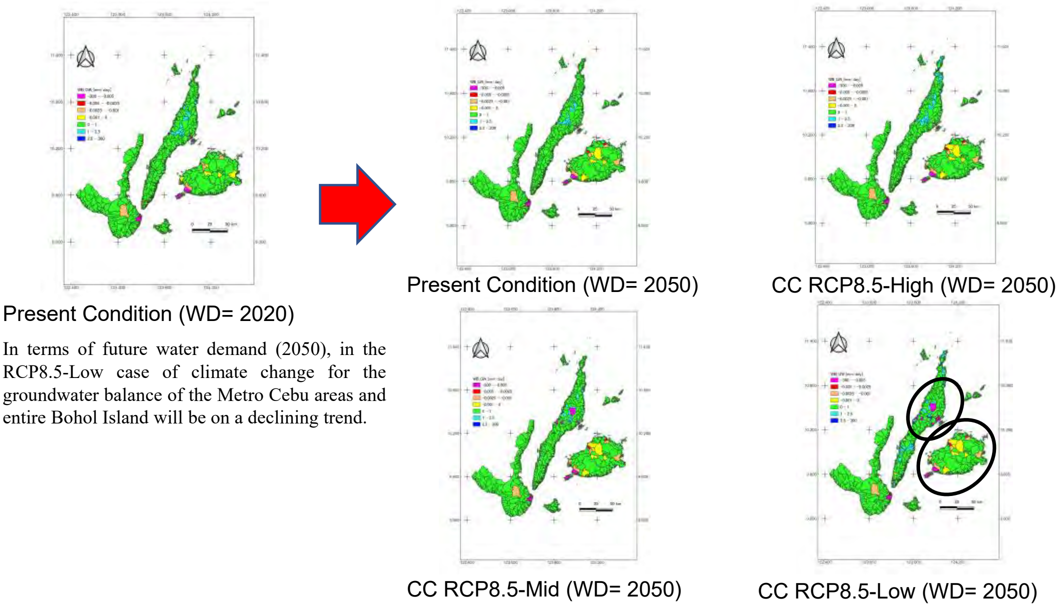
Source: JICA Survey Team

Figure 3.3.7-1 Estimated Sub-Basin-wise Surface Water Balance in WRR VII

(2) Sub-basin-wise Groundwater Balance

Sub-basin-wise groundwater balance at present condition, future (2050) and climate change condition are shown in Figure 3.3.7-2.

In terms of future water demand (2050), in the RCP8.5-Low case of climate change, the groundwater balance of the Metro Cebu areas will be on a declining trend. In terms of future water demand (2050), in the RCP8.5-High case of climate change, the groundwater balance of the entire Bohol Island will be on a declining trend.



Source: JICA Survey Team

Figure 3.3.7-2 Estimated Sub-Basin-wise Groundwater Balance in WRR VII

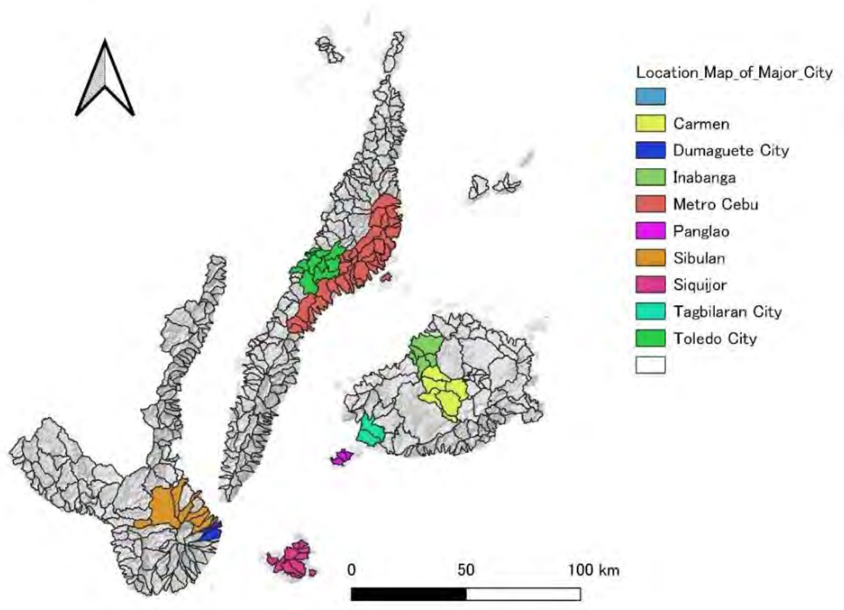
(3) Provincial-wise Water Balance

Provincial-wise surface and groundwater balance in 1/5-dry year at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. The water balance of groundwater in Cebu, Bohol and Siquijor provinces in 2050 will be negative in the future.

The summary of water balance and deficit estimation of provincial-wise surface and groundwater balance at each climate change condition and water demand of 2020 and 2050 are shown in Annex-D: Hydrology. In Cebu Island, Bohol Island and Siquijor Island, negative values of annual water and deficit of groundwater will increase in the future.

(4) Major City/Town-wise Water Balance

Location map of major cities in WRR VII is shown in Figure 3.3.7-3.



Source: JICA Survey Team

Figure 3.3.7-3 Location Map of Major Cities in WRR VII

The surface and groundwater balances in 1/5-dry year in the major cities at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. In most cities, the groundwater balance is projected to be negative against the water demand in 2050, and the negative groundwater balance is particularly large in the Metro Cebu area. All cities will have surplus of surface water (SW) balance in the future. However, these annual SW potentials are included in the flood discharge. Thus, SW reservoirs might be needed.

The summary of water balance and deficit estimation of surface and groundwater balance at each climate change condition and water demand of 2020 and 2050 in Metro Cebu areas are shown in Table 3.3.7-1. In Metro Cebu, negative values of annual water and deficit of groundwater will be increase in the future.

Table 3.3.7-1 Summary of Annual Water Balance and Deficit of Metro Cebu at Each Climate Change Condition

Total Area [km^2]= 829.3

Case No.	Weather Condition	Water Demand	Target Year	SW.Balance [MCM/year]	GW.Balance [MCM/year]	Total W.Balance [MCM/year]	SW.Deficit [MCM/year]	GW.Deficit [MCM/year]	Total W.Deficit [MCM/year]
1	Present	2020	Average Year	562.2	-331.4	230.8	0.0	-331.4	-331.4
2	Present	2020	1/5-Dry Year	282.0	-352.3	-70.4	0.0	-352.3	-352.3
3	Present	2020	1/10-Dry Year	88.0	-378.7	-290.6	0.0	-378.7	-378.7
4	Present	2050	Average Year	550.4	-448.4	101.9	0.0	-448.4	-448.4
5	Present	2050	1/5-Dry Year	270.1	-469.3	-199.2	0.0	-469.3	-469.3
6	Present	2050	1/10-Dry Year	76.2	-495.7	-419.5	0.0	-495.7	-495.7
7	CC RCP8.5-High	2050	Average Year	637.0	-445.6	191.4	0.0	-445.6	-445.6
8	CC RCP8.5-High	2050	1/5-Dry Year	286.7	-468.4	-181.7	0.0	-468.4	-468.4
9	CC RCP8.5-High	2050	1/10-Dry Year	77.6	-495.2	-417.6	0.0	-495.2	-495.2
10	CC RCP8.5-Mid.	2050	Average Year	468.2	-460.3	7.9	0.0	-460.3	-460.3
11	CC RCP8.5-Mid.	2050	1/5-Dry Year	183.5	-487.3	-303.9	0.0	-487.3	-487.3
12	CC RCP8.5-Mid.	2050	1/10-Dry Year	43.1	-512.7	-469.6	-0.1	-512.7	-512.8
13	CC RCP8.5-Low	2050	Average Year	477.6	-496.4	-18.9	0.0	-496.4	-496.4
14	CC RCP8.5-Low	2050	1/5-Dry Year	602.8	-517.4	85.4	0.0	-517.4	-517.4
15	CC RCP8.5-Low	2050	1/10-Dry Year	99.4	-538.2	-438.8	0.0	-538.2	-538.2

Source: JICA Survey Team

The summary of water balance of major cities in WRR-VII at water demand of 2050 are shown in Table 3.3.7-2 below. Annual surface water balance in all cities will be positive, however in dry season, it will be tight in some months. Looking at the groundwater balance forecast for the present weather condition in 2050, all cities have negative groundwater balances, especially in Metro Cebu, Tagbilaran, Dumaguete, Panglao and Toledo.

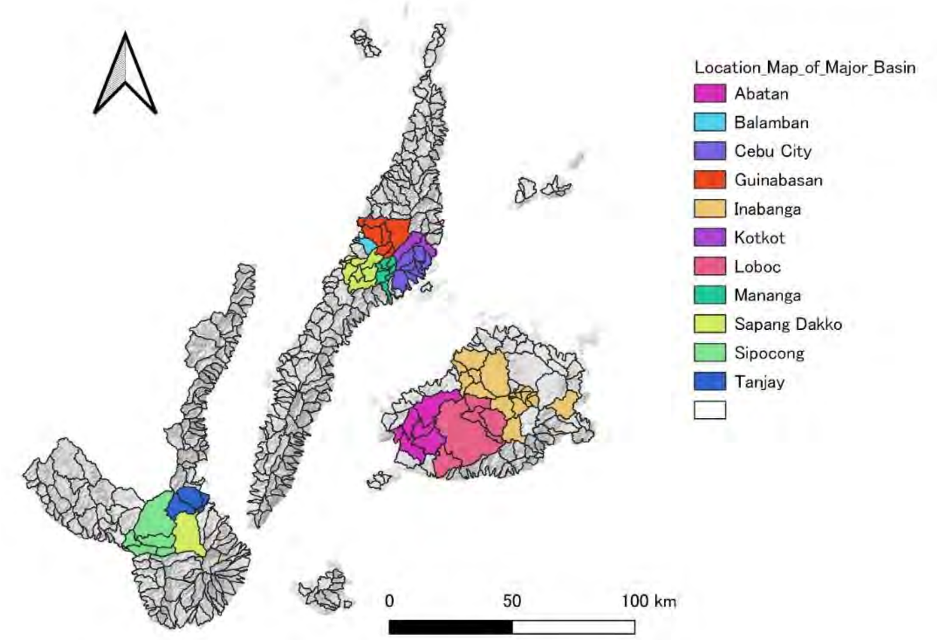
Table 3.3.7-2 Summary of Annual Water Balance of Major Cities in WRR-VII in 2050

City	Weather Condition	Water Demand	Target Year	Total Area [km2]	SW/GW	W.Potential [MCM/year]	Domestic & Industrial W.Demand [MCM/year]	Irrigation W. Demand [MCM/year]	Livestock W. Demand [MCM/year]	Other W. Demand [MCM/year]	Water Balance [MCM/year]
Metro Cebu	Present	2050	1/5-Dry Year	829	SW	352.9	54.1	28.6	0.1	0.0	270.1
					GW	187.6	436.6	14.9	0.3	205.0	-469.3
					Total	540.5	490.8	43.5	0.4	205.0	-199.2
Toledo	Present	2050	1/5-Dry Year	272	SW	130.1	3.5	10.2	0.0	0.0	116.3
					GW	61.9	28.7	1.2	0.0	41.1	-9.0
					Total	192.0	32.2	11.4	0.0	41.1	107.3
Tagbilaran	Present	2050	1/5-Dry Year	105	SW	27.0	3.8	0.3	0.0	0.0	22.8
					GW	0.1	18.7	0.0	0.0	0.1	-18.7
					Total	27.0	22.5	0.3	0.0	0.1	4.1
Panglao	Present	2050	1/5-Dry Year	32	SW	4.5	0.0	0.0	0.0	0.0	4.5
					GW	0.0	11.0	0.0	0.0	0.4	-11.4
					Total	4.5	11.0	0.0	0.0	0.4	-6.9
Carmen	Present	2050	1/5-Dry Year	299	SW	204.0	1.2	9.2	0.5	0.0	193.1
					GW	0.4	3.4	0.0	0.3	0.0	-3.2
					Total	204.4	4.6	9.2	0.7	0.0	189.9
Inabanga	Present	2050	1/5-Dry Year	171	SW	127.4	0.6	1.2	0.0	0.0	125.6
					GW	0.1	4.2	0.0	0.0	0.0	-4.1
					Total	127.5	4.8	1.2	0.0	0.0	121.5
Dumaguete	Present	2050	1/5-Dry Year	52	SW	21.5	5.1	0.6	0.0	0.0	15.9
					GW	0.1	11.8	0.0	0.0	0.3	-12.1
					Total	21.6	16.9	0.6	0.0	0.3	3.8
Sibulan	Present	2050	1/5-Dry Year	360	SW	271.1	3.9	11.9	0.0	0.0	255.2
					GW	7.6	8.3	0.0	0.0	0.0	-0.7
					Total	278.7	12.2	11.9	0.0	0.0	254.5
Siquijor	Present	2050	1/5-Dry Year	163	SW	98.7	9.8	13.4	0.7	0.0	74.9
					GW	3.1	5.4	0.0	0.0	0.0	-2.2
					Total	101.9	15.1	13.4	0.7	0.0	72.7

Source: JICA Survey Team

(5) Major River Basin-wise Water Balance

The location map of the major river basins in WRR VII is shown in Figure 3.3.7-4.



Source: JICA Survey Team

Figure 3.3.7-4 Location Map of Major River Basins in WRR VII

The surface and groundwater balances in 1/5-dry year in the major river basins at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. The Mananga river basin near Cebu city area will have negative groundwater balance in 2050.

The summary of water balance and deficit estimation of surface and groundwater balance at each climate change condition and water demand of 2020 and 2050 in the Mananga river basin areas are shown in Table 3.3.7-3. In the Mananga river basin, negative values of annual water and deficit of both of surface water and groundwater will increase in the future.

Table 3.3.7-3 Summary of Annual Water Balance and Deficit of Mananga River Basin at Each Climate Change Condition

Total Area [km^2]= 85.2

Case No.	Weather Condition	Water Demand	Target Year	SW.Balance [MCM/year]	GW.Balance [MCM/year]	Total W.Balance [MCM/year]	SW.Deficit [MCM/year]	GW.Deficit [MCM/year]	Total W.Deficit [MCM/year]
1	Present	2020	Average Year	27.4	-25.0	2.4	0.0	-25.0	-25.0
2	Present	2020	1/5-Dry Year	12.6	-32.7	-20.1	0.0	-32.7	-32.7
3	Present	2020	1/10-Dry Year	1.6	-39.9	-38.3	-2.5	-39.9	-42.4
4	Present	2050	Average Year	25.2	-38.3	-13.1	0.0	-38.3	-38.3
5	Present	2050	1/5-Dry Year	10.4	-46.0	-35.6	-0.1	-46.0	-46.1
6	Present	2050	1/10-Dry Year	-0.6	-53.2	-53.9	-3.9	-53.2	-57.2
7	CC RCP8.5-High	2050	Average Year	31.2	-37.2	-6.0	0.0	-37.2	-37.2
8	CC RCP8.5-High	2050	1/5-Dry Year	10.9	-45.7	-34.8	-0.1	-45.7	-45.7
9	CC RCP8.5-High	2050	1/10-Dry Year	-0.6	-52.9	-53.5	-4.0	-52.9	-56.9
10	CC RCP8.5-Mid.	2050	Average Year	17.0	-42.5	-25.5	0.0	-42.5	-42.5
11	CC RCP8.5-Mid.	2050	1/5-Dry Year	4.0	-51.4	-47.3	-1.6	-51.4	-53.0
12	CC RCP8.5-Mid.	2050	1/10-Dry Year	-5.0	-57.3	-62.3	-6.5	-57.3	-63.8
13	CC RCP8.5-Low	2050	Average Year	80.6	-48.4	32.2	0.0	-48.4	-48.4
14	CC RCP8.5-Low	2050	1/5-Dry Year	23.9	-53.8	-29.9	0.0	-53.8	-53.8
15	CC RCP8.5-Low	2050	1/10-Dry Year	-0.0	-58.5	-58.5	-3.6	-58.5	-62.1

Source: JICA Survey Team

3.3.8 Conclusion of Water Balance Analysis in Priority Water Resources Region (1) (WRR VII)

As described above, in the Metro Cebu area, negative values of annual water and groundwater will increase in the future. As shown in Table 3.3.7-2 above, annual surface water balance in all cities will be positive, however in dry season, it will be negative in some of month (see Annex-D). Looking at the groundwater balance forecast for the present weather condition in 2050, all cities have negative groundwater balances, especially in Metro Cebu, Tagbilaran, Dumaguete, Panglao and Toledo.

Table 3.3.8-1 below shows the summary of water balance analysis in WRR VII. Looking at the water balance by province and by major river basin, the groundwater balance in 2050 in many of provinces will be negative. The deficit of groundwater balance in Cebu, Siquijor and Bohol provinces are large, and the negative of groundwater balance in the Mananga River Basin in Cebu province will be large in 2050. In Siquijor province, surface water balance will also be negative in 2050.

Table 3.3.8-1 Surface and Groundwater Balance in WRR VII
(1/5-Dry Year, Present Weather Condition, Water Demand=2050)

Surface Water (2050, Present Weather Condition, 1/5-Dry Year)

Item	Classification	Modeled Area	Annual Rainfall	Annual Effective Rainfall**	Annual Evapo-transpiration	Annual Runoff	Annual Runoff (*SW Potential)	Runoff Coefficient	Water Demand (SW)	Water Balance (SW)
		(km^2)	(mm/year)	(mm/year)	(mm/year)	(mm/year)	(MCM/yr)	(%)	(MCM/yr)	(MCM/yr)
Province	Cebu	3,743	1,480	333	815	447	1,672	30.2%	273.6	1,398.8
	Bohol	3,402	1,616	627	770	842	2,865	52.1%	192.9	2,672.1
	East Negros Oriental	3,541	1,692	678	750	910	3,223	53.8%	236.6	2,986.2
	Siquijor	163	1,244	451	614	605	99	48.6%	161.7	-62.9
	Total / Average	10,848	1,508	522	738	701	7,859	46.5%	864.8	6,994.1
Major City	Matro Cebu	829	1,420	317	701	425	353	30.0%	82.8	270.1
Major River Basin	Mananga	85	1,443	253	657	340	29	23.6%	18.6	10.4
	Kotkot	84	1,435	403	718	541	45	37.7%	6.7	38.8
	Inabanga (Bohol)	690	1,674	580	895	779	1,028	46.5%	159.6	868.9

** Effective Rainfall = Runooff * 74.5%

Groundwater (2050, Present Weather Condition, 1/5-Dry Year)

Item	Classification	Modeled Area	Annual Recharge	Annual Recharge	GW Potential*	GW Potential*	Water Demand (GW)	Water Balance (GW)
		(km^2)	(mm/year)	(MCM/yr)	(mm/year)	(MCM/yr)	(MCM/yr)	(MCM/yr)
Province	Cebu	3,743	217.6	814.4	167.4	626.5	844.4	-217.9
	Bohol	3,402	3.2	10.8	2.5	8.3	129.4	-121.0
	East Negros Oriental	3,541	31.7	112.4	24.4	86.5	86.0	0.5
	Siquijor	163	25.0	4.1	19.3	3.1	29.7	-26.5
	Total / Average	10,848	69.4	941.8	53.4	724.4	1,089.4	-364.9
Major City	Matro Cebu	829	294.1	243.9	226.2	187.6	656.9	-469.3
Major River Basin	Mananga	85	445.8	38.0	342.9	29.2	75.2	-46.0
	Kotkot	84	176.1	14.8	135.4	11.4	36.8	-25.4
	Inabanga (Bohol)	690	0.8	0.5	0.6	0.4	10.4	-10.0

*Stable amount of water that can be taken

Source: JICA Survey Team

3.4 Priority Water Resources Region (WRR XI)

3.4 Priority Water Resources Region (WRR XI)

3.4.1 Outline of WRR XI

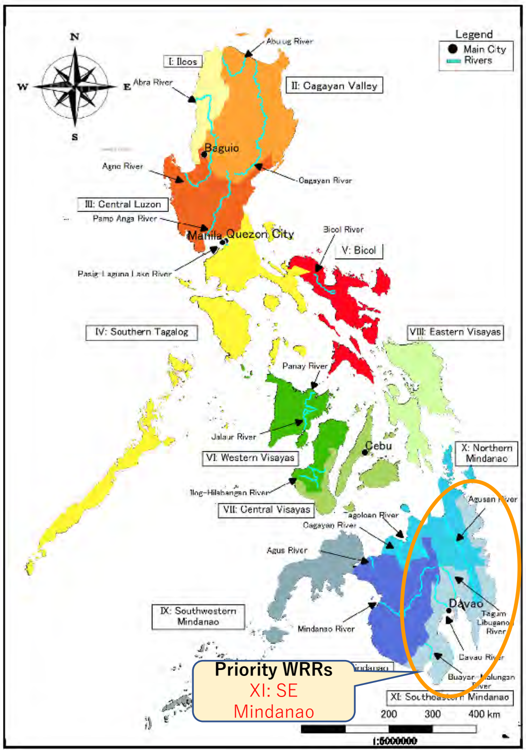
WRR XI is located in South-eastern Mindanao. The administrative region is centered on Region XI, includes parts of Region X in the north, XIII in the northeast, and XII in the southeast. The provincial division consists of 6 Provinces.

In terms of water resources, there are three major river basins, and major cities include Davao City, Tagum City, and General Santos City. The climate is classified into Type III and IV. From the perspective of water resources, water shortages due to growing water demand in major cities, drainage problems in irrigation development, and dam sedimentation problems have become issues.

Table 3.4.1-1 General Information of WRR XI

Water Resources Regions	Major 18 Rivers (Catchment Area)	Major Cities	Climate Classification	Island Name
WRR XI Southeastern Mindanao	Tagum-Libuganon (3,064 km^2) Davao (1,623 km^2) Buayan Margun (1,435 km^2)	Davao City Tagum City General Santos City	Type-III & IV	Mindanao

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.4.1-1 Location Map of Priority WRR (WRR XI)

3.4.2 Socio-Economic Situation and Organization and Legal Framework in the WRR XI

3.4.2.1 Socio-Economic Situation

As described in Section 3.2.1.

3.4.2.2 Organization and Legal Framework in the WRR XI

In this section, the outline of the organizations related to water resources in WRR XI is summarized and the organizations that the JST visited during the site survey are introduced; sorted into (1) National government organization, (2) LGUs, and (3) WSPs, respectively. WRR XI includes Region XI (Davao Region) as well as Region X (Northern Mindanao), Region XII (Soccsksargen Region), and Region XIII (Caraga Region). However, Region XI is the pillar area of WRR XI from the viewpoint of the area occupied, population, industrial agglomeration, urbanization, etc.; thus, JST visited organizations mainly from those within Region XI.

(1) Organizations

1) National Government Organizations

As stated in Section 3.2.2.2. (1) 1), most of the national government organizations provide their regional branch offices, which have jurisdiction over the services of the national government and oversee LGUs. Organizations related to the planning and implementation of water resources projects in WRR XI, which the JST visited, are described below.

- NEDA Region XI

  NEDA Region XI, located in Davao City, shall monitor regional and inter-regional development policies, plans and programs; prepare integrated reports on regional planning; conduct studies on regional development policies; and perform such other planning tasks as may be assigned by the Director-General in its region (Sec.14, Title II, Book V, Administrative Code of 1987). Also, it serves as the secretariat of the Regional Development Council Region XI, which is deeply involved in the preparation of the Regional Development Plan and other investment programs.

- DPWH Region XI

  DPWH Region XI, located in Davao City, shall be responsible for highways, flood control and water resources development systems, and other public works with its region (Sec.20, Title V, Administrative Code of 1987). It also provides some engineering offices within its region for implementing construction works or other duties.

- NIA Region XI

  NIA Region XI, located in Davao City, is composed of four irrigation management offices. Its objective is to develop and maintain irrigation systems in support of the agricultural program of the government; to provide an adequate level of irrigation service on a sustainable basis in partnership with the farmers and local government units; to provide technical assistance to institutions in the development of water resources for irrigation; and to improve and sustain the operation of NIA as a viable corporation and service-oriented agency.

2) LGUs

According to the website of PhilAtlas, Region XI, which occupies most of the area of WRR XI, has five provinces (Davao de Oro, Davao del Sur, Davao del Norte, Davao Occidental, and Davao Oriental), six cities including one highly urbanized city (Davao City), and 43 municipalities. The JST has not visited the LGUs within WRR XI.

3) WSPs

According to the Davao Region Water Supply and Sanitation Databook and Regional Roadmap in the PWSSMP, the overview of the WSPs within the Region XI is as follows;

- As of 2015, of the 25 WDs serving Davao Region, 19 were operational and 6 were non-operational.
- There are 138 LGU-run water utilities within the region.
- There are 18 BWSAs within the region.
- There are 4 RWSA utilities within the region.
- There are 140 private or other types of water service providers within the region.

The WSPs that the JST visited are as follows. The information on water districts is obtained from the interview session with each WSP as well as the annual audit report of 2021 prepared by the Commission of Audit (COA).

- Davao City Water District (MCWD)

  DCWD, created in 1973, is the water district providing water to Davao City. It is categorized as a “Category A” water district. Meanwhile, DCWD has implemented the Davao City Bulk Water Supply Project in partnership with the Apo Agua Infrastractura Inc., which sourced surface water from the Tamugan River.

- Tagum Water District (TWD)

  TWD, created in June 1980, is the water district providing water to the city of Tagum, in the province of Davao del Norte. It is categorized as a “Category A” water district.

Meanwhile, TWD formed a joint venture company, the Tagum Water Company Incorporated (TWCI), with the Davao del Norte Water Infrastructure Company, Inc. in November 2015 to implement the Tagum Water District Bulk Water Supply Project.

- General Santos Water District (GSCWD)

  GSCWD, created in August 1987, is the water district providing water to the city of General Santos in the province of South Cotabato in Region XIII. It has 201 permanent employees, 37 casual, and 22 job order. It is also categorized as a "Category A" water district.

The categorization of water districts (Category A, B, C and D) is explained in Annex C-5.

(2) Plans

The following items are the representative regional plans related to water resources in the WRR XI:

- Regional Development Plan of Region XI 2017-2022

  This is the mid-term development plan between 2017 and 2022 prepared for Region XI. The items related to water resources are described in "Chapter 19 Accelerating Infrastructure Development".

- Davao Region Water Supply and Sanitation Databook and Regional Roadmap

  The Water Supply and Sanitation Databook and Regional Roadmap is an attached document to the PWSSMP. It supplements the PWSSMP with maps, datasets, and charts, and presents the framework, vision, goals, and strategies formulated to achieve the planned targets in Region XI.

- Davao River Basin Management and Development Master Plan

  This is the basic management plan for Davao River, which is one of the 18 major river basins in the Philippines.

In addition, plans related to flood control at regional level are summarized in Table 2.2-20 of the Section 2.2.11.

3.4.3 Natural Condition in WRR XI

3.4.3.1 Land Area, General Topography and Geology in WRR XI

(1) Land Area

WRR XI is in Southeastern Mindanao and consists of Region XIII (Caraga), Region XI (Davao Region), Region X (Northern Mindanao), and Region XII (Soccsksargen) from the north. Metro Davao and Metro General Santos are highly urbanized cities.

The regional center and largest city is Davao City. The land areas of Region XIII, Region XI, and Region XII are 21,478.35 km^2, 20,433.38 km^2, and 22,513.30 km^2, respectively, and the populations based on the 2020 census of each administrative region were 2,804,788; 5,243,536; and 4,360,974, respectively.

(2) General Topography and Geology

Region XIII (Caraga) is characterized by mountainous areas and flat and rolling lands. Mountain ranges divide Agusan and Surigao provinces and sub-ranges separate most of the lowlands along the Pacific coast. In the broader physiographic framework of the Philippine archipelago, Caraga Region occupies the northernmost portion of the Eastern Mindanao Ridge or Mindanao Pacific Cordillera, a more than 400 km NNW-SSE trending orogenic belt comprising eastern Mindanao. The Mindanao Pacific Cordillera is bounded by two major structures that played a key role in the neotectonic evolution of the Philippine Mobile Belt, namely the Philippine Trench and the Philippine Fault Zone.

The topography of Region XI (Davao Region) is dominated by peninsular and island topography characterized by extensive mountain ranges extending along the western border, in the northern central area and the northwestern area leading to the peninsula in the southeast with uneven distribution of plateaus and lowlands. It has a coastline of 1,600 km^2. To the west of Davao City is Mt. Apo (altitude 2,954 m), the highest volcano in the Philippines. Despite Davao Region’s location in the Asian portion of the Pacific Ring of Fire, the region has suffered few earthquakes, and most have been minor. Mt. Apo, 40 kilometers (25 mi) southwest of Davao City proper, is a dormant volcano.

Region XII (Soccsksargen) is bounded on the east by Davao Region, and on the southwest by the Celebes Sea. The region has extensive coastlines, valleys, and mountain ranges. Known for its river system, the region is the drainage basin of Mindanao, particularly the Cotabato Basin, a large depression surrounded by mountain ranges on three sides. Within the basin runs the Rio Grande de Mindanao, the longest river in Mindanao and the second longest in the Philippines. The river empties into the Illana Bay of the larger Moro Gulf at the west of Cotabato City. At the south of the basin lies the Tiruray Highlands, a moderately high mountain range blocking the basin from the southern coastline. Southeast of the mountains lies Sarangani Bay.

3.4.3.2 Meteorology and Hydrology in WRR XI

(1) Climate and Climate Regions of the Study Area

In this study, satellite rainfall data (CHIRPS) and re-analysis rainfall data (ERA5) were used due to the low density of observed rainfall stations within the priority WRR. There are four climatological types that exist in the Philippines characterized as shown in Figure 3.4.3-1.

Source: PAGASA (http://bagong.pagasa.dost.gov.ph/information/climate-philippines)

Figure 3.4.3-1 Climate Regions in Philippines

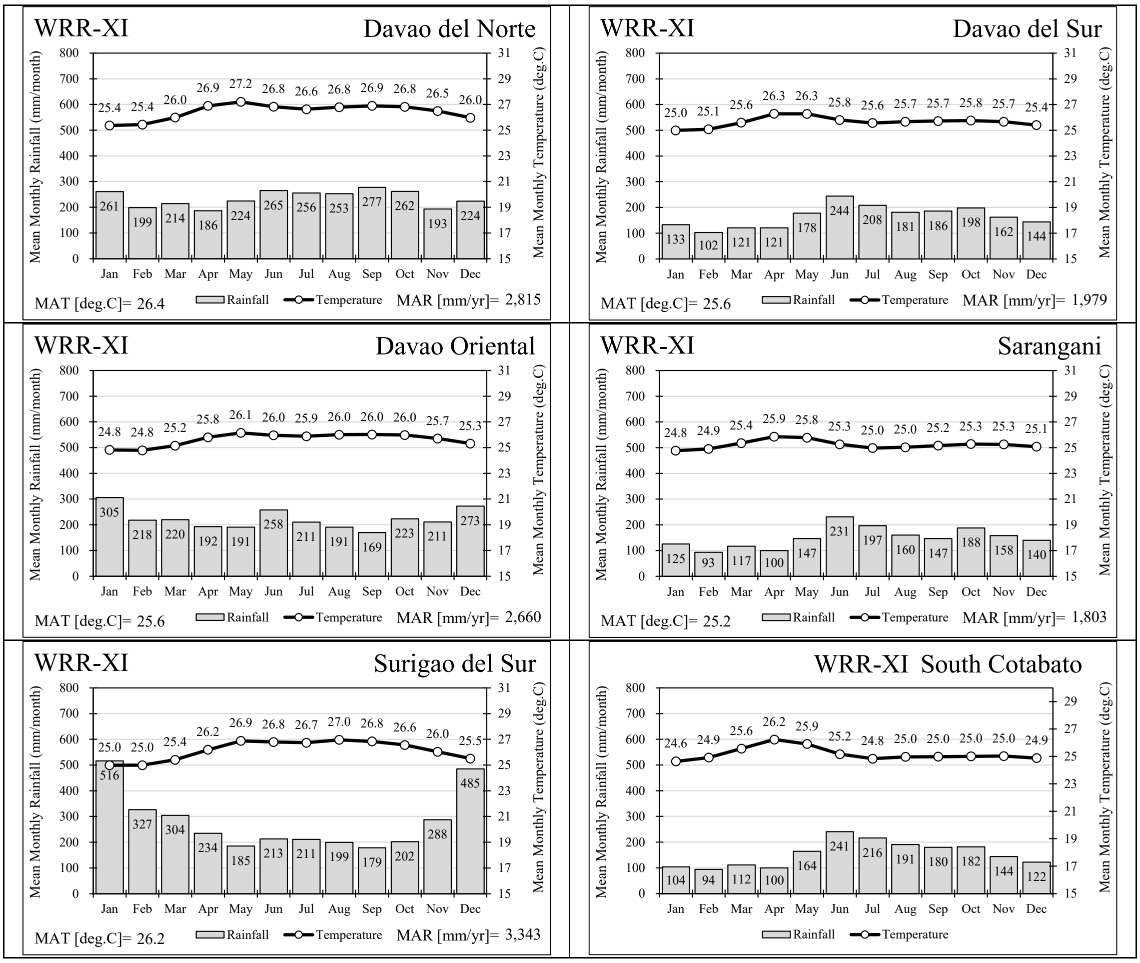
Most of WRR XI are in the climate Type-VI, in which rainfall is more or less evenly distributed throughout the year. This climate type resembles the second type more closely since it has no dry season.

(2) Temperature and Rainfall

The average annual temperature in Davao del Sur is around 25.6 °C. The temperature is stable throughout the year, but the highest temperature is around April to May. Davao del

Sur Province was selected as the representative of WRR-XI because the area occupied by Davao del Sur Province was the largest (22.8%) in WRR-XI.

Daily mean temperatures from 1979 to 2020 of ERA5 (0.25-degree grid; approximately 31 km mesh) were collected from the ECMWF reanalysis datasets. Provincial mean monthly rainfall and mean monthly temperature from 1979 to 2020 (42 years) in each WRR are shown in Figure 3.4.3-2.

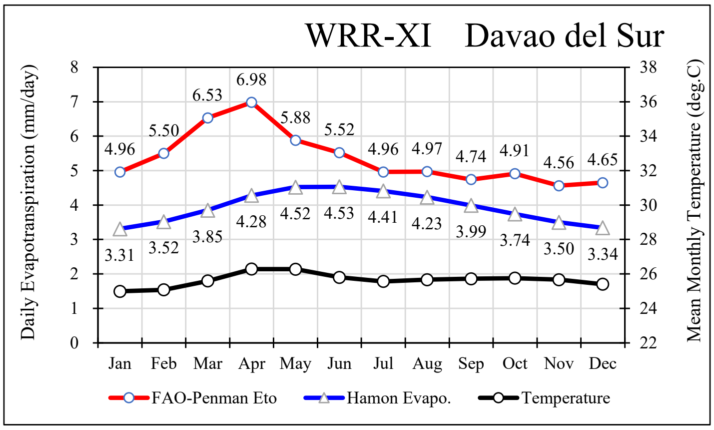


Source: JICA Survey Team, based on ERA5 and CHIRPS data.

Figure 3.4.3-2 Provincial Mean Monthly Rainfall and Mean Monthly Temperature from 1979 to 2020 (42 Years) in Each Province in WRR-XI

(3) Evapotranspiration

The estimated daily evapotranspiration by FAO-ETo and Hamon methods, averaged by province, are shown in the Figure 3.4.3-3.



Source: JICA Survey Team, based on ERA5 and FAO-ClimWat data.

Figure 3.4.3-3 Estimated Daily Potential Evapotranspiration of FAO-ETo and Hamon Method

(4) Precipitation/Weather Data

In this study, satellite rainfall data (CHIRPS) and re-analysis rainfall data (ERA5) were used due to the low density of observed rainfall stations within the priority WRR.

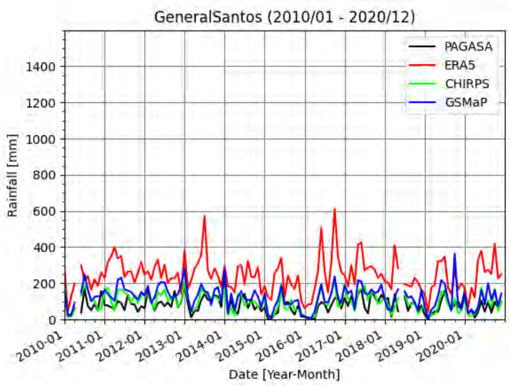
As described in Section 3.3.3(4), the same dataset and methodology is applied for the preparation of the precipitation and weather data in WRR XI. In WRR-XI, datasets at the three PAGASA stations, namely: GENERAL SANTOS, HINATUAN, and DAVAO, are available. Figure 3.4.3-4 shows the locations of the stations. In the comparison of CHIRPS precipitation with PAGASA station's precipitation, since the result for GENERAL SANTOS was the most consistent among the three regions, the results for GENERAL SANTOS are discussed in this section. Annual trends of the monthly precipitation and the biases from the average are shown in Figure 3.4.3-5. Inter-annual trends of each precipitation dataset are almost the same among the three datasets except for an overestimation totally in the ERA5 trend. The CHIRPS's cumulative precipitation amount compared to PAGASA's rain gauge shows a 20.3% of overestimation.

Although there is some bias in the CHIRPS and PAGASA observation data, the CHIRPS is applied for the hydrological analysis without correction in this study considering the limited number of the PAGASA stations.

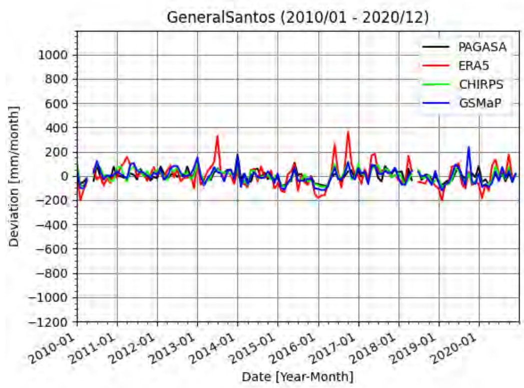
Source: JICA Survey Team

Figure 3.4.3-4 Location at Station in WRR XI

(a)



(b)



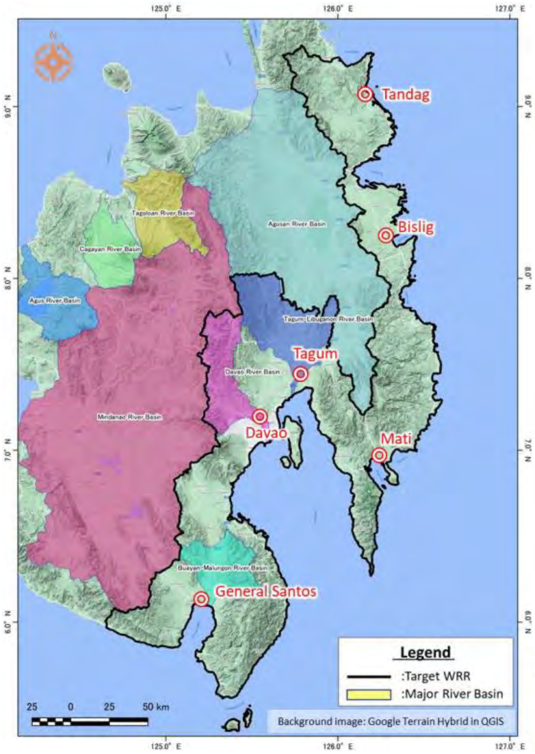
Source: JICA Survey Team

Figure 3.4.3-5 Annual Trends of the Precipitation at GENERAL SANTOS

3.4.3.3 River and Water Resources

(1) River

Out of the 18 major river basins, there are 3 major river basins, i.e. the Tagum-Libuganon River basin, the Davao River basin and the Buayan-Malungon River basin are in WRR XI. There are also several principal river basins as shown in Figure 3.4.3-6.



Source: National Water Resources Council (1976) "Principal River Basins of the Philippines"

Figure 3.4.3-6 Location Map of Major Rivers and Principal Rivers in WRR XI

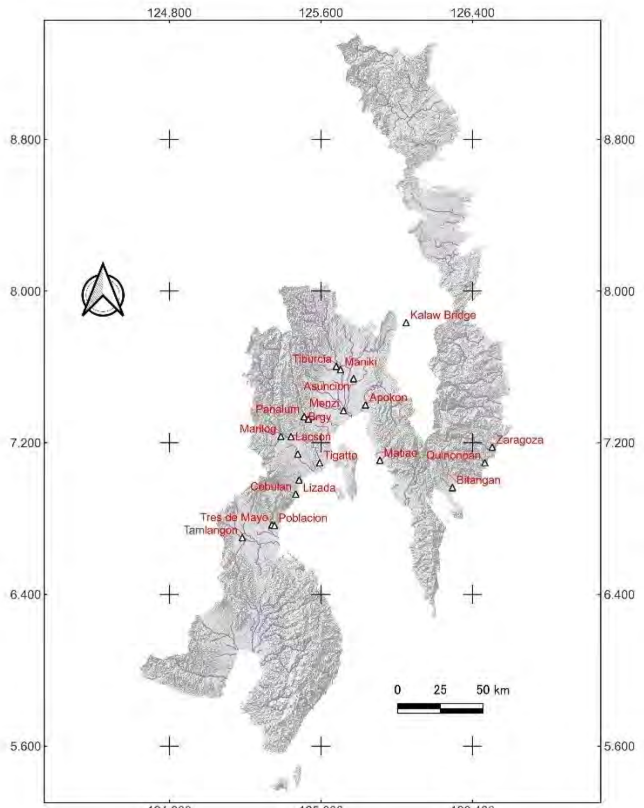
(2) Streamflow Data

Streamflow data were gathered for many of the stations within the survey area. Streamflow records were obtained from DPWH. A total of 25 daily average discharge data as shown in the Figure 3.4.3-7 and Table 3.4.3-1 were collected and used for the low flow analysis of WRR XI.

Table 3.4.3-1 Number of Discharge Observation Stations by WRRs

N	N	Station	River	Basin	Agenc	WR	Province	Town, Village	Latitud	Longitu	Elevati	C.A.(km	Period
218	1	Marilog	Tamugan	Davao	DPWH	XI	Dava del Sur	Marilog, Davao City	7.2333	125.3886	11.6	110.0	2000-2016
175	2	Apokon	Hijo	Hijo	DPWH	XI	Davao del Norte	Apokon, Tagum City	7.3990	125.8350	10.3	634.0	1986-2011, 2013, 2015-16
181	3	Menzi	Tuganay	Tuganay	DPWH	XI	Davao del Norte	Menzi, Sto. Tomas	7.3690	125.7190	12.1	569.0	1985-92, 2001-17
213	4	Kalaw Bridge	Agusan	Agusan	DPWH	XI	Davao del Norte	Kalaw Bridge, Monkayo	7.8333	126.0500		1,355.0	1979-2016
215	5	Tiburcia	Kipaliko	Kipaliko	DPWH	XI	Davao del Norte	Tiburcia, Kapalong	7.6025	125.6808	12.4	147.0	1986-2016
216	6	Maniki	Libuganon	Libuganon	DPWH	XI	Davao del Norte	Maniki, Kapalong	7.5856	125.7033	8.2	1,111.0	2000-2018
217	7	Asuncion	Saug	Saug	DPWH	XI	Davao del Norte	Asuncion	7.5380	125.7720	10.0	779.0	2001-2013
104	8	Lacson	Davao	Davao	DPWH	XI	Davao Del Sur		7.2314	125.4422	10.5	1,469.0	2001-2009
105	9	Tigatto	Davao	Davao	DPWH	XI	Davao Del Sur		7.0939	125.5931	20.0	1,683.0	1984-1999
106	10	Brgy	Lasang	Lasang	DPWH	XI	Davao Del Sur		7.3367	125.5117	15.7	344.0	2002-2010
107	11	Mabuhay	Lasang	Lasang	DPWH	XI	Davao Del Sur		7.3244	125.5339	17.2	354.0	1985-1989
108	12	Angalan II	Talomo	Talomo	DPWH	XI	Davao Del Sur		7.1403	125.4778	13.2	165.0	1986-2010
109	13	Barangay	Lipadas	Lipadas	DPWH	XI	Davao Del Sur		7.0033	125.4844	10.0	149.0	1986-201
170	14	Tamlangon	Balatukan	Balatukan	DPWH	XI	Davao del Sur	Tamlangon, Matanao	6.6990	125.1850	13.8	393.0	1984-2016
172	15	Cebulan	Cebulan	Cebulan	DPWH	XI	Davao del Sur	Cebulan, Sta. Cruz	6.9290	125.4670	18.7	171.0	1986-2016
173	16	Tres de Mayo	Digos	Davao	DPWH	XI	Davao del Sur	Tres de Mayo, Digos	6.7660	125.3410	6.2	131.0	1991-93, 1998-2004, 2008-16
174	17	Poblacion	Digos	Digos	DPWH	XI	Davao del Sur	Poblacion, Digos	6.7630	125.3550	18.1	134.0	1986-1990
176	18	Panalum	Lasang		DPWH	XI	Davao del Sur	Panalum, Paguibato, Davao	7.3370	125.5120		344.0	2010-2018
177	19	Lizada	Lipadas	Lipadas	DPWH	XI	Davao del Sur	Lizada, Toril, Davao City	7.0030	125.4840	2.6	149.0	1986-2005, 2007-18
180	20	Los Amigos	Talomo	Talomo	DPWH	XI	Davao del Sur	Los Amigos, Tugbok, Davao	7.1400	125.4780	13.2	165.0	1986-2017
214	21	Tigatto	Davao	Davao	DPWH	XI	Davao del Sur	Tigatto, Davao City	7.0939	125.5931	-9.7	1,683.0	1984-2011
171	22	Zaragoza	Casauman	Casauman	DPWH	XI	Davao Oriental	Zaragoza, Manay	7.1760	126.5040	-7.6	373.0	1985-1989
178	23	Matiao	Matiao	Matiao	DPWH	XI	Davao Oriental	Matiao, Puntukan	7.1070	125.9110	10.9	167.0	1986-2017
179	24	Quinonoan	Quinonoan	Quinonoan	DPWH	XI	Davao Oriental	Quinonoan, Manay	7.0940	126.4650	14.1	132.0	1986-90, 1994-2003
204	25	Bitangan	Bitanagan	Bitanagan	DPWH	XI	Davao Oriental	Bitangan, Mati	6.9630	126.2940	13.7	84.0	1985-2011

Source: DPWH



Source: JICA Survey Team based on the data of DPWH.

Figure 3.4.3-7 Location Map of Daily Discharge Observation Stations used for Low Flow Analysis (Total 25 Stations)

Unfortunately, these streamflow data were often missing as shown in the figures in Annex-D: Hydrology. In addition, there are limits to the frequency of discharge observations and the accuracy of the water level-discharge rating curves (H-Q curves), as there are many flows in which the value of the flood discharge is questionable. There are many data at observatories where the flow duration curves (FDCs) using the specific discharge are strange as shown in Annex-D: Hydrology. Also, the annual runoff at some stations exceeds the annual rainfall (runoff coefficient is more than 1.0) as shown in Annex-D: Hydrology.

3.4.3.4 Geology, Hydrogeology

The geological map of WRR XI is shown in Figure 3.4.3-8. A hydrogeological overview of the province of: Davao Occidental, Davao Oriental, Davao de Oro, Davao del Norte, and Davao del Sur, are also described separately below.

(1) Davao Occidental

The main aquifer in the province of Davao Occidental is N3+Q1 sedimentary formation and quaternary alluvium deposits It is followed by the sedimentary formation (N1) associated with sequence of pyroclastics, siltstone, sandstone and conglomerate rocks in which groundwater dominantly flows in intergranular way. Most of the upland barangays of the province have abundant groundwater resource through spring sources which were underlain by sedimentary and volcanic rock units and flow either in intergranular, solution cavities and openings, fractures and faults.

(2) Davao Oriental

The main aquifer in the province of Davao Oriental is quaternary alluvium deposits, followed by marine sediments (Kpg) associated with greywacke, siltstone, conglomerates and cherts. The limestone rock unit (N1 Ls and N2) is also a good source of groundwater which occurs in solution openings or cavities.

(3) Davao de Oro

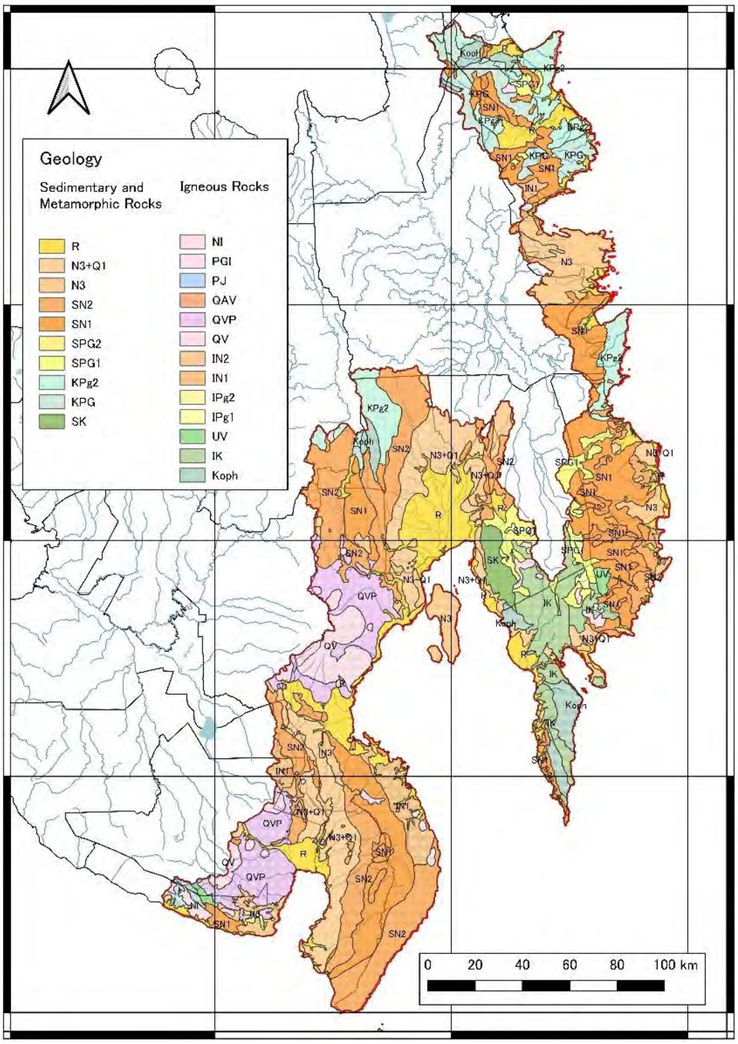
The main aquifer in the province of Davao de Oro is quaternary alluvium deposits. It is followed by marine sediments (N2) associated by well consolidated, compacted and indurated sandstone, shale, conglomerate and calcarenite and silty limestone.

(4) Davao del Norte

The main aquifer of the province of Davao del Norte is being tapped in the quaternary alluvium deposits. It is followed by marine sediments (N3+Q1) associated by well to poorly consolidated sandstone, shale with some sequence of conglomerate and pebbly to conglomerate sandstone. The sedimentary units (N1 and N2) composed of siltstone, sandstone, conglomerate, pyroclastics, and shale where groundwater flow towards grains and fractures are also significant in groundwater source.

(5) Davao del Sur

Aquifer in the province of Davao del Sur is in recent alluvium deposits composed of unconsolidated sand and gravel deposits; pliocene to pleistocene QVP formation composed of volcanic flows and pyroclastic rocks chiefly agglomerate and tuff that underlie the broad slope of the non-active volcanic cone; and pliocene to pleistocene N3+Q1 formation which is composed of well consolidated to poorly consolidated sandstone and shale with some sequence of conglomerate and pebbly to conglomerate sandstone.



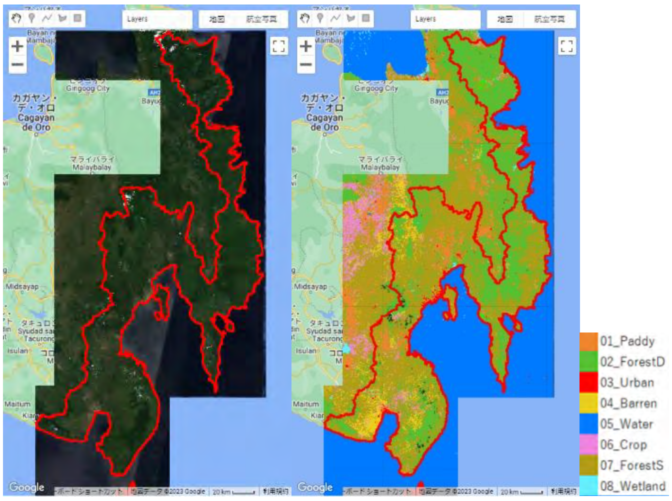
Source: MGB

Figure 3.4.3-8 Geological Map of WRR XI

3.4.3.5 Creation of Land Cover/Land Use Using Satellite Data

(1) 10 m Land cover/land use map creation for WRR XI using Sentinel-2

Land cover/land use map was created for WRR XI using similar procedure as explained in Section 3.3.3(1). The land cover/land use map for the priority water resources region of WRR XI is shown in Figure 3.2.3.4-2.



Note: Left: Sentinel-2 mosaic image, Right: Land cover map

Source: JICA Survey Team

Figure 3.4.3-9 Flow of classification process using satellite data (WRR XI)

3.4.3.6 Current Status of Agricultural Water Use

(1) Irrigation Areas

The irrigation areas covering WRR XI in 2020 are summarized in Table 3.4.3-2.

Table 3.4.3-2 Irrigation Areas of WRR XI in 2020

Province	Area Rate	All Systems				By Surface Water				By Ground Water			
		ISA (ha)	FUSA (ha)	Irrigated Area (ha)		ISA (ha)	FUSA (ha)	Irrigated Area (ha)		ISA (ha)	FUSA (ha)	Irrigated Area (ha)	
				Wet	Dry			Wet	Dry			Wet	Dry
Bukidnon	0.046	1,919	1,536	1,253	1,243	1,919	1,536	1,253	1,243	0	0	0	0
Davao de Oro (Compostela Valley)	0.477	7,082	7,021	5,352	5,352	7,082	7,021	5,352	5,352	0	0	0	0
Davao del Norte	0.989	28,990	27,475	21,499	21,499	28,990	27,475	21,499	21,499	0	0	0	0
Davao del Sur Davao Occidental	0.998	17,439	16,943	13,904	13,765	17,439	16,943	13,904	13,765	0	0	0	0
Davao Oriental	0.949	8,357	8,319	5,812	5,853	8,357	8,319	5,812	5,853	0	0	0	0
Sarangani	0.869	6,145	5,516	4,980	4,638	6,086	5,458	4,922	4,580	58	58	58	58
South Cotabato	0.34	12,266	10,571	9,594	9,479	12,263	10,568	9,591	9,476	3	3	3	3
North Cotabato	0.038	1,725	1,680	1,564	1,557	1,705	1,659	1,547	1,540	21	21	17	17
Sultan Kudarat	0.052	2,035	1,849	1,630	1,333	2,017	1,831	1,612	1,315	18	18	18	18
Agusan del Norte	0.027	471	381	276	275	471	381	276	275	0	0	0	0
Agusan del Sur	0.109	3,105	2,833	1,891	1,829	2,984	2,712	1,876	1,824	121	121	15	5
Surigao del Sur	0.896	14,818	14,253	9,673	8,680	14,764	14,239	9,660	8,680	54	13	13	0
Total		104,352	98,378	77,429	75,502	104,077	98,143	77,304	75,401	275	235	125	102

Source: NIA Inventry Dat modified by JICA Survey Team

(2) Heads of Livestock and Poultry

The heads of livestock and poultry in WRR XI in 2020 are summarized in Table 3.4.3-3.

Table 3.4.3-3 Heads of Livestock & Poultry by Province in WRR XI (2020)

Region	Province	Area Rate	Heads of Livestock & Poultry				
			Carabao	Cattle	Hog	(Sub-total)	Chicken
X	Bukidnon	0.046	2,564	4,059	28,088	34,711	467,357
XI	Davao de Oro (Compostela Valley)	0.477	11,430	3,801	62,023	77,253	509,504
	Davao del Norte	0.989	52,953	48,951	379,080	480,983	7,064,839
	Davao del Sur Davao Occidental	0.998	34,485	51,016	310,849	396,350	1,410,840
	Davao Oriental	0.949	30,191	24,161	110,521	164,874	778,071
XII	Sarangani	0.869	20,943	9,277	57,309	87,528	667,326
	South Cotabato	0.340	14,258	21,362	146,889	182,509	1,930,145
	North Cotabato	0.038	2,611	3,093	8,692	14,396	99,171
	Sultan Kudarat	0.052	3,388	2,036	3,833	9,258	32,261
XIII	Agusan del Norte	0.027	400	290	1,529	2,218	26,406
	Agusan del Sur	0.109	3,289	520	6,498	10,307	79,415
	Surigao del Sur	0.896	16,218	2,465	54,293	72,976	377,839
	Total		192,730	171,030	1,169,604	1,533,364	13,443,173

Source:Philippine Statistics Authority modified by JICA Survey Team

(3) Freshwater Fishpond Areas

The freshwater fishpond areas in WRR XI in 2022 are shown in Table 3.4.3-4.

Table 3.4.3-4 Freshwater Fishpond Areas by Province in WRR XI (2022)

Region	Province	Area Rate	Fishpond Area (ha) in		Water Sources
			Province	WRR	
X	Bukidnon	0.046	No data		
XI	Davao de Oro (Compostela Valley)	0.477	110.47	52.69	NIA Irrigation Canal, Ground water, Spring
	Davao del Norte	0.989	264.02	261.12	(NIA Irrigation Canal, Spring)
	Davao del Sur Davao Occidental	0.998	23.38	23.33	NIA Irrigation Canal, Ground water, Creek
	Davao Oriental	0.949	58.61	55.62	NIA Irrigation Canal, Ground water
XII	Sarangani	0.869	20.69	17.98	NIA Irrigation Canal, Spring
	South Cotabato	0.34	30.92	10.51	River, Ground water, NIA Irrigation Canal
	North Cotabato	0.038	No data		
	Sultan Kudarat	0.052	No data		
XIII	Agusan del Norte	0.027	No data		
	Agusan del Sur	0.109	28.62	3.12	(No Data)
	Surigao del Sur	0.896	69.43	62.21	(No Data)
	Total		**606.14**	**486.59**	

Source: DA-BFAR modified by JICA Survey Team

3.4.3.7 Current Status of Municipal and Industrial Water Use in WRR XI

Basic information for all area was confirmed based on the PWSSMP 2018. In addition, the detailed current status and future plans were confirmed through site surveys in large population cities with huge water demands in WRR XI (Southeastern Mindanao) as shown in Table 3.4.3-5 below.

Table 3.4.3-5 Large Population Cities in WRR XI

WRR	Region		WD	Population (2020)	Note
WRR XI (Southeastern Mindanao)	Region X	Northern Mindanao	-	-	No large city has a significant impact on water demand.
	Region XI	Davao	Davao	1,782,000	The most populous city in WRR XI, listed in HUC.
	Region XII	Soccsksargen	General Santos	700,924	The second largest populous city in WRR XI, listed in HUC.
	Region XIII	Caraga	-	-	Region XIII is mostly out of range of WRR XI.

Source: JICA Survey Team

Current municipal and industrial water demand and existing water supply production in large population cities are shown as Table 3.4.3-6 below.

Table 3.4.3-6 Current Status of Municipal and Industrial Water Use in Large Population Cities

WRR	WRR XI (Southeastern Mindanao)	
WD	**Davao**	**General Santos**
Covered Municipality	Davao City	General Santos City
Total Water Demand (MCM/Year)	**186.7**	**74.7**
Municipal Water Demand (MCM/Year)	145.7	64.9
Industrial Water Demand (MCM/Year)	41.1	9.9
Total Production Capacity (MCM/Year)	**146.7**	**39.0**
Production Source (MCM/Year)	Wells: 80.9 River: 65.8	Wells: 39.0

Source: JICA Survey Team

3.4.3.8 Current Status of Water Use Facilities in WRR XI

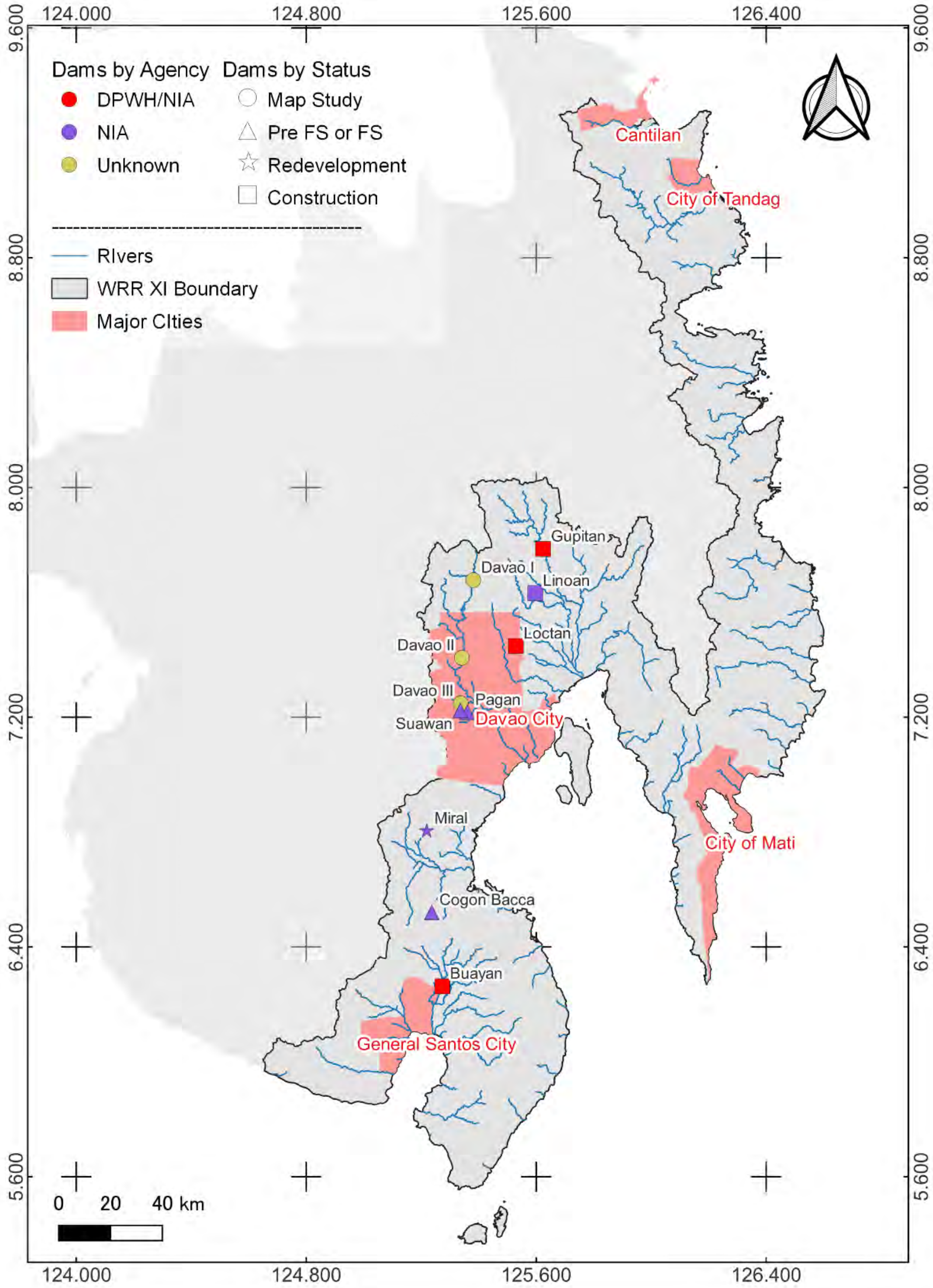
(1) Existing Dams and Dam Construction Plans confirmed before the Field Survey

Table 3.4.3-7 shows the list of existing dams and dam construction plans organized from past reports and information provided from related implementing agencies. In addition, each dam location map is shown in the following Figure 3.4.3-10.

Table 3.4.3-7 List of Existing and Proposed Dams (WRR XI)

Region	Name of Dam	Construction Year /Current Status of Plan	Owner of Dam/ Implementing Agency	Purpose of Dam	Location: Island	Location: River	Dam Specification: Type of Dam	Height	Crest Length	Coordinates: Latitude of Dam Center (° ' "")	Coordinates: Longitude of Dam Center (° ' "")	Data Source
WRR11	Talomo	Existing 1950	NPC	Power	Mindanao	Talomo	-	-	-	-	-	METI(2019)
	Tudaya 1	Existing	NPC	Power	Mindanao	Sibulan	ROR	-	-	-	-	METI(2019)
	Tudaya 2	Existing	NPC	Power	Mindanao	Sibulan	ROR	-	-	-	-	METI(2019)
	Davao I	Map Study	-	Muliti Purpose	Mindanao	Salug	-	-	-	7˚40'36.11" N	125˚22'50.52" E	JICA(1998)
	Davao II	Map Study	-	Muliti Purpose	Mindanao	Davao	-	112	139	7˚24'23.61" N	125˚20'27.55" E	JICA(1998)
	Davao III	Map Study	-	Muliti Purpose	Mindanao	Davao	-	132	296	7.24828° N	125.337° E	JICA(1998)
	Pagan Dam	Pre-FS	NIA	Irrigation	Mindanao	Pagan	Zone-Earthfill Dam	-	-	7˚13'00" N	125˚21'37" E	NIA-11
	Suawan Dam	Pre-FS	NIA	Irrigation	Mindanao	Suawan	Zone-Earthfill Dam	-	-	7˚13'19" N	125˚20'08" E	NIA-11
	Miral Dam	Redevelopment plan in progress	NIA	Irrigation	Mindanao	Bulatukan	-	-	-	6°48'12.74" N	125-13'-7.52" E	NIA-11
	Construction of Cogon Bacaca	F/S	NIA	Irrigation/HP	Mindanao	at Kiblawan	Zone-Earthfill Dam	50	110	6.31.13.23	125.14.10.68	NIA-11
	Construction of Absang	-	NIA	Irrigation	Mindanao	at Matanao	-	-	-	-	-	NIA-11
	Construction of Linoan Dam (SRIP)	-	NIA	Irrigation	Mindanao	Nabunturan	-	-	-	7-37'-53"" N	125-35'-47" E	This survey by our irrigation engineer.
	Construction of Upper Saug Dam (RIP)	-	NIA	Irrigation	Mindanao	-	-	-	-	-	-	This survey by our irrigation engineer.
	Construction of Awano Dam (SRIP)	-	NIA	Irrigation	Mindanao	-	-	-	-	-	-	This survey by our irrigation engineer.
	Construction of Loctan Dam (Flood Control)	-	DPWH/NIA	Muliti Purpose	Mindanao	Tagum	-	45	-	7°26' 51.93" N	125°31' 45.17" E	This survey by our Flood Control Engineer, This Field Survey
	Construction of Gupitan Dam (Flood	-	DPWH/NIA	Muliti Purpose	Mindanao	Tagum	-	20	-	7°47' 9.15" N	125°37' 25.13" E	This survey by our Flood Control Engineer
	Construction of Buayan Dam (Flood Control)	-	DPWH/NIA	Muliti Purpose	Mindanao	Malungon	-	32	916	6°15' 45.65" N	125°16' 23.85" E	-

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.4.3-10 Location Map of Proposed Dams (WRR XI)

(2) Existing Surface Water Resources Development Facilities

1) Mal RIS, Miral SRIP, and Padada RIS

Padada River Irrigation System (RIS) reuses the discharged water from Miral Small Reservoir Irrigation Project (SRIP) and Mal RIS, located upstream (ADCA, 2007).

Miral Dam was constructed under SRIP in the province of Davao Oriental in 1994. The dam is an earth-fill dam with 27 m height. The dam reservoir is heavily silted. The intake is completely clogged with sediment. Massive vegetable farming is ongoing at the watershed. Sedimentation of 3,000 m^3 and 3,400 m^3 were already dredged during the year 2009 and 2010, respectively (METI, 2019).

Source: NIA

Figure 3.4.3-11 Areal Photo of Miral Dam

2) Bulk Water Supply – Apo Agua

Apo Agua Infrastructura, Inc. is building one of the Philippines' largest private bulk water supply facilities that will supply over 300 million liters per day of safe and sustainable water to the Davao City Water District (DCWD) for the people of Davao City. The company entered into an agreement with DCWD to shift the dependence of Davao City's main water supply from groundwater wells to the more sustainably sourced surface water of the Tamugan River. The Davao City Bulk Water Supply Project (DCBWSP) involves two components: Part A component by Apo Agua will cost PHP 12.6 billion and involves the construction of intake facilities, a water treatment facility, and treated water pipelines; Part B which costs PHP 2 billion and is being handled by the DCWD, involves the tapping and interconnecting of pipes, installation of reservoirs, and laying of distribution lines. Set to be one of the country's largest private bulk water supply facilities, the project will provide the DCWD with over 300 million liters per day (MLD) or 109.5 million cubic meters (MCM) per year of safe drinking water. This will serve about 295,000 additional households in the remaining 40% of DCWD's unserved areas and enable them to significantly expand its service area to six new barangays, particularly those in the Panacan and Cabantian water systems, among other areas experiencing low water pressure and intermittent water supply. The treated water will be distributed to over one million Davaoeños through the DCWD's five existing water systems, namely: Dumoy, Calinan, Tugbok, Panacan, and Cabantian, as well as via three additional new water systems at Talandang, Mandug, and Indangan. Apo Agua began its three-year construction phase with engineering design works in 2018 and targets to commence operations by 2022 (Apo Agua website).

Source: Apo Agua

Figure 3.4.3-12 Construction of Intake Weir in Tamugan River

3) Bulk Water Supply – Davao Norte Water

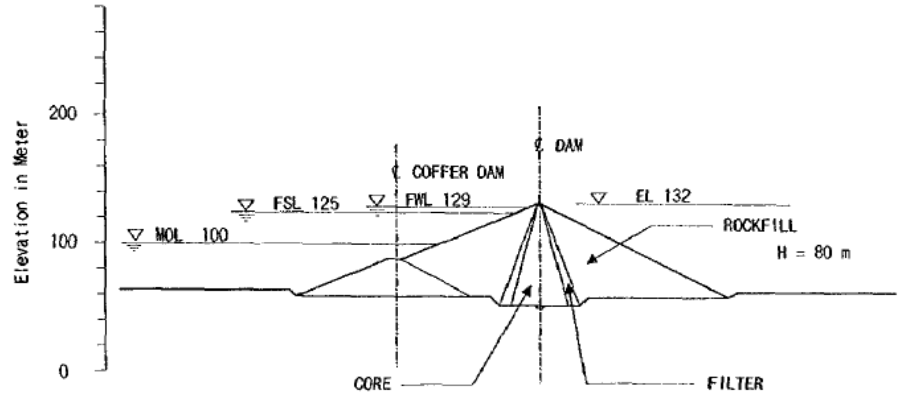
Davao Del Norte Water Infrastructure Company, Inc. (Davao Norte Water), the consortium of Manila Water and iWater, Inc., formalized its joint venture agreement with the Tagum City Water District for a 15-year water project that will supply an additional 38 million liters of water per day (MLD) to Tagum City. The public-private partnership will undertake the construction of a PHP 527 million bulk water supply system for Tagum that includes an intake structure through riverbank filtration, a 38 MLD-capacity water treatment plant, transmission pipeline, and a 5,000 cubic meter water reservoir starting 2016. The project is expected to deliver 26 MLD within the first to third year after commissioning in 2018, 32 MLD within the sixth year, and 38 MLD in the succeeding years until reaching the 15th year of delivery. Davao Norte Water holds 90 percent equity of the consortium, while the remaining 10 percent is held by Tagum City Water District (Manila Water website).

Manila Water Philippine Ventures, a wholly owned subsidiary of Manila Water Company, Inc. now takes 100% ownership of Davao Norte Water after the acquisition of all shares of iWater Inc. Prior to the purchase, the Manila Water firm held 51% while iWater held 49 percent equity interest in Davao Norte Water (Manila Water website).

(3) Surface Water Resources Development Projects Proposed in Past Studies

1) Buhonao Dam

Buhonao Dam was identified in the 1998 M/P by the map study at 1:50,000 scale for hydropower generation, irrigation water supply, and flood control. The conceptual design of the dam considers the dam height at 80 m and the active storage at 720 MCM.

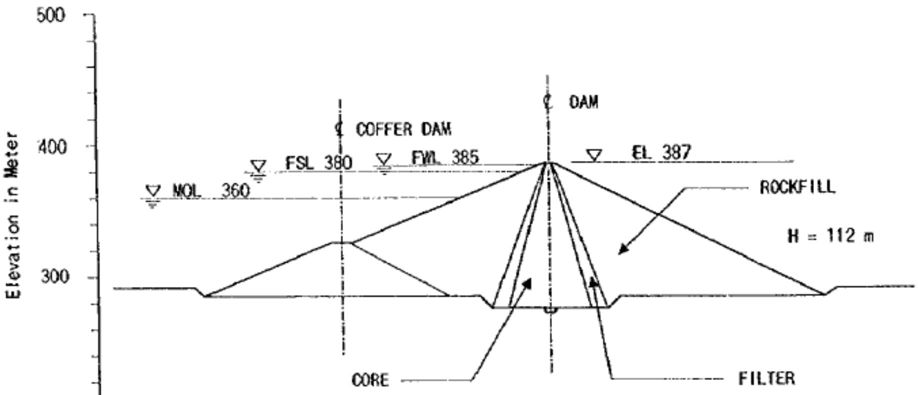


Source: 1998 M/P

Figure 3.4.3-13 Typical Cross Section of Buhonao Dam

2) Davao II Dam

Davao II Dam was identified in the 1998 M/P by the map study at 1:50,000 scale for multi-purpose including municipal water supply, hydropower generation, irrigation water supply, and flood control. The conceptual design of the dam considers the dam height at 112 m and the active storage at 224 MCM.

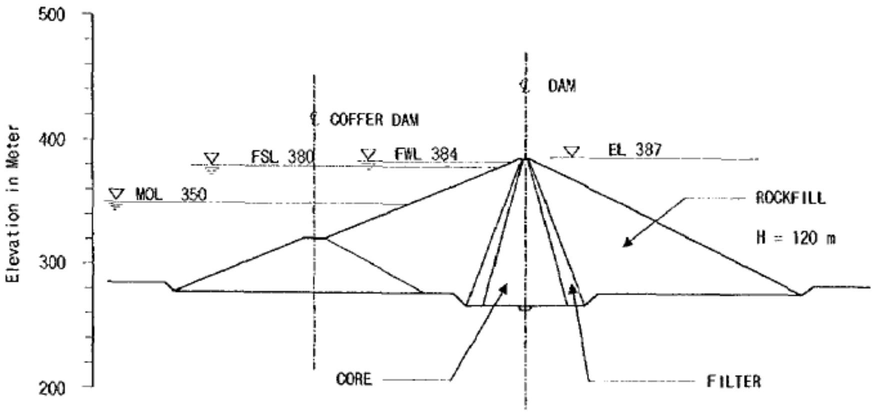


Source: 1998 M/P

Figure 3.4.3-14 Typical Cross Section of Davao II Dam

3) Dimuloc Dam

Dimuloc Dam was identified by NWRC (1978) and re-studied in the 1998 M/P by the map study at 1:50,000 scale for irrigation water supply and flood control. The conceptual design of the dam considers the dam height at 120 m and the active storage at 193 MCM.



Source: 1998 M/P

Figure 3.4.3-15 Typical Cross Section of Dimloc Dam

4) Flood Control Dams

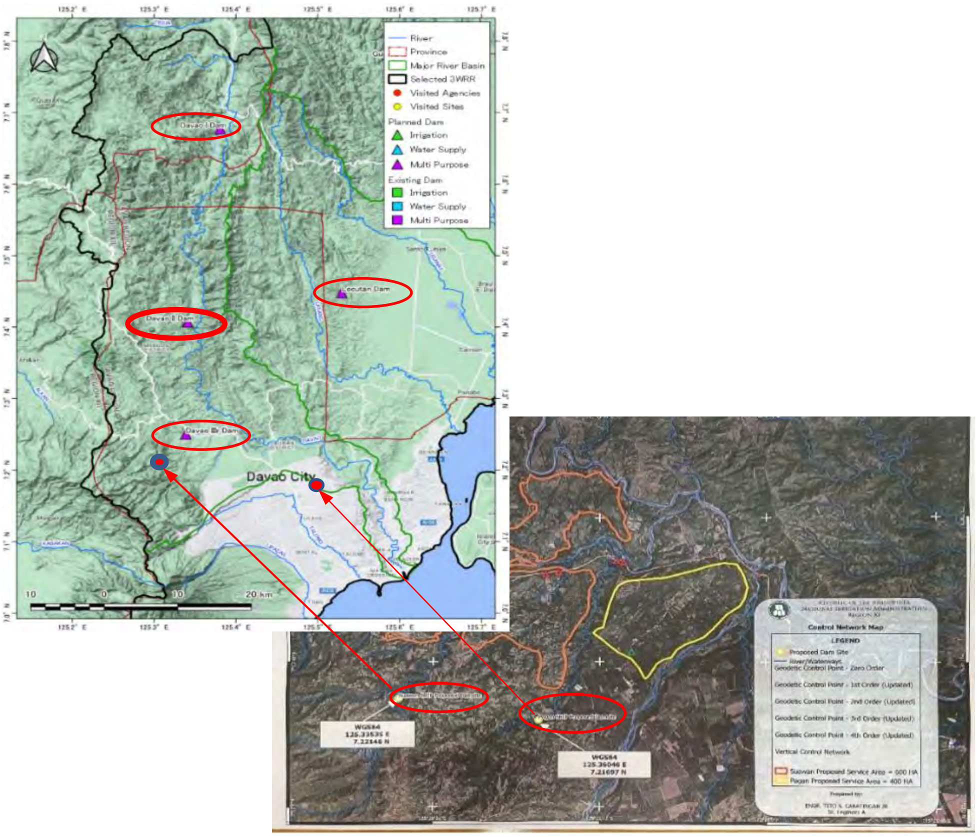
JICA (2021) studied the flood control dams in the Davao River, Matina River, and Talomo River. None of the flood control dams were included in the master plan due to infeasibility. The Davao IV Dam in the Davao River was studied for flood control, and the construction cost was higher than the other alternatives. The potential dam sites in the Matina River and Talomo River were newly identified, and the construction costs were higher than the other alternatives for flood control.

(4) Field Survey Report of WRR XI

The field survey report for each dam site is shown in Table 3.4.3-8 below.

Table 3.4.3-8 Field Survey Report in WRR XI (Davao)

WRR XI (Davao): Sep. 14, 2022 ~ Sep.17, 2022	
Dam site	Information during Site Inspection
1) NIA's planning dams	(Pagan proposed dam site), (Suawan proposed dam site) The proposed dam sites were inspected from a nearby bridge. JST considers these to be a reasonable construction plan so far.
2) Davao I dam	JST visited the site. Many residents live in the submerged area upstream of the Dam. There are some landslides near the proposed dam sites.
3) Davao II dam	JST was not able to visit the dam site due to high river flows.
4) Davao III dam	JST visited the site. The impression was that the dam could be built.
5) Locutan dam	JST visited the site. The proposed site is in the shape of a fan and large banana plantations were being operated. Therefore, the construction of a dam is not suitable.



Source: JICA Survey Team

Figure 3.4.3-16 Location of Dam Sites in WRR XI

WRR XI (Davao) : Dec. 03, 2022

Dam site	Information during Site Inspection
6) Davao II dam	1) Davao 2 Dam is one of the priority proposed dams on the upper Davao River. 2) The scale of development is large, with a dam height of 130 m, a reservoir area of 6,000 hectares, and a water storage capacity of 2500 M. cu.m. 3) The topography is identical to the plan drawings and the geology is favorable. 4) The scale of development should be considered in light of water demand. The distance from Metro Davao is too far, and it would need long water transmission development.

Source: JICA Survey Team

Figure 3.4.3-17 Site Inspection of Proposed Dam Site (Davao II)

WRR XI (Davao): Dec. 03, 2022	
Dam site	Information during Site Inspection
7) Davao III dam	1) Davao 3 Dam is one of the priority proposed dams on the upper Davao River [Right branch of the Davao River (Suawan River)] 2) Because access to the dam site was difficult, JST observed from the bridge located 2 km upstream of the dam site. 3) The river channel around the bridge had good sedimentary rock outcrops. 4) There is a village around the bridge, and it is considered effective to store water at elevations below the bridge girder. (Dam height is less than 20 m)

Upstream

Downstream

Bridge

Source: JICA Survey Team

Figure 3.4.3-18 Site Inspection of Proposed Dam Site (Davao III)

Source: JICA Survey Team

(5) Considerations for Dam Construction

Water demand in WRR XI is increasing due to population growth in the Davao metropolitan area. Currently, water demand is met by collecting groundwater, and flood control is planned through river improvements and other methods. In addition to meeting water demand, dam construction would be an effective mean to prevent floods in the Davao River and other rivers. In the future, a possible option could be to construct a large-scale multi-purpose dam, for not only water supply and flood control, but also for hydroelectric power generation.

At present, General Santos City, located at the southern tip of Mindanao Island, supplies municipal water with groundwater. Since the development speed in the surrounding areas of the city is gradual, the necessity of dam construction is considered low.

The Locutan Dam, which is planned in the north-eastern part of the Davao metropolitan area, was found to be unsuitable for dam construction because of the large-scale banana plantations and gentle terrain.

The other irrigation dams planned by NIA has a topography that does not allow large-scale water storage operation, but it can be considered for irrigation purpose and placed in the vicinity of the service area.

Regarding Davao II Dam and Davao III Dam planned in the upper Davao River, which maintains a large-scale basin, Davao II Dam has a V-shaped valley topography suitable for dam construction, and it would be possible to construct a large-scale dam. In addition, it was confirmed that Davao III Dam can be constructed in a V-shaped valley like Davao II by moving the dam site to the upstream of the existing dam location.

From the above, Davao II Dam and Davao III Dam can be considered as the possible options for large-scale multi-purpose dam projects including flood control measures for Metro Davao area.

3.4.3.9 Current Status of Groundwater Use in WRR XI

Based on the NWRB's water permit records, a total of 363 water permit wells and 53 springs have been issued within WRR XI. This record does not include small domestic wells, and the actual number of well and spring is assumed to be much higher. The number of wells and springs for each Province is shown in Table 3.4.3-9.

Table 3.4.3-9 Water Permit Wells and Springs in WRR XI

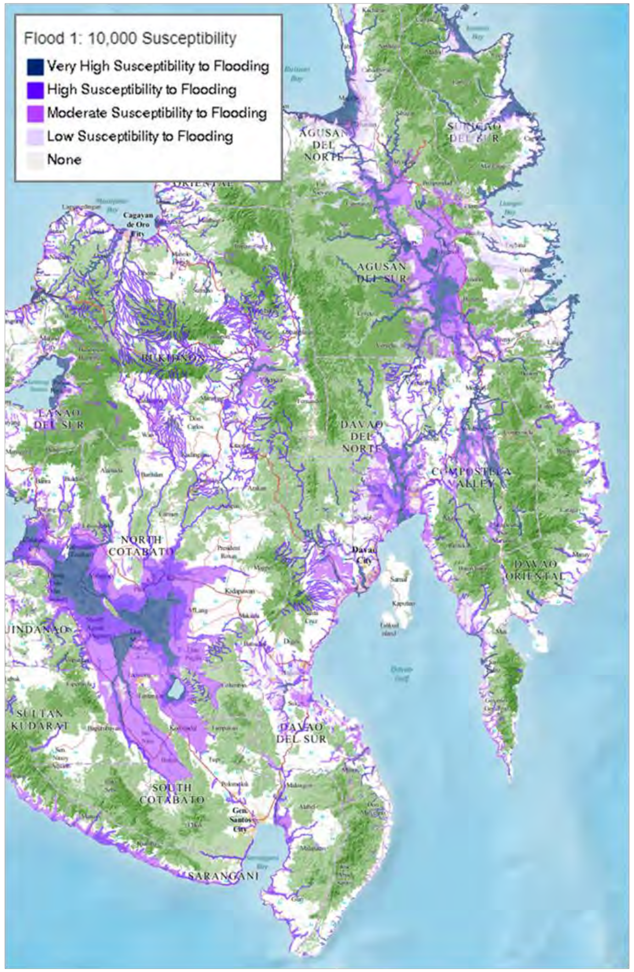
Region	Permit Water Source		Major water source owners
	Groundwater Well	Spring	
XI	250	36	DCWD, Tagum WD
XII	105	4	GenSan WD
XIII	8	13	
Total	363	53	

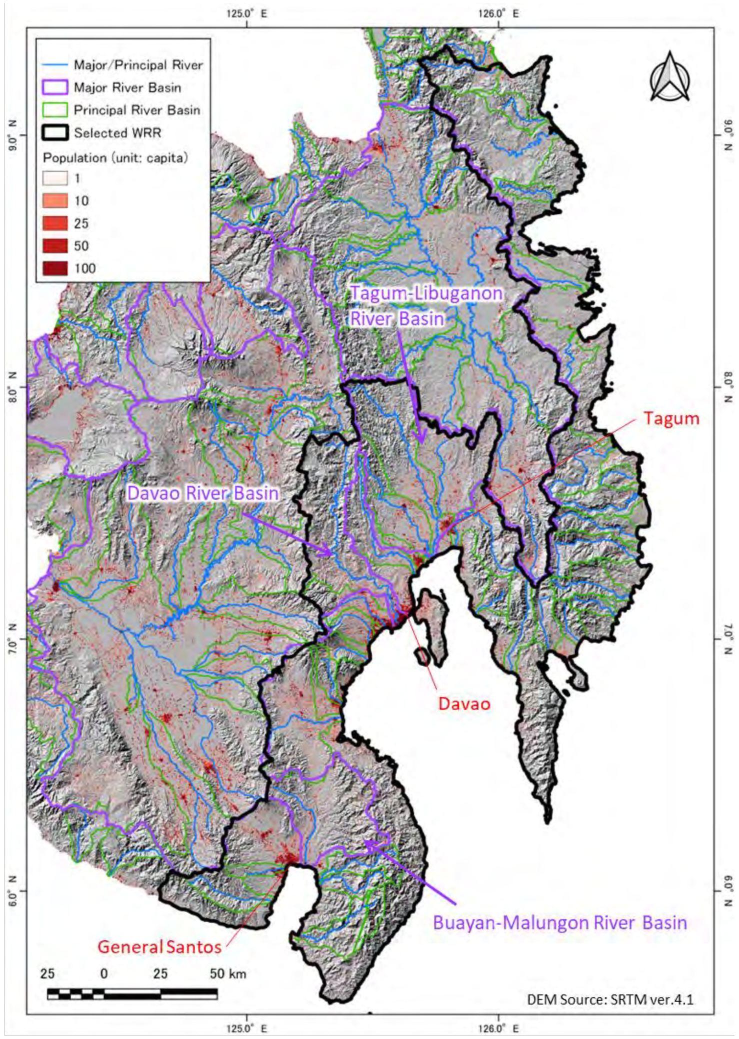
Source: JICA Survey Team

3.4.3.10 Flood Risk Management (FRM) in WRRXI

(1) Overview of Flood Risk in WRR XI

To overview the flood risks in WRR XI, a flood susceptibility map and a population distribution map are compared as shown in Figure 3.4.3-19. By overlapping the flood susceptibility map and a population distribution map, most of the high-risk flood area lies in the Davao River basin and the Tagum-Libuganon River basin. In addition to the two major river basins, there is another major river basin named the Buayan-Maulugon River basin whose outlet is located next to General Santos City. Although the population in the flood susceptibility area in the river basin is relatively low in the figure, the water resources of the Buayan-Malungon River is very important in terms of water utilization for General Santos City and neighboring areas. There are also 35 principal river basins in WRR XI. Most of the drainage areas of the 35 rivers are less than 500 km^2 and their flood susceptibility areas spread in relatively narrow areas along their rivers.





Source of flood susceptibility map: Geoportal PH (https://www.geoportal.gov.ph/#)

Source of population 30m mesh data: Facebook Connectivity Lab and Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. High Resolution Settlement Layer (HRSL). Source imagery for HRSL © 2016 DigitalGlobe.

Figure 3.4.3-19 Flood Susceptibility Map (Left) and Population Distribution Map (Right) in WRR XI

The three major rivers, the Davao River, the Tagum-Libuganon River, and the Buayan-Malungon River, are significantly important in terms of both flood risk management and water resources management. Accordingly, the three major rivers were focused on to study their flood risk management.

(2) Summary of Current FRM Plan

Since flood risk management (FRM) structural measures such as dams, shortcuts, and flood diversion channels affect river flows and furthermore water cycle in the region, as mentioned in Chapter 2.2.11 (1), the current FRM plans of the three major rivers were collected and reviewed. The FRM master plans (FRMMPs) are summarized in Table 3.4.3-10. All three FRMMPs were recently developed, but their target flood levels are different. Since the Davao River basin includes Davao City, the third biggest city in the Philippines, its target flood level is set as a 100-year flood, higher than the other two major rivers. There is no existing flood control dam in the three major river basins. New dams for flood control purposes were studied in the three FRMMPs, but none of them was adopted by comparing to the other alternative solutions. However, two multi-purpose dams in the Tagum-Libuganon River basin and one multi-purpose dam in the Buayan-Malungon River basin are still proposed not strictly within the framework of a flood risk reduction approach, but in the long-term and within the framework of climate change adaptation coping also with drought and water scarcity events.

Table 3.4.3-10 Summary of the Current FRMMPs for the 3 Major River Basins

River Basin Name	Davao	Tagum-Libuganon	Buayan-Malungon
Drainage Area*1	1,760 km^2	3,119 km^2	1,505 km^2
Latest FRMMP	JICA (2022) *2	ADB (2020) *3	ADB (2020) *3
Target Year	2045	2050	2050
Target Flood Level	100-year flood	50-year flood	50-year flood
Consideration of CCI *4 on rainfall	Incorporate a 10% increase in rainfall intensity in the design	50 percentile RIDF curve for each station provided by PAGASA was adopted	Not specifically described
Consideration of CCI *4 on sea level rise	+0.2 m from 2000 to 2045	+0.2 m from 2020 to 2050	Not specifically described
Design Discharge	3,400 m^3/s at Waan Bridge (17 km upstream from the river mouth)	926 m^3/s at upstream of Tagum City	1,985 m^3/s at the confluence of Buayan River and Maribulan River
No. of Existing Flood Control Dam	0	0	0
No. of Potential Flood Control Dam	0	2 *5	1 *5

*1) Drainage area is quoted from the website of River Basin Control Office (https://riverbasin.denr.gov.ph/main/index)
*2) The FRMMP was formulated in the JICA Project, "Master Plan and Feasibility Study on Flood Control and Drainage in Davao City"
*3) The FRMMP was formulated in the ADB Project, "Infrastructure Preparation and Innovation Facility (IPIF) Output 02 Water (Flood Control)"
*4) CCI: Climate Change Impacts
*5) Multi-purpose dams are proposed as an option in the long-term and within climate change adaptation plan coping also with drought and water scarcity events.

Source: JICA Survey Team

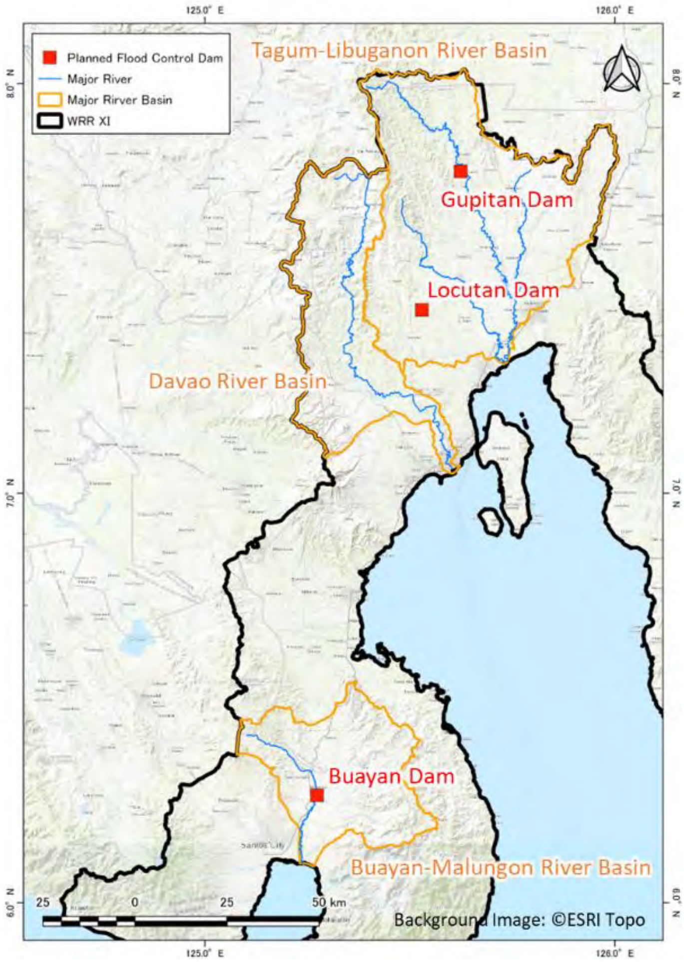
The potential dams studied in the FRMMPs are summarized in Table 3.3 2, and their locations are illustrated in Figure 3.3 2. More details are described in Annex H.

Table 3.4.3-11 Summary of Potential Flood Control Dams in the 3 Major River Basins

River Name	Dam Name	Dam Height	Crest Length	Storage Volume*	Remarks
Davao	**No flood control dam is proposed in the current FRMMP.**				
Tagum-Libuganon	Locutan	45 m	N/A	11 MCM	• Not specifically described
	Gupitan	20 m	N/A	80 MCM	• More than 400 houses will be under the water reservoir level, a remaining number of around 100 households will be strongly impacted. • With a surface of 8 km^2, around 68 ha of agricultural land (mainly perennial crops) will be unavailable.
Buayan-Malungon	Buayan	32 m	916 m	41 MCM	• Noticeable effect to decrease the water level at the Old/New Buayan Bridge by -1 m, but not enough to completely solve existing problems • More or less efficient as a dry dam, but less if combined with other uses

* The storage volume was studied not for flood control volume but for developable storage volume in the FRMMP (ADB, 2020, "Infrastructure Preparation and Innovation Facility (IPIF) Output 02 Water (Flood Control)").

Source: Prepared by JICA Survey Team based on the current FRMMPs



Source: JICA Survey Team

Figure 3.4.3-20 Location of Pontential Dams in the 3 Major River Basins

3.4.3.11 Water Quality in WRR XI

As of 2021, EMB has classified 43 water bodies in Region XI (Davao Region). Of these classified water bodies, the water body classification, water quality monitoring station, and summary of monitoring result of the main water body are shown in Table 3.4.3-12.

Table 3.4.3-12 Classified Water Bodies in WRR XI

Name of Water Body	Water Body Classification	Monitoring Station	Summary of the Monitoring Result
Bunawan River	Class C	8 stations	- Chloride, color, dissolved oxygen, potential hydrogen, and temperature results are within the water quality guideline values. - BOD, nitrates, phosphates, and total suspended solids exceeded the limits.
Davao River	Class B – Sta.1-4 (Downstream) Class A – Sta. 5-11 (Upstream)	17 stations	- Color, dissolved oxygen, nitrate, cadmium, copper, and lead are within the water quality guideline values. - Chloride, fecal coliform, pH, phosphate, temperature, and total suspended solids exceeded the limits.
Ilang River	Class C	3 stations	- BOD, color, dissolved oxygen, pH, and temperature are within the water quality guideline values. - Phosphate, nitrate, and total suspended solids exceeded the limits.
Lipadas River	Class AA – Mt. Apo Nat'l. Park to Brgy. Baracayo Class A - Brgy. Baracayo to Brgy. Bangkas Class B - Midstream (Brgy. Bangkas to Brgy. Alambre) Class C - Downstream (Brgy. Alambre to confluence with Davao Gulf)	9 stations	- BOD, color, dissolved oxygen, the potential of hydrogen, temperature, and total suspended solids are within the water quality guideline values. - Chloride, fecal coliform, phosphate, and nitrate results exceeded the limits.
Talomo River	Class B	14 stations	- Color, dissolved oxygen, and pH are within the water quality guideline values. - BOD, chloride, fecal coliform, nitrates, phosphates, temperature, and total suspended solids exceeded the limits.
Matina River	Class B - Station 3 to upstream Class C – Downstream of Station 3 to mouth of the river	9 stations	- pH is within the water quality guideline value. - Chloride, BOD, DO, temperature, phosphate, and total suspended solids exceeded the limits.

Source: EMB XI Regional State of Brown Environment Report, 2021

3.4.3.12 Natural and Social Environment in WRR XI

(1) Natural Environment

1) Flora, Fauna, and Ecosystem

Davao City is home to different flora and fauna species. In the 235 hectare Malagos Protected Landscape, the DENR observed that the (flora) species evenness was high while the (flora) species diversity was low as of April 2016. For fauna, on the other hand, diversity is measured by animal classes.

2) Protected Area

According to the DENR Biodiversity Management Bureau (BMB), the region has a total of 10 protected areas, two of which are declared within Davao City. Details are shown in Table 3.4.3-13.

Table 3.4.3-13 List of Protected Areas in WRR XI

Protected Area	Location	Total Area	Area in Davao City
Malagos Watershed Reservation	Malagos, Baguio District	235 ha	235 ha
Mt. Apo Natural Park	Kidapawan, Makilala, Magpet, Cotabato; Sta. Cruz, Bansalan, Digos City and Davao City, Davao del Sur	57,974 ha	11,137 ha

Source: DENR; Davao City CLUP

3) Air Quality

Based on available DENR-EMB data on annual ambient air quality monitoring in urban areas, there are five monitoring stations in Davao City for total suspended particulates (TSP). From 2003 to 2012, the average TSP concentration recorded was 70.67 ug/Ncm, which was within the annual guideline value (90 ug/Ncm).

(2) Social Environment

1) Ethnicity

Davao City do not have any known indigenous people communities nor ancestral domains recognized by the National Commission on Indigenous Peoples (NCIP).

2) Local Economy

The Davao Region has the sixth largest economy by region in the Philippines with PHP 1,095.71 billion translating to 4.97% of the national GDP in 2022 according to the PSA.

3) Historic Site / Culture Heritage

Davao City hosts 90 of these historical, tangible, and intangible cultural properties. Table 3.4.3-14 below highlights some of the declared marked structures and important cultural property in Davao City.

Table 3.4.3-14 List of Marked Structures & Important Cultural Properties in WRR XI

Official Name	Declaration/Classification	Type
Andres Bonifacio Monument (Toril) | Andres Bonifacio (30 Nobyembre 1863-10 Mayo 1897) Marker	Marked Structure, NHCP; Registered Property, Davao City	Tangible-Immovable
Ohta Kyozaburo Monument | Ohta Kyozaburo (1876-1917) Marker	Marked Structure, NHCP; Registered Property, Davao City	Tangible-Immovable
Davao City Hall	Marked Structure, NHCP; Registered Property, Davao City	Tangible-Immovable
Port Santa Ana	Marked Structure, NHCP; Registered Property, Davao City	Tangible-Immovable
Filipinas Life Assurance Company Building - Davao City	Work of National Artist for Architecture Leandro V. Locsin; Registered Property, Davao City	Tangible-Immovable
Davao International Airport Terminal Building	Work of National Artist for Architecture Leandro V. Locsin; Registered Property, Davao City	Tangible-Immovable
Davao Insular Hotel	Work of National Artist for Architecture Leandro V. Locsin; Registered Property, Davao City	Tangible-Immovable
Barangay Mintal Japanese Heritage SIte	Local Cultural Property - Japanese Heritage Site, Davao City	Tangible-Immovable

Source: National Commission for Culture and the Arts (NCCA) TALAPAMANA Visayas (2022)

3.4.4 Hydrological Analysis in WRR XI

3.4.4.1 Hydrological Analysis (Surface Water)

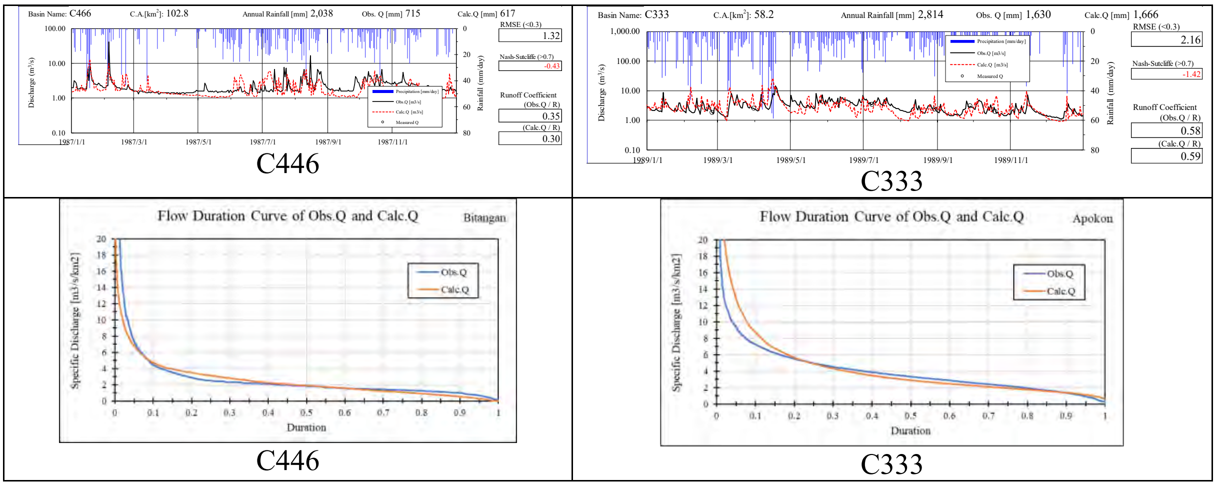
(1) Selection of Hydrological Model

As described in Section 3.3.4.1, in this survey, the physically-based runoff model, the SHER Model, was selected for detailed hydrological analysis for priority WRRs.

(2) Calibration of SHER Model Parameters

As describe in Section 3.3.4.1, the model parameters are calibrated and evaluated with same methods.

The results of hydrographs of simulated and observed discharge are attached in Annex-D: Hydrology. Example of calibrated hydrographs are shown in Figure 3.4.4-1 below.

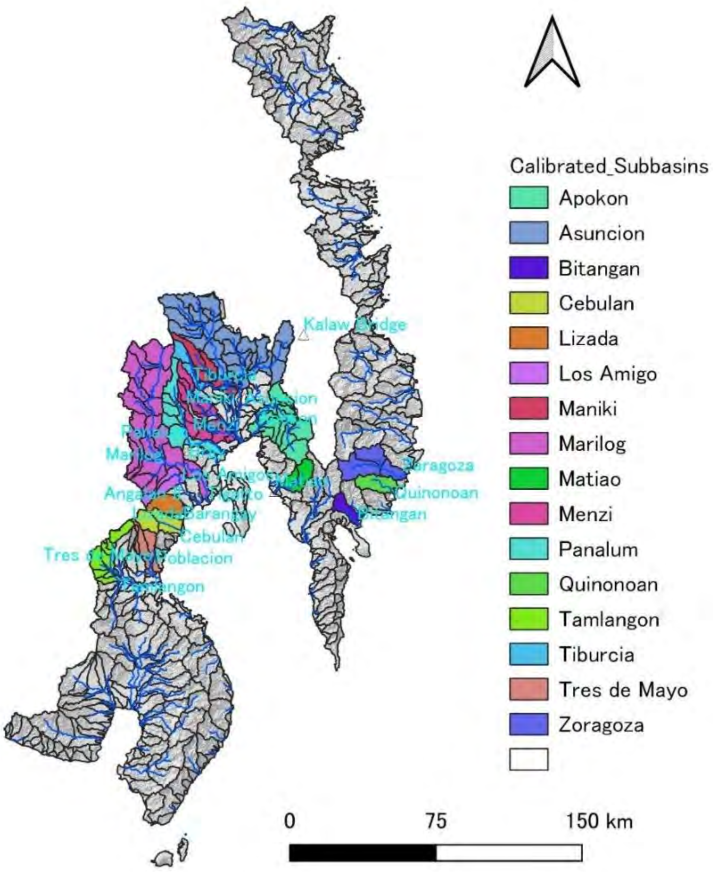


Source: JICA Survey Team

Figure 3.4.4-1 Example of Results of Simulated and Observed Discharge Hydrograph and FDC

(3) Expansion of SHER Model Parameters for Ungauged Sub-basin

Using the calibrated parameters of the SHER Model for sub-basins with the DPWH observed discharges, river discharges for sub-basins without observed discharges were estimated. The Figure 3.4.4-2 below shows the sub-basins where the DPWH observed discharges are located.



Source: JICA Survey Team

Figure 3.4.4-2 Calibrated Sub-Basins in WRR-XI

3.4.4.2 Hydrological Analysis (Groundwater)

(1) Method of Groundwater Analysis

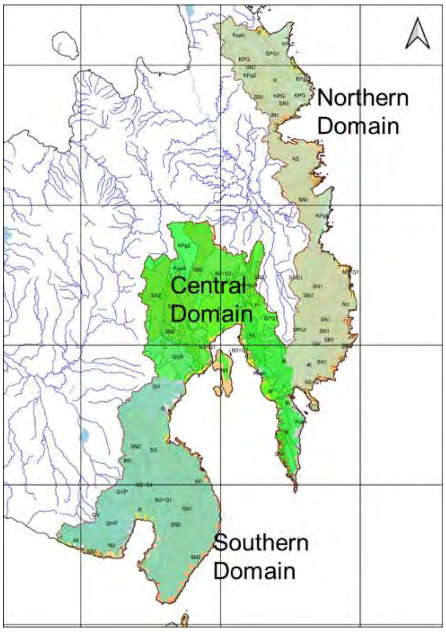
Workflow of the groundwater analysis are described in Section 3.3.4.2.

(2) Groundwater Model Setting

1) Hydrogeological Boundary

Since WRR XI has large area, the modeling area was divided into three parts: western domain, central domain, and eastern domain (Figure 3.4.4-3).

The hydrogeological structure is set by referring the Groundwater Resource Assessment report by MGB, and classified into three layers: high permeable zone, low permeable zone, and impermeable zone.



Source: JICA Survey Team

Figure 3.4.4-3 Groundwater Model Area of WRR XI

2) Numerical Model Setting

Table 3.3.4-2 summarizes the mesh size, number of layers, and number of meshes in each modeling area.

Table 3.4.4-1 Numerical Model Settings of WRR XI

Model Area	Central Domain	Northern Domain	Southern Domain
Grid Size	1,000m	1,000m	1,000m
Cell Number of each Layer	9,620	9,329	8,941
Layer Number	4	4	4
Total Cell Number	38,480	37,316	35,764

Source: JICA Survey Team

3) Groundwater Recharge

Settings of groundwater recharge are same as WRR VII, described in Section 3.3.4.2.

4) Boundary Condition

Settings of boundary condition are same as WRR VII, described in Section 3.3.4.2.

5) Hydrogeological Parameter

Based on literature, the hydraulic conductivity shown in Table 3.4.4-2 was given as the initial set value for each layer.

Table 3.4.4-2 Initial Model Setting of Hydraulic Conductivity in WRR XI

Model Area	Layer	Hydraulic Conductivity (m/s)	Assumed Geology
Central Domain	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Volcanic Ash, Limestone
	3,4	1×10^{-8}	Volcanic Rock, Sandstone, Shale, Tuff
Eastern Domain	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Limestone, Sand
	3,4	1×10^{-8}	Volcanic Rock, Sandstone, Shale, Silt
Western Domain	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Volcanic Ash, Sand
	3,4	1×10^{-8}	Volcanic Rock, Sandstone, Shale, Tuff

Source: JICA Survey Team

6) Pumping Well Setting

Settings of pumping well are same as WRR VII, described in Section 3.3.4.2.

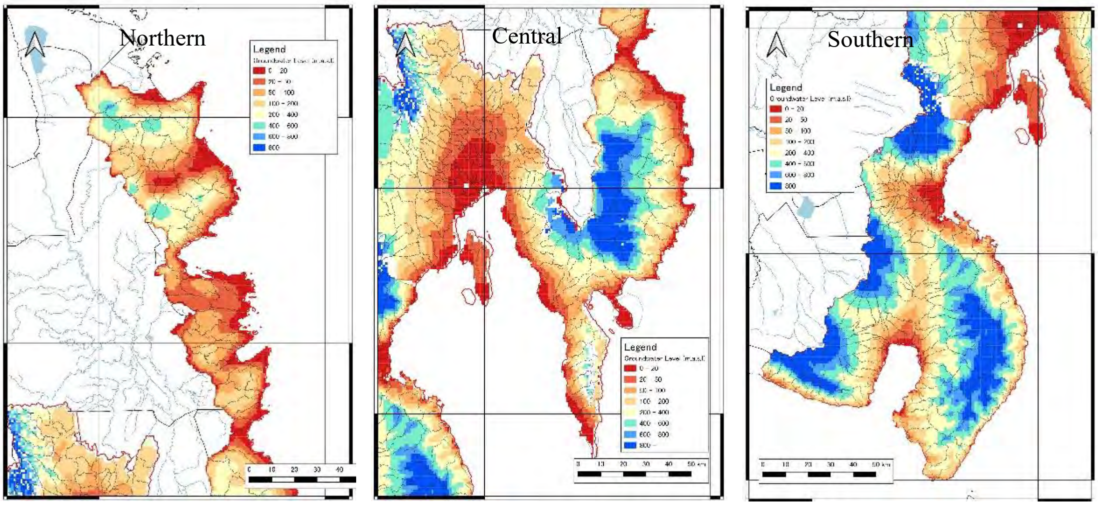
(3) Calibration of Groundwater Model Parameter

1) Groundwater Level Calibration

Calibration of model parameters (hydraulic conductivity) was performed by comparing the groundwater levels calculated by MODFLOW with the measured groundwater levels.

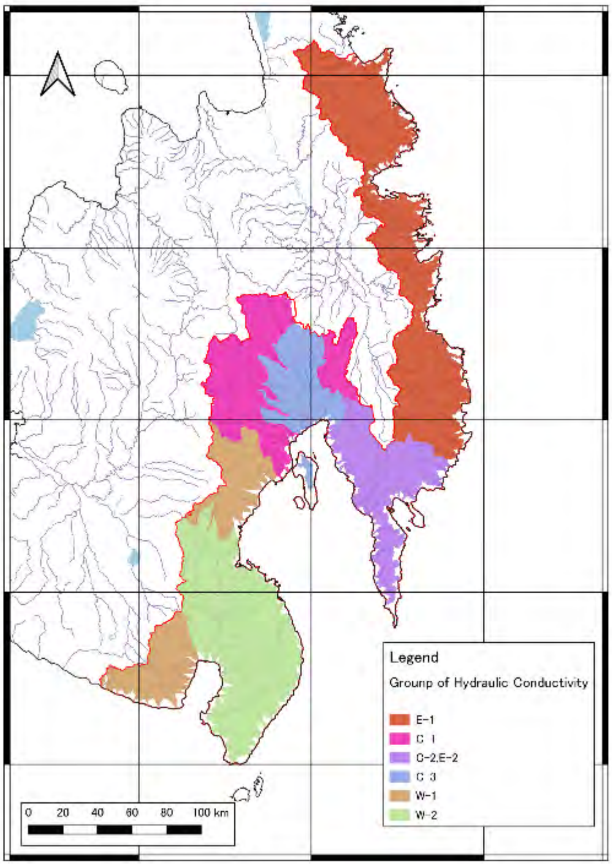
The only measured groundwater levels that can be used for calibration are the groundwater observation wells in Davao managed by DCWD, and very little calibration is possible for other areas. Therefore, the hydraulic conductivity in the areas without calibration targets was adjusted based on the values set by the SHER model.

The results of groundwater level calibration are shown in Figure 3.4.4-4. Figure 3.4.4-5 and Table 3.4.4-3 shows the hydraulic conductivity settings after calibration.



Source: JICA Survey Team

Figure 3.4.4-4 Result of Groundwater Level Calibration in WRR XI



Source: JICA Survey Team

Figure 3.4.4-5 Setting of Hydraulic Conductivity after Calibration of WRR XI

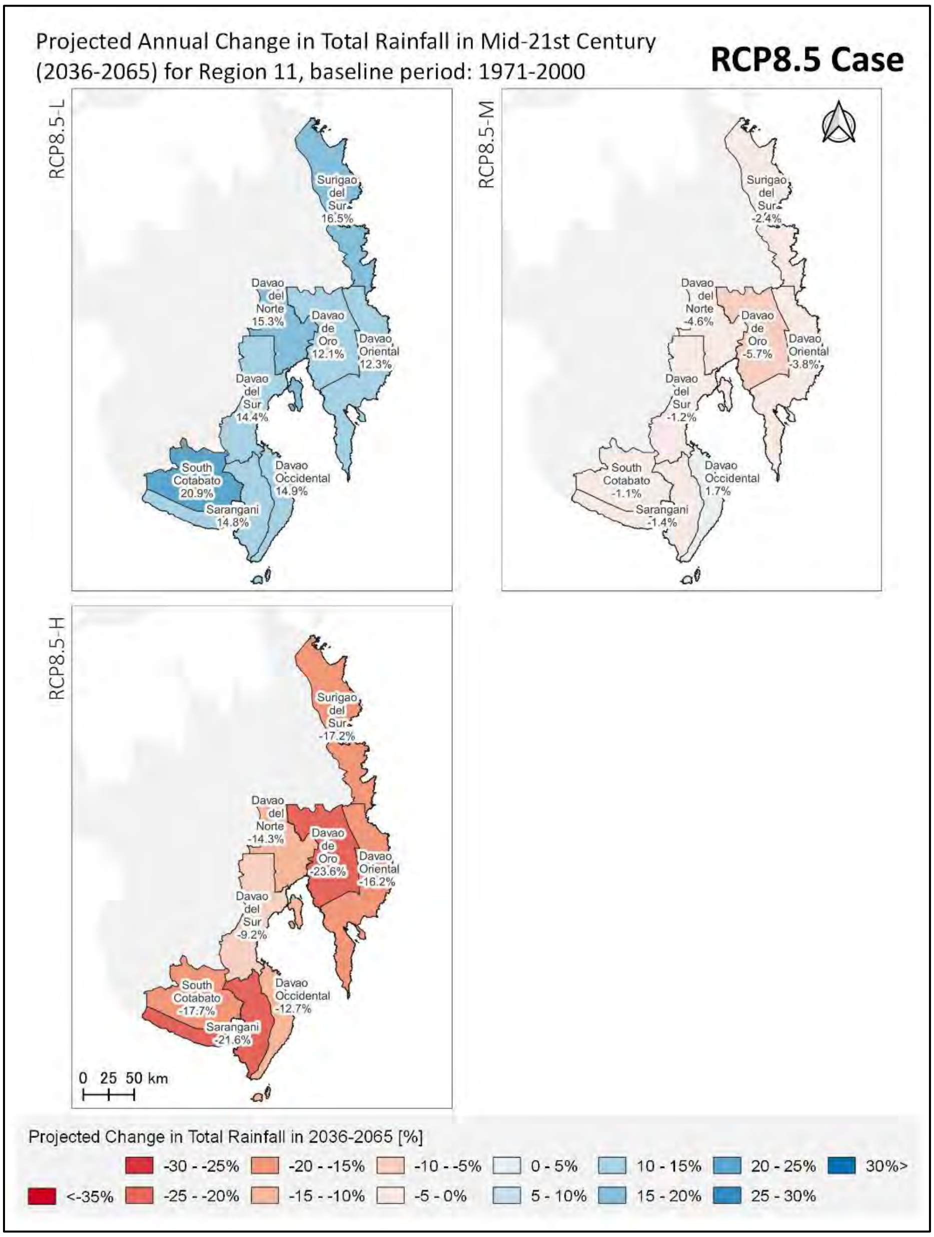
Table 3.4.4-3 Setting of Hydraulic Conductivity after Calibration of WRR XI

Model Area	Group	Layer	Hydraulic Conductivity (m/s)	Model Area	Group	Layer	Hydraulic Conductivity (m/s)
Central Domain	C_1	1	1×10^{-5}	Eastern Domain	E_1	1	1×10^{-6}
		2	1×10^{-6}			2	1×10^{-7}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	C_2	1	1×10^{-6}		E_2	1	1×10^{-6}
		2	1×10^{-7}			2	1×10^{-7}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	C_3	1	1×10^{-2}	Western Domain	W_1	1	1×10^{-3}
		2	1×10^{-3}			2	1×10^{-4}
		3,4	1×10^{-9}			3,4	1×10^{-9}
					W_2	1	1×10^{-6}
						2	1×10^{-7}
						3,4	1×10^{-9}

Source: JICA Survey Team

3.4.4.3 Climate Change Impact Assessment

As described in Section 3.3.4.3 Climate Change Impact Assessment, climate change impact in WRR XI was estimated by the same method. Figure 3.4.4-6 shows the projected annual change in total rainfall in Mid-21st Century (2036-2065) for administrative Region XI and surrounding provinces for RCP8.5 cases. Figures for RCP4.5 as well as seasonal changes in total rainfall are given in Annex-D: Hydrology. The impact of climate change on the water balance is an assessment of future uncertainty (variability). In this study, it was evaluated RCP8.5, which has a large degree of uncertainty. The impact assessment of climate change was estimated by inputting values after changes in future climate change (precipitation and temperature = evapotranspiration) into the input values of the calibrated runoff analysis model. Spatial province-level and temporal quarter-level PAGASA climate change impact data were used.



Source: JICA Survey Team

Figure 3.4.4-6 Projected annual change in total rainfall in Mid-21st Century (2036-2065) for Region XI

3.4.4.4 Results of Hydrological Analysis

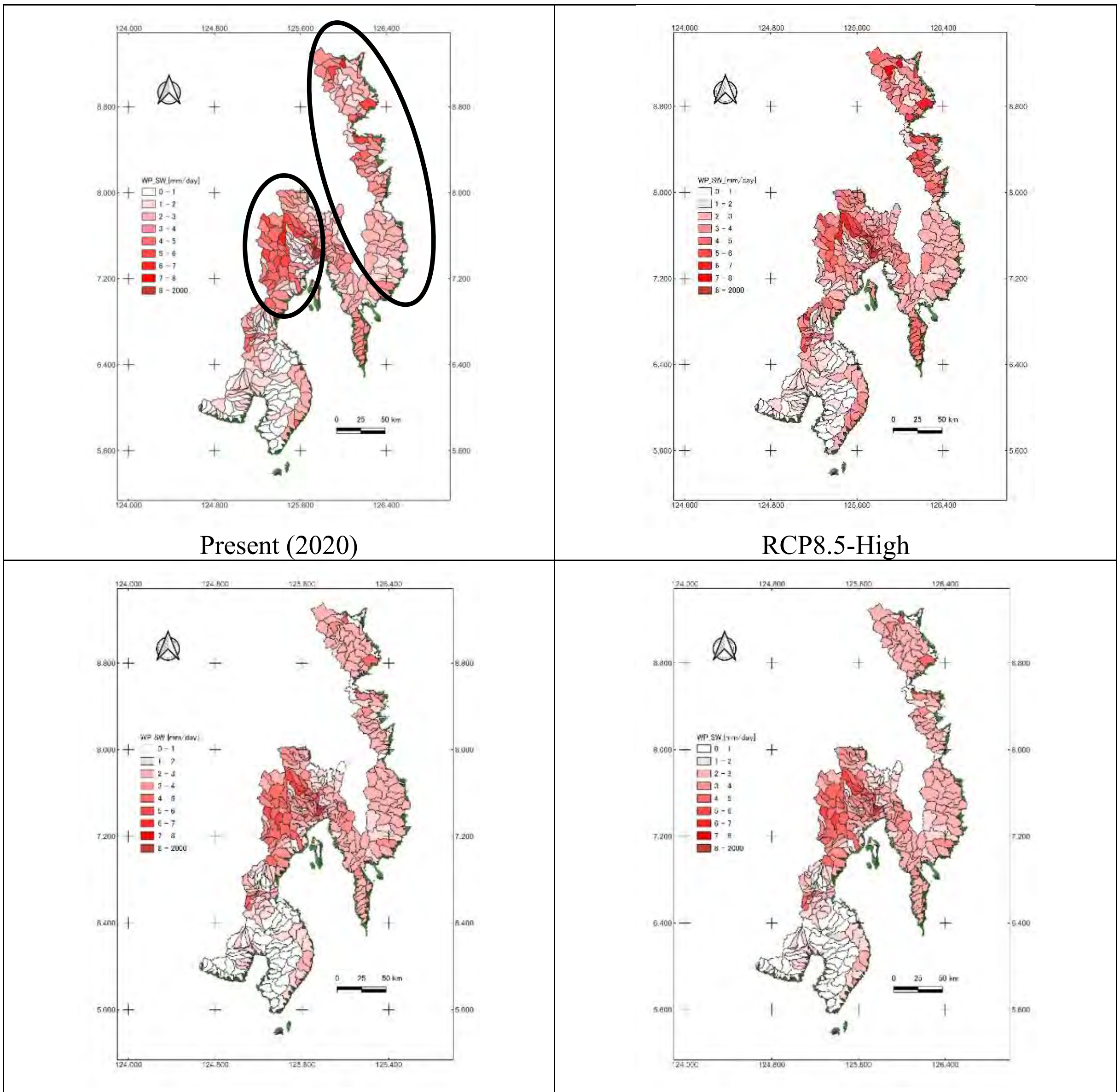
In the detailed hydrological analysis in priority water resources regions, a physically-based water cycle model was used to logically calculate river discharge and groundwater recharge. Groundwater flow could be estimated using physical parameters calibrated in sub-basins with discharge gauging stations and even in sub-basins where there are no discharge gauging stations. Calibration results were generally good as shown in Annex-D: Hydrology. As a result of reducing the sub-basin division, it was possible to determine the regional water potential (surface water and groundwater) of the target water resources regions in detail. The results of water balance analysis with water resources potential and water demand for each sub-basin are described in the following sections.

3.4.5 Water Resources Potential in WRR XI

(1) Surface Water Potential

Surface water potentials (river flow) of each sub-basin in WRR XI were calculated by the SHER Model as shown in Figure 3.4.5-1. Surface water potentials (river flows) are abundant in the eastern part of WRR XI due to plenty of rainfall. As shown in Figure below, the surface water potentials are relatively high downstream of Mt. Tagubud in the eastern part of WRR XI and near Mt. Apo.

However, regarding surface water potential, since the model was generated considering river flows, clarification is sought on the water quality and applicable water use of the said surface water potential. Also in local view, the Region has noted the compliance rates for inland water bodies monitored based on water quality guidelines for fecal coliform and total suspended solids (TSS) repeatedly fell below their annual targets. The non-compliance was attributed to open defecation, backyard piggeries and lack of centralized septage management facilities/programs in the vicinity of the inland water bodies. Dredging activities, river mineral extraction, natural river topography and heavy rainfall were identified as factors contributory to high TSS content. Compliance rate for mercury parameter was also not met in CY 2019 due to upstream gold extraction plants that utilize mercury in processing. Compliance rate for phosphates parameter was also below target in CY 2021 due to high-nutrient wastewater generated by plantations and livestock production.



Present (2020) | RCP8.5-High | RCP8.5-Mid. | RCP8.5-Low

Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

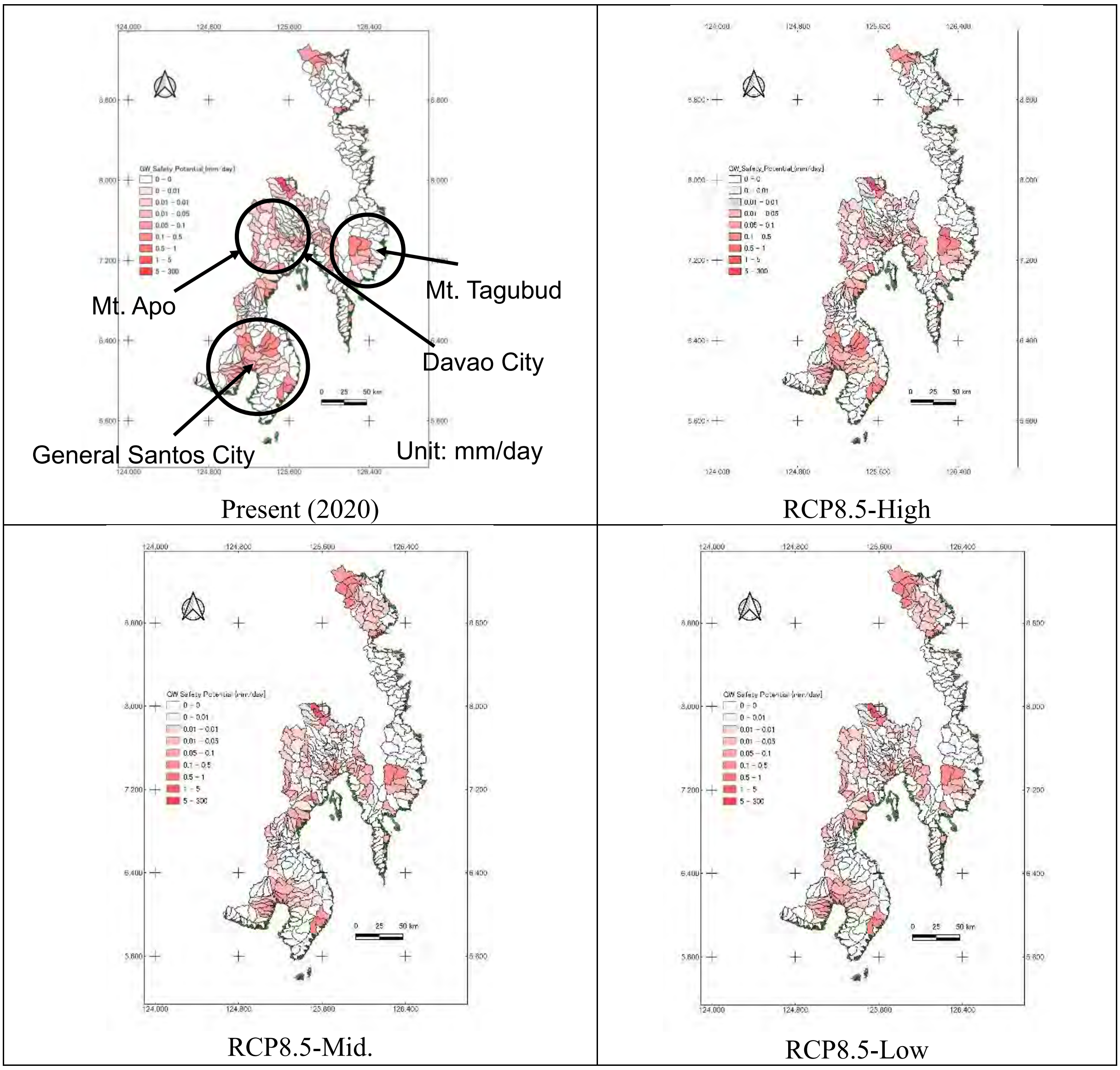
Source: JICA Survey Team

Figure 3.4.5-1 Surface Water Potentials (1/5-Dry-Year) in WRR-XI (Unit: mm/day)

(2) Groundwater Potential

The results of groundwater potentials (groundwater flow) at each block were also calculated by the SHER Model. The groundwater potentials used by the MODFLOW Model will be described in the next section of "Hydrological Analysis (Groundwater)".

As shown in Figure 3.4.5-2, the groundwater potentials are relatively high downstream of Mt. Tagubud in the eastern part of WRR XI, near Mt. Apo, southwest of Davao City and near Metro General Santos. Groundwater potential was calculated by multiplying the groundwater flow of each block by the safe groundwater pumping rate of 0.7.



Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

Source: JICA Survey Team

Figure 3.4.5-2 Groundwater Potentials (1/5-Dry-Year) in WRR-XI (Unit: mm/day)

3.4.6 Water Demand Forecast in WRR XI

3.4.6.1 Socio-Economic Framework

Results of the population projection and GRDP projection of the priority WRRs (V, VII, and XI) are shown in Section 3.2.

3.4.6.2 Water Demand Forecast (Agricultural Use) WRR XI

(1) Irrigation Water Demands

Annual water demands (AWDs) for the irrigation in WRR-XI are summarized in Table 3.4.6-1 for 2020, Table 3.4.6-2 for 2030, Table 3.4.6-3 for 2040, and Table 3.4.6-4 for 2050. The future AWDs are only presented in the case of the irrigation areas estimated based on NIA's past financial programs. The future AWDs in the case of irrigation areas based on NIMP 2020-2030 are explained in Appendix F.

Table 3.4.6-1 Annual Irrigation Water Demands of 2020 in WRR XI

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Bukidnon	0.046	1,919	1,536	1,253	1,243	13.81	0	0	0	0	0.00	13.81
Davao de Oro (Compostela Valley)	0.477	7,082	7,021	5,352	5,352	96.78	0	0	0	0	0.00	96.78
Davao del Norte	0.989	28,990	27,475	21,499	21,499	424.68	0	0	0	0	0.00	424.68
Davao del Sur Davao Occidental	0.998	17,439	16,943	13,904	13,765	339.78	0	0	0	0	0.00	339.78
Davao Oriental	0.949	8,357	8,319	5,812	5,853	128.14	0	0	0	0	0.00	128.14
Sarangani	0.869	6,086	5,458	4,922	4,580	113.05	58	58	58	58	1.38	114.42
South Cotabato	0.340	12,263	10,568	9,591	9,476	272.85	3	3	3	3	0.10	272.95
North Cotabato	0.038	1,705	1,659	1,547	1,540	44.01	21	21	17	17	0.48	44.48
Sultan Kudarat	0.052	2,017	1,831	1,612	1,315	30.57	18	18	18	18	0.37	30.94
Agusan del Norte	0.027	471	381	276	275	6.12	0	0	0	0	0.00	6.12
Agusan del Sur	0.109	2,984	2,712	1,876	1,824	39.90	121	121	15	5	0.19	40.09
Surigao del Sur	0.896	14,764	14,239	9,660	8,680	174.15	54	13	13	0	0.13	174.28
Total		104,077	98,143	77,304	75,401	1,683.85	275	235	125	102	2.63	1,686.48

Source: JICA Survey Team

Table 3.4.6-2 Annual Irrigation Water Demands of 2030 in WRR XI

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Bukidnon	0.046	2,521	2,138	1,825	1,810	26.83	0	0	0	0	0.00	26.83
Davao de Oro (Compostela Valley)	0.477	19,784	19,723	16,765	16,765	303.13	0	0	0	0	0.00	303.13
Davao del Norte	0.989	29,286	27,772	23,606	23,606	416.12	0	0	0	0	0.00	416.12
Davao del Sur Davao Occidental	0.998	22,401	21,905	18,713	18,526	457.30	0	0	0	0	0.00	457.30
Davao Oriental	0.949	11,119	11,081	9,385	9,452	206.93	0	0	0	0	0.00	206.93
Sarangani	0.869	6,086	5,458	4,799	4,465	110.22	58	58	57	57	1.34	111.56
South Cotabato	0.340	18,968	17,273	14,770	14,592	344.25	5	6	5	5	0.12	344.37
North Cotabato	0.038	2,868	2,822	2,408	2,397	57.56	35	35	26	26	0.62	58.18
Sultan Kudarat	0.052	2,179	1,992	1,861	1,518	35.30	19	20	21	21	0.43	35.73
Agusan del Norte	0.027	761	672	572	570	11.62	0	0	0	0	0.00	11.62
Agusan del Sur	0.109	3,914	3,638	3,258	3,167	64.58	159	162	26	9	0.30	64.88
Surigao del Sur	0.896	21,534	21,027	18,832	16,921	339.52	78	20	26	0	0.25	339.77
Total		141,420	135,501	116,793	113,789	2,373.36	355	300	161	118	3.07	2,376.43

Source: JICA Survey Team

Table 3.4.6-3 Annual Irrigation Water Demands of 2040 in WRR XI

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Bukidnon	0.046	3,123	2,740	2,338	2,319	34.38	0	0	0	0	0.00	34.38
Davao de Oro (Compostela Valley)	0.477	32,486	32,425	27,561	27,561	498.35	0	0	0	0	0.00	498.35
Davao del Norte	0.989	29,582	28,068	23,858	23,858	420.57	0	0	0	0	0.00	420.57
Davao del Sur Davao Occidental	0.998	27,364	26,868	22,952	22,723	560.89	0	0	0	0	0.00	560.89
Davao Oriental	0.949	13,880	13,842	11,724	11,808	258.50	0	0	0	0	0.00	258.50
Sarangani	0.869	6,086	5,458	4,799	4,465	110.22	58	58	57	57	1.34	111.56
South Cotabato	0.340	25,673	23,977	20,503	20,257	477.88	7	8	7	7	0.17	478.05
North Cotabato	0.038	4,030	3,984	3,400	3,385	81.27	49	50	37	37	0.88	82.15
Sultan Kudarat	0.052	2,341	2,154	2,012	1,641	38.16	21	21	22	22	0.46	38.62
Agusan del Norte	0.027	1,051	962	819	816	16.64	0	0	0	0	0.00	16.64
Agusan del Sur	0.109	4,844	4,564	4,088	3,973	81.02	196	203	33	12	0.38	81.40
Surigao del Sur	0.896	28,304	27,815	24,912	22,384	449.12	103	26	35	0	0.33	449.45
Total		178,764	172,858	148,966	145,190	3,027.01	434	366	191	135	3.56	3,030.57

Source: JICA Survey Team

Table 3.4.6-4 Annual Irrigation Water Demands of 2050 in WRR XI

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Bukidnon	0.046	3,725	3,342	2,852	2,829	41.94	0	0	0	0	0.00	41.94
Davao de Oro (Compostela Valley)	0.477	45,188	45,127	38,358	38,358	693.57	0	0	0	0	0.00	693.57
Davao del Norte	0.989	29,879	28,364	24,110	24,110	425.01	0	0	0	0	0.00	425.01
Davao del Sur Davao Occidental	0.998	32,326	31,830	27,191	26,920	664.49	0	0	0	0	0.00	664.49
Davao Oriental	0.949	16,642	16,604	14,063	14,164	310.08	0	0	0	0	0.00	310.08
Sarangani	0.869	6,086	5,458	4,799	4,465	110.22	58	58	57	57	1.34	111.56
South Cotabato	0.340	32,378	30,682	26,237	25,921	611.51	9	10	9	9	0.22	611.73
North Cotabato	0.038	5,193	5,147	4,391	4,372	104.98	63	64	47	47	1.13	106.11
Sultan Kudarat	0.052	2,502	2,316	2,163	1,764	41.03	22	23	24	24	0.50	41.52
Agusan del Norte	0.027	1,342	1,252	1,067	1,062	21.66	0	0	0	0	0.00	21.66
Agusan del Sur	0.109	5,773	5,490	4,917	4,779	97.46	234	245	39	14	0.46	97.91
Surigao del Sur	0.896	35,073	34,603	30,991	27,846	558.72	128	33	43	0	0.41	559.14
Total		216,107	210,215	181,139	176,590	3,680.66	514	432	220	152	4.06	3,684.71

Source: JICA Survey Team

(2) Livestock and Poultry Water Demands

AWDs for the livestock and poultry in WRR XI are calculated as shown in Table 3.4.6-5.

Table 3.4.6-5 Annual Water Demands for Livestock & Poultry in WRR XI

Region	Province	Area	Heads in 2020		AWD (MCM) in 2020			AWD (MCM)		
		Rate	Livestock	Poultry	Livestock	Poultry	Total	2,030	2,040	2050
X	Bukidnon	0.046	34,711	467,357	0.266	0.022	0.288	0.327	0.358	0.379
XI	Davao de Oro (Compostela Valley)	0.477	77,253	509,504	0.592	0.024	0.616	0.698	0.766	0.810
	Davao del Norte	0.989	480,983	7,064,839	3.687	0.335	4.022	4.557	4.999	5.289
	Davao del Sur Davao Occidental	0.998	396,350	1,410,840	3.038	0.067	3.105	3.518	3.859	4.083
	Davao Oriental	0.949	164,874	778,071	1.264	0.037	1.301	1.474	1.617	1.710
XII	Sarangani	0.869	87,528	667,326	0.671	0.032	0.703	0.796	0.873	0.924
	South Cotabato	0.340	182,509	1,930,145	1.399	0.092	1.491	1.689	1.853	1.960
	North Cotabato	0.038	14,396	99,171	0.110	0.005	0.115	0.130	0.143	0.151
	Sultan Kudarat	0.052	9,258	32,261	0.071	0.002	0.072	0.082	0.090	0.095
XIII	Agusan del Norte	0.027	2,218	26,406	0.017	0.001	0.018	0.021	0.023	0.024
	Agusan del Sur	0.109	10,307	79,415	0.079	0.004	0.083	0.094	0.103	0.109
	Surigao del Sur	0.896	72,976	377,839	0.559	0.018	0.577	0.654	0.718	0.759
	Total		1,533,364	13,443,173	11.753	0.638	12.391	14.039	15.402	16.294

Source: JICA Survey Team

(3) Freshwater Fishpond Water Demands

AWDs for freshwater fishponds in WRR XI are estimated as shown in Table 3.4.6-6.

Table 3.4.6-6 Water Demands for Freshwater Fishponds in WRR XI

Region	Province	Area	Fishpond Area (ha) in		Annual Water Demands for Fishpond (MCM)			
		Rate	Province	WRR	2022	2030	2040	2050
X	Bukidnon	0.046	No data					
XI	Davao de Oro (Compostela Valley)	0.477	110.47	52.69	1.54	1.75	2.05	2.40
	Davao del Norte	0.989	264.02	261.12	7.62	8.65	10.16	11.89
	Davao del Sur Davao Occidental	0.998	23.38	23.33	0.68	0.77	0.91	1.06
	Davao Oriental	0.949	58.61	55.62	1.62	1.84	2.16	2.53
XII	Sarangani	0.869	20.69	17.98	0.53	0.60	0.70	0.82
	South Cotabato	0.34	30.92	10.51	0.31	0.35	0.41	0.48
	North Cotabato	0.038	No data					
	Sultan Kudarat	0.052	No data					
XIII	Agusan del Norte	0.027	No data					
	Agusan del Sur	0.109	28.62	3.12	0.09	0.10	0.12	0.14
	Surigao del Sur	0.896	69.43	62.21	1.82	2.06	2.42	2.83
	Total		**606.14**	**486.59**	**14.21**	**16.13**	**18.93**	**22.16**

Source: JICA Survey Team

3.4.6.3 Water Demand Forecast for Municipal and Industrial Sector WRR XI

(1) Water Demand Forecast Methodology

1) Target Year

To assess the water resources in 2030, 2040, and 2050, the respective municipal and industrial water demands were estimated.

2) Population Projection

Population projection was based on population projection (medium) in latest census data (2020) publicized by PSA.

3) Unit Water Consumption

Unit water consumption was based on the conditional value of PWSSMP 2018. In addition, the values confirmed in the site survey were applied as shown in Table 3.3.6-7.

Table 3.4.6-7 Unit Water Consumption (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR XI	Davao	Davao	159	166	174	183	192	202	213	DCWD hearing survey
	General Santos	General Santos	180	180	180	180	180	180	180	GSCWD hearing survey
Other cities in Urban Area			120	120	120	120	120	120	120	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	60	60	60	60	60	60	Domestic demand (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

4) Non-Revenue Water Ratio

Non-revenue water ratio was based on the conditional value of PWSSMP 2018. In addition, the values confirmed in the site survey were applied as shown in Table 3.3.6-8.

Table 3.4.6-8 Non-Revenue Water Ratio

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR XI	Davao	Davao	29%	22%	20%	15%	15%	15%	15%	DCWD hearing survey
	General Santos	General Santos	29%	27%	25%	23%	21%	20%	20%	GSCWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

5) Allocation for Municipal Water Demand

Allocation for each category was based on the current consumption result confirmed in PWSSMP 2018 and the site survey as shown in Table 3.3.6-9.

Table 3.4.6-9 Allocation for Municipal Water Demand

WRR	Water District	Municipality	Domestic (%)	Commercial (%)	Institutional (%)	Total (%)	Resource
WRR XI	Davao	Davao	80%	17%	3%	100%	Projected Water Consumption as of 2022 by MDWD hearing survey
	General Santos	General Santos	**80%**	**17%**	**3%**	**100%**	Refer to Davao Data
Other cities in Urban Area			93%	6%	1%	100%	Current Allocation (urban) in PWSSMP2018
Other cities in Rural Area			90%	8%	2%	100%	Current Allocation (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

6) Correlation Formula between GRDP and Industrial Water Demand

In the estimation of the future industrial water demand, the past trend of industrial GRDP was calculated based on the GRDP record and percentage of the industry to GDP on PSA "Regional Accounts of the Philippines" 2021 as shown in Table 3.3.6-10.

Table 3.4.6-10 Past Trend of Industrial GRDP

Water Resource Region		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
WRR XI	REGION X (NORTHERN MINDANAO)	145,481	150,822	163,086	172,845	189,649	200,933	218,908	232,152	250,966	254,954
	REGION XI (DAVAO REGION)	142,474	144,834	156,267	166,034	183,049	197,976	218,376	237,791	257,172	265,722
	REGION XII (SOCCSKSARGEN)	83,707	85,838	93,326	101,759	109,140	113,054	119,267	128,723	138,852	136,774
	REGION XIII (Caraga)	49,082	51,383	57,140	62,554	68,861	73,545	78,847	83,691	88,807	87,247

Source: JICA Survey Team

Also, the past trend of industrial water use was calculated by dividing the NWRB national industrial water rights grant record by the above past trend of industrial GRDP as shown in Table 3.4.6-11.

Table 3.4.6-11 Past Trend of Industrial Water Use

Water Resource Region		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
WRR XI	REGION X (NORTHERN MINDANAO)	105	109	110	111	115	115	121	121	123	125
	REGION XI (DAVAO REGION)	103	104	105	107	111	114	120	124	126	130
	REGION XII (SOCCSKSARGEN)	60	62	63	66	66	65	66	67	68	67
	REGION XIII (Caraga)	35	37	39	40	42	42	43	43	43	43

Source: JICA Survey Team

Based on the above past trend of industrial GRDP and industrial water use, correlation formula between industrial GRDP and industrial water use is calculated using the formula below. Results are shown in Table 3.3.6-12.

Industrial Water Use (MCM/Year) = SLOPE × Industrial GRDP (Million Pesos) ＋ INTERCEPT

Table 3.4.6-12 Correlation Formula Factor Between Industrial GRDP and Industrial Water Use

Water Resource Region		SLOPE	INTERCEPT
WRR XI	REGION X (NORTHERN MINDANAO)	0.00016	83
	REGION XI (DAVAO REGION)	0.00021	72
	REGION XII (SOCCSKSARGEN)	0.00011	52
	REGION XIII (Caraga)	0.00019	28

Source: JICA Survey Team

7) Industrial GRDP Projection

Industrial GRDP projection is calculated by GRDP projection (medium) and percentage of the industry to GDP on PSA "Regional Accounts of the Philippines" 2021 as shown in Table 3.3.6-13.

Table 3.4.6-13 Industrial GRDP Projection

Water Resource Region		2020	2025	2,030	2035	2040	2045	2050
WRR XI	REGION X (NORTHERN MINDANAO)	220,644	273,340	327,418	378,944	410,561	461,618	486,762
	REGION XI (DAVAO REGION)	227,802	306,802	379,944	450,659	497,768	570,104	612,407
	REGION XII (SOCCSKSARGEN)	119,837	148,001	172,689	198,235	217,763	249,409	267,915
	REGION XIII (Caraga)	74,699	72,121	70,731	74,181	81,187	94,277	102,686
	AUTONOMOUS REGION IN MUSLIM MIND/	66,655	68,939	73,191	81,143	91,035	107,672	119,456

Source: JICA Survey Team

(2) Water Demand Forecast Result

1) Water Demand Forecast Result for Municipal Sector

Based on the above population projection and prediction condition for the municipal water demand forecast, the municipal water demand forecast is calculated as shown in Table 3.3.6-14. The detailed water demand forecast result is shown in Appendix A.

Table 3.4.6-14 Result of Municipal Water Demand Forecast for Priority WRRs

Water Resource Region	Municipal Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR XI - SOUTHEASTERN MINDANAO	421	444	463	488	520	552	581

Source: JICA Survey Team

2) Water Demand Forecast Result for Industrial Sector

Based on the above correlation formula and industrial GRDP projection, the industrial water demand forecast is calculated as shown in Table 3.4.6-15. The detailed water demand forecast result is shown in Appendix B.

Table 3.4.6-15 Result of Industrial Water Demand Forecast for Priority WRRs

Water Resource Region	Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR XI - SOUTHEASTERN MINDANAO	159	177	194	210	221	239	248

Source: JICA Survey Team

3.4.6.4 Water Resources Facility Plan (Hydropower Plant, Dam)

Plans of the irrigation dams and flood control dams are presented in Section 3.4.3.8 Current Status of Water Use Facilities in WRR XI and Section 3.4.3.10 Flood Risk Management (FRM) in WRRXI.

3.4.6.5 River Maintenance Flow (Environmental Flow)

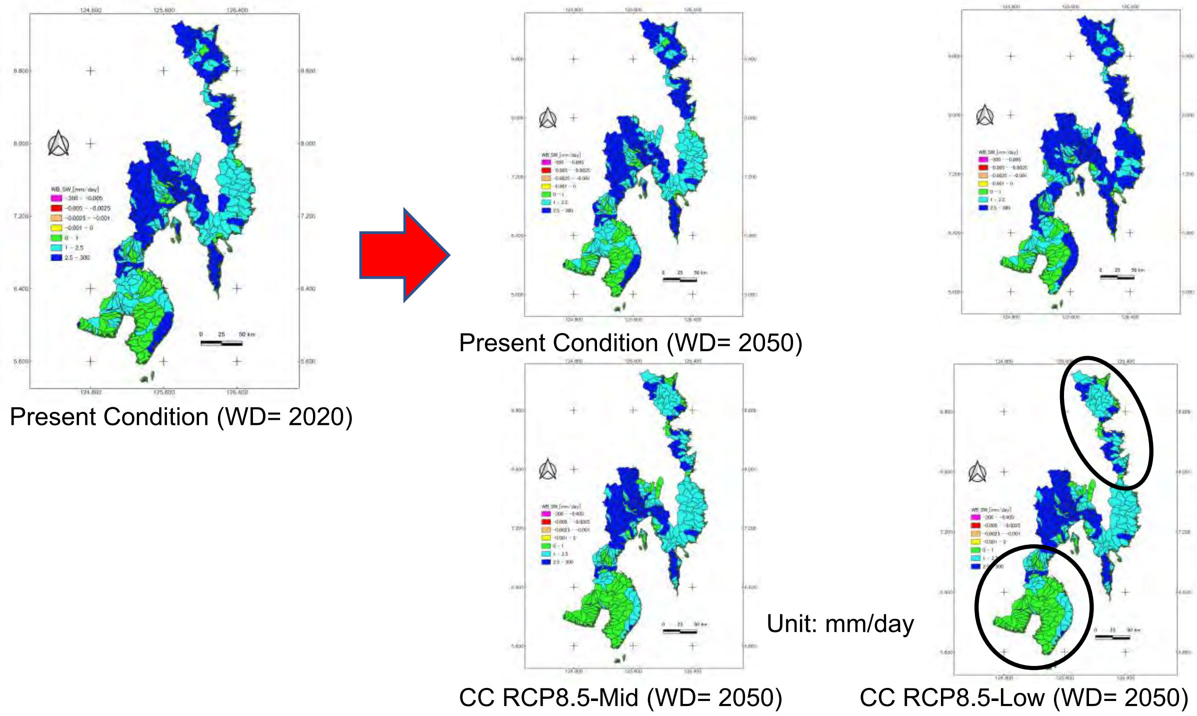
10% of dependable flow (80% of flow duration curve) is applied in the study based on based on DENR-NWRB resolution No. 030613.

3.4.7 Water Balance in WRR XI

(1) Sub-basin-wise Surface Water Balance

Sub-basin-wise surface water balances at the present condition, future (2050), and climate change conditions are shown in the Figure 3.4.7-1.

In terms of future water demand (2050), although it is a severe case that does not take any measures in RCP8.5, in the RCP8.5-Low case of climate change, the surface water balances of the northern part of WRR XI and near the Metro General Santos City areas are on a declining trend.

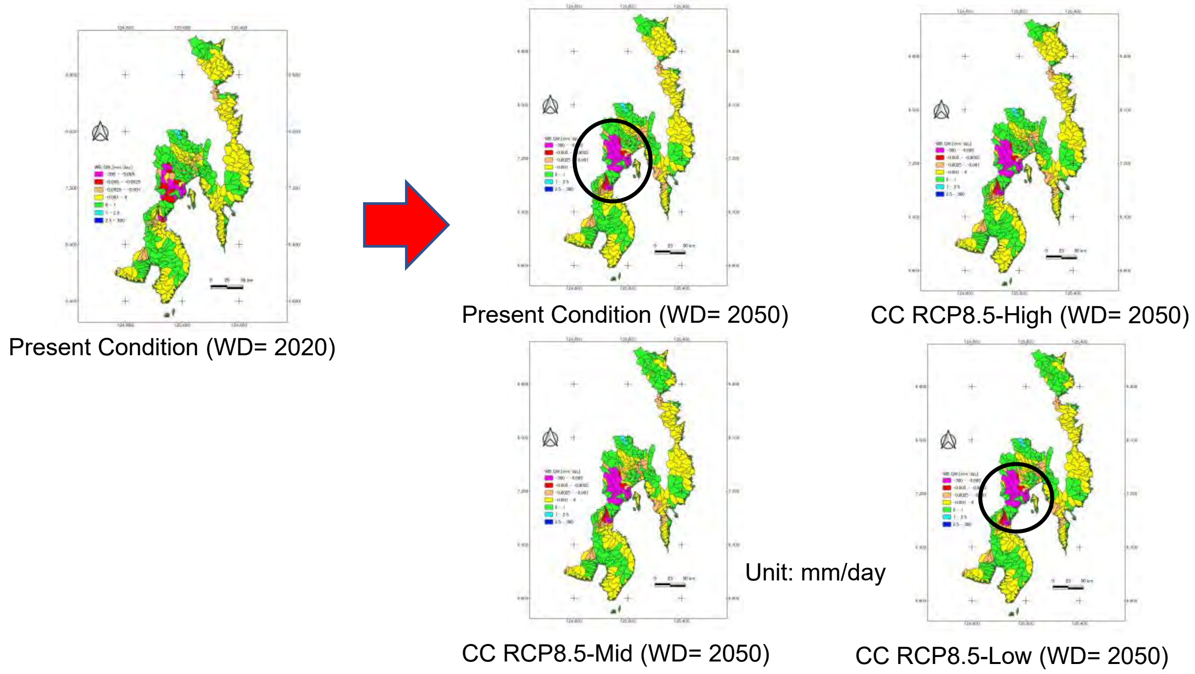


Source: JICA Survey Team

Figure 3.4.7-1 Estimated Sub-basin-wise Surface Water Balance in WRR XI

(2) Sub-basin-wise Groundwater Balance

Sub-basin-wise groundwater balances at the present condition, future (2050), and climate change conditions are shown in Figure 3.4.7-2. In terms of future water demand (2050) of groundwater, in the RCP8.5-Low case of climate change, the groundwater balance near Metro Davao City areas of WRR XI will be on a declining trend.



Source: JICA Survey Team

Figure 3.4.7-2 Estimated Sub-Basin wise Groundwater Balance in WRR XI

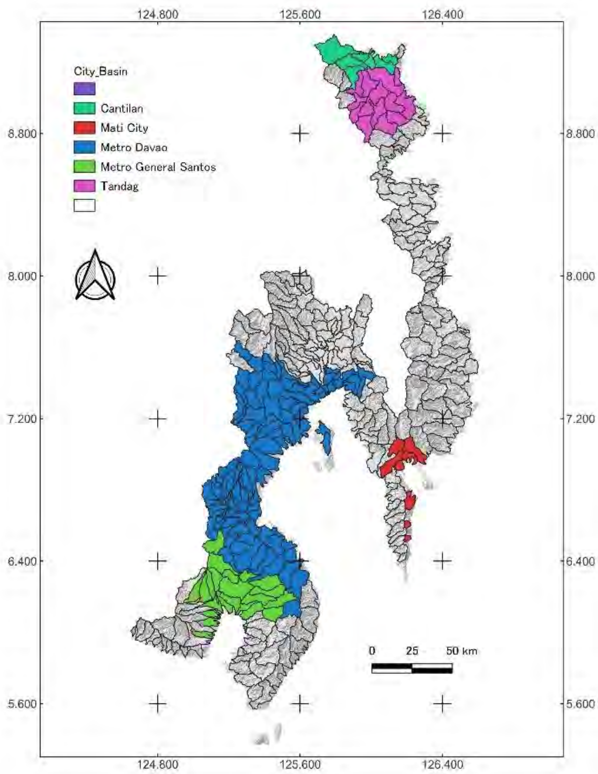
(3) Provincial-wise Water Balance

Provincial-wise surface and groundwater balances in 1/5-dry year at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. The water balance of groundwater in 2050 in Davao del Sur, North Cotabato, South Cotabato, Sultan Kudarat, and Surigao del Sur provinces will be negative in the future.

The summary of water balance and deficit estimation of provincial-wise surface and groundwater balance at each climate change condition and water demand of 2020 and 2050 are shown in Annex-D: Hydrology. In Bukidnon, Davao del Sur, North Cotabato, Sarangani, South Cotabato, Sultan Kudarat, and Surigao del Sur provinces, negative values of annual water and deficit of groundwater will be increased in the future.

(4) Major City/Town-wise Water Balance

The location map of major cities in WRR XI is shown in Figure 3.4.7-3.



Source: JICA Survey Team

Figure 3.4.7-3 Location Map of Major Cities in WRR XI

The surface and groundwater balances in 1/5-dry year in the major cities at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. In most cities, the groundwater balance is projected to be negative against the water demand in 2050, and the negative groundwater balance is particularly large in the Metro Davao and Metro General Santos areas. All cities will have surplus of surface water balance in the future. However, these annual surface water potentials include flood discharge. Thus, surface water reservoirs might be needed.

Table 3.4.7-1 Surface and Groundwater Balance of Metro Davao in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)

City/Town : Metro Davao Target Year= 2050
Weather Condition: Present Total Area [km2]= 5,896 Unit: MCM

Items	1	2	3	4	5	6	7	8	9	10	11	12	Annual	Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deficit
Rainfall	754.3	698.4	560.1	350.2	1,244.3	1,747.3	699.4	1,142.8	1,400.9	1,017.5	710.9	471.2	10,797.1	
Surface Water Potential	**773.5**	**478.8**	**398.2**	**257.8**	**409.8**	**736.5**	**453.7**	**557.5**	**811.7**	**629.9**	**525.0**	**374.2**	**6,406.6**	
Irrigation Water Demand (SW)	137.7	96.2	79.5	52.5	44.1	132.0	112.8	125.1	71.0	21.2	112.9	154.0	1,139.1	
Livestock Water Deamnd (SW)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	5.1	
Municipal and Industrial Water Demand (SW)	10.4	9.4	10.4	10.0	10.4	10.0	10.4	10.4	10.0	10.4	10.0	10.4	122.2	
Other Water Demand (SW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Water Demand (SW)	148.5	106.0	90.4	62.9	54.9	142.5	123.6	135.9	81.5	32.1	123.3	164.9	1,266.4	
SW Water Balance	**625.0**	**372.9**	**307.8**	**194.8**	**354.9**	**594.1**	**330.1**	**421.6**	**730.2**	**597.8**	**401.7**	**209.3**	**5,140.2**	**0.0**
Groundwater Potential	**6.6**	**6.0**	**4.7**	**4.1**	**4.3**	**5.1**	**4.6**	**4.5**	**4.3**	**4.8**	**6.0**	**5.8**	**60.9**	
Safety Groundwater Availability (70% of GWP)	**4.6**	**4.2**	**3.3**	**2.8**	**3.0**	**3.6**	**3.2**	**3.1**	**3.0**	**3.4**	**4.2**	**4.0**	**42.6**	
Irrigation Water Demand (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
Livestock Water Deamnd (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
Municipal and Industrial Water Demand (GW)	43.2	39.0	43.2	41.8	43.2	41.8	43.2	43.2	41.8	43.2	41.8	43.2	508.5	
Other Water Demand (GW)	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	10.9	
Total Water Demand (GW)	44.1	39.9	44.1	42.7	44.1	42.7	44.1	44.1	42.7	44.1	42.7	44.1	519.6	
GW Water Balance	**-39.5**	**-35.7**	**-40.8**	**-39.9**	**-41.1**	**-39.1**	**-40.9**	**-41.0**	**-39.7**	**-40.7**	**-38.5**	**-40.1**	**-477.0**	**-477.0**
Total Water Potential (SW+GW)	**778.1**	**483.0**	**401.5**	**260.6**	**412.9**	**740.1**	**456.9**	**560.7**	**814.7**	**633.3**	**529.2**	**378.2**	**6,449.2**	
Irrigation Water Demand (Total)	137.7	96.2	79.6	52.5	44.1	132.0	112.8	125.1	71.0	21.2	112.9	154.1	1,139.2	
Livestock Water Deamnd (Total)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	5.3	
Municipal and Industrial Water Demand (Total)	53.6	48.4	53.6	51.8	53.6	51.8	53.6	53.6	51.8	53.6	51.8	53.6	630.7	
Other Water Demand (Total)	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	10.9	
Total Water Demand (SW+GW)	192.7	145.8	134.5	105.7	99.1	185.2	167.7	180.0	124.2	76.2	166.0	209.0	1,786.0	
Total Water Balance (SW+GW)	**585.5**	**337.2**	**267.0**	**155.0**	**313.8**	**554.9**	**289.2**	**380.7**	**690.5**	**557.1**	**363.2**	**169.2**	**4,663.2**	-477.0

Source: JICA Survey Team

The summary of water balance and deficit estimation of surface and groundwater balances at each climate change condition and water demand of 2020 and 2050 in Metro Davao and Metro General Santos areas are shown in Annex-D: Hydrology. In Metro Davao, negative values of annual water and the deficit of groundwater will increase in the future.

Table 3.4.7-2 Summary of Annual Water Balance and Deficit of Metro Davao at Each Climate Change Condition

Total Area [km^2]= 5,896

Case No.	Weather Condition	Water Demand	Target Year	SW.Balance [MCM/year]	GW.Balance [MCM/year]	Total W.Balance [MCM/year]	SW.Deficit [MCM/year]	GW.Deficit [MCM/year]	Total W.Deficit [MCM/year]
1	Present	2020	Average Year	7,745.5	-281.8	7,463.6	0.0	-281.8	-281.8
2	Present	2020	1/5-Dry Year	5,677.5	-281.9	5,395.6	0.0	-281.9	-281.9
3	Present	2020	1/10-Dry Year	4,862.8	-282.0	4,580.8	0.0	-282.0	-282.0
4	Present	2050	Average Year	7,208.1	-476.9	6,731.2	0.0	-476.9	-476.9
5	Present	2050	1/5-Dry Year	5,140.2	-477.0	4,663.2	0.0	-477.0	-477.0
6	Present	2050	1/10-Dry Year	4,325.4	-477.1	3,848.3	0.0	-477.1	-477.1
7	CC RCP8.5-High	2050	Average Year	6,878.6	-476.9	6,401.7	0.0	-476.9	-476.9
8	CC RCP8.5-High	2050	1/5-Dry Year	5,236.5	-476.9	4,759.6	0.0	-476.9	-476.9
9	CC RCP8.5-High	2050	1/10-Dry Year	4,584.9	-477.0	4,107.9	0.0	-477.0	-477.0
10	CC RCP8.5-Mid.	2050	Average Year	6,553.1	-491.1	6,062.1	0.0	-491.1	-491.1
11	CC RCP8.5-Mid.	2050	1/5-Dry Year	5,037.1	-491.2	4,545.9	0.0	-491.2	-491.2
12	CC RCP8.5-Mid.	2050	1/10-Dry Year	4,660.8	-491.0	4,169.7	0.0	-491.0	-491.0
13	CC RCP8.5-Low	2050	Average Year	7,253.5	-495.8	6,757.7	0.0	-495.8	-495.8
14	CC RCP8.5-Low	2050	1/5-Dry Year	5,121.9	-495.9	4,626.0	0.0	-495.9	-495.9
15	CC RCP8.5-Low	2050	1/10-Dry Year	4,843.7	-495.6	4,348.0	0.0	-495.6	-495.6

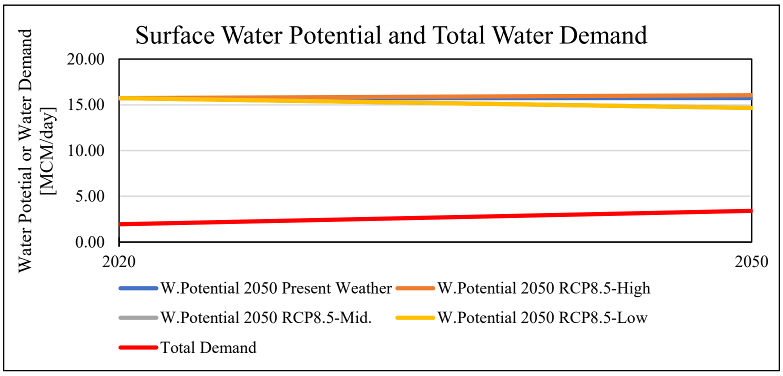
Source: JICA Survey Team

Table 3.4.7-3 Summary of Annual Water Balance and Deficit of Metro General Santos at Each Climate Change Condition

Total Area [km^2]= 1,737

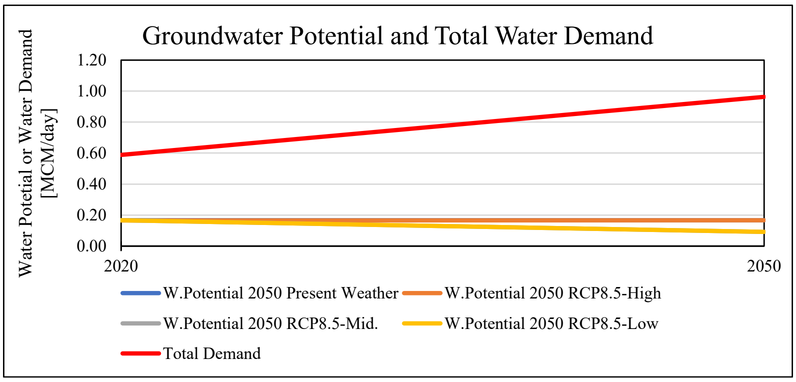
Case No.	Weather Condition	Water Demand	Target Year	SW.Balance [MCM/year]	GW.Balance [MCM/year]	Total W.Balance [MCM/year]	SW.Deficit [MCM/year]	GW.Deficit [MCM/year]	Total W.Deficit [MCM/year]
1	Present	2020	Average Year	2,817.0	-90.0	2,727.1	0.0	-90.0	-90.0
2	Present	2020	1/5-Dry Year	2,576.7	-90.1	2,486.6	0.0	-90.1	-90.1
3	Present	2020	1/10-Dry Year	2,485.3	-90.1	2,395.2	0.0	-90.1	-90.1
4	Present	2050	Average Year	2,745.1	-115.0	2,630.0	0.0	-115.0	-115.0
5	Present	2050	1/5-Dry Year	2,504.7	-115.2	2,389.6	0.0	-115.2	-115.2
6	Present	2050	1/10-Dry Year	2,413.4	-115.1	2,298.2	0.0	-115.1	-115.1
7	CC RCP8.5-High	2050	Average Year	2,646.6	-115.0	2,531.6	0.0	-115.0	-115.0
8	CC RCP8.5-High	2050	1/5-Dry Year	2,401.3	-115.1	2,286.1	0.0	-115.1	-115.1
9	CC RCP8.5-High	2050	1/10-Dry Year	2,400.3	-115.1	2,285.1	0.0	-115.1	-115.1
10	CC RCP8.5-Mid.	2050	Average Year	1,505.9	-125.1	1,380.9	0.0	-125.1	-125.1
11	CC RCP8.5-Mid.	2050	1/5-Dry Year	1,198.6	-125.2	1,073.5	0.0	-125.2	-125.2
12	CC RCP8.5-Mid.	2050	1/10-Dry Year	1,195.4	-125.1	1,070.2	0.0	-125.1	-125.1
13	CC RCP8.5-Low	2050	Average Year	2,819.8	-130.7	2,689.1	0.0	-130.7	-130.7
14	CC RCP8.5-Low	2050	1/5-Dry Year	2,645.2	-130.8	2,514.4	0.0	-130.8	-130.8
15	CC RCP8.5-Low	2050	1/10-Dry Year	2,483.8	-130.8	2,353.0	0.0	-130.8	-130.8

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.4.7-4 Surface Water Balance of Metro Davao in 1/5-Dry Year at Each Climate Change Condition



Source: JICA Survey Team

Figure 3.4.7-5 Groundwater Balance of Metro Davao in 1/5-Dry Year at Each Climate Change Condition

The summary of water balance of major cities in WRR-XI at water demand of 2050 is shown in Table 3.4.7-4 below. Annual water balance in all cities will be positive, however in dry season, it will be tight in some of month. Looking at the groundwater balance forecast for the present weather condition in 2050, Metro Davao, Metro General Santos and Tandag cites have negative groundwater balances, especially in Metro Davao.

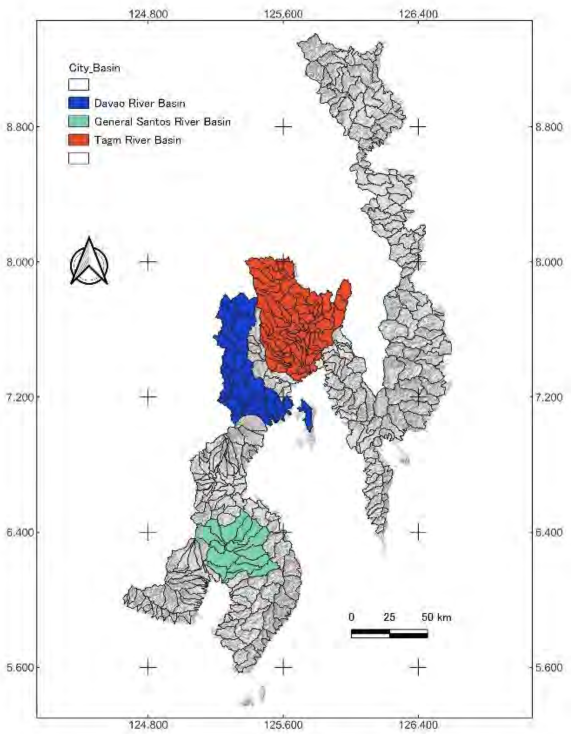
Table 3.4.7-4 Summary of Annual Water Balance of Major Cities in WRR-XI in 2050

City	Weather Condition	Water Demand	Target Year	Total Area [km2]	SW/GW	W.Potential [MCM/year]	Domestic & Industrial W.Demand [MCM/year]	Irrigation W. Demand [MCM/year]	Livestock W. Demand [MCM/year]	Other W. Demand [MCM/year]	Water Balance [MCM/year]
Metro Davao	Present	2050	1/5-Dry Year	5,896.2	SW	6,406.6	122.2	1,139.1	5.1	0.0	5,140.2
					GW	60.9	508.5	0.1	0.1	10.9	-458.7
					Total	6,467.5	630.7	1,139.2	5.3	10.9	4,681.5
Metro General Santos	Present	2050	1/5-Dry Year	1,737.5	SW	2,727.6	29.7	191.9	1.3	0.0	2,504.7
					GW	50.2	147.3	0.5	2.5	0.0	-100.1
					Total	2,777.8	177.0	192.4	3.8	0.0	2,404.6
Cantilan	Present	2050	1/5-Dry Year	628.3	SW	843.2	4.7	13.8	0.1	0.0	824.6
					GW	11.9	1.7	0.0	0.0	0.0	10.1
					Total	855.1	6.4	13.8	0.1	0.0	834.7
Tandag	Present	2050	1/5-Dry Year	1,282.8	SW	1,657.5	7.8	49.5	0.3	0.0	1,599.9
					GW	0.2	5.0	0.0	0.0	0.0	-4.9
					Total	1,657.7	12.8	49.5	0.3	0.0	1,595.1
Mati	Present	2050	1/5-Dry Year	409.1	SW	462.4	14.3	63.0	0.1	0.0	385.0
					GW	5.2	1.7	0.0	0.0	0.0	3.5
					Total	467.6	16.0	63.0	0.1	0.0	388.5

Source: JICA Survey Team

(5) Major River Basin-wise Water Balance

The location map of major river basins in WRR XI is shown in Figure 3.4.7-6.



Source: JICA Survey Team

Figure 3.4.7-6 Location Map of Major River Basins in WRR-XI

The surface and groundwater balances in 1/5-dry year in the major river basins at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. The Davao River basin near Davao City area will have a negative water balance of groundwater in 2050.

Table 3.4.7-5 Surface and Groundwater Balance of Davao River Basin in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)

River Basin: Davao River Basin Target Year= 2050
Weather Condition: Present Total Area [km2]= 2,144 Unit: MCM

Items	1	2	3	4	5	6	7	8	9	10	11	12	Annual	Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deficit
Rainfall	305.8	293.8	266.7	152.1	596.4	757.0	301.7	550.4	673.6	415.8	320.6	183.0	4,816.7	
Surface Water Potential	**280.9**	**176.1**	**180.6**	**145.0**	**226.3**	**321.1**	**198.5**	**259.5**	**355.5**	**262.0**	**210.7**	**146.5**	**2,762.7**	
Irrigation Water Demand (SW)	21.6	20.3	13.6	0.0	0.1	19.0	16.6	21.9	10.8	0.0	12.8	16.0	152.7	
Livestock Water Deamnd (SW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	
Municipal and Industrial Water Demand (SW)	1.4	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	17.0	
Other Water Demand (SW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Water Demand (SW)	23.1	21.7	15.1	1.4	1.6	20.5	18.1	23.4	12.2	1.5	14.2	17.5	170.3	
SW Water Balance	**257.7**	**154.4**	**165.5**	**143.6**	**224.8**	**300.6**	**180.3**	**236.2**	**343.3**	**260.5**	**196.5**	**129.0**	**2,592.4**	**0.0**
Groundwater Potential	**1.4**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.4**	**1.3**	**1.4**	**16.0**	
Safety Groundwater Availability (70% of GWP)	**1.0**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**1.0**	**11.2**	
Irrigation Water Demand (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Livestock Water Deamnd (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Municipal and Industrial Water Demand (GW)	28.2	25.5	28.2	27.3	28.2	27.3	28.2	28.2	27.3	28.2	27.3	28.2	332.2	
Other Water Demand (GW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.2	
Total Water Demand (GW)	28.7	26.0	28.7	27.8	28.7	27.8	28.7	28.7	27.8	28.7	27.8	28.7	338.4	
GW Water Balance	**-27.8**	**-25.1**	**-27.8**	**-26.9**	**-27.8**	**-26.9**	**-27.8**	**-27.8**	**-26.9**	**-27.8**	**-26.9**	**-27.8**	**-327.2**	**-327.2**
Total Water Potential (SW+GW)	**281.8**	**177.0**	**181.5**	**145.9**	**227.3**	**322.0**	**199.4**	**260.5**	**356.4**	**262.9**	**211.6**	**147.5**	**2,773.8**	
Irrigation Water Demand (Total)	21.6	20.3	13.6	0.0	0.1	19.0	16.6	21.9	10.8	0.0	12.8	16.0	152.7	
Livestock Water Deamnd (Total)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	
Municipal and Industrial Water Demand (Total)	29.7	26.8	29.7	28.7	29.7	28.7	29.7	29.7	28.7	29.7	28.7	29.7	349.2	
Other Water Demand (Total)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.2	
Total Water Demand (SW+GW)	51.9	47.6	43.8	29.3	30.3	48.3	46.9	52.1	40.0	30.2	42.0	46.2	508.6	
Total Water Balance (SW+GW)	**230.0**	**129.4**	**137.7**	**116.7**	**197.0**	**273.7**	**152.5**	**208.4**	**316.4**	**232.7**	**169.6**	**101.2**	**2,265.2**	**-327.2**

Source: JICA Survey Team

The summary of water balance and deficit estimation of surface and groundwater balances at each climate change condition and water demand of 2020 and 2050 in the Davao River basin areas are shown in Annex-D: Hydrology. In the Davao River basin, negative values of annual water and deficit of groundwater will increase in the future.

(6) Conclusion

As described above, in the Metro Davao area, negative values of annual water and deficit of groundwater will increase in the future. As shown in Table 3.4.7-5 above, annual surface water balance in all cities will be positive, however in dry season, it will be tight in some of month (see Annex-D). Looking at the groundwater balance forecast for the present weather condition in 2050, Metro Davao, Metro General Santos and Tandag cites have negative groundwater balances, especially in Metro Davao.

Table 3.4.7-6 shows the summary of water balance analysis in WRR XI. Looking at the water balance by province, major city and by major river basin, the groundwater balance in 2050 will be negative. The deficit of groundwater balance in Davao del Sur, South Cotabato and North Cotabato provinces are large, and the negative of groundwater balance in the Metro Davao and Metro General Santos city and the Davao River Basin will be large in 2050.

Table 3.4.7-6 Surface and Groundwater Balance in WRR-XI (1/5-Dry Year, Present Weather Condition, Water Demand=2050)

Surface Water (2050, Present Weather Condition, 1/5-Dry Year)

Item	Classification	Modeled Area	Annual Rainfall	Annual Effective Rainfall**	Annual Evapo-transpiration	Annual Runoff	Annual Runoff (*SW Potential)	Runoff Coefficient	Water Demand (SW)	Water Balance (SW)
		(km^2)	(mm/year)	(mm/year)	(mm/year)	(mm/year)	(MCM/yr)	(%)	(MCM/yr)	(MCM/yr)
Province	Agusan del Sur	930	3,190	955	1,835	1,283	1,736.4	40.2%	273.6	1,462.8
	Bukidnon	353	2,879	957	1,591	1,285	605.4	44.6%	52.7	67.7
	Davao de Oro (Compostela Valley)	2,172	2,376	660	1,479	885	2,067.0	37.3%	733.3	649.3
	Davao del Norte	3,485	2,444	1,051	1,009	1,411	4,937.9	57.7%	518.9	732.1
	Davao del Sur	3,662	1,838	724	861	971	3,584.1	52.8%	713.2	692.8
	Davao Oriental	3,844	2,290	1,478	297	1,985	7,633.8	86.7%	354.3	703.1
	Davao Occidental	1,744	1,687	395	1,126	531	925.3	31.4%	19.8	10.5
	North Cotabato	282	2,142	680	1,224	913	272.7	42.6%	108.3	99.0
	Sarangani	2,507	1,409	422	834	566	1,425.0	40.2%	154.1	87.3
	South Cotabato	1,445	1,139	427	549	*573*	2,901.0	50.3%	643.0	368.3
	Sultan Kudarat	244	*2,338*	953	1,056	1,280	331.0	54.7%	42.5	54.4
	Surigao del Sur	3,269	3,127	929	1,878	1,247	4,082.2	39.9%	587.8	732.7
	Total / Average	23,938	2,238	803	1,145	1,077	30,501.9	48.1%	4,201.6	5,659.8
Major City	Metro Davao	5,896	1,841	798	760	1,071	6,406.6	58.2%	1,266.4	1,356.8
	Metro General Santos	1,737	1,220	457	580	*614*	2,727.6	50.3%	2,950.5	1,810.6
Major River Basin	Davao	2,144	2,265	933	1,006	1,252	2,762.7	55.3%	170.3	213.2
	Tagum-Libuganon	3,208	2,482	957	1,158	1,285	4,231.1	51.8%	768.7	988.0
	Buayan-Malungan (General Santos River)	1,505	1,367	287	932	385	582.8	28.2%	123.5	47.6

** Effective Rainfall = Runooff * 74.5%

Groundwater (2050, Present Weather Condition, 1/5-Dry Year)

Item	Classification	Modeled Area	Annual Recharge	Annual Recharge	GW Potential*	GW Potential*	Water Demand (GW)	Water Balance (GW)
		(km^2)	(mm/year)	(MCM/yr)	(mm/year)	(MCM/yr)	(MCM/yr)	(MCM/yr)
Province	Agusan del Sur	930	73.0	67.9	56.2	60.6	1.1	59.5
	Bukidnon	353	2.8	1.0	2.2	0.8	6.0	-5.2
	Davao de Oro (Compostela Valley)	2,172	11.7	25.4	9.0	19.5	5.3	14.2
	Davao del Norte	3,485	23.8	83.1	18.3	63.9	45.5	18.4
	Davao del Sur	3,662	6.1	22.3	4.7	17.2	492.7	-475.6
	Davao Oriental	3,844	8.0	30.7	6.1	23.6	12.7	10.9
	Davao Occidental	1,744	30.6	53.3	23.5	41.0	10.0	31.1
	North Cotabato	282	3.9	1.1	3.0	0.9	13.0	-12.1
	Sarangani	2,507	8.7	21.8	6.7	16.7	14.9	1.8
	South Cotabato	1,445	16.9	24.4	13.0	18.8	165.6	-146.8
	Sultan Kudarat	244	2.3	0.6	1.8	0.4	1.8	-1.3
	Surigao del Sur	3,269	3.2	10.5	2.5	8.1	16.5	-8.5
	Total / Average	23,938	15.9	381.1	6.1	271.4	785.1	-513.6
Major City	Metro Davao	5,896	9.4	55.4	7.2	60.9	519.6	-458.7
	Metro General Santos	1,737	26.3	45.7	20.2	50.2	150.3	-100.1
Major River Basin	Davao	2,144	6.8	14.5	5.2	16.0	338.4	-322.4
	Tagum-Libuganon	3,208	38.7	124.0	29.7	144.0	31.0	113.0
	Buayan-Malungan (General Santos River)	1,505	49.7	74.7	38.2	82.1	72.7	9.5

*Stable amount of water that can be taken

Source: JICA Survey Team

3.5 Priority Water Resources Region (WRR V)

3.5 Priority Water Resources Region (WRR V)

3.5.1 Outline of WRR V

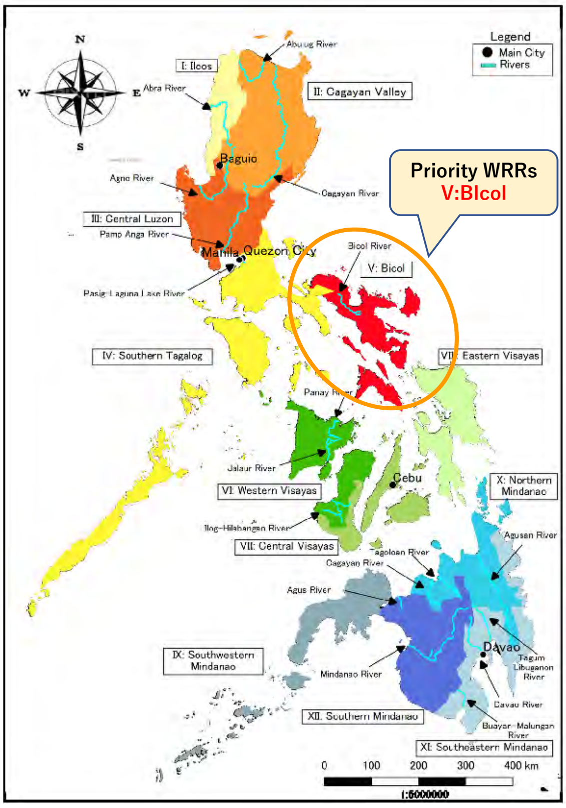
WRR V is located in the southeastern part of Luzon and includes the islands of Catanduanes and Masbate. The administrative region includes all of Region V and part of Region IV-A in the northwest. The provincial division includes six provinces of Region V and part of one province of Region IV-A.

In terms of water resources, there is one major river basin, the Bicol River basin, and major cities such as Legazpi City and Naga City. The climate is classified into Type-III and Type-IV. From the perspective of water resources, water shortages due to growing water demand in major cities, drainage problems in irrigation development, and dam sedimentation problems have become issues.

Table 3.5.1-1 General Information of WRR V

Water Resources Regions	Major 18 Rivers (Catchment Area)	Major Cities	Climate Classification	Island Name
WRR V Bicol	Bicol (3,771 km^2)	—	Type-II & IV	Luzon

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.5.1-1 Location Map of Priority WRR (WRR V)

3.5.2 Socio-Economic Situation and Organization and Legal Framework

3.5.2.1 Socio-Economic Situation

As described in previous Section 3.3.2.

3.5.2.2 Organization and Legal Framework in the WRR V

In this section, the outline of the organizations related to water resources in WRR V is summarized, and the organizations that JST visited during the site survey are introduced; sorted into (1) National government organizations, (2) LGUs, and (3) WSPs. Meanwhile, most of WRR V belongs to the administrative division of Region V (Bicol) although it covers a small part of Region IV-A (Calabarzon). Thus, JST visited organizations mainly from those within Region V.

(1) Organizations

1) National Government Organizations

As stated in Section 3.3.2(1)1), most of the national government organizations provide their regional branch offices, which have jurisdiction over the services of the national government and oversee LGUs. The organizations related to the planning and implementation of water resources projects in WRR XI that are visited by JST are introduced below.

- NEDA Region V

  In the Philippines, "Regions" are set as administrative divisions that primarily serve to coordinate planning and organize national government services across multiple LGUs. Also, most national government organizations provide their regional branch offices, which have jurisdiction over the services of the national government and oversee LGUs.

- DPWH Region V

  DPWH Region V, located in the city of Legaspi in the province of Albay, shall be responsible for highways, flood control, and water resources development systems, and other public works in its region (Sec.20, Title V, Administrative Code of 1987). It also provides some engineering offices within its region for implementing construction works or other duties.

- NIA Region V

  NIA Region V, located in the city of Naga in the province of Camarines Sur, is composed of the Sorsogon-Masbate IMO, the Camarines Norte IMO, the Camarines Sur IMO, and Albay-Catanduanes IMO. Its objective is to develop and maintain irrigation systems in support of the agricultural program of the government; to provide an adequate level of irrigation service on a sustainable basis in partnership with the farmers and local government units; to provide technical assistance to institutions in the development of water resources for irrigation; and to improve and sustain the operation of NIA as a viable corporation and service-oriented agency.

2) LGUs

According to the website of PhilAtlas, Region V, which occupies most of the area of WRR V, has six provinces (Albay, Camarines Norte, Camarines Sur, Catanduanes, Masbate, and Sorsogon), seven cities, and 107 municipalities. Meanwhile, JST has visited two LGUs, the municipality of Virac, which is the capital of the province of Catanduanes, and the city of Masbate, which is the capital of the province of Masbate, in order to collect information on water resources in the respective provinces.

3) WSPs

According to the Bicol Region Water Supply and Sanitation Databook and Regional Roadmap in the PWSSMP, the overview of the WSPs within Region V is as follows:

- As of 2015, there were 55 WDs, 37 of which were operational and 18 were non-functional.
- There are 435 LGU-run water utilities within the region.
- There are 223 BWSA utilities within the region.
- There are 65 RWSA utilities within the region.
- There are 840 private or other types of water service providers within the region.

Meanwhile, the information on water districts is obtained from the interview session with each WSP as well as the annual audit report of 2021 prepared by the Commission on Audit (COA). The water service providers the JST visited are as follows:

- Metro Naga Water District (MNWD)

  MNWD, created in May 1974, is the water district providing water to the city of Naga, and the municipalities of Camaligan, Canaman, Gainza, and Magrao. It is categorized as a "Category A" water district.

- Legaspi City Water District (LCWD)

  LCWD, created in December 1981, is the water district providing water to the city of Legaspi in the province of Albay. It has 133 regular employees and 39 job contractors. It is categorized as a "Category B" water district.

- Virac Water District (VIWAD)

  VIWAD, created in 1981, is the water district providing water to the municipality of Virac in the province of Catanduanes. It is categorized as a "Category C" water district.

- Masbate-Mobo Water District (MMWD)

MMWD, created in 1978, is the water district providing water to the city of Masbate and the municipality of Mobo in the province of Masbate.

The categorization of water districts (Category A, B, C and D) is explained in Annex C-5.

(2) Plans

The following items are the representative regional plans related to water resources in WRR V.

- Regional Development Plan of Region V 2017-2022

  This is the mid-term development plan between 2017 and 2022 prepared for Region V. The items related to water resources are described in “Chapter 19 Accelerating Infrastructure Development”.

- Bicol Region Water Supply and Sanitation Databook and Regional Roadmap

  The Water Supply and Sanitation Databook and Regional Roadmap is an attached document to the PWSSMP. It supplements the PWSSMP with maps, datasets, and charts, and presents the framework, vision, goals, and strategies formulated to achieve the planned targets in the Bicol Region.

- Integrated Bicol River Basin Management and Development Master Plan

  This is the basic management plan for the Bicol River, which is the biggest river in the Bicol Region, and whose basin is one of the 18 major river basins in the Philippines.

In addition, plans related to flood control at regional level are summarized in Table 2.2-20 of the Section2.2.11.

3.5.3 Natural Condition

3.5.3.1 Land, General Topography and Geology in WRR V

(1) Land Area

WRR V belongs mainly to the administrative Region V (Bicol), and part of the north includes administrative Region IV-A (Calabarzon). Naga and Legazpi are highly urbanized cities. Bicol comprises six provinces, four on the Bicol Peninsula mainland (the southeastern end of Luzon) - Albay, Camarines Norte, Camarines Sur, and Sorsogon - and the offshore island provinces of Catanduanes and Masbate. The regional center is Legazpi City and it has one independent component city, the pilgrim city of Naga. The region is bounded by Lamon Bay to the north, the Philippine Sea to the east, and the Sibuyan Sea and Ragay Gulf to the west. The northernmost provinces, Camarines Norte and Camarines Sur, are bordered to the west by the province of Quezon. The land area of WRR V is 18,155.82 km^2, while the population of administrative region V is 6,082,165 based on the 2020 census.

(2) General Topography and Geology

Bicol region is highly volcanic in origin and part of the Pacific Ring of Fire. Known as the Bicol Volcanic Arc or Chain, the volcanoes are the results of the Philippine Sea Plate subducting under the Philippine Mobile Belt, along the Philippine Trench. Mt. Mayon Volcano is the most prominent of the volcanoes in the region, famous for its perfect conical shape and for being the most active in the Philippines. Its eruptions have repeatedly inflicted disasters on the region, but during lulls in activity, it is a particularly magnificent peak. The southernmost tip of the peninsula is dominated by Bulusan Volcano, the other active volcano in the region.

3.5.3.2 Meteorology and Hydrology in WRR V

(1) Climate and Climate Regions of the Study Area

Most of WRR V are located in Type-II and Type-III climatological types as shown in Figure 3.5.3-1.

Source: PAGASA (http://bagong.pagasa.dost.gov.ph/information/climate-philippines)

Figure 3.5.3-1 Climate Regions in Philippines

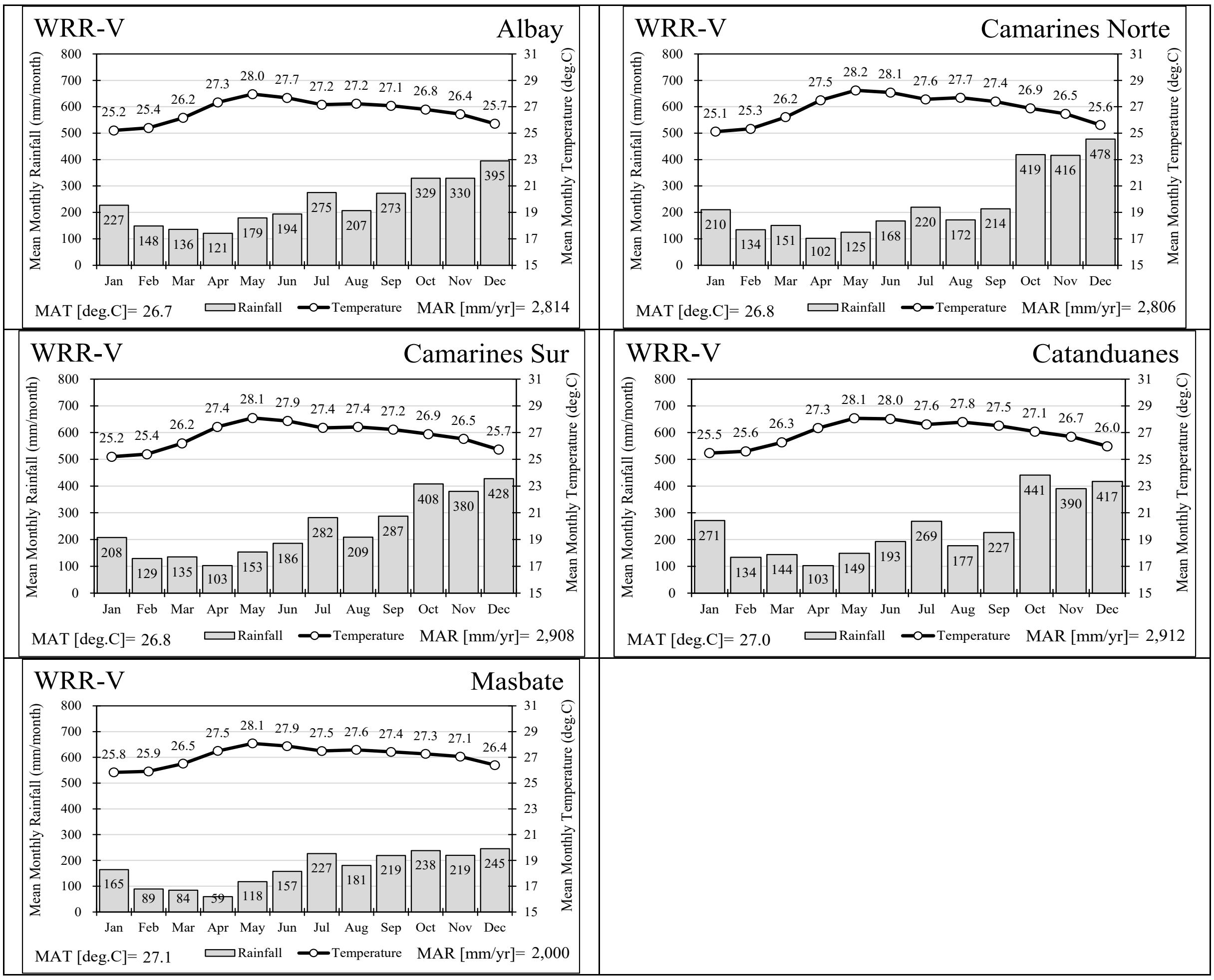
The northern part of WRR V has climate Type-II, where there is no dry season with a very pronounced maximum rain period from December to February in general. There is not a single dry month. Minimum monthly rainfall occurs during the period from March to May.

In the southern part of WRR V, which has the climate type-III, there is no pronounced maximum rain period, with a short dry season lasting only from one to three months, either during the period from December to February or from March to May in general. This climate type resembles Type-I since it has a short dry season.

(2) Temperature and Rainfall

The average annual temperature in Camarines Sur is around 26.8 °C. The temperature is stable throughout the year, but the highest temperature is around April to July.

Daily mean temperatures from 1979 to 2020 of ERA5 (0.25-degree grid; approximately 31 km mesh) were collected from the ECMWF reanalysis datasets. Provincial mean monthly rainfall and mean monthly temperature from 1979 to 2020 (42 years) in each water resources region are shown in the Figure 3.5.3-2.



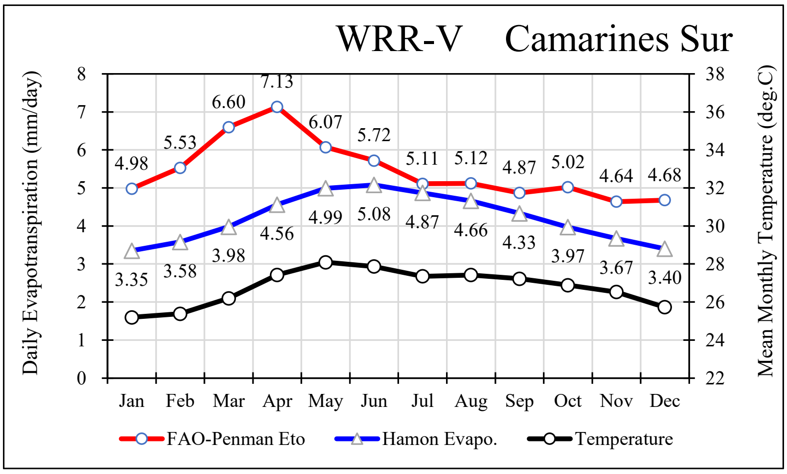
Source: JICA Survey Team, based on ERA5 and CHIRPS data.

Figure 3.5.3-2 Provincial Mean Monthly Rainfall and Mean Monthly Temperature from 1979 to 2020 (42 Years) in Each Province in WRR-V

(3) Evapotranspiration

The estimated daily potential evapotranspiration (reference crop evapotranspiration) (ETo) averaged by each province using the FAO-Penman-Monteith equation was used for paddy fields and the estimated daily average potential evapotranspiration by province using Hamon's equation was used for other land use fields. The ten-day reference crop evapotranspiration (ETo) was also used for the estimation of the crop water requirement of paddy by province. The evapotranspiration calculation formulas for each estimation are shown in Chapter 2 Section 2.4.2.

The estimated daily evapotranspiration by FAO-ETo and Hamon methods, averaged by province, are shown in Figure 3.5.3-3.



Source: JICA Survey Team, based on ERA5 and FAO-ClimWat data.

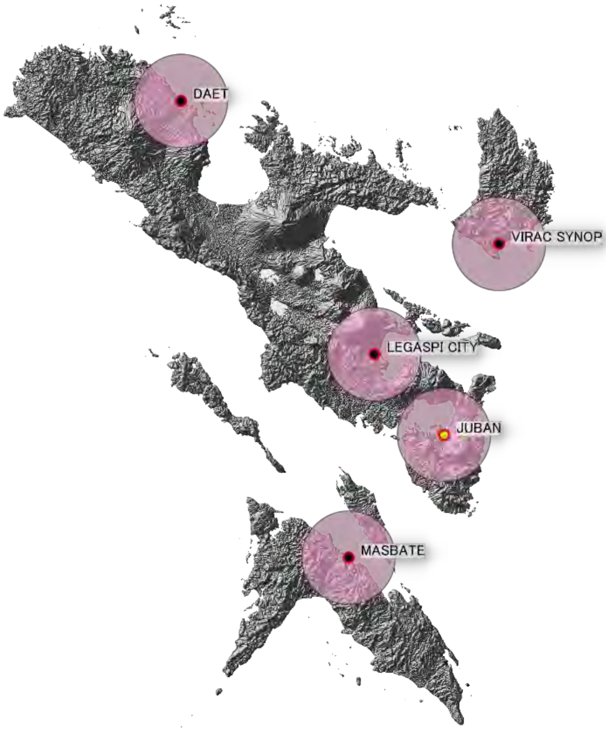
Figure 3.5.3-3 Estimated Daily Potential Evapotranspiration of FAO-ETo and Hamon Method

(4) Precipitation/Weather Data

In this study, satellite rainfall data (CHIRPS) and re-analysis rainfall data (ERA5) were used due to the low density of observed rainfall stations within the priority WRR.

As described in Section 3.3.3(4), the same dataset and methodology are applied for the preparation of the precipitation and weather data in WRR V. In WRR V, datasets at five of PAGASA's stations, namely: VIRAC SYOP, DAET, LEGASPI CITY, JUBAN, and MASBATE, are available. Figure 3.5.3-4 shows the locations of the stations. In this section, the results of VIRAC SYOP are described. Annual trends of the monthly precipitation and the biases from the average are shown in Figure 3.5.3-5. Inter-annual trends of each precipitation dataset are almost the same among three datasets except for an underestimation around December in the ERA5 trend. The CHIRPS's cumulative precipitation amount compared to PAGASA's rain gauge shows 0.5% of overestimation.

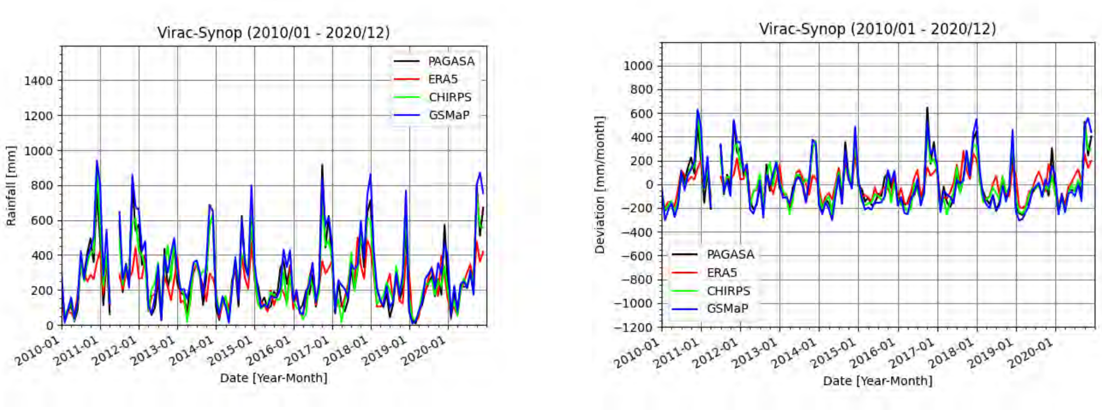
Although there is some bias in the CHIRPS and PAGASA observation data, the CHIRPS is applied for the hydrological analysis without correction in this study considering the limited number of the PAGASA stations.



Source: JICA Survey Team

Figure 3.5.3-4 Location at Station in WRR-V

(a) (b)



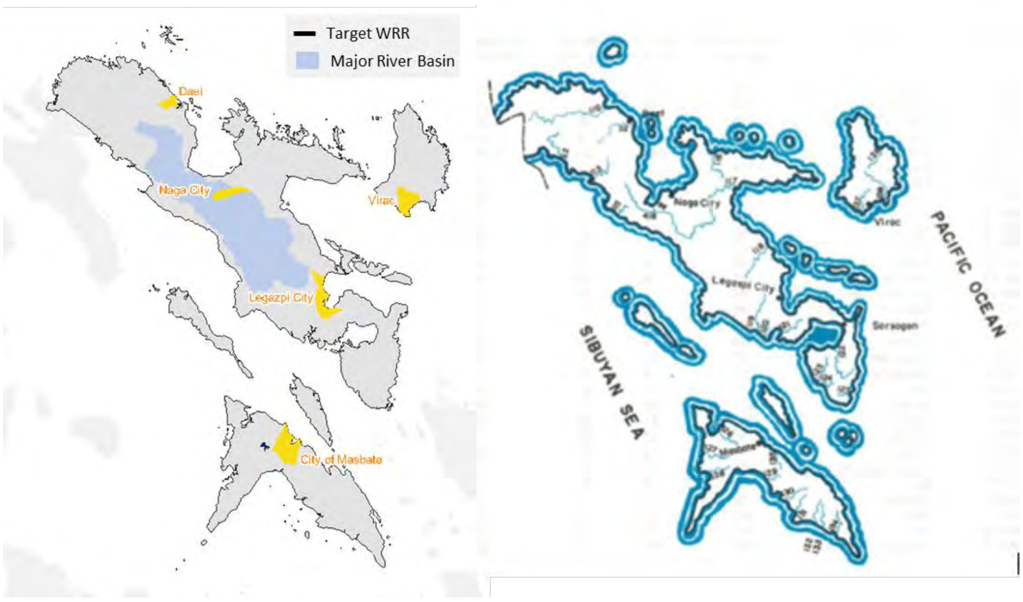
Source: JICA Survey Team

Figure 3.5.3-5 Annual Trends of the Precipitation at VIRAC SYNOP

3.5.3.3 River and Water Resources

(1) River

Out of the 18 major river basins, there is one major river basin, the Bicol River basin. There are also several principal river basins as shown in Figure 3.5.3-6.



Source: (left)JICA Survey Team, (right) National Water Resources Council (1976) "Principal River Basins of the Philippines"

Figure 3.5.3-6 Location Map of Major Rivers and Principal Rivers in WRR V

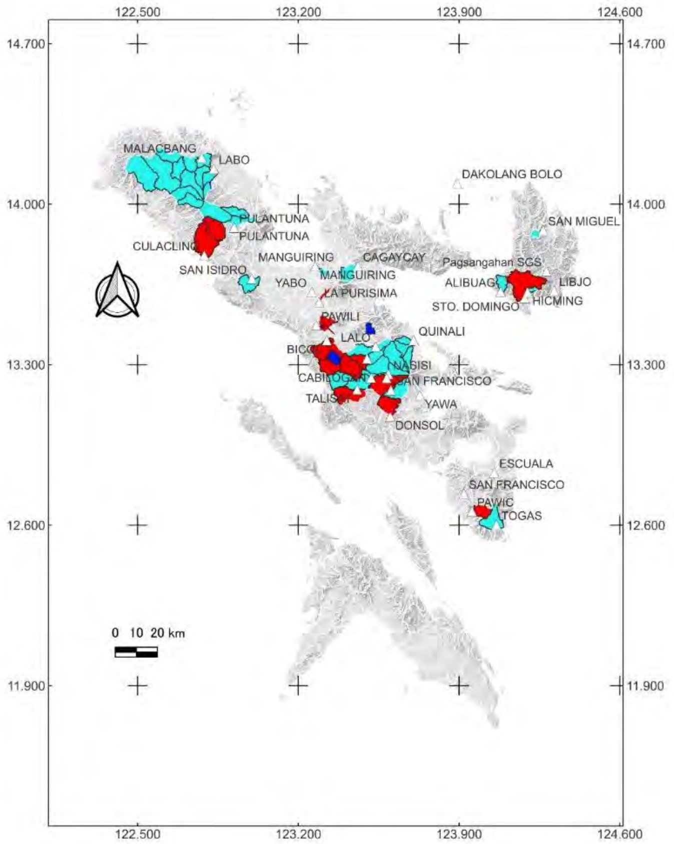
(2) Streamflow Data

Streamflow data were gathered for many of the stations within the survey area. Streamflow records were obtained from DPWH. A total of 35 daily average discharge data shown in the figure and table below were collected and used for low flow analysis of WRR V.

Table 3.5.3-1 Number of Discharge Observation Stations in WRR-V

N	N	Station	River	Basin	Agenc	WRF	Province	Town, Village	Latitud	Longitu	Elevatio	C.A.(km	Period
361	1	DONSOL	DONSOL RIVER	DONSOL RIVER BASIN	DPWH	V	Albay	Calzada, Jovellar	13.0730	123.6000	82.578 & 81.	94.0	1981-1998, 2000-2003
365	2	NASISI	NASISI RIVER	NASISI RIVER BASIN	DPWH	V	Albay	Nasisi, Ligao	13.2580	123.5920	104.4	39.0	1982-1985
371	3	QUINALI	QUINALI RIVER	BICOL RIVER BASIN	DPWH	V	Albay	Balza, Malinao	13.4060	123.7020	0.7	146.0	1980-1993, 1995-1998, 2000-2005
372	4	SAN AGUSTIN	SAN AGUSTIN RIVER	SAN AGUSTIN RIVER BASIN	DPWH	V	Albay	San Agustin, Libon	13.3260	123.4990	0.0	262.0	1982-1997
377	5	TALISAY	TALISAY RIVER	TALISAY RIVER BASIN	DPWH	V	Albay	Alliang, Ligao	13.1910	123.4560	6.7	90.0	1982-1987, 1991-1999, 2002-2005
380	6	YAWA	YAWA RIVER	BICOL RIVER BASIN	DPWH	V	Albay	Bogtong, Legaspi City	13.1660	123.7290	1.7	60.0	1980-1988
445	7	BINANOWAAN	OGSONG	OGSONG	DPWH	V	Albay	BINANOWAAN, LIGAO	13.2410	123.5840	3.3	14.0	1982-1989, 1991-2009
358	8	CABILOGAN	CABILOGAN RIVER	BICOL RIVER BASIN	DPWH	V	Albay	Bobongsoran, Ligao	13.2420	123.5170	35.6	129.0	1982-1999, 2000, 2002-2005
362	9	LABO	LABO RIVER	LABO RIVER BASIN	DPWH	V	Camarines Norte	Anahaw, Labo	14.1540	122.8310		800.0	2006-2016
364	10	MALACBANG	MALACBANG RIVER	MALACBANG RIVER BASIN	DPWH	V	Camarines Norte	Paracale	14.2030	122.7790		25.0	2007-2015
440	11	DAKOLANG BOLO	DAET	DAET	DPWH	V	Camarines Norte	DAKOLANG BOLO, IMELDA	14.0910	123.8910	8.7	66.0	1982-1986
357	12	BICOL	BICOL RIVER	BICOL RIVER BASIN	DPWH	V	Camarines Sur	Sto. Domingo, Nabua	13.4050	123.3240	0.5	905.0	1982-1989
359	13	CAGAYCAY	CAGAYCAY RIVER	CAGAYCAY RIVER BASIN	DPWH	V	Camarines Sur	Cagaycay, Goa	13.7290	123.4590	52.3	50.0	1982-2004
360	14	CULACLING	CULACLING RIVER	BICOL RIVER BASIN	DPWH	V	Camarines Sur	Del Rosario, Lupi	13.7770	122.7900	3.6	64.0	1982-1987, 1989-1999
363	15	LALO	LALO RIVER	BICOL RIVER BASIN	DPWH	V	Camarines Sur	Antipolo, Buhi	13.3790	123.5370	14.2	22.0	1982-2016
368	16	PAWILI	PAWILI RIVER	BICOL RIVER BASIN	DPWH	V	Camarines Sur	San Roque, Bula	13.4710	123.2780	0.2	240.0	1980-1985
369	17	PULANTUNA	PULANTUNA RIVER	BICOL RIVER BASIN	DPWH	V	Camarines Sur	Napulidan, Lupi	13.8980	122.9200	40.8	172.0	1980-2005
370	18	PULANTUNA	PULANTUNA RIVER	BICOL RIVER BASIN	DPWH	V	Camarines Sur	Napulidan, Lupi	13.8980	122.9200		172.0	2005-20016
379	19	YABO	YABO RIVER	YABO RIVER BASIN	DPWH	V	Camarines Sur	San Isidro, Naga City	13.6170	123.2590	45.7	19.5	1982-1984
437	20	LA PURISIMA	ANAYAN	ANAYAN	DPWH	V	Camarines Sur	LA PURISIMA, PILI	13.5720	123.2900		5.0	2005-2016
438	21	SAN ISIDRO	ASLONG	ASLONG	DPWH	V	Camarines Sur	SAN ISIDRO, LIBMANAN	13.6740	122.9970		10.0	2007-2016
441	22	MANGUIRING	HINAGUIANAN	HINAGUIANAN	DPWH	V	Camarines Sur	MANGUIRING, CALABANGA	13.7290	123.2730		18.0	1982-1994, 2000-2009
442	23	MANGUIRING	HINAGUIANAN	HINAGUIANAN	DPWH	V	Camarines Sur	MANGUIRING, CALABANGA	13.7290	123.2730		15.0	2010-2016
59	24	Pagsangahan SGS	Kaliwa	Bicol	DPWH	V	Catanduanes	Kilikilihan, San Miauel	13.7080	124.2800		218.0	2002
366	25	PAGSANGAHAN	PAGSANGAHAN RIVE	PAGSANGAHAN RIVER BAS	DPWH	V	Catanduanes	Kilikilihan, San Miguel	13.7080	124.2800		100.0	2005-2014
376	26	STO. DOMINGO	STO. DOMINGO RIVER	STO. DOMINGO RIVER BAS	DPWH	V	Catanduanes	Sto. Domingo, Virac	13.5910	124.1860		150.0	2012-2014
436	27	ALIBUAG	ALIBUAG	ALIBUAG	DPWH	V	Catanduanes	ALIBUAG, DATAG, SAN ANDRES	13.6180	124.0810	3.3	10.0	1982-1989, 1991-2004
439	28	HICMING	CAWAYAN	CAWAYAN	DPWH	V	Catanduanes	HICMING, VIRAC	13.6160	124.1980	8.8	12.0	1982-1999, 2002-2004
443	29	LIBJO	LIBJO	LIBJO	DPWH	V	Catanduanes	LIBJO, BATO	13.6220	124.3140	3.6	4.0	1991-2002, 2004-2008
446	30	SAN MIGUEL	PAYO	PAYO	DPWH	V	Catanduanes	SAN MIGUEL, PANGANIBAN	13.8860	124.2660	8.9	18.0	1982-1998, 2000-2005
367	31	PAWIC	PAWIC RIVER	PAWIC RIVER BASIN	DPWH	V	Sorsogon	San Isidro, Bulan	12.6600	123.9560	12.5	42.0	1981-2005
373	32	SAN FRANCISCO	SAN FRANCISCO RIVE	SAN FRANCISCO RIVER BA	DPWH	V	Sorsogon	San Francisco, Bulan	12.7370	123.9210	16.0	20.0	1982-2002
374	33	SAN FRANCISCO	SAN FRANCISCO RIVE	BICOL RIVER BASIN	DPWH	V	Sorsogon	Guinobatan Albay	13.1890	123.6030	13.1	70.0	2003-2006
378	34	TOGAS	TOGAS RIVER	TOGAS RIVER BASIN	DPWH	V	Sorsogon	Balocawe, Matnog	12.6010	124.0620	1.6	27.0	1981-1985
444	35	ESCUALA	NAMUAT	NAMUAT	DPWH	V	Sorsogon	ESCUALA, CASIGURAN	12.8290	124.0530	5.6	2.0	1985-2005

Source: DPWH



Source: JICA Survey Team based on the data of DPWH.

Figure 3.5.3-7 Location Map of Daily Discharge Observation Stations used for Low Flow Analysis (Total 35 Stations)

Unfortunately, these streamflow data were often missing as shown in the figures in Annex-D: Hydrology. In addition, there are limits to the frequency of discharge observations and the accuracy of the water level-discharge rating curves (H-Q curves), as there are many flows in which the value of the flood discharge is questionable. There are many data at observatories where the flow duration curves (FDCs) using the specific discharge are strange as shown in Annex-D: Hydrology. Also, the annual runoff at some stations exceeds the annual rainfall (runoff coefficient is more than 1.0) as shown in Annex-D: Hydrology.

3.5.3.4 Geology and Hydrogeology

The geological map of WRR V is shown in Figure 3.5.3-8. A geological overview of Bicol, Masbate island, and Catanduanes islands, is also separately described below.

(1) Bicol

In Albay Province, the majority of the supplied and developed groundwater occurs mainly in the limestone and volcanic aquifers. Extensive recent alluvial deposits consisting primarily of unconsolidated gravel, sand, silt and lenses of clay could be found in the municipalities of Oas, Libon and Polangui as well in the cities of Ligao and Legazpi. The aquifer that produces high yield of groundwater in form of springs are the limestones. Solution channels in the crystalline limestone formed by circulating groundwater act as secondary porosity which provide underground catchments for water. Moreover, the Polangui Volcanic Complex that includes the pyroclastics and lahar deposits of Mayon Volcano and fractured volcanic flows in addition to pyroclastics of Masaraga Volcano and Malinao Volcano are host to numerous high yielding springs and deep wells.

In Sorsogon province, the majority of the aquifers are intergranular volcaniclastics and highly fractured volcanic rocks and lava flows. In the City of Sorsogon and in Bacon Area, high yielding springs were observed along the foot slopes of the Pocdol Mountains which is mostly composed of andesites, dacites, basalts and pyroclastics.

(2) Masbate Island

The Masbate Island lies roughly 60 km. on the southwest of an active Miocene-Recent volcanic belt related to the westward subduction along the Philippine Trench. The Philippine Fault Zone lies immediately parallel offshore the eastern Masbate coastline. There are no active volcanoes in Masbate except for Pliocene volcanic plugs.

Groundwater in Masbate Island occurs mainly in the interconnected fractures and cavities of the limestone and limestone formations. Solution tubular springs are then formed when the groundwater makes its way through the interconnected channels and emerges on the land surface.

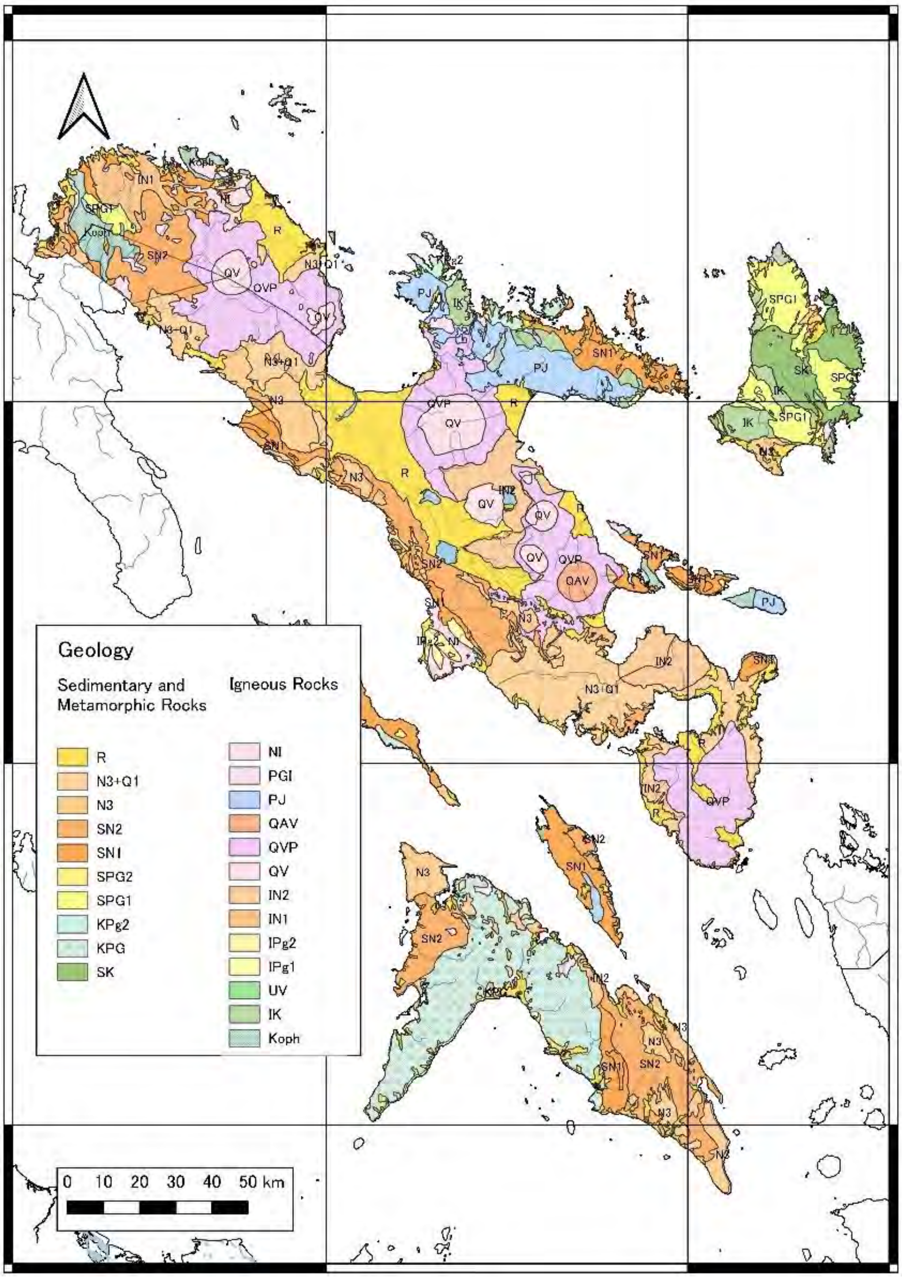
Springs with relatively high discharge are likewise associated with the intrusive of diorite. Fractures in the diorite serve as secondary porosity for the percolating groundwater. Volcanic Formation also yield significant discharge of groundwater through springs. This rock unit contains groundwater along fractures and interflow zones.

(3) Catanduanes Island

The main aquifer of Catanduanes is mainly from alluvial deposits, solution openings in limestone and in fractured and/or weathered zones of older formations. The alluvial deposits consisting chiefly of unconsolidated gravel, sand, silt, and lenses of clay could be found in the municipalities of Bagamanoc, Panganiban, Viga, Virac and San Andres.

The major aquifers that produce springs are the limestones of the Sto. Domingo Formation in San Andres and Virac, the Hilawan Limestone, which was observed in the municipalities of Caramoan and Bagamanoc.

Groundwater was also observed to come out in the fractures of the highly indurated clastic rocks, volcanics and intrusive rocks.



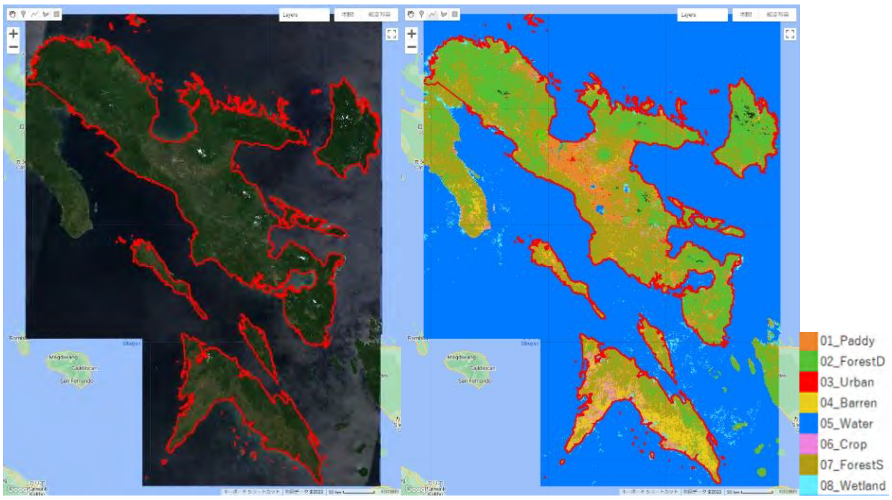
Source: MGB

Figure 3.5.3-8 Geological Map of WRR V

3.5.3.5 Creation of Land Cover/Land Use Using Satellite Data

(1) 10 m Land cover/land use map creation for WRR V using Sentinel-2

Land cover/land use map was created for WRR V using similar procedure as explained in Section 3.3.3(1). The land cover/land use map for the priority water resources region of WRR V is shown in Figure 3.5.3-9.



Note: Left: Sentinel-2 mosaic image, Right: Land cover map

Source: JICA Survey Team

Figure 3.5.3-9 Flow of classification process using satellite data (WRR V)

3.5.3.6 Current Status of Agricultural Water Use

(2) Irrigation Areas

The irrigation areas covered by WRR V in 2020 are summarized in Table 3.5.3-2.

Table 3.5.3-2 Irrigation Areas of WRR V in 2020

Province	Area Rate	All Systems				By Surface Water				By Ground Water			
		ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry
Quezon	0.053	1,082	974	818	751	1,016	908	773	707	66	66	44	44
Albay	1	31,749	30,429	23,045	21,651	30,541	29,647	22,729	21,335	1,208	782	316	316
Camarines Norte	1	9,695	9,236	6,725	6,710	8,649	8,383	6,561	6,546	1,046	853	164	164
Camarines Sur	1	77,665	55,218	34,313	32,880	52,588	52,417	33,230	31,932	25,077	2,801	1,083	948
Catanduanes	1	3,211	3,113	1,805	1,839	2,965	2,876	1,790	1,824	246	237	15	15
Masbate	1	6,848	6,582	3,456	3,519	6,656	6,396	3,456	3,519	192	186	0	0
Sorsogon	1	14,102	13,712	9,094	9,052	11,238	11,202	9,094	9,052	2,864	2,510	0	0
Total		144,352	119,264	79,256	76,402	113,653	111,829	77,633	74,915	30,699	7,435	1,622	1,487

Source: NIA Inventry Dat modified by JICA Survey Team

(3) Heads of Livestock and Poultry

The heads of livestock and poultry in WRR V in 2020 are summarized in Table 3.5.3-3.

Table 3.5.3-3 Heads of Livestock & Poultry by Province in WRR V (2020)

Region	Province	Area Rate	Heads of Livestock & Poultry				
			Carabao	Cattle	Hog	(Sub-total)	Chicken
IV-A	Quezon	0.053	4,346	3,272	12,628	20,246	223,527
V	Albay	1	85,562	8,180	181,136	274,878	1,741,647
	Camarines Norte	1	49,295	6,611	154,413	210,319	780,880
	Camarines Sur	1	78,796	25,325	289,819	393,940	4,575,399
	Catanduanes	1	6,078	1,807	68,371	76,256	89,586
	Masbate	1	64,083	57,500	108,483	230,066	941,703
	Sorsogon	1	32,714	15,573	89,235	137,522	622,320
	Total		**320,874**	**118,268**	**904,085**	**1,343,227**	**8,975,062**

Source:Philippine Statistics Authority modified by JICA Survey Team

(4) Freshwater Fishpond Areas

The freshwater fishpond areas in WRR V in 2022 are shown in Table 3.5.3-4.

Table 3.5.3-4 Freshwater Fishpond Areas by Province in WRR V (2022)

Region	Province	Area Rate	Fishpond Area (ha) in		Water Sources
			Province	WRR	
IV-A	Quezon	0.053	7.77	0.41	Ground water, Creek, etc
V	Albay	1	37.33	37.33	NIA Irrigation Canal, Creek, Spring
	Camarines Norte	1	103.36	103.36	Ground water, etc.
	Camarines Sur	1	11.64	11.64	NIA Irrigation Canal, Ground water, etc.
	Catanduanes	1	No data		
	Masbate	1	0.00	0.00	(No Fresh Water Fishpond)
	Sorsogon	1	7.77	7.77	Spring
	Total		**167.87**	**160.51**	

Source: DA-BFAR modified by JICA Survey Team

3.5.3.7 Current Status of Municipal and Industrial Water Use in WRR V

Basic information for all area was confirmed based on the PWSSMP 2018. In addition, the detailed current status and future plans were confirmed through site surveys in large population cities with huge water demands in WRR V (Bicol) as shown in Table 3.5.3-5 below.

Table 3.5.3-5 Large Population Cities in WRR V

WRR	Region		WD	Population (2020)	Note
WRR V (Bicol)	Region IV-A	Calabarzon	-	-	Region IV-A is mostly out of range of WRR V
	Region V	Bicol	Metro Naga	309,350	The second largest city in WRR V in terms of population size, listed in ICC
			Legazpi	209,985	The most populous city in WRR V, listed in CC.
			Virac	76,621	The most populous city in Catanduanes Island.
			Masbate-Mobo	145,736	The most populous city in Masbate Island, listed in CC

Source: JICA Survey Team

Current municipal and industrial water demand and existing water supply production in large population cities are shown as Table 3.5.3-6 below.

Table 3.5.3-6 Current Status of Municipal and Industrial Water Use in Large Population Cities

WRR	**WRR V (Bicol)**			
WD	**Metro Naga**	**Legazpi**	**Virac (Catanduanes)**	**Masbate-Mobo**
Covered Municipality	Naga, Camaligan, Canaman, Gainza, Magarao	Legazpi City	Virac	Masbate City, Mobo
Total Water Demand (MCM/Year)	**29.1**	**14.3**	**6.1**	**11.8**
Municipal Water Demand (MCM/Year)	25.3	11.8	5.2	10.0
Industrial Water Demand (MCM/Year)	3.7	2.5	0.9	1.8
Total Production Capacity (MCM/Year)	**24.5**	**17.2**	**5.4**	**5.8**
Production Source (MCM/Year)	Wells: 17.3 Springs: 7.2	Wells: 5.0 Springs: 1.8 Bulk purchase: 10.4	Wells: 2.5 River: 2.9	Wells: 1.4 River: 4.4

Source: JICA Survey Team

3.5.3.8 Current Status of Water Use Facilities in WRR V

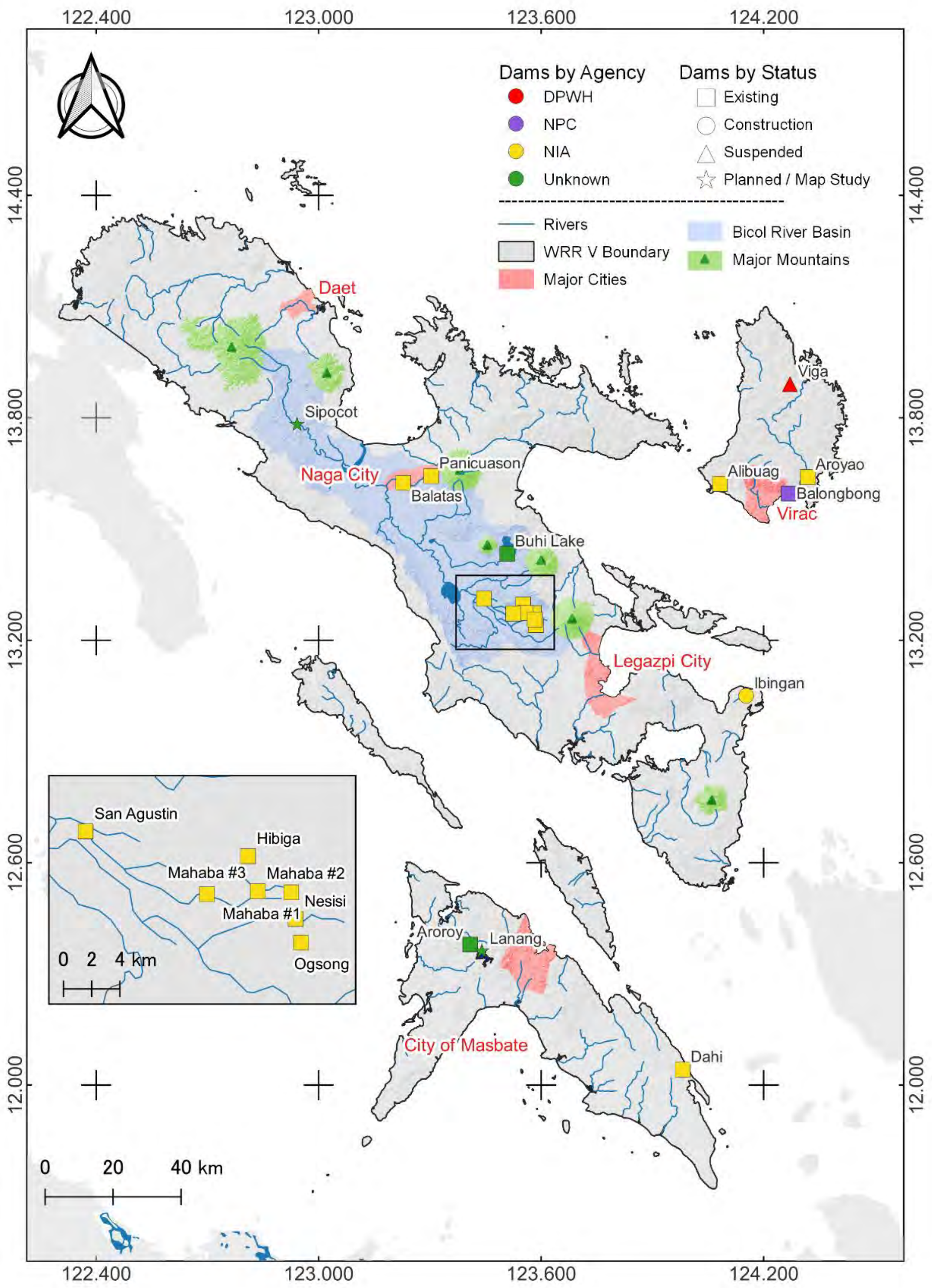
(1) Existing Dams and Dam Construction Plans Confirmed before the Field Survey

Table 3.5.3-7 shows the list of existing dams and dam construction plans organized from past reports and information provided from related implementing agencies. In addition, each dam location map is shown in the following Figure 3.5.3-10.

Table 3.5.3-7 List of Existing and Proposed Dams (WRR V)

Region	Name of Dam	Construction Year /Current Status of Plan	Owner of Dam/ Implementing Agency	Purpose of Dam	Location		Dam Specification							Data Source
					Island	River	Type of Dam	Height (m)	Crest Length (m)	Coordinates		Reservoir Gross Storage (MCM)	Reservoir Usable Storage (MCM)	
										Latitude of Dam Center	Longitude of Dam Center			
WRR V	Viga Dam	Suspended in 2019	DPWH	Muliti Purpose	Catanduanes	Viga	-	20	34	13° 53' 26.81" N	124° 16' 14.56" E	-	-	This Survey
	Alibuag CIS	Existing	Nia	Irrigation	Catanduanes	-	-	-	-	13° 37' 17.96" N	124°4' 54.95" E	-	-	This Survey
	Panganiban CIS dam	Existing	Nia	Irrigation	Catanduanes	-	-	-	-	13° 53' 34.524" N	124°15' 36" E	-	-	This Survey
	Aroyao CIP	Existing	Nia	Irrigation	Catanduanes	-	-	-	-	13.3825 N	124°19' 09 E	-	-	This Survey
	Balongbong Hydro Power Plant	Existing	NPC	Power	Catanduanes	-	-	-	-	13.59604 N	124.26732 E	-	-	This Survey
	Ibingan Dam	Under construction	Nia	Irrigation	Luzon/ Sorsogon	Ibingan	Zone-Earthfill Dam	27.2	142.52	13° 03' 0.30" N	124° 09' 9.30" E	0.661	0.372	This Survey
	Sipcot Dam	Map Study	-	Muliti Purpose	Lizon/Bicol	Sipcot	Rockfill	64	600	13°46' 54.611" N	122°56' 28.007" E	1270	870	1998 M/P (Water Resources Development Study, USAID 1976)
	Libmanan-Cabusao Dam	-	Nia	Irrigation	Lizon/Bicol	Sipcot	-	11.3	-	-	-	-	-	-
	Talisay Dam	Map Study	-	Muliti Purpose	Lizon/Albay	Talisay	Rockfill	58	400	-	-	315	231	1998 M/P (Water Resources Development Study, USAID 1976)
	Ogsong RIS dam	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°14' 26.45" N	123°35 9" E	-	-	This Survey
	Hibiga RIS dam	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°17' 46.04" N	123°33 4.59" E	-	-	This Survey
	San Agustin CIS dam	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°18' 43.506" N	123°26' 42.468" E	-	-	This Survey
	Mahaba RIS dam #1	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°16' 22.62" N	123°34' 46.20" E	-	-	This Survey
	Mahaba RIS dam #2	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°16' 25.43" N	123°33' 27.55" E	-	-	This Survey
	Mahaba RIS dam #3	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°16' 19" N	123°31' 28" E	-	-	This Survey
	Nasisi RIS dam	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°15' 21.39" N	123°34' 56.44" E	-	-	This Survey
	Panicuason CIS	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°38' 34.782" N	123°18' 12.222" E	-	-	This Survey
	Balatas CIS	Existing	Nia	Irrigation	Lizon/Albay	-	-	-	-	13°37' 28.734" N	123°13' 40.734" E	-	-	This Survey
	Buhi Lake	-	-	Muliti Purpose	Lizon/Albay	Buhi Lake	Control Wier & Spillway	-	-	13.43328 N	123.50848 E	-	-	This Survey
	Waras Dam	Suspension of plan	Nia	Irrigation	Lizon/Albay	Waras	-	-	-	-	-	-	-	This Survey
	Ogod （SRIP)	-	NIA	Irrigation (SRIP)	Luzon/Albay	-	-	-	-	-	-	-	-	This survey by JST irrigation engineer. (FS is on-going)
	Haguimit （SRIP)	-	NIA	Irrigation (SRIP)	Luzon/Camarines Sur	-	-	-	-	-	-	-	-	This survey by JST irrigation engineer. (On- going review of Final FSR by the RO)
	Aroroy Dam	Existing	-	-	Masbate	-	-	-	-	12.37906 N	123.40831 E	-	-	This Survey
	Dahi CIS	Existing	NIA	Irrigation	Masbate	-	-	-	-	12.04163 N	123.98153 E	-	-	This Survey
	Lanang Dam	-	-	Muliti Purpose	Masbate	Lanang	-	-	-	12°21'39.473" N	123°26'23.356" E	-	-	This Survey

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.5.3-10 Location Map of Existing and Proposed Dams (WRR V)

(2) Existing Surface Water Resources Development Facilities

1) Buhi Barit Hydroelectric Plant

Lake Buhi, through the Barit River, is the main source of water for the hydroelectric plant with a rated capacity of 1.8 MW. The plant was constructed on February 5, 1955, and was placed in commercial operation on September 10, 1957. Hydropower is supplied from a reservoir with a gross storage capacity of 1,188,978 m^3 (NPC website).

2) South Quinale and Cabilogan-San Juan Rubber Dams

Two major projects implemented in the Bicol Region are the South Quinale and the Cabilogan-San Juan Rubber Dams in Oas and Ligao City, Albay, respectively. Both projects are funded by the Agrarian Reform Infrastructure Support Project (ARISP) of the Department of Agrarian Reform (DAR) (NIA website).

Source: NIA

Figure 3.5.3-11 Picture of South Quinale Rubber Dam

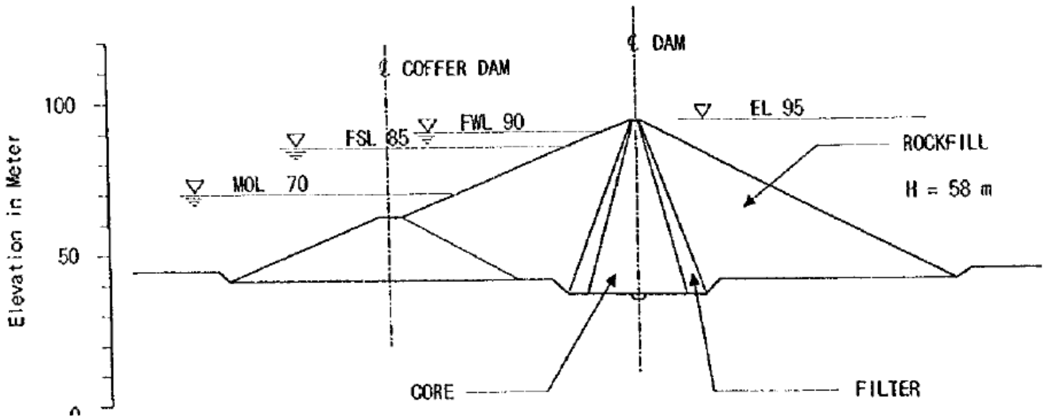
Source: NIA

Figure 3.5.3-12 Picture of Cabilogan-San Juan Rubber Dam

(3) Surface Water Resources Development Projects Proposed in Past Studies

1) Talisay Dam

Talisay Dam and Sipocot Dam were identified by USAID (1976) at a pre-feasibility study level and re-studied in the 1998 M/P. The development of Talisay Dam was prioritized in the 1998 M/P. The purpose of the dam is flood control, irrigation, and hydropower. The conceptual design of the dam considers the dam height at 58 m and the active storage at 231 MCM.



Source: 1998 M/P

Figure 3.5.3-13 Typical Cross Section of Talisay Dam

2) Libmanan-Cabusao Dam (Sipocot Dam)

The Libmanan-Cabusao Dam Project will cover the construction of the following components: an 11.3 m-high and 150 m-wide concrete dam along the Sipocot River in Barangay Malaguico, Sipocot, Camarines Sur; a 10.20 km main canal to convey the water from the dam to the existing canal of the Libmanan-Cabusao Pump Irrigation System (LCPIS), including a 10.75 km service road; and the construction and repair of new and existing irrigation and drainage structures and facilities. The dam will replace the four units of the 250-hp engines and pumps that presently irrigate some 2,195 ha of rice lands in the towns of Libmanan and Cabusao (NIA website).

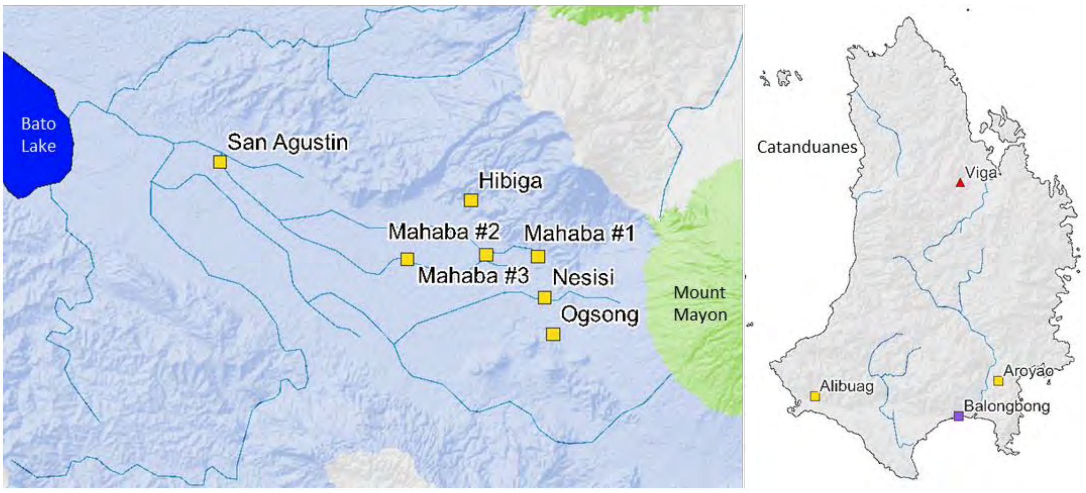
(4) Field Survey Reports

The field survey report for each dam site is shown below in Table 3.5.3-8.

Table 3.5.3-8 Field Survey Report of Dam Sites in WRR V

WRR V (Legazpi): Sep. 20, 2022	
Dam site	Information during Site Inspection
1) Ogsong RIS weir, 2) San Agustin CIS weir 3) Mahaba RIS weir #1	There are plans to raise the height of the weir with rubber weirs to increase water resources.
4) Others	Four other irrigation weirs were inspected. It was observed that there were some damages on the structures due to flooding, and many areas would need repair.
WRR V (Catanduanes): Sep. 21 - 22, 2022	
Dam site	Information during Site Inspection
1) Alibuag CIS	Survey of existing communal irrigation system.
2) Panganiban CIS weir	There is a plan to raise the height of the weir with rubber gate to increase water resources. There is also a plan to build a new weir on an adjacent river (the Suraan River).

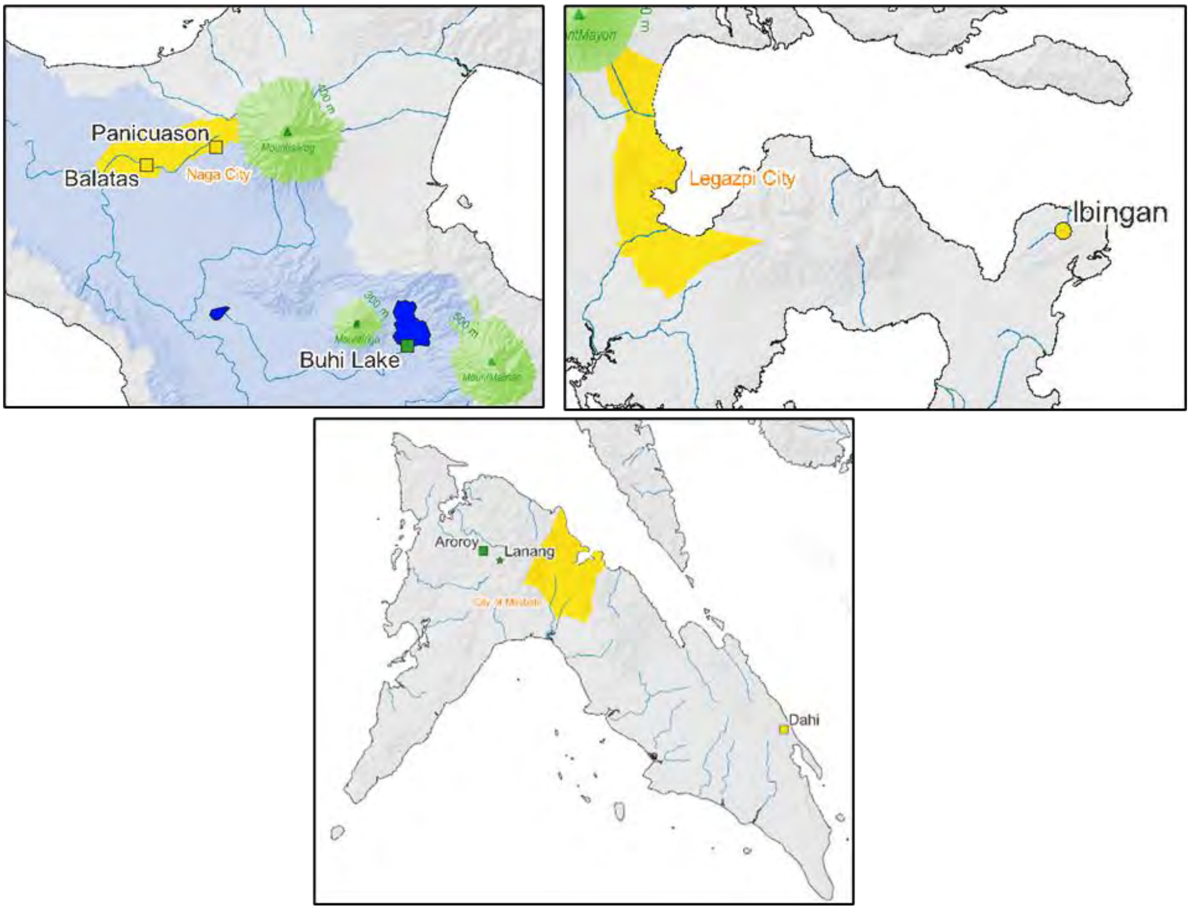
3) Aroyao CIP	Survey of proposed weir (Serbian (Tyrolean) -type intake)
4) Others	Observation of existing Balongbong Hydro Power Plant.



Source: JICA Survey Team

Figure 3.5.3-14 Location Map of Field Survey Dams in WRR V (1)

WRR V (Naga): Sep. 24, 2022	
Dam site	Information during Site Inspection
1) Farm pond of THIRIS	Survey of existing farm pond & pump house (Sto. Domingo) and planned site (San Antonio).
2) Panicuason CIS	Survey of Serbian (Tyrolean) -type intake in existing communal irrigation system.
3) Balatas CIS	Survey of Ogee -type weir in existing communal irrigation system.
4) Waras Dam	No site visit, JST were informed by NIA's local office that the project was suspended due to social problems with the indigenous population.
5) Lake Buhi Control Structure	Survey of Lake Buhi Control Structure, and it was confirmed that increase of effective depth of the lake by about 1 m could increase the water supply potential.
WRR V (Sorsogon): Sep. 25, 2022	
1) Ibingan Earthfill Dam	Survey of the construction of the Ibingan Earthfill Dam (under construction, progress: 82%). The construction company provided information on dam specifications, construction quantities, and unit prices.
WRR V (Masbate): Sep. 26, 2022	
1) Dahi CIS	Survey of Ogee -type dam in existing communal irrigation system.
2) Aroroy dam	No site visit, and JST were informed by staff of the Governmental Office of Masbate that there is a plan to build a multi-purpose dam on the upper Lanang River. However, no progress has been made on this plan.



Source: JICA Survey Team

Figure 3.5.3-15 Location Map of Field Survey Dams in WRR V (2)

Source: JICA Survey Team

(5) Considerations for Dam Construction

1) Bicol Area

As an existing dam plan, Sipocot Dam is planned as a large-scale multi-purpose dam. It will need further study to confirm its possibility.

2) Albay/Naga Area

Currently, there are many water intake facilities including weirs for agricultural irrigation and hydroelectric power generation, as well as renewal plans.

For irrigation water, it was confirmed that the NIA's plan was well examined and detailed.

Regarding the use of water from the Lake Buhi, which is operated with an effective water level difference of only 0.50 m currently, there needs to be further study to increase its capacity. One possibility is the renewal of the regulating weir.

3) Masbate Area

The city of Masbate, a major city in the northern part of Masbate Island, has a large population with concentration of resort facilities. Lack of rainfall on Masbate Island has resulted in a serious water shortage. Therefore, priority will be given to the construction of a dam that uses the Lanang River, which is the main river in the north, as its water source.

3.5.3.9 Current Status of Groundwater Use in WRR V

Based on the NWRB's water permit records, a total of 206 water permit wells and 135 springs have been issued within WRR V. This record does not include small domestic wells, and the actual number of well and spring is assumed to be much higher. The number of wells and springs for each Province is shown in Table 3.5.3-9.

Table 3.5.3-9 Water Permit Wells and Springs in WRR V

Province	Permit Water Source		Major water source owners
	Groundwater Well	Spring	
Bicol	176	129	Metro Naga, Legaspi, NIA
Masbate	22	2	Masbate WD
Catanduanes	8	4	ViracWD
Total	206	135	

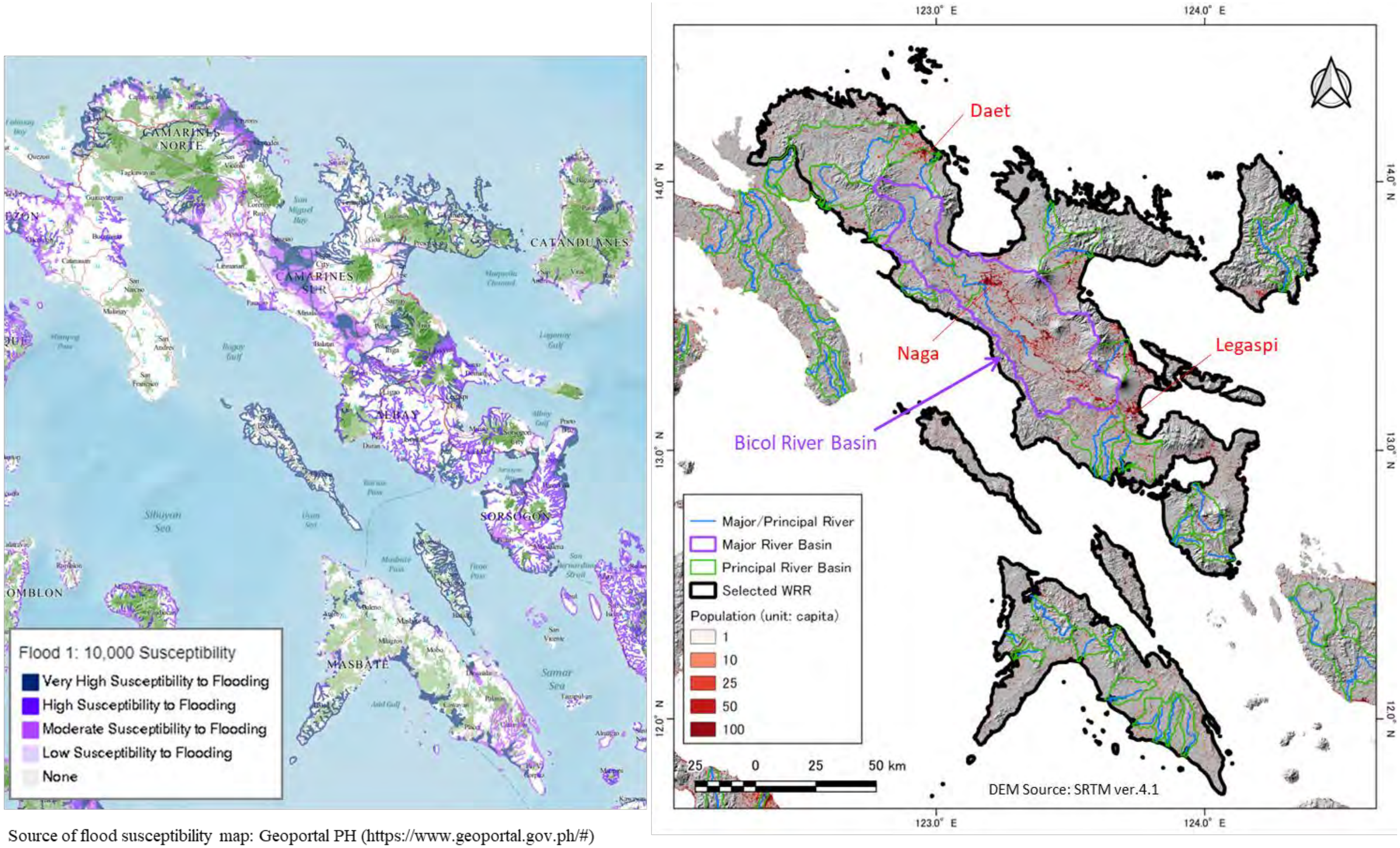
Source: JICA Survey Team

3.5.3.10 Flood Risk Management (FRM) in WRR V

(1) Overview of Flood Risk in WRR V

To overview the flood risks in WRR V, the flood susceptibility map and the population distribution map are compared as shown in Figure 3.5.3-16. By overlapping the flood susceptibility map on the population distribution map, the largest high-risk flood area lies in the Bicol River basin. There are also 29 principal river basins in WRR V. Most of the drainage areas of the 29 rivers are less than 500 km^2 and their flood susceptibility areas spread in relatively narrow areas along their rivers.

The Bicol River is significantly important in terms of both flood risk management and water resources management. Accordingly, the Bicol River was focused on to study its flood risk management.



Source of flood susceptibility map: Geoportal PH (https://www.geoportal.gov.ph/#)

Source of population 30m mesh data: Facebook Connectivity Lab and Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. High Resolution Settlement Layer (HRSL). Source imagery for HRSL © 2016 DigitalGlobe.

Figure 3.5.3-16 Flood Susceptibility Map (Left) and Population Distribution Map (Right) in WRR V

(2) Summary of Current FRM Plan

Since flood risk management (FRM) structural measures such as dams, shortcuts, and flood diversion channels affect river flows and water cycle in the region as mentioned in Chapter 2.2.11 (1), the current FRM plans of the Bicol River were collected and reviewed. The FRM master plan (FRMMP) is summarized in Table 3.5.3-10. The target safety level is not clarified in the current FRMMP, but in the old FRMMPs which were formulated in 2003 by World Bank[3] or in 1992 by Asian Development Bank[4], it was set at 5-year or 10-year flood.

Table 3.5.3-10 Summary of the Current FRMMP for the Bicol River Basin

River Basin Name	Bicol River Basin
Drainage Area (km^2)	3,171 *1
Estimated Population (thousand people) and Estimated Year	2,011 (2010) *1
Latest FRMMP and Formulated Year	DENR (2015) *2
Target Year	2030
Target Flood Level	5- or 10-year flood*3
Design Flood Discharge	Not clearly described
Consideration of CCI *4 on rainfall	Not clearly described
Consideration of CCI *4 on sea level rise	Not clearly described
No. of Existing Flood Control Dam	0
No. of Potential Flood Control Dam	0

*1) The values of “Drainage Area” and “Estimated Population” are quoted from the website of River Basin Control Office (https://riverbasin.denr.gov.ph/main/index)
*2) DENR, 2015, “Integrated Bicol River Basin Management and Development Master Plan”
*3) In the latest FRMMP (DENR, 2015), the target flood level is not clarified. In the previous FRMMPs (WB, 2003/ ADB, 1992), the target flood level was set at 5 or 10-year flood.
*4) CCI: Climate Change Impacts

According to the interview with the DPWH Flood Control and Sabo Engineering Center (FCSEC), the selected seven priority projects illustrated in Figure 3.5.3-17 are going to be implemented as phase 1 project based on the feasibility study and detailed engineering design conducted by DPWH Region 5. Among the seven priority projects, the Libmanan-Cabusao Embankment, Balatas Retarding Basin, and the Nabua Ring Dike are located in Camarines Sur Province and the remaining four sites of Nagasgasan Retarding Basin, San Francisco-Cabilogan Retarding Basin, Quinali Diversion Channel, and Quinali-Talisay Embankment are located in Albay Province.

3 WB Project titled “The Basin Plan for the Water Resources Development and Management”

4 ADB Project titled “Bicol River Basin Flood Control and Irrigation Development Project”

Source: DPWH, The Feasibility Study and Detailed Engineering Design for the Proposed Flood Control Projects in Bicol River Basin, 2022, Project Briefer

Figure 3.5.3-17 Location Map of Priority Flood Control Projects in the Bicol River Basin

More details are described in Annex H.

3.5.3.11 Water Quality in WRR V

The primary parameters monitored by EMB Region V from 2014 to 2019 are listed in Table 3.5.3-11.

Table 3.5.3-11 Primary Parameters Monitored by EMB Region V from 2014 to 2019

Parameter	Description
Biochemical Oxygen Demand	Most aquatic organisms cannot survive if the BOD level is above 7 mg/L.
Chloride	Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/L). Sewage contains large amounts of chloride, as do some industrial effluents.
Color	Obviously, the more vegetable matter in the water the greater is the color. Exceptionally, natural color may arise from the presence of colloidal iron/manganese in a water, but organic matter is almost always the cause.
Dissolved Oxygen	Fish and other aquatic organisms require at least 5 mg/L of DO to live.
Fecal Coliform	The PNSDW prescribed that drinking water should contain less than 1.1 MPN/100mL Fecal Coliform level. This parameter is especially significant for water bodies that involve high human interface.
Nitrate	Like phosphates, nitrates in water bodies come from agricultural runoff and sewage discharge where they are formed as by-products of decomposition. High nitrate concentrations can inhibit fish growth, impair immune system, and cause stress in some aquatic species.
pH	The range of natural pH in freshwaters extends from around 4.5, for acid, peaty upland waters, to over 10.0 in waters where there is intense photosynthetic activity by algae. However, the most frequently encountered range is 6.5-8.0.
Phosphate	Once a vast mass of excess algae dies and decomposes by oxidation, the water is depleted of DO and may result to fish kill.

Parameter	Description
Temperature	The effect of temperature, and especially changes in temperature, on living organisms can be critical. Elevated temperatures and, more importantly, steep temperature gradients can have directly harmful effects on fish. It is for such reason that changes in temperature are subject to limits.
Total Suspended Solids	TSS measures the concentration of undissolved solid particles in water, such as silt, decaying plant and animal matter, and domestic and industrial wastes. Higher TSS value suggests decreased ability of the water to support aquatic life due to reduced light penetration. TSS level in sources of water supply should not exceed 25 mg/L for Class AA and 50 mg/L for Class A.

Source: DENR Administrative Order No. 2016-08; Ireland Environmental Protection Agency (2001)

3.5.3.12 Natural and Social Environment in WRR V

(1) Natural Environment

1) Protected Area

According to the DENR Region V, WRR V has a total of 19 protected areas. These protected areas cover approximately a total land area of 500,221 ha. The list and distribution of protected areas in the region are summarized in Table 3.5.3-12.

Table 3.5.3-12 List of Protected Areas in WRR V

Protected Area	Province
Mt. Mayon Natural Park	Albay
Mt. Masaraga Watershed Forest Reserve	
Abasig-Matogdon-Mananap Natural Biotic Area	Camarines Norte
Lagonoy Natural Biotic Area	Camarines Sur
Mt. Isarog Natural Park	
Buhi Wildlife Sanctuary	
Caramoan Natural Park	
Libmanan Caves Natural Park	
Malabungot Protected Landscape	
Catanduanes Natural Park	Catanduanes
Bongsanglay Natural Park	Masbate
Tugbo Watershed Forest Reserve	
Naro Island Wildlife Sanctuary	
Matang-Tubig Watershed Forest Reserve	
Chico Island Wildlife Sanctuary	
Juban Magallanes Watershed Forest Reserve	Sorsogon
Bulusan Volcano Natural Park	
Ticao-Burias Pass Protected Seascape	Albay, Masbate, Sorsogon
Bicol Natural Park	Camarines Norte; Camarines Sur

Source: DENR Region V

(2) Social Environment

1) Local Economy

Region V is the 9th largest economy by region in the Philippines with 2.9% of the national GDP in 2022 according to the PSA. The economic activities of Bicol are predominantly service-oriented, comprising 57.5% of the economy, followed by industry and agriculture, hunting, forestry, and fishing (AHFF). Tourism will continue to play a vital growth driver in Bicol's economy.

2) Historic Site / Culture Heritage

Bicol is currently home to 458 historical, tangible, and intangible cultural properties recorded in the PRECUP-TALAPAMANA. The declared marked structures and important cultural properties in Bicol Region are shown in Table 3.5.3-13.

Table 3.5.3-13 List of Marked Structures & Important Cultural Properties in WRR V

Official Name	Location	City/ Municipality	Declaration/Classification	Type
Jose Panganiban Monument | Jose Ma. Panganiban y Enverga (1863-1890) Marker	-	Jose Panganiban	Marked Structure, NHCP; Registered Property, Province of Camarines Norte	Tangible-Immovable
Metropolitan Cathedral of Saint John the Evangelist of Naga | Cathedral of Naga Marker; Church of Nueva Caceres Marker	-	Naga City	Marked Structure, NHCP; Local Cultural Property - Naga City Historical Buildings and Structures (Ordinance Number 2003-003)	Tangible-Immovable
Holy Rosary Minor Seminary Historical Landmark | Seminary of Nueva Caceres Marker	-	Naga City	National Historical Landmark, NHCP; Local Cultural Property - Naga City Historical Buildings and Structures (Ordinance No. 2003-003)	Tangible-Immovable
Universidad de Santa Isabel | Colegio de Santa Isabel Marker; Universidad de Santa Isabel Marker	Elias Angeles corner Santonja Streets	Naga City	Marked Structure, NHCP; Local Cultural Property - Naga City Historical Buildings and Structures (Ordinance Number 2003-003)	Tangible-Immovable
Jose Rizal National Monument Daet | First Rizal Monument	Daet National Park, Daet Heritage Center, Magallanes corner Justo Lukban Streets	Daet	National Monument, NHCP; Registered Property, Province of Camarines Norte	Tangible-Immovable
Laniton Battle Memorial | Bantayog Para Sa Kapayapaan Marker	Barangay Laniton	Basud	Marked Structure, NHCP; Registered Property, Province of Camarines Norte	Tangible-Immovable
Bicolano Penitensya (Penitential Flagellation)		Paracale; Santa Elena; Vinzons	Philippine Intangible Cultural Heritage Inventory; Registered Property, Province of Camarines Norte	Intangible
Parish Church of the Holy Cross of Nabua | Church of Nabua Marker	San Esteban	Nabua	Marked Structure, NHCP; Registered Property, Municipality of Nabua	Tangible-Immovable
Batalay Church | Dambana sa Batalay Marker	Batalay	Bato	Marked Structure, NHCP; Registered Property, Municipality of Bato	Tangible-Immovable
Shrine of Our Lady of Peñafrancia of Naga | Church of Nuestra Señora de la Peña de Francia Marker		Naga City	Marked Structure, NHCP; Local Cultural Property - Naga City Historical Buildings and Structures (Ordinance Number 2003-003)	Tangible-Immovable

Official Name	Location	City/ Municipality	Declaration/Classification	Type
Parish Church of Nuestra Señora de la Porteria of Daraga | Simbahan ng Daraga Marker		Daraga	National Cultural Treasure, National Museum (referring to the Eastern and Western Façade, Belfry and Baptistry of the Church); Marked Structure, NHCP; Local Cultural Property - Provincial Cultural Treasure, Albay	Tangible-Immovable
Parish Church of Saint John the Baptist of Camalig | Simbahan ng Camalig Marker	Barangay 2	Camalig	Important Cultural Property, National Museum; Marked Structure, NHCP; Registered Property, Municipality of Camalig, Albay	Tangible-Immovable
Parish Church of Saint Peter the Apostle of Vinzons | Simbahang San Pedro Apostol Marker	Francisco O. Balce Street, Barangay II	Vinzons	Marked Structure, NHCP; Local Cultural Property - Provincial Cultural Treasure, Camarines Norte; Registered Property, Province of Camarines Norte	Tangible-Immovable
Parish Church of Saint Mary Magdalene of Bula | Church of Bula Marker			Marked Structure, NHCP; Registered Property, Municipality of Bula	Tangible-Immovable

Source: National Commission for Culture and the Arts (NCCA)

3.5.4 Hydrological Analysis in WRR V

3.5.4.1 Hydrological Analysis (Surface Water)

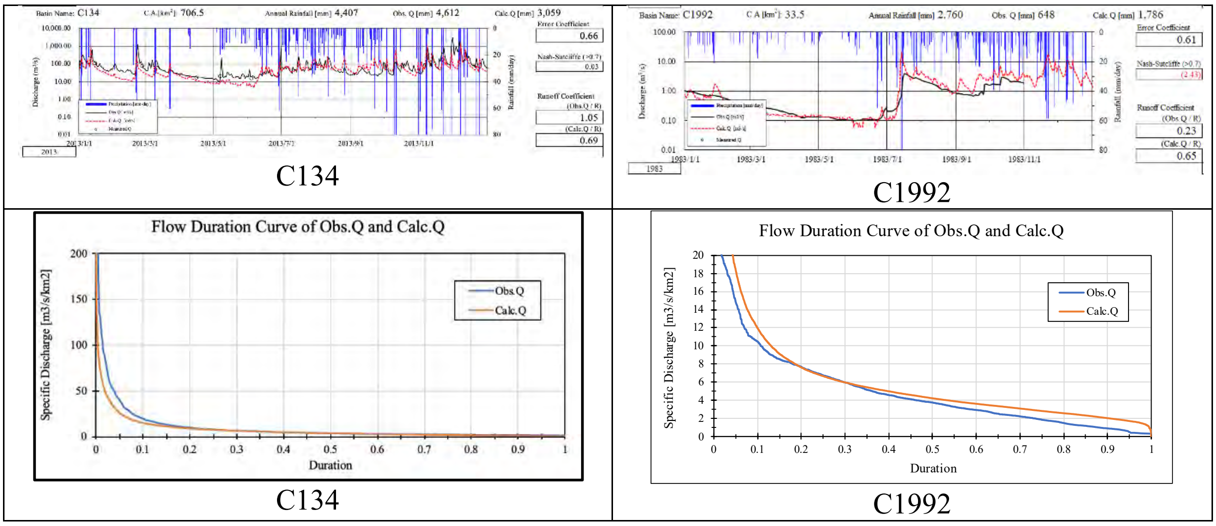
1) Selection of Hydrological Model

As described in Section 3.3.4.1 Hydrological Analysis (Surface Water), in this survey, the physically-based runoff model, the SHER Model, was selected for the detailed hydrological analysis for priority WRRs.

2) Calibration of SHER Model Parameters

As describe in Section 3.3.4.1 Hydrological Analysis (Surface Water), the model parameters are calibrated and evaluated with the same methods.

The results of the hydrographs of simulated and observed discharge are attached in Annex-D: Hydrology. Examples of calibrated hydrographs are shown in Figure 3.5.4-1. Calibration was evaluated using the hydrograph shape, error coefficient, the Nash–Sutcliffe (NS) model efficiency coefficient, and the flow-duration curves (FDCs). The calibration was carried out by selecting the year in which the observed and the calculated discharge are the best fit.

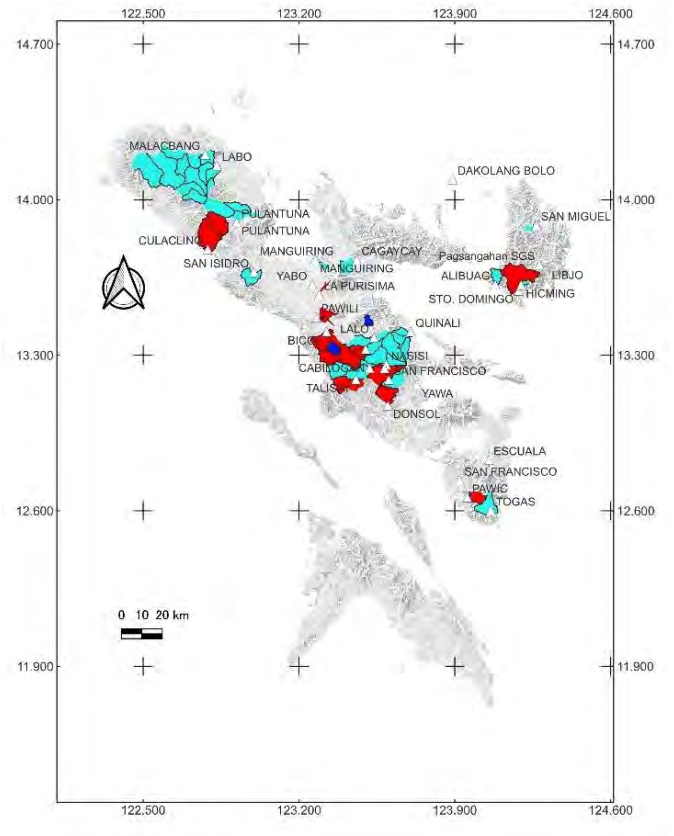


Source: JICA Survey Team

Figure 3.5.4-1 Example of Results of Simulated and Observed Discharge Hydrograph and FDC

3) Expansion of SHER Model Parameters for Ungauged Sub-Basin

Using the calibrated parameters of the SHER Model for sub-basins with DPWH observed discharges, river discharges for sub-basins without observed discharges were estimated. Figure 3.5.4-2 shows the sub-basins where the DPWH observed discharges are located.



Source: JICA Survey Team

Figure 3.5.4-2 Calibrated Sub-Basins in WRR-XI

3.5.4.2 Hydrological Analysis (Groundwater)

(1) Method of Groundwater Analysis

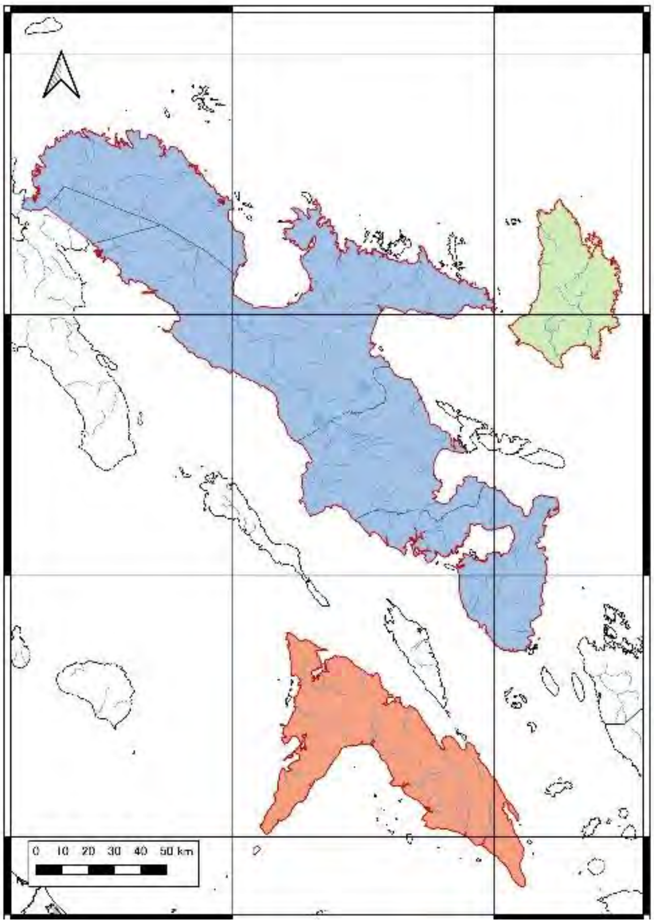
Workflow of the groundwater analysis are described in Section 3.3.4.2.

(2) Groundwater Model Setting

1) Hydrogeological Boundary

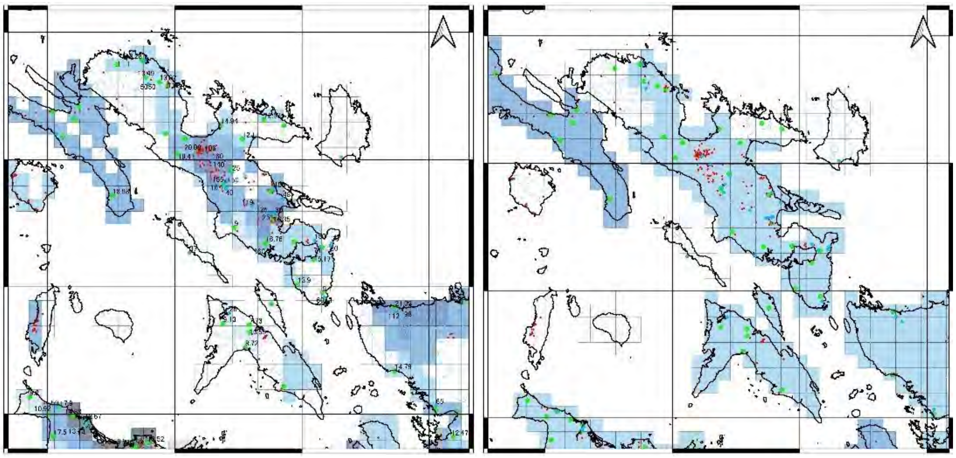
Since WRR V has several islands, the modeling area was divided into three area: main bicol island, Masbate island, and Catanduanes island (Figure 3.5.4-3).

The hydrogeological boundary is set by referring the Groundwater Resource Assessment report published by MGB, and classified into three layers: high permeable zone, low permeable zone, and impermeable zone. However, since the boundary information in the depth direction is unknown in many areas, the boundary depths were set based on aquifer depths estimated from the drilling depths of existing wells (Figure 3.5.4-4).



Source: JICA Survey Team

Figure 3.5.4-3 Groundwater Model Area of WRR V



Source: JICA Survey Team

Figure 3.5.4-4 Groundwater Model Area of WRR V

2) Numerical Model Setting

Table 3.3.4-2 summarizes the mesh size, number of layers, and number of meshes in each modeling area.

Table 3.5.4-1 Numerical Model Settings of WRR V

Model Area	Bicol	Masbate	Catanduanes
Grid Size	1,000m	1,000m	1,000m
Cell Number of each Layer	12,808	3,563	1,619
Layer Number	4	4	4
Total Cell Number	51,232	14,282	6,476

Source: JICA Survey Team

3) Groundwater Recharge

Settings of groundwater recharge are same as WRR VII, described in Section 3.3.4.2.

4) Boundary Condition

Settings of boundary condition are same as WRR VII, described in Section 3.3.4.2.

5) Hydrogeological Parameter

Based on the literature, the hydraulic conductivity shown in Table 3.5.4-2 was given as the initial set value for each layer.

Table 3.5.4-2 Initial Model Setting of Hydraulic Conductivity in WRR V

Model Area	Layer	Hydraulic Conductivity (m/s)	Assumed Geology
Bicol	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Volcanic Ash,
	3,4	1×10^{-8}	Volcanic Rock, Sandstone, Shale, Tuff
Catanduanes	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Limestone, Sand
	3,4	1×10^{-8}	Sandstone, Shale, Silt, Tuff
Masbate	1	1×10^{-4}	Sand, Gravel
	2	1×10^{-5}	Volcanic Ash,
	3,4	1×10^{-8}	Volcanic Rock, Sandstone, Shale, Tuff

6) Pumping Well Setting

Settings of pumping well are same as WRR VII, described in Section 3.3.4.2.

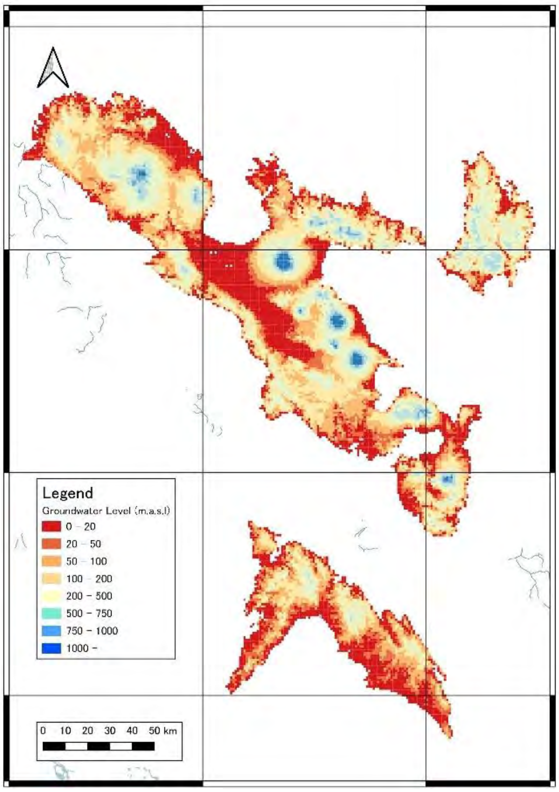
(3) Calibration of Groundwater Model Parameter

1) Groundwater Level Calibration

Calibration of model parameters (hydraulic conductivity) was performed by comparing the groundwater levels calculated by MODFLOW with the measured groundwater levels.

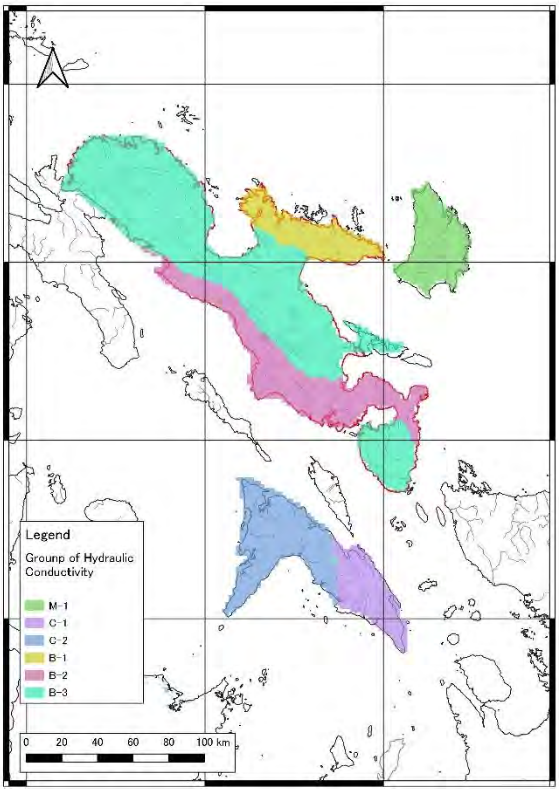
However, sufficient observation data were not available for WRR V. Therefore, while taking into account the hydraulic conductivity setting of the SHER model, the settings were adjusted so that the calculated groundwater level did not exceed the ground surface. The hydraulic conductivity in areas without calibration targets was adjusted based on the values set by the SHER model.

The results of groundwater level calibration are shown in Figure 3.5.4-5. Figure 3.5.4-6 and Table 3.5.4-3 shows the hydraulic conductivity settings after calibration.



Source: JICA Survey Team

Figure 3.5.4-5 Setting of Hydraulic Conductivity after Calibration of WRR V



Source: JICA Survey Team

Figure 3.5.4-6 Setting of Hydraulic Conductivity after Calibration of WRR V

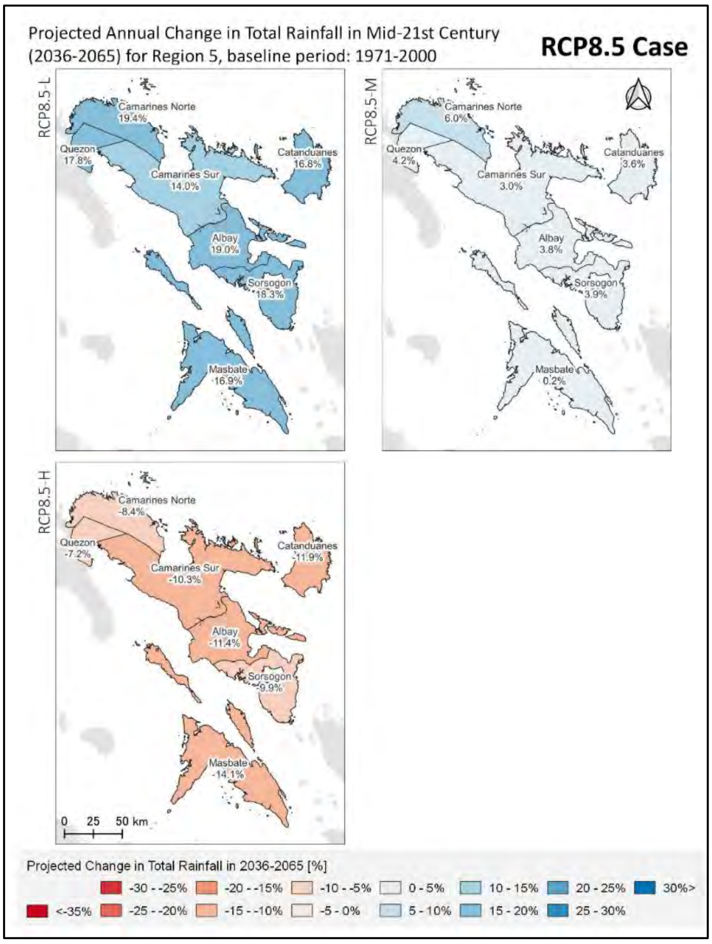
Table 3.5.4-3 Setting of Hydraulic Conductivity after Calibration of WRR V

Model Area	Group	Layer	Hydraulic Conductivity (m/s)	Model Area	Group	Layer	Hydraulic Conductivity (m/s)
Bicol	B_1	1	1×10^{-5}	Masbate	M_1	1	1×10^{-3}
		2	1×10^{-6}			2	1×10^{-4}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	B_2	1	1×10^{-6}		M_2	1	1×10^{-6}
		2	1×10^{-7}			2	1×10^{-7}
		3,4	1×10^{-9}			3,4	1×10^{-9}
	B_3	1	1×10^{-2}	Catanduanes	C_1	1	1×10^{-6}
		2	1×10^{-3}			2	1×10^{-7}
		3,4	1×10^{-9}			3,4	1×10^{-9}

Source: JICA Survey Team

3.5.4.3 Climate Change Impact Assessment

As described in Section 3.3.4.3 Climate Change Impact Assessment, climate change impact in WRR V was estimated by the same method. Figure 3.5.4-7 shows the projected annual change in total rainfall in Mid-21st Century (2036-2065) for administrative region V and part of Quezon Province for RCP8.5 cases. Figures for RCP4.5 as well as seasonal changes in total rainfall are given in Annex-D: Hydrology. The impact of climate change on the water balance is an assessment of future uncertainty (variability). In this study, it was evaluated RCP8.5, which has a large degree of uncertainty. The impact assessment of climate change was estimated by inputting values after changes in future climate change (precipitation and temperature = evapotranspiration) into the input values of the calibrated runoff analysis model. Spatial province-level and temporal quarter-level PAGASA climate change impact data were used.



Source: JICA Survey Team

Figure 3.5.4-7 Projected annual change in total rainfall in Mid-21st Century (2036-2065) for Region V

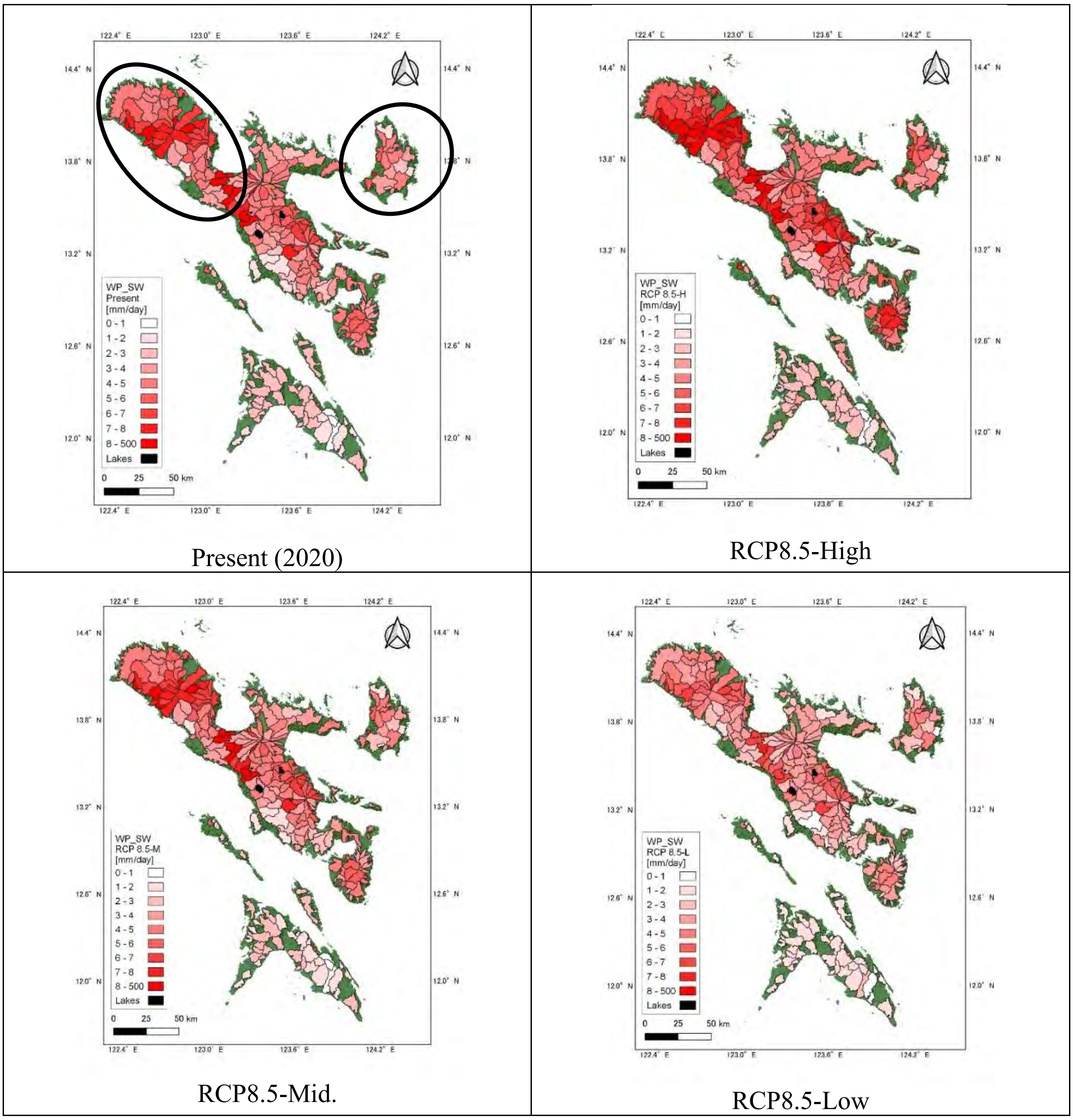
3.5.4.4 Results of Hydrological Analysis

In the detailed hydrological analysis in priority water resources regions, a physically-based water cycle model was used to logically calculate river discharge, groundwater recharge, and groundwater flow, which could be estimated using physical parameters calibrated in sub-basins with discharge gauging stations and even in sub-basins where there are no discharge gauging stations. Calibration results were generally good as shown in Annex-D: Hydrology. As a result of reducing the sub-basin division, it was possible to determine the regional water potential (surface water and groundwater) of the target water resources regions in detail. The results of the water balance analysis with water resources potential and water demand for each sub-basin are described in the following sections.

3.5.5 Water Resources Potential in WRR V

(1) Surface Water Potential

Surface water potentials (river flow) of each sub-basin in WRR V were calculated by the SHER Model as shown in Figure 3.5.4-7.. Surface water potential (river flows) is abundant throughout WRR V, especially in the northern part of WRR V and Catanduanes Island, where precipitation is high and surface water potential is also abundant. Also, the groundwater potential is abundant in Catanduanes Island. On the other hand, surface water potentials are relatively low in the southern part of WRR V, especially in Masbate Island due to less rainfall.



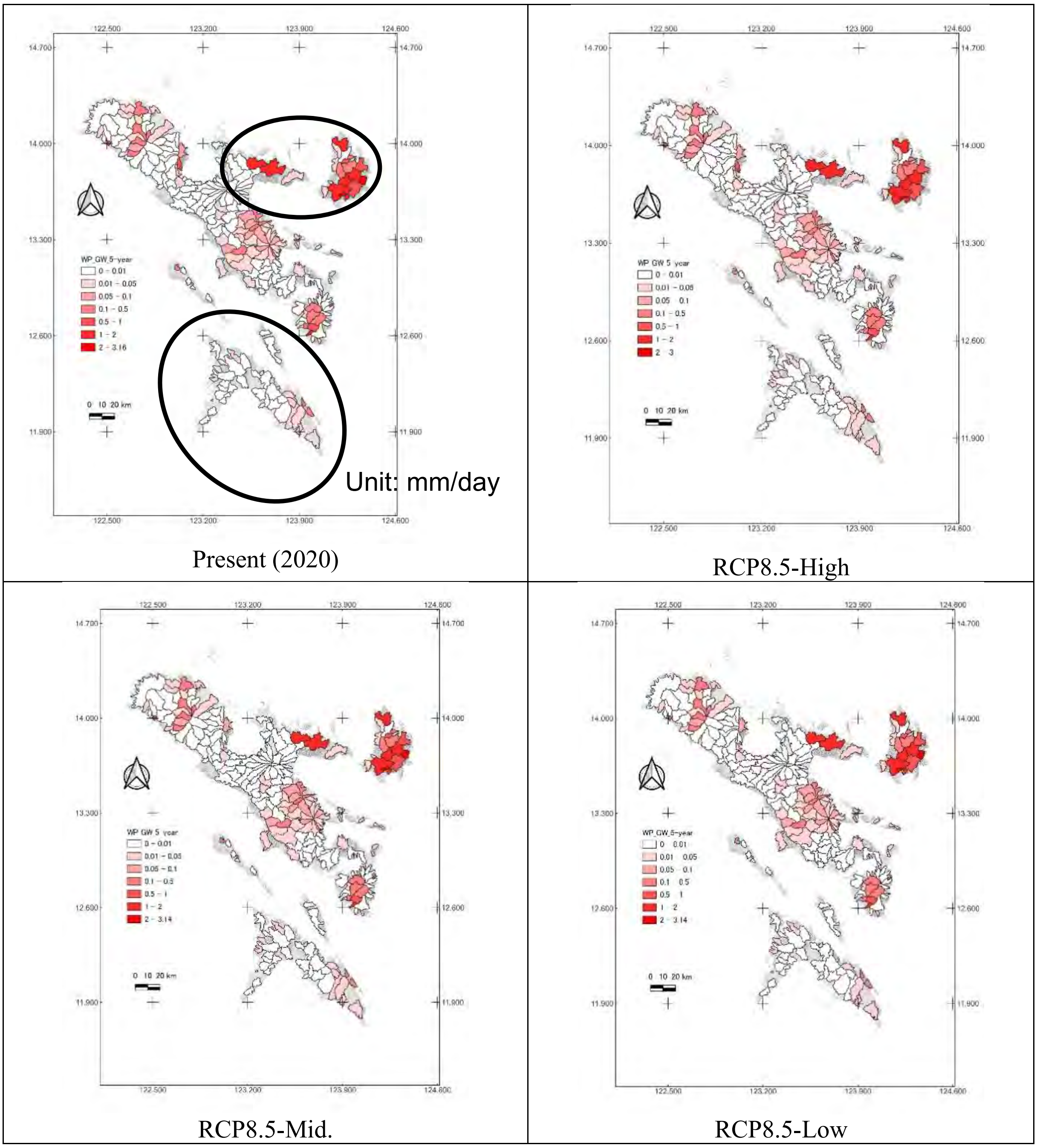
Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).
Source: JICA Survey Team

Figure 3.5.5-1 Surface Water Potentials (1/5-Dry-Year) in WRR-V (Unit: mm/day)

(2) Groundwater Potential

The results of groundwater potentials (groundwater flow) at each block were calculated by the SHER Model. The groundwater potentials used by the MODFLOW Model will be described in the next section of "Hydrological Analysis (Groundwater)".

As shown inFigure 3.5.5-2, groundwater potential is relatively abundant in the northeastern part of WRR V due to plenty of rainfall. On the other hand, groundwater potential is relatively low in the southern part of WRR V, especially in Masbate Island. Groundwater potential was calculated by multiplying the groundwater flow of each block by the safe groundwater pumping rate of 0.7.



Note) 1/5-Dry Year: The goal is to plan facilities so that water demand can be secured even during droughts that occur approximately once every five years (20% probability occurrence).

Source: JICA Survey Team

Figure 3.5.5-2 Groundwater Potentials (1/5-Dry-Year) in WRR-V (Unit: mm/day)

3.5.6 Water Demand Forecast in WRR V

3.5.6.1 Socio-Economic Frame

As described in previous Section 3.3.6.1 Socio-Economic Framework.

3.5.6.2 Water Demand Forecast (Agricultural Use)

(1) Irrigation Water Demands

Annual water demands (AWDs) in WRR-V are summarized in Table 3.5.6-1 for 2020 , Table 3.5.6-2 for 2030, Table 3.5.6-3 for 2040, Table 3.5.6-4 for 2050. The future AWDs are only presented in the case of the irrigation areas estimated based on the NIA past financial programs. The future AWDs in the case of the irrigation areas based on NIMP 2020-2030 are explained in Annex-F.

Table 3.5.6-1 Annual Irrigation Water Demands of 2020 in WRR V

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Quezon	0.053	1,016	908	773	707	10.57	66	66	44	44	0.63	11.20
Albay	1.000	30,541	29,647	22,729	21,335	535.99	1,208	782	316	316	7.70	543.70
Camarines Norte	1.000	8,649	8,383	6,561	6,546	149.29	1,046	853	164	164	3.74	153.03
Camarines Sur	1.000	52,588	52,417	33,230	31,932	878.56	25,077	2,801	1,083	948	27.11	905.67
Catanduanes	1.000	2,965	2,876	1,790	1,824	47.34	246	237	15	15	0.39	47.74
Masbate	1.000	6,656	6,396	3,456	3,519	89.99	192	186	0	0	0.00	89.99
Sorsogon	1.000	11,238	11,202	9,094	9,052	212.80	2,864	2,510	0	0	0.00	212.80
Total		113,653	111,829	77,633	74,915	1,924.54	30,699	7,435	1,622	1,487	39.57	1,964.11

Source: JICA Survey Team

Table 3.5.6-2 Annual Irrigation Water Demands of 2030 in WRR V

Province	Area	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
	Rate	ISA	FUSA	Irrigated Area (ha)		AWD	ISA	FUSA	Irrigated Area (ha)		AWD	AWD
		(ha)	(ha)	Wet	Dry	(MCM)	(ha)	(ha)	Wet	Dry	(MCM)	(MCM)
Irrigation Area based on NIA Financial Program												
Quezon	0.053	1,104	996	896	819	17.89	72	72	51	51	1.07	18.96
Albay	1.000	37,634	36,831	32,680	30,675	788.13	1,489	971	454	454	11.34	799.47
Camarines Norte	1.000	12,378	12,177	11,138	11,112	253.73	1,497	1,239	278	278	6.35	260.08
Camarines Sur	1.000	62,719	66,620	59,002	56,697	1,585.66	29,908	3,560	1,923	1,683	49.12	1,634.78
Catanduanes	1.000	3,133	3,044	2,751	2,804	74.12	260	251	23	23	0.62	74.74
Masbate	1.000	10,773	10,512	9,112	9,278	238.20	311	306	0	0	0.00	238.20
Sorsogon	1.000	11,496	11,467	11,959	11,903	281.91	2,930	2,569	0	0	0.00	281.91
Total		139,236	141,645	127,536	123,288	3,239.64	36,466	8,969	2,730	2,490	68.49	3,308.13

Source: JICA Survey Team

Table 3.5.6-3 Annual Irrigation Water Demands of 2040 in WRR V

Province	Area Rate	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
		ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	AWD (MCM)	ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	AWD (MCM)	AWD (MCM)
Irrigation Area based on NIA Financial Program												
Quezon	0.053	1,192	1,084	974	891	19.46	77	79	56	55	1.16	20.62
Albay	1.000	44,726	44,014	39,053	36,658	941.85	1,769	1,161	543	543	13.55	955.40
Camarines Norte	1.000	16,106	15,970	14,607	14,574	332.78	1,948	1,625	365	365	8.33	341.11
Camarines Sur	1.000	72,849	80,822	71,581	68,785	1,923.70	34,739	4,319	2,333	2,042	59.59	1,983.30
Catanduanes	1.000	3,301	3,212	2,903	2,958	78.21	274	265	24	24	0.65	78.86
Masbate	1.000	14,889	14,628	12,679	12,911	331.46	430	425	0	0	0.00	331.46
Sorsogon	1.000	11,755	11,732	12,235	12,178	288.43	2,996	2,629	0	0	0.00	288.43
Total		164,819	171,462	154,033	148,955	3,915.90	42,232	10,502	3,321	3,030	83.28	3,999.18

Source: JICA Survey Team

Table 3.5.6-4 Annual Irrigation Water Demands of 2050 in WRR V

Province	Area Rate	Irrigation Area By Surface Water					Irrigation Area By Ground Water					Total
		ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	AWD (MCM)	ISA (ha)	FUSA (ha)	Irrigated Area (ha) Wet	Irrigated Area (ha) Dry	AWD (MCM)	AWD (MCM)
Irrigation Area based on NIA Financial Program												
Quezon	0.053	1,281	1,172	1,053	963	21.04	83	85	60	60	1.26	22.29
Albay	1.000	51,819	51,198	45,427	42,641	1,095.57	2,050	1,350	632	632	15.76	1,111.33
Camarines Norte	1.000	19,835	19,764	18,077	18,036	411.83	2,399	2,011	452	452	10.31	422.14
Camarines Sur	1.000	82,980	95,025	84,159	80,872	2,261.75	39,570	5,078	2,743	2,401	70.07	2,331.82
Catanduanes	1.000	3,468	3,380	3,055	3,113	82.30	288	278	26	26	0.68	82.98
Masbate	1.000	19,006	18,743	16,247	16,543	424.72	548	545	0	0	0.00	424.72
Sorsogon	1.000	12,013	11,997	12,511	12,453	294.94	3,062	2,688	0	0	0.00	294.94
Total		190,402	201,278	180,530	174,622	4,592.15	47,999	12,036	3,912	3,570	98.07	4,690.22

Source: JICA Survey Team

(2) Livestock and Poultry Water demands

AWDs for the livestock and poultry in WRR V are calculated as shown in Table 3.5.6-5.

Table 3.5.6-5 Annual Water Demands for Livestock & Poultry in WRR V

Region	Province	Area Rate	Heads in 2020 Livestock	Heads in 2020 Poultry	AWD (MCM) in 2020 Livestock	AWD (MCM) in 2020 Poultry	AWD (MCM) in 2020 Total	AWD (MCM) 2,030	AWD (MCM) 2,040	AWD (MCM) 2050
IV-A	Quezon	0.053	20,246	223,527	0.155	0.011	0.166	0.188	0.206	0.218
V	Albay	1.000	274,878	1,741,647	2.107	0.083	2.190	2.481	2.722	2.879
	Camarines Norte	1.000	210,319	780,880	1.612	0.037	1.649	1.868	2.050	2.169
	Camarines Sur	1.000	393,940	4,575,399	3.020	0.217	3.237	3.667	4.023	4.256
	Catanduanes	1.000	76,256	89,586	0.585	0.004	0.589	0.667	0.732	0.774
	Masbate	1.000	230,066	941,703	1.763	0.045	1.808	2.049	2.248	2.378
	Sorsogon	1.000	137,522	622,320	1.054	0.030	1.084	1.228	1.347	1.425
Total			1,343,227	8,975,062	10.296	0.426	10.722	12.148	13.327	14.099

Source: JICA Survey Team

(3) Freshwater Fishpond Water Demands

AWDs for the freshwater fishponds in WRR-V are estimated as shown in Table 3.5.6-6.

Table 3.5.6-6 Water Demands for Freshwater Fishponds in WRR V

Region	Province	Area Rate	Fishpond Area (ha) in		Annual Water Demands for Fishpond (MCM)			
			Province	WRR	2022	2030	2040	2050
IV-A	Quezon	0.053	7.77	0.41	0.01	0.01	0.02	0.02
V	Albay	1	37.33	37.33	1.09	1.24	1.45	1.70
	Camarines Norte	1	103.36	103.36	3.02	3.43	4.02	4.71
	Camarines Sur	1	11.64	11.64	0.34	0.39	0.45	0.53
	Catanduanes	1	No data					
	Masbate	1	0.00	0.00	0.00	0.00	0.00	0.00
	Sorsogon	1	7.77	7.77	0.23	0.26	0.30	0.35
	Total		**167.87**	**160.51**	**4.69**	**5.32**	**6.24**	**7.31**

Source: JICA Survey Team

3.5.6.3 Water Demand Forecast for Municipal and Industrial Sector in WRR V

(1) Water Demand Forecast Methodology

1) Target Year

To assess the water resources in 2030, 2040, and 2050, the respective municipal and industrial water demands were estimated.

2) Population Projection

Population projection was based on population projection (medium) in latest census data (2020) publicized by PSA.

3) Unit Water Consumption

Unit water consumption was based on the conditional value of PWSSMP 2018. In addition, the values confirmed in the site survey were applied as shown in Table 3.3.6-7.

Table 3.5.6-7 Unit Water Consumption (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	175	175	175	200	200	200	200	MNWD hearing survey
	Legazpi	Legazpi	100	146	**146**	**146**	**146**	**146**	**146**	LCWD hearing survey
	Virac	Virac	130	130	130	130	130	130	130	VWD hearing survey
	Masbate-Mobo	Masbate, Mobo	113	107	100	100	100	100	100	MWD hearing survey
Other cities in Urban Area			120	120	120	120	120	120	120	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	60	60	60	60	60	60	Domestic demand (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

4) Non-Revenue Water Ratio

Non-revenue water ratio was based on the conditional value of PWSSMP 2018. In addition, the values confirmed in the site survey were applied as shown in Table 3.3.6-8.

Table 3.5.6-8 Non-Revenue Water Ratio

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	28%	20%	20%	20%	20%	20%	20%	MNWD hearing survey
	Legazpi	Legazpi	35%	23%	**20%**	**20%**	**20%**	**20%**	**20%**	LCWD hearing survey
	Virac	Virac	30%	28%	25%	24%	23%	22%	20%	VWD hearing survey
	Masbate-Mobo	Masbate, Mobo	40%	34%	28%	20%	20%	20%	20%	MWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

5) Allocation for Municipal Water Demand

Allocation for each category was based on the current consumption result confirmed in PWSSMP 2018 and the site survey as shown in Table 3.3.6-9.

Table 3.5.6-9 Allocation for Municipal Water Demand

WRR	Water District	Municipality	Domestic (%)	Commercial (%)	Institutional (%)	Total (%)	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	81%	16%	4%	100%	Actual consumption result as of Dec. 2021 by MNWD hearing survey
	Legazpi	Legazpi	76%	16%	8%	100%	Actual consumption result as of Dec. 2021 by LCWD hearing survey
	Virac	Virac	**76%**	**16%**	**8%**	**100%**	Refer to Legazpi Data
	Masbate-Mobo	Masbate, Mobo	**76%**	**16%**	**8%**	**100%**	Refer to Legazpi Data
Other cities in Urban Area			93%	6%	1%	100%	Current Allocation (urban) in PWSSMP2018
Other cities in Rural Area			90%	8%	2%	100%	Current Allocation (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

6) Correlation Formula between GRDP and Industrial Water Demand

In the estimation of the future industrial water demand, the past trend of industrial GRDP was calculated based on the GRDP record and percentage of the industry to GDP on PSA "Regional Accounts of the Philippines" 2021 as shown in Table 3.3.6-10.

Table 3.5.6-10 Past Trend of Industrial GRDP

Water Resource Region		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
WRR V	REGION IV-A (CALABARZON)	491,964	492,507	535,504	575,141	615,032	658,325	710,261	765,625	827,359	825,378
	REGION V (BICOL REGION)	88,238	89,317	99,028	109,129	116,871	129,457	140,072	147,927	159,547	161,527

Source: JICA Survey Team

Also, the past trend of industrial water use was calculated by dividing the NWRB national industrial water rights grant record by the above past trend of industrial GRDP as shown in .

Table 3.5.6-11 Past Trend of Industrial Water Use

Water Resource Region		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
WRR V	REGION IV-A (CALABARZON)	355	355	361	370	373	378	391	398	405	405
	REGION V (BICOL REGION)	64	64	67	70	71	74	77	77	78	79

Source: JICA Survey Team

Based on the above past trend of industrial GRDP and industrial water use, correlation formula between industrial GRDP and industrial water use is calculated using the formula below. Results are shown in Table 3.3.6-12.

Industrial Water Use (MCM/Year) = SLOPE × Industrial GRDP (Million Pesos) ＋ INTERCEPT

Table 3.5.6-12 Correlation Formula Factor Between Industrial GRDP and Industrial Water Use

Water Resource Region		SLOPE	INTERCEPT
WRR V	REGION IV-A (CALABARZON)	0.00015	282
	REGION V (BICOL REGION)	0.00021	47

Source: JICA Survey Team

7) Industrial GRDP Projection

Industrial GRDP projection is calculated by GRDP projection (medium) and percentage of the industry to GDP on PSA "Regional Accounts of the Philippines" 2021 as shown in Table 3.3.6-13.

Table 3.5.6-13 Industrial GRDP Projection

Water Resource Region		2020	2025	2,030	2035	2040	2045	2050
WRR V	REGION IV-A (CALABARZON)	656,964	757,268	853,525	959,392	1,046,192	1,192,713	1,275,299
	REGION V (BICOL REGION)	132,102	169,971	203,051	237,591	263,882	305,026	330,702

Source: JICA Survey Team

(2) Water Demand Forecast Result

1) Water Demand Forecast Result for Municipal Sector

Based on the above population projection and prediction condition for the municipal water demand forecast, the municipal water demand forecast is calculated as shown in Table 3.3.6-14. The detailed water demand forecast result is shown in Appendix A.

Table 3.5.6-14 Result of Municipal Water Demand Forecast for Priority WRRs

Water Resource Region	Municipal Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR V - BICOL	243	252	259	283	303	320	336

Source: JICA Survey Team

2) Water Demand Forecast Result for Industrial Sector

Based on the above correlation formula and industrial GRDP projection, the industrial water demand forecast is calculated as shown in . The detailed water demand forecast result is shown in Appendix B.

Table 3.5.6-15 Result of Industrial Water Demand Forecast for Priority WRRs

Water Resource Region	Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR V - BICOL	113	120	128	136	142	152	158

Source: JICA Survey Team

3.5.6.4 Water Resources Facility Plan (Hydropower Plant, Dam)

Plan of the irrigation dams and flood control dams are presented in Section 3.5.3.8 Current Status of Water Use Facilities in WRR V and Section 3.5.3.10 Flood Risk Management (FRM) in WRR V respectively.

3.5.6.5 River Maintenance Flow (Environmental Flow)

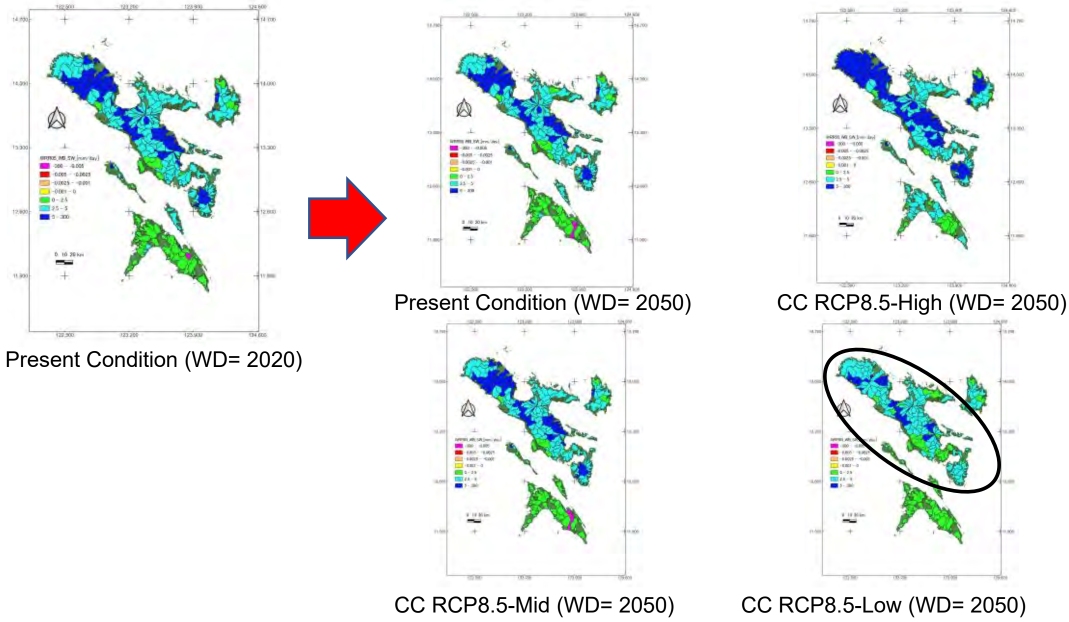
10% of dependable flow (80% of flow duration curve) is applied in the study based on based on DENR-NWRB resolution No. 030613.

3.5.7 Water Balance in WRR V

(1) Sub-basin-wise Surface Water Balance

Sub-basin-wise surface water balances at present condition, future (2050), and climate change conditions are shown in Figure 3.5.7-1.

In terms of future water demand (2050), although it is a severe case that does not take any measures in RCP8.5, in the RCP8.5-Low case of climate change, the surface water balance of the northern, central, and southern parts of WRR V is on a declining trend.



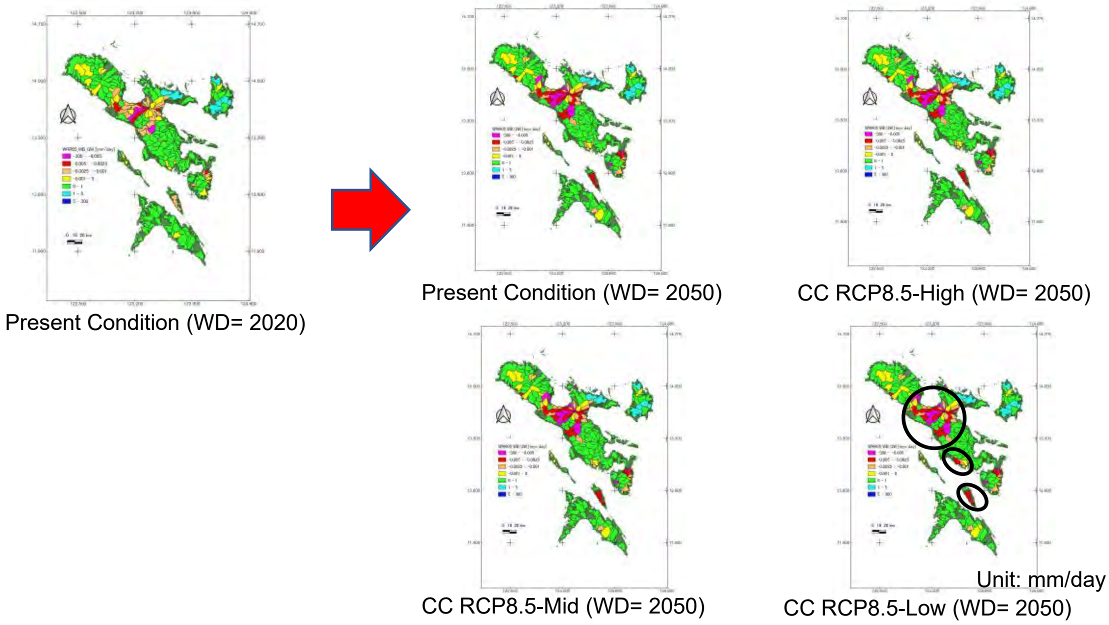
Source: JICA Survey Team

Figure 3.5.7-1 Estimated Sub-Basin wise Surface Water Balance in WRR-V

(2) Sub-Basin-wise Groundwater Balance

Sub-basin-wise groundwater balance at present condition, future (2050), and climate change conditions are shown in Figure 3.5.7-2.

In terms of future water demand (2050), in the RCP8.5-Low case of climate change, the groundwater balance of the central part of WRR V, Donsol City, and Ticao Island will be on a declining trend especially in the Naga City area.



Source: JICA Survey Team

Figure 3.5.7-2 Estimated Sub-Basin wise Groundwater Balance in WRR-V

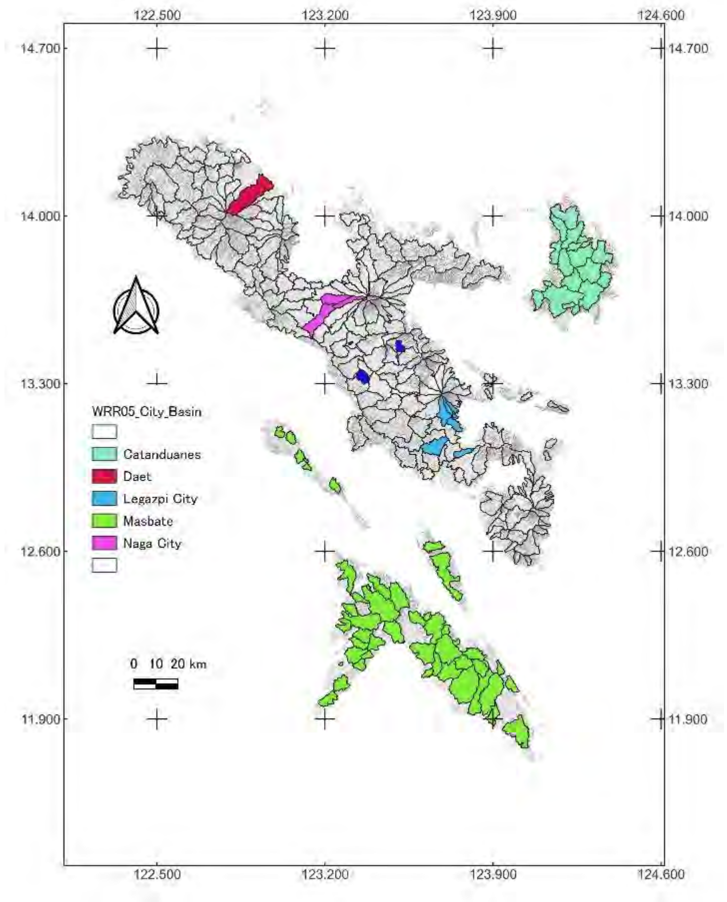
(3) Provincial-wise Water Balance

Provincial-wise surface and groundwater balances in 1/5-dry year at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology.

The summary of water balance and deficit estimation of provincial-wise surface and groundwater balances at each climate change condition and water demand of 2020 and 2050 are shown in Annex-D: Hydrology. In Albay, Camarines Norte, Camarines Sur, and Masbate provinces, negative values of annual water and deficit of groundwater will increase in the future.

(4) Major City/Town-wise Water Balance

The location map of the major cities in WRR V is shown in Figure 3.5.7-3.



Source: JICA Survey Team

Figure 3.5.7-3 Location Map of Major Cities in WRR-V

The surface and groundwater balances in 1/5-dry year in the major cities at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. In most cities, the groundwater balance is projected to be negative against the water demand in 2050, and the negative groundwater balance is particularly large in Naga and Legazpi cities.

Table 3.5.7-1 Surface and Groundwater Balance of Naga City in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)

Town/City: Naga City Target Year= 2050
Weather Condition: Present Total Area [km2]= 148 Unit: MCM

Items	1	2	3	4	5	6	7	8	9	10	11	12	Annual	Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deficit
Rainfall	16.8	9.6	10.9	7.0	18.1	14.6	41.5	43.4	50.2	35.1	54.4	35.5	337.1	
Surface Water Potential	**60.1**	**40.9**	**32.9**	**30.2**	**20.0**	**16.3**	**39.1**	**14.4**	**22.7**	**25.7**	**45.5**	**33.8**	**381.6**	
Irrigation Water Demand (SW)	19.5	20.9	29.3	3.8	19.4	21.1	15.0	16.1	0.0	0.0	0.0	10.5	155.7	
Livestock Water Deamnd (SW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	
Municipal and Industrial Water Demand (SW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	
Other Water Demand (SW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Water Demand (SW)	19.6	21.0	29.3	3.9	19.5	21.1	15.1	16.1	0.0	0.1	0.0	10.6	156.3	
SW Water Balance	**40.5**	**20.0**	**3.6**	**26.3**	**0.5**	**-4.8**	**24.0**	**-1.7**	**22.7**	**25.7**	**45.4**	**23.3**	**225.3**	**-6.5**
Groundwater Potential	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	
Safety Groundwater Availability (70% of GWP)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
Irrigation Water Demand (GW)	0.4	0.5	0.6	0.1	0.5	0.5	0.4	0.4	0.0	0.0	0.0	0.2	3.6	
Livestock Water Deamnd (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	
Municipal and Industrial Water Demand (GW)	4.6	4.1	4.6	4.4	4.6	4.4	4.6	4.6	4.4	4.6	4.4	4.6	53.6	
Other Water Demand (GW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Water Demand (GW)	5.0	4.6	5.2	4.5	5.1	4.9	4.9	5.0	4.4	4.6	4.4	4.8	57.5	
GW Water Balance	**-5.0**	**-4.6**	**-5.2**	**-4.5**	**-5.0**	**-4.9**	**-4.9**	**-5.0**	**-4.4**	**-4.6**	**-4.4**	**-4.8**	**-57.4**	**-57.4**
Total Water Potential (SW+GW)	**60.1**	**40.9**	**32.9**	**30.2**	**20.0**	**16.3**	**39.1**	**14.4**	**22.7**	**25.7**	**45.5**	**33.8**	**381.7**	
Irrigation Water Demand (Total)	20.0	21.4	29.9	3.9	19.9	21.6	15.4	16.5	0.0	0.0	0.0	10.7	159.3	
Livestock Water Deamnd (Total)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	
Municipal and Industrial Water Demand (Total)	4.6	4.1	4.6	4.4	4.6	4.4	4.6	4.6	4.4	4.6	4.4	4.6	53.9	
Other Water Demand (Total)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Water Demand (SW+GW)	24.6	25.6	34.5	8.4	24.5	26.1	20.0	21.1	4.5	4.6	4.5	15.4	213.8	
Total Water Balance (SW+GW)	**35.5**	**15.4**	**-1.6**	**21.8**	**-4.6**	**-9.7**	**19.1**	**-6.7**	**18.3**	**21.1**	**41.0**	**18.5**	**167.9**	**-64.0**

Source: JICA Survey Team

The summary of water balance and deficit estimation of surface and groundwater balances at each climate change condition and water demand of 2020 and 2050 in Legazpi, Daet, and Naga cities are shown in Annex-D: Hydrology. In Naga, Daet, and Legazpi cities, negative values of annual water and deficit of groundwater will increase in the future. All cities will have a surplus of surface water balance in the future. However, these annual surface water potentials include flood discharge. Thus, surface water reservoirs might be needed.

Table 3.5.7-2 Summary of Annual Water Balance and Deficit of Legazpi City at Each Climate Change Condition

Total Area [km^2]= 177

Case No.	Weather Condition	Water Demand	Target Year	SW.Balance [MCM/year]	GW.Balance [MCM/year]	Total W.Balance [MCM/year]	SW Deficit [MCM/year]	GW Deficit [MCM/year]	Total Deficit [MCM/year]
1	Present	2020	Average Year	233.5	-4.9	228.6	0.0	-4.9	-4.9
2	Present	2020	1/5-Dry Year	258.4	-4.9	253.5	0.0	-4.9	-4.9
3	Present	2020	1/10-Dry Year	198.8	-4.9	193.9	0.0	-4.9	-4.9
4	Present	2050	Average Year	203.8	-7.0	196.8	-2.7	-7.0	-9.6
5	Present	2050	1/5-Dry Year	228.7	-7.0	221.7	0.0	-7.0	-7.0
6	Present	2050	1/10-Dry Year	169.0	-7.0	162.0	-2.8	-7.0	-9.7
7	CC RCP8.5-High	2050	Average Year	269.6	-7.0	262.6	-0.7	-7.0	-7.7
8	CC RCP8.5-High	2050	1/5-Dry Year	296.1	-7.0	289.2	0.0	-7.0	-7.0
9	CC RCP8.5-High	2050	1/10-Dry Year	231.3	-7.0	224.3	-0.7	-7.0	-7.6
10	CC RCP8.5-Mid.	2050	Average Year	213.8	-7.0	206.9	-2.8	-7.0	-9.7
11	CC RCP8.5-Mid.	2050	1/5-Dry Year	229.1	-7.0	222.1	0.0	-7.0	-7.0
12	CC RCP8.5-Mid.	2050	1/10-Dry Year	171.0	-7.0	164.1	-3.0	-7.0	-10.0
13	CC RCP8.5-Low	2050	Average Year	141.3	-7.0	134.3	-8.0	-7.0	-15.0
14	CC RCP8.5-Low	2050	1/5-Dry Year	167.1	-7.0	160.1	0.0	-7.0	-7.0
15	CC RCP8.5-Low	2050	1/10-Dry Year	117.2	-7.0	110.2	-6.7	-7.0	-13.6

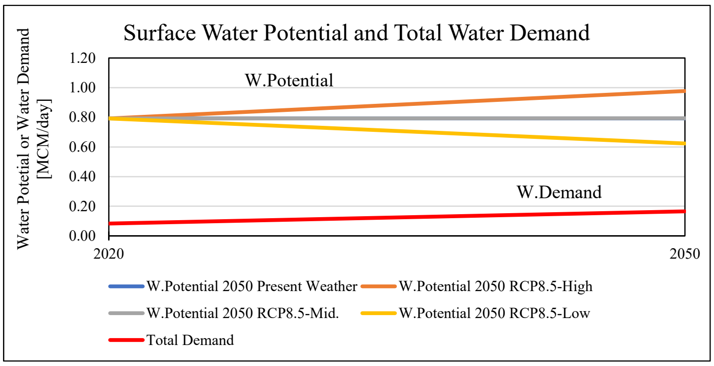
Source: JICA Survey Team

Table 3.5.7-3 Summary of Annual Water Balance and Deficit of Naga City at Each Climate Change Condition

Total Area [km^2]= 148

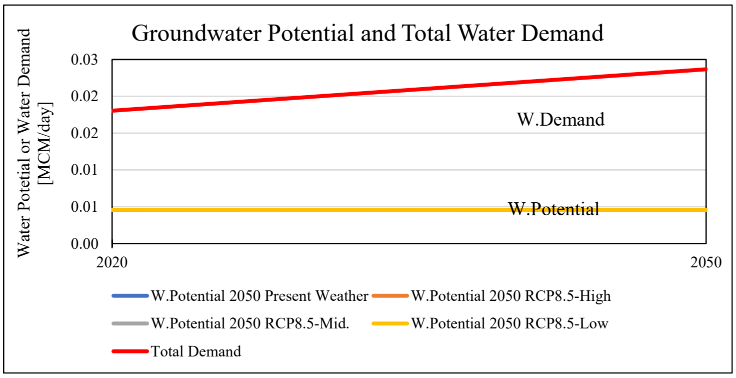
Case No.	Weather Condition	Water Demand	Target Year	SW.Balance [MCM/year]	GW.Balance [MCM/year]	Total W.Balance [MCM/year]	SW Deficit [MCM/year]	GW Deficit [MCM/year]	Total Deficit [MCM/year]
1	Present	2020	Average Year	421.6	-22.4	399.2	0.0	-22.4	-22.4
2	Present	2020	1/5-Dry Year	321.1	-22.4	298.7	0.0	-22.4	-22.4
3	Present	2020	1/10-Dry Year	326.7	-22.4	304.2	0.0	-22.4	-22.4
4	Present	2050	Average Year	326.0	-35.0	290.9	0.0	-35.0	-35.0
5	Present	2050	1/5-Dry Year	225.4	-35.0	190.4	-6.5	-35.0	-41.5
6	Present	2050	1/10-Dry Year	231.0	-35.0	196.0	-4.5	-35.0	-39.5
7	CC RCP8.5-High	2050	Average Year	387.8	-35.0	352.8	0.0	-35.0	-35.0
8	CC RCP8.5-High	2050	1/5-Dry Year	266.1	-35.0	231.1	-3.2	-35.0	-38.3
9	CC RCP8.5-High	2050	1/10-Dry Year	314.3	-35.0	279.3	-4.1	-35.0	-39.2
10	CC RCP8.5-Mid.	2050	Average Year	315.3	-35.0	280.3	0.0	-35.0	-35.0
11	CC RCP8.5-Mid.	2050	1/5-Dry Year	213.9	-35.0	178.9	-9.0	-35.0	-44.1
12	CC RCP8.5-Mid.	2050	1/10-Dry Year	259.4	-35.0	224.4	-5.3	-35.0	-40.4
13	CC RCP8.5-Low	2050	Average Year	128.0	-35.0	92.9	-33.3	-35.0	-68.3
14	CC RCP8.5-Low	2050	1/5-Dry Year	77.0	-35.0	42.0	-37.5	-35.0	-72.6
15	CC RCP8.5-Low	2050	1/10-Dry Year	57.7	-35.0	22.6	-35.6	-35.0	-70.6

Source: JICA Survey Team



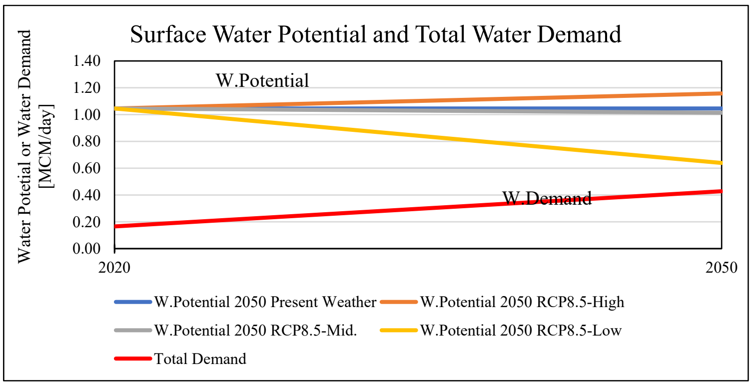
Source: JICA Survey Team

Figure 3.5.7-4 Surface Water Balance of Legazpi City in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)



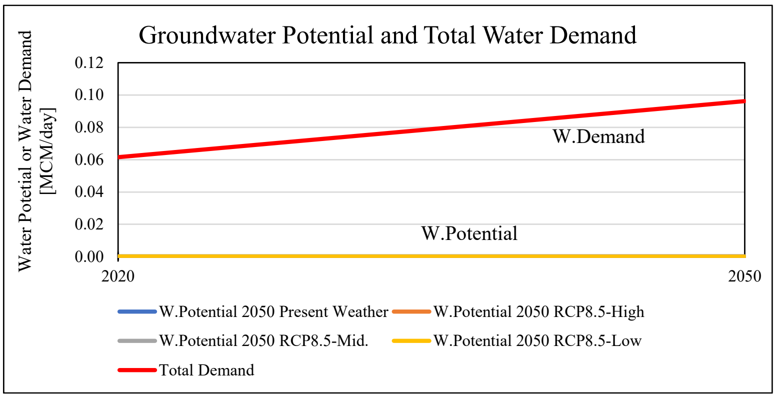
Source: JICA Survey Team

Figure 3.5.7-5 Groundwater Balance of Legazpi City in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)



Source: JICA Survey Team

Figure 3.5.7-6 Surface Water Balance of Naga City in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)



Source: JICA Survey Team

Figure 3.5.7-7 Groundwater Balance of Naga City in 1/5-Dry Year, (Present Weather Condition, Water Demand=2050)

The summary of water balance of major cities in WRR-V at water demand of 2050 are shown in Table below. Annual water balance in all cities will be positive, however in dry season, it will be tight in some of month. Looking at the groundwater balance forecast for the present weather condition in 2050, Naga, Daet, Legazpi and Mastbate cites have negative groundwater balances, especially in Naga City.

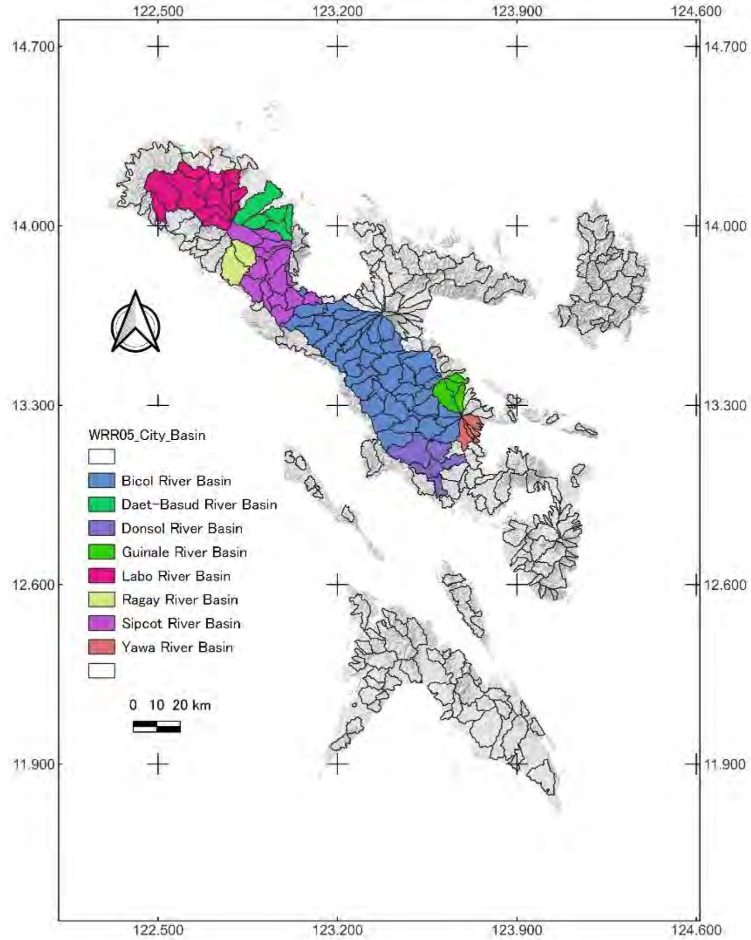
Table 3.5.7-4 Summary of Annual Water Balance of Major Cities in WRR-V in 2050

City	Weather Condition	Water Demand	Target Year	Total Area [km2]	SW/GW	W.Potential [MCM/year]	Domestic & Industrial W.Demand [MCM/year]	Irrigation W. Demand [MCM/year]	Livestock W. Demand [MCM/year]	Other W. Demand [MCM/year]	Water Balance [MCM/year]
Legazpi	Present	2050	1/5-Dry Year	176.7	SW	289.1	12.1	48.2	0.1	0.0	228.7
					GW	1.7	8.5	0.0	0.0	0.1	-7.0
					Total	290.8	20.6	48.2	0.1	0.1	221.7
Daet	Present	2050	1/5-Dry Year	142.2	SW	312.2	7.1	13.7	0.1	0.0	291.3
					GW	1.6	7.9	0.3	0.1	14.1	-20.9
					Total	313.7	15.0	14.0	0.1	14.1	270.5
Naga	Present	2050	1/5-Dry Year	148.1	SW	381.6	0.2	155.7	0.3	0.0	225.4
					GW	0.0	31.2	3.6	0.2	0.0	-35.0
					Total	381.7	31.4	159.3	0.5	0.0	190.4
Catanduanes	Present	2050	1/5-Dry Year	943.3	SW	1,347.2	15.0	109.1	0.6	0.0	1,222.5
					GW	307.4	2.6	1.2	0.4	0.0	303.2
					Total	1,654.6	17.7	110.2	1.0	0.0	1,525.6
Masbate	Present	2050	1/5-Dry Year	2,107.7	SW	1,759.6	44.7	208.7	1.0	0.0	1,505.2
					GW	13.6	14.5	3.5	0.2	0.0	-4.6
					Total	1,773.3	59.3	212.1	1.3	0.0	1,500.7

Source: JICA Survey Team

(5) Major River Basin-wise Water Balance

The location map of the major river basins in WRR V is shown in Figure 3.5.7-8 below.



Source: JICA Survey Team

Figure 3.5.7-8 Location Map of Major River Basins in WRR V

The surface and groundwater balances in 1/5-dry year in the major river basins at present weather condition and water demand of 2050 are shown in Annex-D: Hydrology. The Bicol and Sipocot river basins will have a negative water balance of groundwater in 2050.

The summary of water balance and deficit estimation of surface and groundwater balance at each climate change condition and water demand of 2020 and 2050 in the Bicol and Sipocot river basin areas are shown in Annex-D: Hydrology. In the Bicol and Sipocot river basins, negative values of annual water and deficit of groundwater will increase in the future.

(6) Conclusion

As described above, annual surface water balance in all cities will be positive, however in dry season, it will be tight in some of month. As shown in Table 3.5.7-4, looking at the groundwater balance forecast for the present weather condition in 2050, Naga, Daet, Legazpi and Masbate cites have negative groundwater balances, especially in Naga City.

Table 3.5.7-5 shows the summary of water balance analysis in WRR V. Looking at the water balance by province, major city and by major river basin, the groundwater balance in 2050 in many of provinces will be negative. The deficit of groundwater balance in Camarines Sur, Albay and Camarines Norte provinces are large, and the negative of groundwater balance in the Naga city and the Bicol River Basin will be large in 2050.

Table 3.5.7-5 Surface and Groundwater Balance in WRR-V
(1/5-Dry Year, Present Weather Condition, Water Demand=2050)

Surface Water (2050, Present Weather Condition, 1/5-Dry Year)

Item	Classification	Modeled Area	Annual Rainfall	Annual Effective Rainfall**	Annual Evapo-transpiration	Annual Runoff	Annual Runoff (*SW Potential)	Runoff Coefficient	Water Demand (SW)	Water Balance (SW)
		(km^2)	(mm/year)	(mm/year)	(mm/year)	(mm/year)	(MCM/yr)	(%)	(MCM/yr)	(MCM/yr)
Province	Albay	1,922	2,631	1,223	971	1,642	3,172	62.4%	1,202.6	1,969.6
	Camarines Norte	1,633	3,152	1,586	1,009	2,129	3,488	67.5%	479.0	3,008.5
	Camarines Sur	4,055	2,560	1,473	558	1,978	8,070	77.3%	2,333.7	5,736.2
	Catanduanes	943	2,876	1,061	1,028	1,424	1,347	49.5%	111.0	1,236.2
	Masbate	2,108	1,881	619	1,041	831	1,760	44.2%	486.6	1,273.0
	Quezon	309	3,009	1,995	271	2,678	835	89.0%	56.2	779.3
	Sorsogon	1,220	2,421	1,082	917	1,453	1,777	60.0%	339.8	1,436.9
	Total / Average	12,189	2,647	1,291	828	1,734	20,449	65.5%	5,009	15,440
Major City	Naga	148	2,276	1,111	785	*1,491*	382	65.5%	156.2	225.4
	Legazpi	177	2,670	1,216	1,025	1,633	289	61.1%	60.5	228.7
Major River Basin	Bicol	2,284	2,444	1,513	404	2,031	4,668	83.1%	1,719.8	2,947.8
	Lanang (Masbate)	139	1,934	691	1,003	928	129	48.0%	5.4	123.9

** Effective Rainfall = Runoff * 74.5%

Groundwater (2050, Present Weather Condition, 1/5-Dry Year)

Item	Classification	Modeled Area	Annual Recharge	Annual Recharge	GW Potential*	GW Potential*	Water Demand (GW)	Water Balance (GW)
		(km^2)	(mm/year)	(MCM/yr)	(mm/year)	(MCM/yr)	(MCM/yr)	(MCM/yr)
Province	Albay	1,922	17.7	34.1	13.6	26.2	68.4	-54.7
	Camarines Norte	1,633	14.5	23.7	11.1	18.2	42.8	-31.6
	Camarines Sur	4,055	23.8	96.7	18.3	74.4	243.6	-225.3
	Catanduanes	943	423.6	399.6	325.9	307.4	5.0	320.9
	Masbate	2,108	8.4	17.7	6.5	13.6	22.1	-15.7
	Quezon	309	60.1	18.6	46.2	14.3	2.4	43.8
	Sorsogon	1,220	51.1	62.3	39.3	47.9	56.8	-17.5
	Total / Average	12,189	85.6	1,043.6	89.3	502.0	441.1	19.9
Major City	Naga	148	0.4	0.1	0.3	0.0	35.1	-34.8
	Legazpi	177	12.3	2.2	9.5	1.7	8.6	0.9
Major River Basin	Bicol	2,284	9.1	20.8	7.0	16.0	177.3	-170.3
	Lanang (Masbate)	139	2.9	0.4	2.3	0.3	0.1	2.2

*Stable amount of water that can be taken

Source: JICA Survey Team

CHAPTER 4 PREPARTION OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT PLAN (IDEA) IN PRIORITY WATER RESOURCES REGIONS

In this chapter, the basic policy for plan formulation was established based on the results of the review of 1998 M/P (Section 4.1). In accordance with this basic policy, by each priority water resources region, alternative study for the water resources development and management options was conducted and the water resources development and management plan (idea) was proposed to solve the water supply-demand gap by the targe year of 2050 considering climate change impacts. The priority projects concepts were created by combining some components of the short-term plan (Sections 4.3 to 4.5 for WRR VII, XI and V, respectively).

In addition, in the course of the Survey, the strategic environmental assessment (SEA) was conducted for initial environmental and social impacts assessment on the proposed plan and proposed project concepts. As a part of SEA, the stakeholder meetings (SHM) were held two times in each priority WRR. The results of SHM are described in Section 4.2.

4.1 Basic Policy for Plan Formulation

4.1.1 Basic Policy for Formulation of Water Resources Development and Management Plan (idea)

In this Survey, the 1998 M/P is reviewed, and from the current point of view, the obstacles for realizing the proposed projects are identified as well as the kinds of actions to be taken. These results are reflected in the proposal for formulating a highly feasible water resources development and management plan (draft) and priority project concepts. Table 4.1-1 below shows the 1998 M/P main contents and the basic policy for the formulation of water resources development and management plan.

Table 4.1-1 Basic Policy for Formulation of Water Resources Development and Management Plan (idea)

Items	1998 M/P	Basic Policy for Formulation of Water Resources Development and Management Plan (★)
Survey Target	Whole country	Whole country
Priority Area	Priority river basins and Critical cities (Manila, Cebu, Baguio)	★Three WRR: V (Bicol), VII (Central Visayas), XI (Southeastern Mindanao). In this survey, Metro Manila was excluded in TOR.
Target Year	Year 2025	Year 2050
Climate Change Impact	Without consideration	Considered
Water Demand Forecast	Calculated based on two scenarios: economic growth (high/low) by sector and WRR/state/basin/city	★Add "medium" to the economic growth scenario.
Urban Water	7.29 billion m^3/year (3.7 times increase rate)	★Water demand forecasting is based on figures with improved accuracy based on: latest socio-economic framework, irrigation development plan, field survey results of water usage, revenue records, latest industrial development plans, etc. are collected.
Industrial	3.31 billion to 5.00 billion m^3/year (increased rate 2.29 times)	
Agriculture	38.8 to 59.8 billion m^3/year	
Others (Livestock and Fisheries)	11 to 13.1 billion m^3/year	

Items	1998 M/P	Basic Policy for Formulation of Water Resources Development and Management Plan (★)
Water Resource Potential Surface Water Groundwater	Calculated by water resources region/state/basin/city 206.2 billion m^3/year (50% of natural daily flow) 20.2 billion m^3/year (5% of rainfall)	★ In this survey, a new water balance model both for surface water and groundwater is constructed and analyzed, but it is confirmed by comparing it with the 1998 M/P data.
Annual Water Balance (Potential/Demand)	Nationwide: 2.65 to 3.74 (calculated in 12 water resource regions)	★Same as above
Reliability of Water Utilization	(Irrigation 1-5 years, water supply / industrial water 1-20 years)	Adopting 1-5 years of irrigation and 1-10 years of water supply and industrial water utilization, respectively.
Water Utilization Program	Dam plan for 17 major basins (22 dams) Water supply facility plans for the three major cities (combination of dams, water conveyance, seawater desalination, etc.) Manila: 4 projects Cebu: 3 projects Baguio: 2 projects	★Confirm the execution status of the 1998 M/P proposal project ★Consider various developments that do not rely solely on dams (river mouth weirs, groundwater, reservoirs, water conservation, dam regeneration, seawater desalination, water reuse, water leakage countermeasures). ★Proposals from the perspective of water management (organization/legal framework, personnel, finance, maintenance, environment, water information management)
Environmental and Social Considerations	Preliminary review level (alternative submerged, relocated, indigenous)	★Conduct strategic environmental assessment (SEA) and stakeholder consultation
Expense	Approximate project cost calculation at M/P level with reference to actual construction costs for similar projects, etc., based on the layout plan of major structures and basic specifications	★Calculate by referring to the project cost of the 1998 M/P proposed facility and the latest results of similar projects.

Source: JICA Survey Team

In particular, the following approaches including the IWRM concept are adopted to propose highly feasible plans when studying the priority project concept:

- Selection of the priority projects considering financial aspects of the project implementation entity, such as the project scale and funding sources (PPP scheme, etc.)
- Consensus building by SEA for social environment consideration and incorporating stakeholders from the alternative planning stage
- Study and consideration of organizational and institutional aspects such as implementation system and legal framework for the proposed projects that would go beyond the existing administrative framework
- Proposal and selection of priority projects taking into consideration the technical aspects such as the technical capabilities and operational maintenance management capabilities of the project implementation entity.

4.1.2 Review of the 1998 M/P

The 1998 M/P is reviewed in terms of i) its utilization status, ii) current situation of the proposed projects, iii) differences of water demand forecasts from the actual results, and iv) key points to be considered in this survey. These results are reflected on the proposal for formulating the water resources development and management plan (idea) and priority project concepts.

(1) Utilization Status

In the 1998 M/P, water resources throughout the Philippines were analyzed and evaluated in a unified manner, and the results, with high reliability and quality, have contributed in formulating national development policies. Data construction and analysis and recommendations based on the results are still being utilized as shown in Table 4.1-2.

On the other hand, most of the large-scale projects proposed in the 1998 M/P have not been implemented yet. Based on this fact, it is a challenge to consider and propose projects that can be realized, taking into consideration the scale of implementation, finance, technical aspects, environmental and social considerations, and organizational/legal framework aspects.

Table 4.1-2 Utilization Status of 1998 M/P

Item	Proposal, Output	Utilization Status
Organization	Tentative Proposal: Strengthening the National Water Resources Board (NWRB) Final: Establishment of the Philippine Department of Water Resources	In line with the recommendations of 1998 M/P, NWRB was reorganized into a department of the Department of Environment and Natural Resources (DENR) in 2010 to strengthen the finance and personnel of the NWRB. [Current Situation] - NWRB created two extension offices in Cebu and Davao. - Both of the number of NWRB's employees and its revenue are on the rise in the last decade though they are not sufficient yet.
Legal System	Institutionalization of periodic review of water resources development master plan	It was proposed that legislation should be developed with the aim of consolidating the powers and roles related to water resources development and management, which are scattered among various departments and agencies, and strengthening the organization of NWRB. Legislation related to the organizational strengthening of NWRB has already been developed, but legislation related to consolidating the powers and roles related to water resources development and management has not yet been implemented. Update of the M/P have not been implemented.
Water Resources Data	Collection and organization of hydrological data, installation of water information network system	Hydrological information and water supply and sewerage sector information have been organized, and are being referred to and utilized as the basic database for current water resources planning.
Proposed Projects	Plans for dam construction in 17 major river basins (22 dams) Plans for water supply facilities in the three major cities (a combination of dams, water conveyance, seawater desalination, etc.) Manila: 4 projects Cebu: 3 projects Baguio: 2 projects	The study focused on formulating a development plan limited to the water supply project targeting large cities such as Manila, Cebu and Baguio. For several proposed dams, D/D and bidding preparations are underway for the construction, but many projects have not been implemented due to issues such as social environmental problems and project financing. A seawater desalination plant construction project was proposed in the Metro Cebu area, and was examined through a JICA Study in 2010. Seawater desalination is currently being planned as a priority project by MCWD.

Item	Proposal, Output	Utilization Status
Water Resources Management	Recommendation for implementation of the master plan study and feasibility study for the industrial water supply to Metro Manila, Cebu City, and Baguio City. Technical assistant projects - Collection and development of hydrological data - Establishment of national water information network system - Review of National Water Resources M/P - Implementation of master plan for specific river basin	Efforts were made for the proposed "collection and development of hydrological data," "establishment of a water information network system," and "feasibility study for the follow-up of the national water resources M/P." On the other hand, the "review and update of the National Water Resources M/P" had not been implemented prior to this Survey.

Source: JICA Project Research "Examination of Aid Approaches for Integrated Water Resources" (2011)

(2) Current Situation and Review of the Proposed Projects

The progress of the water resources development schemes in the plan is summarized in ANNEX G Surface Water Resources Development, Appendix G-3: Progress of Water Development Schemes Proposed by 1998 M/P.

In the 1998 M/P, construction projects for large-scale water utilization dams and trans-basin water supply projects were proposed, but most of them have not been implemented. Based on interviews and meetings with the related organizations, the reasons can be categorized as follows:

1) Challenges related to environmental and social considerations

The construction of dams has not been carried out as planned due to environmental and social considerations such as land acquisition and resettlement associated with dam/reservoir development, and changes in land use, flow conditions, and water use. The following points should be noted elated to environmental and social considerations.

a) Categorization in the EIA system in the Philippines

A development project will be categorized based on the degree of environmental impact of the project judged by the project description such as type, scale and location as category A, B, C and D as shown in Annex I. A dam project is categorized as an Environmental Critical Projects (ECPs) but actually categorized according to the Reservoir flooded/inundated area or water storage capacity as follows. Category A project and pert of Category B project are needed to prepare an Environmental Impact Statement (EIS) with necessary procedures including detail assessment and an Environmental Compliance Certificate (ECC) must be secured.

- Category A: flooded/inundated area ≥ 25 ha or water storage capacity ≥ 20 MCM
- Category B with EIS: 25 ha > flooded/inundated area > 5 ha or 20 MCM > water storage capacity > 5 MCM

- Category B with IEE (initial environmental examination): flooded/inundated area < 5 ha or water storage capacity 5 MCM
- Category D: None

b) Involuntary Resettlement and Land Acquisition

A project including a large-scale construction such as dam construction may need to secure the involuntary resettlement and land acquisition, and these issues have to be proceeded sensitively. In these project, preparation of a resettlement action plan (RAP) is needed, and necessary procedures basically include eligibility for receiving compensation and resettlement assistance, compensation and entitlements, the indigenous people's policy framework, implementation procedures that ensure complaints are processed, public support and participation, and the provision of internal and external monitoring of the implementation of the RAP and safeguard instruments for IPs.

2) Challenges for upstream and downstream issues of inter-basin water transfer

In a project to transfer water between river basins, there is a conflict of interest (upstream/downstream issues) between the residents of the water source area and the demand area. There is no system or organization to proactively coordinate it, and it is extremely difficult to build a consensus among stakeholders.

3) Challenges for organizational and legal issues for multipurpose water resources development

The organization and legal system for centralizing and implementing multi-sectoral and multi-purpose water resources development projects have not been sufficiently developed. There is no financial burden or subsidy system for water resources development and management, or a legal system for determining the reservoir capacity allocation of multi-purpose dams and sharing costs by water user accordingly.

Most of the existing dams in the Philippines are dedicated dams developed for each function, such as irrigation water supply, domestic water supply, and hydroelectric power generation. There are seldom examples of dams that were planned and constructed for multi-purpose use. At present, there are several multi-purpose dams currently under planning, but the main purpose of these dams is irrigation, with subsidiary functions such as water utilization, power generation, and flood control added to the dam. Coordination is required for each individual project and region.

4) Challenges in the implementation capacity of the executing agency

From the perspective of securing future water resources, dam construction is very important for the Philippines. Among related agencies in the Philippines, only NIA and hydropower generators are currently promoting dam construction project. Other organizations involved in flood control and water utilization development, such as the Department of Public Works and Highways (DPWH) and water districts (WDs), do not have sufficient experience or organizational capability in dam planning/construction and operation/management, and lack technical capacity.

In addition, multi-purpose water resources development and management projects require enormous project costs due to the scale of the project. However, the financial capacity of the organizations (NIA, DPWH, WD, etc.) that will implement the project, as well as the above-mentioned financial burden system and subsidy system, etc., are inadequate. This is one of the reasons that the proposed projects have not been implemented.

5) Challenges of administrative continuity without influence of the political system

In the Philippine electoral system, the presidential position is held for one six-year term, and multiple elections are not possible. Due to the change in the political system by election, the local project promotion system has also been reversed each time. It is said that there were several cases that the long-term projects such as water resources development projects has not been realized yet due to change in the policy and strategy of the proposed plan by two times or three times. For promoting the large-scale project, long-term and continuous support from local stakeholders is indispensable. Thus, administrative continuity is important even though a political situation would be changed.

6) Challenges in investment planning and development planning

The large-scale irrigation dams and inter-basin water transfer projects proposed in the 1998 M/P have the above-mentioned problems, and it will take a long time to implement them.

In order to deal with actual water shortages, the continuation of groundwater development, which is easy to implement and highly feasible, and the development of surface water by constructing water intake weirs and small-scale dams are being prioritized. Some projects, such as bulk water project, are operated and managed with private funds invested in their development.

Proposals for large-scale water resources development projects are considered inevitable in long-term investment plans and development plans. However, it is also considered necessary to study various developments options (tidal barrage, groundwater, small reservoir, water saving, dam restoration, seawater desalination, reuse, and leakage control) that do not rely solely on dams and take into consideration the sense of speed until the large-scale project is realized.

(3) Analysis of Difference of Water Demand Forecast

Table 4.1-3 below shows the difference of water demand forecast results estimated in the 1998 M/P from the current water demand calculated in this survey. Though it should be noted that the target year data is 2025 for 1998 M/P and 2020 (current situation) for this survey, there are some minor differences. As shown in the table, the water demand in the national level was predicted to be between 60.4B and 83.5B in 1998 M/P, but the current figure is 42.6B, which is actually smaller than the forecasted. This trend is the same for each type of water use for municipal, industrial and agricultural water. In other words, it can be seen that water demands on a national level has not grown as much as forecasted in 1998. Regarding water potential, since the calculation methods used in this survey was basically different from those at that time, it is difficult to consider comparative results, but the water potentials of both surface water and groundwater have increased.

In 1998 M/P, the 50% of river discharge of the flow duration curves were defined as the surface water potential, and 5% of the precipitation as the groundwater potential. In this survey, the total discharge (considering reservoir planning) including floods of river flow calculation values for each sub-basin over the long term (41 years from 1980 to 2020) calculated by the runoff analysis model (SHER model). Thus, the surface water potential of this survey is larger than 1998 M/P. In addition, 70% of the groundwater flow is taken as groundwater potential (amount of groundwater that can be safely pumped) based on the groundwater recharge amount from SHER model.

Table 4.1-3 Difference of Water Demand Forecast

Unit: Billion m^3/year

Item	Sub Item	1998 M/P	This Survey		
		(2025)	Present (2020)	Future (2050) w/o climate change	Future (2050) w/ climate change (M)
Water Demand	Municipal	7.3	5.5	7.1	7.1
	Industrial	3.3	2.5	2.9	2.9
	Agriculture	38.8 - 59.8	31.5	55.1	55.1
	Livestock, Fishery	11－13.1	-		
	Others	-	3.0	4.1	4.1
	Total	60.4-83.5	42.6	69.1	69.1
Water Potential	Surface Water	206.2	283.9	283.9	262.7
	Groundwater	20.2	32.0	32.0	32.1
	Total	226.4	315.9	315.9	294.8

Source: JICA Survey Team

(4) Lessons Learnt from 1998 M/P Planning and Implementation

Based on the considerations as mentioned in above (2) 1)-6) and (3), the following points should be considered:

- Based on the review of the 1998 M/P, proposals from the viewpoint of water managements, 1) environmental and social considerations, 2) consensus building for upstream and downstream issues of inter-basin water transfer, 3) coordination for organizational and legal issues for multipurpose water resources development, 4) implementation capacity of the executing agency, 5) administrative continuity without influence of the political system, 6) proper investment planning and development planning,) are included.
- Various developments options (tidal weirs, groundwater (deep wells, recharge, restriction, etc.), small reservoirs, water conservation, dam restoration, seawater desalination, reuse, and measures against water leakage) that do not rely solely on dams shall be studied.

4.1.3 Basic Conditions for Plan Formulation

(1) Target Year of the Plan

The target years of the plan are set at short, medium, and long terms for the years 2030, 2040, and 2050, respectively.

(2) Safety Level by Water Use and Priority of Water Use

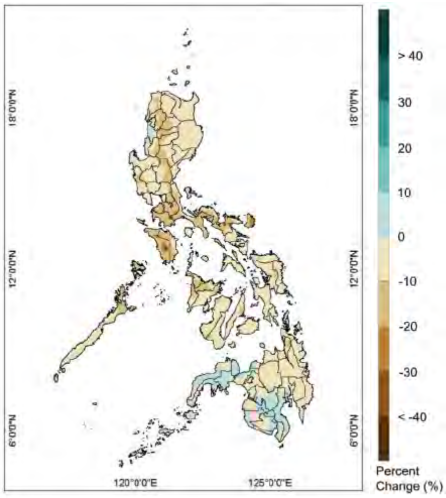
Referring to the Philippine standards and water safety standards recommended by international organizations such as FAO and the World Bank, the safety level is set at 1-5 years of irrigation water and 1-10 years of municipal and industrial water supply, in consultation with related organizations in the Philippines.

Priority of the water use is set at i) environment flow, ii) drinking water, iii) agricultural water, and iv) industrial water.

(3) Climate Change Impact Consideration

The climate change impact forecast of this survey is carried out by the following method in consideration of the accuracy and data collection time.

Detailed information on climate change forecast data for the Philippines has already been organized in PAGASA's "Observed Climate Trend and Projected Climate Change in the Philippines" report (2018). The report includes the upper, middle, and lower three cases of two scenarios, RCP4.5 (medium) and RCP8.5 (high), by water resources region and state in the middle of the 21st century (2036-2065). The predicted changes in precipitation and temperature every three months are shown. This data in the report is effectively utilized in this survey for confirming the latest trends in climate change forecasts and calculating the future water resources potentials in consideration of the effects of climate change. The impact of climate change on the water balance is an assessment of future uncertainty (variability). In this study, RCP8.5, which has a larger degree of uncertainty, was applied.



Source: DOST-PAGASA (2018)

Figure 4.1-1 Mid-21st Century (2036-2065) July-September Average Precipitation Change Prediction (RCP8.5 Scenario Average)

4.1.4 Setting Priority Policy for Formulation of Sustainable Water Resources Development and Management Plan

In the previous section, the lessons learned from the 1998 M/P planning and implementation were analyzed. Based on these, the basic approach and priority policy for formulation of sustainable water resources development and management plan are established.

(1) Common Challenge and Basic Approach for Sustainable Water Use

Based on the study results in Chapter 3, the common challenges and basic approaches for sustainable water use in the priority water resources areas is summarized in Table 4.1-4 below.

Table 4.1-4 Common Challenges and Basic Approach for Sustainable Water Use

Common Challenges	Basic Approach
Increase of water demands	▪ Demand management of domestic water and irrigation water
Deficit of water supply	▪ Development of water resources facilities ▪ Conservation of watershed
Saltwater intrusion of groundwater	▪ Monitoring and regulation of groundwater use ▪ Shift of water sources from GW to SW
Aging of existing facilities	▪ Upgrading and rehabilitation of existing facilities ▪ Countermeasures for reservoir sedimentation
Organization and Institution	▪ Integrated water management (multi-purpose use) ▪ Capacity developments of executing agency for technical and O&M ▪ Administrative continuity without influence of the political system ▪ Financial arrangements based on proper investment planning and development planning
Environmental and social consideration	▪ Consideration of environmental and social issues ▪ Consensus building among stakeholders including upstream and downstream issues of inter-basin water transfer, for proposed water resources development and management plan and priority projects

Source: JICA Survey Team

(2) Establishment of Priority Policy

Following four priority policies are established for formulating sustainable water resources development and management plans for priority water resources areas.

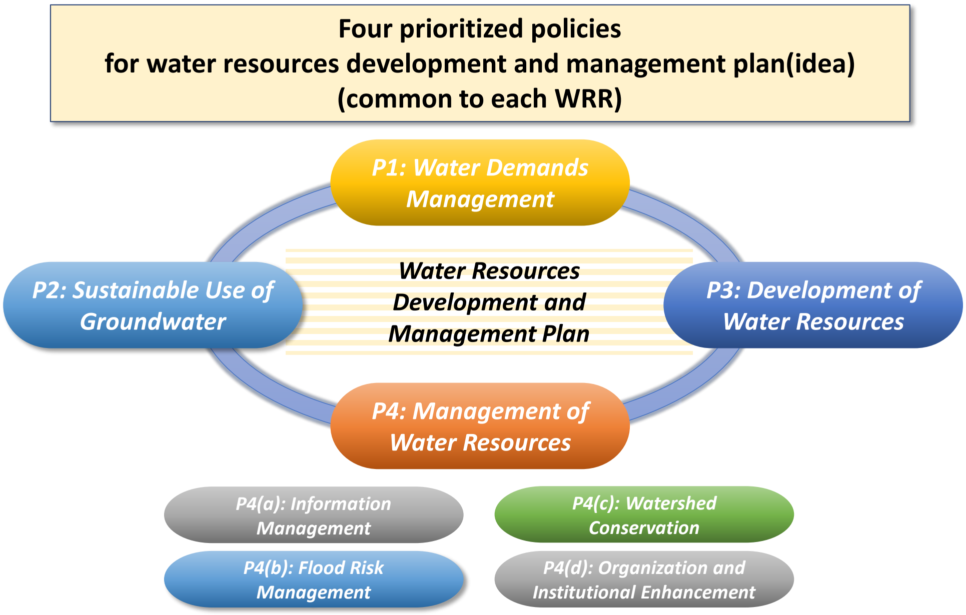
Priority Policy 1 (P1) Water Demands Management

Priority Policy 2 (P2) Sustainable Use of Groundwater

Priority Policy 3 (P3) Development of Water Resources

Priority Policy 4 (P4) Management of Water Resources

The Priority Policy 4 comprises of p4(a): information management, p4(b): flood risk management, p4(c): watershed conservation and p4(d): organization and institutional enhancement.



Source: JICA Survey Team

Figure 4.1-2 Priority Policy for Formulation of Sustainable Water Resources Development and Management Plans

4.2 Stakeholder Meetings

Stakeholder analysis is conducted through the stakeholder meeting (hereinafter referred to as "SHM") as part of the environmental assessment to select the most feasible and optimal project concept in the priority water resource regions. The results of the discussion of the SHMs, existence of conflicts and their status, etc., were fed back to the comparison study of development options and reflected in the proposal of the water resources development and management plan (draft).

SHMs were conducted twice with each purpose as follows.

Table 4.2-1 Summary of the Stakeholder Meetings

Item	1st SHM	2nd SHM
Purpose	- Explanation of survey contents - Sharing of the interim result of the survey - Stakeholder analysis, gathering of issues	- Publication of survey results and sharing of prospects and challenges - Promotion of consensus building for the project
Contents	- Explanation of survey objectives, timeline and presentation of result of water balance study in priority areas - Q&A	- Explanation of project survey results and priority projects - SEA evaluation result - Future outlook, Q&A
No. of participants	20 to 50 per area (selected region) in-person	20 to 50 per area (selected region) in-person
Schedule	In September and December 2022	In April and May 2023
Target participants	C/P (NEDA, NWRD), local residents (expected affected residents, beneficiary residents), related local governments / barangay officials, local influential people, related local companies, NGOs, academic experts, etc.	

Source: JICA Survey Team

4.2.1 1st Stakeholder Meeting

(1) Outlines

The 1st SHMs were held at WRR VII and XI in September 2022 and at WRR V in December 2022 as follows.

Table 4.2-2 Summary of the 1st SHM

Region	WRR VII	WRR XI	WRR V
Date	September 8, 2022	September 15, 2022	December 7, 2022
Venue	Quest Hotel & Conference Center in Cebu city	Waterfront Insular Hotel in Davao city	NEDA V Regional Office Conference Center in Legazpi city
Participants	Total: 133 - In-person: 42 - Virtual: 88	Total: 182 - In-person: 41 - Virtual: 141	Total: 134 - In-person: 41 - Virtual: 93
Program	- Opening Ceremony - Project Description & Initial Activities - Environmental and Social Consideration for the Project - Open Forum - Closing Remarks		
Purpose	- To share the description and progress result of the survey - To avoid the conflict between stakeholders for the implementation of the proposed project - To collect several opinions, concerns, issues ideas and recommendations - To reflect above to the result of the survey and future planning		

Source: JICA Survey Team

With the emergence of the Corona Virus Disease 2019 (COVID-19) in the Philippines, the implementation of the SHM was done in accordance with the minimum health and safety guidelines and protocols for mass gatherings set by the Inter-Agency Task Force for the Management of Emerging Infectious Diseases (IATF).

(2) Result of the 1st Stakeholder Meeting

Open forum was conducted at each SHM and the following opinions/suggestions/questions were mentioned.

Table 4.2-3 Summary of Main Opinions raised in Open Forum in the 1st SHM

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
WRR VII			
Did you consider the **service sector** in the water demand forecast for Region 7, which is a tourism-driven industry?	City of Lapu-Lapu, Cebu	The water demand for municipal (domestic, commercial, institutional) and industrial sector was used for the calculation in this study. The tourist water demand is included in the municipal water demand.	Refer to 3.3.6.3 for WRR VII
In the climate change presentation, a high **emission scenario** was used (RCP 8.5). Would you like to consider using the moderate emissions as well?	NEDA Region 7	The 8.5 case as the most serious was selected. A range of temperature and rainfall variations and climate change are taken into consideration. In this study, RCP8.5 was adopted to represent the worst case of climate change	Refer to 2.6.8

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
		impacts on the water balance. In the medium case of RCP4.5, the impact on the water balance is small and almost no impact is seen, so it is not adopted.	
Siquijor, Bohol, Cebu, and portions of Negros Island are mostly karst. Did you consider the **karst landscape** of the water resource region? Did you consider the implications of **ocean/sea-level rise** on the region's spring systems?	'oil and Water Conservation Foundation, Inc.	We will take note of these issues.	Karst areas are modeled as limestone distribution areas in the groundwater analysis. Sea level rise is also taken into account in the groundwater analysis, and the impact on the whole groundwater environment, not just on springs, was considered.
Proposing that more emphasis be placed on **equality concerns**; the poor frequently have restricted access to water and pay the highest prices for safe, drinking water. Furthermore, places with high rates of **poverty** are frequently located on the outskirts rather than in metropolitan areas, making them vulnerable to being the least and last served.	LGU-Bantayan, Cebu	This is noted.	Poverty condition was mentioned and considered in the social assessment (refer to 4.3.6).
Steep hilly places have high groundwater flow. Could there be a **link between surface run-off**, which is higher in steep places, **and surface water percolation**?	DENR-MGB Region 7	The slope is particularly steep in mountainous locations and its flow of groundwater is considerable. However, the basin's catchment area in a hilly terrain is quite tiny. Mountain locations have very limited groundwater potential.	Steep topography increases groundwater flow and is evaluated as having relatively high groundwater potential. However, Cebu Island has a relatively small catchment area, so surface water potential is small. (Refer to 3.3.5 for WRR VII)
WRR XI			
Both short-term and mid-term project concepts for groundwater are focused on the resource **utilization** in urban areas **rather than conservation and preservation**. Can there be a **consideration** of a **project concept for the long term** that will focus on **replenishment** of the resource, like rainwater harvesting, and use it for **groundwater recharge** (e.g., use of injection well in groundwater stressed areas)	DENR MGB - Central Office	The JICA survey team can consider rainwater harvesting that will be used to recharge groundwater.	In the proposed groundwater management, the study of optimal groundwater conservation measures, including artificial recharge of groundwater, are proposed after field observations and future projection simulations are conducted (refer to 4.3.4.2(2) for WRR XI). In addition, introduction of rainwater storage and infiltration as water supply is proposed as a priority project (refer to 4.4.4.2 (4) for WRR XI)
Based on a result of a study conducted by an NGO, the **wetlands in Davao City are decreasing 79.2%.** The preservation of wetlands might help or affect the city's projected water balance. What are your reconsiderations if we **include preservation of wetlands in the development plans**?	Ateneo de Davao University	The study did not cover wetlands. However, the decrease of wetlands may impact groundwater recharge. The survey team's hydrologist can consider such scenarios.	Wetland conservation is important for water retention and proposed in a River Basin Environmental Conservation (refer to 4.4.3.8)
In the case of Central Mindanao where it was shaken by **earthquakes**, certain **paths of aquifers and springs** were **diverted, altering the water supply** of major water concessionaires. Did the study or data collection include such scenario?	Cotabato Province – LGU	The presented groundwater analysis did not account for earthquake-induced changes in aquifer and spring pathways. However, we will take this into account and assess it separately.	A Japanese example of possible earthquake impacts is described in 4.3.3.3 .
Population growth, rapid development at the watershed such as mountain resorts, and the urban development of hospitals, hotels etc.,	NIA Region 11	This is noted and the survey team will look into this.	As a result of review, items such as resort and hospital development, which have many uncertainties and require detailed surveys in

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
solar powered irrigation projects using both groundwater and surface water, should be **considered in the projection of water demand**.			each small-scale area, were not included because they are beyond the scope of the survey.
Was the **quality** of **our inland waters** considered as well, specifically with regards to **saline intrusion**? In terms of social aspects, **indigenous people** can be found in the areas covered by WRR XI. Did you consider their **social practices** in terms of **sanitation**? Regions 10, 11, 12 and 13 also have lot of **mining areas**, aside from salinity, we also have **heavy metals** reflected on the regions monitoring of ambient waters.	DENR-EMB Region 11	In the project concept, we will consider the water quality aspect of inland waters. For the social aspect, we also considered the indigenous people.	Condition of the water quality and social aspect depend on the specific site condition so these were considered for the proposed priority project concepts as the initial assessment (refer to 4.4.6 for WRR XI).
What are the **possible projects** in Region 10 that will **maintain and/ or increase water security**?	DENR Region 10	A comprehensive solution is required for water security. We are researching not only structural solutions (such as developing a pond or dam), but also water demand management, which includes groundwater and surface water.	Water resources development & management plans and priority project concept were set considering several aspects for each WRR.
There are **rivers** that have been designated as **Water Quality Management Areas** (WQMA), such as the Davao River and Talomo River; and you may request the data from DENR-EMB.	NIA Region 11	This is noted. The water quality status report includes the classification, description, monitoring, catchment, and sources of pollution for the classified rivers.	Water quality was considered for the priority project concept as the initial assessment (refer to 4.4.6 for WRR XI).
WRR V			
Regarding water demand prediction, were you able to consider the **current and future policies of the government**. One which may have an impact in terms of the water demand is the Mandanas Ruling. Under the National Irrigation Management Plan (NMIP), most of the projects will be implemented by the NIA; but under the Mandanas ruling, some of the communal irrigation systems will already be devolved to the LGUs. There is no certainty that the irrigation systems will be implemented by the LGUs.	NEDA V	Such policy decisions and recommendations should be considered as much as possible. Regarding the devolution of irrigation to the LGUs, recently, there are a considerable number of LGUs who are of the opinion that irrigation should not be devolved because of the big amount required for irrigation projects. If they would be doing that, that would eat a big percentage of their local budget.	In municipal water demand prediction are contingent on achieving the LWUA's proposed target of 20% non-revenue water. (refer to 3.4.6 for WRR V) The irrigation development plans were studied based on the past NIA Corporate Plans and the National Irrigation Master Plan 2020-2030. It is commonly understood that the communal irrigation projects (CIPs) are difficult to be implemented by LGUs (under Local Government Cord). NIA has been implementing the small-scale irrigation project like CIPs as CARP-IC and SRIP instead of LGUs.
Were these **water management practices** considered? - V**olumetric water pricing**: Saving on the use of surface water/irrigation water, because farmers will only be paying for what they use unlike now that there is a lot of wastage in terms of water usage. - Policy on using **sprinkler irrigation system** instead of surface water - Policy in terms of the **multi-purpose use of our reservoirs and dams**. Currently, most of our reservoirs and dams are used for	NEDA V	These are noted.	Water pricing is the political challenge and it might be difficult for society to accept the pricing, thus, it is not recommended in the survey. Payment of the irrigation service fee was abolished by the previous administration. At present, farmers do not pay the water charge and the irrigation water management is one of the important issues. Thus, the irrigation telemetry system for the effective utilization of rainfall is proposed to minimize the loss of surface water use (refer to 4.5.4.2 (1) for WRR V).

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
irrigation and hydropower. There is also a conflict in terms of the utilization of these water resources.			The sprinkler irrigation system is the effective water use system and shall be introduced with due assessment of the investment costs and the profits. Multi-purpose dam requires adjustment for each stakeholder so this is recommended as an organization framework (refer to 4.3.3.8).
My understanding of the SEA is we establish first certain multi-criteria prior to the preparation of the plan. My suggestion is to **expand the analysis**, not only limited to those two factors; also **include economic and political**.	NEDA V	SEA framework being done by other development partners (e.g., ADB and World Bank) was also reviewed. Some aspects for the SEA will be considered.	In the process of priority project selection, several aspects were considered with alternatives such as water production, cost technical aspect, organization and environmental and social aspect (refer to 4.3.2.4)
Regarding **subdividing the WRR V into 243 sub-basins**, I disagree with the delineation of the sub-basins. By definition, a sub-basin should have a common outlet, and there are sub-basins that do not have a common outlet there.	NEDA V	The definition of the sub-basins with NEDA V may be compared and reconciled.	The sub-basins were subdivided in consideration of topography, flow direction of the river channel, etc. Some sub-basins have a common exit, and some sub-basins do not. (Refer to 3.5.5)
Have you considered sea waters that enters agricultural farms leaving salt/silts that hinder farm produce especially low-lying municipalities.	LGU Camaligan	This comment was duly noted for consideration of the JST.	The water quality shall be analyzed in the feasibility study period for the proposed project, not under the survey period.

Source: JICA Survey Team

1st SHM at WRR VII

1st SHM at WRR XI

1st SHM at WRR V

Online participants

Source: JICA Survey Team

Figure 4.2-1 Pictures from 1st SHM

4.2.2 2nd Stakeholder Meeting

(1) Outlines of the 2nd Stakeholder Meeting

2nd SHMs were held at WRR VII and V in April 2023 and at WRR XI in May 2023 as follows.

Table 4.2-4 Summary of the 2nd SHM

Region	WRR VII	WRR XI	WRR V
Date	April 19, 2023	May 9, 2023	April 25, 2023
Venue	Quest Hotel & Conference Center in Cebu city	Acacia Hotel in Davao city	NEDA V Regional Office Conference Center in Legazpi city
Participants	Total: 112 - In-person: 51 - Virtual: 61	Total: 150 - In-person: 48 - Virtual: 102	Total: 114 - In-person: 50 - Virtual: 64
Program	- Opening Ceremony - Regional Development Plan by NEDA Regional Office - Survey Result & Priority Project Concept - Open Forum - Closing Remarks		
Purpose	- To share the survey result & priority project concept - To avoid the conflict between stakeholders for the implementation of the proposed project concept - To collect several opinions, concerns, issues ideas and recommendations		

Source: JICA Survey Team

(2) Result of the 2nd Stakeholder Meeting

Open forum was conducted at each SHM and the following opinions/suggestions/questions were mentioned.

Table 4.2-5 Summary of Main Opinions raised in Open Forum in the 2nd SHM

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
WRR VII			
Desalination plants should be used to address the issue of water supply in the country. However, the use of desalination plants may also contribute to greenhouse gas emissions because the use of desalination plants relies on fossil fuels. Will the study also suggest desalination plant designs that probably produce less greenhouse gas emissions?	NEDA Region-7	One of the concepts is the utilization of solar energy for desalination facilities.	The installation of desalination plant is proposed as an option. The use of less greenhouse gas emission technology in desalination plants shall be considered in the detail planning.
Will you be able to include the countryside in your long-term plan, given that the metropolitan area is already congested?	Cebu Provincial Government	The survey team performed the water balance analysis up to the municipal level in response to the recommendation that the countryside be included in the research. The municipality may use the results of the study for planning purposes.	Since the survey can share water balance data for each small basin in the region, utilization of these data for regional planning is recommended.
To address the water issue, we needed to see a really comprehensive strategy that took into account hydrology, water management, micro-water cycles, water recharge, and how water is tied to land use. We don't want to see us concentrating just on groundwater, surface	Movement for Livable Cebu	We also recommended comprehensive water resource management and development in the region since the construction of water reservoirs will take years. Additionally, we want to include fresh concepts.	Four priority policies were established for formulating sustainable water resources development and management plans (refer to 4.1.4).

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
water, and technical solutions without considering nature-based solutions.			
Has the study also considered the effects of mining areas in Region VII? (Hydrology, water intrusion, outflows, etc.)	DHSUD Region 7 (online)	Our hydrological and groundwater analysis was unable to take the effects of mining into account. It is better to take this effect into account in future studies.	Mining has the same effect as earthquakes on groundwater veins, and may also affect water quality, so a detail investigation is required in case of starting new mining.
WRR XI			
Will it still be possible to get an En Bank Resolution from NCIP? Have we considered the involvement of our Indigenous Peoples because they also have their valid claims on water resources?	HELP Davao Network-Davao River Initiatives / Valencia City Water District	We know that the FPIC process and obtaining the CP is a long process. Rest assured that the project will consider and follow the standard procedure and the JICA Safeguards Policy.	Issue on IPs was mentioned as the initial social assessment and suggested as general issue in the project (refer to 4.4.6 for WRR XI)
We recommend that all plans should be aligned, harmonized, and integrated so that there will be no conflicts or overlaps in any of the abovementioned plans. The DOST-PNRI is using isotope techniques to monitor the recharge of areas in Davao City.	DOST-XI	We also wanted to harmonize with Davao Region's vision, policy, and development plans. It is good time to collaborate our plan and your vision. We would also like to coordinate in the future. The JST took note of this suggestion.	In order to ensure that the proposed plan and project concepts conform to regional plans and are harmonious and integrated projects, In the future, necessity to increase the maturity of inter-regional and inter-sectoral coordination and consideration and to promote planning and project implementation by the Philippine side is recommended.
Can we include the current situation that DCWD and Apo Agua Infrastuctura, Inc. are requesting for the declaration of the "Panigan-Tamugan Watershed" as a protected area?	HELP Davao Network-Davao River Initiatives	The JST took note of this suggestion.	This is described as a reference information.
At present, we have an approved proposal for water education called Water Innovation and Security Education (WISE). We will implement WISE, together with other agencies, to expand the reach of our initiatives related to water governance.	Davao del Sur State College (DSSC) / HELP Davao Network	We agreed that education is also important for water saving. We agree with your idea of non-structural measures should be considered in our plans.	As part of the water demand management, reduction of water demand per capita through education of water saving activities is recommended. (refer to 4.4.3.5)
Could it be possible to include in the recommendations at this early the stopping of conversion of forest areas into alienable and disposable lands in order to increase the watershed areas?	Valencia City Water District (online)	Regarding the forest conservation, this should follow the forest management policy/plan prepared by Philippines government so we will refer it first and consider this issue and recommendation as needed.	Forest conservation is important for water retention and proposed in a River Basin Environmental Conservation (refer to 4.4.3.8)
Is there an alignment with the proposed infrastructure projects for water resources and flood control proposals in the DPWH Masterplan	DOST XI and HELP Davao Network	We think that it is important to consider the existing and future infrastructure plans in the river. We selected the location of our proposed new construction dam for water resource development in consideration of not interfering	The review of the DPWH masterplans is summarized in ANNEX H. Flood risk management plan considering the existing

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
		or adversely affecting the other infrastructure.	plans is proposed (refer to 4.4.3.7 for WRR XI).
Can we consider technologies or instrumentation to improve data or information management as part of priority concept projects? And how can the regional offices assist in the deployment of this project?	DOST XI and HELP Davao Network	Regarding the Water Data Management System Project, we agree on the comment on the importance of data-sharing among the agencies. The Central and Regional Offices should manage the data-sharing diligently. Non-structural measures are also included in the report of this study.	Information management including data sharing was proposed (refer to 4.3.3.6 for WRR XI)
Did the study consider the sand and/or gravel extraction/mining activities in some rivers in the region? These activities could impact on our water management.	DENR-MGB XI	In the survey, JST did not consider the mining activities in the region. However, it should be considered in future studies.	Mining may also affect water quality, so a detail investigation is required in case of starting new mining. Measures for sediment were proposed in the water resources management plan and priority projects
WRR V			
How were you able to compute the effective depth of Lake Buhi? Is the range computed during normal times only? There is a dam and is located further downstream. How would you mitigate a flood or how would you conserve/ store water in the swollen dam during large flood events? The JST should also consider non-structural measures including enhancing settlements inside of the boundaries the lake's legal easements.	DENR-MGB Region 5	The team showed the normal level of water which is considered for irrigation purposes or water usage. Regarding the volume capacity of the dam, its capacity is estimated to be 70 mcm per year, which is feasible to store flood water there during the rainy season so that it may be used. Regarding non-structural measures, we considered the combination of rainwater-flood forecasting systems. Additionally, we can take environmental improvement into account.	Refer to 4.5.4.2 (3) in detail
The lake was filled with rubble from landslides and debris flows that occurred in the northeastern and eastern parts of Lake Buhi in 2018. I recommend desilting or dredging of the lakebed should also be included in the plan.	DENR-MGB Region 5	We can consider landslide management such as dredging and excavation of debris flows.	Dredging was proposed in the project concept (refer to 4.5.4.2 (3))
On the challenges that need to be addressed, particularly in the "increasing access to water for domestic, agricultural, industrial, ecological, and recreational purposes." Do we have a computation or projection for how much water will be consumed by each household member, as well as for the other sectors (agriculture, industry, ecological objectives, and recreation)?	DHSUD Region 5	The first statement was based on the RDP 2017-2022. The basis for our water demand forecast is the population projection of the PSA Census. The calculation up to the municipal level up to the year 2050 has already been taken into consideration. For the industrial sector, the water projection in 2050 was estimated based on the GRDP of the region.	Refer to 3.5.6 for the water demand forecast in WRR V.
Bicol Region is one of the regions prone to flooding. Are there programs possible for proposal to harness these said flood waters based on the data gathered as an alternative or additional source of water?	NIA Region 5 (online)	Lake Baao and Lake Bato might be utilized as a natural basin for lowering flood water flow in terms of flood risk management and both lakes are significant from the perspective of integrated water resource management. The utilization of Lake Bato and Baao can be considered in future studies.	Comprehensive study for the integrated lake management is proposed as a recommendation (refer to 4.5.3.7 (5))
We suggest that the study must consider big sources of water for possible distribution that can cater for several provinces and municipalities. Stakeholders should also be consulted to attain the goal of having good water quality.	Legazpi City Water District Bicol University	For each city/municipality and province, we can provide the hydrological water balance analysis result. We also presented a comprehensive approach for the region. For localization and integration, we recommend coordination of the water district.	Integration and expansion of water supply area are proposed (refer to 4.5.5 for WRR V)

Questions and Suggestion	Raised by	Responses in the meeting	Reflect to the survey
Did the survey include the sea level rise problem in the study and how will it affect the Bicol River Basin?.	LGU Legazpi City- CPDO	For the groundwater analysis, the sea-level rise data up to 2050 is considered. We also learned that Naga will be the most negatively impacted by the present extraction of groundwater and the impending saltwater intrusion.	Refer to 3.5.4.2.
On the social aspect of the priority projects, the team may overlook one of the vulnerable sectors in Buhi Lake which is the local fish farmers. They can be affected during and after the upgrading of Buhi Lake. The improvement of the water quality in the lake may also mean limiting the aquaculture practices in the area.	Bicol University	In this stage, we have a few pieces of information and a brief initial assessment to come up with the concept of the priority projects. For the mentioned suggestions, it will also be considered.	This is posed as an issue in the assessment result.
There is a proposal on the expansion of regional offices. I suggest this area be given utmost consideration and attention. This must be detailed further, including the instruments that will operationalize the arrangements so that resources and actions of DPWH, NIA, water districts, LGUs, etc. are cohesive and complementary.	LGU Canaman (online)	The JST noted this comment.	Expansion of regional offices are proposed in relation to promotion of IWRM (refer to 4.3.4.3 (2)). On the other hand, strengthen the relation between DWR and the organizations in charge of construction/management of water infrastructure at national and regional level is also proposed.

Source: JICA Survey Team

2nd SHM at WRR VII

2nd SHM at WRR XI

2nd SHM at WRR V

Online participants

Source: JICA Survey Team

Figure 4.2-2 Pictures from 2nd SHM

4.3 Priority Water Resources Region (WRR VII)

4.3 Priority Water Resources Region (WRR VII)

4.3.1 Analysis of Present Status of Water Resources in WRR VII

(1) Present Status of Water Resources

The present status of water resources development and management in the priority water resources regions and the result of the water balance analysis are summarized in Chapter 3.

(2) Summary Results of Water Balance Analysis

In this survey, the water resources potential is divided into surface water and groundwater. The water demands are classified into agricultural water uses and municipal and industrial water uses by each source. The water potential of the entire water resources region is calculated by each sub-basin using a runoff model and groundwater analysis model.

The results of the sub-basin water balance analysis are aggregated for the entire basin and converted to the municipal and provincial level in consideration of the specific discharge. In addition, the data related to the water balance calculation is compiled into annual and monthly water balance tables, and the tightness of the water balance is evaluated from the data of water potential (P) and total demand (D) by source and by major river basin and province, city, and municipal level.

In the water balance analysis, the following scenarios and cases are considered for the assessment of the climate change impacts, shown in Table 4.3-1. A summary of the water balance calculation results for the current situation and climate change scenarios (4 cases: current climate and 3 cases of climate change LMH) in WRR VII is shown in Table 4.3-2.

Table 4.3-1 Examination Case of Water Balance Analysis

Scenario	Target Year of Water Demands	Cases and Scenario of Climate Change Impact (RCP8.5)	Countermeasure
Present	2020	Present climate	None
Future (w/o measures)	2050	4 cases No impact (Present climate) & 3scenario (L, M, H)	None
Future (w/measures)	2050 (w/ demand management)	4 cases No impact (Present climate) & 3scenario (L, M, H)	Based on the case in left, water balance and combination of countermeasures is studied.

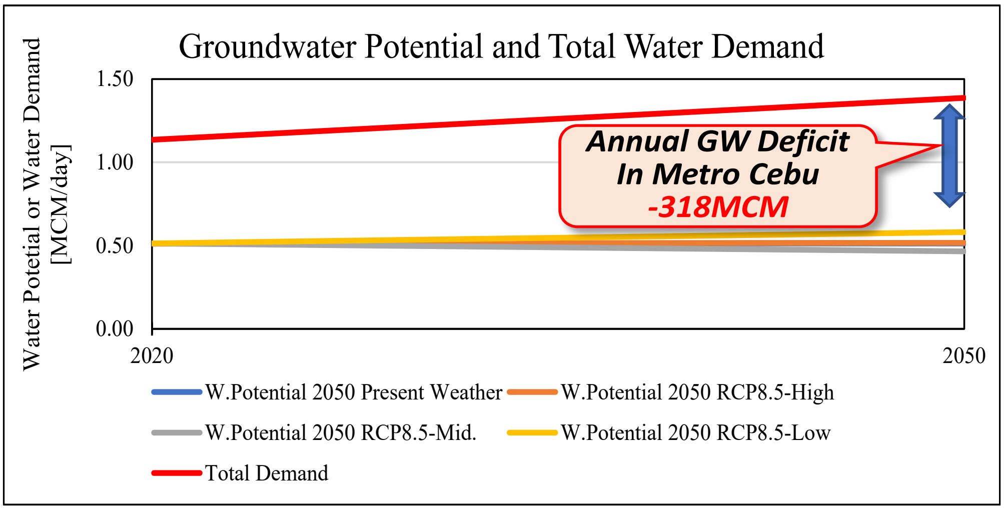
Source: JICA Survey Team

Table 4.3-2 Summary of Water Balance by Province and Major City (2050 with climate change, 1/5 drought year)

Province		Annual Water Balance in 2050 (MCM)		
		Surface Water	Groundwater	Total
Cebu		○ (+1,428)	× (-40)	○ (1,388)
Bohol		○ (+2,267)	× (-76)	○ (2,191)
Negros Oriental		○ (+2,874)	○ (+39)	○ (2,912)
Siquijor		○ (+75)	× (-2)	○ (+73)
Whole Area (WRR VII)		○ (+6,644)	○ (-80)	○ (+6,564)
Province	**Major City**	**Annual Water Balance (MCM)**		
		Surface Water	**Groundwater**	**Total**
Cebu	Metro Cebu	○ (+289)	× (-318)	× (-29)
	Toledo	○ (+116)	× (-9)	○ (+107)
Bohol	Tagbilaran	○ (+25)	× (-19)	○ (+4)
	Panglao	○ (+5)	× (-11)	× (-7)
	Carmen	○ (+193)	× (-3)	○ (+190)
	Inabanga	○ (+126)	× (-4)	○ (+122)
Negros Oriental	Dumaguete	○ (+16)	× (-12)	○ (+4)
	Sibulan	○ (+255)	× (-1)	○ (+254)
Siquijor	Siquijor	○ (+75)	× (-2)	○ (+73)

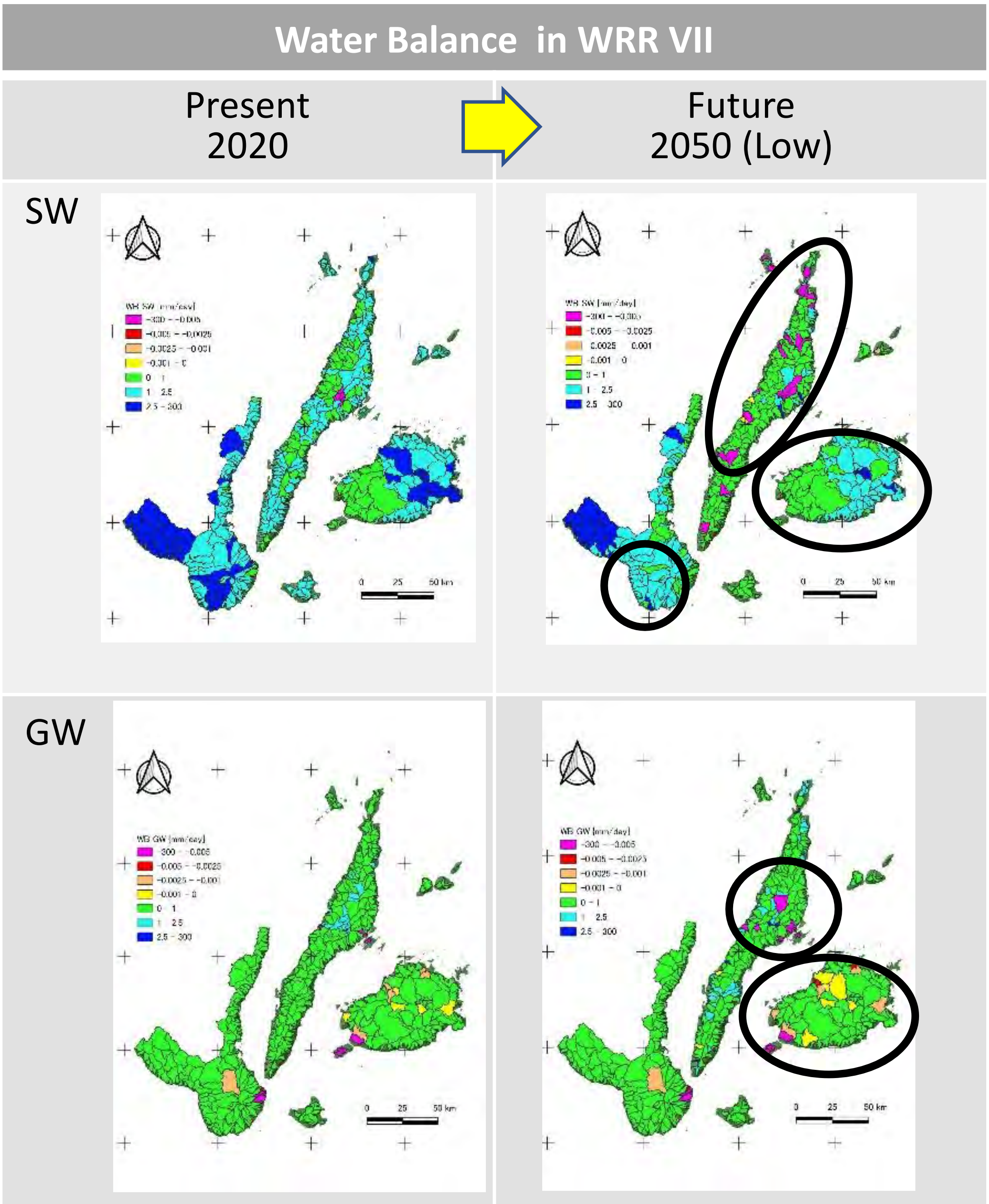
Source: JICA Survey Team

As shown in Table 4.3-2 above, there is a marked shortage of groundwater potential in the region as a whole, while surface water potential is abundant in whole region. By major city, the risk of water shortage in Metro Cebu is high; the estimated groundwater shortage is -318 MCM, total -29 MCM, in case of year 2050, 1/5 drought year, with climate change.



Source: JICA Survey Team

Figure 4.3-1 Prediction of Future Water Balance of Groundwater in Metro Cebu



Source: JICA Survey Team

Figure 4.3-2 Overall Location Map of Water Balance Change in WRR VII

(3) Current Water Resources Development Plan

Metro Cebu Water District (MCWD) has a water resource development plan up to mid-2030 as shown in Figure 4.3-3 below. Because of the constraint of groundwater potential and the difficulty in implementing large-scale surface water developments, the proposed water sources are mainly seawater desalination plants. However, the proposed development volume in the current plan is not sufficient for the future water demand in 2050 mentioned above. It is necessary to develop other new water resources and convert water sources from groundwater to surface water.

- ✓ **Surface Water : 2 projects, 185,000 cmd (67.5MCM)**
- ✓ **Desalination Plant: 13 projects, 252,000 cmd (92.0 MCM)**
- ✓ **Ground Water: 7.080 cmd (2.6MCM)**
- ✓ **TOTAL: 162 MCM (←not sufficient for future water demands in 2050)**

MCWD's Project Prospects in 2022

Location	Project Type	Source Type	Ave. Daily Supply (cmd)	Project Cost (Php)	Year
Lusaran, Cebu City	Bulk Water Supply	Surface Water	30,000	1.2B	2023
Canjulao, Lapu-Lapu City	Bulk Water Supply	Desalination	25,000	Under Negotiation	2025
Talisay City	Bulk Water Supply	Desalination	20,000	Under Negotiation	2026
Liloan	Bulk Water Supply	Desalination	30,000	Under Negotiation	2025
SRP, Cebu City	Bulk Water Supply	Desalination	30,000	Under Negotiation	2026
Cordova	Bulk Water Supply	Desalination	20,000	Under Negotiation	2023
Marigondon, Lapu-Lapu City	Bulk Water Supply	Desalination	30,000	Under Negotiation	2025
Inayawan, Cebu City	Bulk Water Supply	Desalination	25,000	Under Negotiation	2029
Consolacion	Bulk Water Supply	Desalination	30,000	Under Negotiation	2025
Opao, Mandaue City	Bulk Water Supply	Desalination	5,000	Under Negotiation	2025
Mambaling, Cebu City	Bulk Water Supply	Desalination	25,000	Under Negotiation	2025
Marigbago, Lapu-Lapu City	Bulk Water Supply	Desalination	2,000	Under Negotiation	2023
MEPZ, Lapu-Lapu City	Bulk Water Supply	Desalination	5,000	Under Negotiation	2023
Inabanga	Bulk Water Supply	Surface Water	155,000	Under Negotiation	2026
Dumlog, Talisay City	Inhouse	Desalination	5,000	Proposed	2026
Inhouse Wells	Inhouse	Groundwater	7,080	Proposed	2024 - 2032

Source: MCWD

Figure 4.3-3 Water Resources Development Plan up to mid-2030 by MCWD

4.3.2 Study for Water Resources Development and Management Options in WRR VII

4.3.2.1 Map Survey and Field Investigation of New Water Resources (Dams, Weirs, Possible Reservoirs)

Related information on existing plans including the 1998 M/P proposed projects and new possible water source candidate sites were collected, and a map study referring to topographic maps, geological maps, and land use maps was conducted to find candidate sites of proposed dams, weirs, water conveyance points, and construction roads. In addition, at the stage of scoping down to the more promising candidate sites for water resources, on-site investigations were conducted to check the local situation and collect information from local stakeholders.

The maximum feasible development capacity was studied while paying attention to the residential houses, land use, and rare creatures at the study site.

The following challenges and strategies in each area were considered and proposed by the Survey Team based on the results of the field investigation, but after discussions with NEDA/NWRB and at the stakeholder meetings, it was understood that it was a reasonable policy that the Philippines side could adopt.

(1) Cebu

In Cebu, the MCWD/ LGUs are developing and operating domestic water supply facilities, and NIA is developing and operating irrigation water supply facilities. They are facing a serious water shortage problem in case of drought and saltwater intrusion of groundwater due to the rapidly increasing water demands in Metro Cebu. As mentioned in the previous section, MCWD has a development plan that prioritizes the construction of desalination facilities in the current plan.

The main findings of the field investigation and results of the assessment of water resources facilities in Cebu are presented in Table 4.3-3.

1) Current situation

- River basin is relatively small and steep, and the water potential is relatively small.
- In Metro Cebu, due to growing water demand, MCWD is developing bulk water using both groundwater and surface water, as well as developing seawater desalination plants, but there is still water shortage.
- Irrigation facilities are developed by small weirs and reservoirs and is relatively small.

2) Challenges

- Water shortage will worsen in the future due to increase of water demands and climate change impacts.
- Salinization of groundwater due to excessive use
- Aging and sedimentation problem of existing dams of major water sources (Buhisan Dam, Can-Asujan Dam)
- Existing dam plans have not been implemented due to issues in social environment, consensus building for trans-basin diversion, and political issues.

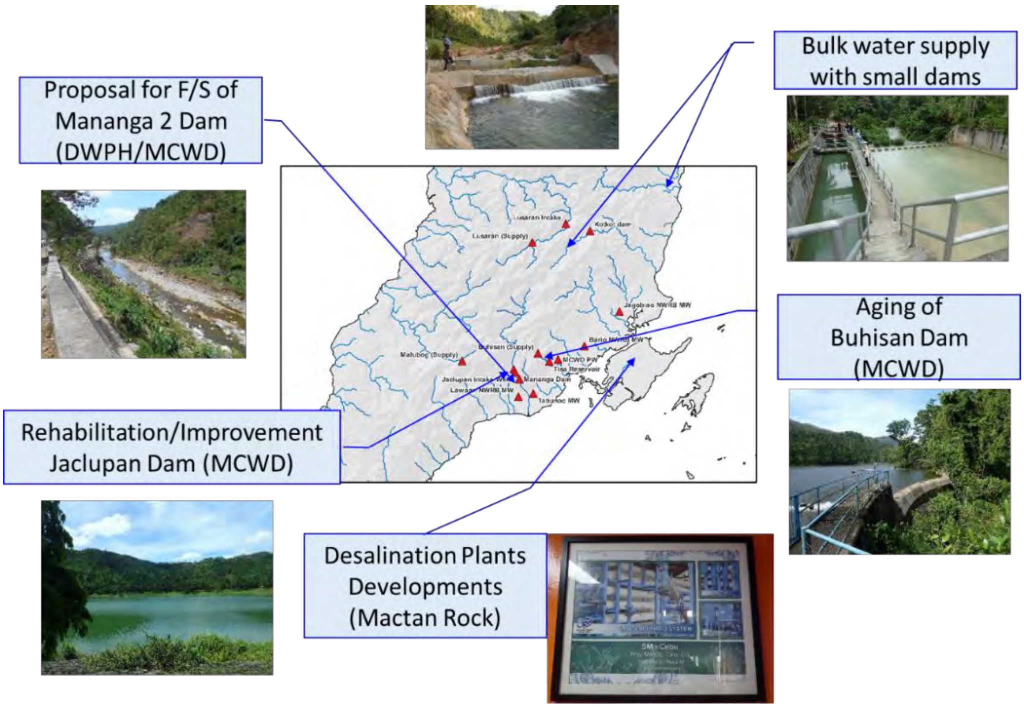
3) Strategy for countermeasures

- Promotion of current plans (seawater desalination, bulk water developments)
- Monitoring and regulation of groundwater (conversion from groundwater to surface water use)
- Rehabilitation of existing dams and countermeasures against sedimentation
- Review for highly feasible dam plans (downsizing for social impact mitigation, multi-purpose integrated use)

Table 4.3-3 Result of Assessment of Water Resources Facilities in Cebu

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Metro Cebu	■Existing Dam [MCWD]: Buhisan, Jaclupan [NIA]: Can-Asujan Dam	Aging and sedimentation of Buhisan Dam (⇒ Dam upgrading) Plan for upgrading of Can-Asujan Dam
	■Planned Dam [MCWD]: Mananga II, Inabanga (Bohol conveyance) [NIA]: Kotkot, Languyon	Necessity of revised dam plans: Mananga II ⇒ downscale Kotkot ⇒ multipurpose use Bohol conveyance ⇒ Consensus with LGUs in water sources areas
	■Existing Desalination Plant [MCWD-PPP] 3 plants	Investment cost is high but less social impacts Plan for new desalination plants (⇒ 13 projects by 2032)
	■Existing Water Supply [MCWD] Wells with WTP	Necessity of groundwater monitoring and regulation
	■Bulk Water Intake [MCWD-PPP] Carmen weir, Lusaran weir	Water supply by PPP (⇒ in progress)

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-4 Result of Field Investigation and Assessment of New Water Resources in Cebu

(2) Bohol

In Bohol, BWUI/LGUs/PPP are developing and operating water supply facilities, and NIA is developing and operating irrigation water supply facilities with several high dams and small dams. They are facing a water shortage problem in urban areas due to the increasing water demand in relation to tourism development.

The main findings of the field investigation and results of the assessment of water resources facilities in Bohol are presented in Table 4.3-4.

1) Current situation

- Surface water potential is relatively abundant.
- NIA is conducting large-scale irrigation developments with dams, and plans for future development.
- Demand for water in tourist areas is high.
- There is a water transfer plan from Bohol to Cebu (Development Plan of Inabanga Dam Project).

2) Challenges

- Problems of low efficiency of reservoir operation and sedimentation at existing dams
- Fragmentation of urban water supply systems
- The Inabanga Project has not been implemented yet due to large-scale water transfer project between basins and islands.
- Groundwater is expected to keep a balance in the future, but there is a risk of decline in tourist areas.

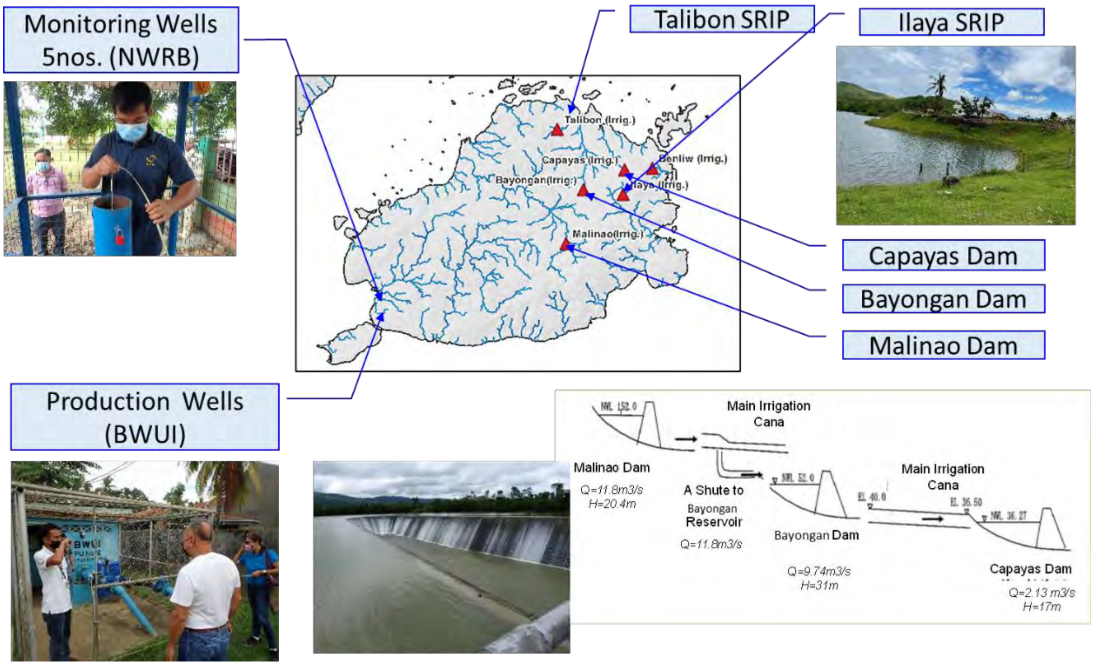
3) Strategy for countermeasures

- Continuation of the existing irrigation development plan based on abundance of surface water potential. In addition, upgrading of existing dams by improving water utilization rate through operation improvements.
- Coordination and expansion of wide water supply organizations in urban area
- Promotion by introducing the IWRM policy (fair and equitable water development) in the Inabanga Basin
- Groundwater monitoring in urban areas

Table 4.3-4 Result of Assessment of Water Resources Facilities in Bohol

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Bohol	■Existing Dam [NIA]: Malinao, Bayongan, Capayas, Ilaya, Talibon Dams [Hydropower Plants]	There is a plan to rehabilitate the existing Malinao Dam (dam leveling, sedimentation countermeasures)
	■Planned Dam [MCWD]: Inabanga Dam (Cebu-Bohol water conveyance) [NIA]: Hibale, Mandaug, Catugawan Dams	Need to review the Inabanga Dam plan (⇒Detailed investigation of multi-purpose development including own basin) Irrigation Dam Development Plan (⇒ Ongoing)
	■Existing Water Supply Facility BWU's wells	Detailed survey of groundwater development Necessity of coordination and expansion of water supply organizations

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-5 Result of Field Investigation and Assessment of New Water Resources in Bohol

(3) Negros Oriental

In Negros Oriental, water potential is rich for the development of surface water (reservoir, weir, and natural springs) and groundwater. The WDs/LGUs are developing and operating domestic water supply from the water sources of wells and springs. A PPP water supply system is introduced in Dumaguete City. NIA is developing and operating irrigation water supply facilities with small reservoir irrigation systems (SRIPs). There are problems with sedimentation in the existing dams. Considering the rich groundwater potential, a detailed survey for groundwater development can be considered.

The main findings of the field investigation and results of the assessment of water resources facilities in Negros Oriental are presented in Table 4.3-5 and Figure 4.3-6 below.

1) Current situation

- Surface water (natural springs) and groundwater potentials are relatively abundant.
- NIA is conducting large-scale irrigation developments with dams, and plans to continue development in the future.
- Operation and management of water supply system by PPP in Dumaguete

2) Challenges

- Sedimentation problem of existing dams of major water sources
- Aging local water supply facilities and high NWR

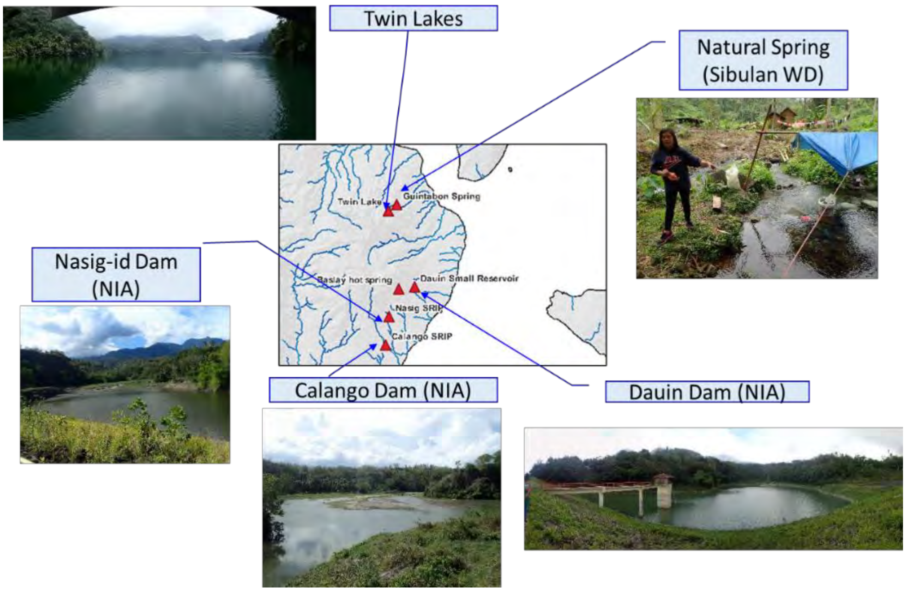
3) Strategy for countermeasures

- Continuation of the existing irrigation development plan based on abundance of surface water potential
- Improving water utilization rate through sedimentation countermeasures and operational improvements

Table 4.3-5 Result of Assessment of Water Resources Facilities in Negros Oriental

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Negros Oriental	■Existing Dam [NIA]: Dauin, Calango, Nasig-id Dams	Sedimentation of existing dams (⇒ sedimentation countermeasure project)
	■Planned Dam [NIA]: Kinalan Dam (Bio-os, Canaway, Tabuay, Buayan are not investigated)	On-going irrigation dam development plan (⇒ continuation)
	■Existing Water Supply Facility Sibulan WD (Natural Spring)	Detailed survey of groundwater development

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-6 Result of Field Investigation and Assessment of New Water Resources in Negros Oriental

(4) Siquijor

In Siquijor, the WDs/LGUs are developing and operating domestic water supply from the water sources of wells and springs, and NIA is developing and operating irrigation water supply facilities. There is rich potential for the development of surface water (weir and natural springs). There is a need for the improvement of NRW and the potential expansion of existing WDs.

The main findings of the field investigation and results of the assessment of water resources facilities in Siquijor are presented in Table 4.3-6 below.

1) Current situation

- Relatively abundant water sources.
- Water sources from springs and groundwater for local water supply and small-scale irrigation development.
- No existing dam.

2) Challenges

- Increase in water demand for tourism season
- NWR is high due to aging water supply facilities and inability to expand and repair due to lack of budget.

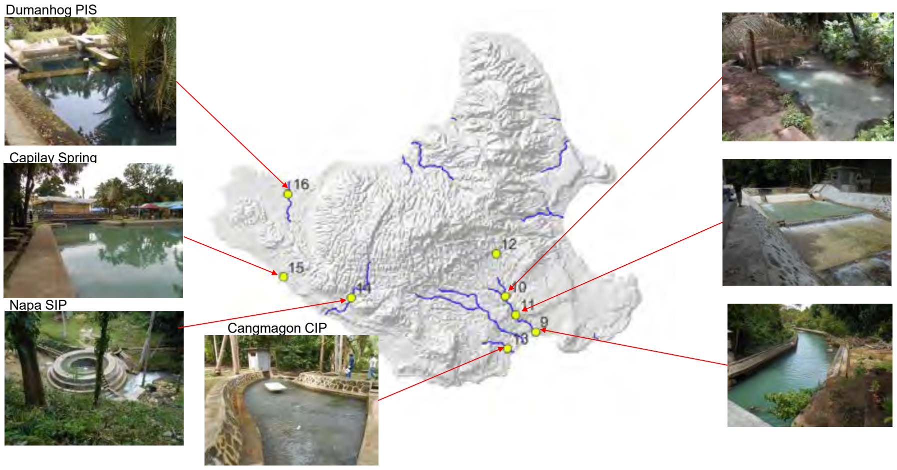
3) Strategy for countermeasures

- Securing backup water sources to cover temporary demand during the tourist season
- Rehabilitation and expansion of water supply facilities. Integration of existing water utilities and operational supports.

Table 4.3-6 Result of Assessment of Water Resources Facilities in Siquijor

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Siquijor	■Existing Dam None	
	■Existing Water Supply Facility Siquijor WD (Groundwater Natural Spring)	Groundwater development and surface water (weir) development Necessity of NRW improvement, expansion of existing WD

Source: JICA Survey Team

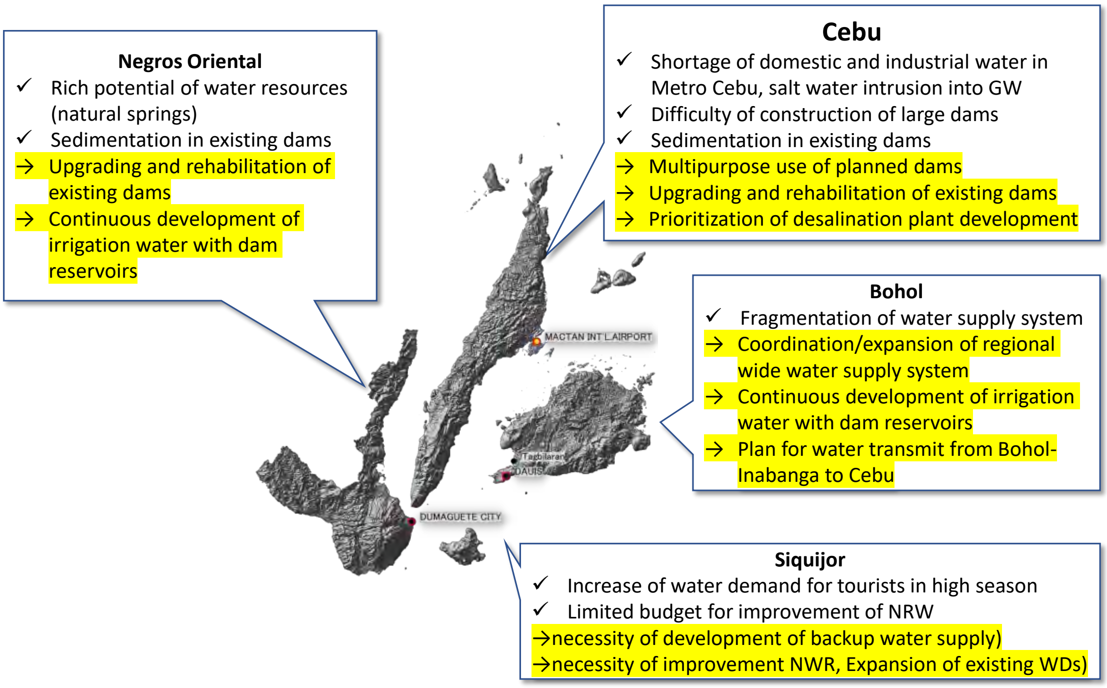


Source: JICA Survey Team

Figure 4.3-7 Result of Field Investigation and Assessment of New Water Resources in Siquijor

(5) Results of Map Survey and Field Investigation

Overall results of the map survey and field investigation of water resources facilities are summarized in Figure 4.3-8 below.

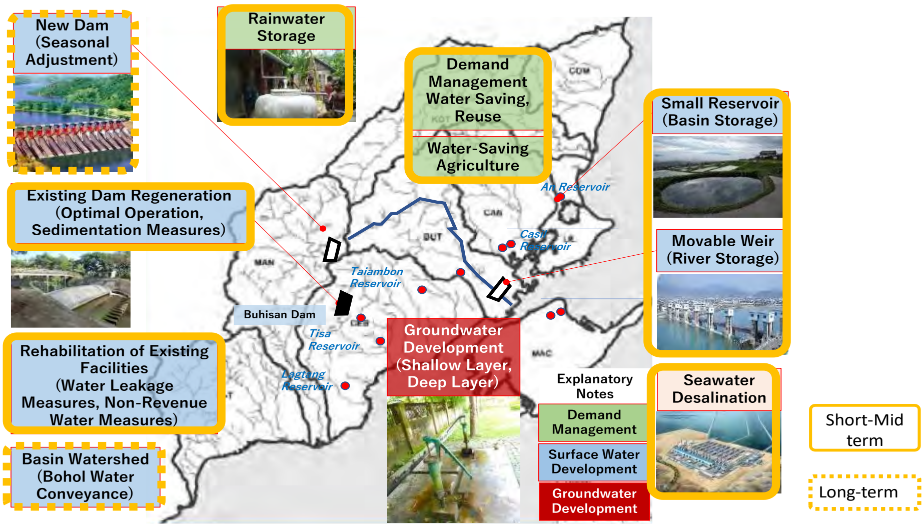


Source: JICA Survey Team

Figure 4.3-8 Result of Field Investigation and Assessment of Water Resources in WRR VII

4.3.2.2 Alternative Study for New Water Resources Development Options (First Screening)

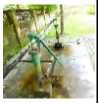
Possible individual countermeasures are formulated as shown in Figure 4.3-9 and Table 4.3-7. For these measures, primary screening is conducted to compare the adoptability based on the map survey and the field survey results to select multiple realistic plans. In the areas where water sources are limited, demand management should be included as one of the options to be considered.



Source: JICA Survey Team

Figure 4.3-9 Individual Countermeasures for Water Sources and Water Utilization Facilities in Metro Cebu

Table 4.3-7 Result of First Screening of Countermeasures of Water Source Development Options (WRR VII)

Counter-measure Plan		Surface Water Development				Groundwater Development		Seawater Desalination	Water Saving (Demand management)	Recycling Sewerage Water
		Dam/ Reservoir	Movable Weir	Small Pond	Inter-basin Diversion	Shallow Layer	Deep Layer			
Overview		Control structure with seasonal discharge	Structures for bulk water and local irrigation	Structures for local irrigation	Proposed in the existing plan	Currently implemented locally	Groundwater deeper than existing wells	Complementary measures when the amount of water is low	Water-saving agriculture, water leakage, etc.	Recycling Sewerage Water
										
Adoptability	Short-term	×	◎	○	×	×	×	○ (Cebu)	◎	×
	Mid-term	○ (Dam Upgrading)	○	○	×	×	△	○ (Cebu)	◎	×
	Long-term	○ (Mananga 2,Kotkot Dam)	○	○	○ (Cebu-Bohol water conveyance)	×	△	○ (Cebu)	◎	○ (Cebu)

Legend: ◎Very Effective, ○Effective, △Somewhat Effective, ×Not Subject to Consideration (based on assessment for the adaptability based on the map survey and the field survey results)

Source: JICA Survey Team

Among these countermeasures, the applicability was first evaluated "qualitatively". As a result, in Metro Cebu, groundwater development is not suitable due to the current problems of groundwater salinity intrusion, and the construction of a seawater desalination plant is considered an applicable option in line with the present program. For those that have applicability, the secondary screening is proceeded to adopt the criterion of the amount of water to be developed.

4.3.2.3 Water Balance Analysis of Countermeasures

Assuming basic countermeasure alternatives that combine the above options that consider staged development for the short-term, medium-term, and long-term, water balance analysis for each alternative options are performed using the hydrological analysis model. In this way, the amount of water that can be developed and the scale of the facility can be examined.

(1) Concept and Procedure for Measures to Improve Water Balance

In this section, the approach of the study for countermeasures for future water balance improvement in consideration of the supply and demand balance of water is explained for Cebu. The concept and procedure for measures to improve the balance of water and supply in Cebu is shown in Figure 4.3-10.

1) Figure (A) Water supply and demand balance diagram based on the current plan

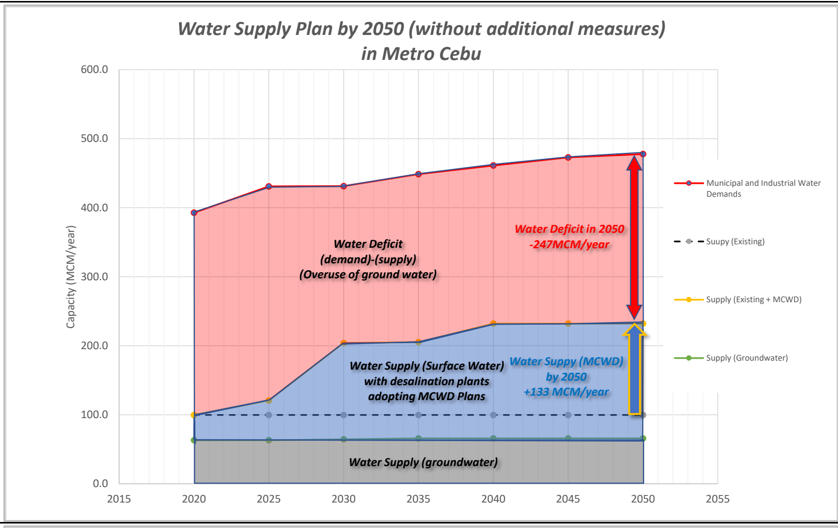
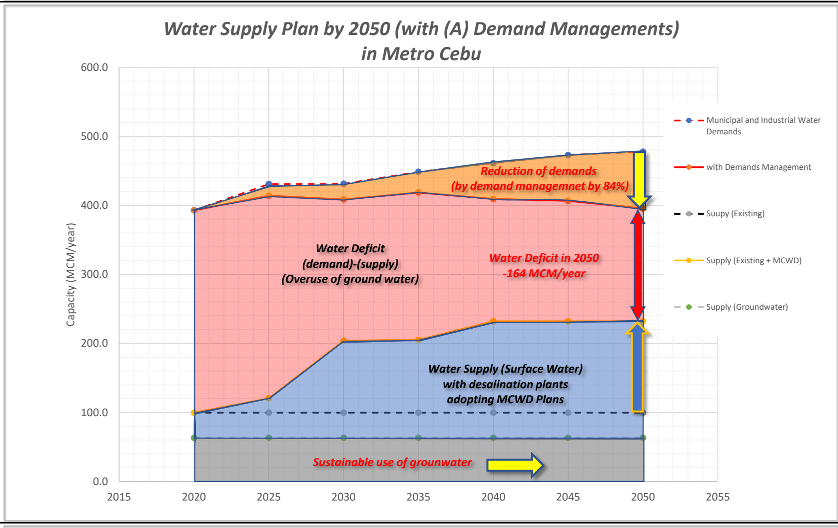
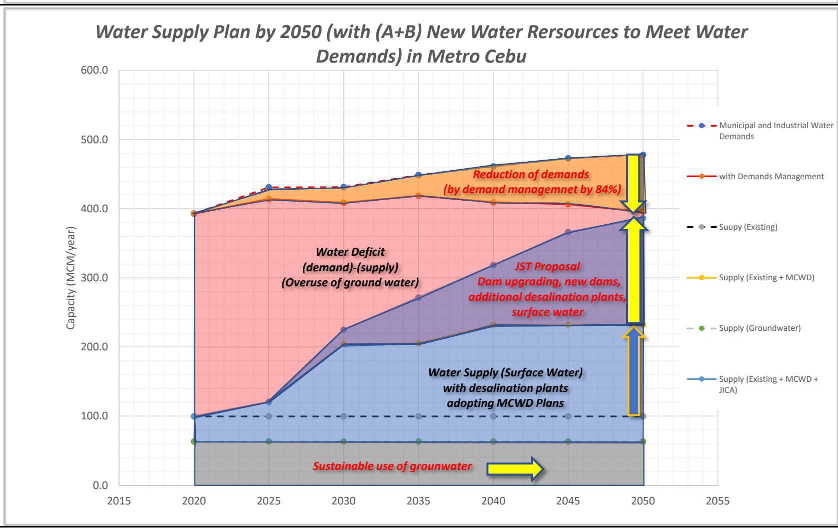
- At present, the amount of water demand has exceeded the water supply capacity with the shortage of about 293 MCM/year.
- In addition, even with the development of new water resources of about 133 MCM/year based on the current MCWD's water supply development plan (such as seawater desalination), the water supply capacity will be insufficient with the shortage of about 247 MCM/year in 2050. The state of insufficient supply capacity is not resolved.

2) Figure (B) Demand management measures diagram

- As the first step to improve the water balance, the introduction of water demand management measures should be considered.
- As measures to manage demands, measures to control demand for water supply (water saving, strengthening countermeasures against non-revenue water), which will be described later in 4.3.3.6, and measures to control demand for irrigation water, which will be described in 4.3.3.5 (waterway leakage countermeasures, introduction of ITS for irrigation efficiency improvement) are studied. As a result, in the case of Cebu Province, future water demand can be expected to be reduced by about 16%.
- Regarding groundwater use, the main policy / strategy is sustainable use. This will prevent increase in demand from the current level, or at least maintain it at the current level. If it is absolutely necessary, the option of reducing the amount of groundwater supply by conversion to surface water sources can be applied.
- However, despite adopting above measures, the water shortage situation in 2050 will not yet been resolved (shortage of about 164 MCM/year).

3) Figure (C) Development of Additional Water Resources

- In order to compensate for the shortage of water supply capacity even with the implementation of the above-mentioned water demand management measures, an additional water resources development (164 MCM) shall be considered. As applicable alternative options that has passed the primary screening (listed in 4.3.2.2), the development scale and applicability of each option is individually examined., and then a combination of measures to cover the shortage is studied and proposed.

<table>
<tr><td>(A)
Water supply and demand balance diagram based on the current plan</td><td>
</td></tr>
<tr><td>(B)
Measure 1 (Demand management measures diagram)</td><td>
</td></tr>
<tr><td>(C)
Measure 2 (Measure 1 + water resources development measures)</td><td>
</td></tr>
</table>

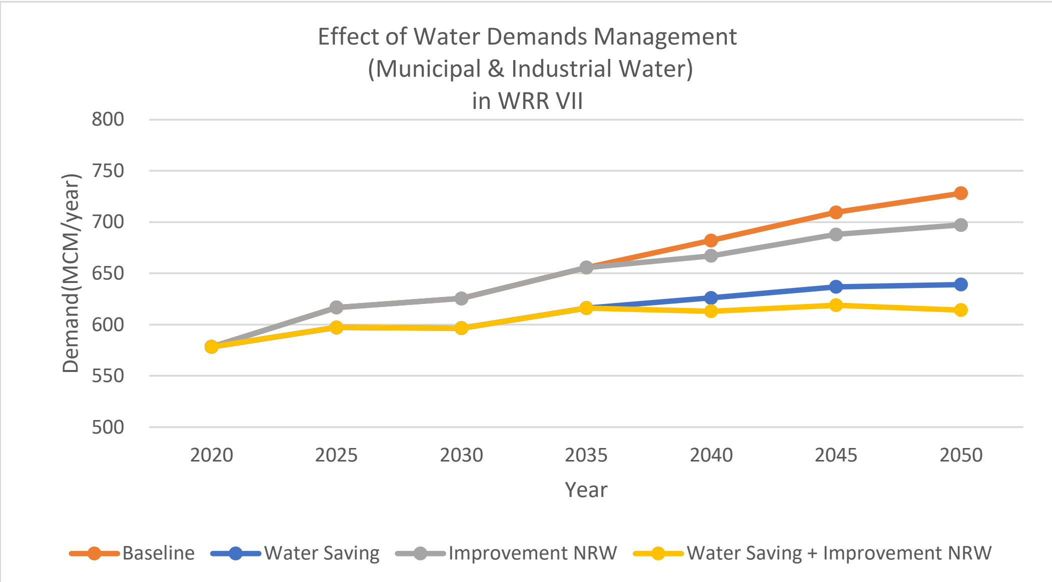
Source: JICA Survey Team

Figure 4.3-10 Concept and Procedure for Measures to Improve Water Balance (Example of Cebu)

(2) Measures 1 (Water Demand Management)

1) Demand Management (Municipal and Industrial Water Use)

As for the demand management measures for municipal and industrial water use, water saving and enhancement of non-revenue water measures as described later in 4.3.3.6 are considered to be applied. The reduction effect is estimated as 16% in total in the whole WRR VII as shown in Figure 4.3-11 below.



Water Resource Region		Municipal & Industrial Water Demand Projection (MCM/Year)							Reduction Effect in 2050
		2020	2025	2030	2035	2040	2045	2050	
WRR VII - CENTRAL VISAYAS	Baseline	578	617	625	656	682	710	728	100%
	Water Saving	578	597	596	616	626	637	639	88%
	Improvement NRW	578	617	625	656	667	688	697	96%
	Water Saving + Improvement NRW	578	597	596	616	613	619	614	84%

Source: JICA Survey Team

Figure 4.3-11 Reduction Effect of Demands Management (Municipal and Industrial Water Use) in WRR VII

2) Demand Management (Irrigation Water Use)

As for the demand management measures for irrigation water use, waterway leakage countermeasures, irrigation efficiency improvement by introducing ITS as described in 4.3.3.5 are considered to be applied. The reduction effect is estimated as 7.9% in total in the whole WRR VII as shown in Table 4.3-8 below.

Table 4.3-8 Reduction Effect of Demands Management (Irrigation Water Use) in WRR VII

WRR VII (Region VII and part of Region VI)

Province	Irrigated Area (ha)		Without measures	With measures	Without - With	
	Wet	Dry	Irrigation Water Demands in 2050 (MCM)		Reduction of Irrigation Water Demands in 2050 (MCM)	
Bohol	24,910	22,321	560	495	64	11.5%
Cebu	6,949	6,029	146	144	2	1.3%
Negros Oriental	10,809	10,804	279	263	16	5.7%
Siquijor	665	321	13	13	0	0.0%
Negros Occcidential	5,305	3,746	132	126	7	5.1%
Total	**48,637**	**43,221**	**1,131**	**1,042**	**89**	**7.9%**

Source: JICA Survey Team

3) Total Demand Management

The reduction of total water demand adopting both of 1) and 2) measures is summarized by each province in Table 4.3-9 below.

Table 4.3-9 Reduction of Total Water Demand adopting Demand Management Countermeasures by Province in WRR VII

Provence	SW/GW	Without	With	Without-With	
		Total Demand	Total Demand	Reduction of Total Demand	
		[MCM/day]	[MCM/day]	[MCM/day]	[%]
Cebu	SW	273.6	229.2	44.4	16%
	GW	844.4	599.9	244.5	29%
	Total	1,118.0	829.1	288.9	26%
Bohol	SW	192.9	179.6	13.3	7%
	GW	129.4	95.7	33.7	26%
	Total	322.3	275.3	47.0	15%
Negros Oriental	SW	236.6	207.3	29.3	12%
	GW	86.0	63.1	22.9	27%
	Total	322.6	270.4	52.2	16%
Siquijol	SW	161.7	152.5	9.2	6%
	GW	29.7	25.7	4.0	14%
	Total	191.3	178.1	13.2	7%
WRR-VII all	**SW**	**864.8**	**768.6**	**96.3**	**11%**
	GW	**1,089.4**	**784.3**	**305.1**	**28%**
	Total	**1,954.2**	**1,552.9**	**401.3**	**21%**

Note: Present Climate, 2050, 1/5-dry year

Source: JICA Survey Team

(3) Required Storage Volume for Reservoir Operation

In order to calculate the amount of development water necessary to cover the shortage of water supply and demand in the future 2050 even if the water demand adjustment program will be implemented, reservoir operation study is conducted assuming the proposed dam site upstream. The following conditions are applied for the calculation.

- Water safety level: 1-10 year for municipal and industrial water
- Development site: proposed dam sites in the upstream of high demand area (see Subsection 4.3.3.2 below)
- Calculation method: Reservoir operation analysis is performed using the daily flow data for 42 years (1981 to 2022) calculated by the water balance calculation model (SHER) at the proposed dam site. Based on the result of analysis, the amount of water supply from the reservoir is estimated to satisfy the require water safety level (developable discharge) in the downstream demand areas.

Details are given in Annex D Chapter 13.

4.3.2.4 Comparison of Alternative Options

(1) Evaluation Criteria

The proposed evaluation criteria for the screening of WRDM Plan (idea) and priority project concepts were established through series of discussions with NEDA and NWRB are shown in Table 4.3-10 below. The weighting of each criterion was also introduced.

Table 4.3-10 Summary of Evaluation Criteria for Screening of WRDM Plan(idea) and Priority Project Concepts

Evaluation Criteria	Weight	Contents of the Criteria
Needs	2.5	Emergence of water problem, reediness of implementation plan. Add 1 point effect of flood risk management
Volume of Annual Water Production	1.5	Quantity, size of target area and population for water supply.
Development Cost per Annual Water Production	1.0	Economic efficiency (unit cost per developed water volume)
Technical Difficulty	0.5	Type of developed and managed facilities, and degree of technical capability required for project implementation.
Implementing Organization	1.0	Implementation entity for water resources development and its capability (technical and financial)
Environmental and Social Considerations	2.0	Scale of relocation / land acquisition, environmental conservation areas, conservation species, presence of IP areas, etc. revised
Sustainability	1.5	Impact on the future groundwater balance, availability of technical and financially capacity to perform operation and maintenance of the executing agency

Source: The Survey Team

Criteria and its weights and allocation of points were determined through discussions with NEDA and NWRB. The initial value of the weight was set at 1.0 and the total weight of the 7 items is 10. In consideration of the importance of project implementation, “Needs” is the most important item and its weight is set to 2.5. As the next important item, the environmental and social consideration aspect is given 2.0, and the volume of annual water production and sustainability is given 1.5. As for the technical aspects, there are aspects that can be resolved during the implementation of the project, so the allocation of weight is set at 0.5. Points allocation was set based on the range (minimum value, maximum value) of each item that could be calculated as a numerical value. Detailed contents of the criteria are shown in Table 4.3-11 below.

Table 4.3-11 Detailed Evaluation Criteria for Screening of WRDM Plan(idea) and Priority Project Concepts

<table>
<tr><th>Evaluation Criteria</th><th>Weight</th><th>Detailed Contents of the Criteria</th></tr>
<tr><td>Needs</td><td>2.5</td><td>As project needs, the emergence of water problems in the project target area and the tightness of the water balance are evaluated in 3 stages (High: 3, Medium: 2, Low: 1).
If an implementation plan has been formulated and is consistent with the regional development plan, 1 point is added.
If the flood control effect is entrusted to the project (for example, multipurpose dam with flood control function), 1 point is added.</td></tr>
<tr><td>Volume of Annual Water Production</td><td>1.5</td><td>Volume of annual water production that can be developed by the project is evaluated in the 5 stages as shown in the table below.
<table>
<tr><td>Point</td><td>Volume of annual water production</td></tr>
<tr><td>1</td><td><1MCM</td></tr>
<tr><td>2</td><td>1<x≦10MCM</td></tr>
<tr><td>3</td><td>10<x≦100MCM</td></tr>
<tr><td>4</td><td>100<x≦500MCM</td></tr>
<tr><td>5</td><td><500MCM～with large service area</td></tr>
</table></td></tr>
<tr><td>Development Cost per Annual Water Production</td><td>1.0</td><td>Economic efficiency of the project is evaluated by the ratio of the cost per annual water production volume (LCOW: Levelized Cost of Water) in the five stages as shown in the table below.
The cost is composed of initial cost (construction cost) and annual operation and maintenance cost.
LCOW is calculated by the following formula considering the project cost, project lifetime and O&M cost as below:
LCOW = (Project Cost / Lifetime + Annual O&M Cost) /Volume of annual water production
<table>
<tr><td>Point</td><td>LCOW (x)</td></tr>
<tr><td>1</td><td>PHP 30 /m^3<</td></tr>
<tr><td>2</td><td>PHP 10/m^3<x≦30</td></tr>
<tr><td>3</td><td>PHP 3/m^3<x≦10</td></tr>
<tr><td>4</td><td>PHP 1/m^3<x≦3</td></tr>
<tr><td>5</td><td>x≦PHP 1 /m^3</td></tr>
</table></td></tr>
<tr><td>Technical Difficulty</td><td>0.5</td><td>Technical difficulty of the project is evaluated by taking into consideration the facility to be developed and managed, and the degree of technical capability required of the implementation of the project. This is evaluated in the 5 stages as shown in the table below.
If the project is technically difficult but can be developed in a short period of time (until 2030) with technical assistance such as from donors, 1 point is added.
<table>
<tr><td>Point</td><td>Outline</td><td>Case</td></tr>
<tr><td>1</td><td>Project that requires highly advanced construction technology and products that can only be carried out by specific contractors</td><td>—</td></tr>
<tr><td>2</td><td>Project that involves the construction of large-scale facilities, and requires even more advanced construction techniques and facilities.</td><td>(Recycle sewerage water/Desalination Plant)</td></tr>
<tr><td>3</td><td>Project that involves the construction of large-scale facilities and requires technology that can be implemented by large-scale contractors</td><td>Large Dam, (H≧15m or V≧20MCM), Existing Dam Upgrading</td></tr>
<tr><td>4</td><td>Project that involves the construction of normal-scale facilities using technology that can be implemented by ordinary Filipino contractors.</td><td>Traditional Facility (Small dam: H<15m)</td></tr>
<tr><td>5</td><td>Project that involves construction of small-scale facility with technology that can be implemented by ordinary Filipino contractors</td><td>Traditional Facility (weir, pond), wells</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Evaluation Criteria</th><th>Weight</th><th>Detailed Contents of the Criteria</th></tr>
<tr><td>Implementing Organization</td><td>1.0</td><td>Capacity of the implementing agency is evaluated by the budget/financial aspects and technical capabilities in the 5 stages as shown in the table below.
In addition, private investment projects (PPP) and multi-purpose projects involving multiple implementing agencies are evaluated considering the difficulty of the actual implementation.
If the project can strengthen the capacity of the implementing agency or strengthen cooperation among implementing agencies through technical assistance from donors, 1 point is added.
<table>
<tr><th>Point</th><th>Outline</th><th>Case</th></tr>
<tr><td>1</td><td>Implementing organization for very complex multi-purpose project</td><td>Large scale multi-purposed dam</td></tr>
<tr><td>2</td><td>Implementing organization for PPP and multi-purpose project</td><td>PPP/multi-purpose project</td></tr>
<tr><td>3</td><td>Implementing organization for single purpose project that can be managed by agencies with low budget and capacity</td><td>WD/LGUs/NWRB</td></tr>
<tr><td>4</td><td>Implementing organization for single purpose project that can be managed by agencies with average and sufficient budget and capacity</td><td>NIA</td></tr>
<tr><td>5</td><td>Implementing organization for single purpose project that can be managed by agencies with higher budget and capacity</td><td>DPWH, DENR</td></tr>
</table></td></tr>
<tr><td>Environmental and Social Considerations</td><td>2.0</td><td>This is evaluated by the scale of the relocation/land acquisition, environmental conservation areas, conservation species, presence of IP areas, etc. The details are separately shown in Table 4.3-15.</td></tr>
<tr><td>Sustainability</td><td>1.5</td><td>Sustainability is evaluated by the impact on the future groundwater balance, availability of technical and financial capacity to perform operation and maintenance of the executing agency in the 5 stages as shown in the table below.
Add 1 point if there is a point worthy of special mention in terms of sustainability.
<table>
<tr><th>Point</th><th>Outline</th></tr>
<tr><td>1</td><td>Serious impact on future groundwater use</td></tr>
<tr><td>2</td><td>Future groundwater use will be affected. Alternatively, the executing agency's capacity for operation and maintenance is low.</td></tr>
<tr><td>3</td><td>There will be no problems with future groundwater use, and the executing agency's operation and maintenance capabilities are standard.</td></tr>
<tr><td>4</td><td>There will be no problems with future groundwater use, and the executing agency's capacity for operation and maintenance is excellent.</td></tr>
</table></td></tr>
</table>

Source: JICA Survey Team

In addition to the above, as a comprehensive balanced evaluation, when a project including evaluation point (1) is selected by the total point evaluation, that project will be examined separately in detail for the final selection.

Table 4.3-12 Criteria for Environmental and Social Considerations

Point	Level	Outlines	Case
1	Impact which is impossible to manage	-Project impacts which are difficult to be controlled -Project which is recommended to set alternatives	-Construction of new large-scale dams with a large resettlement / land acquisition or in the significant protected area
2	Significant impact (equal to Category A*)	-Project with significant adverse impacts or classified as an Environmental Critical Project (ECP) as defined by the DENR -Project with complicated or unprecedented impacts that are difficult to assess, or project with a wide range of impacts or irreversible impacts	-Construction of a new large-scale dam or major rehabilitation works of an existing large-scale dam (i.e., ≥25 hectares reservoir flooded / inundated area or ≥20 million cubic meters water storage capacity) -Project with a large-scale resettlement / land acquisition
3	Moderate impact (equal to Category B with EIS requirement*)	-Project with potential adverse impacts -Project that is classified as a Non-Environmentally Critical Project (non-ECP) but is located in Environmentally Critical Area (ECA) as defined by DENR	-Construction of a new dam or major rehabilitation of an existing dam (i.e., <25 hectares reservoir flooded / inundated area or <20 million cubic meters water storage capacity) -Construction of a new facility in the protected / historical area / cultural communities -Project with a small-scale resettlement (ex. less than 10 households) / land acquisition
4	Small impact (equal to Category B – with IEE Checklist requirement or Category C*)	-Project including those that will directly address existing environmental problems with potential adverse impacts that are not large and less than above -Project which is site-specific, with few irreversible impacts, and can be addressed by general mitigation measures	-Construction of a new small scale of a facility or major rehabilitation of an existing facility -Project outside the protected / historical area / cultural communities -Project with no resettlement / land acquisition
5	Minimum impact (equal to Category C or Category D*)	-Project including those that will directly address existing environmental problems with minimal or little adverse impact -Project which does not require specific mitigation measures	-Project with no construction '-Introduction of equipment

Source: JICA Survey Team

Note: * Categorization according to EMB Memorandum Circular No. 2014-05 (Revised Guidelines for Coverage Screening and Standardized Requirements under the Philippine EIS System)

(2) Alternative Options of Water Resources Development

Based on the results of the detailed water balance calculations in the previous chapter as well as the results of the map studies, field surveys, and interviews with concerned organizations, the alternative options of water resources developments for each area were set and evaluated as shown in Table 4.3-13 below.

Table 4.3-13 Alternative Options for Water Resources Development and Management in WRR VII

Sector	Options	Cebu	Bohol	Negros Oriental	Siquijol
Surface Water	Dam/Small Pond (WS)	Mananga II	-	-	-
	Dam/Small Pond (IR)	Kotkot, Languyon	Hibale, Mandaung, Catungawan, San Isidro Banlasan, Bagasico, Cabatang	Kinalan, Cabuay, Canaway, Bio-os Dam	-
	Upgrading of Existing Dam	Buhisan (upgrade) Can-asujan (upgrade)	Malinao, Bayongan (upgrade)	Dauin, Calango, Nasig-id Dam	-
	Inter-basin Diversion	Inabanga Dam with Bohol Conveyance	Inabanga Dam with Bohol Conveyance	-	-
	Irrigation Weir	NIA's plan (SRIP/IP)			
Groundwater Development		Deep wells Recharge facilities			
Water Supply Development		Bulk water Seawater desalination Recycle sewerage water			
Demand Management	Municipal and Industrial Water Use	Measures for non-revenue water Promotion of water saving Improvement of recycle rate of industrial water Rainwater harvesting Monitoring of groundwater			
	Irrigation Water Use	Modernization of irrigation system Measures for water leakage of irrigation canals			

Source: JICA Survey Team

(3) Results of Comparison Alternatives

Applying the afore-mentioned evaluation criteria, a comparative evaluation of the alternative options for each of the above areas was carried out. The results of comparison are shown in Table 4.3-14.

The alternative options listed in Table 4.3-14 are items that were studied in past master plans and development plans in the Philippines, as well as items that were newly brought up in exchanging opinions with related organizations involved in this Survey. These proposed measures were the comprehensive ones selected through explanation and discussions with NEDA/NWRB and other related agencies and stakeholders in the Survey.

Table 4.3-14 Result of Comparison of Alternative Options in WRR VII

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
		Weight of Point	**2.5**	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**			
VII-CB-D-1-(1)	WS/FC	Construction of Mananga 2 Dam (high)	4	3	4	3	3	1	3	21	29.5	x
VII-CB-D-1-(2)	WS	Construction of Mananga 2 Dam (low)	4	2	4	4	3	2	3	22	30.5	O
VII-CB-D-2-(1)	WS	Construction of Kotkot Dam (Water Supply)	3	3	3	3	3	2	3	20	28.0	x
VII-CB-D-2-(2)	IR	Construction of Kotkot Dam (Irrigation)	3	3	3	3	4	2	3	21	29.0	x
VII-CB-D-2-(3)	FC	Construction of Kotkot Dam (Flood Control)	4	3	3	3	5	2	3	23	32.5	x
VII-CB-D-2-(4)	WS/IR/FC	Construction of Kotkot Dam (Multi-purpose)	4	4	3	3	2	2	3	21	31.0	O
VII-CB-D-3	IR	Construction of Launyon Dam (Irrigation)	3	4	4	3	4	1	3	22	29.5	x
VII-CB-D-4	WS	Construction of Inabanga Dam with Bohol Conveyance	4	3	1	2	3	2	3	18	28.0	O
VII-CB-D-5	FC	Construction of Butuanon Dam (Flood Control)	4	1	1	3	5	1	3	18	25.5	x
VII-CB-D-6	WS	Upgrading of Buihisan Dam	4	2	2	3	3	3	3	20	30.0	O
VII-CB-D-7	IR	Upgrading of Canasuan Dam	4	2	2	3	4	3	3	21	31.0	O
VII-CB-D-8	WS	Bulk Water Developments	3	2	2	5	3	4	4	23	32.0	O
VII-CB-D-9	WS	Construction of Desalination Plants	4	2	3	2	3	3	3	20	30.5	O
VII-CB-D-10	WS	Recycle of Sewerage Water	3	3	2	2	3	3	3	19	28.5	O
VII-CB-D-11	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	x	x	x	x
VII-CB-D-12	GW	Groundwater Development (Recharge Facility)	3	4	2	2	3	3	x	x	x	x

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
		Weight of Point	**2.5**	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**	**10**		
VII-BH-D-1	IR	Construction of Hibale Dam (on-going)	5	2	2	4	4	4	3	24	36.0	on-going
VII-BH-D-2	IR	Construction of Mandaug Dam (SRIP)	3	2	2	4	4	3	3	21	29.0	on-going
VII-BH-D-3	IR	Construction of Catungawan Dam (SRIP)	3	2	2	4	4	3	3	21	29.0	on-going
VII-BH-D-4	IR	Construction of San Isidro Banlasan (SRIP)	1	x	x	4	4	x	3	12	13	x
VII-BH-D-5	IR	Construction of Bagasico (SRIP)	1	x	x	4	4	x	3	12	13	x
VII-BH-D-6	IR	Construction of Cabatang (SRIP)	1	x	x	4	4	x	3	12	13	x
VII-BH-D-7	IR	Construction of Other Irrigaion Dams (SRIP, IP)	3	3	2	4	4	3	3	22	30.5	on-going
VII-BH-D-8	WS	Construction of Inabanga Dam with Bohol Coneyance	4	3	1	2	0	2	3	15	25.0	O
VII-BH-D-9	IR	Upgrading of Malinao Dam	5	2	2	3	3	2	3	20	30.5	on-going
VII-BH-D-10	IR	Upgrading of Malinao-Bayongan-Capayas Dams	3	2	2	3	4	2	3	19	26.5	O
VII-BH-D-11	WS	Bulk Water Development (Loboc, Sibilya, Sikatuna, and or Carmen)	3	2	2	5	3	4	4	23	32.0	O
VII-BH-D-12	WS	Construction of Desalination Plants	2	2	3	2	3	3	3	18	25.5	x
VII-BH-D-13	GW	Recycle of Sewerage Water	2	3	2	2	3	3	3	18	26.0	x
VII-BH-D-14	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	24	33.5	O
VII-BH-D-15	GW	Groundwater Development (Recharge Facility)	2	3	2	2	3	3	3	18	26.0	O

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**	**10**		
VII-NE-D-1	IR	Construction of Kinalan Dam	4	2	3	4	4	4	3	20	34.5	on-going
VII-NE-D-2	IR	Construction of Tabuay Dam	3	3	4	4	4	3	3	21	32.5	on-going
VII-NE-D-3	IR	Construction of Canaway Dam	3	3	4	4	4	3	3	21	32.5	on-going
VII-NE-D-4	IR	Construction of Bio-os Dam	3	2	4	4	4	3	3	20	31	on-going
VII-NE-D-5	IR	Construction of Other Irrigaion Dams (SRIP, IP)	3	3	2	4	4	2	3	18	28.5	O
VII-NE-D-6	IR	Upgrading of Existing Dams (Dauin, Calango, Nasig-id Dams)	4	2	4	4	4	4	3	21	35.5	O
VII-NE-D-7	WS	Construction of Desalination Plants	2	2	3	2	3	3	3	x	25.5	x
VII-NE-D-8	GW	Recycle of Sewerage Water	2	3	2	2	3	3	3	x	26	x
VII-NE-D-9	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	20	33.5	O
VII-NE-D-10	GW	Groundwater Development (Recharge Facility)	2	3	2	2	3	3	3	16	26	x

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**	**10**		
VII-SQ-D-1	IR/WS	Construction of New Dam	1	x	x	x	x	x	x	0	2.5	x
VII-SQ-D-2	IR	Construction of Other Irrigaion Weirs (CIS)	3	2	4	5	4	4	4	23	35	○
VII-SQ-D-3	WS	Bulk Water Development	3	2	2	5	3	4	4	20	32	○
VII-SQ-D-4	WS	Construction of Desalination Plants	1	2	3	2	3	3	3	16	23	x
VII-SQ-D-5	GW	Recycle of Sewerage Water	1	3	2	2	3	3	3	16	23.5	x
VII-SQ-D-6	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	20	33.5	○
VII-SQ-D-7	GW	Groundwater Development (Recharge Facilities)	2	2	2	2	3	3	3	15	24.5	x

Note: IR: Irrigation, WS: Water Supply, GW: Groundwater, FC: Flood Control, HP:Hydropower

Source: JICA Survey Team

(4) Selected Options

Selected water resources development options and water resource management options are shown in Table 4.3-18 and Table 4.3-19 below. The roadmap is given in Figure 4.3-12 below.

Table 4.3-15 Selected Plans for Water Resources Development in WRR VII

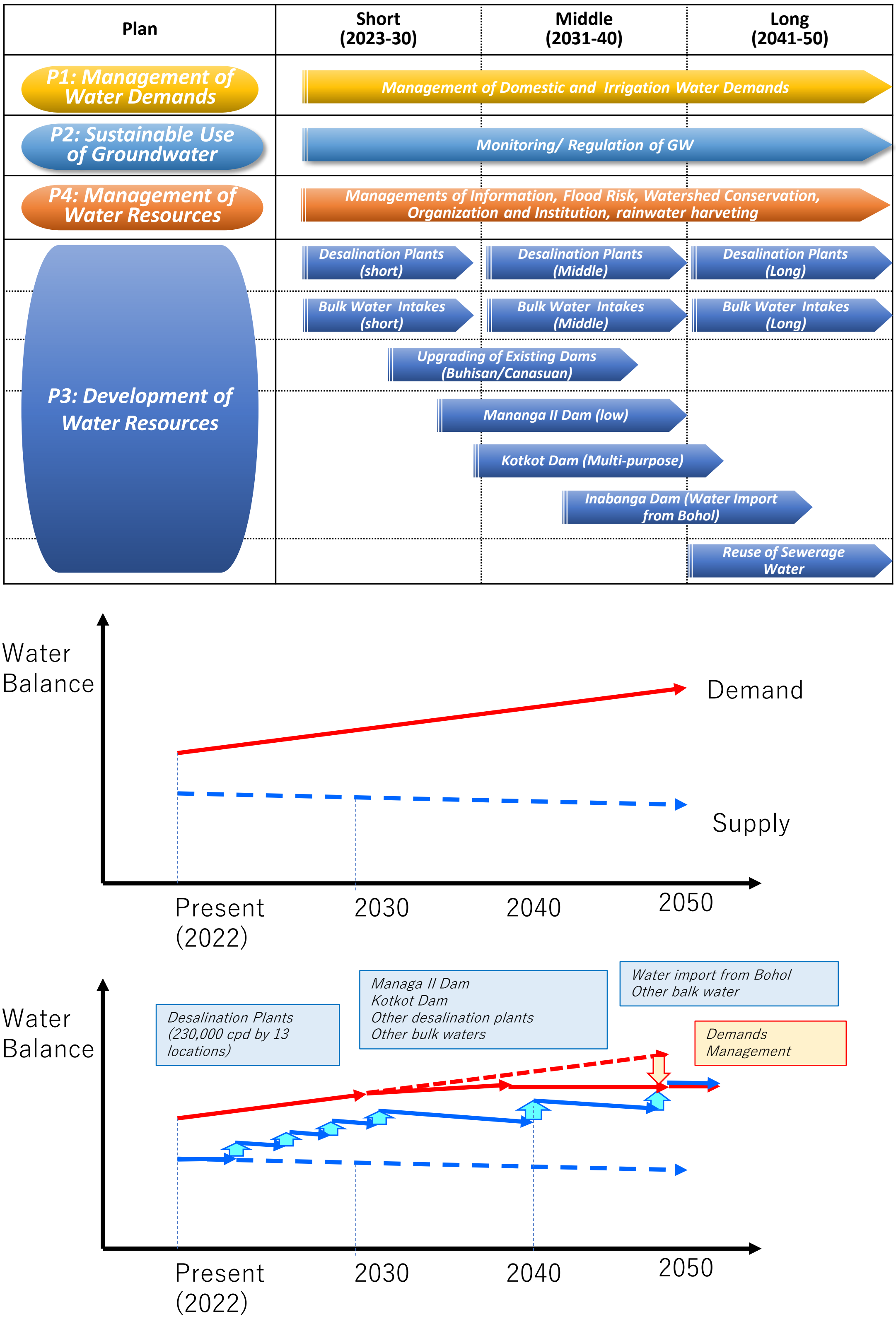
No	Proposed Measures	Location (Province)	Responsible Organization	Sector /Purpose	Implementation		
					Short	Medium	Long
1	Construction of Mananga II Dam (Low)	Cebu	MCWD	WS	● Study	●	-
2	Construction of Kotkot Dam	Cebu	MCWD / NIA7	Multi, WS/IR/FC	-	● Study	●
3	Construction of Inabanga Dam w/ Bohol Conveyance	Bohol	MCWD/ Related Water Utilities	Multi, WS/FC	-	● Study	●
4	Upgrading of Buhisan Dam	Cebu	MCWD	WS	Study	○	-
5	Upgrading of Can-Asujan Dam	Cebu	NIA7	IR	Study	○	-
6	Bulk Water Development	Cebu/Bohol/ Negros /Siquijor	Related Water Utilities	WS	●	○	○
7	Construction of Desalination Plants	Cebu	MCWD	WS	●	○	○
8	Recycle of Sewerage Water	Cebu	-	WS	-	-	○
9	Construction of Irrigations Dams, Ponds	Bohol/Negros	NIA 7	IR	● Study	○	
10	Upgrading of existing dams	Bohol/Negros	NIA 7	IR	Study	○	
11	Groundwater development (deep wells)	Bohol/Negros /Siquijor	Related Water Utilities	WS	●	○	○

Note: ●With exiting plan, ○: Newly proposed plan, IR: Irrigation, WS: Water Supply, GW: Groundwater
Source: JICA Survey Team

Table 4.3-16 Selected Plans for Water Resources Management in WRR VII

No	Proposed Measures	Location	Responsible Organization	Sector	Implementation		
					Short	Medium	Long
1	Measures for Non-Revenue Water	all	Related Water Utilities	WS	○	○	○
2	Promotion of Water Saving	all	Related Water Utilities w/ Public Promotion Activities	WS	○	○	○
3	Improvement of Recycle Rate of Industrial Water	all	Industrial Water Users	WS	○	○	○
4	Measures for Water Leakage of Irrigation Canals	all	NIA & Related Irrigation Associations	IR	○	○	○
5	Modernization of Irrigation System	all	NIA & Related Irrigation Associations	IR	○	○	○
6	Rainwater Harvesting	all	Related Irrigation Associations	SW	○	○	○
7	Monitoring of Groundwater	all	NWRB	GW	○	○	○
8	Regulation of Groundwater Use	all	NWRB	GW	○	○	○

Note: ●With exiting plan, ○: Newly proposed plan, IR: Irrigation, WS: Water Supply, GW: Groundwater
Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-12 Roadmap (idea) for Water Resources Development and Management Plan and Concept of Future Water Balance Without/With Projects in WRR VII

4.3.3 Proposal for Water Resources Development and Management Plans (idea) in WRR VII

4.3.3.1 Composition of the Plan

Water resources development and management plan (idea) is prepared to close the water supply-demand gap up to the proposed target year 2050 based on the above study. The composition of the plan is shown below in Table 4.3-17. The content of each plan is to summarize the current situation, issues, study results, and recommendations for planning and management aspects (short-term, medium-term, and long-term plans) obtained through this survey. The proposed plans will contribute to the future upgrading by the counterpart organizations from the Philippine side.

Table 4.3-17 Composition Plan of Water Resources Development and Management Plan (Idea)

Water Resources Development and Management Plan (idea)	Contents	Related Agencies
1.Surface Water Development Plan	Water balance, surface water development options, short, medium, and long-term roadmap (surface water)	NEDA, NWRB
2. Groundwater Development Plan	Same as above (groundwater)	NEDA, NWRB
3. Water Supply Plan		
3-1 Agriculture Water Use	Excerpt from agriculture sector from the surface water development plan	NIA, DA
3-2 Municipal and Industrial Water Use	Excerpt from the water supply and sewerage sector from the surface water development plan	WD, MWSS, LGUs, LWUA
4. Water Resource Management Plan	Composed of 4-1 to 4-5 below	
4-1. Water Resources Information Management Plan	Current status, management method, utilization method of hydrometeorology, groundwater, water rights, remote sensing data, etc., collected in this survey	NWRB, PAGASA, DPWH
4-2. Flood Management Plan	Current status and issues, management recommendations	DPWH
4-3. Basin Environmental Conservation Plan	Environmental and social conditions and issues, management recommendations (conservation of water source forests, improvement of dam water quality and sedimentation measures, river maintenance flow, improvement of environment around facilities)	DENR
4-4. Organization/Legal System	Current status and issues, recommendations for improving the organization and legal system, if the proposal exceeds the existing administrative framework, the implementation system and maintenance system are included.	NEDA/NWRB,
4-5. Demand Management	Water-saving agriculture, rainwater utilization, greywater utilization, etc.	NWRB, NIA,

Source: JICA Survey Team

4.3.3.2 Surface Water Development Plan in WRR VII

(1) List of Priority Proposed Dams

As surface water development plans for WRR VII, the following dams are selected in the primary screening of the current and planned dams and reservoirs described in Chapter 3. These dams are preliminary reviewed for layout, size, and estimated construction costs.

Table 4.3-18 List of Priority Proposed Dams (WRR VII)

Name of Island	Cebu	Cebu	Cebu	Cebu	Bohol
Name of Dam	Mananga-II (High)	Mananga-II (Low)	Kotkot	Buhisan (Redevelopment)	Inabanga
Name of River	Mananga	(Same as left)	Kotkot	Kinalumsan	Inabanga
Catchment Area	68 sq.km	(Same as left)	19 sq.km	–	544 sq.km
Flood Discharge (100-Yr Design)	850 cu.m/sec	(Same as left)	300 cu.m/sec	–	2,360 cu.m/sec
Dam Type	Rockfill	(Same as left)	Rockfill	Concrete Arch	Rockfill
Dam Height (Approximately)	80m	40m	60m	31m	40m
Dam Top Elevation	EL.154.5m	EL.114.5m	EL.287.5m	EL.108.3m	EL.66.5m
Dam Crest Length	278m	167m	509m	65m	161m
Dam Volume	2.4 M.cu.m	0.4 M.cu.m	2.3 M.cu.m	–	0.4 M.cu.m
Upstream Slope ratio	1:3.0	(Same as left)	1:3.0	–	1:3.0
Downstream Slope ratio	1:2.5	(Same as left)	1:2.5	–	1:2.5
Foundation bedrock Elevation	EL.70.0m	(Same as left)	EL.220.0m	–	EL.20.0m
Foundation bedrock properties	good sedimentary rock outcrops	(Same as left)	good sedimentary rock outcrops	–	---
Channel bottom Elevation (Crest EL. Spillway)	EL.145.5m	EL.105.5m	EL.287.5m	–	EL.55.5m
Area of Resorvoir	130.8 ha	30.2 ha	61.5 ha	–	136.3 ha
Capacity of Reservoir	39.7 M.cu.m	5.8 M.cu.m	15.2 M.cu.m	0.23 M.cu.m (Current Status)	26.8 M.cu.m
Minimum Operation WL. (MOL)	WOL.88.1m	WOL.88.1m	WOL.239.2m	–	WOL.39.5m
Dead Storage Volume	0.67 M.cu.m	0.67 M.cu.m	0.27 M.cu.m	–	3.35 M.cu.m
Dam Coordinates (Latitude)	10° 19' 33.816"N	(Same as left)	10° 27' 11.566"N	10° 18' 48.708"N	9° 58' 25.346"N
Dam Coordinates (Longitude)	123° 49' 6.534"E	(Same as left)	123° 53' 8.469"E	123° 50' 54.672"E	124° 9' 13.869"E
Total Construction Cost	**4,715 M.PHP**	**781 M.PHP**	**4,624 M.PHP**	**–**	**859 M.PHP**
Dam Volume	2,375,254 cu.m	393,594 cu.m	2,329,518 cu.m	–	432,928 cu.m

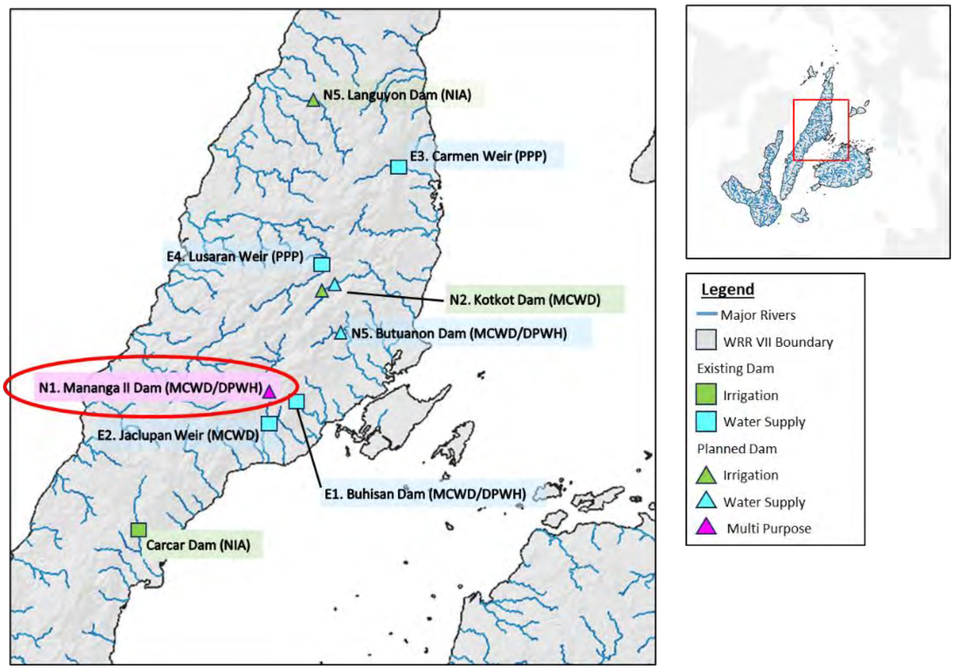
Source: JICA Survey Team

(2) Outline of Layout Study

1) Mananga-II Dam (Current Plan)

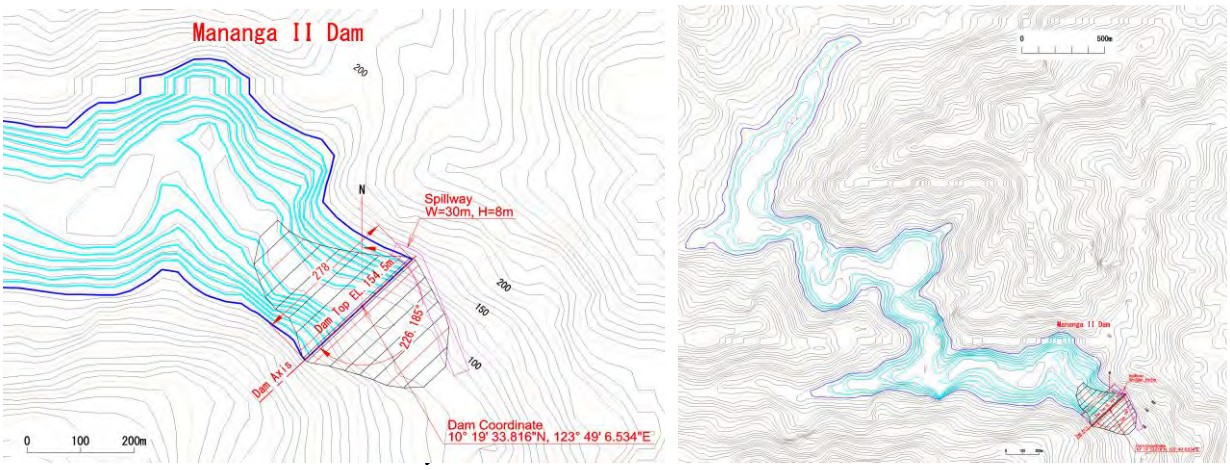
The dam axis position is based on the master plan presented in the JICA (2015) report. It is in the upper reaches of the Mananga River, west of Cebu City. Approximately 3.5 km downstream along the Mananga River is the MCWD reservoir, which is named Mananga-I. Therefore, the dam under consideration is named Mananga-II Dam. Location map and dam facility layout plan are shown below.

Dam cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



Source: JICA Survey Team

Figure 4.3-13 Location Map (Mananga-II Dam)



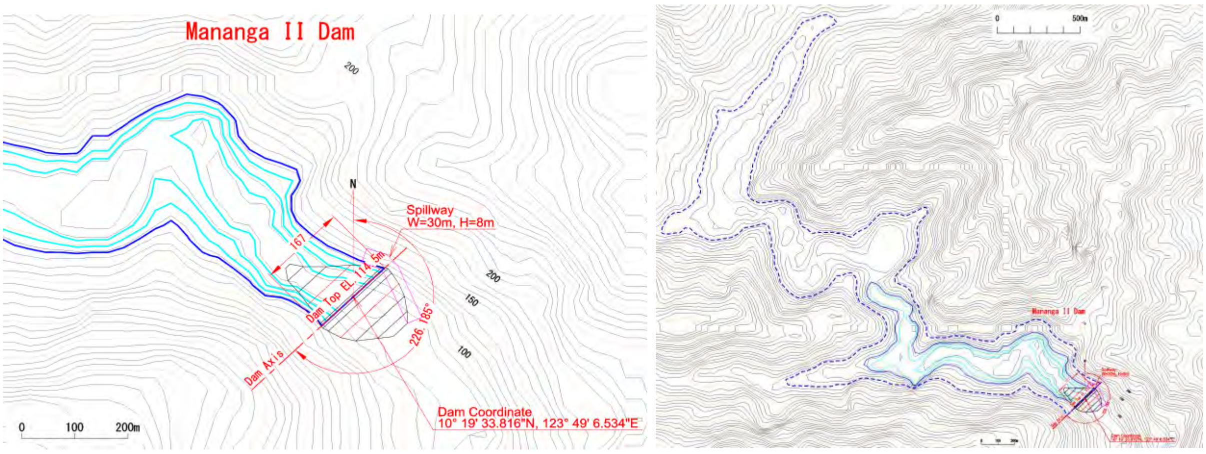
Source: JICA Survey Team

Figure 4.3-14 Layout Plan (Mananga-II Dam (High))

2) Mananga II Dam (Low)

The Mananga II Dam (high dam) has a large scale of development and has a large social impact in terms of relocated houses and land acquisition. In addition, the existing road will need to be replaced due to partial flooding and foundation excavation. Therefore, based on the results of the house survey, a dam height of 40 m was planned to reduce the number of houses to be relocated.

Location is as same as the Mananga II Dam (high dam). Dam facility layout plan are shown below. Dam cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.

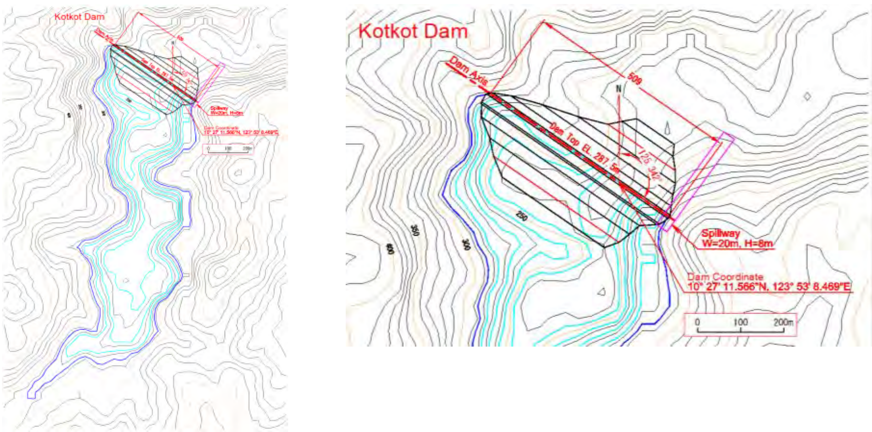


Source: JICA Survey Team

Figure 4.3-15 Layout Plan (Mananga-II Dam (Low))

3) Kotkot Dam

The dam axis position is based on the NIA-7 (Aug. 2022) Report. Location of the dam is in the upper part of the Kotkot River in the north of Cebu City. Dam facility layout plan is shown below. Dam cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



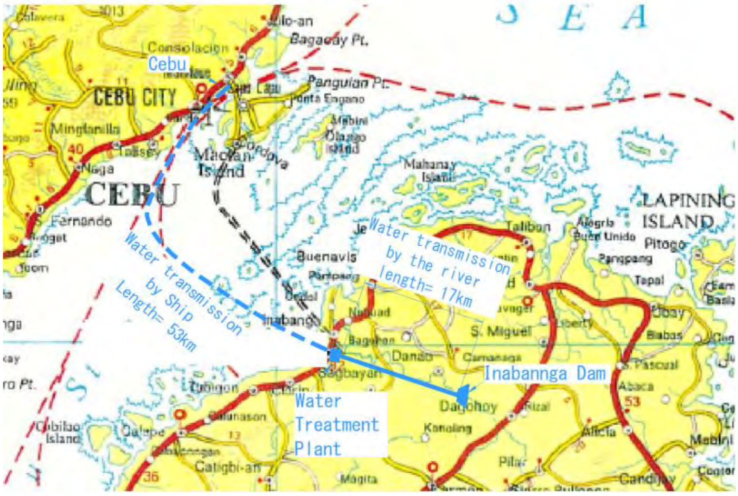
Source: JICA Survey Team

Figure 4.3-16 Layout Plan (Kotkot Dam)

4) Inabanga Dam in Bohol Island

The dam axis position is based on the report presented by Japanese Ministry of Construction (March 1994). Location of the dam is in the upper part of the Inabanga River, east of Inabanga City. Water is conveyed from the Inabanga Dam to the water treatment plant at the mouth of the Inabanga River. From the plant, water will be transported to Cebu City via tankers.

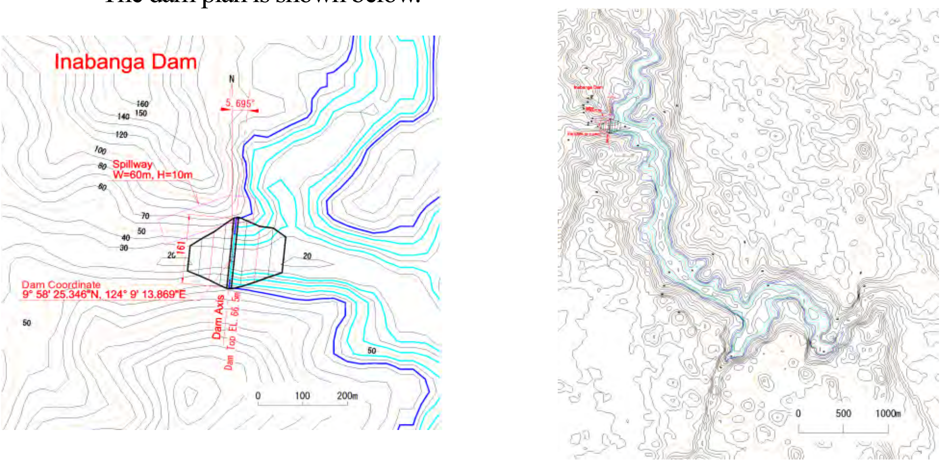
Location map and dam facility layout plan are shown below. Dam cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



Source: JICA Survey Team

Figure 4.3-17 Location Map (Inabanga Dam)

The dam plan is shown below.



Source: JICA Survey Team

Figure 4.3-18 Layout Plan (Inabanga Dam)

(3) Estimated construction cost

1) Method of preliminary cost estimation

The preliminary construction cost was examined by referring to the BOQ of the Ibinga Dam (NIA) currently under construction, which was obtained in this survey. Since detailed design for temporary work, spillway, water utilization facilities, etc. of the proposed dam has not been carried out this time, the preliminary construction cost is calculated using the cost ratio to the embankment volume capacity.

2) Estimated construction cost

The preliminary construction cost of the priority dams is shown in Table 4.3-19. The construction cost for the headrace and transmission channels from the dam is estimated by adopting the pipeline unit cost of 105,000 yen/m (44,118 PHP/m) [exchange rate 2.38 yen/PHP], referring to that of the Mananga II project in 2015.

In this cost estimation, the cost of construction and renovation of water treatment facilities and the cost of transport in Inabanga are not included.

Table 4.3-19 Estimated construction cost of Priority Dams

Name of Island	Cebu	Cebu	Cebu	Cebu	Bohol
Name of Dam	Mananga-II (High)	Mananga-II (Low)	Kotkot	Buhisan (Redevelopment)	Inabanga
Name of River	Mananga	(Same as left)	Kotkot	Kinalumsan	Inabanga
(1)Total Construction Cost	**4,715 M.PHP**	**781 M.PHP**	**4,624 M.PHP**	**-**	**859 M.PHP**
Dam Volume	2,375,254 cu.m	393,594 cu.m	2,329,518 cu.m	-	432,928 cu.m
Temporary works	49.9 M.PHP	8.3 M.PHP	48.9 M.PHP	-	9.1 M.PHP
Dam area	1,577.2 M.PHP	261.3 M.PHP	1,546.8 M.PHP	-	287.5 M.PHP
Spillway area	1,674.6 M.PHP	277.5 M.PHP	1,642.3 M.PHP	-	305.2 M.PHP
Outlet works	1,325.4 M.PHP	219.6 M.PHP	1,299.9 M.PHP	-	241.6 M.PHP
Other works	87.9 M.PHP	14.6 M.PHP	86.2 M.PHP	-	16.0 M.PHP
Water Supply Distance	3.9 km	3.9 km	15.0 km	0.0 km	0.0 km
(2)Water Supply Line Cost	**172 M.PHP**	**172 M.PHP**	**662 M.PHP**	**0 M.PHP**	**0 M.PHP**
Grand Total (1)+(2)	**4,887 M.PHP**	**953 M.PHP**	**5,286 M.PHP**	**0 M.PHP**	**859 M.PHP**

Source: JICA Survey Team

4.3.3.3 Groundwater Development and Management Plan in WRR VII

(1) Current Issues of Groundwater Use

Based on the results of interviews in the field survey and the groundwater analysis in this study, the current issues of groundwater use in WRR VII are listed in Table 4.3-20.

Establishment of a monitoring system to understand the groundwater environment is essential for sustainable use of groundwater resources, but at present, the only monitoring systems that can be used continuously are in Metro Cebu (6 monitoring wells in NWRB and 21 monitoring wells in MCWD) and Bohol (6 monitoring wells in NWRB), while other areas are experiencing difficulties.

Over pumping is especially seen in urban areas, particularly in Metro Cebu and Tagbilaran. Figure 4.3-19 shows the groundwater level drop from 2020 to 2050 if the groundwater demand continues to increase until 2050. Compared to groundwater demand for industrial water and agricultural water, the amount of groundwater drop is particularly large in Metro Cebu, where demand is expected to increase. Groundwater levels are also declining in the northern edge of Cebu island and Tagbilaran, where demand for industrial water is expected to increase, as well as along the northeastern coast of Cebu island.

Saltwater intrusion, a problem related to over pumping, is also observed in Metro Cebu and Tagbilaran. Groundwater lowering due to over pumping may also be a potential cause of subsidence and sinking in areas where limestone and alluvial deposits are distributed.

There are also concerns about water pollution by nitrate in parts of Cebu and deterioration of water quality due to volcanic fluids around volcanoes in Negros Oriental.

In addition, although it is difficult to identify specific phenomena, in general, the following disturbances may occur as a result of earthquakes.

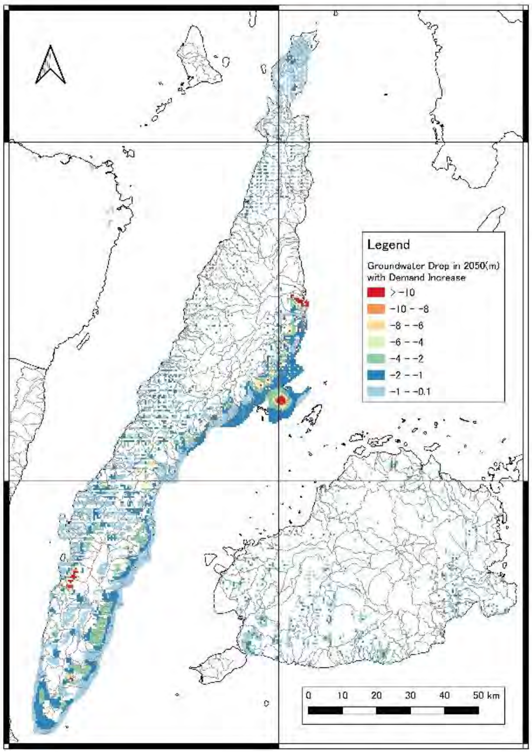
- Changes in water levels and discharge in groundwater and spring systems, such as changes in permeability due to seismic waves, release of soil pore water due to vibration, and mitigation of fluids along fractures
- Changes in water quality due to groundwater mixing from different aquifers or new pathways like crack
- Decreased pumping rate and turbidity due to damage to the well structure

Table 4.3-20 Summary of Current Issues of Groundwater Use in WRR VII

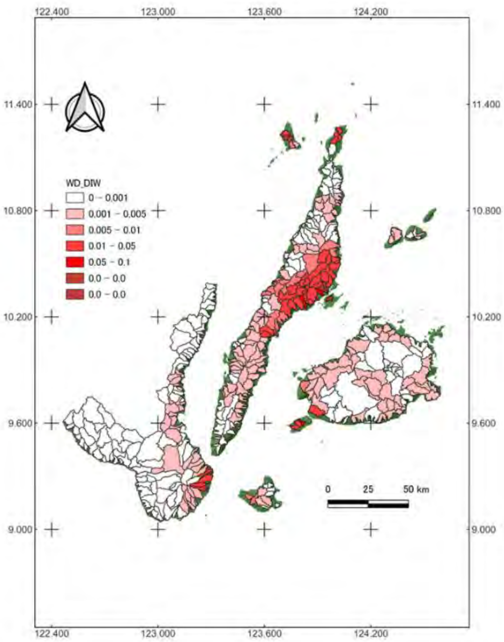
Area	Groundwater Monitoring	Groundwater Related Issues			
		Over Pumping	Saltwater Intrusion	Water Quality	Subsidence
Cebu	✓ 6 wells by NWRB 21 wells by MCWD	✓ Especially in Metro Cebu	✓ Especially in Metro Cebu	✓	✓
Bohol	✓ 6 wells by NWRB	✓ Especially in Tagbilaran	✓	None	✓
Negros Oriental	None	None	None	✓ In Volcano Area	None
Siquijor	None	None	None	None	None

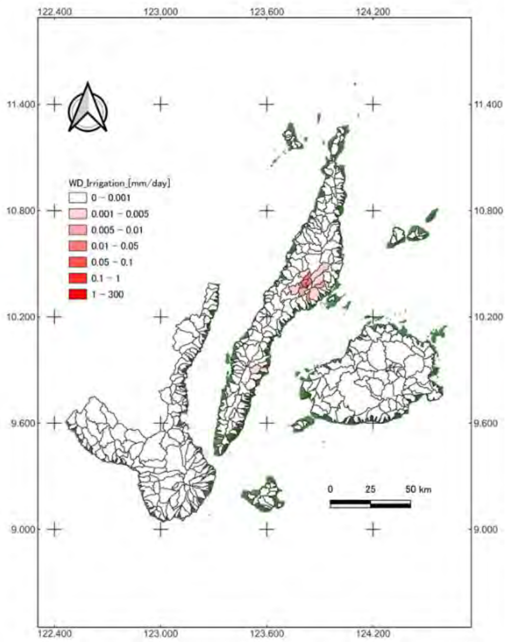
Source: JICA Survey Team

(a) Groundwater Level Drop Map



(b) Groundwater Demand of Industrial Use (c) Groundwater Demand of Agricultural Use





Source: JICA Survey Team

Figure 4.3-19 Groundwater Level Drop in Cebu and Bohol

(2) Basic Concept of Priority Project

Based on the issues related to groundwater described above, the proposed priority projects that can be considered at this time are shown in Table 4.3-21.

Since the foremost priority is the understanding of the actual status of groundwater use, short-term plans include the development of an observation network and understanding of current pumping amounts.

In areas where water level drops have already occurred due to over pumping, pumping regulations and relocation of water sources (surface water or wells in other areas) are also envisioned as short-term developments.

Medium-term projects could include the development of deep wells for water sources based on the understanding of the groundwater environment, or the securing of freshwater areas through artificial recharge.

Long-term projects could include securing water sources by relocating water sources and constructing deep wells, and controlling saltwater intrusion by developing underground dams and utilizing grey water and sewage (artificial recharge).

Table 4.3-21 Summary of Priority Project Concept

Development Item	Short-term (2023-30)	Mid-term (2031-40)	Long-term (2041-50)
Groundwater Management	・ Regulation of groundwater use ・ Development of groundwater monitoring network ・ Determination of the current production amount from existing well ・ Relocation of water source ・ Detailed analysis for prediction	・ Relocation of water source ・ Construction of Deep well (after investigation and study)	・ Relocation of water source ・ Construction of Deep well (after investigation and study)
Countermeasure for Saltwater Intrusion	・ Observation and evaluation of saltwater intrusion	・ Expansion of freshwater area through artificial recharge	・ Construction of underground dams ・ Sewage/ grey water use
Countermeasure for Water Quality	・ Observation and evaluation of contamination	・ Groundwater Quality Control ・ Deep Well	・ Groundwater Quality Control

Source: JICA Survey Team

4.3.3.4 Water Supply Plan (Agriculture Water Use) in WRR-VII

The irrigation development projects in Bohol and Negros Oriental provinces are important to improve the supply and demand balance of rice. NIA proposes many SRIPs in both provinces, which shall be given high priority in future irrigation development plans. For the implementation of SRIP as well as the improvement of the existing reservoir irrigation systems, it is indispensable to implement the watershed management plans and to introduce the irrigation telemetry system for proper water management at the same time.

(1) Irrigation Development Areas

As shown in Table 4.3-22, in the Stage 1 Study, the future irrigation development areas in 2030, 2040, and 2050 were estimated based on the past NIA financial programs and NIMP 2020-2030. As a result of the water balance studies for the irrigation areas by the NIA financial programs, the estimated irrigation area with 170% cropping intensity in 2050 could be fully irrigated if the surface water is properly developed as required.

Table 4.3-22 Forecasted Future Irrigation Development Areas in WRR VII

Province	Potential Irrigable Area (ha)	Year 2020				Remaining Irrigable Area (ha)	Newly Developed ISA (ha) by		
		ISA (ha)	FUSA (ha)	Irrigated Area (ha)			Year 2,030	Year 2,040	Year 2,050
				Wet	Dry				
NIA Financial Program									
Bohol	29,232	25,254	23,904	18,677	16,736	3,978	1,293	2,586	3,879
Cebu	8,106	9,504	7,634	6,742	5,850	0			
Negros Oriental	15,638	14,865	11,960	10,158	10,153	773	251	502	754
Siquijor	698	734	580	329	159	0			
Total	53,674	50,357	44,078	35,906	32,898	4,751	1,544	3,088	4,632
NIMP 2020-2030									
Bohol	86,291	25,254	23,904	18,677	16,736	61,037	18,270	26,980	31,073
Cebu		9,504	7,634	6,742	5,850				
Negros Oriental	50,997	14,865	11,960	10,158	10,153	36,132	10,815	15,971	18,394
Siquijor		734	580	329	159				
Total	137,288	50,357	44,078	35,906	32,898	97,169	29,085	42,951	49,468

Source: JICA Survey Team based on NIA Data

Cebu and Siquijor provinces do not have the remaining potential irrigable areas in both NIA financial program basis and NIMP 2020-2030. Therefore, the future irrigation development plans are studied for Bohol and Negros Oriental provinces under this survey work.

(2) Rice Supply and Demand Forecast

Table 4.3-23 shows the per capita consumption of rice at the provincial level in 2020. It is considered that in Region VII, rice self-sufficiency of provinces or regions is quite difficult to attain.

Table 4.3-23 Per Capita Consumption of Rice in 2020 in WRR VII

Province	Palay Production (ton) in 2020			Population 2020	Per Capita Consumption*1 (kg)		
	Irrigated	Rainfed	Total		Irrigated	Rainfed	Total
Bohol	122,072	66,761	188,833	1,365,108	58	32	90
Cebu	10,541	665	11,206	5,085,207	1	0	1
Negros Oriental	48,197	10,786	58,983	1,406,275	22	5	27
Siquijor	1,369	133	1,502	100,456	9	1	10
Total	182,179	78,345	260,524	7,957,046	15	6	21

Remarks *1: (Palay Production) x (0.65)/(Population), adopting 065% of milling rate

Source: JICA Survey Team based on Data from Bureau of Agricultural Statistics, Department of Agriculture

As for the irrigable areas in 2050 based on the past NIA financial programs, the per capita consumptions of each province in 2050 are also estimated as shown in Table 4.3-24. The rice supply and demand situation in 2050 would be almost the same as in 2020.

Table 4.3-24 Per Capita Consumption of Rice in 2050 in WRR VII

Province	Irrigable Area (ha) 2050		Palay Production *1(ton)	Population 2050	Per Capita Consumption *2(kg)
	Wet	Dry			
Bohol	24,910	22,321	255,044	1,988,651	83
Cebu	6,949	6,029	70,080	6,324,794	7
Negros Oriental	10,809	10,804	116,712	1,915,315	40
Siquijor	665	321	5,324	178,134	19
Total	43,332	39,475	447,161	10,406,894	28

Remarks *1: Palay unit yield = 5.4 ton/ha
Remarks *2: (Palay Production) x (0.65)/(Population), adopting 065% of milling rate
Souece: JICA Survey Team

(3) NIA Priority Irrigation Development Projects

As of February 2022, NIA presented the priority projects in Region VII as shown in Table 4.3-25.

Table 4.3-25 NIA Priority Irrigation Development Projects in Region VII

(Excludes on-going projects)

	Project Name	Province	Municipality	Program		Target Area (ha)		Project Status (As of March 2022)		
				TRIP	PIP	New	Restore	Feasibility Study (FS)	Detailed Engineering and Design (DED)	Remarks
1	Bohol Northeast Basin Multipurpose Project	Bohol	Danao, San Miguel, Trinidad, Dagohoy, Bien Unido, Ubay	✓	✓	2,133		Reformulation of FS is ongoing by the end of 2022.		
2	Mandaug SRIP	Bohol		✓	✓	265		Final FSR under-review by Consultant.		(F/S not feasible)
3	San Isidro Banlasan SRIP	Bohol		✓	✓					*Target Implementation Period 2024-2027*
4	Bagasico SRIP	Bohol			✓			(Pre-F/S)		*Target Implementation Period 2024-2026*
5	Cabatang SRIP	Bohol			✓			(Pre-F/S)		*Target Implementation Period 2024-2026*
6	Kinalan SRIP	Negros Oriental		✓	✓	600		FS aproved on Nov. 22, 2017		*Target Implementation Period 2024-2027*
7	Bayawan Multipurpose IP	Negros Oriental	Bayawan	✓	✓	2,872		Ongoing FS under VEVA Stage	DED Inhouse for funding FSDE CY 2023.	
8	Dagangdang-Tampaga IP	Negros Oriental	Siaton	✓	✓	1,800		FS by the end of the 1st semester of 2022.		
9	Bio-os SRIP	Negros Oriental				700		Pre-FS completed Dec. 2021	DED proposed in 2022	Proposed by Negros Oriental Satellite Office
10	Canauay SRIP	Negros Oriental				3,200		Pre-FS undergoing		Proposed by Negros Oriental Satellite Office
11	Tabuay SRIP	Negros Oriental				3,700		Pre-FS undergoing		Proposed by Negros Oriental Satellite Office
	Total					**15,270**				

TRIP: Three-year Rolling Infrastructure Program - DBM and NEDA Joint Circular No. 2016-01
PIP: Public Investment Program - NEDA Memorandum dated May 19, 2021, Updating of the 2017-2022 PIP
Source: NIA

The above programmed development areas are sufficient with the 2050 target development areas based on the NIA financial programs, but not enough with those based on NIMP 2020-2030. NIA shall assess further potential projects in Bohol and Negros Oriental provinces.

NIA Regional Office VII explained that the decrease in water sources and the heavy siltation in the reservoirs and canals were found to be the big issues due to climate changes. To mitigate these issues, watershed recovery programs are undertaken by NIA.

(4) Recommendations on Future Irrigation Development Plans

As a result of the assessment above and the field inspection explained in Annex-F: F3, future irrigation development plans are recommended in consideration of the following present situations:

1) Water resources and potential irrigation areas

In Region VII, especially Bohol and Negros Oriental provinces, irrigation development is constrained by the limited potential areas, not by the water resources. Negros Oriental Province has enough water resources for the irrigation areas estimated based on NIMP, judging from the results of the water balance studies on the irrigation areas estimated based on the NIA financial programs. But for Bohol Province, the irrigable areas shall be studied through a detailed analysis of the available water resources.

The NIA Negros Oriental satellite office has many irrigation development programs. The four permanent engineers are carrying out the investigation, planning, design, and supervision of construction works with the support of about 80 contract-based workers. For the acceleration of the development, not only further engineering assistant but also manpower and financial support are indispensable.

2) Reservoir dam irrigation systems

There are many reservoir irrigation systems and projects like the SRIP in Region VII. Many existing reservoirs have the heavy siltation problems, and the irrigated areas are decreased due to water shortage. The recovery of the reservoir capacity is urgently needed.

The following future irrigation development plans are recommended in the consideration of the above conditions.

1) New irrigation development projects

The irrigation development projects in Bohol and Negros Oriental provinces are important to improve the supply and demand balance of rice. The potential irrigable areas estimated in NIMP 2020-2030, which include the 3-8% slope area, shall be assessed to clarify the suitable farmlands for paddy cultivation.

NIA proposes many SRIPs in both provinces, which shall be given high priority in future irrigation development plans. For the implementation of SRIP, it is indispensable to implement the watershed management plans and to introduce the ITS for proper water management. There are several improved recovery plans for the uncontrolled watershed, e.g., construction of sabo dam and slope protection works. The definite plans shall be formulated through field survey and further assessment of the present situation. The ITS is explained in the following Sub-section F4.5.

2) Improvement of the existing NISs

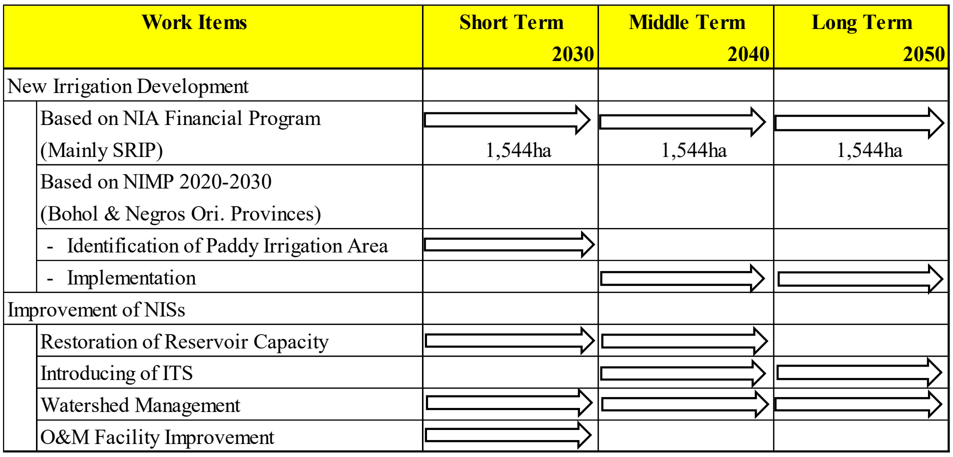
Reservoir irrigation systems shall be restored to the reservoir capacity, and the watershed management plans including reforestation shall be implemented simultaneously. The introduction of the ITS is also recommended for the proper water management of the reservoir systems, especially to maximize effective rainfall.

The several NISs are located in remote areas from the Negros Oriental satellite office, and the access roads are in poor condition, with no pavement, and are hard to drive in during the rainy season. For proper water control/management, the operation and maintenance (O&M) office with operational staff and road improvement are also required in the improvement works.

NIA shall study whether the above-mentioned improvement works will be implemented as the next phase of the NISRIP.

(5) Implementation Plan

Above future irrigation development plans are proposed to be implemented by the short term (urgent), middle term and long term as shown in Figure 4.3-20.



Source: JICA Survey Team

Figure 4.3-20 Implementation Plan of Future Irrigation Development in Region VII

4.3.3.5 Water Supply Plan (Municipal and Industrial Water Use) in WRR VII

(1) Proposal of Priority Project Concept

Summary of municipal and industrial water demand projection in WRR VII is shown in Table 4.3-26 below. The water demand is expected to increase gradually, and there are concerns about future water balance constrains. This water demand projection without project is defined as the Baseline.

Table 4.3-26 Summary of Municipal and Industrial Water Demand Projection in WRR VII (Baseline)

Water Resource Region	Municipal+Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR VII - CENTRAL VISAYAS	578	617	625	656	682	710	728

Source: JICA Survey Team

The following five priority project concepts have been identified as candidates for mitigating future water balance constraints.

- Reduction of Non-Revenue Water
- Promotion of Water Saving Activity

- Introduction of Desalination Technology
- Recycling of Sewerage Water
- Recycling of Industrial Wastewater

(2) Reduction of Non-Revenue Water

Reducing the non-revenue water (NRW) is proposed as one of the priority project concepts because it contributes to reducing the water demand.

LWUA has not stated a specific year for achieving the target year but has set a target value of NRW to 20% in MC2010-004, ACCEPTABLE NON-REVENUE WATER PERCENTAGE, February 23, 2010. Interviews with the major water districts during the field survey confirmed that most cities have set a future NRW target value of 20% following LWUA's target. In addition, in Bohol and Davao water districts, the current NRW ratio is low enough to be improved to 15% as a future NRW target. The NRW ratio for the baseline is shown in Table 4.3-27 below.

Table 4.3-27 Non-Revenue Water Ratio in WRR VII (Baseline)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	25%	25%	20%	20%	20%	20%	20%	MCWD hearing survey
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	15%	15%	15%	15%	15%	15%	15%	BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	40%	25%	23%	20%	20%	20%	**20%**	DCWD hearing survey
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	24%	22%	20%	20%	20%	20%	20%	MSWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

The 20% NRW ratio is considered to be at the stage of full-scale measures and can be achieved by implementing underground leakage and sectorization, in addition to aboveground leakage measures and apparent loss measures (water leakage, water theft, non-detection meter, etc.), which are relatively easy to implement. Therefore, it is considered that sufficient efforts by each water district will be required to achieve an NRW ratio of 20% by 2050.

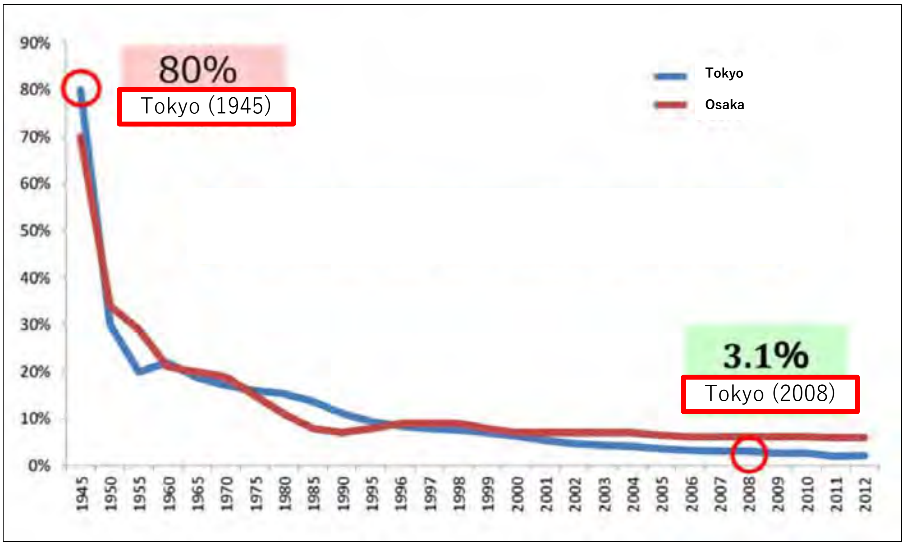
On the other hand, in Japan, an average non-revenue water ratio of around 10% has been achieved by further strengthening pipe materials and thorough underground leak detection in the 1990s.

Non-revenue water reduction measures by level and actual non-revenue water rate improvement trends in Japan (Tokyo and Osaka) is shown below.

Table 4.3-28 Non-Revenue Water Reduction Measures by Level

Level		Estimated NRW Ratio	Outline	Main Measures
1	Awareness Raising Stage	Abandoned at more than 40%.	Stage to understand the current problems and confirm the commitment of the executives.	1) Raising awareness of the need for non-revenue water control measures 2) Demonstration of countermeasures 3) Measurement of non-revenue water, development of monitoring system, and preparation of basic data such as pipeline maps, customer ledgers, etc. 4) Establishment of non-revenue water reduction plans and systems 5) Measures to prevent aboveground leakage 6) Improvement of water service, such as securing water sources, if necessary before taking measures to prevent non-revenue water.
2	Initial Countermeasure Stage	Currently well above 30%, but in the process of reaching the 30% level	Stage in which measures that are relatively cost-effective and technically easy to implement, such as above-ground leakage control and apparent loss control, can be initiated.	1) Establishment of basic data such as non-revenue water measurement, monitoring system, pipeline maps, customer ledgers, etc. 2) Formulate a non-revenue water reduction plan and develop a system to reduce non-revenue water 3) Thoroughly implement measures to prevent aboveground leakage and renew old pipelines with high priority 3) Improve construction and repair techniques 4) Take measures to prevent apparent losses, and if aboveground leakage is low, shift to underground leakage measures
3	Full-Scale Countermeasure Stage	Currently at 30%, but in the process of reaching the 20% level	Stage in which more sophisticated measures can be initiated, such as detecting underground leakage and dividing water distribution area.	1) Improve accuracy of non-revenue water measurement by blocking, etc. 2) Measures against underground leakage 3) Thorough implementation of aboveground leakage and apparent loss prevention measures 4) Systematic renewal of pipelines 5) Further improvement of construction and repair techniques
4	Advanced Countermeasure Stage	Currently at 20%, but in the process of reaching the 10% level	Final stage in which all non-revenue water measures have been implemented and pipe materials have been strengthened, DMA has been installed, and underground leakage detection has been further enhanced.	1) Installation of DMAs for precise monitoring and identification of priority areas to be addressed 2) Thoroughly implement systematic measures to prevent underground leakage 3) Improvement of pipe materials and construction techniques 4) Implementation of various highly accurate countermeasures

Source: Project Research Non-Revenue Water Control Project Identification and Formation/Implementation Supervision Consideration (2020, JICA)



Source: Japan's Experience in Water Utilities (2017, JICA)

Figure 4.3-21 Actual Non-Revenue Water Ratio Improvement Trends in Japan

The 20% non-revenue water rate is considered to be a full-scale countermeasure stage and can only be achieved by implementing underground leakage and dividing distribution area, in addition to aboveground leakage countermeasures and apparent loss countermeasures (leakage, water theft, non-detection meter, etc.), which are relatively easy to implement.

Furthermore, the 10% non-revenue water rate proposed as a priority project concept is considered to be at the advanced countermeasure stage and can be achieved by implementing a full range of non-revenue water measures, and then further strengthening pipe materials and thoroughly detecting underground leaks. Following the example of Japan, 10% non-revenue water ratio can be achieved by leak detection, pipe renewal, and establishment of a precise monitoring system by installation of DMAs.

Although an optimistic projection, the following are trends and estimates of non-revenue water rates assuming that non-revenue water rate reductions of up to 10% will be achieved in major cities by 2050.

Table 4.3-29 Non-Revenue Water Ratio in WRR VII (NRW Reduction)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	25%	25%	20%	20%	15%	13%	10%	MCWD hearing survey
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	15%	15%	15%	15%	15%	13%	10%	BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	40%	25%	23%	20%	15%	13%	10%	DCWD hearing survey
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	24%	22%	20%	20%	15%	13%	10%	MSWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: Changes from baseline condition due to NRW reduction is highlighted in red.

Source: JICA Survey Team

Table 4.3-30 Summary of Municipal and Industrial Water Demand Projection in WRR VII (NRW Reduction)

Water Resources Region	Municipal + Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR VII - CENTRAL VISAYAS	578	617	625	656	667	688	697

Note: Changes due to NRW reduction is highlighted in red.

Source: JICA Survey Team

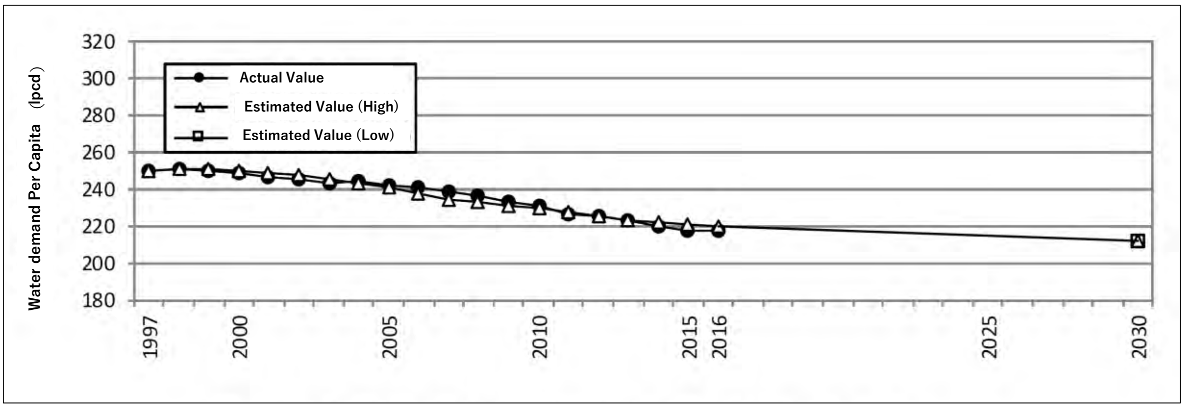
As a result of the above, it was confirmed that if NRW measures were thoroughly implemented up to the advanced countermeasure stage, there would be savings of 2 - 4% (8~31 MCM) of water demand.

The main cost of NRW reduction measures is expected to be the cost of renewing pipelines. The cost of renewing pipelines varies depending on the length of pipelines installed by each water utility and the number of years they have been in service. The estimated cost of PHP 2.3 billion for renewing 273 km of old pipes installed after 1990 in Cagayan de Oro as a project to reduce NRW is one reference. Therefore, a very rough estimated project cost for a similar NRW reduction project in 10 major cities can be estimated at PHP 23 billion.

(3) Promotion of Water Saving Activity

Promotion of water saving activity contributes to the reduction of water demand per capita (Lpcd). Since organized data on trends in water conservation in the Philippines cannot be confirmed, the Japanese case is used as a reference.

The following shows the actual and estimated trends of water supply intensity in Tokyo, which has been decreasing by about 15% over the past 30 years from 1997 to 2030, and is attributed to the spread of water-saving devices, higher performance of home appliance, and increased water-saving awareness.



Source: Results of Calculation of Future Demand and Availability of Supply in the Tone River System and the Ara River System (Ministry of Land, Infrastructure, Transport and Tourism in Japan, 2020)

Figure 4.3-22 Actual and Estimated Trends of Water Demand Per Capita in Tokyo

Following the Japanese example, measures to achieve a 15% reduction in the basic unit of water supply include water conservation PR activities (e.g., campaigns, websites, media, flyers, mascots, etc.), water conservation awareness activities (community-dissemination, classroom visits to schools, etc.), promotion of water-saving devices and water-saving cups, and education on how to detect water leaks inside homes. The following shows the water demand per capita of the baseline (without project).

Table 4.3-31 Water Demand Per Capita in WRR VII (Baseline)

Water Consumption per Capita (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	151	159	159	159	159	159	159	MCWD hearing survey
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	180	180	190	190	200	200	200	BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	155	**155**	**155**	**155**	**155**	**155**	**155**	DCWD hearing survey
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	118	122	125	128	130	135	135	MSWD hearing survey
Other cities in Urban Area			120	120	120	120	120	120	120	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	60	60	60	60	60	60	Domestic demand (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

Although an optimistic projection, referring to the transition of water demand per capita in Japan, as a result of the promotion of water conservation, the following table shows the results of the estimation of water demand per capita in WRR, assuming that the promotion of water conservation by about 15% is achieved in the WRR from 2020 to 2050.

Table 4.3-32 Water Demand Per Capita in WRR VII (Water Saving Promotion)

Water Consumption per Capita (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR VII	Metro Cebu	Talisay, Cebu, Mandaue, Lapu-Lapu, Consolacion, Liloan, Compostela, Cordova	151	148	145	142	137	133	128	MCWD hearing survey
	Bohol	Tagbilaran, Dauis, Baclayon, Corella	180	176	173	169	164	158	153	BWUI hearing survey
	Dumaguete	Dumaguete, Sibulan, Valencia, Bacong	155	152	149	146	141	136	132	DCWD hearing survey
	Siquijor	Enrique Villanueva, Larena, Lazi, Maria, San Juan, Siquijor	118	116	113	111	107	104	100	MSWD hearing survey
Other cities in Urban Area			120	118	115	113	109	106	102	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	59	58	56	55	53	51	Domestic demand (rural) in PWSSMP2018

Note: Changes from baseline condition due to water saving promotion is highlighted in red.
JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

Table 4.3-33 Summary of Municipal and Industrial Water Demand Projection in WRR VII (Water Saving Promotion)

Water Resources Region	Municipal + Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR VII - CENTRAL VISAYAS	578	597	596	616	626	637	639

Note: Changes from baseline condition are highlighted in red.

Source: JICA Survey Team

As a result of the above, it was confirmed that if water saving promotion was thoroughly implemented, there would be savings of 11-17% (58-139 MCM) of water demand.

It is assumed that the cost of water saving promotion can be accounted for as part of each water utility's public relations activities and that no construction or other cost will be incurred.

(4) Introduction of Desalination Technology

The introduction of desalination technology is proposed as one of the priority project concepts because it contributes to covering the water demand.

In the Philippines, a 9,600 m^3/day desalination plant is currently in operation in Cebu City, and an additional 15,000 m^3/day desalination plant is scheduled for construction in the future.

The following is an estimate of the projected water demand in Cebu City, assuming that the 15,000 m^3/day (5 MCM) desalination plant will be constructed in 2030 and the use of desalinated water will be promoted.

Table 4.3-34 Summary of Municipal and Industrial Water Demand Projects in Cebu City (Desalination Technology Introduction)

	Status	2020	2025	2030	2035	2040	2045	2050
CEBU CITY	without Project	91	101	101	105	108	111	112
	New Water Production	0	0	5	5	5	5	5
	with Project	91	101	96	100	103	105	107

Note: Changes from baseline condition are highlighted in red.
Source: JICA Survey Team

As a result of the above, it was confirmed that if desalination technology was introduced, there would be savings of 4% (5 MCM) of water demand.

In general, the desalination cost varies from approximately PHP 20-80/m^3 depending on the scale and design specifications. Tentatively referring to the estimated desalination cost of PHP 40/m^3 for the Chennai desalination plant project in India, the project cost is estimated at PHP 4.4 billion (PHP 40/m^3 × 15,000 m^3/day × 365 day/year × 20 years).

(5) Recycling of Sewerage Water

Recycling sewerage water is proposed as one of the priority project concepts because it contributes to covering the water demand.

In the Philippines, 10,000 m^3/day sewerage water recycling is currently in operation by Maynilad with a conditional operating permit (COP) from the Department of Health (DOH) in the Paranaque Sewerage Treatment Plant, Manila.

It is necessary to implement a sewerage development project that will enable continuous sewerage supply. However, only Metro Cebu WD and Davao City WD are in the process of formulating a master plan for sewerage development in WRR. Therefore, it is assumed that the sewerage system in Cebu City and Davao City will be upgraded by 2040 and that 50,000 m^3/day (18 MCM) sewerage will be recycled in a 100,000 m^3/day sewerage treatment plant. In this case, the result of the water demand forecast is shown below.

Table 4.3-35 Summary of Municipal and Industrial Water Demand Projects in Cebu City (Recycling of Sewerage Water)

	Status	2020	2025	2030	2035	2040	2045	2050
CEBU CITY	without Project	91	101	101	105	108	111	112
	New Water Production	0	0	0	0	18	18	18
	with Project	91	101	101	105	90	93	94

Note: Changes from baseline condition are highlighted in red.
Source: JICA Survey Team

As a result of the above, it was confirmed that if the recycling of sewerage water was introduced, it would cover 16% (18 MCM) of water demand in Cebu City and 6% (18 MCM) of water demand in Davao City.

The construction cost of the 10,000 m^3/day Paranaque Sewerage Recycling Plant is PHP 450 million, so if a 50,000 m^3/day sewerage recycling plant was to be built, the project cost would be PHP 2.3 billion. This cost does not include the cost of the sewage improvement project.

(6) Recycling of Industrial Wastewater

Recycling of industrial wastewater is proposed as one of the priority project concepts because it contributes to covering the water demand.

On the other hand, the recycling condition varies depending on the type of industry and each factory, and organized data cannot be confirmed in the Philippines. Therefore, it was decided not to propose the recycling of industrial wastewater as a priority project concept.

(7) Comparison of Priority Project Concept

Comparison of priority project concept is shown below.

Table 4.3-36 Comparison of Priority Project Concepts

Priority Project Concept	Reduction of NRW	Promotion of Water Saving Activity	Introduction of Desalination Technology	Recycling of Sewerage Water	Recycling of Industrial Wastewater
Target City	Large Scale Major Municipalities （Metro Cebu, Bohol, Dumaguete, Siquijor）	All Municipalities	Cebu City	Ceby City	—
Reduction Effect (2050)	WRR VII: 31 MCM	WRR VII: 89 MCM	WRR VII: 5 MCM(Cebu)	WRR VII: 18 MCM (Cebu)	—
Very Rough Project Cost	9.2 billion PHP	- (It is included in municipalities public relations budget)	4.4 billion PHP	2.3 billion PHP (This does not include sewerage development cost)	—
Feasibility	Low (NRW 20% is a high target, but the alternative is an even higher target of 10%.)	Middle (No typical project cost and water demand per capita is already declining in other countries.)	Middle (Although the project cost is high, there are already examples of installation in Cebu.)	Low (Progress of sewerage project, which is required for sewerage water recycle, is uncertain.)	—

Source: JICA Survey Team

4.3.3.6 Water Resources Management Plan (Information Management) in WRR VII

(1) Summary of Plan

At present, meteorological and precipitation observation data, groundwater, hydrogeological data, maps for integrated water resource management, and flood mitigation data are observed or prepared by many organizations in the Philippines, but each observes and manages them individually.

As a result, valuable observation data cannot be used comprehensively. For integrated water resources management, it is desirable to centrally manage and update these observation data so that the past observation data and real-time observation data can be referred to at any time in an integrated manner by the water resources manager.

In the hydrological analysis, remote sensing data can be obtained. Basic data such as remote sensing data required for hydrological analysis and water balance analysis, their types, utilization methods, and significance are shown in the table below. The latest data (river discharge, groundwater level, etc.) owned by PAGASA, NWRB, and DPWH, etc. should be collected. Table 4.3-37 shows the summary of basic data related to hydrological analysis. The Central and Regional Offices should manage the data-sharing diligently.

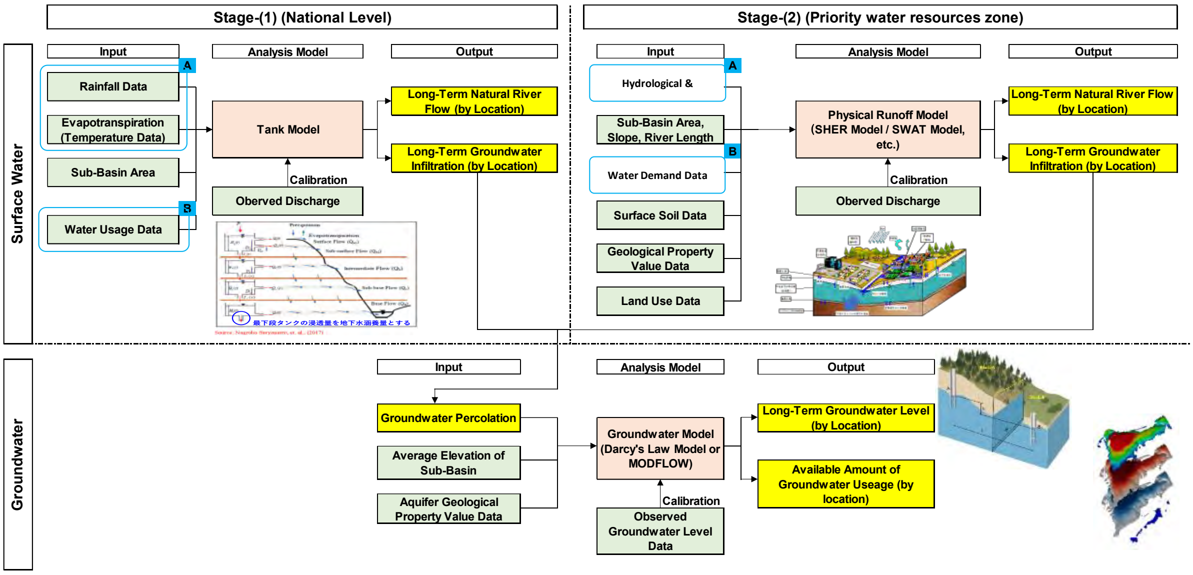
Table 4.3-37 Basic Data Related to Hydrological Analysis

Data Item	Type of Data		Usage Method	Significance
	National Level Survey	Detailed Survey on Priority Region		
Terrain	SRTM, 30-90m resolution (free)	SRTM, Resolution 30 m (free) and NAMRIA topographic map (1/50,000) (paid)	Used for topographic parameter calculation of Stage I hydrological model and facility design of water source.	Save money and time with DEM which can be obtained free of charge from the web. Adjustment and verification using existing topographic maps.
Surface Soil Classification	-	FAO digital soil map, resolution about 10 km (free)	Used for surface soil parameter estimation of Stage II runoff model.	Obtained free of charge from FAO, reducing cost and time.
Geology	-	CCOP geological information data 1:1,000,000 scale (free)	Used for estimating the hydraulic conductivity and porosity of Stage I and II groundwater models.	Digital data saves time and enables remote analysis.
Land Cover/Land Use	Landsat resolution 30 m (free). Interpretation of land cover and land use change since 1980's.	ESA Sentinel-2, resolution 10 m (free). Interpretation of land cover change at 10 m resolution (higher resolution than Landsat dataset)	Used for surface parameter estimation of Stage II hydrological model. Used for land use of water source and judgment of the number of houses (However, it takes a considerable amount of time to read).	It is possible to grasp changes of land use over time using a long-term data of Landsat and verification of irrigation area and cropping for each period.
Precipitation/Weather Data	ERA5 of ECMWF reanalysis data (31 km grid) 1979-present (free)	JAXA satellite global precipitation map GSMaP (approximately 11 km grid) 2000-present (free of charge)	Used for input data of Stage I and II hydrological analysis models and calculation of irrigation water requirements. Observed and measured values and verification as necessary.	Data can be complemented in areas where there is no observation data, and analysis can be performed with uniform data with little variation in observation accuracy.
River Discharge Data	Observed discharge data of PAGASA and DPWH (paid)	Same as on the left. Collect more observed discharge data (paid).	Used for calibration of Stage I and II hydrological models.	Verify the output of the hydrological model based on the observed values and improve the accuracy.
Groundwater Level Data	Groundwater observation data from PAGASA and NWRB (paid)	Same as on the left. Collect more observation data as needed (paid).	Used for calibration of Stage I and II groundwater models.	The accuracy of the groundwater analysis model is improved by the measured values.
Aquifer Data	CCOP geological data (free) and boring data from PAGASA	Same as on the left. Collect more observation data as needed (paid).	Used for input data (aquifer thickness, saturated hydraulic conductivity, porosity, etc.) of Stage I and II groundwater models.	The accuracy of the groundwater analysis model is improved by the measured values.
Water Usage Data	National level, inter-basin watershed data (around Manila), large intake facility, dam	Regional level water use data (all major facilities of NIA), water intake data for water supply works, dams, small ponds, groundwater use (water rights)	Used for calibration of Stage I and II runoff models and water demand forecasting.	Verify the output of the hydrological model based on the observed values and improve the accuracy.

Note: SRTM：Space Shuttle Topography Mission Digital Elevation Model (DEM) Data, NAMRIA: National Mapping and Resource Information Authority of the Philippines, CCOP: Coordinating Committee for Geoscience Programmes in East and Southeast Asia, ESA：European Space Agency, ECMWF: European Centre for Medium-Range Weather Forecasts

Source: JICA Survey Team

Based on the basic data acquired above, a hydrological model will be constructed and the water resources potentials (surface water and groundwater) in each water resources region are calculated. Figure 4.3-23 shows the workflow and basic data/information of the hydrological analysis.



Source: JICA Survey Team

Figure 4.3-23 Workflow and Inputs and Outputs of Hydrological Analysis

(2) Plan Goals

The goals of the water resources management plan for information management are as follows:

i) Various data and information related to water resources management are centrally managed and updated.

ii) The data and information collected above can be viewed by anyone at any time.

iii) Hourly meteorological and hydrological data, more detailed climate change data and GIS data (such as land use data) are constantly updated.

iv) Philippine engineers are being strengthened to update those data and GIS. First, central government engineers who centrally manage and update the dataset will be trained. Next, local engineers who view and use the dataset will be trained.

(3) Examination of Plans

1) Meteorology and Hydrological Data Information Management

At present, meteorological and precipitation observation data are observed by many organizations such as PAGASA, DOST-ASTI, NIA, NPC, and LGUs, but each observes and manages them individually.

As a result, valuable observation data cannot be used comprehensively. For integrated water resource management, it is desirable to centrally manage these observation data so that the past observation data and real-time observation data can be referred to at any time in an integrated manner by the water resources manager.

River water level and discharge data are also observed by many organizations such as DPWH, PAGASA, DOST-ASTI, NIA, NPC, and LGUs, but each observes and manages them individually. In some cases, different organizations are conducting water level observations at the same point.

As for hydrological data, it is necessary to prepare the discharge data based on the water level-discharge curves (H-Q rating curves). Therefore, at the river water level gauging station, not only the water level observation but also the cross-section survey of the river channel and discharge measurement should be conducted. It is important to be able to monitor the river discharge. It is proposed to construct a system that centrally manages these valuable meteorological and hydrological data.

In addition, in many cases, rainfall and water level observations are performed in the field on an hourly or 10 to15-minute basis, but central agencies in Manila only maintain the daily base data. For this reason, it is desirable to retroactively organize short-term rainfall, water level, and discharge data, and to construct a display system for real-time observation data using the telemetric automatic rainfall gauge (ARG), the telemetric automatic water level gauge (AWLG), the non-contact radar sensor automatic radio current meter (ARCM) and the simple river surveillance live camera (RSLC).

To be able to monitor data from dams and intake weirs in real time, it is also necessary to organize past operation record data.

2) Climate Change Data Information Management

Currently, PAGASA publishes provincial-wise, three-month climate change data (precipitation and temperature changes) using CMIP-5. PAGASA is currently updating climate change data using the latest climate model of CMIP-6. It is desirable that a more detailed regional (preferably mesh data) and monthly or daily climate change data in the Philippines be available for download in CSV format and some graphs on the PAGASA website.

3) Groundwater and Hydrogeological Data Information Management

Data and information such as groundwater level, groundwater quality data, hydrogeological data, geological data, boring data, pumping test data of wells, saturated hydraulic conductivity, and porosity data are observed or collected by various organizations such as NWRB and DENR. It is difficult to collect such data and information for water resources management. Therefore, the construction of a system that centrally manages these data and information as tertiary source data is desired. Also, the drilling of more monitoring wells is desired to increase the spatial distribution of monitoring wells for groundwater level and groundwater quality.

4) Flood Forecast and Early Flood Warning System

In the Philippines, the spatial distribution of telemeter-type ARG and telemeter-type AWLG is not sufficient. In addition, the introduction of a radar rain gauge system is being promoted in some areas, but the coverage ratio is currently not sufficient.

For this reason, it is necessary to proceed with the installation of telemeter-type ARGs, telemeter-type AWLGs, the non-contact radar sensor ARCM, and the simple RSLC on the ground and the real-time radar (X or C-band) rainfall gauge systems.

It is also important to develop a flood forecasting and early flood warning system. In addition to the observed rainfall and river water levels, the re-analysis rainfall forecast data by the European Centre for Medium-Range Weather Forecasts (ECMWF), or satellite rainfall forecast data by USGS (CHIRPS), or other commercial satellites are also utilized. Also, the construction of a river water level and discharge prediction system by using AI technology is desired.

5) GIS/Map Data

GIS data (especially land use/land cover maps) may not be updated. In addition, there are cases where geological maps, soil maps, and hydrogeological maps, etc. are not digital data.

It is also desirable to update and centrally manage more detailed digital geological maps, soil maps, hydrogeological maps, environmental maps, land use/land cover maps, satellite images, digital elevation data, river sub-basin maps and river line, and river structural location maps, etc. as necessary. Remote sensing and GIS data can be used for purposes other than water resources, such as agriculture. Therefore, it is desirable to be able to utilize and share data across administrative agencies. This will be a more efficient use of costs and human resources.

(4) Proposed Plan

The proposed composition of the information management plan is shown in Table 4.3-38 below.

Table 4.3-38 Composition of Information Management Plan (Idea)

Information Management Plan (Idea)	Contents	Related Agencies
• Meteorology and Hydrological Data Information Management	• River water level observation, cross-section survey of the river channel, discharge measurement, and the creation of water level-discharge curves (H-Q rating curves). • Retroactively organize short-term rainfall, water level and discharge data, and construct a display system for real-time observation data using a telemeter on real-time hourly or 10 to 15-minute basis. • Monitoring system of dams and intake weirs operations in real-time and organizing past operation record data. • Installation of telemetric ARG, telemetric AWLG, ARCM, and RSLC.	DPWH, PAGASA, DOST-ASTI, NIA, NPC, LGUs
• Climate Change Data Information Management	• More detailed regional (preferably mesh data) and monthly or daily climate change data in the Philippines. Downloadable in CVS format and some graphs on the PAGASA website.	PAGASA
• Groundwater and Hydrogeological Data Information Management	• Monitor and collect the groundwater level, groundwater quality data, hydrogeological data, geological data, boring data, pumping test data of wells, saturated hydraulic conductivity, porosity data, etc. • Construction of a central monitoring and management system of data and information. • Drilling of more monitoring wells is desired to increase the spatial distribution of monitoring wells for groundwater level and groundwater quality.	NWRB, DENR, LGUs
• Flood Forecast and Early Flood Warning System	• Installation of telemeter-type ARGs and telemeter-type AWLGs, ARCM, and RSLC on the ground. • Installation of the real-time radar (X or C-band) rainfall gauge systems. • Develop a flood forecasting and early flood warning system. • Utilization of observed rainfall and river water levels, re-analysis rainfall forecast data by the ECMWF or satellite rainfall forecast data by USGS or other commercial satellites. • Construction of a river water level and discharge prediction system using AI technology is desired.	PAGASA, DOST-ASTI, DRRMO, DPWH, LGUs
• GIS/Map Data	• To update and centrally manage more detailed digital geological maps, soil maps, hydrogeological maps, environmental maps, land use/land cover maps, satellite image, digital elevation data, river sub-basin maps and river line, and river structural location maps, etc. • For example, rapidly changing land use/land cover maps will be changed every 3 to 5 years. And once every 10 to 15 years for topographic data, etc., which do not change so much. • Capacity building for engineers of central and regional government.	DENR, NAMRIA, NWRB, PAGASA, DPWH, etc.

Source: JICA Survey Team

The proposed draft information management plan for priority WRRs is shown in Table 4.3-39 below. The Central and Regional Offices should manage the data-sharing diligently.

Table 4.3-39 Draft Information Management Plan for the Priority WRRs

<table>
<tr><th>WRR</th><th>Short-Term (2030)</th><th>Mid-Term (2040)</th><th>Long-Term (2050)</th></tr>
<tr><td>Common (Structural Measures)</td><td colspan="3">• Installation of telemeter-type ARGs, telemeter-type AWLGs, ARCM, and RSLC.
• Installation of the real-time radar (X or C-band) rainfall gauge systems.
• Construction of a display system for real-time or short-term rainfall, WL, discharge, and GWL, SW and SW quality data, dams/intake weirs operation data using a telemeter system.
• Drilling of monitoring wells of GWL and quality by telemetric system.</td></tr>
<tr><td>Common (Non-Structural Measures)</td><td colspan="3">• River WL observation, cross-section survey, discharge measurement, and to create H-Q rating curves.
• Central monitoring and management system of meteorological, hydrological, and hydrogeological data and information.
• Past meteorological, hydrological, and dams/weirs operation record data arrangement.
• Detailed spatial-temporal climate change data website.
• Monitor and collect the GWL, GW quality data, hydrogeological data, geological data, boring data, pumping test data of wells, etc.
• Update and centrally manage more detailed GIS data of geological, soil, hydrogeological, environmental, land use/land cover, river structural location maps satellite images, etc.
• Develop a flood forecasting and early flood warning system utilization of observed rainfall and river water levels, re-analysis, or satellite rainfall forecast data.
• Construction of a river water level and discharge prediction system by AI technology.
• Capacity building</td></tr>
<tr><td>Meteorology and Hydrological Data Information Management</td><td>• Installation of ARGs, AWLGs, ARCM, and RSLC.
• Real-time meteor-hydrological, dams/intake weirs operation.
• Cross-section survey, discharge measurement, and H-Q rating curves.</td><td>• Installation of ARGs, AWLGs, ARCM, and RSLC,
• Installation of the real-time radar (X or C-band) rainfall gauge systems.</td><td>• Installation of the real-time radar (X or C-band) rainfall gauge systems.</td></tr>
<tr><td>Climate Change Data Information Management</td><td>• Detailed spatial-temporal climate change data website.</td><td>• Updating of climate change data website.</td><td>• Updating of climate change data website.</td></tr>
<tr><td>Groundwater and Hydrogeological Data Information Management</td><td>• Past meteor-hydrological, dams/weirs operation, and GW data arrangement.
• Monitoring wells.
• GWL and quality, boring, pumping test data collection.</td><td>• Drilling of more monitoring wells of groundwater level and groundwater quality.</td><td>• Drilling of more monitoring wells of groundwater level and groundwater quality.</td></tr>
<tr><td>Flood Forecast and Early Flood Warning System</td><td>• Flood forecasting and early flood warning system.
• Utilization of re-analysis or satellite rainfall forecast data.
• River WL and discharge prediction system by AI.</td><td>• Updating flood forecasting and early flood warning system.
• Utilization of re-analysis or satellite rainfall forecast data.</td><td>• Updating flood forecasting and early flood warning system.
• Utilization of re-analysis or satellite rainfall forecast data.</td></tr>
<tr><td>GIS/Map Data</td><td>• Decide on a policy for centralized data management and update frequency.
• Capacity building for engineers</td><td>• Regularly update data and train personnel.</td><td>• Regularly update data and train personnel.</td></tr>
</table>

Note: ARG: telemetric automatic rainfall gauge, AWLG: the telemetric automatic water level gauge, ARCM: the non-contact radar sensor automatic radio current meter, RSLC: the simple river surveillance live camera.

Source: JICA Survey Team

4.3.3.7 Water Resources Management Plan (Flood Risk Management)

(1) The Objective of the Draft FRM Plan

As mentioned in Chapter 2.2.9, flood risk management (FRM) plays an important role in integrated water resource management (IWRM). In formulating a water resources development and management plan (WRDMP), the following perspectives of FRM are required: (i) Flood inundation risks in the beneficiary area of WRDMP, and (ii) Integrated planning of river projects in terms of FRM, water resources management, and social and environmental management. Since floods threaten human lives and livelihoods and hamper city development, flood inundation risks must be considered when formulating WRDMP. For example, developing water supply for city or irrigation in flood prone area, it will increase the exposure against flood hazards such as houses, factories, rice fields, etc. and cause more severe damage in the future. Thus, the water resources development projects should be planned not to increase the exposure as much as possible and to expect more benefits than damage with no casualties by future floods. River projects such as construction of dams, weirs, dikes or river dredging and excavation affects river flow pattern, sediment transportation, river morphology, water quality, ground water recharge, etc. As is the case in the Philippines, if river projects are planned separately for different purposes such as FRM, waterworks, irrigation, and hydropower generation, their impacts must be carefully studied not to give negative impacts each other. In the case that negative impacts are inevitable, it is indispensable to coordinate among the stakeholders and to modify the plan in some cases. Consequently, river basin management planning in an integrated manner can make the plan more effective and efficient. A Multi-purpose dam is a representative example. Since both floods and droughts are caused by opposite sides of extreme events in natural variability of rainfall, controlling river flow variability by dam can be an effective solution.

To consider the above mentioned FRM perspectives, flood inundation risks and river projects for FRM are studied in this survey. Flood inundation risks can be clarified by existing flood hazard or susceptibility maps and flood hazard analysis in FRM master plans (FRMMPs). In this survey, flood susceptibility maps are collected and compared with population distribution maps to identify high flood risk area in the FRM section of Chapter 3. Planned river projects for FRM are studied by reviewing the current FRMMPs and by the interviews to DPWH. The summary of the current FRMMPs and potential flood control dams are described in this section and the FRM section of Chapter 3 because dams give especially large impacts among various kinds of river projects. More details of planned river projects are described in ANNEX H.

In addition, issues on FRM are identified based on reviewing existing FRMMPs of DPWH and integrated river basin management and development master plans of DENR-RBCO and interviews to relevant government agencies. Recommendations are also made based on the identified issues.

(2) Target of Draft FRM Plan

Due to the natural and social conditions, flood disasters frequently occur in the Philippines. Aiming to reduce flood risks, DPWH suggests the target design flood in FRMMPs as 100 years in return period for the rivers with the drainage area over 40 km^2 in the Design Guidelines, Criteria and Standards (DGCS, 2015). Because most of rivers still have a long way to go to achieve their goals, the implementation of structural and non-structural measures based on FRMMPs should be accelerated.

The National Water Resources Council (NWRC, the predecessor of NWRB) classifies the river basins in the Philippines by the drainage areas as 18 major river basins (larger than 1,400 km^2), 421 principal river basins (between 40 km^2 and 1,400 km^2) and the others. In WRR VII, there exists no major river basin and 19 principal river basins. Since there are numerous rivers in the region, the rivers in Central Cebu River Basin are focused considering the scale of flood risks and the importance of water resources development and management. The summary of the current FRMMP for the Central Cebu River Basin is shown in the table below. As the current FRMMP is lately formulated, steady implementation of proposed measures along the plan is also pursued in this Draft FRM Plan.

Table 4.3-40 Summary of the Current FRMMP for the Central Cebu River Basin

River Basin Name	Central Cebu River Basin
Drainage Area (km^2)	679 *1
Estimated Population (thousand people) and Estimated Year	1,780 (2018) *1
Latest FRMMP and Formulated Year	DPWH (2018) *2
Target Year	2028
Target Flood Level	50- or 100- year flood*3
Design Flood Discharge	Kotkot River: 450 m^3/s (100 year), Butuanon River: 740 m^3/s (100 year), Mananga River: 1,120 m^3/s (100 year), etc.
No. of Existing Flood Control Dam	0
No. of Potential Flood Control Dam	4 *4

*1) The values of "Drainage Area" and "Estimated Population" are quoted from the website of River Basin Control Office (https://riverbasin.denr.gov.ph/main/index)
*2) DPWH, 2018, "Comprehensive Study for a Metro Cebu Integrated Flood and Drainage System Master Plan"
*3) 50 or 100-year flood depending on the size of drainage area
*4) Dams were studied as an alternative countermeasure, but they were not adopted in the FRMMP.
Source: JICA Survey Team

(3) Potential Dams for Flood Control Purposes

Because dams can give especially large impacts among various kinds of river projects, potential dams for flood control purpose are studied. There is no existing flood control dam in the region, but new flood control dams were roughly studied as one of alternative solutions in the current FRMMP. Although the studied dams were not adopted in the FRMMP, there remains the possibility that the potential dam projects will be feasible when it is reviewed as multi-purpose dam projects also considering the benefits of irrigation, water supply and hydropower generation from the perspective of IWRM. The potential flood control dams are summarized in the table below. More details are described in ANNEX H.

Table 4.3-41 Potential Dams for Flood Control Purpose in the Central Cebu River Basin

Dam Name	Dam Height	Crest Length	Storage Volume*	Remarks
Kotkot	29.5 m	110 m	6 MCM	• New dams are also proposed along the same river from NIA and MCWD.
Butuanon	18 m	320 m	2 MCM	• This dam was studied only for flood control purpose.
Buhisan (upgrading)	31 m	65 m	0.1 MCM	• Upgrading of the existing Buhisan Dam (water supply purpose only) is proposed. • Existing dam was constructed with the storage volume of 500,000 m^3, but the current volume is only up to 12,000 m^3 due to sedimentation. • Existing access road to the dam is too narrow to transport heavy machinery.
Mananga II	70 m	370 m	31 MCM	• This dam was originally concepted in 1991 under ADB project as a water supply dam for Metro Cebu, but still not realized. • Location of dam body is slightly different between the proposed dam by MCWD and DPWH.

Note: *The flood control volume was studied as storing a part of 100-year flood and decreasing the peak discharge in the downstream equivalent to 25-year flood discharge.
Source: JICA Survey Team

(4) Present Conditions and Issues on FRM

1) Overall Present Conditions and Issues

a) Overall Present Conditions on FRM

Overviewing the natural conditions in the selected 3 WRRs, the following factors can increase flood risks: (i) typhoon and storm surge and (ii) large sediment inflow by landslides and volcanic eruptions. Typhoons often cause severe floods with intensive rainfalls and storm surges. Heavy rainfalls increase river flow, in addition, sea level rise caused by storm surges induces backwater from the sea in the downstream. Coinciding with intensive rainfall and high tide intensifies flood hazard. WRR V and WRR VII are frequently severely affected by typhoons due to their locations in the typhoon belt. Large volume of sediment inflow to rivers by soil erosion, landslides and volcanic eruptions reduces river flow capacity resulting in the increase of flood magnitude and frequency. It also causes rivers to meander and change their courses, which involves riverbank erosion and varies flood prone areas. River sedimentation problem is especially significant in the Bicol River (WRR V) and the Buayan-Malungon River (WRR XI) due to the existence of active volcanoes and steep slopes.

In terms of the social conditions in the selected 3 WRRs, the following factors can increase flood risks: (i) forests degradation, (ii) city development, (iii) settlement of people in flood prone areas, (iv) flow obstruction, (v) land subsidence and (vi) unregulated sand mining. Forest degradation by illegal logging, mining, or agricultural land development changes rainfall-runoff process and often increases flood peak discharge. It also increases sediment runoff from the upstream. City development increases the exposure against flood hazards such as houses, buildings and factories, infrastructures, etc. Such exposure should be decreased as much as possible by proper land use planning and management. In particular, settlement of people in flood prone areas are big issues. Some of them lives in river easement zones as informal settler families (ISF), which makes it difficult to implement flood control projects. River flow obstruction by bridges, weirs, illegal house pillars and garbage rises the upstream water level. Land subsidence by excessive groundwater pumping or earthquakes or active faults increases flood risks. Unregulated sand mining changes the balance of river-bed slope, which would cause riverbank erosion or river works destruction and end up increasing flood risks.

b) Overall Issues on FRM

The main issues on FRM are extracted as follows: (i) Formulating an integrated river basin management plan, (ii) Project implementation along FRMMPs, and (iii) Planning, construction and management of dams. The details are described below.

(i) Issues on formulating an integrated river basin management plan

There is an issue on coordinating various plans and projects at river basin scale and developing an integrated river basin management plan in the IWRM approach. One of main reasons would be the decentralization of river basin management among many government agencies and the difficulty in coordinating inter-agency plans and projects and in developing integrated river basin development and management plans effectively.

The administration of river basin management is mandated to a number of government agencies in the Philippines. For example, planning, construction and maintenance of flood control and water resource development systems is mandated to DPWH and LGUs depending on the scale and importance of river basins. Granting water permits is the jurisdiction of NWRB. Development and management of national irrigation systems is responsible for NIA (National Irrigation Administration). Management of water quality and other environmental matters is overseen by EMB (Environmental Management Bureau). Flood forecasting and early warning is mandated to PAGASA. Disaster relief and evacuation assistance is responsible for OCD, etc.

Since the rivers and their river basins are managed by various government agencies, the River Basin Control Office (RBCO) was established in 2006 under the Arroyo administration (2001-2010) as a lead government agency for inter-project coordination and integrated river basin management at river basin scale. However, RBCO seems not to be functioning adequately as a coordinating body. Two possible reasons might be the lack of technical skills and experiences of RBCO staff regarding flood control and water resources development planning, and the insufficient number of staff and budget. In the succeeding Aquino III administration (2010-2016), the President designated the DPWH Secretary as the "Water Czar" who will coordinate the programs, projects and activities of water-related agencies of the Government to achieve efficiency in developing and operating water-related infrastructure. To assist the DPWH Secretary, DPWH Integrated Water Resources Management Coordination Team (IWRMCT) was established by the Department Order (DO No.71, 2014) to coordinate the formulation of integrated water resources management policies and development plans and programs covering flood control and drainage, water supply and sanitation in accordance with the river basin management approach. In 2016, the Integrated Water Resources Management Planning Guidelines for DPWH were developed with the support of the World Bank. Nonetheless, this attempt also appears not to have worked sufficiently. Given this situation, the Duterte administration (2016-2022) promoted to establish the Department of Water Resources (DWR), a new department that will consolidate functions related to integrated river basin management approach. The current President Marcos is also proceeding the establishment of this new department.

There are also attempts by DENR-RBCO to create river basin management committees/ councils which consist of government agencies, academic experts, relevant civil society groups, etc. to enhance coordination among the stakeholders applying integrated river basin management approach. As the number of such committees are increasing, these attempts seem to work to some extent. According to the interviews in this survey, however, there are some cases that the information of new river projects such as small dams were firstly introduced in the committee after the completion of feasibility studies of the projects. The plans of new river projects should be discussed and coordinated from an earlier stage, otherwise, it would be difficult to make a river basin management plan effective and efficient integrating FRM, water resources management, and environment management purposes. For example, even if a flood control dam is not adopted among various alternative measures in a FRMMP of DPWH, there might be a case that a new dam for irrigation or water supply is planned by NIA or water-supply corporation in the same watershed. In such case, the new dam project might be more effective by reviewing it as a multi-purpose dam project. This example works vice versa.

(ii) Issues on implementing river projects along FRMMPs

As this issue is also relevant to the issue mentioned above, there is an issue on implementing flood control projects in accordance with FRMMPs due to the decentralized administration of river area and river management. For example, there are some cases that river dikes are partially constructed by LGUs or private companies not in consistency with the FRMMP. Such river dikes may give negative impacts on the upstream and the downstream during floods and become obstacles when implementing the flood control projects along the FRMMP. The possible main reasons are decentralization of river management, insufficient or improper control of permit system for river projects and lack of close coordination between DPWH and LGUs.

The Presidential Decree and the Executive Order mandate DPWH to carry out the planning, design, construction and maintenance of flood control structures and to grant permits for river projects within river areas and to order the removal of any structure that encroaches into river areas. The 1976 Water Code (PD No. 1067) provides that the Secretary of Public Works, Transportation and Communications (the predecessor of DPWH) may declare flood control areas to promote the best interest and the coordinated protection of flood plain lands. In declared flood control areas, 1) Guidelines may be promulgated for governing flood plain management plans (in Article 53); 2) Rules and regulations may be promulgated to prohibit or control activities that may damage or cause deterioration of lakes and dikes, obstruct the flow of water, change the natural flow of the river, increase flood losses or aggravate flood problems (in Article 54); and 3) Necessary flood control structures may be constructed, and for this purpose it shall have a legal easement as wide as may be needed along and adjacent to the river bank and outside the bed or channel of the river. Besides, the implementing rules and regulations (IRR) of the Water Code mandates the Minister of Public Works (MPW, the predecessor of DPWH) to be able to order the removal of any construction or structure that encroaches into any public river and its easement (in Section 27 and 28). The IRR also provides (in Section 29) that a permit/authority shall be secured from the MPW in the following instances: a) Construction of dams, bridges and other structures in navigable or floatable waterways; b) Cultivation of river beds, sand bars and tidal flats; c) Construction of private levees, revetments and other flood control and river training and other flood control and river training works; and d) Restoration of river courses to former beds. The Executive Order (EO No. 124, 1987) mandates the DPWH, as the State’s engineering and construction arm, to carry out the planning, design, construction and maintenance of infrastructure facilities, especially national highways, flood control and water resource development systems, and other public works in accordance with the national development objectives.

The 1991 Local Government Code (RA No.7160) devolved the part of the functions and responsibilities of national agencies including FRM to LGUs. The Code stipulates (in Section 17) that LGUs shall discharge the functions and responsibilities of national agencies and offices devolved to them pursuant to this Code. LGUs shall likewise exercise such other powers and discharge such other functions and responsibilities as are necessary, appropriate, or incidental to efficient and effective provision of the basic services and facilities which includes the facilities for flood control and water resources management in the case of provincial/ municipal government. Accordingly, river management for flood control is responsible not only for DPWH but also for LGUs. As clarified by the DO No.23 in 2015, the implementation of flood control and river control works in major or principal river basins under the DPWH Infrastructure Program are mandated to DPWH. On the other hand, the works on minor or local rivers and creeks are expected to be funded and undertaken by the LGUs.

The 1976 Water Code (PD No. 1067) also provides (in Article 57) that any person may erect levees or revetments to protect his property from flood, encroachment by the river or change in the course of the river, provided that such constructions does not cause damage to the property of another. In fact, there are examples of levees (parapet walls) and revetments constructed by LGUs or private companies or individuals with the permission from LGUs. As described above, the IRR of Water Code mandates DPWH to give permits for constructing river structures in navigable or floatable waterways. However, the definition of navigable or floatable waterways is unclear. Since LGUs also have jurisdiction of managing small rivers within their administrative districts, the extent of the power of DPWH's permission should be clarified. In addition, even if the extent is clear, there remains the issue that this rule does not work properly. Here is an outstanding example of Upper Wawa Dam in the Pasig-Marikina River Basin. The construction plan of Upper Wawa Dam had to first be approved by DPWH first in compliance with the IRR of Water Code. By contrast, DPWH opposes the plan because DPWH also has a construction plan of Marikina Dam close to the proposed site of Wawa Dam and requested to modify the dam plan including the necessary flood control capacity. Nonetheless, the construction of Wawa Dam has started without DPWH's permission. As in this example, the permit system by DPWH is not functioning properly, there are also some cases of dike construction which is not in accordance with FRMMPs.

As described above, river management for flood control is mandated to DPWH and LGUs depending on the scale and importance of river basins. There exists an issue of coordination between DPWH and LGUs, though. Besides, the issue of coordination also lies within DPWH, namely between DPWH's head office, regional offices and district engineering offices. As a result, the DPWH permit system does not work properly, which causes the construction of unregulated flood control structures and makes the implementation of FRMMPs more difficult.

(iii) Issues on planning, construction and management of dams

As mentioned above, DPWH has jurisdiction to carry out the planning, design, construction and maintenance of infrastructure facilities including flood control and water resource development systems, whereas DPWH seems to have lost their technical capacity for planning and building dams. There are a lot of dams in the Philippines, but almost all dams were constructed by NIA or National Power Corporation (NPC) or foreign assistance. NIA is considered to be the agency in the Philippines with the most technology and experience in dams. According to the official website of NIA[1], NIA is a government-owned and controlled corporation primarily responsible for irrigation development and management. Overviewing the history of NIA, NIA's forerunner was the Irrigation Division of the defunct Bureau of Public Works. NIA was placed under the Office of the President (OP) upon its creation. It was attached to the Department of Public Works, Transportation, and Communication under PD No.1, dated 23 September 1972. The issuance also integrated all irrigation activities under the Agency. The Administrative Code of 1987, dated 25 July 1987, attached NIA to both DPWH and Department of Agriculture (DA). But NIA remained attached to DPWH. It was transferred to OP pursuant to Executive Order No. 22, dated 14 September 1992. Then, it was attached to DA under Administrative Order No. 17, dated 14 October 1992. Finally, NIA has to be transferred to the OP by the EO No. 165, 5 May 2014. In short, NIA is used to be a part of DPWH, but has been separated from DPWH since 1992.

DPWH suggests the target design flood in FRMMPs as 100 years in return period for the rivers with the drainage area over 40 km2 in the Design Guidelines, Criteria and Standards (DGCS, 2015). Considering the natural and social conditions in the Philippines, targeting a 100-year flood sounds high goal in the sense that most of rivers still have a long way to go to achieve their goals, which requires large investments for long time. Under the circumstances, the implementation of flood control structural measures needs to be accelerated.

As the natural conditions in the Philippines, flood discharge is generally high relative to its watershed area due to frequent typhoons and heavy rainfalls. In addition, the Philippines have many steep slopes, resulting in rapid rainfall runoff and sharp flood hydrographs in many watersheds. In watersheds which have sharp flood hydrographs, flood control by dams will be effective because the peak flow reduction is large relative to the amount of storage required for peak cutoff of the flood hydrograph.

In terms of social conditions in the Philippines, many cities are developed along rivers, and land acquisition and resettlement are always big issues when implementing river improvement works for flood control. In particular, in areas such as Manila and Cebu, where cities are highly developed up to riverfronts, it may be difficult to achieve the goals of FRMMPs without dams in some river basins.

Looking at these circumstances, dams will be one of important structural measures for flood control. Besides, dams can work not only for flood control but also for water resources development. It is often the case that watersheds with rapid rainfall-runoff and sharp flood hydrographs, as mentioned above, have large annual flow variability. In other words, both flood and drought risks tend to be higher in rivers where the storage capacity of the basin is small, and rain is quickly drained. Since both floods and droughts are caused by opposite sides of extreme events in natural variability of rainfall, controlling river

[1] NIA Official Website (https://www.nia.gov.ph/content/overview)

flow variability by dam can be an effective solution. Consequently, DPWH should build technical capacity to plan dams for flood control and water resources development, or DPWH should develop a dam plan in an integrated manner in close coordination between NIA, NWRB, RBCO, NPC, LGUs and the other related agencies.

DPWH is responsible not only for supervising the formulation of all FRMMPs including the plans developed by the support of development assistance partners, but also for their construction and maintenance. Therefore, DPWH needs to have technical capacity not only for planning but also construction, operation, and maintenance.

2) Present Conditions and Issues in the Central Cebu River Basin

Present Conditions and main issues in the Central Cebu River Basin are organized based on the current FRMMP as shown in the table below.

Table 4.3-42 Present Conditions and Main FRM Issues in the Central Cebu River Basin

Present Conditions	Main Issues
• Typhoons frequently hit the river basin and cause intensive rainfall and storm surge. • The urban areas lie within approx. 3 to 4 km from the shoreline where are low-lying flood prone areas. While the river headwaters locate in mountain with the elevation ranging from 50-800 m. Thus, most rivers have small catchment areas with steep river-bed slopes. • There exist some bottleneck cross-sections at bridges. Most of the bridges have low deck clearance and the abutments occupy portion of the waterways and reduces the flow capacity.	• The existing waterways (rivers and creeks) have flow capacities only adequate for 2 to 5 year return period, which is not close to satisfying the target flood levels (50 or 100 year) in the FRMMP. • Some parts of river channels are narrowed primarily due to massive encroachment. • Being clogged with garbage and deposited with heavy silt and mud, the flow capacities of river and drainage channels are decreased. • Land acquisition for flood control projects is very difficult in the downstream.

Source: Prepared by JICA Survey Team based on the reviews of current FRMMPs and field surveys.

(5) Recommendation on FRM

1) Overall Recommendation

Recommendations on FRM are summarized as follows:

- Although the Philippines practice integrated river basin management mainly for major river basins, plans and projects are not properly coordinated at the river basin scale because the government agencies involved in river basin management are diverse and coordinating interagency plans and projects are difficult. For more effective and efficient integrated river basin management planning, it would be necessary to closely coordinate the plans and projects among the relevant government agencies from the initial stage, or to centralize the agency for formulating the integrated river basin management plan.
- In the Philippines, river administrators are not centralized, and DPWH and LGUs are responsible for river management. However, there is not enough coordination between DPWH and LGUs. Even when a FRMMP is in place, flood control projects may not be implemented as planned. In order to implement flood control measures along the FRMMP effectively, the

permit system for river projects by DPWH should be properly implemented through close coordination between DPWH and LGUs. It is also necessary to coordinate between FRMMPs and comprehensive land use plans (CLUPs) which LGUs develop considering city planning and disaster risks.

- In the Philippines, it seems to be difficult to implement flood control dam and multi-purpose dam projects in their own agencies. The NIA, which has the technology and experience in dams, used to be under the DPWH, but has been separated from the DPWH since 1992 due to reorganization. In order to promote flood control dam projects, it is necessary to establish an office within the DPWH with the technology and experience in planning, design, and construction of dams, or to work closely with the dam office of the NIA. In addition, in order to promote the multi-purpose dam project, it is necessary to establish laws to promote the construction of multi-purpose dams, such as a compensation system for water source areas and a cost allocation method among stakeholders. Alternatively, it would be efficient to establish an organization to implement integrated water resource management in a centralized manner and to plan multi-purpose dams within the organization.

2) Recommendation for the Central Cebu River Basin

Recommendations in terms of FRM for the Central Cebu River Basin are summarized as follows:

- Flood control projects should be steadily implemented in accordance with the current FRMMP. Since the area of Central Cebu River Basin is highly developed, the most important issue will be land acquisition and consensus building for resettlement from the project sites. To proceed the land acquisition and consensus building, it is indispensable to coordinate closely with relevant LGUs. If agreement cannot be reached on the issue, other alternatives such as dams, retarding basins or underground channel, etc. should be considered.
- No flood control dam is adopted in the current FRMMP, but potential flood control dams are roughly studied as alternative measures in the FRMMP. Considering the possibility that the planned river improvement works cannot be realized because of resettlement and land acquisition issues, there remain needs for flood control dams. However, there is an issue on flood control planning as described in Chapter 4.3.3.7 (4) 2). On the other hand, Mananga II Dam and Kotkot Dam are proposed in the Central Cebu River Basin as priority projects for water resource development in this survey. Because the potential flood control dams are also studied close to the proposed two dams, the two dam projects may be more effective by including flood control purpose to be multi-purpose dams. Accordingly, a feasibility study for the two multi-purpose dam projects should be conducted.

(6) Draft FRM Plan

As mentioned in this subsection (2), since the current FRMMP of the focused rivers are lately formulated, steady implementation of proposed measures along the plans should be pursued. The proposed FRM measures in the FRMMP are summarized in the table below.

Table 4.3-43 Draft FRM Plan for WRR VII

River Name	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common (Structural Measures)	• Riverbank & Bed Protection (Revetment, Spur Dike, Groundsill, etc.) • Drainage Improvement (Drainage Channel Improvement, Pumping Station, etc.) • Sabo Facility (Slope Protection, Check Dam, etc.) • Rehabilitation of Old River Structures (Weir, Revetment, Bridge, etc.)		
Common (Non-Structural Measures)	• River & Drainage Channel Maintenance (Dredging, Cleaning, etc.) • Flood Forecasting and Early Warning • Evacuation Planning & Drill • Educational Activities • Forests Conservation (regulating illegal logging, mining, unsuitable agricultural activities, etc.) • Land-use Regulation (regulating the land use in flood prone areas, etc.)		
Central Cebu	• River Improvement • Retention Pond • Diversion Channel	• River Improvement • Retention Pond • Diversion Channel	• Potential Dams (Kotkot, Butuanon, Mananga II) • Existing Dam Upgrading (Buhisan)

Note: River improvement includes river excavation, widening, revetment, etc.

Source: Prepared by JICA Survey Team based on the reviews of current FRMMPs and field surveys.

4.3.3.8 Water Resources Management Plan (River Basin Environmental Conservation) in WRR VII

(1) Issues and Challenges on River Basin Environment in WRR VII

1) Water Balance

There is a shortage of groundwater potential, especially in the Metro Cebu area, and surface water potential is abundant in the whole WRR VII. Metro Cebu is facing a serious water shortage problem and saltwater intrusion of groundwater due to rapidly increasing water demands.

Bohol is also facing a water shortage problem in urban areas due to increasing water demand in relation to tourism development.

2) Facility Plan

NIA is developing and operating irrigation water supply facilities such as dams in WRR VII and MCWD has a development plan that prioritizes the construction of desalination facilities in the Metro Cebu area. Considering the feasibility of these facilities, environmental and social aspects should be considered and evaluated.

3) Sedimentation

There is sedimentation problem in existing dams, especially in Negros Oriental so its countermeasure is needed.

(2) Objective of the River Basin Environmental Conservation Plan in WRR VII

Objectives of the River Basin Environmental Conservation Plan in WRR VII are as follows considering the above present conditions.

- To secure good quality and enough amount of water resources in WRR VII through environmental conservation measures.
- To protect and improve the waterfront environment and water quality that ensure the sustainability between the natural environment and development/livelihood activities towards the prosperity of communities.

(3) Strategy of the River Basin Environmental Conservation Plan in WRR VII

1) Securing Abundant Water Resources

Shortage of water resources especially groundwater is a big challenge in WRR VII. Securing abundant water resources and sustainable maintenance of the water resources are very important as mid to long term goals of basin reservation. The following measures are suggested to maintain sustainable water resources:

- Appropriate forest management: Providing support for appropriate forest management according to the characteristics of water source areas based on forest planning to enhance the water retention function of forests such as improvement of devastated forests, avoiding unregulated conversion of forest land to land development, reforestation, forest road network development, and thinning and pruning.
- Improvement of water retention function in urban areas: Restriction of rainwater runoff by the installation of rainwater storage and infiltration facilities, the development of permeable pavement and development of green space such as promotion of city greening.
- Consideration for water retention function in development projects: Consideration of alternative measures such as rainwater infiltration, installation of water storage facilities, restriction of groundwater use and reforestation when there is concern that the water retention function is declining due to deforestation by development projects.

2) Securing Clean Water

Effective use of water is an important factor for water resources management. The water quality of the river basin in WRR VII is relatively good; hence sustaining and securing clean water is required for the effective use of water.

The following measures are suggested to secure clean water.

- Source countermeasures: Treatment of wastewater generated from domestic, industries, agriculture, and fisheries such as sewage systems, agricultural drainage, and septic tank.

- Purification of rivers and lakes: Installation and development of purification facility, utilization of natural purification function using plants and aquatic life, and removal of sediment directly such as dredging.
- Monitoring of water quality: Formulation of a water quality monitoring system to prevent contamination of water bodies and establishment of a close communication system between residents, LGUs, and national agencies to understand the current situation and cause of the accident and to prevent the spread of damage.

3) Establishment of Interaction between Nature and People

Waterfront environments such as rivers, lakes, reservoirs, and wetlands are important habitats for aquatic life and places of recreation and relaxation for people. The creation of a comfortable water area is important for both the natural environment and people. The following measures are suggested to establish interaction between nature and people:

- Conservation of waterfront where diverse life grows and inhabits: Promotion of multi-natural waterfront development considering the natural environment and landscape of rivers and lakes that coexist with aquatic life.
- Conservation of biodiversity: Conservation of waterfront ecosystems by securing a place for the growth and habitat of a variety of life and forest around the water body, conservation of wetlands, conservation of aquatic life with the Red Data Book, the extermination of alien species, and research on aquatic life.
- Creating friendly waterfronts and promotion of tourism: Creation of opportunities to become familiar with water area and development and promotion of waterfront tourism especially in Bohol province.

(4) Proposal of the River Basin Environmental Conservation Plan in WRR VII

Tentative river basin environmental conservation plans in WRR VII divided into three terms (short, middle and long) based on the above strategies are shown in Table 4.3-44.

Table 4.3-44 Draft River Basin Environmental Conservation Plan for WRR VII

Strategy	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common	• Monitoring of water quality at the existing monitoring stations • Consideration of alternative measures such as rainwater infiltration, installation of water storage facilities and reforestation when there is concern that the water retention function is decline by development projects. • Reforestation		
Securing Abundant Water Resources	• Development of sustainable forest plan • Planning of green space such as city greening	• Development of forest road network • Improvement of devastated forests • Restriction of rainwater runoff by the installation of rainwater storage and infiltration facilities in urban areas • Development of green space such as city greening	• Improvement of devastated forests • Development of permeable pavement • Development of green space such as city greening
Securing Clean Water	• Removal (dredging) of sediment directly • Utilization of natural purification function using plants and aquatic life • Planning of water quality monitoring system and its close communication system	• Development of agricultural drainage • Development of septic tank around the water body • Formulation of water quality monitoring system and establishment of its close communication system	• Development of sewage system • Installation and development of purification facility • Updating of water quality monitoring system and its close communication system
Establishment of Interaction between Nature and People	• Planning of multi-natural waterfront development • Planning of waterfront ecosystems conservation • Planning of tourism development considering waterfront environment	• Promotion of multi-natural waterfront development • Development of waterfront ecosystems conservation • Development of tourism development considering waterfront environment	

Source: JICA Survey Team

4.3.3.9 Water Resources Management Plan (Organizations and Legal Frameworks) in WRR VII

(1) Introduction

In this section, the following items are summarized in order to clarify the current status and issues, recommendations for improving the organizations and legal frameworks relating to the proposed plans for water resources development and management in WRR VII.

- ✓ Outline for considering the implementation scheme
- ✓ Possible implementation schemes for water resources development and management projects
- ✓ Recommendations and plan in the aspect of organizations and legal frameworks
- ✓ Recommendations relating to the proposed plans for water resources development and management

(2) Outline for Considering the Implementation Scheme

The implementation schemes for the water projects strongly relate to their purpose. The implementation bodies are usually the organizations that need to achieve the purposes, and the management bodies for the water infrastructure will be the continuous implementation bodies after completing the water projects. However, other implementation schemes should be considered in the case of water projects with multiple purposes. In this regard, the way of considering the implementation scheme for projects related to 1) water development, 2) water supply, and 3) irrigation are summarized below.

1) Water Resources Development

Projects for water resources development are usually implemented by the organizations which need their purposes. Also, it is noted that:

- ✓ If there is an existing planning body for the water development project, it will be the same implementing body.
- ✓ If there is a need or possibility of a multi-purpose project, a project implementation scheme suitable for the multi-purpose project should be considered.
- ✓ Based on existing interviews and other studies, it is assumed that water utilities such as water districts are unlikely to be the direct implementing body for the development of surface water such as dams. Based on this, a suitable scheme (e.g., bulk water development with PPP scheme), in which water utilities are not the direct implementing body, can be considered.

2) Water supply

Projects related to water supply are usually implemented by the relevant water utilities. The measurements for water demand management are also usually implemented by the relevant water utilities. In addition, it is noted that there have been some cases implemented by PPP scheme including joint venture (JV) schemes between government organizations (such as WDs) and private companies.

With regards to the measurement of water demand management:

- ✓ Programs for non-revenue water rate reduction are usually implemented by relevant water utilities. There have been such programs under JV schemes in the Philippines (case of Zamboanga Water Company Inc.). Thus, there is a possibility to make use of a PPP scheme.
- ✓ Programs for the promotion of water saving are also usually implemented by relevant water utilities. In addition, educational activities by the related local LGUs, etc. to promote water conservation are also important for water-saving activities.
- ✓ The measurement of treated water used for drinking water will be available in areas with well-developed sewerage systems. The representative case is in the city of Paranaque by Maynilad Water, Inc. This measurement also has a high affinity with the bulk water development scheme, so the PPP scheme may be highly suitable for it.

3) Irrigation

The organization that oversees irrigation projects is NIA, hence it is the main implementation body. In the Philippines, there are different forms of irrigation system including the “National Irrigation System (NIS)” and “Communal Irrigation System (CIS)”; the NIA website shows the schemes for the two forms of irrigation systems, as organized below, and in Table 4.3-45.

- ✓ The implementation body for irrigation projects related toNIS will be NIA, and the operation and maintenance will be provided by NIA and related irrigation associations.
- ✓ In the case of irrigation projects related to CIS, NIA will be the implementation body in partnership with the related farmers through their irrigation association. However, it should be noted that the authority on CIS may be delegated to LGUs in the near future because of the current policy of decentralization in the Philippines.

Table 4.3-45 Comparison between National and Communal Irrigation Systems

For Comparison	National Irrigation System	Communal Irrigation System
Area (ha)	> 1,000	< 1,000
Implementation/construction	NIA	NIA with farmers' participation
Operation and Maintenance	NIA and Irrigators Associations	Irrigators Associations
Water charges	Farmers pay irrigation service fee per hectare/season/crop	Farmers pay amortization

Source: NIA Website (https://www.nia.gov.ph/content/construction-irrigation-systems)

(3) Possible Implementation Schemes for Water Resources Development and Management Projects

In this sub-section, possible implementation schemes are summarized based on the description in the above sub-section (2); those are sorted out by the two items, "Water Resources Development" and" Water Resources Management (Demand Management)" in line with the classification in the Section 4.3.2.4.

1) Possible implementation schemes for water resources development projects are sorted out from the viewpoint of "Single Purpose or Multiple Purpose" and "Public Sector Only or PPP" and shown in the Table 4.3-46.

Table 4.3-46 Possible Implementation Schemes for Water Resources Development Projects

Sector		Public Sector Only	PPP
Single	Irrigation	NIA (Projects related to National Irrigation System are targeted in this table.)	(PPP may be possible if profitable projects such as hydropower generation can be added on the irrigation project.)
	Water Supply	Relevant public WSPs (WDs, LGU-Run Utilities etc.)	Private WSPs themselves
			PPP between public WSPs (WDs, LGU-Run Utilities etc.) and private entities (BOT, JV etc.)
	Flood Control	DPWH or Relevant LGUs	-
Multiple	Water Use + Water Use	[Option 1] One organization is selected from several related organizations for water utilization to be the main entity for implementing the multipurpose projects, and the said organization will construct and manage the dam. The non-implementing entities bear the part of cost of construction and management to the implementing entity.	Basically, the contents of the left column [Option 1] & [Option 2] are applicable. In addition, there is possibility to utilize JV scheme between Government-owned and controlled corporation such as NIA, WDs etc., and private entities.

Sector		Public Sector Only	PPP
		[Option 2] Establish an entity to carry out construction and management of multipurpose projects (assuming dams, etc.) on a river basin level and implement the projects.	
	Flood Control + Water Use	Basically, same as the above case of "Water Use + Water Use", except for being involved with the organization in charge of flood control (assuming DPWH)	Same as the contents of the left column of "Flood Control + Water Use".

Source: JICA Study Team

2) Possible implementation scheme for water resources management (Demand Management) are sorted out in Table 4.3-47.

Table 4.3-47 Possible Implementation Schemes for Water Resources Management (Demand Management)

Sector	Measurements	Possible Implementation Body	Remarks
Water Supply	Water Saving	Relevant WSPs	Supportive education activities for water saving by relevant LGUs or CSOs should be considered
	NRW Reduction	Relevant WSPs	There have been cases in applying PPP
	Introduction of Rainwater Storage and Infiltration Facilities	Households, Building Owners, Government Offices, Urban Developers	Incentive schemes such as subsidy system should be considered.
Irrigation	Introduction of irrigation ITS	NIA (Projects related to National Irrigation System are targeted in this table.)	—
	Improvement of Irrigation O&M Facilities	NIA (Projects related to National Irrigation System are targeted in this table.)	—
Groundwater	Capacity Enhancement for Sustainable Groundwater Management	NWRB	It is necessary to collaborate with relevant WSPs or LGUs

Source: JICA Survey Team

(4) Recommendations and Plan in the Aspect of Organizations and Legal Frameworks

1) Water Resources Development

In this survey, JST proposes some multipurpose dam projects in WRR VII, however at the same time, has a recognition of issues especially on enhancing multipurpose water resources development projects in the Philippines. JST also recognizes that the following items are necessary at least for implementing multipurpose projects proposed as the priority project in this survey since different administrative bodies are in charge of various water-related purposes such as flood control, water supply, irrigation, etc.

- ✓ An integrated basin-level plan for the construction and management of multi-purpose dams that transcends the jurisdiction of ministries and agencies.

- ✓ Existence of an entity to implement and maintain multi-purpose dam projects at the basin level, beyond the jurisdiction of ministries or government organizations.

JST would like to propose the following items for improvement in the aspect of organizations and legal frameworks in order to deal with these issues. Meanwhile, comments related to multipurpose dams are described in the following subsection (5).

- ✓ Creation of DWR and integration of planning functions

  Early establishment of DWR is recommended since it will make possible the achievement of integrated planning scheme related to water resources.

- ✓ Preparation of plans for multipurpose dam projects

It is recommended that plans for multi-purpose dams be led by the DWR regional office, if one has been established, or by the NEDA regional office in charge of regional planning, if not, and be compiled with the cooperation of the relevant agencies.

- ✓ Strengthening of the River Basin Committees and utilizing them for consensus building

  The planning of a multi-purpose dam relates the interests of many stakeholders in the basin, so it is essential to reach a consensus among them. In this regard, it is proposed to strengthen the existing River Basin Committees and utilize them for consultative frameworks among stakeholders.

- ✓ Development of consultative scheme for the Inabanga Dam Projects

  The beneficiary areas of Inabanga dam project belongs to two Provinces (Bohol and Cebu), thus it is necessary to set up a consultative framework across the two Provinces. In addition, it is necessary to consider compensatory measurements for the reservoir area.

- ✓ Proposal for "MODEL PROJECT" of multipurpose dams

  The option of implementing "MODEL PROJECT" is proposed. The "MODEL PROJECT" includes establishing an organization with expertise and engineers from DPWH, NIA, LGUs, etc., upon agreement of all parties concerned, and implementing the multi-purpose dam construction project. The organization for the "MODEL PROJECT" can be remained for operation & management office of the multipurpose dam after completion of the dam construction.

2) Water Resources Management (Demand Management)

Regarding the promotion of water demand management measurements, the following activities for improvement are proposed from the viewpoint of organizations and legal frameworks.

- ✓ Strengthening of organization and human resources of the regulatory organization

  NWRB, which especially plays a main role for groundwater regulation and monitoring, does not have adequate organizational scale and human resources. Thus, NWRB should expand its regional offices to each region or WRR which is in charge of water resource management at regional level in line with the movement of creating DWR.

✓ Consideration of incentive schemes for introduction of rainwater storage and infiltration

Incentive schemes such as subsidies should be considered in order to promote introduction of rainwater storage and infiltration facilities.

3) Plans for improvement in the aspect of organizations and legal frameworks

Based on the mentioned above, the plans for improving the issues on organizations and legal frameworks are proposed as follows.

Table 4.3-48 Plans for Improving the Issues on Organizations and Legal Frameworks (WRR VII)

Items	Short Term (-2030)	Middle Term (2030-2040)	Long Term (2040-2050)
National Level			
Creating DWR	→		
Consideration of incentive scheme for rainwater storage and infiltration	→	→	→
Region/Basin Level			
Preparation of plans for multipurpose dams	→		
Strengthening the functions of River Basin Committee	→		
Development of consultative scheme for the Inabanga Dam project	→		
"MODEL PROJECT" of multipurpose dams	→ Preparation	→ Implementation	→
Strengthening of organization and human resources of the regulatory organization	→		

Source: JICA Survey Team

(5) Recommendation Related to Enhancing Multi-purpose Dam Projects

PDP 2023-2028 declares "Water storage reservoirs for water supply and drought mitigation or multi-purpose dams with flood control functions", so we can say that the Philippine government recognizes the necessity for enhancing multi-purpose dam projects including flood control. On the contrary, as described in the section 4.1.2 (2) 3), JST recognizes that the Philippines have challenges for organizational and legal issues for multipurpose water resources development. Also as indicated, in order to promote the construction and management of multi-purpose dams under the current situation where the government organizations in charge of various types of purposes related to water, such as flood control, water supply, and irrigation, are different, the following items are needed, at least from an institutional standpoint:

- ✓ An integrated basin-level plan for the construction and management of multi-purpose dams that transcends the jurisdiction of ministries and agencies.
- ✓ Existence of an entity to implement and maintain multi-purpose dam projects at the basin level, beyond the jurisdiction of ministries or government organizations.

In this regard,

- ✓ Although the basin-level plans have been established for 18 major basins and other areas in the Philippines, there are no integrated plans for the construction and management of infrastructure, including dams.
- ✓ There is no entity for the implementation and maintenance of dam projects beyond the jurisdiction of ministries and agencies.

Therefore, it is necessary to promote planning and organizational schemes to improve these points. With regard to the "establishment of an integrated plan and organization for the construction and management of multi-purpose dams" to improve these problems, the Basic Plan for Water Resources Development and the Water Resources Development Public Corporation (At present the Japan Water Agency) during Japan's high-growth period may serve as references. Please refer to the attached article "IWRM Experience in Japan" (Annex C).

However, it is also true that it will take an extremely long time to develop laws and regulations and create a planning scheme and organization for the construction and management of multi-purpose dams. Therefore, JST proposes that the Philippine government select a small number of multi-purpose projects from the list, and enhance them as "Model Projects" in cooperation with the related organizations in an integrated manner as follows:

- ✓ NEDA and its regional offices, which are responsible for formulating a comprehensive plan, will develop an integrated plan for the construction and maintenance of the multi-purpose dam in consultation and coordination with related ministries and agencies such as DPWH, NIA, and related water utilities. At that time, cost-sharing rules among related parties will also be determined through consultation.
- ✓ After the creation of DWR, which will have the authority on planning, DWR and its regional offices will lead to develop an integrated plan for the construction and management of multi-purpose dams, in consultation and coordination with relevant departments and agencies as necessary at national and regional level. Furthermore, existing river basin committees can be utilized for consultative framework for the planning.
- ✓ After the integrated planning, an organization with engineers of expertise and knowledge from DPWH, NIA, local LGUs, etc. will be established to implement the multipurpose dam project as a "Model Project", and the dam construction project will be implemented. After the completion of the construction project, the organization will be scaled down but will continue to function as a dam maintenance and management body.

In addition, since there are multiple beneficiary entities for the construction and management of multi-purpose dams, it is important to develop rules for cost-sharing among beneficiaries. However, since there are no clear rules on cost-sharing for multi-purpose dams in the Philippines, it is necessary to establish such rules. On the other hand, the cost-sharing rules need to be carefully considered because they should be in line with the actual situation in the country, including the burden-bearing capacity of the beneficiary entities.

In implementing the "Model Project" for a multi-purpose dam, Japan may also consider providing technical assistance so that it can make use of Japanese knowledge and experience in integrated planning, construction, and maintenance of multi-purpose dams in the future.

4.3.4 Proposal for Priority Project Concept in WRR VII

Based on the basic policy for formulating plans for priority projects, stakeholder meetings, and examination of alternatives in priority water resources regions as mentioned above, the water resources development and management plans (idea) were examined and proposed for each policy and sector in the studies up to the previous section.

In this section, based on the above water resources development and management plan (idea), priority projects will be selected, and the concept of each selected priority project will be studied and proposed. This conceptual study is positioned at the level prior to the master plan, and preliminary examined the project goals, target organizations, target areas, results, effects, and estimated costs as the concepts of priority projects.

4.3.4.1 Selection of Priority Project

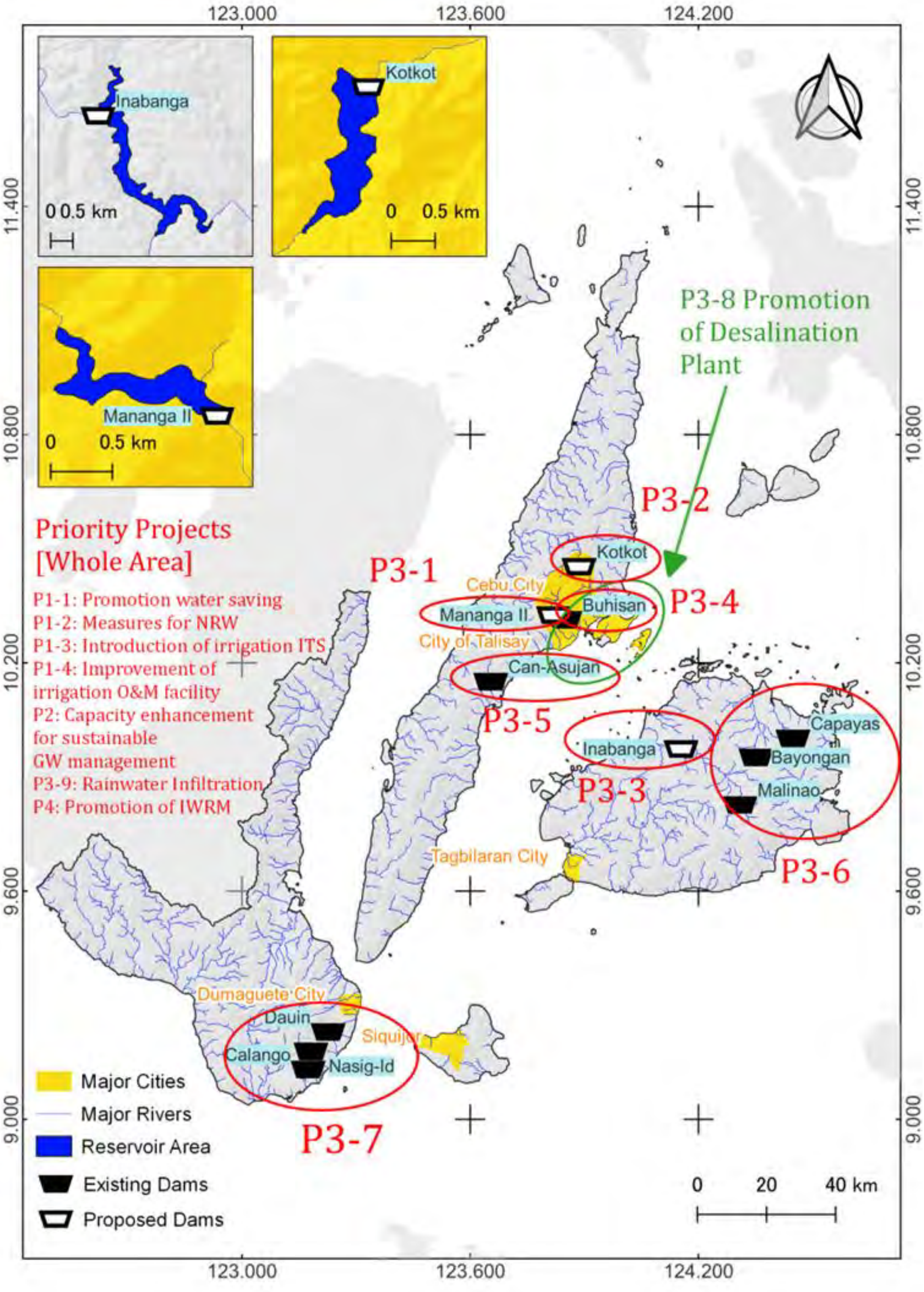
Table 4.3-49 shows the short-term (2030), medium-term (2040), and long-term (2050) project implementation schedule up to 2050 as a roadmap for the water resources development and management plan proposed in the previous section. Of these, the projects selected as short-term proposals that are of high need and urgency, are selected as the priority projects. In addition to this, among the medium-term proposals, it is decided to include the projects with high feasibility and high importance as priority projects, shown in red frames in the table and in the following Figure 4.3-24.

Table 4.3-49 Roadmap of Water Resources Development and Management Plan (Idea) and Priority Projects in WRR VII

Priority Policy	Development Items	Short-term (2024-30)	Mid-term (2031-40)	Long-term (2041-50)
1	Demand Management	P1-1: Promotion of water-saving P1-2: Measures for NRW (20%) P1-3:Introduction of Irrigation ITS P1-4: Improvement of Irrigation O&M Facility	Promotion of water-saving Measures for NRW (15%) Introduction of Irrigation ITS Improvement of Irrigation O&M Facility	Promotion of water-saving Measures for NRW (10%) Introduction of Irrigation ITS Improvement of Irrigation O&M Facility
2	Groundwater Management	P2: Capacity Enhancement for Sustainable Groundwater Management	Monitoring and regulation of GW	Monitoring and regulation of GW
3(1)	Surface water development	-Promotion of mid-long term plans (P3-1:Mananga 2 (low), P3-2:Kotkot, P3-3: Inabanga) -Upgrading existing dams (P3-4: Buhisan in Cebu, P3-5 Canasujan in Cebu, P3-6: in Bohol, P3-7: in Negros oriental) ●Development of irrigation weirs ●Development of irrigation dams (SRIP)	Mananga 2 Dam(low), Kotkot Dam (multi-purpose) -Upgrading existing dams (P3-4: Buhisan in Cebu, P3-5 Canasujan in Cebu, P3-6: in Bohol, P3-7: in Negros oriental)	Bohol water conveyance (Inabanga Dam) Recycle of Sewerage Water
3(2)	Water Supply and Sewerage Development	●Desalination plants (13 nos.) P3-8: Promotion of other desalination plants ●Bulk water developments ●Groundwater developments (Bohol, Negros, Siquijor)	Other desalination plants P3-9: Promotion of recycle of Sewerage Water in Cebu Bulk water developments Groundwater developments (Bohol, Negros, Siquijor)	Other desalination plants Recycle of Sewerage Water in Cebu Bulk water developments Groundwater developments (Bohol, Negros, Siquijor)
4	Water Resources Management Plan	P4: Promotion of IWRM (management of information, flood risks, watershed conservation, organization and institution)	Promotion of IWRM	Promotion of IWRM

●based on the existing / on-going plans
[red frame] Priority Projects

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-24 Priority Projects Map in WRR VII

4.3.4.2 Priority Project Concept

(1) P1: Demand Management

1) P1-1: Reduction of Non-Revenue Water

Reduction of Non-Revenue Water (NRW) is proposed as one of the priority project concepts of the demand management. Outline of the project concept is presented in Table 4.3-50 below.

Table 4.3-50 Outline of the Project Concept (Reduction of Non-Revenue Water)

Title:	Reduction of Non-Revenue Water
Goal:	Reduction of NWR down to 10% by year 2050
Target:	Water supply systems and agencies in whole area
Location:	Whole area
Profiles:	(For the 20% of NWR ratio) implementing underground leakage and sectorization, in addition to aboveground leakage measures and apparent loss measures (water leakage, water theft, non-detection meter, etc.) (For the 10% of NWR ratio) strengthening pipe materials and/or renewing pipe thorough underground leak detection
Effect:	Saving of 2-4 % (8～31MCM) of water demand
Cost:	Approximately 2.3 billion PHP/ city (around renewing 273km of old pipes)
Others:	-

Source: JICA Survey Team

2) P1-2: Promotion of Water Saving Activities

Promotion of water saving is proposed as one of the priority project concepts of demand management.

Table 4.3-51 Outline of the Project Concept (Promotion of Water Saving Activities)

Title:	Promotion of Water Saving Activities
Goal:	Reduction of water demand per capita by 15 % from 2020 to 2050
Target:	Water users and water supply agencies in whole area
Location:	Whole area
Profiles:	Spread of water-saving devices and increased awareness of water conservation by water saving promotion as part of each water utility's public relations
Effect:	Saving of 11-17 % (58-139 MCM) of water demand.
Cost:	No direct construction cost
Others:	In Cebu, at the village level, rural water supply systems using rainwater and groundwater support is being promoted. Although there is potential in terms of water balance, the facility design and construction are poor. The waterway has an inverse slope, and there are leakages, so the water utilization rate is low. Commercial facilities also operate rainwater and sewage recycling businesses.in Mactan area.

Source: JICA Survey Team

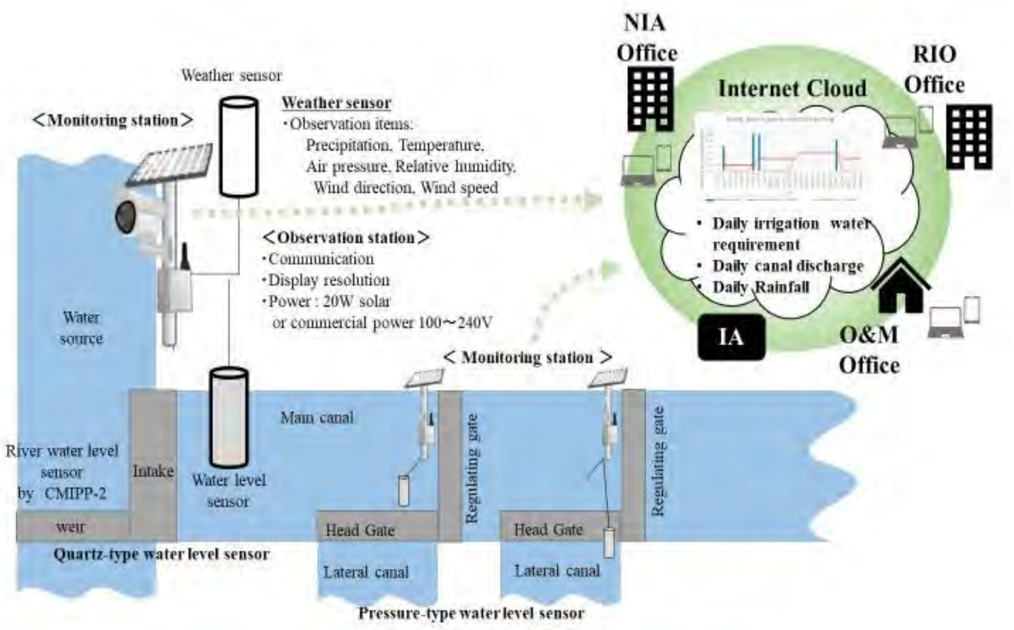
3) P1-3: Introduction of Irrigation Telemetry System

The ultimate goal of the proper irrigation water management is to improve the agricultural productivity and farmers' economy through the maximum utilization of available land and water resources. The introduction of irrigation telemetry system (ITS) is proposed as one of the most effective tools for the establishment of proper water management system in NISs, especially NISs with reservoir dam.

Table 4.3-52 Outline of the Project Concept (Introduction of Irrigation Telemetry System)

Title:	Introduction of Irrigation Telemetry System
Goal:	Through the direct monitoring and evaluation of irrigation water supply by farmer themselves (IAs), - To increase paddy production (improve productivity), - To accelerate crop diversification (improve farm economy). Through the establishment of proper irrigation water management systems by NIA in collaboration with IAs, - To increase paddy production areas in both dry and wet seasons (no more inundation damages in the wet season by excess irrigation water which can be saved for the dry season irrigation). - To minimize operation and maintenance costs.(main purpose of Irrigation Management Transfer, IMT). - To minimize impact of climate changes like El Nino, typhoons, flooding, etc..
Target:	National Irrigation Systems (NIS) of NIA
Location:	Irrigation areas
Profiles:	In order to establish the proper irrigation water management system, it is recommendable to provide the following devices in the major monitoring sites. General concept of irrigation telemetry systems is shown in Figure F4-4. 1) Water level sensor 2) Weather sensor (Meteorological observation such as rainfall, temperature, wind, etc.) 3) Camera and communication module (Mobile-phone network or Wifi) 4) Solar panel w/ charge controller, buttery 5) Computer units (Display, data recording and reporting devices) 6) Others (Current Meter, etc.) The following sites are proposed for the installation of monitoring devices. 1) Downstream of Diversion Dam Intake 2) Downstream of Major Head Gates The discharges (Diversion Water Requirements) required for each objective sub-areas are estimated by the cropping stages prior to the cropping. Monitoring of the actual discharges against the required discharges is the basis of water management. If there are gaps between both discharges, the released water volume from the dam shall be adjusted. Through the monitoring and proper operation of reservoir dam, the effective water utilization is maximized. The canal discharges are managed based on the farm water requirements considering the effective rainfall through the daily monitoring and assessment system. For the proper execution of the system, farmers' participation is indispensable.
Effect:	Saving of around 7.7% of irrigation water demand with improvement (item 4 below).
Cost:	243 Mil. Peso (for all NIS)
Others:	-

Source: JICA Survey Team



Source: Feasibility Study for Introduced of Irrigation Telemetry Systems Using Sensor Networks and Cloud Technology in the Philippines, E-Trust & Takuwa

Figure 4.3-25 General Concept of Irrigation Telemetry Systems

4) P1-4: Improvement of Irrigation O&M Facility

Several NISs are located in the remote areas from the Negros Oriental Satellite Office, and the access roads are the poor conditions, no pavement and hard drive during the rainy season. For proper water control/ management, the O&M office with operational staffs and road improvement are also required in the improvement works.

Table 4.3-53 Outline of the Project Concept (Improvement of Irrigation O&M Facility)

Title:	Improvement of Irrigation O&M Facility
Goal:	Through the direct monitoring and evaluation of irrigation water supply by farmer themselves (IAs), - To increase paddy production (improve productivity), - To accelerate crop diversification (improve farm economy). Through the establishment of proper irrigation water management systems by NIA in collaboration with IAs, - To increase paddy production areas in both dry and wet seasons (no more inundation damages in the wet season by excess irrigation water which can be saved for the dry season irrigation) - To minimize operation and maintenance costs (main purpose of Irrigation Management Transfer, IMT) - To minimize impact of climate changes like El Nino, typhoons, flooding, etc..
Target:	National Irrigation Systems (NIS) of NIA
Location:	Irrigation areas
Profile:	Main and lateral canals shall be improved as concrete lining or flume canal to minimize the conveyance losses. Gate works of diversion dams shall be improved to prevent their damages from flood. All gates shall be replaced to the mechanical operation type with electric/generator power. As same as new projects, the remote-control operation system shall also be introduced in the flood prone area and in the case that the residential gate-keeper cannot be assigned.

Effect:	Saving of around 7.7% of irrigation water demand with introduction of ITS (item 3) above).
Cost:	The O&M costs and replacement costs of such equipment/facilities shall be properly estimated in comparison with those of the simple types.
Others:	The projects including upgrading equipment/facilities for the mechanical operation gate shall be carefully formulated in due consideration of their profits, and the projects shall be flexibly evaluated. The procurement contract of these equipment/facilities are recommended to include the long-term O&M works for the sustainable operation of them.

Source: JICA Survey Team

The preliminary cost estimate for introduction of irritaion telemetry system and improvemen of O&M facility in WRR VII is presented in table below.

Table 4.3-54 Preliminary Cost Estimate for Introduction of Irritaion Telemetry System and Improvemen of O&M Facility in WRR VII

Irrigation Telemetry System	Target System	ISA (ha)	Unit Cost (Peso/ha)	Amount (million P)
	(All NISs)	16,184	15,000	242.76
Diversion Dam Sluice & Intake Gate	Gate Nos.	Gate Area (sqm)	Unit Cost (Peso/sqm)	Amount (million P)
	0.0	0		0.00
Concrete Flume Canal (Lateral Canals)	Target System	ISA (ha)	Unit Cost (Peso/ha)	Amount (million P)
	(All NISs)	16,184	80,000	1,294.72
Total (million PHP)				**1,537.48**
Total (million Yen)				**3,844**

Source: JICA Survey Team

(2) P2: Groundwater Management

All of the short-term items listed in Table 4.3-55 should ultimately be implemented on the Philippine side, and capacity strengthening through technology transfer is considered essential. Therefore, it is considered optimal to formulate and update the groundwater management plan through implementation of the technical cooperation projects shown below as a short-term development plan.

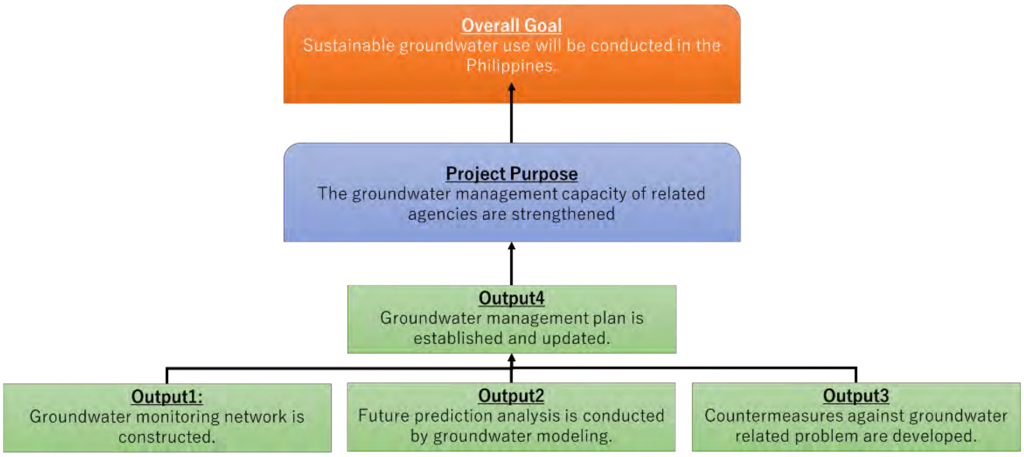
Table 4.3-55 Outline of the Project Concept (Groundwater Management Project)

Title:	Project on Capacity Enhancement for Sustainable Groundwater Management in WRR VII
Goal:	Groundwater management capacity of related agencies are strengthened.
Target:	NWRB, MGB, MCWD, etc
Location:	Cebu Island, Bohol Island
Output:	Output1: Groundwater monitoring network is developed. Output2: Future prediction analysis is conducted by groundwater modeling. Output3: Countermeasures against groundwater related problem are developed. Output4: Groundwater management plan is established and updated.
Effect:	Groundwater usage will be optimized.

Approx. Cost:	Output1: 82 mil. PHP Output2: 33 mil. PHP Output3: 50 mil. PHP Output4: 20 mil. PHP

Source: JICA Survey Team

The relationship between the overall goal, project purpose, and the overall goal, project purpose, and each outcome is shown in Figure 4.3-26.



Source: JICA Survey Team

Figure 4.3-26 Proposed Overall Goal, Project Purpose, Output of Technical Cooperation Project in WRR VII

The following is a description of the activities and their contents for each of the expected outcomes.

1) <Output 1> Groundwater monitoring network is established

[Activity 1-1] Conduct Well Inventory Survey

To ascertain the status of groundwater use, the use of wells for domestic, agricultural, and industrial purposes will be confirmed and organized into a list.

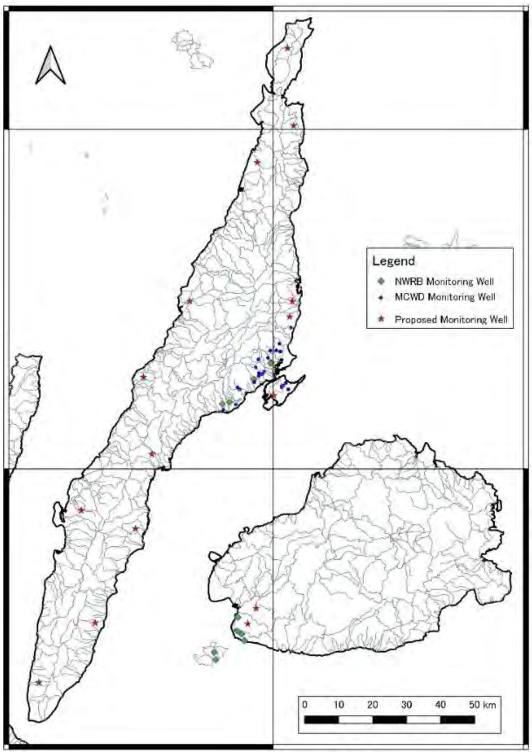
[Activity 1-2] Conduct hydrogeological, hydrological, and geophysical surveys

Conduct various geological surveys to determine aquifer capacity; since NWRB and others have electrical survey equipment, it is desirable to include the implementation of an electrical survey to estimate the vertical structure of the aquifer. In addition, among the wells organized in 1-1, simultaneous hydrometric surveys should be conducted at least twice, once in the dry season and once in the rainy season, for wells where groundwater levels can be measured, in order to understand the distribution status of groundwater levels.

[Activity 1-3] Drilling of new observation wells, pumping tests, and installation of observation equipment

Considering the expected distribution of the lowering of the groundwater table and the existing monitoring wells, it is necessary to establish a groundwater monitoring network that covers the entire source area. Figure 4.3-24 shows proposed locations for drilling new monitoring wells.

For the island of Cebu, 13 new monitoring wells are proposed to construct at distance intervals of up to 50 km, focusing on areas around Metro Cebu that can cover areas of groundwater decline or areas where water level drop is a concern. For Bohol Island, the main groundwater decline area is in Tagbilaran, where there is an existing observation well in NWRB, but two observation wells are proposed because of concerns about water level lowering more inward.



Source: JICA Survey Team

Figure 4.3-27 Proposal of Groundwater Monitoring Network in WRR VII

[Activity 1-4] Pumping test at existing observation wells and production wells, installation of observation equipment

Among the wells identified in 1-1, those wells for which pumping tests can be conducted shall be selected and tested. Also, wells where observation equipment can be installed will be confirmed and instrumentation will be installed.

[Activity 1-5] Construction of observation network

NWRB publishes monitoring data of 25 observation wells on the website (https://admuwater.com/gmp). By adding the observation wells constructed in Activity 1-3 and Activity 1-4 to the publicly available data, an observation network will be established and managed.

2) <Output 2> Future Prediction Analysis is Conducted Using Groundwater Modeling

[Activity 2-1] Data collection, organization, and analysis for groundwater modeling

Various groundwater data obtained in Outcome 1 and the results of existing hydrological investigations will be collected, organized, and analyzed for groundwater modeling.

[Activity 2-2] Construction of groundwater flow model and advection-dispersion model

The groundwater analysis conducted in this survey was intended to estimate the groundwater potential of each water resource region, and because of the wide area covered, the hydrogeological structure, actual pumping conditions, and other settings were simplified. In order to conduct a more detailed study in the future, it is necessary to conduct the analysis after creating an elaborate groundwater model for each basin and city.

[Activity 2-3] Groundwater model calibration based on observed data

Using the data obtained in output 1, the groundwater model constructed in 2-2 will be calibrated to improve the accuracy of the groundwater model.

[Activity 2-4] Future Prediction Analysis

The groundwater model calibrated in activity 2-3 is used to predict future water table drop and saltwater intrusion analysis.

3) <Output 3> Countermeasure plans against groundwater related problem are developed

The following studies will be conducted to develop countermeasures to address the various problems caused by groundwater use that have been identified in the field investigations.

In areas where groundwater-related problems are not recognized and groundwater potential is relatively large, groundwater development through drilling of new production wells will be implemented as a pilot project. If further development is deemed feasible, further production wells could be developed as a water supply development project. In WRRVII, Dumaguete and Siquijor will be targeted.

[Activity 3-1] Collecting and organizing examples of countermeasures

[Activity 3-2] Mapping of groundwater salinization area, subsidence and sinking risk areas

[Activity 3-3] Selection of target sites and study of optimal construction methods

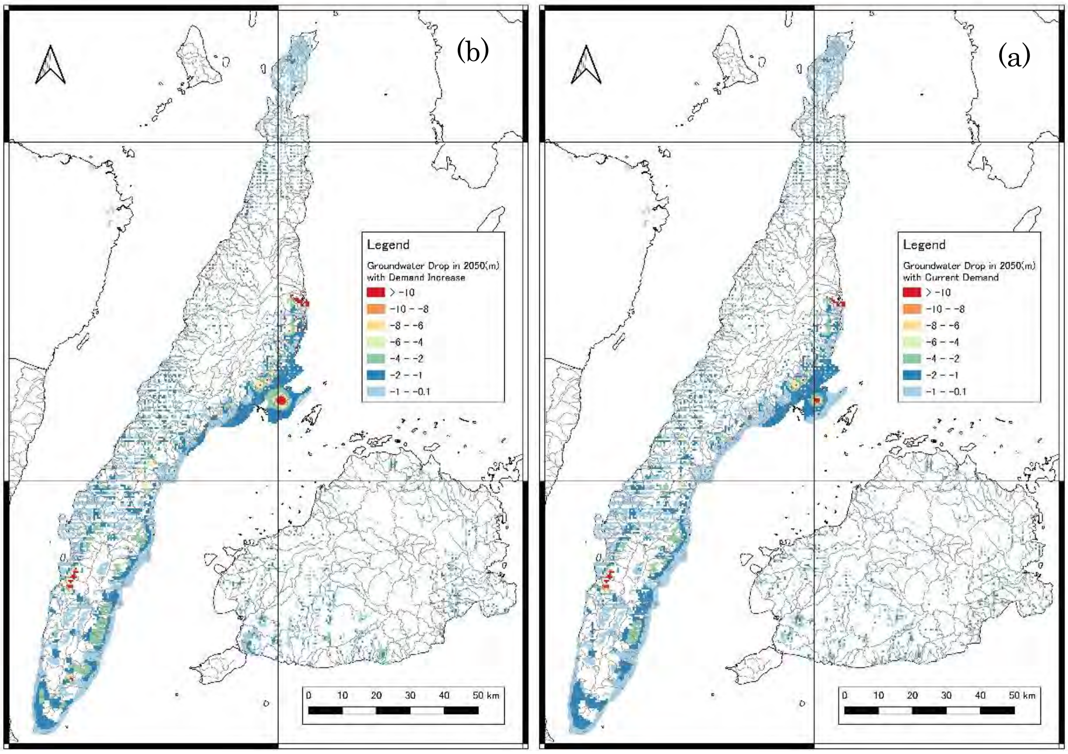
[Activity 3-4] Schematic design of optimal construction method, FS

[Activity 3-5] Implementation of pilot project (production well construction)

4) <Output 4> Groundwater management plan is established and updated

[Activity 4-1] Acceptable Groundwater Criteria (Condition)

Based on the future prediction analysis obtained in Activity 2-4, establish an acceptable groundwater standard criterion (condition). For example, if future groundwater demand could be maintained at the current level of use, the amount of decline in groundwater levels would be shown in Figure 4.3-28(b), thus reducing the decline in groundwater levels.



Source: JICA Survey Team

Figure 4.3-28 Groundwater Level Drop (2020-2050) by considering increased groundwater demand and by limiting within current groundwater demand

[Activity 4-2] Development of a regulation (mitigation) plan for groundwater use based on the results of the prediction analysis

Based on the results of the prediction analysis obtained in Activity 4-1, a feasible groundwater use regulation plan will be developed. Since the groundwater demand shortage caused by the regulation must be met by alternative water sources such as surface water, it is desirable to set a target value for groundwater use regulation after taking into account the amount of surface water and desalinated water that can be developed.

[Activity 4-3] Develop a plan to introduce the countermeasures for saltwater intrusion and artificial groundwater recharge

Develop a future plan based on Output 3.

[Activity 4-4] Development of a middle/long-term groundwater management plan and guidelines

Develop a comprehensive groundwater management plan based on all of the above considerations.

(3) P3(1): Surface Water Development

1) P3-1: Study/Construction of Mananga II Dam (low dam)

The information on the status of the Mananga II Dam is summarized in Chapter 3 section 3.3.3.8, and the basic specifications of the dam plan are summarized in section 4.3.3(2). This dam project has been studied and proposed for many years since the 1980s with the aim of supplying urban water to the Cebu metropolitan area. In 1996, the groundwater recharge facility and adjacent well water supply facility were completed at the Jaclupan site as the first phase project. The Mananga II Dam was planned as the second phase of the project, with the objective of constructing a high dam at approximately 4.8 km upstream of the Jaclupan Dam to store and regulate the inflow of the Mananga River and develop a stable water supply.

However, due to the high cost of the dam construction project, the large scale of land acquisition and resettlement associated with the construction of the reservoir, and the political situation, the plan, which was proposed as a priority project in the past has not been implemented as expected. At present, MCWD is currently requesting DPWH to update the F/S, but it has not yet taken action.

On the other hand, in this study, the Mananga II dam is selected as a priority alternative option as the result of comparison of alternatives options in consideration of the needs, urgency, and development effects of water source development in the metro Cebu area.

As mentioned in section 4.3.3(2), a site inspection of the planned dam construction site was conducted to confirm the dam geology, hydrology, land use conditions, position and height relationship with the existing main road. In addition, the number of affected houses for the current plan (dam height of 76 m) and the plan to lower the dam height (dam height of 40 m) was carried out through a map study. As a result, by lowering the height of the dam, the development water volume would be smaller (5.8 MCM), but it will not be necessary to replace the existing road on the right bank of the dam, which was necessary in the original plan, and the number of affected houses and the area of land acquisition can be greatly reduced (Approximately 300 houses → 70 houses, 130.8 ha → 30.2 ha). Taking these into account, and aiming for early implementation of the project, a dam height of 40 m is proposed as a priority project concept.

Table 4.3-56 Outline of the Project Concept (Study/Construction of Mananga II Dam (low dam))

Title:	Study/Construction of Mananga II Dam (low dam)
Goal:	Surface water development for municipal water supply
Target:	Water supply system of MCWD
Location:	Mananga River, Cebu City
Profiles:	(Basic Dimension) Dam Type: Rockfill Dam Height and Crest Length: H 40 m and L 278 m Catchment Area: 68 km^2 Area of Reservoir: 30.2 ha Number of Affected House Holds: around 72 hh Capacity of Reservoir: 6 MCM In addition to the dam, it is necessary to construct water intake facilities, transmission pipes, water treatment plants, water pumping stations, and water distribution mains.
Effect:	Regulated water supply by using reservoir storage of 15MCM
Cost:	Approx. 781 mil. PHP (for dam construction) Approx. 762 mil. PHP (for pipelines, WTPs)
Others:	Prior to implement the project, a study for design change of dam height as well as social and environmental assessment is necessary.

Source: JICA Survey Team

Site Inspection to Mananga II Dam Site
Dec. 09, 2022

Source: JICA Survey Team

Figure 4.3-29 Site Photos of Mananga II Dam Site

2) P3-2: Study/Construction of Kotkot Dam (multi-purpose use)

Kotkot Dam is a dam planned on the upper reaches of the Kotkot River in the northern part of Metro Cebu. In the 2015 JICA study, it was positioned in the medium-term plan (2030) of the water resources development plan for Metro Cebu. Regarding past plans for the same dam, as far as it was confirmed, individual dam plans have been formulated by multiple agencies in the same river, such as an NIA irrigation dam, a DPWH flood control dam, and a WD water supply dam. Of these, the NIA's irrigation dam plan is currently under consideration for project implementation. The NIA dam is intended to share irrigation water with the local farmlands around the reservoir, contributing to the agricultural development in the adjacent areas of the water source.

On the other hand, there was a water supply dam planned by MCWD on the same site, but this dam plan would have many submerged residents, and there would be many social problems such as opposition to watershed diversion for water supply to Cebu. Therefore, this dam plan was suspended.

Considering the plan to integrate the KotKot Dam Project and taking into account the current situation, it is advised to proceed with the development mainly on the basis of the irrigation dam, which is beneficial to the local area and relatively easy to accept. In addition, based on NIA's irrigation dam plan, by adding the capacity required for water supply development to this dam, the benefit of water supply development per developed water volume is higher than agricultural development, so the benefits of the integrated dam construction will increase further. With a rural water supply program to residents around the dam site, it would be more feasible to implement a water resources development project that is more economical and easier to understand for consensus building on the integrated water resources development.

Based on the above, in this study, it is recommended to combine the purposes and functions of the existing proposed plans in the same Kot-Kot River system into a single multi-purposed dam.

Table 4.3-57 Outline of the Project Concept (Study/Construction of Kotkot Dam)

Title:	Study/ Construction of Kotkot Dam (multi-purpose use)
Goal:	Surface water development for irrigation water supply, municipal water supply and flood control
Target:	Irrigation systems of NIA and water supply system of water utilities
Location:	Kotkot River, Cebu City
Profiles:	Dam Type: Rockfill Dam Height and Crest Length: H 60 m and L 509 m Catchment Area: 19 km^2 Area of Reservoir: 61.5 ha Number of Affected House Holds: around 29 hh Capacity of Reservoir: 15 million cubic meters In addition to the dam, it is necessary to construct water intake facilities, transmission pipes, water treatment plants, water pumping stations, and water distribution mains.
Effect:	Regulated water supply by using reservoir storage of 15MCM
Cost:	Approx. 4,624 mil. PHP (for dam construction)
Others:	Prior to implement the project, investigation and survey as well as study for multi-purpose use of the dam and organizational set up is necessary.

Source: JICA Survey Team

Site Inspection to Teruvian Weir in Kotkot River
D/s of Kotkot Dam Site Dec. 09, 2022

Site Inspection to Kotkot Dam Site Dec. 09, 2022

Site Inspection to Kotkot Dam Site Dec. 09, 2022

NK/CTII/JWA

Source: JICA Survey Team

Figure 4.3-30 Site Photos of Kotkot Dam Site

3) P3-3: Study/Construction of Inabanga Dam (Bohol-Cebu Integrated Water Utilization Project)

The Inabanga Dam (Bohol-Cebu Integrated Water Utilization Project) is a project to construct a dam on the Inabanga River in the northern part of Bohol Island to store and regulate river water in the dam, and then convey the treated water from Bohol Island to Cebu Island. It was planned and proposed in 1998 M/P and is still included in MCWD's future development plans. At present, the method of water conveyance plan is being considered to change from water transmission by undersea pipeline to water transportation by ship.

In this study, field surveys and interviews were conducted with officials of Inabanga City located in the water sources, and the following points were discussed.

- Floods and droughts are a problem in the region.
- Although the Inabanga River has abundant water, there are problems with the water supply system, which hinders the supply of domestic water. Without solving the water supply problems in the Inabanga River, it will not be possible to obtain the understanding of the local people to supply water to Cebu first.
- Prior to implementing the project, a hydrological and water balance analysis similar to this Survey is necessary to quantitatively assess the water resources potential and water demand in the area. It is necessary to proceed with the projects as part of the framework of the integrated water resource management plan.
- Each ministry and agency are doing its own projects, but collaboration is necessary.

- It is also necessary to strengthen the capacity of the staff on how to assess and develop the water resources in the area. This will be beneficial not only for the Inabanga River Basin, but also for whole Bohol Island.

This project is a water conveyance project from Bohol Island to Cebu Island. It will be an integrated water management development project with fair distribution of water use based on scientific and technical studies, environmental and social considerations, and consensus building for project implementation. Although this project is positioned as one of the long-term plans in the above-mentioned water resources development plan (idea), implementation of the survey and planning of the project is proposed as a priority project.

Table 4.3-58 Outline of the Project Concept (Study/Construction of Inabanga Dam (Bohol-Cebu Integrated Water Utilization Project))

Title:	Study/Construction of Inabanga Dam (Bohol-Cebu Integrated Water Utilization Project)
Goal:	Irrigation water supply, municipal water supply and flood control
Target:	Irrigation systems of NIA and water supply system of water utilities
Location:	Inabanga River, Bohol Province
Profiles:	Dam Type: Rockfill Dam Height and Crest Length: H 40 m and L 161 m Area of Reservoir: 136.3 ha Number of Affected House Holds: almost none Capacity of Reservoir: 27 million cubic meters
Effect:	Regulated water supply by using reservoir storage of 15MCM
Cost:	Approx. 859 mil. PHP (for dam construction) Approx. 762 mil. PHP (for pipelines, WTPs) Additional operational cost for water transportation by tanker from Bohol to Cebu
Others:	Prior to implement the project, investigation and survey as well as study for multi-purpose use of the dam and organizational set up is necessary.

Source: JICA Survey Team

4) P3-4: Study/Upgrading Existing Dams (Buhisan Dam)

Information on the current situation of Buhisan Dam is summarized in Chapter 3 section 3.3.3.8. Buhisan Dam is a dam built in the western part of Metro Cebu in 1910. Since the reservoir has been silted, it is reported that the effective reservoir storage is 0.1 MCM, and the daily supply is 4000 m^3/day, but it is still used as a water supply facility to Metro Cebu. It is proposed to extend and upgrade the functions as a priority project.

Prior to preparing a comprehensive plan for dam upgrading, it is necessary to conduct a safety inspection of the dam, a soundness survey, and a study related to the restoration projects. The components of the Buhisan Dam Upgrading Project are considered at this time as follows: (1) Deterioration measures (safety inspection and repair, rehabilitation and seismic reinforcement), (2) sediment survey and sedimentation measures, (3) dam heightening with spillway modification, and (4) power generation expansion.

Table 4.3-59 Outline of the Project Concept (Study Existing Dams (Buhisan Dam))

Title:	Study/Upgrading Existing Dams (Buhisan Dam)
Goal:	Extend and strengthen of water supply function of existing Buhisan Dam
Target:	Water supply system of MCWD
Location:	Buhisan Dam, Cebu Province
Profiles:	Study and investigation for dam upgrading Candidate options for dam upgrading (1) Deterioration measures (safety inspection, repair, seismic reinforcement, etc.), (2) sedimentation measures, (3) dam heightening with spillway modification, (4) power generation expansion, etc.
Effect:	Water supply by using reservoir storage of 0.1 MCM (4,000 m^3/day)
Cost:	project cost shall be estimated based on the results of study and investigation
Others:	Prior to implement the project, investigation and survey as well as study for dam upgrading is necessary.

Source: JICA Survey Team

5) P3-5: Study/Upgrading Existing Dams (Can-Asujan Dam)

Can-Asujan Dam is an irrigation dam built in 2009 with ADB assistance on the Carcar River in western Cebu. The dam type is hardfill with dam height of 25 m, dam capacity of 2.45 MCM, catchment area of 39 km^2 and service area of 719 ha. Rice and vegetables are cultivated by irrigation.

According to NIA, due to the progress of sedimentation in the dam, the intake was buried by sedimentation, which caused a water shortage downstream in 2014, then dredging was carried out in front of the intake. There are two outlet culverts for normal discharge facilities from the dam. One was a temporary diversion channel during the construction of the dam and had been already plugged after construction, but the other is still used as a discharge facility for irrigation water. There is a gate valve install in the discharge facility, and when sedimentation in front of the gate progresses, the gate is opened to flush out the sand. The discharge amount is adjusted by the valve.

Although this is a rough evaluation based on a site visit, there is a possibility that irrigation-dependent hydroelectric power generation can be installed. It is necessary to study operation of additional power generation based on the dam water level and the discharge data. In addition, at the time of the inspection, there was 0.2 to 0.4 m^3/s of discharge from the spillway. If such ineffective spill out discharge can be reduced by improving the dam operations, or taking measures against sedimentation, and increasing the storage capacity by dam heightening, the water supply capacity could be increased. From this point of view, the extension and upgrading of existing dam functions is proposed as a priority project.

Prior to preparing a comprehensive plan for dam upgrading, it is necessary to conduct a safety inspection of the dam, a soundness survey, and a study related to the restoration projects. The components of the Can-Asujan Dam Upgrading Project are considered at this time as follows: (1) Deterioration measures (safety inspection and repair, rehabilitation and seismic reinforcement), (2) sediment survey and sedimentation measures, (3) dam heightening with spillway modification, and (4) power generation expansion.

Table 4.3-60 Outline of the Project Concept (Study/Upgrading Existing Dams: Can-Asujan Dam)

Title:	Study/Upgrading Existing Dams (Can-Asujan Dam)
Goal:	Extend and strengthen of irrigation water supply function of existing Dam
Target:	Irrigation water supply system of NIA
Location:	Can-Asujan Dam in Carcar River, Cebu Province
Profiles:	<Basic Information of Existing Dam> Construction year: 2000, Dam type: Hardfill, Dam height: H=25m. Dam capacity: V=2.45 MCM, Catchment area: CA=39 km^2, Service area: SA = 719 ha (782 ha). <Study and investigation for dam upgrading> <Implementation of candidate options for dam upgrading> (1) Safety inspection and soundness assessment, (2) sedimentation survey, measures, (3) dam heightening with spillway modification, (4) power generation expansion, etc.
Effect:	Extension of irrigation water supply function by using reservoir storage of 2.45 MCM
Cost:	project cost shall be estimated based on the results of study and investigation
Others:	Prior to implement the project, investigation and survey as well as study for dam upgrading is necessary.

Source: JICA Survey Team

6) P3-6: Study/Upgrading Existing Dams (Bohol)

Bohol Island has three major irrigation facilities: Malinao Dam, Bayongan Dam, and Capanas Dam. Although the river basins of the three dams are different, the irrigation areas of each basin are connected by irrigation canals, and these dams are integrated to supply large-scale irrigation water (10,040 ha). Currently, at the Malinao Dam, which is located in the uppermost stream, a dam upgrading project is being procured to raise the spillway height.

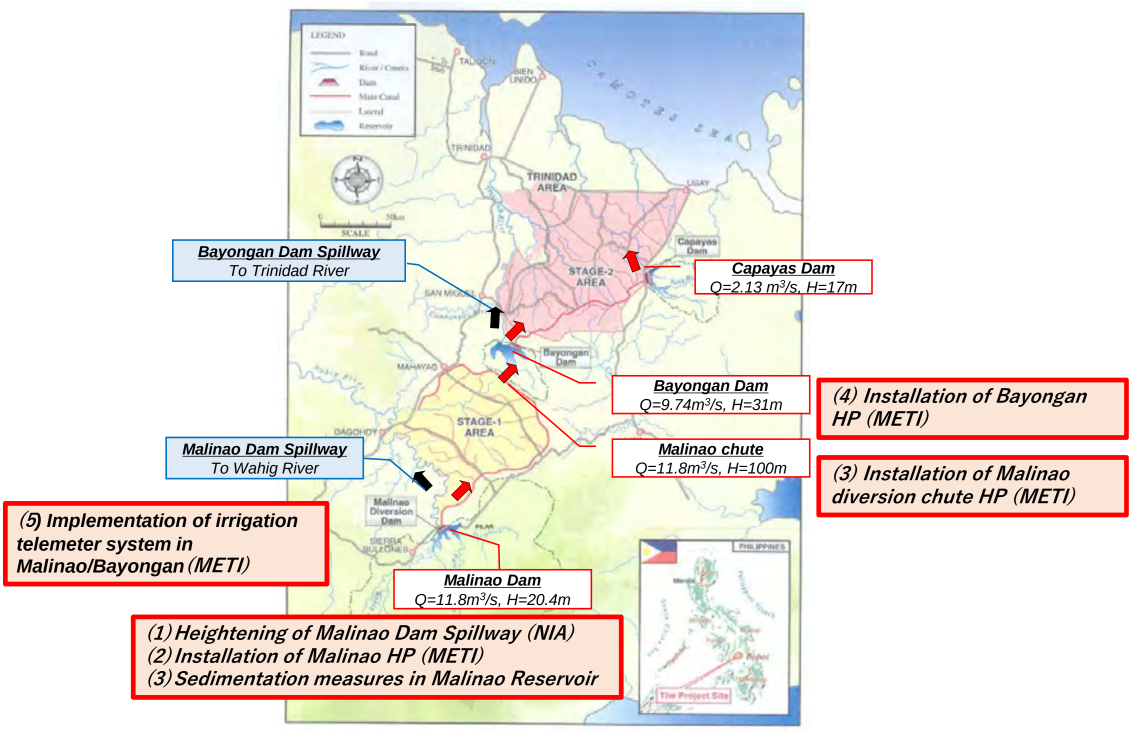
While NIA is promoting irrigation developments with new dam constructions in Bohol, the METI Study conducted in 2019 showed that there is room for surplus development of water resources by improvement of cooperative operation of existing dams, sedimentation countermeasures, and installation of additional power generation facilities. In addition, since the existing dams upgrading project will have less impact on the social environment for its development, it can be expected to make more effective use of stored water. From these points of view, the extension and upgrading of existing dam functions is proposed as a priority project.

Table 4.3-61 Outline of the Project Concept (Study/Upgrading Existing Dams in Bohol)

Title:	Study/Upgrading Existing Dams in Bohol
Goal:	Extend and strengthen of irrigation water supply function of existing Dam
Target:	Irrigation water supply system in Bohol, NIA 7
Location:	Malinao Dam, Bayongan Dam and Capayas Dam, Bohol Province
Profiles:	<Basic Information of Existing Dam> Malinao Dam: 1984, Rockfill dam, Q=11.8 m^3/s, H=20.4 m, 4,740 ha Bayongan Dam: 2000, Rockfill dam, Q=9.74 m^3/s, H=31 m, 4,140 ha Capayas Dam: 1990, Rockfill dam, Q=2.13 m^3/s, H=17 m, 1,160 ha <Study and investigation for dam upgrading> - Implementation of candidate options for dam upgrading (1) Heightening of Malinao Dam Spillway (on-going procurement by NIA) (2) Installation of Malinao HP (METI)

	(3) Sedimentation measures in Malinao Reservoir (METI) (4) Installation of Malinao diversion chute HP (METI) (5) Installation of Bayongan HP (METI) (6) Implementation of irrigation telemeter system in Malinao/Bayongan(METI) (7) Sedimentation measures
Effect:	Extension of irrigation water supply function by using reservoir storage of 2.45 MCM Hydropower generation by newly installed hydropower plants.
Cost:	Project cost shall be estimated based on the results of study and investigation
Others:	Prior to implement the project, investigation and survey as well as study for dam upgrading is necessary.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-31 Outline of Upgrading of Existing Dams in Bohol

7) P3-7: Study/Upgrading Existing Dams (Negros Oriental)

The existing dams (Dauin, Calango, Nasig-id Dams) in the eastern part of Negros Island are suffering from reservoir sedimentation problems due to active sediment production in the basins. This area has been experiencing droughts. The upgrading of existing dams, which have less social impact such as land acquisition and relocation, has more advantages than new dam development.

Therefore, from the viewpoint of effective utilization of the existing dams, the upgrading of the existing dams in Negros Oriental is proposed as a priority project by combining dam operation improvement and sedimentation countermeasures.

Table 4.3-62 Outline of the Project Concept (Study/Upgrading Existing Dams in Negros Oriental)

Title:	Study/Upgrading Existing Dams in Negros Oriental
Goal:	Extend and strengthen of irrigation water supply function of existing Dam
Target:	Irrigation water supply system in Bohol, NIA 7
Location:	Dauin, Calango, Nasig-id Dams, Province of Negros Oriental
Profiles:	<Basic Information of Existing Dam> Dauin, 2004, Fill dam, SA=1000 ha, Calango: 1983, Fill dam, H=26 m, V=0.646 MCM, SA-545 ha Nasig-id: 1997, Fill dam, H=32 m, V=0.663 MCM, SA=1,000 ha < Study and investigation for dam upgrading> < Implementation of candidate options for dam upgrading> (1)Safety inspection and soundness assessment, (2) sedimentation survey, measures, (3) improvement of dam operation, etc.
Effect:	Extension of irrigation water supply function by using reservoir storage of around 2 MCM
Cost:	project cost shall be estimated based on the results of study and investigation
Others:	Prior to implement the project, investigation and survey as well as study for dam upgrading is necessary.

Source: JICA Survey Team

(4) P3(2): Water Supply System

1) P3-8: Introduction of Desalination Technology

In Metro Cebu recently, the policy of water resources development has changed to promote the construction of seawater desalination plants instead of the existing dam plans. This is due to the fact that the groundwater salinization problem is becoming more serious, and that dam projects have time to respond to environmental and social considerations and build consensus among stakeholders. In addition, the economic competitiveness of the desalination plant becomes increasingly feasible because of technology innovation and increasing of the water demands.

In this survey, based on the current development policy of MCWD, the promotion of seawater desalination project is proposed as a priority project for the purpose of development of new municipal and industrial water to cope with serious shortage of water supply in the Metro Cebu areas.

Table 4.3-63 Outline of the Project Concept (Introduction of Desalination Technology)

Title:	Introduction of Desalination Technology
Goal:	Increase of water supply capacity of water supply utilities
Target:	Water supply system in Cebu Island
Location:	Metro Cebu and urban areas, Cebu Province
Profiles:	Water supply capacity by desalination plants in Cebu City - Present (MCWD):180,00 m^3/day by 3 projects - Present (others): 100～2,000 m^3/day/unit, 24 units - Existing plan: 252,000 m^3/day (91MCM/year) by 13 projects (by2030) - Additional new plan: as required based on the water balance analysis
Effect:	Development of water supply by desalination plants (around 5.5 MCM)
Cost:	Approx. 4.4 bil. PHP for a plant (with water supply capacity of 15,000m3/day)
Others:	Prior to implement the project, investigation and survey as well as study for dam upgrading is necessary.

Source: JICA Survey Team

2) P3-9: Introduction of Rainwater Storage and Infiltration

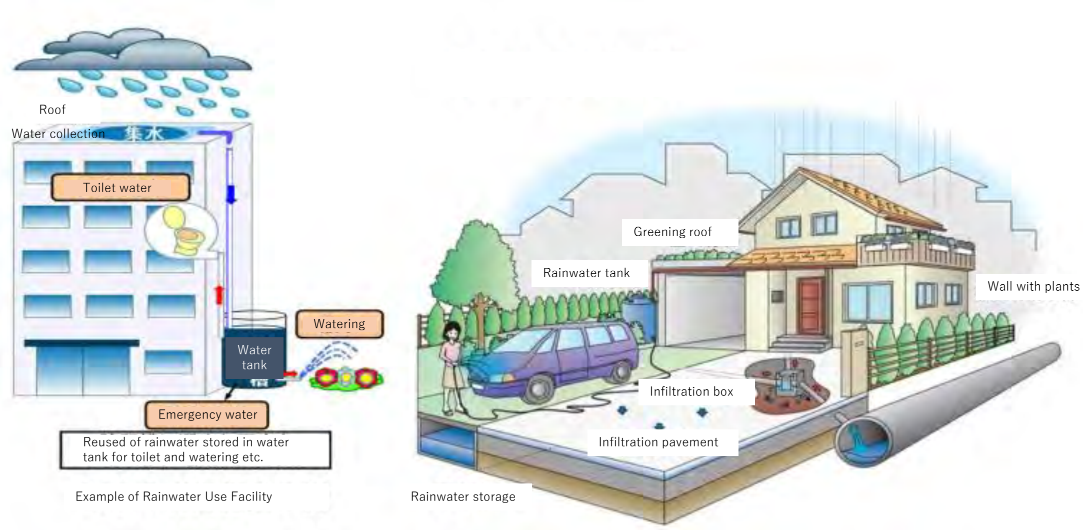
Rapid urbanization has led to deforestation and paving of the ground. As a result, rainwater flows directly to drainage channels and rivers, instead of seeping down to the ground. This leads to serious problems such as decrease of river low flows, deteriorating water quality, floods in cities and depletion of groundwater resources. Rainwater storage and infiltration technology provides a highly effective means for solving such problems, not only for preventing flood damages but also for improving living environment.

Metro Cebu City has an ordinance to set up rainwater storage tanks of 0.5m^3 per 30m^2 in residential areas and 0.5m^3 per 15m^2 in commercial areas. According to this, the potential rainwater storage capacity in the City is estimated at 5,800 m^3/day in residential areas and 2,600 m^3/day in commercial areas, in total 8,400 m^3/day. The promotion of installation of rainwater storage to water shortage areas is proposed as a priority project as a supplementary measure since it is difficult to use stably as a large water source.

Table 4.3-64 Outline of the Project Concept (Rainwater Storage and Infiltration)

Title:	Introduction of Rainwater Storage and Infiltration
Goal:	Increase of water supply capacity of water supply utilities
Target:	Municipal water supply system
Location:	Water shortage areas in WRR VII
Profiles:	Water supply capacity by rainwater storage in Cebu City - Residential area: 5,800 m^3/day (2.1 MCM/year) - Commercial area: 2,600m^3/day (0.95 MCM/year)
Effect:	Development of water supply by installation of rainwater storage and infiltration
Cost:	Around 1,360M PHP (for storage tanks)
Others:	-

Source: JICA Survey Team



Source: MILT, Guideline for Promotion of Rainwater Use

Figure 4.3-32 Image of Rainwater Storage System

(5) P4: Water Resources Management

Promotion or priority project of each water resources management plan(idea) such as information management, flood risk management, river basin environmental conservation and organizational and legal frameworks) as mentioned in Sub Sections 4.3.3.6 – 4.3.3.9 are recommended to implement.

4.3.4.3 Implementation and Management Scheme for the Priority Project Concept

(1) Introduction

In this section, JST considers and proposes the appropriate implementation and management schemes for the priority project concepts described in Section 4.3.3, divided in the items of short-term (2023-2030) and middle-term (2030-2040), based on the description in Section 4.3.3.9.

(2) Promotion of IWRM such as managements of information, flood risk, watershed conservation etc., (P4: Management of Water Resources)

Integrated Water Resources Management (IWRM) is defined as "A process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment (Global Water Partnership)." Also, Chapter 12 of the PDP 2023-2028 "Expand and Upgrade Infrastructure" describes the following:

The strategy in the water sector is to implement effective water governance through IWRM as applied in the planning and management of land, water, and coastal resources. The major pillars in this strategy are as follows:

(a) ensure water availability through efficient water infrastructures and management;
(b) allocate and utilize water efficiently especially over competing water uses;
(c) maintain and enhance surface and ground water quality;
(d) ensure good sanitation and drainage (including proper disposal);
(e) protect land, water and coastal resources;
(f) protect life and property from water and coastal hazards including dam-related hazards; and
(g) manage flood effectively (with sediment control) and mitigate droughts.

As indicated in Chapter 2, one of the issues related to water resources in the Philippines is that there are over 30 water-related agencies with overlapping and sometimes conflicting mandates or functions over the country's water resources. Thus, it is necessary to improve this "fragmented" circumstance and update it to the "integrated" one. As introduced in Chapter 2, the bill deliberation for creation of DWR and WRC is now on-going in the Congress, which is based on the idea to integrate some water-related offices/divisions/units under various departments in a fragmented manner under one department. JST recommends the earlier creation of DWR and WRC since integration among the water-related organizations at national level can be expected through the creation of them. Particularly, at present, the President Mr. Marcos Jr. shows his willingness to establish the DWR, and WRMO was established in April 2023 as a transitory body until DWR is created. Thus, taking these opportunities, it is strongly recommended to enact the bill and achieve the creation of DWR and WRC.

Also, JST makes following additional recommendations in relation to the promotion of IWRM.

- ✓ **Strengthening the relation with organizations that are in charge of construction and management of water infrastructure**

According to the existing drafted bill for establishment of the DWR, it is mainly in charge of planning and regulation, and does not relate to development and management of water infrastructures directly. However, water resources development and management should be implemented in line with the plans prepared by the new DWR, thus it is necessary for the DWR to strengthen the relationship with organizations involved with construction and management of water infrastructures directly (e.g., DPWH, NIA), and those for water supply (e.g., Local water districts) not only at national level but also regional level. As for DPWH especially, although the transfer of the planning division to DWR is envisioned, the divisions involved in construction projects will remain under the previous DPWH. Since IWRM aims at integrated management that includes not only water utilization but also flood control, it is particularly important to strengthen the relationship with DPWH.

- ✓ **Strengthening the function of the organizations for river basin management**

In the Philippines, River Basin Committees (RBCs) have been established mainly in 18 major basins. These committees should be strengthened so that they can be used for consensus building among stakeholders for water infrastructure projects. Currently, the River Basin Control Office (RBCO) of DENR is in charge of basin management, and the RBCO might be scheduled to be transferred to DWR. The establishment of DWR should be an opportunity to strengthen the basin management function, including strengthening the RBC. JST strongly recommends that RBCs should play a role for consensus building in planning and implementing large-scale water projects.

In this regard, meanwhile, it would be beneficial to select a pilot basin from among the 18 major basins in which a large-scale project is to be considered, and utilize the relevant RBC for promoting IWRM on a trial basis. Then, the Philippines side should organize the key points of the activities (e.g., coordination among stakeholders and promotion of multi-purpose projects) implemented and studied in the selected basin for the promotion of IWRM, and share and extend them as good practices to other basins nationwide.

✓ **Expansion of regional offices for water resources management**

Regulatory function is necessary for IWRM especially from the viewpoint of "equitability". In this regard, the regional offices also need to be expanded: the present NWRB, responsible for regulatory function, has branch offices only in Cebu and Davao which were established in 2018 in addition to its headquarters in Manila, but it is difficult to accurately fulfill regulatory functions related to water resources management with this limited operational structure. In this regard, DWR should establish regional offices in each region or WRR to expand the organizational scale, which will be in charge of water resources management at the regional level. Also, it should be noted that budgets and personnel must be secured for this purpose.

(3) Short term (2023-2030)

1) Promotion of Water Saving Activity (P1: Demand Management)

Promotion of water saving activities will be implemented by relevant WSPs as one of the public relation activities to their water consumers (end users). Also, relevant LGUs or Civil Society Organizations (CSOs) should be involved with the supportive educational activities in cooperation with the WSPs.

2) Non-Revenue Water Improvement (P1: Demand Management)

With regard to the NRW Improvement, comparatively easy measurements are proposed for achieving the 20% NRW ratio, including measurements against aboveground leakage, apparent loss measures (water leakage, water theft, non-detection meter, etc.), as well as those of underground leakage and introduction of water supply block operational system.

These measurements will be implemented by the relevant WSPs themselves. Also, NRW improvement activities should be implemented as one of the daily maintenance works of WSPs and continued for a long time. From the viewpoint of organization and legal framework, it is effective to prepare both the long-term plan for feasible NRW improvement activities and the yearly plan depending on the available budget; also, the long-term plan should be revised corresponding to the progress of the NRW improvement. Furthermore, it is desirable for WSPs to provide the exclusive division and personnel.

3) Introduction of Irrigation ITS (P1: Demand Management)

As shown in the Section 4.3.3.4 (4), the introduction of ITS is proposed as one of the most effective tools for proper water management in NISs, especially NISs with reservoir dam. Thus, in line with Table 4.3-46 in Section 4.3.3.9, the introduction of irrigation ITS will be implemented by NIA VII, and the placed system will be managed by NIA VII in cooperation with relevant irrigation associations.

4) Improvement of Irrigation O&M Facilities (P1: Demand Management)

As shown in the Section 4.3.3.4 (4), the improvement of irrigation O&M facilities includes access road improvement and other related components targeted for NISs. Thus, in line with Table 4.3-46 in Section 4.3.3.9, the improvement of irrigation O&M facilities will be implemented by NIA VII, and the placed system will be managed by NIA VII in cooperation with relevant irrigation associations.

5) Capacity Enhancement for Sustainable Groundwater Management (P2: Groundwater Management)

At present, in the Philippines, the monitoring and regulation of groundwater is overseen by NWRB, which shall be the implementation body for the program, and also shall be implemented in cooperation with relevant WSPs. As described in Chapter 2, recently there have been good practices, which include cooperative activities between NWRB and LGUs on development of groundwater management plan and installation of monitoring wells. Such cooperation should be enhanced for the future.

In line with it, it is important to strengthen the organization, human resource and financial basis of NWRB in order to enhance the monitoring and regulation of groundwater. Also, it is desirable that DWR, which will be in charge of monitoring and regulation of groundwater, will be established earlier.

6) Promotion of mid-long-Term Plans – Study of Mananga II Dam (low dam) (P3 (1): Surface Water Development)

This project is targeted only for the water supply of MCWD, and its construction work is expected to be implemented in the next decade (2030-2040). Thus, MCWD should continue the study for preparing the plans for the project in order to implement it in the next decade.

7) Promotion of mid-long-Term Plans – Study of Kotkot Dam (multipurpose use) (P3 (1): Surface Water Development)

This proposed project includes multiple purposes of 1) irrigation water for NIA, 2) water supply for MCWD and residents around the dam site, and 3) flood control; and its construction work is expected to be implemented in the next decade (2030-2040). Thus, it is necessary to set a planning scheme suitable for multipurpose dams and leading agency for the planning, in order to implement the project in the next decade (2030-2040). Here, JST recommends the following options for the leading agency for planning;

- ✓ DWR region office if it is successfully created in the near future
- ✓ NEDA region office in cooperation with relevant agencies if DWR cannot be created

Also, JST likes to propose the option to utilize the existing River Basin Committee (The Central Cebu River Basin Management Committee) as the consultative framework to build consensus for implementing the projects among stakeholders. Furthermore, it is desirable if the recommendations related to multipurpose dam projects described in 4.3.3.9 (5) are taken into account when conducting the study.

8) Promotion of mid-long-Term Plans – Study of Inabanga Dam (multipurpose use) (P3 (1): Surface Water Development)

This proposed project includes multiple purposes of 1) irrigation water for NIA, 2) water supply both for MCWD and the Municipality of Inabanga, and 3) flood control for Inabanga river basin, and its construction work is expected to be implemented in the decade of 2040 – 2050. Thus, it is necessary to set a planning scheme suitable for multipurpose dams and leading agency for the planning, in order to implement the project in that timeframe. Here, JST recommends the following options for the leading agency for planning;

- ✓ DWR region office if it is successfully created in the near future
- ✓ NEDA region office in cooperation with relevant agencies if DWR cannot be created

One of the important points related to Inabanga Dam Project is that the reservoir area (Bohol) and the main beneficiary area (Cebu) belong to different provinces (islands) respectively. Thus, it should be considered to form a consultative framework crossing the administrative boundary of the provinces. A compensatory framework for the reservoir area in the Province of Bohol should also be considered. Furthermore, it is desirable if the recommendations related to multipurpose dam projects described in 4.3.3.9 (5) are taken into account when conducting the study.

9) Promotion of mid-long-Term Plans – Study of Upgrading Buhisan Dam (P3 (1): Surface Water Development)

Buhisan Dam is a water supply dam owned by MCWD. The upgrading project of Buhisan Dam is expected to be implemented in the next decade (2030-2040) for recovering the reservoir capacity. Thus, MCWD should conduct a study for the project in order to implement it in the next decade.

JST expects that two options of implementation scheme can be applied; 1) MCWD itself will implement it, and 2) PPP scheme (ROT (Rehabilitate-Operate-Transfer) or RO (Rehabilitate-Operate)) will be applied.

10) Promotion of mid-long-Term Plans – Study of Upgrading Irrigation Dams (P3 (1): Surface Water Development)

JST's proposed priority project concept includes some of upgrading projects of irrigation dams owned by NIA VII, which is expected to be implemented in the next decade (2030-2040) for recovering the reservoir capacity. Thus, NIA VII should conduct studies for the projects in order to implement them in the next decade.

11) Introduction of Desalination Technology (P3 (2): Water Supply and Sewerage Development)

In WRR VII, MCWD has the plan to develop 13 desalination plants for water supply. Judging from the result of interview session with its officials, as MCWD seems to prefer the PPP scheme for developing water source, JST proposes the PPP scheme for the desalination plant development. The implementation scheme is as follows:

- ✓ Implementation Scheme:

  BOT or other PPP related schemes will be preferred. A private entity (such as Special Purpose Vehicle (SPV)) will enter the BOT contract about construction, operation and maintenance of the desalination plant during the limited contact period with MCWD, which will receive desalinated water from the private entity as an off-taker.

- ✓ Management Scheme:

  Private entity such as SPV will be in charge of the operation and maintenance of the desalination plant during the contract period.

12) Introduction of Rainwater Storage and Infiltration (P3 (2): Water Supply and Sewerage Development)

Rainwater storage and infiltration needs facilities such as infiltration inlet, rainwater storage tank, or storage space. Entities such as households, building owners, and urban developers implement rainwater storage and infiltration by setting the above facilities first. JST recommends the Philippines side to introduce some incentive schemes such as a subsidy policy for such facilities setting.

(4) Middle term (2030-2040)

1) Introduction of Desalination Technology (P3 (2): Water Supply and Sewerage Development)

JST recommends the further enhancement of desalination technology besides the existing plan of MCWD's 13 desalination plants in the next decade. With regard to the implementation scheme of this item, please see the above (3) 11).

2) Promotion of Recycle of Sewerage Water (P3 (2): Water Supply and Sewerage Development)

In WRR VII, recycle of sewerage water is proposed for MCWD's activity. This project concept should be implemented and managed similar to the above-described case of desalination plants.

- ✓ Implementation Scheme:

  BOT or other PPP related schemes will be preferred. A private entity (such as Special Purpose Vehicle (SPV)) will enter the BOT contract about construction, operation and maintenance of the sewerage plant during the limited contact period with MCWD, which will receive treated water from the private entity as an off-taker.

- ✓ Management Scheme:

  The private entity such as SPV will be in charge of operation and maintenance of the sewerage plant during the contract period.

Outline of the above proposals of implementation schemes for the priority project concept is summarized in Table 4.3-65, Table 4.3-66, and Table 4.3-67.

Table 4.3-65 Proposal of Implementation Schemes for Priority Projects in WRR VII (Short Term : 2023-2030) (1)

<table>
<tr><th>Type</th><th>Proposed Project</th><th>Sector/Purpose</th><th>Original Planning Body/Owner</th><th>Possibility for PPP</th><th>Expected Implementation Scheme/Body</th><th>Expected Management Scheme/Body</th></tr>
<tr><td rowspan="4">P1: Demand Management</td><td>Water Saving</td><td>Water Supply</td><td>LGUs/DENR/WSPs</td><td>-</td><td>Relevant WSPs w/ supportive education activity from relevant LGUs or CSOs</td><td>Relevant WSPs w/ supportive education activity from relevant LGUs or CSOs</td></tr>
<tr><td>NRW Reduction</td><td>Water Supply</td><td>LGUs/WSPs</td><td>Possible</td><td>Relevant WSPs</td><td>Relevant WSPs</td></tr>
<tr><td>Introduction of Irrigation ITS</td><td>Irrigation</td><td>NIA</td><td>-</td><td>NIA VII
(National Irrigation System (NIS) is assumed.)</td><td>NIA V w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)</td></tr>
<tr><td>Improvement of Irrigation O&M Facilities</td><td>Irrigation</td><td>NIA</td><td>-</td><td>NIA VII
(National Irrigation System (NIS) is assumed.)</td><td>NIA V w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)</td></tr>
<tr><td>P2: Groundwater Management</td><td>Capacity Enhancement for Sustainable Groundwater Management</td><td>Groundwater</td><td>NWRB</td><td>-</td><td>NWRB (Organization to oversee the groundwater monitoring and regulation) in cooperation with relevant WSPs and LGUs</td><td>NWRB (Organization to oversee the groundwater monitoring and regulation) in cooperation with relevant WSPs and LGUs</td></tr>
<tr><td rowspan="3">P3(1): Surface Water Development</td><td rowspan="3">Promotion of mid-long-term plans of Multipurpose Dams (Mananga II Dam (Low), Kotkot Dam, Inabanga Dam)</td><td rowspan="3">Water Resources</td><td>- Mananga II (Low)
MCWD</td><td>Possible</td><td>MCWD to conduct study for Mananga II dam projects, which is planned to be implemented in the next decade.</td><td rowspan="3">-</td></tr>
<tr><td>- Kotkot Dam (Multipurpose)
MCWD/NIA VII /DPWH
*Flood Control・Irrigation・Water Supply</td><td>-</td><td rowspan="2">NEDA regional office (or DWR regional office if it is created) will lead to develop the plan of multipurpose dam projects and make necessary coordination to promote them in the next decade. Also, the option to utilize the existing River Basin Committee as the consultative framework should be considered for consensus building among stakeholders.</td></tr>
<tr><td>- Inabanga Dam (Multipurpose)
MCWD/DPWH
*Flood Control・Water Supply</td><td>-</td></tr>
</table>

Source: JICA Survey Team

Table 4.3-66 Proposal of Implementation Schemes for Priority Projects in WRR VII (Short Term : 2023-2030) (2)

Type	Proposed Project	Sector/ Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P3(1): Surface Water Development	Study and Investigation for Upgrading existing dams (Buhisan Dam, Can-asujan Dam etc.)	Water Supply	MCWD	Possible-	MCWD to conduct study for upgrading Buhisan Dam projects, which is planned to be implemented in the next decade.	-
		Irrigation	NIA VII	Possible	NIA VII to conduct study for upgrading existing dam projects including Can-asujan Dam, which is planned to be implemented in the next decade.	-
	●Development irrigation weirs and dams (SRIP)	Irrigation	NIA VII	-	NIA VII to implement the construction projects of irrigation weirs and dams in line with its development plan.	NIA VII w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)
P3(2): Water Supply & Sewerage Development	●Desalination Plant	Water Supply	MCWD	Possible	A private entity such as SPV, which enters into BOT or other types of PPP contract with MCWD, will implement the desalination plant development project. MCWD will purchase water as an off-taker.	In the case of BOT, a private entity such as SPV will be in charge of O&M during the contract period.
	●Bulk Water Developments	Water Supply	WSPs	Possible	A private entity such as SPV will enter into BOT or other types of PPP contract will implement the bulk water supply project. WSPs will purchase water as an off-taker.	In the case of BOT, a private entity such as SPV will be in charge of O&M during the contract period.
	●Groundwater Development (Bohol, Negros, Siquijor)	Water Supply	WSPs	Possible	Relevant WSPs	Relevant WSPs
	Introduction of rainwater storage and Infiltration	Water Supply	NEDA/NWRB/LGUs/WSPs	Possible	Entities such as households, building owners, and urban developers to set the facilities for rainwater storage and infiltration. Also, an incentive scheme such as subsidy may be considered.	

Source: JICA Survey Team

Table 4.3-67 Proposal of Implementation Schemes for Priority Projects in WRR VII (Middle Term: 2030-40)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P3: Surface Water Development	Desalination Plant	Water Supply	MCWD	Possible	A private entity such as SPV, which enters into BOT or other types of PPP contract with MCWD, will implement the desalination plant development project. MCWD will purchase water as an off-taker.	In the case of BOT, a private entity such as SPV will be in charge of O&M during the contract period.
	Promotion of Recycle of Sewerage Water	Water Supply	MCWD	Possible	A private entity such as SPV, which enters into BOT or other types of PPP contract with MCWD, will implement the sewerage water recycle project. MCWD will purchase water as an off-taker.	In the case of BOT, a private entity such as SPV will be in charge of O&M during the contract period.

Source: JICA Survey Team

4.3.5 Regional Collaboration among Water Utilities in WRR VII

(1) Introduction

In this section, with regard to the proposed water resources development and management plan (Section 4.3.3) and the priority project concept (Section 4.3.4), if there are multiple water utilities in the area covered by the proposed water resource, the possibility of business efficiency improvement through regional collaboration among water utilities (e.g., Joint Operation and Management, Joint Use of Facilities, Consolidation of Water Utilities, and Integrated Management) will be considered.

(2) Conceptual framework for the policy on regional collaboration among water utilities and the expected effects and disadvantages

1) Conceptual framework for the policy on regional collaboration among water utilities in Japan

In Japan, water supply services have been run by local government units at city, municipality or village level, hence many water utilities are small and have weak business foundations. Thus, regional collaboration among water utilities has been promoted in order to improve the efficiency of facilities and management, and to strengthen the infrastructure. This is expected to stabilize fee revenues, correct disparities in service levels, efficiently utilize human, financial, facility, and other management resources, and strengthen emergency preparedness for disasters, accidents, and other emergencies.

There are various forms of regional collaboration among water utilities in Japan. The concept of regional collaboration among water utilities in Japan is summarized in Table 4.3-68.

Table 4.3-68 The forms of Regional Collaboration among Water Utilities

Forms		Contents
Consolidation of Water Utilities		The form in which both the management body and the water supply services are consolidated into one (Form in which business approval, organization, water rate and management etc. are consolidated). 1) Consolidation among multiple water utilities (Horizontal Consolidation) 2) Consolidation between bulk water supply service and water utilities (Vertical Consolidation)
Integrated Management		The form in which the same management body operates multiple water services (Form in which organization, operations and management are consolidated, but water rate system and business approval are divided).
Joint Implementation	Joint Operation & Management	Joint implementation / joint commissioning of maintenance works (Water quality testing and facility management, etc.) Joint implementation / joint commissioning of administrative works
	Joint Use of Facilities	Joint installation and sharing of water supply facilities (Water intake facilities, water purification plants, water quality testing centers, etc.) Connection of emergency communication pipe
Others		Mutual support system in the event of a disaster, joint maintenance of materials, etc.

Source: The Guideline for Regional Collaboration of Water Supply (Japan Water Works Association)

2) Disadvantages on the policy on regional collaboration among water utilities

On the contrary, the disadvantages on the policy on regional collaboration among water utilities are summarized as follows. They should be noted when considering regional collaboration among water utilities.

- ✓ Implementing the policy on regional collaboration among water utilities is restricted by the geographical and topographical conditions between the targeted water utilities.
- ✓ Decrease in readiness may occur because of expansion of business scale
- ✓ Particularly in the case of “Consolidation of Water Utilities”:
  - The merits derived from the consolidation may be small when it is difficult to integrate the water facilities because of the geographical conditions
  - Consolidation of areas with low population density and industrial concentration may result in lower average facility utilization rates and higher average maintenance costs due to longer pipelines
  - In cases where water rates are to be integrated in different regions, rate determination may be difficult when accompanied by an increase in water rates.
- ✓ Management burden will increase on the core water utility side if it merges water utilities with poor water supply conditions.

3) Current situation on regional collaboration among water utilities in the Philippines

JST obtained following information on regional collaboration among water utilities through the literature survey and interview session.

- ✓ JST held the interview session with LWUA officials about the policy on regional collaboration among water utilities and obtained the following comments:
  - The Philippines has some experiences where WDs in core cities expand their water supply areas to the adjacent small LGUs.
  - There has been only one case of consolidation between WDs in the Region 1 (Ilocos Norte).
  - Approval by LUWA is needed when WDs expand their water supply areas or consolidate with other WDs
- ✓ In the report "The Philippine Local Government Water Sector" issued by the Philippines Institute for Development (Research Institute of NEDA) in 2020, several cases of duplication of water supply areas between WD and LGU-run utilities including that in Taytay town, the Province of Palawan, are mentioned. However, the report does not mention measures to solve the duplication issue including the consolidation of water utilities.

- ✓ Literature surveys through websites and other sources did not reveal any cases of consolidation among water utilities; nor did any articles which recommends the consolidation to improve the financial and management issues of water utilities. Also, JST has not confirmed any water utilities which expressed the intention to expand their service areas to other adjacent LGUs, through interview sessions held during the field surveys.
- ✓ Moreover, particularly in the Philippines, as described in Chapter 2, each water districts, LGU-run utilities, and private service providers belong to a different regulatory organization (LWUA, LGU itself, and NWRB, respectively), which makes it more difficult to enhance the policy on regional collaboration among water utilities.

(3) Areas/water utilities for consideration of regional collaboration among water utilities

In this survey, the selection of areas/water utilities for consideration of regional collaboration among water utilities will be made based on the following condition: "In proposing the plans for water resources development and management or priority project concept, regional collaboration among water utilities will be considered if there are multiple water utilities in the area covered by the proposed water source". JST selects the areas/water utilities for consideration from the above perspective.

1) The Province of Cebu

JST proposed the Inabanga Dam, which is located in Bohol Island. This dam is expected to be the water source both for the municipality of Inabanga and MCWD with water transmission from Bohol Island to Metro Cebu. This situation meets the condition that there are multiple water utilities covered by the proposed water source; hence this area is selected.

2) The Province of Bohol

For the province of Bohol, there is only the Inabanga Dam mentioned above, which meets to the condition that there are multiple water utilities covered by the proposed water source.

On the other hand, in the City of Tagbilaran, the capital the Province of Bohol, JST found that 3 water utilities (The Bohol Water Utility Incorporated (BWUI), The Tagbilaran City Waterworks (TCW), and the Richli Water) have been implementing their operation competitively in the same area, and also JST found problems related to duplicating operations in the same area in the city. Thus, this area is selected.

3) The Province of Negros Oriental and Siquijor

For the Province of Negros and the Siquijor, there are no case that meets the condition that there are multiple water utilities covered by the proposed water source. Thus, this area is not selected.

(4) Possibility for regional collaboration among water utilities

1) Metro Cebu

1)-1 Current situation on the management of MCWD

According to the Annual Audit Report of the MCWD 2021 issued by the Commission of Audit, MCWD has a total workforce of 789 employees composed of 539 regular personnel, 227 job order/contractual employees and 23 casual employees. Also, it belongs to Category A, the highest category, in the present Local Water District Categorization prescribed by the LWUA.

The comparative financial position and results of operation for Calendar Years 2021 and 2020 are shown in Table 4.3-69 and Table 4.3-70.

Table 4.3-69 Comparative Statement of Financial Condition

	2021(PHP)	2020(PHP)	Increase (Decrease)	Percentage
Total Assets	5,229,332,461.05	5,194,846,131.00	34,486,330.05	0.66%
Total Liabilities	1,225,644,139.79	1,265,251,638.99	-39,607,499.2	-3.13%
Total Equity	4,003,688,321.26	3,929,594,492.01	74,093,829.25	1.89%

Source: The Annual Audit Report of the MCWD 2021 issued by the Commission of Audit

Table 4.3-70 Comparative Statement of Comprehensive Income

	2021(PHP)	2020(PHP)	Increase (Decrease)	Percentage
Total Income	1,879,964,300.84	1,819,373,820.39	60,590,480.45	3.33%
Expenses	1,845,691,987.56	1,742,485,703.69	103,206,283.9	5.92%
Net Income	34,272,313.28	76,888,116.7	-42,615,803.42	-55.43%

Source: The Annual Audit Report of the MCWD 2021 issued by the Commission of Audit

The operational situation of the MCWD in Calendar Year 2021 and 2020 is as follows.

Table 4.3-71 Operational Highlights

Category	2021	2020	Increase (Decrease)
Service Connection			
No. of Service Connection	200,959	198,911	2,048
Population Served	854,867	855,317	-450
Water Production (in cubic meters)			
Bulk Supply (purchased water)	28,945,366.3	25,537,360.2	3,408,006.1
Pumped	53,782,126.7	52,376,909.0	1,405,217.7
Gravity	1,780,912.0	1,404,021.0	376,891.0

Source: The Annual Audit Report of the MCWD 2021 issued by the Commission of Audit

1)-2 Information from the interview session

The interview session with MCWD officials was held on 7th September 2022. The interviewee told JST that MCWD does not have an intention to expand its current service area (4 cities and 4 municipalities) to the adjacent areas; and it was confirmed that MCWD's high priority is to strengthen the water supply capacity and expand the coverage area within the current service area. It is assumed that they recognize that the water supply rate in the current service area has not yet reached the target.

1)-3 Possibility of regional collaboration among water utilities

- ✓ There is minimal possibility that MCWD takes wide-area expansion policy, expanding its service area because it has no such intension.
- ✓ On the other hand, JST proposed the Inabanga dam project in the Province of Bohol, which will provide water both for the Municipality of Inabanga and Metro Cebu. It seems to be difficult to propose "Joint Operation and Management" and "Joint Use of Facilities" since there is a distance between two places; however, "Integrated Management" between two water utilities (The Inabanga Municipality waterworks and MCWD) may be one of the options because they will have common water resource. In addition, MCWD is one of the largest-scale water districts in the Philippines, and this integration may contribute to the upgrading of the operation and maintenance of the water utility in the Municipality of Inabanga. Also, there may be good compensation for the location of water source, from Metro Cebu to the Municipality of Inabanga.

2) The City of Tagbilaran

2)-1 Current situation on the management of water supply in the City of Tagbilaran

Information on 3 water service providers through the literature survey and interview session is as follows:

- BWUI is the joint venture consists of the Province of Bohol (Equity Ratio: 30%) and the Salcon Consortium (Equity Ratio: 70%), which was formed in 2000. According to the Listang Tubig, its supply area includes the City of Tagbilaran, and the Municipality of Corella, Dauis, and Baclayon.
- TCW is the LGU-run water service provider owned by the City of Tagbillaran. According to the Listang Tubig, its supply area is the City of Tagbilaran only.
- Richli Water is a private water utility, whose supply area includes the City of Tagbilaran, the Municipality of Baclayon, Cortes, Dauis, and Panglao according to the Listang Tubig.

2)-2 Information from the interview session

- ✓ The interview session to the BWUI officials was held on 19th January 2023. The interviewee told JST the following:
  - Three water utilities (BWUI, TCW and the Richli Water) are operating competitively in the City of Tagbilaran, and there also is duplication among them.
  - The scale of the water supply level: the biggest one is BWUI, and the second one is TCW and the last one is Richli Water.
  - The water rate: the most expensive one is Richli Water, and the second one is BWUI, and the most reasonable one is TCW.
- ✓ Duplication problems have also arisen in terms of maintenance and management of water distribution pipes, such as water distribution pipes being laid parallel to the same area/road (the pipes of different water utilities are laid parallel to the same road, which makes confusion in management). There seems to be a recognition that there is inefficiency in operation and management.
- ✓ The interviewee had a comment that the consolidation of the water utilities may contribute to the improvement of the inefficiency in operation and management.
- ✓ On the contrary, it seems to be difficult to consolidate these water utilities immediately since there is some reasons including the difference in water rate among them. Also, there reportedly have been conflict between BWUI and Richli Water, which has been filed to NWRB.

2)-3 Possibility of regional collaboration among water utilities

- ✓ JST assumes that there are needs for rationalization in operation of water supply services through the consolidation of the three water utilities since competitive operation in the same area has made inefficient management of water supply services. However, it is difficult to achieve the consolidation right away.
- ✓ The related water utilities consist of two private utilities and one LGU-run utility, and a water district is not included. It means that LWUA, which has comparatively strong regulatory authority on the local water districts, is not involved in this situation. This point might be one of the reasons for the confusion of duplication.
- ✓ It would be appropriate that NEDA and NWRB, the counterpart agencies of this Survey, recognize the situation of duplication in the City of Tagbilaran. Also, there may be some similar cases elsewhere in the Philippines.
- ✓ There has reportedly been a conflict between BWUI and Richli Water, which has been filed to NWRB. Firstly, this conflict should be resolved soon. In addition, JST believes that NWRB should cooperate with the province of Bohol and the City of Tagbilaran to

conduct a study jointly on the possibility of consolidating water supply services in the region, confirm the feasibility of the consolidation, and identify issues that need to be addressed in order for the consolidation.

(5) Issues and recommendations

As described above, there seem to be some cases that multiple water utilities are operating competitively and hold duplication issues in the same area such as the City of Tagbilaran; hence the policy on regional collaboration among water utilities may be effective for improving the situations. Issues and recommendations are summarized below.

1) Issues on organizations and legal frameworks

- ✓ In the Philippines, as described in Chapter 2, each water district, LGU-run utilities, and private service providers belongs to a different regulatory organization (LWUA, LGU itself, and NWRB, respectively), which makes it more difficult to enhance regional collaboration among water utilities.
- ✓ It would be appropriate to establish the DWR and WRC in the future, which would also centralize regulatory authority over water utilities (e.g., issuance of water use permits, Certificate of Public Convenience (CPC)) and promote consolidation of water utilities based under the integrated regulatory authority in DWR and WRC.

2) Issues related to the duplication of service areas between multiple water utilities

- ✓ Previously, the case of multiple water utilities operating in the same area and duplicating in their service areas in the City of Tagbilaran was introduced. Duplication of water supply areas should be an avoidable situation from the perspective of efficient water utility management and efficient water use.
- ✓ When issuing or updating the CPC, the regulatory agency on water utilities should also check for duplicating service areas and coordinate the elimination of such duplications.
- ✓ Also, it would be appropriate that such confusions related to duplication of water service areas will be solved after establishing DWR and WRC in the near future.

3) Other issues towards enhancement of regional collaboration among water utilities

- ✓ According to the PWSSMP or other administrative documents, the Philippines Government seems to recognize the issues related to efficiency of water use or necessity for management improvement of some of water districts. However, JST could not confirm literatures which recommends the policy on regional collaboration among water utilities. Thus, the policy on regional collaboration among water utilities may not recognized as the measure for improving these issues.

- ✓ JST firstly recommends that the Philippines side recognize that the policy on regional collaboration among water utilities may be one of the solutions for the issues related to efficiency of water use or the necessity for management improvement of some of the water districts. Also, NEDA may consider the necessary frameworks including development of subsidy systems for enhancing the policy.

4) Making use of Japan's experiences and knowledge

- ✓ In Japan, the policy on regional collaboration among water utilities has been promoted as a measure to cope with the depopulation of rural areas and the decrease in water supply population. the policy on regional collaboration among water utilities includes "Consolidation of Water Utilities" as well as "Joint Operation and Management", "Joint Use of Facilities", and "Integrated Management". Efforts to share such Japanese experience and knowledge with the Philippine side are also considered necessary.
- ✓ In enhancing the efforts, it may be necessary to provide incentives for integration, such as subsidies, which was developed in Japan.
- ✓ In addition, in Japan, it is considered important for prefectures that encompass cities, municipalities and villages to play an active role in promoting the policy on regional collaboration among water utilities, and each prefecture has established a system for regional collaboration among water utilities. There may be a direction that provinces take a leading role to enhance the policy.

4.3.6 Initial Environmental and Social Impact Assessment in WRR VII

4.3.6.1 Necessity of the Environmental and Social Impact Assessment

The Environmental Impact Assessment (EIA) in Philippines is defined as a "process that involves predicting and evaluating the likely impacts of a project (including cumulative impacts) on the environment during construction, commissioning, operation, and abandonment". EIA is primarily presented in the context of a requirement to integrate environmental concerns in the planning process of projects at the feasibility stage. Through the EIA process, adverse environmental impacts of proposed actions are considerably reduced through a reiterative review process of project siting, design and other alternatives, and the subsequent formulation of environmental management and monitoring plans.

On the other hand, Strategic Environmental Assessment (SEA) is one of the concepts of assessment system evaluating the environmental and social impact at the earliest stage of decision making targeting a proposed policy, plan or program. Compared with EIA, SEA provides recommendations at a strategic level, and contributes to a better control for projects. However, on SEA application in the Philippines, there have been no formal integration of the SEA process into the Philippine laws, rules, and regulations. Thus, SEA in the Survey was implemented based on the requirement of JICA Guidelines for Environmental and Social Consideration.

The objective of the SEA is to evaluate the environmental and social considerations contributing to the proposed plan prior to the implementation of various development interventions on water resources development and management in the Philippines. Specific objectives of the SEA survey including SHMs in the Survey are as follows.

- To find the possibility of the significant impacts by the proposed plans / projects at early stages
- To consider the environmental and social conditions in the proposed plans/projects
- To communicate with stakeholders at the early stages to achieve smooth consensus building

Based on above concept, initial assessment for the environmental and social conditions was conducted for the proposed pilot projects.

On the other hand, in case the proposed projects are implemented in the future after the Survey, the EIA process must be planned and implemented according to the EIA system in the Philippines including: screening, scoping, EIA study and report preparation, EIA review and evaluation, decision making, and post monitoring, validation and evaluation/audit stage.

4.3.6.2 Components Considered for the Environmental and Social Condition in WRR VII

Initial environmental and social impact assessment was conducted for the following priority projects in WRR VII considering the necessity of the assessment in the SEA stage, shown in Table 4.3-72.

Table 4.3-72 Profiles of the Priority Projects Selected for Assessment in WRR VII

No.	Priority Project	Location	Profile	Necessity
1	P1: Demand Management	Whole area	- Reduction of Non-Revenue Water: 1) Implementing underground leakage and sectorization, aboveground leakage measures and apparent loss measures, 2) Strengthening pipe materials and/or renewing pipe thorough underground leak detection - Promotion of Water Saving Activities: Spread of water-saving devices and increased awareness of water conservation - Introduction of Irrigation Telemetry System: Providing the devices for establishing the proper irrigation water management system - Improvement of Irrigation O&M Facility: 1) Improvement of main and lateral canals as concrete lining or flume canal and gate works of diversion dams, 2) Replacement of all gates, 3) Introduction of the remote-control operation system	× Adverse impacts by some improvement / upgrading works of existing facilities are expected but these impacts are not major and less than installation of new facilities so that these impacts are not evaluated here.
2	P2: Groundwater Management	Cebu Island, Bohol Island	- Formulating and updating the groundwater management plan through the implementation of the technical cooperation projects	× This project is a technical assistance so major adverse impact is not expected.
3	P3-1 Construction of Mananga II Dam (low dam)	Mananga River, Cebu City & Talisay City	Name of River: Mananga River Dam Type: Rockfill Dam Height and Crest Length: H 40 m and L 278 m Area of Reservoir: 30.2 ha Capacity of Reservoir: 6 million cubic meters	○ Construction of new dam has a significant impact
4	P3-2 Construction of Kotkot Dam (multi-purpose use)	Kotkot river, Cebu City	Name of River: Kotkot River Dam Type: Rockfill Dam Height and Crest Length: H 60 m and L 509 m Area of Reservoir: 61.5 ha Capacity of Reservoir: 15 million cubic meters	○ Construction of new dam has a significant impact
5	P3-3 Construction of Inabanga Dam	Inabanga River, Municipalities of Danao and Inabanga	Name of River: Inabanga River Dam Type: Rockfill Dam Height and Crest Length: H 40 m and L 161 m Area of Reservoir: 136.3 ha Capacity of Reservoir: 27 million cubic meters	○ Construction of new dam has a significant impact
6	P3-4~7 Upgrading of existing dams (Buhisan Dam, Can-Asujan Dam, Bohol and Negros Oriental)	Buhisan Dam, Cebu	- Buhisan Dam: 1) Deterioration measures, 2) Sedimentation measures, 3) Dam heightening with spillway modification, 4) Power generation expansion - Can-Asujan Dam: 1) Safety inspection and soundness assessment, 2) Sedimentation measures, 3) Dam heightening with spillway modification, 4) Power generation expansion - Bohol: 1) Dam heightening with spillway, 2) Hydropower installation, 3) Sedimentation measures, 4) Implementation of irrigation telemeter system - Negros Oriental: 1) Safety inspection and soundness assessment, 2) Sedimentation	× Adverse impacts by upgrading works of existing dams are not major and less than construction of new dams so that these impacts are not evaluated here.

No.	Priority Project	Location	Profile	Necessity
			measures, 3) Improvement of dam operation	
7	P3-8: Introduction of Desalination Technology	Metro Cebu and urban areas, Cebu	Water supply capacity - Existing plan: 91 MCM/year by 13 projects by2030 - Additional new plan: as required based on the water balance analysis	○ Construction of new facility has a significant impact
8	P3-9: Introduction of Rainwater Storage and Infiltration	Water shortage areas in WRR VII	Installation of rainwater storage and infiltration Water supply capacity by rainwater storage in Cebu City - Residential area: 2.1MCM/year - Commercial area: 0.95MCM/year	× Installation of equipment does not major adverse impact.
9	P4 Water Resources Management	Whole area	Information management, Flood risk management, River basin environmental conservation and Organizational and legal frame works	× Major adverse impact is not expected by these managements.

Source: JICA Survey Team

4.3.6.3 Environmental and Social Conditions in the Targeted Area in WRR VII

Characteristic environmental and social conditions in WRR VII are shown as follows.

(1) Water Quality

Current conditions of water quality at each priority project area are shown in Table 4.3-73.

Table 4.3-73 Water Quality Conditions for the Priority Project Area in WRR VII

No.	Priority Project	Location	Condition for Water Quality
1	P3-1 Construction of Mananga II Dam (low dam)	Mananga River, Cebu City & Talisay City	The Mananga River is classified as a Class A There are 5 monitoring stations. After review of the 2016 1st Quarter Water Quality Status Report, the values could not be determined as only three (3) stations were sampled during the time. No samples were taken in Mananga River during the 2nd Quarter monitoring due the lack of good representative water in the sample stations.
2	P3-2 Construction of Kotkot Dam (multi-purpose use)	Kotkot river, Cebu City	Kotkot River is classified as Class A There are 4 monitoring stations. - DO: only one station was able to attain the minimum DO of 5 mg/L, the standard for Class A waters. - BODs: three out of the four stations exceeded the DENR standard for Class A water (3 mg/L). - TSS: ranges from 12- 66 mg/L in the monitored sites.
3	P3-3 Construction of Inabanga Dam	Inabanga River, Municipalities of Danao and Inabanga	The Inabanga river is classified as Class A upstream of Barangay Cawayan, Inabanga and Class C downstream. EMB is not monitoring the water body in the Municipality of Inabanga, Bohol.

Source: JICA Survey Team

(2) Flora, Fauna and Ecosystem

Using the Integrated Biodiversity Assessment Tool (IBAT), 50-km IUCN Red List assessment was performed. The center of the assessment is located in the City Hall of Cebu, the City Hall of Talisay and the Public Market of Inabanga. The results are as follows:

Table 4.3-74 IBAT Assessment Results Summary

Area	CR	EN	VU	NT	LC	DD	Total
Cebu City	17	45	245	210	2878	242	3637
Talisay City	21	48	249	210	2905	250	3683
Inabanga City	14	47	248	210	2891	246	3657

Notes: CR – Critically Endangered | EN – Endangered | VU – Vulnerable | NT – Near Threatened | LC – Least Concern | DD – Data Deficient
Source: Integrated Biodiversity Assessment Tool (IBAT) (ibat-alliance.org)

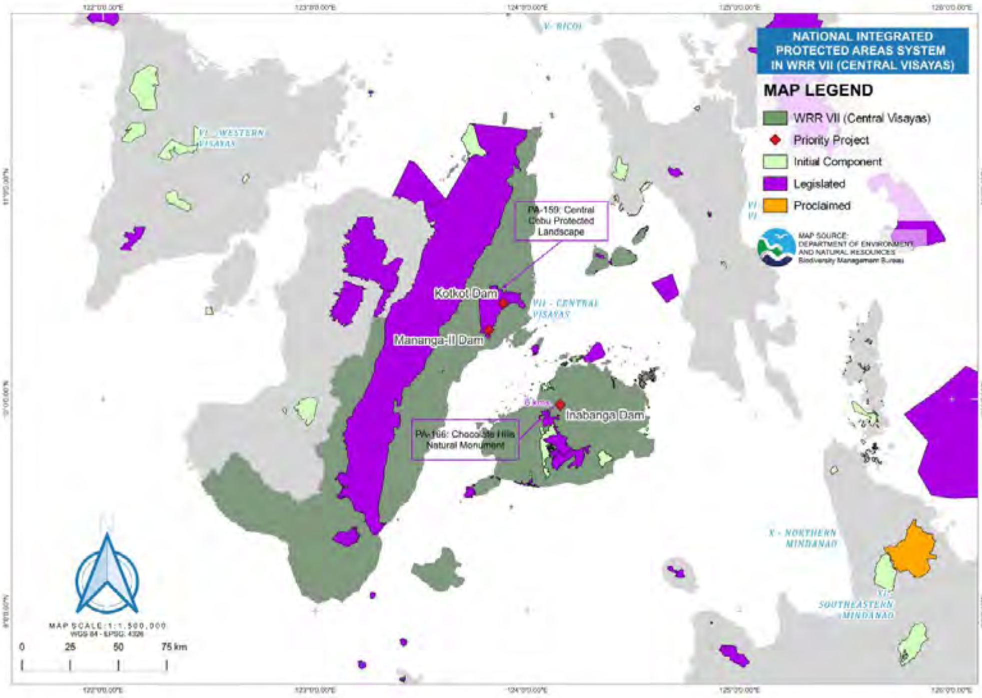
(3) Protected Area

Conditions of the priority project area covered in the protected area are shown below.

Table 4.3-75 Protected Area in the Priority Project Area in WRR VII

No.	Priority Project	Location	Protected Area
1	P3-1 Construction of Mananga II Dam (low dam)	Mananga River, Cebu City & Talisay City	The project site falls within a NIPAS-legislated protected area, the Central Cebu Protected Landscape (CCPL) that covers the Mananga Watershed Forest Reserve.
2	P3-2 Construction of Kotkot Dam (multi-purpose use)	Kotkot river, Cebu City	The proposed project site falls within a NIPAS-legislated protected area, the Central Cebu Protected Landscape (CCPL) that covers the Kotkot-Lusaran Watershed Forest Reserve.
3	P3-3 Construction of Inabanga Dam	Inabanga River, Municipalities of Danao and Inabanga	The nearest NIPAS-legislated protected area to the project site is the Chocolate Hills Natural Monument located approximately 7 km away. However, there are locally identified protected areas in the Municipality of Danao, Bohol: the Wahig-Inabanga Watershed; the Assisted Natural Regeneration (ANR) Forest Reserve, and the Bat Colony in Barangay Taming.
4	P3-8: Introduction of Desalination Technology	Metro Cebu; urban areas in Cebu	Central Cebu Protected Landscape (CCPL) covers the Kotkot-Lusaran Watershed Forest Reserve.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3-33 Location Map of the Priority Project and Protected Area in WRR VII

(4) Resettlement / Land

Possibility of resettlement and land acquisition are summarized in Table 4.3-76.

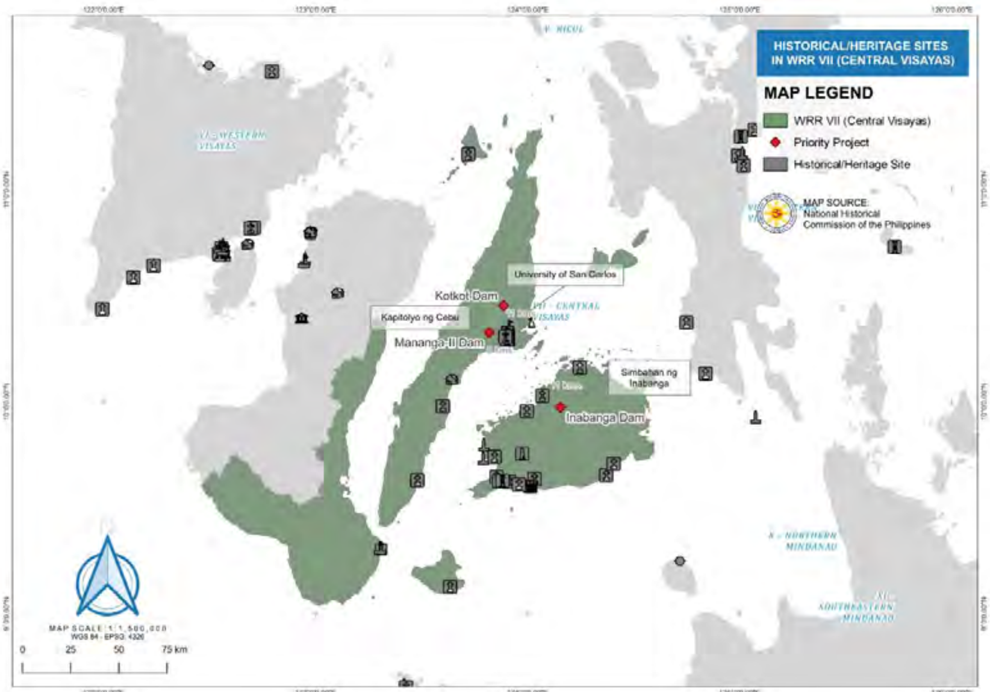
Table 4.3-76 Possibility of Resettlement for the Priority Project Area in WRR VII

No.	Priority Project	Location	Condition for Water Quality
1	P3-1 Construction of Mananga II Dam (low dam)	Mananga River, Cebu City & Talisay City	In case of dam height of 40 m, there is a possibility that around 70 households need to be resettled. Land of reservoir is 30.2 ha, which need to be secured.
2	P3-2 Construction of Kotkot Dam (multi-purpose use)	Kotkot river, Cebu City	In case of dam height of 60 m, there is a possibility that around 30 households need to be resettled. Land of reservoir is 61.5 ha, which need to be secured.
3	P3-3 Construction of Inabanga Dam	Inabanga River, Municipalities of Danao and Inabanga	In case of dam height of 40 m, affected household is not identified. Land of reservoir is 136.3 ha, which need to be secured.

Source: JICA Survey Team

(5) Heritage

Each priority project area is away from the tangible-immovable marked structures and important cultural properties specified by NCCA as shown in Figure 4.3-34.

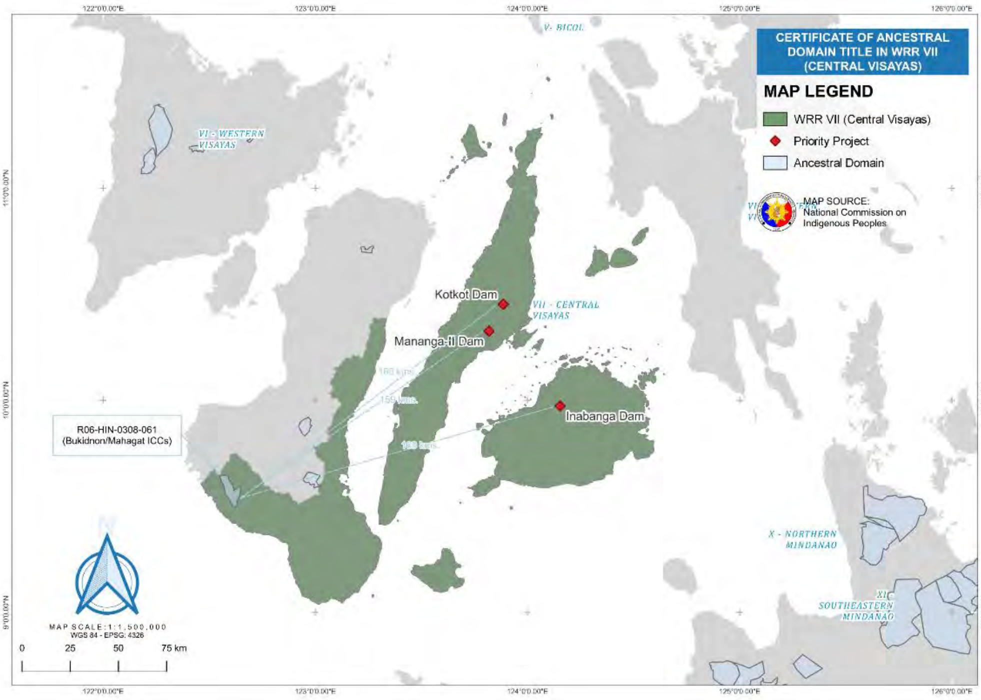


Source: JICA Survey Team

Figure 4.3-34 Location Map of the Priority Project and Cultural Properties in WRR VII

(6) Ethnic Minorities and Indigenous Peoples

According to the National Commission on Indigenous Peoples (NCIP), there is one ancestral domain (AD) with Certificate of Ancestral Domain Title (CADT) in WRR VII, but CADT area is far from the proposed priority project area as shown in Figure 4.3-35.



Source: JICA Survey Team

Figure 4.3-35 Location Map of the Priority Project and CADT Area in WRR VII

(7) Poverty

There are places with high rates of poverty on the outskirts rather than in metropolitan areas. Poverty gap in WRR VII is estimated as 5.7% and 6.0% in Cebu province and Negros Oriental province against national rate as 3.0% in 2021[2]. There is a poverty gap in Cebu province while Cebu city is very developed.

In addition, PSA defines Poverty Incidence (PI) as the proportion of families/individuals with per capita income/expenditure less than the per capita poverty threshold to the total number of families/individuals. The 2021 poverty estimates show that poverty incidence in Cebu province increased from 11.3% in 2018 to 22.8% in 2021 against national rate as from 12.1% in 2018 to 13.2% in 2021[3], which indicates that Cebu province have a poverty risk.

4.3.6.4 Scoping of the Priority Projects

Considering the project character and baseline conditions, the scoping was conducted as shown in Table 4.3-77 and Table 4.3-78.

[2] · Official Poverty Statistics of the Philippines (Preliminary 2021 Full Year), "Poverty Gap" is calculated that the weighted total income shortfall (expressed in proportion to the poverty threshold) of families/ individuals with income below the poverty threshold divided by the weighted total number of families/ individuals
[3] PSA 2021 Full Year Official Poverty Statistics Tables

Table 4.3-77 Scoping of the Targeted Priority Projects in WRR VII (1)

Items		Construction of New Dams (Mananga II dam, Kotkot dam and Inabanga dam)		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Pollution Control				
1	Air quality (including greenhouse gas)	✓		**<Construction>** - Air pollution by gas emission caused by construction machines and vehicles is expected - Dust caused by earth works and transportation of materials etc. is expected. - These adverse impacts will be limited around the construction site and during construction period.
2	Water quality	✓	✓	**<Construction>** - Water pollution to the water body by turbid water caused by construction works is expected. **<Operation>** - Adverse impact to water quality in the water reservoir such as eutrophication and dissolved oxygen caused by the storage of water is expected.
3	Waste	✓		**<Construction>** - Generation of construction waste and residual soil by construction works is expected. - Its impact will be limited during construction period.
4	Soil contamination	✓		**<Construction>** - Contamination caused by outflow of construction oil, fuel etc. is expected. - Its adverse impact will be limited during construction period.
5	Noise and vibration	✓		**<Construction>** - Noise and vibration caused by construction works, machines and vehicles are expected. - These adverse impacts will be limited around the construction site and during construction period.
6	Subsidence			- Subsidence is generally not expected
7	Odor			- Odor is generally not expected
8	Sediment		✓	**<Operation>** - Inflow and stock of sediments in the reservoir by river erosion are expected. - Outflow of sediment to the downstream is changed
Natural Environment				
9	Protected areas	✓	✓	**<Construction / Operation>** The proposed Mananga-II Dam and Kotkot Dam are situated within a protected area; hence, direct impact on the protected area is expected from project construction and operations.
10	Ecosystem and biodiversity	✓	✓	**<Construction>** - Adverse impact to fauna and flora around/inside the project area caused by construction work is expected. **<Operation>** - Adverse impact to fauna and flora around/inside the project area caused by changes of their habitats and river flow is expected.
11	Hydrology	✓	✓	**<Construction>** - Impact on hydrology of the downstream caused by temporarily damming and excavation of the riverbed is expected. **<Operation>** - Impact on hydrology of the downstream caused by change of water flow volume is expected.
12	Topography and geology	✓		**<Construction>** - Geographical impact caused by the earth works is expected. - Its adverse impact will be limited during construction period.
Social Environment				
13	Resettlement and Land acquisition	✓		**<Pre-Construction>** - There is high possibility of resettlement at the proposed site of Mananga-II Dam and Kotkot Dam, hence, direct impact to residents is expected. Each proposed site requires the large area of reservoir, hence, there is high possibility of land acquisition.
14	Ethnic minorities and indigenous peoples / Poverty	✓	✓	**<Construction / Operation>** - There may be some poverty areas so restrict and gap for access to safe and drinking water may be caused. - Detail survey and frequent communication for the impact to poverty areas are needed.

Items		Construction of New Dams (Mananga II dam, Kotkot dam and Inabanga dam)		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
15	Local economies	✓	✓	<Construction> - The project will bring some benefits such as job creation and economic opportunities to sell foods/goods to workers. <Operation> - Economy is expected to growth by expanding the usage of water - Compensation for the livelihood will be done if any
16	Water use	✓	✓	**<Construction>** - Temporary adverse impact for water use at the downstream caused by the construction works and generation of turbidity water is expected. **<Operation>** - Impact for water use at the downstream caused by water flow management is expected.
17	Existing social infrastructures and Services	✓	✓	**<Construction>** - Traffic impact caused by the construction vehicles is expected. **<Operation>** - After the operation, the project will contribute to efficient water use.
18	Cultural Heritage			Adverse impact to cultural heritage is currently not expected but detail survey is needed.
19	Landscape		✓	**<Operation>** - Structural design shall consider harmonization with surroundings.
20	Gender / Children's right	✓		**<Construction>** - Gender and children's right shall be evaluated in detail to consider the equal employment opportunities, provision of break rooms, avoidance of child labor and safety of school zone etc.
21	Working conditions / Accident	✓		**<Construction / Operation>** - Working conditions and Accident shall be evaluated in detail with construction and operation plan to consider working security, traffic safety and fall prevention to water etc.

Source: JICA Survey Team

Table 4.3-78 Scoping of the Targeted Priority Projects in WRR VII (2)

Items		Introduction of Desalination Technology		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Pollution Control				
1	Air quality (including greenhouse gas)	✓		**<Construction>** - Air pollution by gas emission caused by construction machines and vehicles is expected - This adverse impact will be limited around the construction site and during construction period.
2	Water quality	✓	✓	**<Construction>** - Seawater will be muddy by the temporally excavation work for offshore intake pipes and discharge pipes. - Its impact will be limited during construction period. **<Operation>** - Salinity concentration and- Total Dissolved Solid (TDS) will be Increased in the sea near the plant by discharging water.
3	Waste	✓		**<Construction>** - Generation of construction waste by construction works is expected. - Its impact will be limited during construction period.
4	Soil contamination	✓		**<Construction>** - Contamination caused by outflow of construction oil, fuel etc. is expected. - Its adverse impact will be limited during construction period.
5	Noise and vibration	✓		**<Construction>** - Noise and vibration caused by construction works, machines and vehicles are expected. - These adverse impacts will be limited around the construction site and during construction period.
6	Subsidence			- Subsidence is not expected basically
7	Odor			- Odor is not expected basically
8	Sediment	✓		**<Construction>** - Impact to sediment will be expected by the temporally excavation work for offshore intake pipes and discharge pipes. - Its impact will be limited during construction period.

Items		Introduction of Desalination Technology		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Natural Environment				
9	Protected areas			Project site is currently not identified so impact to protected area is unknown.
10	Ecosystem and biodiversity	✓	✓	**<Construction>** - Excavation work for intake and discharge pipes may affect habitat of marine ecosystems. **<Operation>** - Salinity concentration and- Total Dissolved Solid (TDS) may affect habitat of marine ecosystems.
11	Hydrology	✓		**<Construction>** - There is a possibility to temporarily change the ocean current by burying intake pipes and discharge pipes. - Its impact will be limited during construction period.
12	Topography and geology			- Adverse impact to topography and geology is not expected.
Social Environment				
13	Resettlement and Land acquisition			Project site is currently not identified so impact to resettlement and land acquisition is unknown.
14	Ethnic minorities and indigenous peoples / Poverty			Project site is currently not identified so impact to ethnic minorities and indigenous peoples is unknown.
15	Local economies	✓	✓	**<Construction>** - The project will bring some benefits such as job creation and economic opportunities to sell foods/goods to workers. **<Operation>** - Economy is expected to growth by expanding the usage of water - There is a possibility to affect fishing activities by discharging water.
16	Water use		✓	**<Operation>** - There is a possibility to affect fishing activities by discharging water.
17	Existing social infrastructures and Services	✓	✓	**<Construction>** - Traffic impact caused by the construction vehicles is expected. **<Operation>** - After the operation, the project will contribute to efficient water use.
18	Cultural Heritage			Project site is currently not identified so impact to cultural heritage is unknown.
19	Landscape		✓	**<Operation>** - Structural design shall consider harmonization with surroundings.
20	Gender / Children's right	✓		**<Construction>** - Gender and Children's right shall be evaluated in detail to consider the equal employment opportunities, provision of break rooms, avoidance of child labor and safety of school zone etc.
21	Working conditions / Accident	✓		**<Construction / Operation>** - Working conditions and Accident shall be evaluated in detail with construction and operation plan to consider working security, traffic safety and fall prevention to water etc.

Source: JICA Survey Team

4.3.6.5 Evaluation for the Impact Items in WRR VII

Initial evaluation for the impact items which may cause adverse impact in the scoping items of the construction of new dam is as follows. Initial evaluation for the introduction of desalination technology is not conducted since the project site is currently not identified.

(1) Water Quality and Water Use

Kotkot River, Mananga River, and Inabanga River are classified as Class A. The water quality at these rivers is not monitored frequently and some parameters such as BOD have exceeded these standards. In addition, these rivers are utilized for many activities such as fishing and irrigation.

To avoid impacts to above conditions, control of turbid water is mainly needed during the construction considering the seasonal climate.

In the operation phase, water quality in the water reservoir may be worse in case untreated wastewater is discharged from urbanized areas so the prevention of the inflow of wastewater is needed.

(2) Sediment

The condition of the sediments will be changed by the project, thus a detailed survey for the impact on the sediments downstream is needed. In case sediments cause an adverse impact on the surroundings, the removal of sediments and the design of the facility to avoid the stock of sediment should be considered.

(3) Ecosystem

Detailed surveys on the vulnerable species and their habitation are needed before the construction. In the operation stage, monitoring is also needed, and mitigation measures such as reforestation should be conducted as needed.

(4) Hydrology

The impact on downstream hydrology needs to be considered and a survey and communication with residents in the downstream area should be conducted before construction.

(5) Resettlement and Land acquisition

Affected households are expected in the dam construction projects and there may be possibilities of resettlement and land acquisition around the project site, thus, detail survey and frequent communication with residents are needed to evaluate these impacts. Preparation of a RAP is necessary including eligibility for receiving compensation and resettlement assistance, compensation and entitlements, implementation procedures that ensure complaints are processed, public support and participation, and the provision of internal and external monitoring of the implementation of the RAP.

(6) Ethnic minorities and indigenous peoples / Poverty

There may be some poverty areas around the project area. Access to safe drinking water and its utilization may be restricted and gaps for them between areas may be caused. Detailed surveys for the impacts on poverty areas and frequent communication with the poor people are needed to evaluate these impacts. This consideration planning should be planned in the RAP before the construction.

4.3.6.6 Possible Mitigation Measures and Management Plan in WRR VII

As a result of initial evaluation above, possible mitigation measures and the environmental management plan are shown in Table 4.3-79.

Table 4.3-79 Possible Mitigation Measures and Management Plan in WRR VII

No.	Impact Item	Mitigation and Management Measures	Implementer
1	Water Quality and Water Use	<Construction> - Earth works inside and near the water body during the dry season - Temporary cofferdam method at the time of excavation works - Countermeasures for the sediment and turbidity <Operation> - Direct purification of river water by filtration and vegetation purification and excavation of sediment etc. - Prevention of load inflow by protection of dam slope, wastewater treatment and reforestation etc. - Management of discharge flow considering the environmental flow	- Contractor - Manager of facility
2	Sediment	<Operation> - Excavation and dredging of sediment to remove it. - Installation of sediment trap dam at the upstream to prevent its inflow. - Designing sand discharge facility	- Design consultant - Manager of facility
3	Protected Areas and Ecosystems	<Pre-Construction> - Securing of clearance from the Protected Area Management Board (PAMB) of the Central Cebu Protected Landscape (CCPL) <Construction> - Attention to wildlife at the time of site clearance and restricting the loss of vegetation within the project area < Construction / Operation> - Confirmation of the existence of vulnerable species and continuous monitoring - Reforestation	- Contractor - Manager of facility
4	Hydrology	<Construction> - Implementation of appropriate drainage plan <Operation> - Development and implementation of an appropriate water intake plan - Management of water intake amount according to the season change.	- Contractor - Manager of facility
5	Resettlement and Land acquisition / Ethnic minorities and indigenous peoples / Poverty	<Pre-Construction> - Secure accessibility for poverty areas - Assistance to access social welfare and support. - Secure adequate compensation and support indicated in the RAP	- Design consultant - Manager of facility

Source: JICA Survey Team

4.4 Priority Water Resources Region (WRR XI)

4.4 Priority Water Resources Region (WRR XI)

4.4.1 Analysis of Present Status of Water Resources in WRR XI

(1) Present Status of Water Resources

The present status of water resources development and management in the priority water resources regions and the result of the water balance analysis are summarized in Chapter 3.

(2) Summary Results of Water Balance Analysis

In the water balance analysis, the following scenarios and cases are considered for the assessment of the climate change impacts. A summary of the water balance calculation results for the current situation and climate change scenarios (4 cases: current climate and 3 cases of climate change LMH) in WRR XI is shown in Table 4.4-1and Table 4.4-2.

Table 4.4-1 Examination Case of Water Balance Analysis in WRR XI

Scenario	Target Year of Water Demands	Cases and Scenario of Climate Change Impact (RCP8.5)	Countermeasure
Present	2020	Present climate	None
Future (w/o measures)	2050	4 cases No impact (Present climate) & 3scenario (L, M, H)	None
Future (w/measures)	2050 (w/ demand management)	4 cases No impact (Present climate) & 3scenario (L, M, H)	Based on the case in left, water balance and combination of countermeasures is studied.

Source: JICA Survey Team

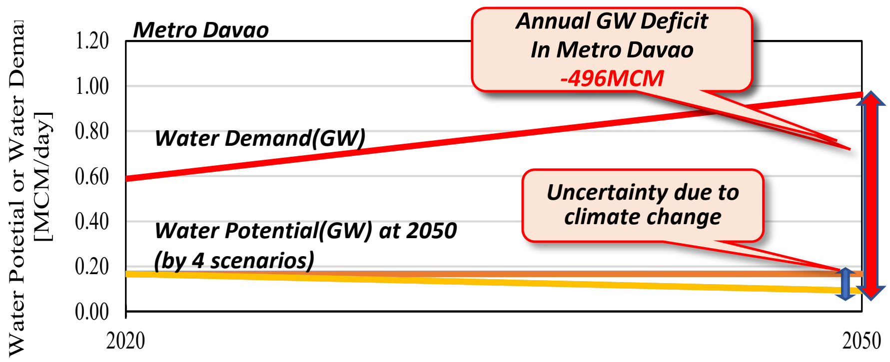
Table 4.4-2 Summary of Water Balance by Province and by Major City (2050 climate change (low), 1/5 drought year) in WRR XI

Province	Annual Water Balance in 2050 (MCM)		
	Surface Water	Groundwater	Total
Agusan del Sur	○ (+795)	○ (+69)	○ (+864)
Bukidnon	○ (+314)	× (-4)	○ (+310)
Davao de Oro (Compostela Valley)	○ (+961)	○ (+14)	○ (+975)
Davao del Norte	○ (+5,632)	○ (+19)	○ (+5,651)
Davao del Sur	○ (+2,561)	× (-479)	○ (+2,082)
Davao Oriental	○ (+10,781)	○ (+11)	○ (+10,792)
Davao Occidental	○ (+578)	○ (+5)	○ (+583)
North Cotabato	○ (+89)	× (-12)	○ (+77)
Sarangani	○ (+911)	× (-12)	○ (+899)
South Cotabato	○ (+2,475)	× (-147)	○ (+2,328)
Sultan Kudarat	○ (+240)	× (-1)	○ (+238)
Surigao del Sur	○ (+4,710)	× (-5)	○ (+4,705)
Whole Area (WRR XI)	○ (+30,048)	× (-541)	○ (+29,507)

Province(s)	Major City	Annual Water Balance (MCM)		
		Surface Water	Groundwater	Total
Davao del Norte/ de Oro/ del Sur/ Occidental/ Oriental	Metro Davao	◯ (+5,146)	× (-496)	◯ (+4,651)
South Cotabato	Metro General Santos	◯ (+2,645)	× (-131)	◯ (+2,514)
Surigao del Sur	Cantilan	◯ (+531)	◯ (+8)	◯ (+539)
	Tandag	◯ (+3,796)	× (-2)	◯ (+3,795)
Davao Oriental	Mati	◯ (+699)	◯ (+2)	◯ (+701)

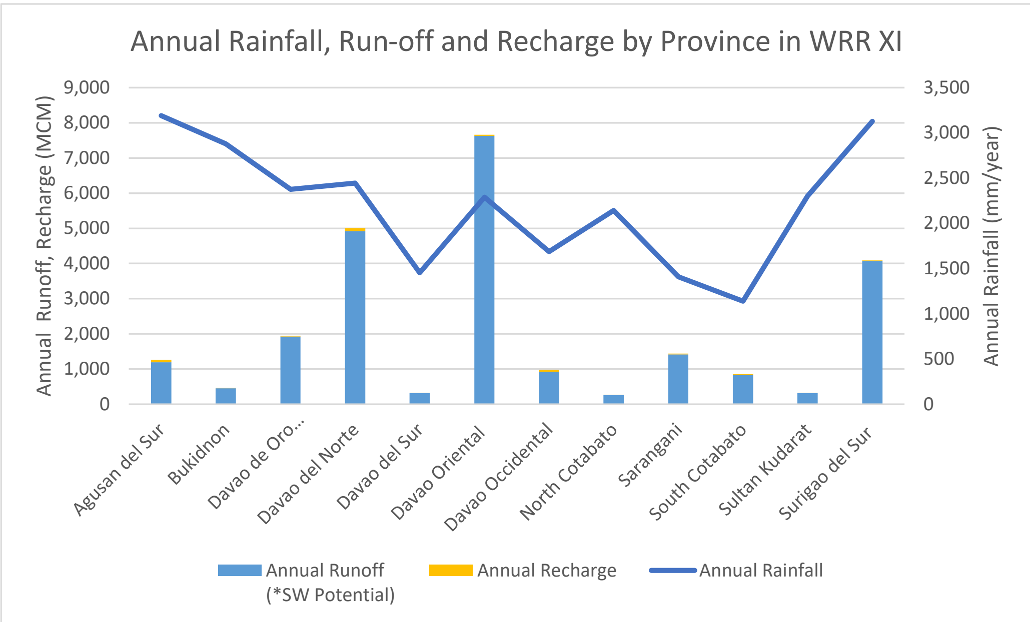
Source: JICA Survey Team

As shown in the table above, there is a marked shortage of groundwater potential in the region, while surface water potential is abundant in the whole region. By municipality, the risk of water shortage in Metro Davao is high; the estimated groundwater shortage is –496 MCM, in case of year 2050, 1/5 drought year, with climate change.



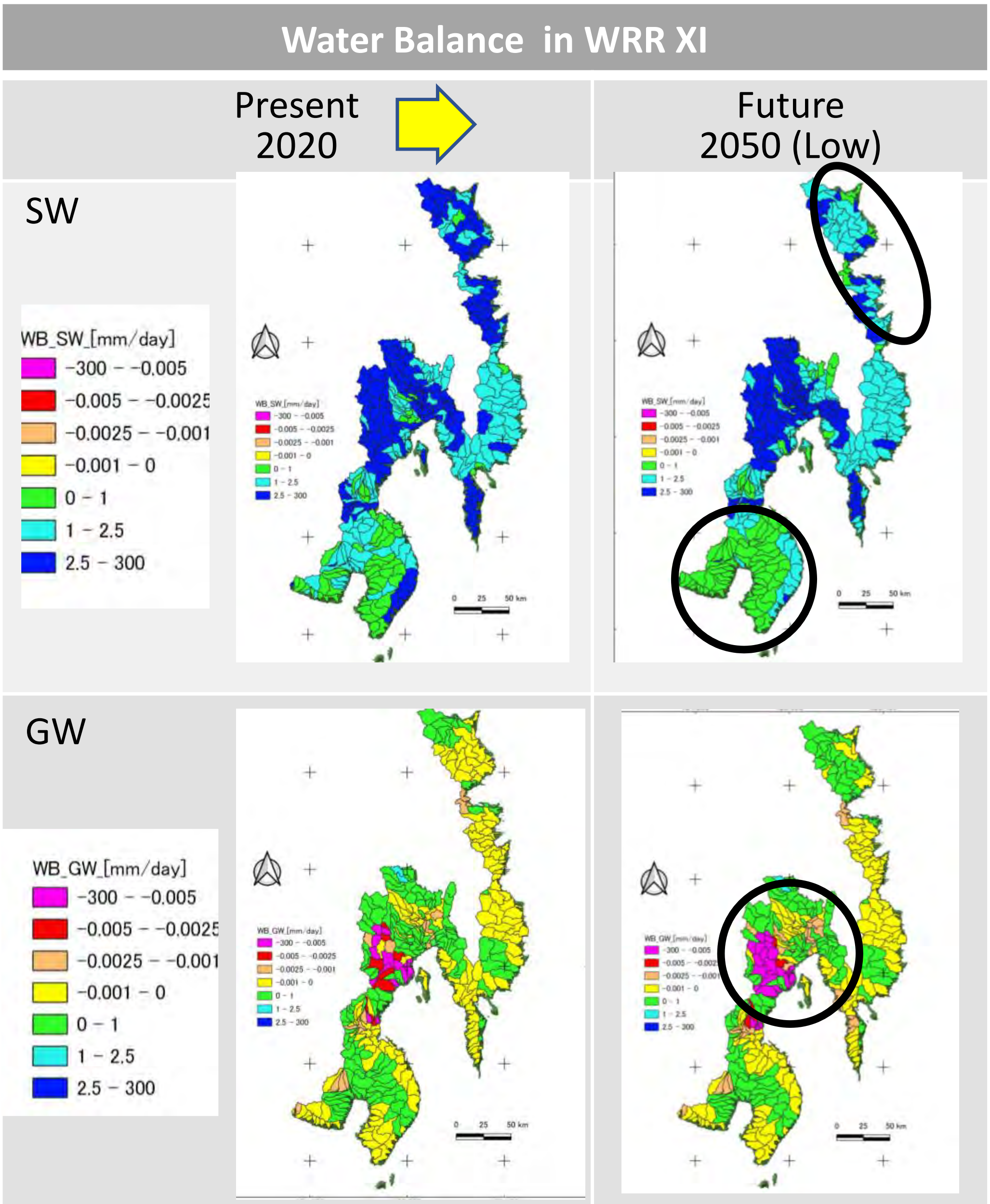
Source: JICA Survey Team

Figure 4.4-1 Prediction of Future Water Balance of Groundwater in Metro Davao



Source: JICA Survey Team

Figure 4.4-2 Water Resources Potential and Annual Rainfall by Provinces in WRR XI



Source: JICA Survey Team

Figure 4.4-3 Overall Location Map of Water Balance Change in WRR XI

(3) Current Water Resources Development Plan

Metro Davao Water District (MDWD) has a water resources development plan by 2030 including PPP (Apo Aguau). However, the proposed development volume in the current plan is not sufficient for the future water demand in 2050 mentioned above. It is necessary to develop other new water resources and convert water sources from groundwater to surface water.

Metro Davao WD plan by 2030

- ✓ **Surface Water : Davao City Bulk Water Supply**
  - ✓ **Part A – Apo Agua: 350 MLD (128MCM/year)**
  - ✓ **Part B – Implemented by MDWD to upgrade the wells and pipelines for the efficient distribution of the bulk water supplied by AAII**
- ✓ **Ground Water: 540MLD (198MCM/year) (←would not be sustainable in future)**
- ✓ **TOTAL (surface water) : 128 MCM (←not sufficient for future water demands of 311 MCM in 2050)**

Projected Supply and Demand, in MLD

Year	DEMAND (in MLD)			SUPPLY (in MLD)			Supply-Demand Ratio	Excess Supply (in MLD)
	Total Water Demand	Bulk Water Required	Groundwater Required	Total Water Supply	Bulk Water Supply	Groundwater Supply		
2022	402	180	222	557	180	377	1.39	155
2023	465	330	134	719	330	389	1.55	254
2024	517	343	174	745	343	402	1.44	228
2025	562	348	214	794	348	447	1.41	232
2026	598	348	251	817	348	469	1.37	219
2027	630	348	282	836	348	488	1.33	206
2028	660	349	311	854	349	505	1.30	195
2029	692	348	344	869	348	521	1.26	177
2030	712	348	364	889	348	541	1.25	177

Source: Metro Davao Water District

Figure 4.4-4 Current Water Resources Development Plan in Metro Davao Water District

4.4.2 Study for Water Resources Development and Management Options in WRR XI

4.4.2.1 Map Survey and Field Investigation of New Water Resources (Dams, Weirs, Possible Reservoirs)

Related information on existing plans including the 1998 M/P proposed projects and new possible water source candidate sites were collected, and a map study referring to topographic maps, geological maps, and land use maps were conducted to find candidate sites of proposed dams, weirs, water conveyance points, and construction roads. In addition, at the stage of scoping down to the more promising candidate sites for water resource, on-site investigations were conducted to check the local situation and collect information from the local stakeholders.

The maximum feasible development capacity was studied while paying attention to the residential houses, land use, and rare flora and fauna at the study site.

The following challenges and strategies in each area were considered and proposed by the Survey Team based on the results of the field investigation, but after discussions with NEDA/NWRB and at the stakeholder meetings, it was established that it was a reasonable policy that the Philippines side could recognize.

(1) Davao River Basin

1) Current Situation

- In Davao River, relatively rich water potential of surface water from large river basin
- Surface water development is being promoted with private funds (Apo Agua)
- Water shortage in Samal Island

2) Challenges

- Future shortage of GW is predicted due to high demands for domestic and industrial water in Metro Davao
- There are some dam plans which need to be reviewed for multi-purpose use

3) Strategy for countermeasure

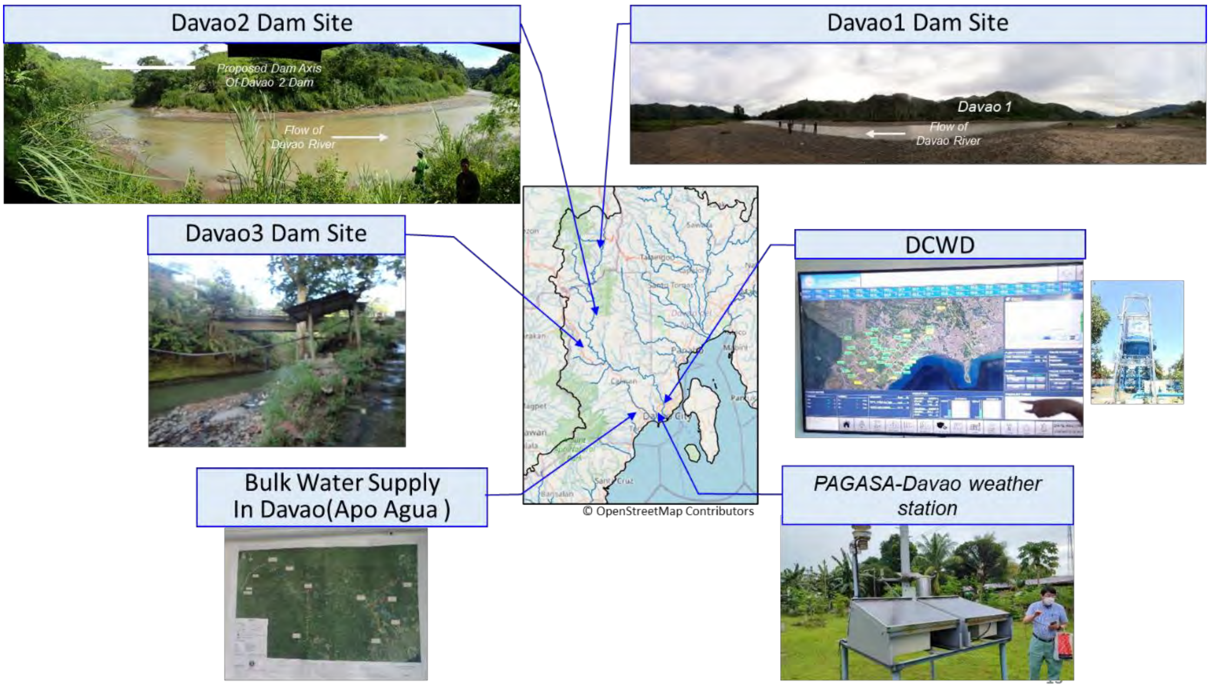
- Necessity of shifting from groundwater to surface water developments
- Sustainable use of groundwater through monitoring and regulation
- Implementation of feasible dam plans after review for multi-purpose use

Result of assessment of water resources facilities in Davao River Basin is presented Table 4.4-3 below.

Table 4.4-3 Result of Assessment of Water Resources Facilities in Davao River Basin

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Davao River Basin	■Existing Dam None	✓
	■Planned Dam [1998M/P]: Davao 1, 2 and 3 [NIA]: Suawan, Pagan	Necessity of revised dam plan; - Davao 3, Suawan, Pagan⇒integrated multi-purpose use - Davao 2 ⇒ detailed survey - Davao 1 Dam is not suitable (topography, land slide, resettlement issues)
	■Existing Water Supply [MDWD]: Groundwater (wells)	✓ Necessity of groundwater monitoring and regulation
	■Bulk Water [MDWD-PPP] Bulk Water from tributary of Davao River (Apo Agua) [PPP] Groundwater (wells) by BP Water, etc.	Water supply by PPP is in progress

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.4-5 Result of Field Investigation and Assessment of New Water Resources in Davao River Basin

(2) Tagum-Libuganon River Basin

1) Current Situation

- In Tagum-Libuganon River, there is relatively rich water potential of surface water from large river basin.
- Surface water development is being promoted with private funds (Tagum Bulk Water Supply by Manila Water).

2) Challenges

- There is a trend of declining groundwater due to high demands for domestic and industrial water in Tagum City.
- Although there is a dam plan (Locutan Dam) upstream of the Tagum River, it is not suitable because the planned water storage site is located within banana plantation areas.
- The irrigation area has problems of flood and drainage.

3) Strategy for countermeasure

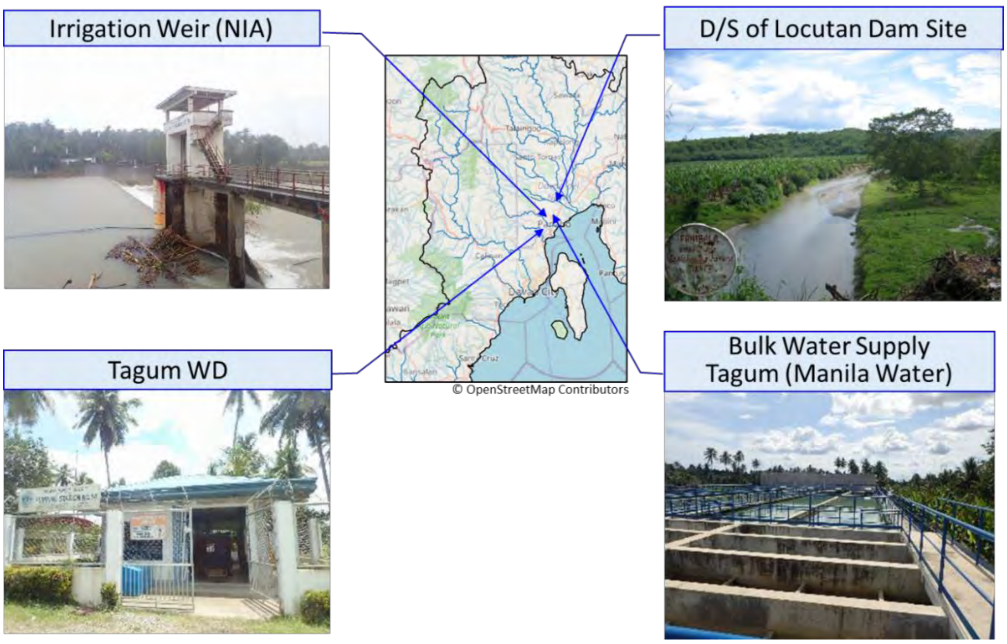
- Necessity of shifting from groundwater to surface water developments
- Sustainable use of groundwater through monitoring and regulation

Result of assessment of water resources facilities in Tagum-Libuganon River Basin is presented below.

Table 4.4-4 Result of Assessment of Water Resources Facilities in Tagum-Lubuganon River Basin

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Tagum-Libuganon River Basin	■Existing Dam None (only irrigation weir)	
	■Planned Dam [DPWH]: Locutan dam	✓ Planned Locutan Dam is not suitable (land use issue)
	■Existing Water Supply [Tagum WD]: Groundwater (wells) [PPP] Bulk Water from Hijo River (Tributary of Tagum River) (by Manila Water)	✓ Necessity of groundwater monitoring and regulation

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.4-6 Result of Field Investigation and Assessment of New Water Resources in Tagum-Libuganon River Basin

(3) Davao del Sur

1) Current Situation

- Relatively rich water potential of surface water over alluvial fan at the foot of Mt. Apo
- NIA develops irrigation areas with headworks
- Hydropower developments in Tudaya and Tagum Rivers by PPP

2) Challenges

- Miral dam (NIA) has been almost fully silted. Since 2012, the outlet was clogged due to sedimentation, and operation is run-off through type. Cultivation in the watershed causes large amount of soil erosions.
- According to NIA, there is a shortage of irrigation water during dry season. There are some proposed irrigation dam plans (SRIP).

3) Strategy for countermeasure

- Implementation of countermeasures for sedimentation and watershed management in Miral Dam.
- Continuous irrigation development with coordination with hydropower developments.

Result of assessment of water resources facilities in Davao del Sor is presented below.

Table 4.4-5 Result of Assessment of Water Resources Facilities in Davao del Sur

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Davao del Sur	■Existing Dam [NIA]: Miral, Headworks [PPP]: for Hydropower (Tudaya HP)	✓ Sedimentation in existing dams（⇒Dam upgrading, desiltation, Hydropower)
	■Planned Dam [NIA]: Cocong Bacaca in Kiblawan, Absang Dam in Matanao	✓ No inspection
	■Existing Water Supply	✓ No inspection

Source: JICA Survey Team

Source: JICA Survey Team

Figure 4.4-7 Result of Field Investigation and Assessment of New Water Resources in Davao del Sur

(4) General Santos City

Main findings of the field investigation and results of assessment of water resources facilities in General Santos City are presented in tables below.

1) Current Situation

- Relatively rich water potential in an alluvial fan surrounded by Buayan-Maulungan River and mountains.
- Main water source of GSWD is groundwater with 65 MLD (23.7 MCM) with service coverage of 30% (210,000 people). NRW ration is 29%, and there is a pilot project to improve NWR.
- No problem of deterioration of groundwater, water quality, saltwater intrusion, and land subsidence except for a water quality (color) problem of wells in the eastern region.

2) Challenges

- Increase of demand for domestic water in General Santos City.
- There was a surface water development plan in the Buayan River (by USAID), but it was evaluated as economically not viable.

3) Strategy for countermeasure

- Continuous groundwater & surface water developments by weirs are recommended.
- Continuous NWR improvements for more effective use of surplus water potential

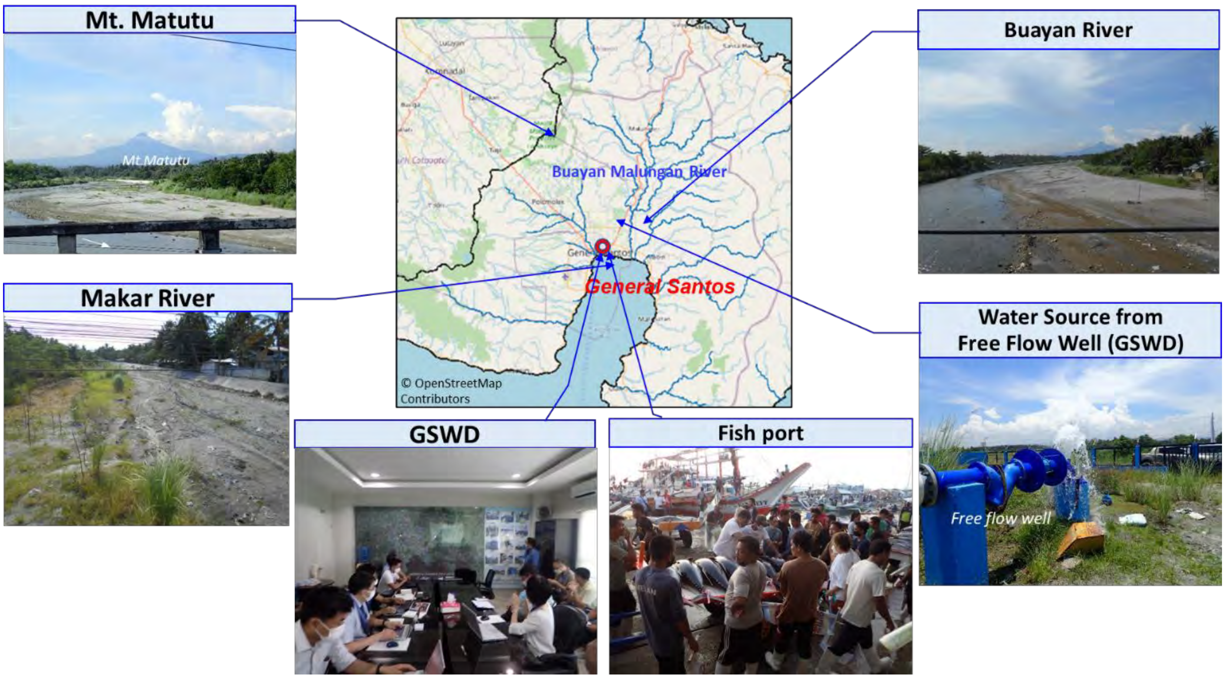
- There are topographically and hydrologically favorable candidate dam sites. In the future, multi-purpose use such as power generation, irrigation, and water utilization will be considered as required.

Result of assessment of water resources facilities in General Santos City is presented in the tables below.

Table 4.4-6 Result of Assessment of Water Resources Facilities in General Santos City

Area	Water Resources Facilities	Result of Field Investigation and Assessment
General Santos City	■Existing Dam None	
	■Planned Dam [GSCWD]: Buayan Dam	✓ Buayan Dam was evaluated as not economical in the past study
	■Existing Water Supply [GSCWD]: Groundwater wells	✓ NRW improvement (⇒ in progress) ✓ Needs for GW development

Source: JICA Survey Team

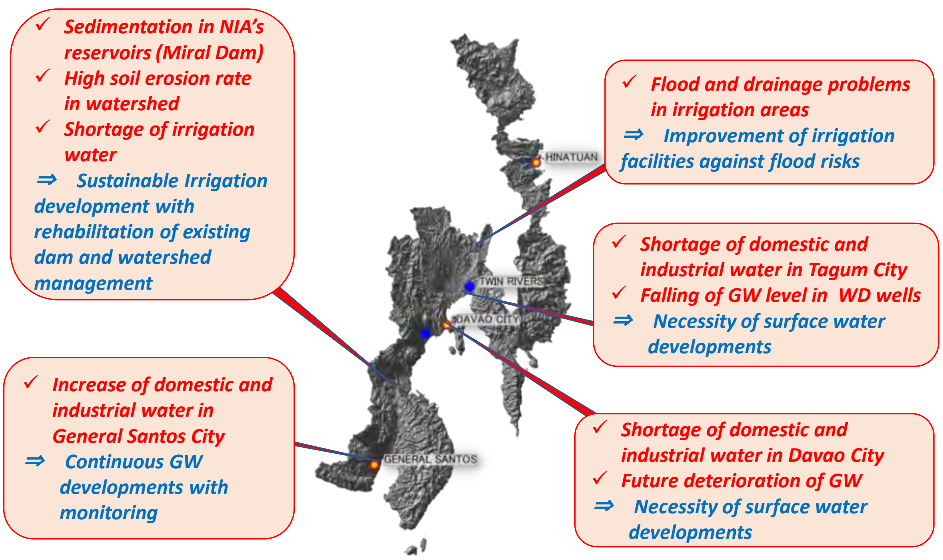


Source: JICA Survey Team

Figure 4.4-8 Result of Field Investigation and Assessment of New Water Resources in General Santos City

(5) Results of Map Survey and Field Investigation

Overall results of the map survey and field investigation of water resources facilities in WRR XI are summarized in Figure 4.4-9 below.

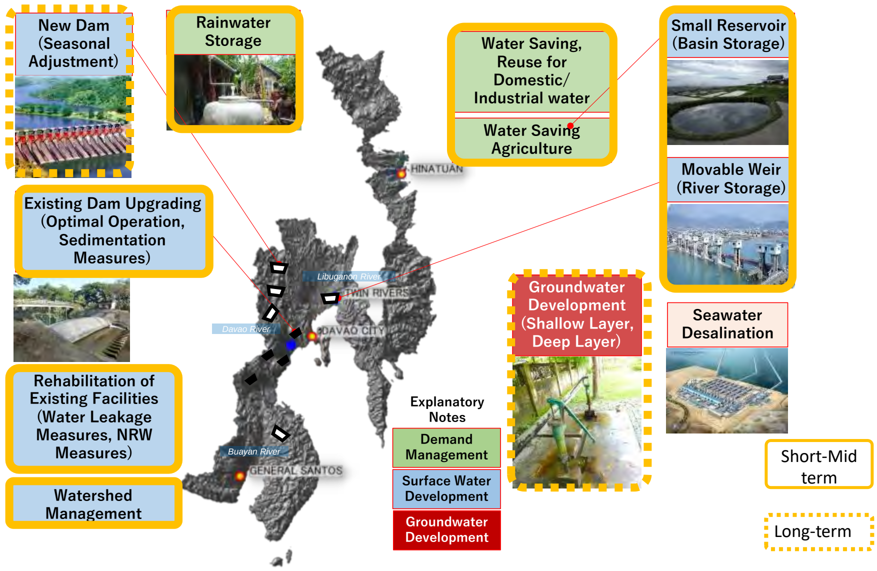


Source: JICA Survey Team

Figure 4.4-9 Result of Field Investigation and Assessment of Water Resources in WRR XI

4.4.2.2 Alternative Study for New Water Resources Development Options (First Screening)

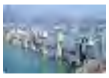
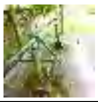
Possible individual countermeasures are formulated as shown in Figure 4.4-10 and Table 4.4-7. For these measures, primary screening is conducted to compare the adoptability based on the map survey and the field survey results to select multiple realistic plans. In the areas where water sources are limited, demand management should be included as one of the options to be considered.



Source: JICA Survey Team

Figure 4.4-10 Individual Countermeasures for Water Sources and Water Utilization Facilities in WRR XI

Table 4.4-7 Result of First Screening of Countermeasures of Water Source Development Options (WRR XI)

Countermeasure Plan		Surface Water Development				Groundwater Development		Seawater Desalination	Water Saving (Demand management)
		Dam/Reservoir	Movable Weir	Small Pond	Inter-basin Diversion	Shallow Layer	Deep Layer		
Overview		Control structure with seasonal discharge	Structures for bulk water and local irrigation	Structures for local irrigation	Proposed in the existing plan	Currently implemented locally	Groundwater deeper than existing wells	Complementary measures when the amount of water is low	Water-saving agriculture, water leakage, etc.
									
Adoptability	Short-term	×	◎	○	×	○	△	×	◎
	Mid-term	○ Dam Upgrading/ Davao3 Dam	○	○	×	△	○	×	◎
	Long-term	○ (Davao 2 Dam)	○	○	×	△	○	△ Davao	◎

Legend: ◎Very Effective, ○Effective, △Somewhat Effective, ×Not Subject to Consideration (based on assessment for the adaptability based on the map survey and the field survey results)
Source: JICA Survey Team

Among these countermeasures, the applicability was first evaluated qualitatively. For those that have applicability, secondary screening is proceeded with different criterion such as amount of water to be developed.

4.4.2.3 Water Balance Analysis of Countermeasures

Assuming basic countermeasure alternatives that combine the above options that consider staged development for the short-term, medium-term, and long-term, water balance analysis for each alternative options are performed using the hydrological analysis model. In this way, the amount of water that can be developed and the scale of the facility can be examined.

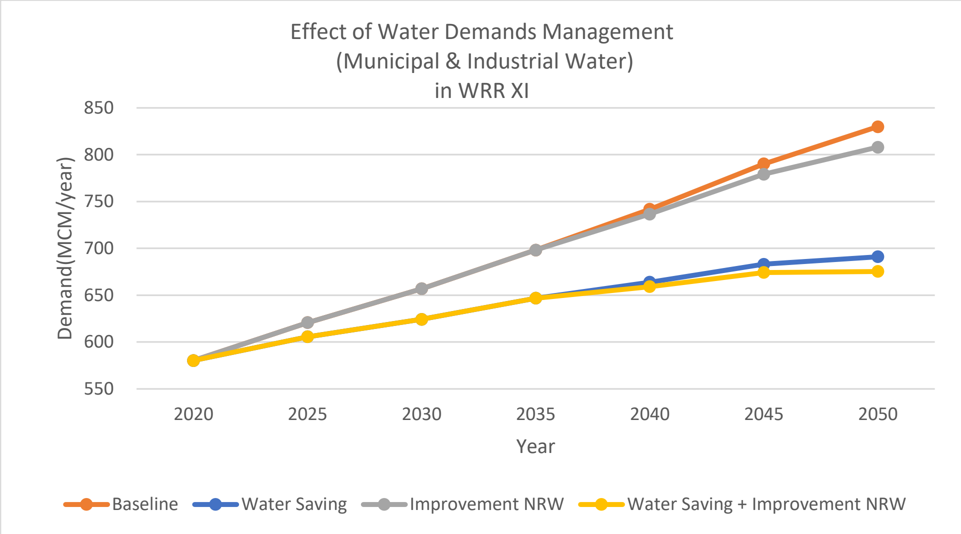
(1) Concept and Procedure for Measures to Improve Water Balance

The same concept and procedure for measures to improve the balance of water and supply in Cebu as mentioned in Section 4.3.2.3 is applied.

(2) Measures 1 (Water Demand Managements)

1) Demand Management (Municipal and Industrial Water Use)

As for the demand management measures for municipal and industrial water use, water saving, and enhancement of non-revenue water measures as described in 4.3.3.6 are considered to be applied. The reduction effect is estimated as 19% in total in whole WRR XI as shown in figure below.



Water Resource Region		Municipal & Industrial Water Demand Projection (MCM/Year)							Reduction Effect in 2050
		2020	2025	2030	2035	2040	2045	2050	
WRR XI - SOUTHEASTERN MINDANAO	Baseline	580	621	657	698	742	790	830	100%
	Water Saving	580	606	624	647	664	683	691	83%
	Improvement NRW	580	621	657	698	737	779	808	97%
	Water Saving + Improvement NRW	580	606	624	647	659	674	675	81%

Source: JICA Survey Team

Figure 4.4-11 Reduction Effect of Demands Management (Municipal and Industrial Water Use) in WRR XI

2) Demand Management (Irrigation Water Use)

As for the demand management measures for irrigation water use, waterway leakage countermeasures, irrigation efficiency improvement by introducing ITS as described in 4.3.3.5 are considered to be applied. The reduction effect is estimated as 7.9% in total in the whole WRR XI as shown in Table 4.4-8 below.

Table 4.4-8 Reduction Effect of Demands Management (Irrigation Water Use) in WRR XI

WRR XI (Region XI and parts of Regions X, XII and XIII)

Province	Irrigated Area (ha)		Without measures	With measures	Without - With	
	Wet	Dry	Irrigation Water Demands in 2050 (MCM)		Reduction of Irrigation Water Demands in 2050 (MCM)	
Bukidnon	2,852	2,829	42	39	3	6.0%
Compostela Valley	80,415	80,415	694	628	65	9.4%
Davao del Norte	24,378	24,378	425	386	39	9.1%
Davao del Sur	27,246	26,974	664	616	49	7.4%
Davao Oriental	14,819	14,925	310	286	24	7.6%
Sarangani	5,588	5,204	110	110	0	0.0%
South Cotabato	77,194	76,266	612	567	45	7.3%
North Cotabato	116,810	116,299	105	97	8	7.5%
Sultan Kudarat	42,056	34,388	41	40	1	2.3%
Agusan del Norte	39,509	39,331	22	20	2	7.7%
Agusan del Sur	45,471	43,974	97	92	5	5.6%
Surigao del Sur	34,637	31,079	559	507	52	9.3%
Sub Total	**510,973**	**496,061**	**3,681**	**3,389**	**291**	**7.9%**

Source: JICA Survey Team

3) Total Demand Management

The reduction of total water demand adopting both of 1) and 2) measures is summarized by each province as shown in Table 4.4-9 below.

Table 4.4-9 Reduction of Total Water Demand adopting Demand Management Countermeasures by Province in WRR XI

Province	SW/GW	Without	With	Without-With	
		Total Demand	Total Demand	Reduction of Total Demand	
		[MCM/day]	[MCM/day]	[MCM/day]	[%]
Agusan del Sur	SW	100.2	94.7	5.5	5%
	GW	1.1	1.1	0.0	1%
	Total	101.3	95.8	5.5	5%
Bukidnon	SW	52.7	47.4	5.3	10%
	GW	6.0	4.0	2.0	33%
	Total	58.7	51.4	7.3	12%
Davao de Oro	SW	733.3	669.5	63.8	9%
	GW	5.3	5.0	0.3	5%
	Total	738.6	674.5	64.1	9%
Davao del Norte	SW	518.9	455.3	63.6	12%
	GW	45.5	29.2	16.3	36%
	Total	564.4	484.5	79.9	14%
Davao del Sur	SW	713.2	655.5	57.7	8%
	GW	492.7	242.8	249.9	51%
	Total	1,206.0	898.3	307.6	26%
Davao Oriental	SW	354.3	325.3	28.9	8%
	GW	12.7	11.7	0.9	7%
	Total	366.9	337.1	29.8	8%
Davao Occidental	SW	19.8	16.2	3.6	18%
	GW	10.0	8.1	1.9	19%
	Total	29.8	24.3	5.4	18%
North Cotabato	SW	108.3	106.2	2.1	2%
	GW	13.0	8.0	5.0	39%
	Total	121.3	114.2	7.1	6%
Sarangani	SW	154.1	153.7	0.4	0%
	GW	14.9	14.7	0.2	1%
	Total	169.0	168.5	0.6	0%
South Cotabato	SW	643.0	598.5	44.5	7%
	GW	165.6	165.6	0.0	0%
	Total	808.6	764.1	44.5	6%
Sultan Kudarat	SW	42.5	41.5	1.0	2%
	GW	1.8	1.7	0.1	3%
	Total	44.3	43.2	1.1	2%
Surigao del Sur	SW	587.8	535.9	51.9	9%
	GW	16.5	16.5	0.0	0%
	Total	604.3	552.4	51.9	9%
WRR-XI all	**SW**	**4,028.2**	**3,699.7**	**328.4**	**8%**
	GW	**785.1**	**508.6**	**276.5**	**35%**
	Total	**4,813.2**	**4,208.3**	**604.9**	**13%**

Note: Present Climate, 2050, 1/5-dry year
Source: JICA Survey Team

(3) Required Storage Volume for Reservoir Operation

To calculate the amount of development water necessary to cover the shortage of water supply and demand in 2050, even if the water demand adjustment program is to be implemented, reservoir operation study is conducted assuming the existence of the proposed dam site upstream. The following conditions are applied for the calculation:

- Water safety level: 1-10 year for municipal and industrial water
- Development site: proposed dam sites in the upstream of high demand area (see Subsection 4.5.3.2 below)
- Calculation method: Reservoir operation analysis is performed using daily flow data for 42 years (1981 to 2022) calculated by the water balance calculation model (SHER) at the proposed dam site. Based on the result of the analysis, the amount of water supply from the reservoir to satisfy the require water safety level (developable discharge) in the downstream demand areas is estimated.

Details are given in Annex D Chapter 13.

4.4.2.4 Comparison of Alternative Options

(1) Evaluation Criteria

As mentioned in Section 4.3.2.4, the evaluation criteria for screening of WRDM Plan (idea) and Priority Project Concepts were established through series of discussions with NEDA and NWRB.

(2) Alternative Options of Water Resources Development

Based on the results of the detailed water balance calculations in the previous chapter, as well as the results of the map studies, field surveys, and interviews with concerned organizations, the alternative options of water resources developments for each area in WRR XI were set and evaluated as shown in Table 4.4-10.

Table 4.4-10 Alternative Options for Water Resources Development and Management in WRR XI

Sector	Options	Davao River/ Davao City	Tagum-Libuganon River/ Tagum City	Buayan-Malungan River/ General Santos
Surface Water	Dam/Small Pond (WS)	Davao 1 Dam Davao 2 Dam Davao 3 Dam	-	-
	Dam/Small Pond (IR)	Suawan Dam (SRIP) Pagan Dam (SRIP) Cogon Bacaca Dam (SRIP) Absang Dam (SRIP) Linoan Dam (SRIP) Upper Saug Dam (RIP) Awano Dam (SRIP)	-	-
	Dam/Small Pond (FC)	Davao Flood Control Dam	Locutan Dam Gupitan Dam	Buayan Dam Dumolog Dam Maribulan Dam
	Upgrading of Existing Dam	Miral Dam	-	-

Sector	Options	Davao River/ Davao City	Tagum-Libuganon River/ Tagum City	Buayan-Malungan River/ General Santos
	Inter-basin Diversion	None	None	None
	Irrigation Weir	NIA's plan (SRIP/IP)		
Groundwater Development		Deep wells Recharge facilities		
Water Supply Development		Bulk water Seawater desalination Recycle sewerage water		
Demand Management	Municipal and Industrial Water Use	Measures for non-revenue water Promotion of water saving Improvement of recycle rate of industrial water Rainwater harvesting Monitoring of groundwater		
	Irrigation Water Use	Modernization of irrigation system Measures for water leakage of irrigation canals		

Source: JICA Survey Team

(3) Results of Comparison Alternatives

Applying the afore-mentioned evaluation criteria, a comparative evaluation of the alternative options for each of the above areas was carried out. The result of the comparison is shown in Table 4.4-11 below.

The alternative options listed in the Table 4.4-11 are items that were studied in past master plans and development plans in the Philippines, as well as items that were newly brought up in exchanging opinions with related organizations involved in this Survey. These proposed measures were the comprehensive ones selected through explanation and discussions with NEDA/NWRB and other related agencies and stakeholders in the Survey.

Table 4.4-11 Result of Comparison of Alternative Options in WRR XI

Alternative Plans of Water Resrouces Development			Evaluation Criteria*1									
ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**	**10**		
XI-DV-D-1	WS	Construction of Davao 1 Dam	3	4	4	1	2	1	2	17	25	x
XI-DV-D-2	WS/IR/FC	Construction of Davao 2 Dam(Multi-purpose)	4	5	5	3	2	2	2	23	33	△
XI-DV-D-3	WS/IR	Construction of Davao 3 Dam (High)	4	4	4	3	2	1	2	20	28.5	x
XI-DV-D-4	WS/IR	Construction of Davao 3 Dam (Low)	4	3	3	3	2	2	3	20	29.5	O
XI-DV-D-5	IR	Construction of Suawan Dam (SRIP)	3	-	-	3	4	2	3	15	21.5	△
XI-DV-D-6	IR	Construction of Pagan Dam (SRIP)	3	-	-	3	4	2	3	15	21.5	△
XI-DV-D-7	IR/HP	Construction of Cogon Bacaca Dam@Kiblawan (SRIP)	3	2	2	3	4	2	3	19	26.5	x
XI-DV-D-8	IR	Construction of Absang Dam@Matanao (SRIP)	3	-	-	3	4	-	3	13	17.5	x
XI-DV-D-9	IR	Construction of Linoan Dam (SRIP)	3	-	-	3	4	-	3	13	17.5	x
XI-DV-D-10	IR	Construction of Upper Saug Dam (RIP)	3	-	-	3	4	-	3	13	17.5	x
XI-DV-D-11	IR	Construction of Awano Dam (SRIP)	3	-	-	3	4	-	3	13	17.5	x
XI-DV-D-12	FC	Construction of Davao Flood Control Dam (Flood Control)	4	4	4	3	5	1	2	23	31.5	△
XI-DV-D-13	IR	Upgrading of Miral Dam	4	2	2	3	4	4	3	22	33	O
XI-DV-D-14	IR	Construction of Irrigaion Weirs	3	2	4	5	4	4	4	26	35	O
XI-DV-D-15	WS	Bulk Water Development	3	2	2	5	3	4	4	23	32	O
XI-DV-D-16	WS	Construction of Desalination Plants	3	2	3	2	3	3	3	19	28	△
XI-DV-D-17	GW	Recycle of Sewerage Water	3	3	2	2	3	3	3	19	28.5	△
XI-DV-D-18	GW	Groundwater Development (Deep Wells)	3	1	4	5	3	4	2	22	29.5	x
XI-DV-D-19	GW	Groundwater Development (Recharge Facilities)	2	3	2	2	3	3	3	18	26	x

	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**	**10**		
	FC	Construction of Loctan Dam (Flood Control)	3	3	3	2	5	1	2	19	26	x
	FC	Construction of Gupitan Dam (Flood Control)	3	3	5	2	5	1	2	21	28	x
	IR	Construction of Irrigation Weirs	3	2	4	5	4	4	4	26	35	O
	WS	Bulk Water Development	3	2	2	5	3	4	4	23	32	O
	WS	Construction of Desalination Plants	2	2	3	2	3	3	3	18	25.5	O
	GW	Recycle of Sewerage Water	2	3	2	2	3	3	3	18	26	x
	GW	Groundwater Development (Deep Wells)	3	1	4	5	3	2	2	20	25.5	x
	GW	Groundwater Development (Recharge Facility)	2	3	2	2	3	3	3	18	26	x

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	**1.5**	**1**	**0.5**	**1**	**2**	**1.5**	**10**		
XI-BU1998	Multi	Construction of Dimloc Dam (Multi-purpose) in 1998M/P										
XI-BU-D-1	FC	Constuction of Buayan Dam (Flood Control)	3	3	2	2	5	1	2	18	25	x
XI-BU-D-2	FC	Constuction of Dumolog Dam (Flood Control)	3	3	3	2	5	1	2	19	26	x
XI-BU-D-3	FC	Constuction of Maribulan Dam (Flood Control)	3	2	2	3	5	2	3	20	27.5	x
XI-BU-D-4	IR	Construction of Irrigaion Weirs	3	2	4	5	4	4	4	26	35	O
XI-BU-D-5	WS	Bulk Water Development	3	2	2	5	3	4	4	23	32	O
XI-BU-D-6	WS	Construction of Desalination Plants	2	2	3	2	3	3	3	18	25.5	x
XI-BU-D-7	GW	Recycle of Sewerage Water	2	3	2	2	3	3	3	18	26	x
XI-BU-D-8	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	24	33.5	O
XI-BU-D-9	GW	Groundwater Development (Recharge Facilities)	2	3	2	2	3	3	3	18	26	○

Note: IR: Irrigation, WS: Water Supply, GW: Groundwater, FC: Flood Control, HP: Hydropower

Source: JICA Survey Team

(4) Selected Options

Selected water resources development options and water resource management options are shown in Table 4.4-12 and Table 4.4-13 below.

Table 4.4-12 Selected Plans for Water Resources Development in WRR XI

No	Proposed Measures	Location	Responsible Organization	Sector /Purpose	Implementation		
					Short	Medium	Long
1	Construction of Davao 2 Dam	Davao	NIA11/DPWH 11/MDWD -	Multi WS/IR/FC	-	Study	○
2	Construction of Davao 3 Dam	Davao	NIA11/ MDWD	Multi WS/IR	Study	○	-
3	Upgrading of Miral Dam	Davao	NIA11	IR	○	○	-
4	Construction of Irrigation Weirs	-	NIA11	IR	○	○	○
5	Bulk Water Development	-	Related Water Utilities	WS	○	○	○
6	Construction of Desalination Plants	Davao	MDWD	WS	●	○	○
7	Recycle of Sewerage Water	Davao	LGUs	GW	-	Study	○
8	Groundwater Development (Deep Wells)	-	Related Water Utilities	GW	Study	○	-

Note: ●With exiting plan, ○: Newly proposed plan, IR: Irrigation, WS: Water Supply, GW: Groundwater, FC: Flood Control

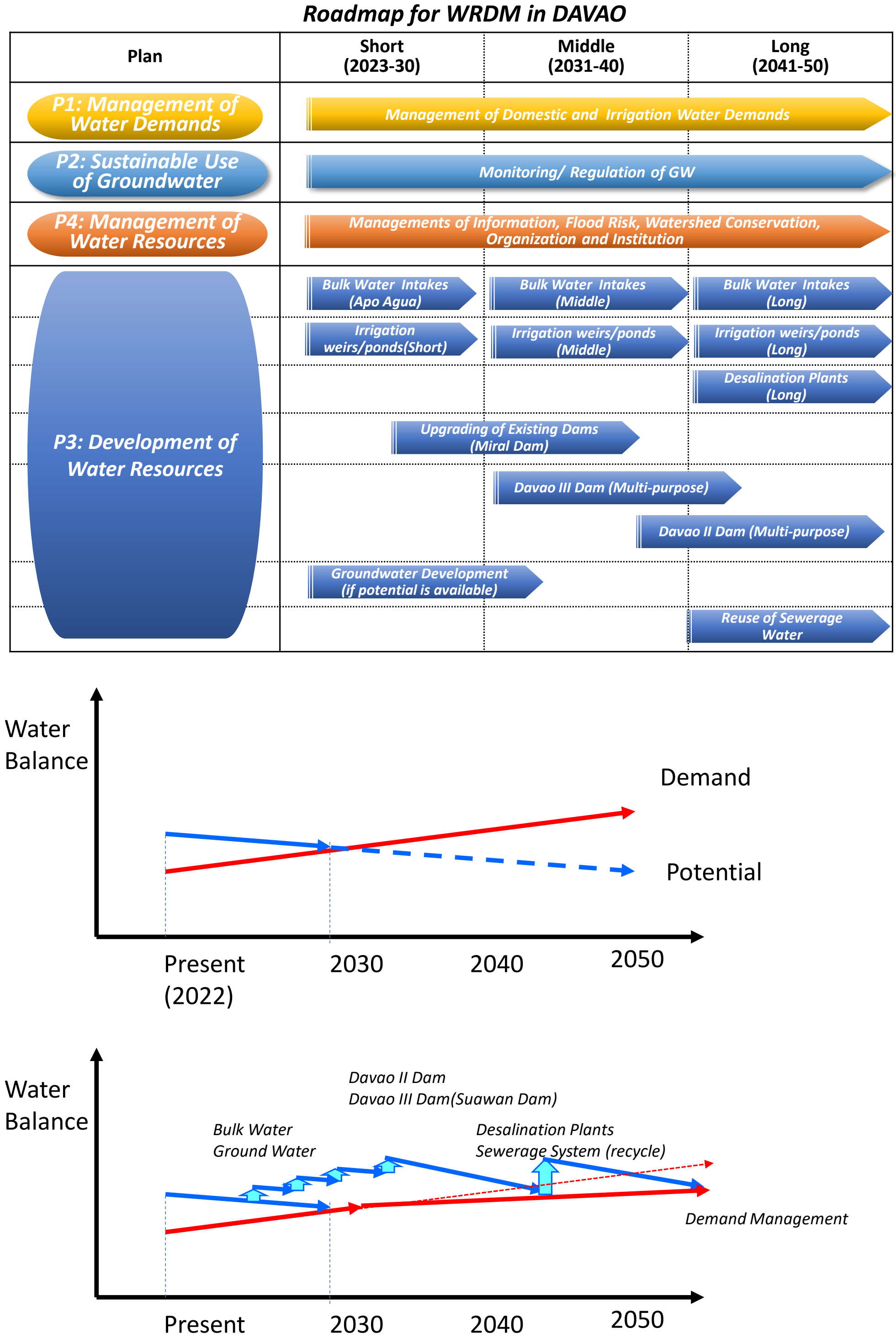
Source: JICA Survey Team

Table 4.4-13 Selected Plans for Water Resources Management in WRR XI

No	Proposed Measures	Location	Responsible Organization	Sector	Implementation		
					Short	Medium	Long
1	Measures for Non-Revenue Water	all	Related Water Utilities	WS	○	○	○
2	Promotion of Water Saving	all	Related Water Utilities w/ Public Promotion Activities	WS	○	○	○
3	Improvement of Recycle Rate of Industrial Water	all	Industrial Water Users	WS	○	○	○
4	Measures for Water Leakage of Irrigation Canals	all	NIA & Related Irrigation Associations	IR	○	○	○
5	Modernization of Irrigation System	all	NIA & Related Irrigation Associations	IR	○	○	○
6	Rainwater Harvesting	all	Related Irrigation Associations	SW	○	○	○
7	Monitoring of Groundwater	all	NWRB	GW	○	○	○
8	Regulation of Groundwater Use	all	NWRB	GW	○	○	○

Note: ●With exiting plan, ○: Newly proposed plan, IR: Irrigation, WS: Water Supply, GW: Groundwater

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.4-12 Road Map (idea) for Water Resources Development and Management Plan in WRR XI

4.4.3 Proposal for Water Resources Development and Management Plans (idea) in WRR XI

4.4.3.1 Composition of the Plan

Composition of the water resources development and management plan (idea) in WRR XI is same as WRR VII as described in sub section 4.3.3.1.

4.4.3.2 Surface Water Development Plan in WRR XI

(1) List of Priority Proposed Dams

As surface water development plan for WRR XI, the following dams were selected in the primary screening of the current and planned dams and reservoirs described in Chapter 3. These dams are preliminary reviewed for their layout, size, and estimated construction costs.

Table 4.4-14 List of Priority Proposed Dams (WRR XI)

Name of Island	Mindanao	Mindanao	Mindanao
Name of Dam	Davao-II	Davao-III	Davao-III (Low)
Name of River	Davao	Davao	(Same as left)
Catchment Area	814 sq.km	151 sq.km	(Same as left)
Flood Discharge (100-Yr Design)	2,510 cu.m/sec	1,100 cu.m/sec	(Same as left)
Dam Type	Rockfill	Rockfill	(Same as left)
Dam Height (Approximately)	130m	140m	62m
Dam Top Elevation	EL.437.5m	EL.499.5m	EL.421.5m
Dam Crest Length	707m	467m	270m
Dam Volume	12.9 M.cu.m	10.5 M.cu.m	1.2 M.cu.m
Upstream Slope ratio	1:3.0	1:3.0	(Same as left)
Downstream Slope ratio	1:2.5	1:2.5	(Same as left)
Foundation bedrock Elevation	EL.300.0m	EL.370.0m	(Same as left)
Foundation bedrock properties	bedrock	good sedimentary rock outcrops (mudstone)	(Same as left)
Channel bottom Elevation (Crest EL. Spillway)	EL.437.5m	EL.488.5m	EL.410.5m
Area of Resorvoir	6,125.6 ha	571.9 ha	56.1 ha
Capacity of Reservoir	2,537.7 M.cu.m	215.8 M.cu.m	11.5 M.cu.m
Minimum Operation WL. (Top of Dead Storage)	EL.340.2m	EL.429.8m	EL.408.4m
Dead Storage Volume (Sediment Yield 100%)	72.6 M.cu.m	19.6 M.cu.m	5.5 M.cu.m
Dam Coordinates (Latitude)	7° 24' 10.516"N	7° 15' 22.074"N	(Same as left)
Dam Coordinates (Longitude)	125° 20' 11.193"E	125° 18' 50.508"E	(Same as left)
Total Construction Cost	**25,684 M.PHP**	**20,844 M.PHP**	**2,314 M.PHP**

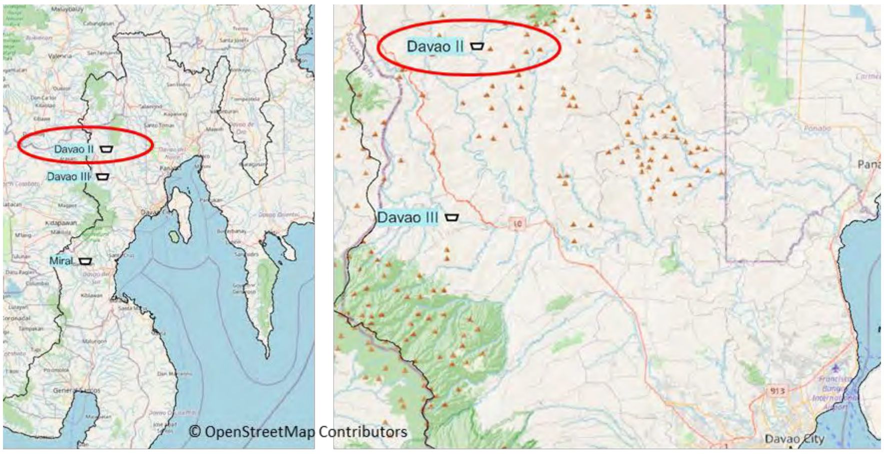
Source: JICA Survey Team

(2) 1) Outline Layout Study

1) Davao-II Dam

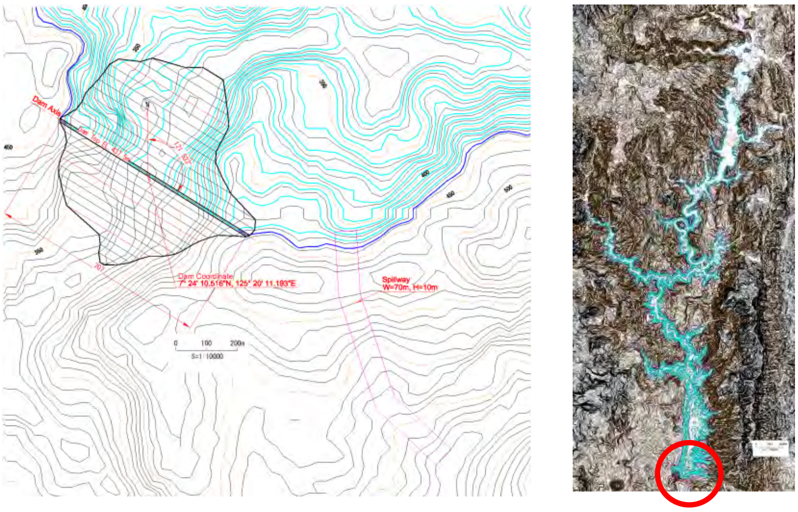
The dam axis position is according to the master plan presented in the JICA (1998) report. It is located north of Davao City, upstream of the main Davao River. Location map and layout plan are show in figures below.

Dam facility layout plan, cross section, water utilization facility, sedimentation, resettlement, and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



Source: JICA Survey Team

Figure 4.4-13 Location Map (Davao-II Dam)

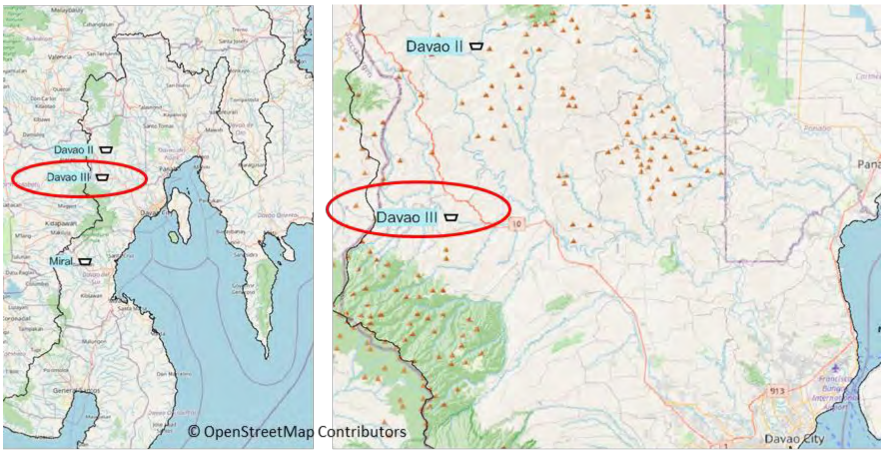


Source: JICA Survey Team

Figure 4.4-14 Layout Plan (Davao-II Dam and Reservoir)

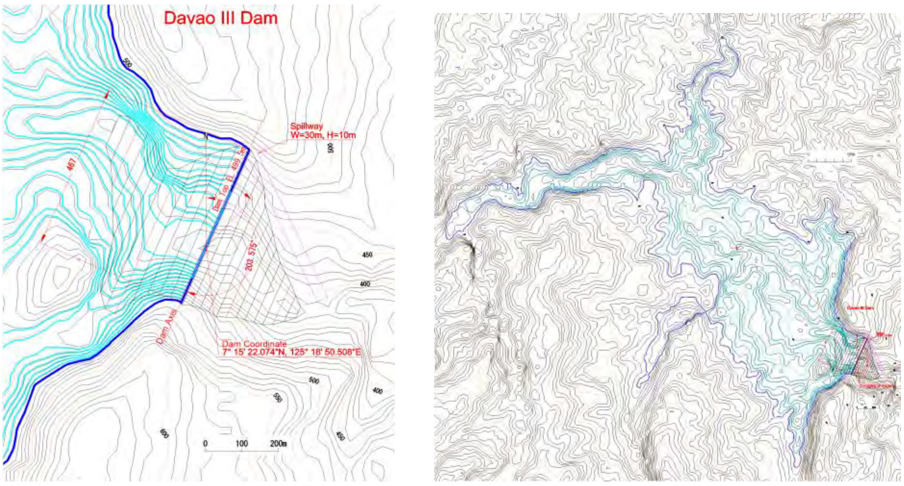
2) Davao III Dam

Since the dam axis location of the Davao-III Dam indicated in the JICA (1998) report has a small storage capacity, the dam axis location was considered to be about 2.4km upstream from the location in this survey. It is in the middle of the Suawan River, the right tributary of the Davao River, north of Davao City. Location map and dam facility layout plan are shown in figures below. The dam cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



Source: JICA Survey Team

Figure 4.4-15 Location Map (Davao-III Dam)



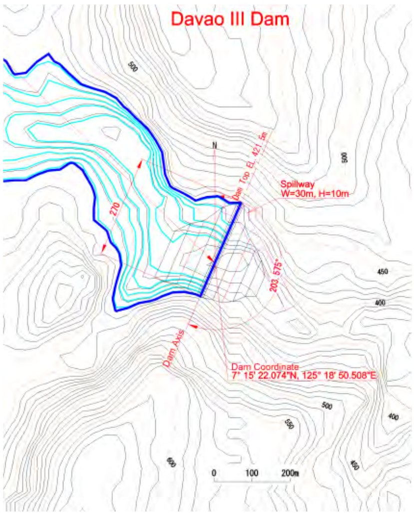
Source: JICA Survey Team

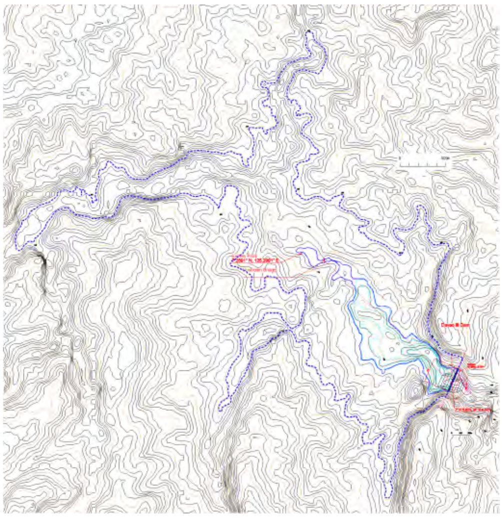
Figure 4.4-16 Layout Plan (Davao-III Dam (High) and Reservoir)

3) Davao III Dam (Low)

The original Davao III Dam has a large development scale and requires relocation of the main road upstream, so the dam height is planned to be lowered to 51.5m in order to prevent the main road bridge from submerging. The location of the dam is as same as that of Davao III Dam (high).

Dam facility layout plan is shown in the figure below. The dam cross section, water utilization facility, sedimentation, resettlement, and land acquisition of reservoir of the proposed dam are presented in ANNEX G.





Source: JICA Survey Team

Figure 4.4-17 Layout Plan (Davao-III Dam (Low) and Reservoir)

4.4.3.3 Groundwater Development and Management Plan in WRR XI

(1) Current Issues of Groundwater Use

Based on the results of interviews in the field and the groundwater analysis in this study, the current issues in groundwater use in WRR XI are listed in Table 4.4-15.

Establishment of a monitoring system to understand the groundwater environment is essential for sustainable use of groundwater resources, but at present there are no sufficient groundwater monitoring network in WRR XI except for periodic observations by WD.

Over pumping is especially seen in urban areas, particularly in Davao city and Tagum. Figure 4.4-18 shows the groundwater level drop from 2020 to 2050 in case groundwater demand continue to increase until 2050. Near Davao, large water level drops are estimated in Samar Island and small basins in eastern Davao Bay. In addition, there is a small but widespread water level drop area in the eastern side of Mt. Apo and the area around General Santos. Compared to groundwater demand for industrial water and agricultural water, the water level drop can be seen at the large demand area of eastern side of Mt. Apo and General Santos.

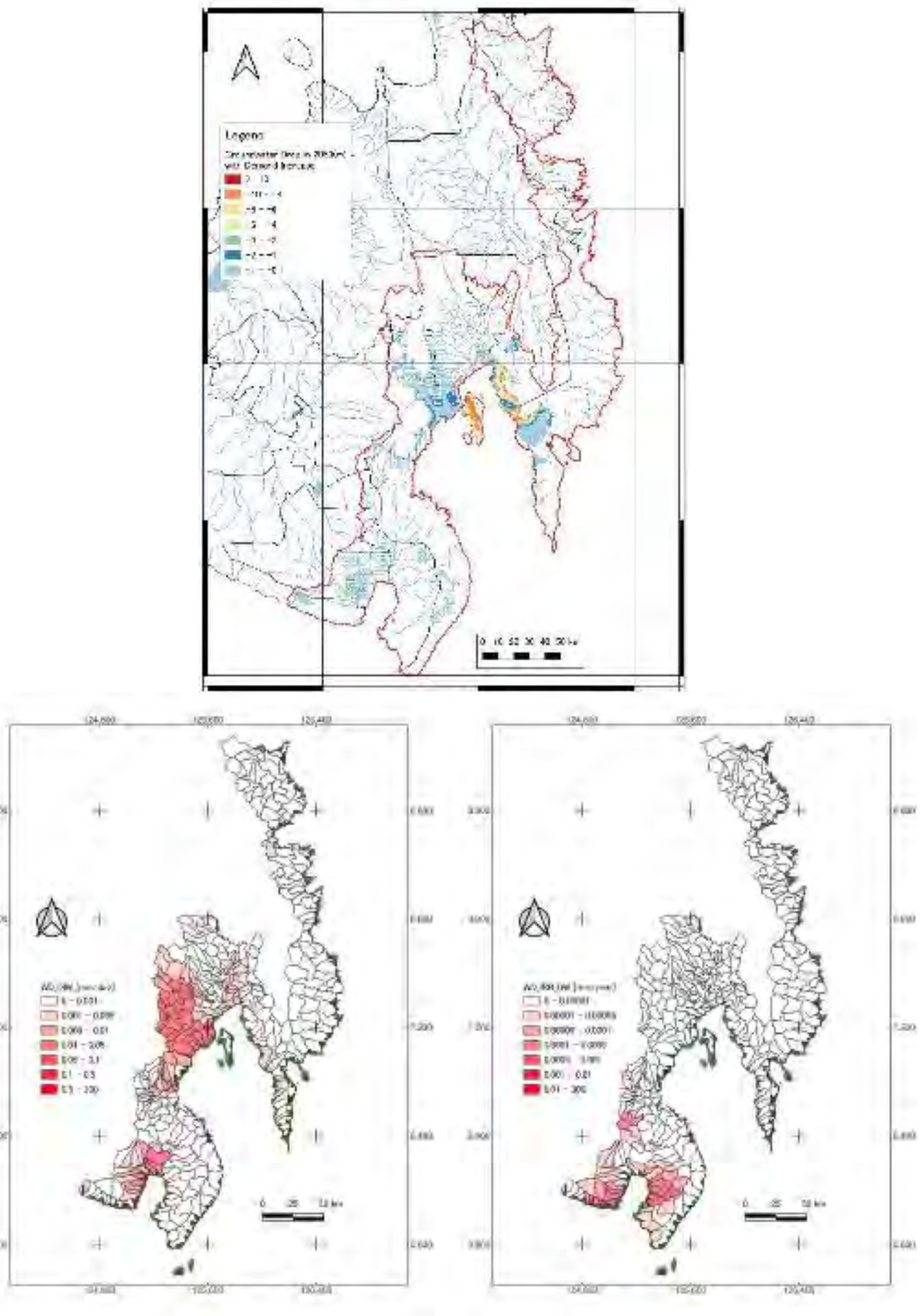
Saltwater intrusion, a problem related to over pumping, is also observed in Davao. Groundwater lowering due to over pumping may also be a potential cause of subsidence and sinking in areas where limestone and alluvial deposits are distributed.

As noted in 4.3.3.3, there is also the potential for impacts to groundwater and spring systems and well failures in the event of an earthquake.

Table 4.4-15 Summary of Current Issues of Groundwater Use in WRR XI

Area	Groundwater Monitoring	Groundwater Related Issues			
		Over Pumping	Saltwater Intrusion	Water Quality	Subsidence
Davao/Tagum	No specific monitoring well (NWRB has a plan to construct 20 monitoring wells in Davao)	✓	✓ Especially in Davao	None	✓
General Santos	No specific monitoring well	None	None	None	None

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.4-18 Groundwater Level Drop in WRR XI

(2) Basic Concept of Priority Project

Based on the issues related to groundwater described above, the proposed priority projects that can be considered at present are shown in Table 4.4-16.

Since the foremost priority is understanding the actual status of groundwater use, the short-term plan include the development of an observation network and understanding of the current pumping amounts.

In areas where water level drops have already occurred due to over pumping, pumping regulations and relocation of water sources (surface water or wells in other areas) are also envisioned as short-term developments.

Medium-term projects could include the development of deep wells for water sources based on the understanding of the groundwater environment, or the securing of freshwater areas through artificial recharge.

Long-term projects could include securing water sources by relocating water sources and constructing deep wells, controlling saltwater intrusion by developing underground dams, and utilizing grey water and sewage (artificial recharge).

Table 4.4-16 Summary of Priority Project Concept

Development Item	Short-term (2023-30)	Mid-term (2031-40)	Long-term (2041-50)
Groundwater Management	・ Regulation of Groundwater use ・ Development of groundwater monitoring network ・ Determination of the current production amount from existing well ・ Relocation of water source ・ Detailed analysis for prediction	・ Relocation of water source ・ Construction of Deep well (after investigation and study)	・ Relocation of water source ・ Construction of Deep well (after investigation and study
Countermeasure for Saltwater Intrusion	・ Observation and evaluation of saltwater intrusion	・ Expansion of freshwater area through artificial recharge	・ Construction of underground dams ・ Sewage/ grey water use

Source: JICA Survey Team

4.4.3.4 Water Supply Plan (Agriculture Water Use) in WRR-XI

For Davao de Oro, Davao del Norte, and Davao Oriental provinces, the irrigation development plans are prepared in consideration of the target areas estimated based on the NIA financial programs. For Davao del Sur and Davao Occidental Provinces, the potential irrigable areas estimated in NIMP 2020-2030, which include the 3-8% slope area shall be assessed to clarify the suitable farmlands for paddy cultivation. The new development projects as well as the improvement of existing systems shall be implemented to focus on i) lining of main and lateral canals, ii) introducing the mechanical operation sluice gate with electric/generator power, iii) the remote-control operation system of the diversion dam gates, and iv) the watershed management plans.

(1) Irrigation Development Areas

As shown in Table 4.4-17, in the Stage 1 Study, the future irrigation development areas in 2030, 2040 and 2050 were estimated based on the past NIA financial programs and NIMP 2020-2030. As the results of the water balance studies for the irrigation areas by NIA's financial programs, the estimated irrigation area with 170% cropping intensity in 2050 could be fully irrigated if surface water is properly developed as required.

Table 4.4-17 Forecasted Future Irrigation Development Areas in WRR XI

(Provinces only having large drainage area)

Province	Potential Irrigable Area (ha)	Year 2020				Remaining Irrigable Area (ha)	Newly Developed ISA (ha) by		
		ISA (ha)	FUSA (ha)	Irrigated Area (ha)			Year 2,030	Year 2,040	Year 2,050
				Wet	Dry				
NIA Financial Program									
Davao de Oro (Compostela Valley)	96,780	14,846	14,719	11,221	11,221	81,934	26,629	53,258	79,887
Davao del Norte	30,234	29,312	27,781	21,738	21,738	922	300	599	899
Davao del Sur Davao Occidental	32,773	17,474	16,977	13,932	13,793	15,299	4,972	9,944	14,917
Davao Oriental	17,760	8,806	8,766	6,124	6,168	8,954	2,910	5,820	8,730
Sarangani	6,964	7,071	6,348	5,731	5,337	0			
Surigao del Sur	39,870	16,538	15,907	10,796	9,687	23,332	7,583	15,166	22,749
Total	224,381	94,047	90,498	69,542	67,944	130,441	42,394	84,788	127,182
NIMP 2020-2030									
Davao de Oro (Compostela Valley)	52,005	14,846	14,719	11,221	11,221	37,159	11,123	16,425	18,917
Davao del Norte	94,456	29,312	27,781	21,738	21,738	65,144	19,499	28,795	33,164
Davao del Sur Davao Occidental	75,370	17,474	16,977	13,932	13,793	57,896	17,330	25,591	29,474
Davao Oriental	44,541	8,806	8,766	6,124	6,168	35,735	10,697	15,796	18,192
Sarangani	3,499	7,071	6,348	5,731	5,337	0			
Surigao del Sur	70,487	16,538	15,907	10,796	9,687	53,949	16,148	23,847	27,465
Total	340,358	94,047	90,498	69,542	67,944	249,883	74,797	110,455	127,212

Source: JICA Survey Team based on NIA Data

(2) Rice Supply and Demand Forecast

Table 4.4-18 shows the per capita consumption of rice by provincial level in 2020. At present, the per capita consumptions of rice for all provinces are less than the national target of 128kg.

Table 4.4-18 Per Capita Consumption of 2020 in WRR XI

Province	Palay Production (ton) in 2020			Population 2020	Per Capita Consumption*1 (kg)		
	Irrigated	Rainfed	Total		Irrigated	Rainfed	Total
Davao de Oro (Compostela Valley)	104,694	20,239	124,933	774,104	88	17	105
Davao del Norte	120,853	8,884	129,737	1,056,458	74	5	80
Davao del Sur	123,676	34	123,710	2,520,852	32	0	32
Davao Occidental	1,445	921	2,366	338,925	3	2	5
Davao Oriental	60,783	10,584	71,367	600,530	66	11	77
Saragani	32,577	6532	39,109	583791	36	7	44
Surigao del Sur	66,624	20,406	87,030	620531	70	21	91
Total	510,652	67,600	578,252	6,495,191	51	7	58

Remarks *1: (Palay Production) x (0.65)/(Population), adopting 065% of milling rate

Source: JICA Survey Team based on Data from Bureau of Agricultural Statistics, Department of Agriculture

As for the irrigable areas in 2050 based on the past NIA financial programs, the per capita consumptions of each province in 2050 are also estimated as shown in Table 4.4-19. In three provinces of "Davao de Oro", "Davao del Norte" and "Surigao del Sur", the rice self-sufficiency would be attained through irrigation development.

Table 4.4-19 Per Capita Consumption of 2050 in WRR XI

Province	Irrigable Area (ha) 2050		Palay Production *1(ton)	Population 2050	Per Capita Consumption *2(kg)
	Wet	Dry			
Davao de Oro (Compostela Valley)	80,415	80,415	868,482	990,276	570
Davao del Norte	24,378	24,378	263,282	1,315,439	130
Davao del Sur	27,246	26,974	292,785	3,700,657	51
Davao Occidental	*(can not be estimated)*			482,165	
Davao Oriental	14,819	14,925	160,616	851,351	123
Saragani	5,588	5,204	58,275	750,225	50
Surigao del Sur	34,637	31,079	354,862	877,716	263
Total	187,082	182,974	1,998,301	8,967,829	145

Remarks *1: Palay unit yield = 5.4 ton/ha
Remarks *2: (Palay Production) x (0.65)/(Population), adopting 065% of milling rate
Souece: JICA Survey Team

(3) NIA Priority Irrigation Development Projects

As of February 2022, NIA presented the priority projects in Region XI as shown in Table 4.4-20.

Table 4.4-20 NIA Priority Irrigation Development Projects in Region XI
(Excludes On-going Projects)

	Project Name	Province	Municipality	Program		Target Area (ha)		Project Status (As of March 2022)		
				TRIP	PIP	New	Restore	Feasibility Study (FS)	Detailed Engineering and Design (DED)	Remarks
1	Cogon Bacaca SRIP	Davao del Sur	Kiblawan	□		880		FSR approved on December 2021	For In-house DED this CY 2022.	Not included in PIP
2	Linoan SRIP	Davao de Oro	Montevista	□		300		FS approved on January 2022.	For in-house DED this CY 2022.	Not included in PIP
3	Awao SRIP	Davao de Oro	Monkayo	□		600				The project is subject for Pre-FS.
4	Upper Saug RIP	Davao del Norte	New Corella		□	980				Reservoir dam not feasible w/ fault
	Total					**2,760**				

TRIP: Three-year Rolling Infrastructure Program - DBM and NEDA Joint Circular No. 2016-01
PIP: Public Investment Program - NEDA Memorandum dated May 19, 2021, Updating of the 2017-2022 PIP
Source: NIA

Above programed development areas are not sufficient for the 2030 target development areas of 42,394 ha shown in Table 4.4-17. It is necessary for NIA to identify further irrigation development projects.

(4) Recommendations on Future Irrigation Development Plans

As a result of the assessment above and the field inspection explained in Annex-F: F3, the future irrigation development plans are recommended in consideration of the following present situations:

1) Water resources and potential irrigation areas

In Region XI, there are enough irrigation development areas with water resources. The major factors hampering proper irrigation operation and development are the flood nd inefficient water management system.

2) Per capita consumption of rice

The per capita consumption of rice could be improved through irrigation development. It is important to increase productivity through not only the new irrigation development but also the improvement of the existing irrigation systems.

3) Flood problem

Flood is the most serious problem in WRR-XI. The construction of proper flood control facilities is of course the most important requirements. However, irrigation facilities shall also be constructed and improved to prevent their damage from the floodings as much as possible.

4) Project evaluation for implementation

According to NIA Regional Office XI, the economic internal rate of return (EIRR) is a "must" criterion for the formal approval of irrigation development projects. If NIA plans high-quality systems for effective and sustainable irrigation operations, the systems require expensive costs of materials and construction work. With such development costs, the EIRR required for the project evaluation cannot be achieved.

The following future irrigation development plans are recommended in consideration of the above conditions:

1) New irrigation development projects

In order to complete the new irrigation area of 127,182 ha in 2050, NIA-RO-XI shall implement new irrigation projects of about 4,500 ha per year from 2023 to 2050. The key factors in the formulation of the new projects are as follows:

(i) The main and lateral canals are concrete lining or flume canal from the viewpoints of water saving and mitigation of flood damages.

(ii) The sluice gates and intake gates of diversion dams for the NISs shall be mechanical operation type with electric/generator power.

(iii) The remote-control operation system shall also be introduced in the flood prone area and in the case that the residential gatekeeper cannot be assigned.

(iv) The watershed management plans including re-forestation shall be implemented to achieve sustainable irrigation farming. There are several improvements and recovery plans for the uncontrolled watershed, e.g. construction of sabo dam and the slope protection works. The definite plans shall be formulated through the field survey and further assessment of the present situation.

2) Improvement of the existing NISs

The productivity of existing irrigation systems shall be maintained and upgraded through the improvement of irrigation facilities. The extension of service areas shall also be programmed in consideration of utilizing the water resources saved by effective irrigation water management. The following improvement plans are mainly recommended to realize sustainable irrigation farming in Region-XI:

(i) Main and lateral canals shall be improved as concrete lining or flume canals to minimize the conveyance losses.

(ii) Gate works of diversion dams shall be improved to prevent their damages from flood. As shown in Annex F: Table F-61, there are 66 gate works for NISs in Region XI. 26 gates are manual operation type and 29 gates are required for the rehabilitation works. All gates shall be replaced to the mechanical operation type with electric/generator power. As same as new projects, the remote-control operation system shall also be introduced in the flood prone area and in the case that the residential gatekeeper cannot be assigned.

(iii) Denudation of watersheds shall be recovered by reforestation programs to prevent the irrigation facilities and waterways from siltation.

(iv) Mal RIS was rehabilitated under NISRIP. NIA shall also study whether the above-mentioned improvement works will be implemented as NISRIP's next phase.

(v) The projects including upgrading equipment/facilities for the mechanical operation gate shall be carefully formulated in due consideration of their profits, and the projects shall be flexibly evaluated. The O&M costs and replacement costs of such equipment/facilities shall be properly estimated in comparison with those of the simple types. The procurement contract of these equipment/facilities is recommended to include the long-term O&M works for the sustainable operation.

(5) Implementation Plan

Above future irrigation development plans are proposed to be implemented by the short term (urgent), middle term and long term as shown in Figure 4.4-19.

Work Items	Short Term 2030	Middle Term 2040	Long Term 2050
New Irrigation Development			
Based on NIA Financial Program	⇨ 42,394 ha	⇨ 42,394 ha	⇨ 42,394 ha
Based on NIMP 2020-2030 (Mainly Davao del Sur Province)			
- Identification of Paddy Irrigation Area		⇨	
- Implementation			⇨
Improvement of NISs			
Lining of Main & Lateral Canals	⇨		
Upgrading of Gate Works in Diversion Dam	⇨		
Watershed Management	⇨	⇨	⇨

Source: JICA Survey Team

Figure 4.4-19 Implementation Plan of Future Irrigation Development

4.4.3.5 Water Supply Plan (Municipal and Industrial Water Use) in WRR XI

(1) Proposal of Priority Project Concept

Summary of municipal and industrial water demand projection in WRR XI is shown below. The water demand is expected to increase gradually, and there are concerns about future water balance constrains. This water demand projection without new projects is defined as the "baseline".

Table 4.4-21 Summary of Municipal and Industrial Water Demand Projection in WRR XI (Baseline)

Water Resource Region	Municipal+Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR XI - SOUTHEASTERN MINDANAO	580	621	657	698	742	790	830

Source: JICA Survey Team

The Proposal of priority project concept in WRR XI is the same contents of the one in WRR VII as described in Sub Section. 4.3.3.5.

(2) Reduction of Non-Revenue Water

NRW ratio for baseline is shown below.

Table 4.4-22 Non-Revenue Water Ratio in WRR XI (Baseline)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR XI	Davao	Davao	29%	22%	20%	15%	15%	15%	15%	DCWD hearing survey
	General Santos	General Santos	29%	27%	25%	23%	21%	20%	20%	GSCWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Source: JICA Survey Team

NRW ratio with NRW reduction case is shown below.

Table 4.4-23 Non-Revenue Water Ratio in WRR XI (NRW Reduction)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR XI	Davao	Davao	29%	22%	20%	15%	15%	13%	10%	DCWD hearing survey
	General Santos	General Santos	29%	27%	25%	23%	15%	13%	10%	GSCWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: Changes from baseline condition due to NRW reduction is highlighted in red.

Source: JICA Survey Team

Summary of municipal and industrial water demand projection in WRR XI with NRW reduction case is shown below.

Table 4.4-24 Summary of Municipal and Industrial Water Demand Projection in WRR XI (NRW Reduction)

Water Resources Region	Municipal + Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR XI - SOUTHEASTERN MINDANAO	580	621	657	698	737	779	808

Note: Changes due to NRW reduction is highlighted in red.

Source: JICA Survey Team

As a result of the above, it was confirmed that if NRW measures were thoroughly implemented up to the advanced countermeasure stage, there would be a saving of 3 % (22MCM) of water demand.

Very rough estimated project cost for a similar NRW reduction project in 2 major cities can be estimated at 4.6 billion PHP.

(3) Promotion of Water Saving Activity

Water demand per capita for baseline is shown below.

Table 4.4-25 Water Demand Per Capita in WRR XI (Baseline)

Water Consumption per Capita (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR XI	Davao	Davao	159	166	174	183	192	202	213	DCWD hearing survey
	General Santos	General Santos	180	180	180	180	180	180	180	GSCWD hearing survey
Other cities in Urban Area			120	120	120	120	120	120	120	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	60	60	60	60	60	60	Domestic demand (rural) in PWSSMP2018

Source: JICA Survey Team

Water demand per capita with water saving promotions is shown below.

Table 4.4-26 Water Demand Per Capita in WRR XI (Water Saving Promotion)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR XI	Davao	Davao	159	156	153	149	145	140	135	DCWD hearing survey
	General Santos	General Santos	180	176	173	169	164	158	153	GSCWD hearing survey
Other cities in Urban Area			120	118	115	113	109	106	102	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	59	58	56	55	53	51	Domestic demand (rural) in PWSSMP2018

Note: Changes from baseline condition due to water saving promotion is highlighted in red.

Source: JICA Survey Team

Summary of municipal and industrial water demand projection in WRR XI with water saving promotion is shown below.

Table 4.4-27 Summary of Municipal and Industrial Water Demand Projection in WRR XI (Water Saving Promotion)

Water Resources Region	Municipal + Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR XI - SOUTHEASTERN MINDANAO	580	606	624	647	664	683	691

Note: Changes from baseline condition are highlighted in red.

Source: JICA Survey Team

As a result of the above, it was confirmed that if water saving promotion were thoroughly implemented, there would be a saving of 17 % (139 MCM) of water demand.

It is assumed that the cost of water saving promotion can be accounted for as part of each water utility's public relations activities and that no construction or other cost will be incurred.

(4) Recycling of Sewerage Water

It is assumed that the sewerage system in Davao City will be upgraded by 2040, and that 50,000 m^3/day (18 MCM) sewerage will be recycled in 100,000 m^3/day sewerage treatment plant. In this case, the result of water demand forecast is as below.

Table 4.4-28 Summary of Municipal and Industrial Water Demand Projection in Davao City (Recycling of Sewerage Water)

	Status	2020	2025	2030	2035	2040	2045	2050
DAVAO CITY	without Project	187	203	224	239	262	288	312
	New Water Production	0	0	0	0	18	18	18
	with Project	187	203	224	239	244	270	294

Note: Changes from baseline condition are highlighted in red.

Source: JICA Survey Team

As a result of the above, it was confirmed that if recycling of sewerage water were introduced, there would cover 6% (18MCM) of water demand in Davao City.

The construction cost of 10,000 m^3/day Paranaque sewerage recycling plant is 450 million PHP, so if 50,000 m^3/day sewerage recycling plant were to be build, the project cost would be 2.3 billion PHP. This cost does not include the cost of the sewage improvement project.

(5) Comparison of Priority Project Concept

Comparison of priority project concept is shown in Table 4.4-29 below.

Table 4.4-29 The Comparison of Priority Project Concept in WRR XI

Priority Project Concept	Reduction of NRW	Promotion of Water Saving Activity	Introduction of Desalination Technology	Recycling of Sewerage Water	Recycling of Industrial Wastewater
Target City	Large Scale Major Municipalities (Davao, General Santos)	All Municipalities	–	Davao City	–
Reduction Effect (2050)	WRR XI: 22 MCM	WRR XI: 139 MCM	–	WRR XI: 18 MCM(Davao)	–
Very Rough Project Cost	4.6 billion PHP	- (It is included in municipalities public relations budget)	–	2.3 billion PHP (It is not including sewerage development cost)	–
Feasibility	Low (NRW 20% is a high target, but the alternative is an even higher target of 10%.)	Middle (No typical project cost and water demand per capita is already declining in other countries.)	–	Low (The progress of the sewerage project, which is required for sewerage water recycle, is uncertain.)	–

Source: JICA Survey Team

4.4.3.6 Water Resources Management Plan (Information Management) in WRR XI

Water Resources Management Plan (Information Management) in WRR XI is same as WRR VII described in sub section 4.3.3.6. The proposed composition of the information management plan is shown in Table 4.4-30 below. The Central and Regional Offices should manage the data-sharing diligently.

Table 4.4-30 Composition of Information Management Plan (Idea)

Information Management Plan (Idea)	Contents	Related Agencies
Meteorology and Hydrological Data Information Management	• River water level observation, cross-section survey of the river channel, discharge measurement, and the creation of water level-discharge curves (H-Q rating curves). • Retroactively organize short-term rainfall, water level and discharge data, and construct a display system for real-time observation data using a telemeter on real-time hourly or 10 to 15-minute basis. • Monitoring system of dams and intake weirs operations in real-time and organizing past operation record data. • Installation of telemetric ARG, telemetric AWLG, ARCM, and RSLC.	DPWH, PAGASA, DOST-ASTI, FMB, NIA, NPC, LGUs
Climate Change Data Information Management	• More detailed regional (preferably mesh data) and monthly or daily climate change data in the Philippines. Downloadable in CVS format and some graphs on the PAGASA website.	PAGASA
Groundwater and Hydrogeological Data Information Management	• Monitor and collect the groundwater level, groundwater quality data, hydrogeological data, geological data, boring data, pumping test data of wells, saturated hydraulic conductivity, porosity data, etc. • Construction of a central monitoring and management system of data and information. • Drilling of more monitoring wells is desired to increase the spatial distribution of monitoring wells for groundwater level and groundwater quality.	NWRB, DENR, LGUs
Flood Forecast and Early Flood Warning System	• Installation of telemeter-type ARGs and telemeter-type AWLGs, ARCM, and RSLC on the ground. • Installation of the real-time radar (X or C-band) rainfall gauge systems. • Develop a flood forecasting and early flood warning system. • Utilization of observed rainfall and river water levels, re-analysis rainfall forecast data by the ECMWF or satellite rainfall forecast data by USGS or other commercial satellites. • Construction of a river water level and discharge prediction system using AI technology is desired.	PAGASA, DOST-ASTI, DRRMO, DPWH, LGUs
GIS/Map Data	• To update and centrally manage more detailed digital geological maps, soil maps, hydrogeological maps, environmental maps, land use/land cover maps, satellite image, digital elevation data, river sub-basin maps and river line, and river structural location maps, etc. • For example, rapidly changing land use/land cover maps will be changed every 3 to 5 years. And once every 10 to 15 years for topographic data, etc., which do not change so much. • Capacity building for engineers of central and regional government.	DENR, NAMRIA, NWRB, PAGASA, DPWH, etc.

Source: JICA Survey Team

The proposed draft information management plan for priority WRRs is shown in Table 4.4-31 below.

Table 4.4-31 Draft Information Management Plan for the Priority WRRs

WRR	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common (Structural Measures)	• Installation of telemeter-type ARGs, telemeter-type AWLGs, ARCM, and RSLC. • Installation of the real-time radar (X or C-band) rainfall gauge systems. • Construction of a display system for real-time or short-term rainfall, WL, discharge, and GWL, SW and SW quality data, dams/intake weirs operation data using a telemeter system. • Drilling of monitoring wells of GWL and quality by telemetric system.		
Common (Non-Structural Measures)	• River WL observation, cross-section survey, discharge measurement, and to create H-Q rating curves. • Central monitoring and management system of meteorological, hydrological, and hydrogeological data and information. • Past meteorological, hydrological, and dams/weirs operation record data arrangement. • Detailed spatial-temporal climate change data website. • Monitor and collect the GWL, GW quality data, hydrogeological data, geological data, boring data, pumping test data of wells, etc. • Update and centrally manage more detailed GIS data of geological, soil, hydrogeological, environmental, land use/land cover, river structural location maps satellite images, etc.		

WRR	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
	• Develop a flood forecasting and early flood warning system utilization of observed rainfall and river water levels, re-analysis, or satellite rainfall forecast data. • Construction of a river water level and discharge prediction system by AI technology. • Capacity building		
Meteorology and Hydrological Data Information Management	• Installation of ARGs, AWLGs, ARCM, and RSLC. • Real-time meteor-hydrological, dams/intake weirs operation. • Cross-section survey, discharge measurement, and H-Q rating curves.	• Installation of ARGs, AWLGs, ARCM, and RSLC, • Installation of the real-time radar (X or C-band) rainfall gauge systems.	• Installation of the real-time radar (X or C-band) rainfall gauge systems.
Climate Change Data Information Management	• Detailed spatial-temporal climate change data website.	• Updating of climate change data website.	• Updating of climate change data website.
Groundwater and Hydrogeological Data Information Management	• Past meteor-hydrological, dams/weirs operation, and GW data arrangement. • Monitoring wells. • GWL and quality, boring, pumping test data collection.	• Drilling of more monitoring wells of groundwater level and groundwater quality.	• Drilling of more monitoring wells of groundwater level and groundwater quality.
Flood Forecast and Early Flood Warning System	• Flood forecasting and early flood warning system. • Utilization of re-analysis or satellite rainfall forecast data. • River WL and discharge prediction system by AI.	• Updating flood forecasting and early flood warning system. • Utilization of re-analysis or satellite rainfall forecast data.	• Updating flood forecasting and early flood warning system. • Utilization of re-analysis or satellite rainfall forecast data.
GIS/Map Data	• Decide on a policy for centralized data management and update frequency. • Capacity building for engineers	• Regularly update data and train personnel.	• Regularly update data and train personnel.

Note: ARG: telemetric automatic rainfall gauge, AWLG: the telemetric automatic water level gauge, ARCM: the non-contact radar sensor automatic radio current meter, RSLC: the simple river surveillance live camera.

Source: JICA Survey Team

4.4.3.7 Water Resources Management Plan (Flood Risk Management) in WRR XI

(1) The Objective of Draft FRM Plan

The objective is the same as described in sub section 4.3.3.7 (1).

(2) Target of Draft FRM Plan

Due to the natural and social conditions, flood disasters frequently occur in the Philippines. Aiming to strengthen flood disaster resilience, DPWH suggests planning target design flood as 100 years in return period for the rivers with the drainage area over 40 km^2 in the Design Guidelines, Criteria and Standards (DGCS, 2015). Because most of rivers still have a long way to achieve their goals, the implementation of structural and non-structural measures based on FRMMPs should be accelerated.

The National Water Resources Council (NWRC, the predecessor of NWRB) classifies the river basins in the Philippines by the drainage areas as 18 major river basins (larger than 1,400 km^2), 421 principal river basins (between 40 km^2 and 1,400 km^2) and others. In WRR XI, there are 3 major river basins and 35 principal river basins. Since there are numerous rivers in the region, the 3 major rivers, namely Davao River, Tagum-Libuganon River and Buayan-Malungon River, are focused considering the scale of flood risks and the importance of water resources development and management. The summary of the current FRMMPs for the 3 major river basins is shown in the table below. As the current FRMMP is lately formulated, steady implementation of proposed measures along the plans is also pursued in this Draft FRM Plan.

Table 4.4-32 Summary of the Current FRMMPs for the 3 Major River Basins

River Basin Name	Davao	Tagum-Libuganon	Buayan-Malungon
Drainage Area (km^2) *1	1,760	3,119	1,505
Estimated Population (thousand people) and Estimated Year *1	626 (2010)	831 (2010)	218 (2007)
Latest FRMMP and Formulated Year	JICA (2023) *2	ADB (2020) *3	ADB (2020) *3
Target Year	2045	2050	2050
Target Flood Level	100-year	50-year	50-year
Design Flood Discharge	3,400 m^3/s at Waan Bridge (17 km upstream from the river mouth)	926 m^3/s at just upstream of Tagum City	1,985 m^3/s at the confluence of Buayan River and Maribulan River
No. of Existing Flood Control Dam	0	0	0
No. of Potential Flood Control Dam	0	2 *4	1 *4

*1) The values of "Drainage Area" and "Estimated Population" are quoted from the website of River Basin Control Office (https://riverbasin.denr.gov.ph/main/index)
*2) JICA. 2023, "Master Plan and Feasibility Study on Flood Control and Drainage in Davao City"
*3) ADB, 2020, "Infrastructure Preparation and Innovation Facility (IPIF) Output 02 Water (Flood Control)"
*4) Multi-purpose dams are proposed as an option in the long-term and within climate change adaptation and mitigation plan coping also with drought and water scarcity events.

Source: JICA Survey Team

(3) Potential Dams for Flood Control Purposes

Because dams can give large impacts on various kinds of river projects, potential dams for flood control purpose are studied. There is no existing flood control dam and planned flood control dams in the current FRMMPs. On the other hand, several new flood control dams were studied as alternative solutions in the current FRMMPs. The dams are not listed in the project timeline of the FRMMPs because their efficiencies were evaluated lower than the other alternative solutions such as river improvement works and dike construction by multi-criteria analysis. However, there still remains a possibility that the new dam projects will be feasible when it is reviewed as multi-purpose dam projects considering the benefits of irrigation, water supply and hydropower generation from the perspective of IWRM. The potential flood control dams are summarized in the table below. More details are described in ANNEX H.

Table 4.4-33 Potential Dams for Flood Control Purpose in the 3 Major River Basins

River Name	Dam Name	Dam Height	Crest Length	Storage Volume*	Remarks
Davao	No flood control dam is proposed in the current FRMMP.				
Tagum-Libuganon	Locutan	45 m	N/A	11 MCM	• Not specifically described
	Gupitan	20 m	N/A	80 MCM	• More than 400 houses will be under the water reservoir level, a remaining number of around 100 households will be strongly impacted. • With a surface of 8 km2, around 68 ha of agricultural land (mainly perennial crops) will be unavailable.
Buayan-Malungon	Buayan	32 m	916 m	41 MCM	• Noticeable effect to decrease the water level at the Old/New Buayan Bridge by -1m, but not enough to completely solve the existing problem • More or less efficient as a dry dam, but less if combined with other uses

* The storage volume was studied not for flood control volume but for developable storage volume in the FRMMP (ADB, 2020, "Infrastructure Preparation and Innovation Facility (IPIF) Output 02 Water (Flood Control)").

Source: Prepared by JICA Survey Team based on the current FRMMPs

Constructing a flood control dam has not been adopted in the current FRMMP for the Davao River Basin due to its cost-benefit performance and environmental and social impacts. On the other hand, a new dam project in the Davao River upstream is proposed as a priority project for water resource development in this survey. Because the new dam project can be more effective including flood control volume as a multipurpose dam, the required flood control volume is roughly estimated based on the design hydrograph and the project timeline of the FRMMP.

The Davao River downstream is highly developed in the center of Davao City, while there remain unused lands in the upstream. In the current FRMMP, the design flood discharge is planned as 3,400 m^3/s equivalent to 100-year flood discharge at the Waan Bridge in the downstream. On the other hand, the present flow capacity in the downstream is approximately 600 m^3/s, which is far short of the design flood discharge. According to the planned allocation of flood discharge, seven artificial retarding basins in total are to be constructed in the mid-stream to reduce the flood discharge to 1,700 m^3/s, and the flow capacity in the downstream is to be increased to 1,700 m^3/s by river improvement works. In the proposed project timeline, river dredging and construction of three retarding basins are scheduled as priority projects for the short-term plan (2023-2032). River dredging is going to increase the downstream flow capacity to 800 m^3/s and construction of three retarding basins are going to decrease flood peak discharge by 700 m^3/s, which will accommodate the flood discharge up to 1,500 m^3/s which is equivalent to 5 to 10-year flood. Successively, river cut-off and widening and construction of four retarding basins are scheduled for the mid to long-term plan (2033-2045). River cut-off and widening is going to increase the downstream flow capacity to 1,700 m^3/s and construction of four retarding basins are going to decrease flood peak discharge by 1,700 m^3/s, which will accommodate the design flood discharge of 3,400 m^3/s equivalent to 100-year flood. Because river cut-off and widening works require resettlement and land acquisition and it will involve a lot of difficulties (although the idea for resettlement and land acquisition is also studied and proposed in the FRMMP), the required flood control volume is estimated assuming that the effect of river cut-off and widening is replaced by the dam. As a result, the required flood control volume is roughly estimated as 10 million m^3 (MCM) based on the design hydrograph. Likewise, assuming that the proposed projects for the mid-long term are all replaced by the dam, the required flood control volume will be approximately 35 MCM.

When the proposed dam in this survey is studied as a multipurpose dam, it is recommended to study the allocation of the storage capacity for flood control purpose as 10 or 35 MCM based on detailed hydrological analysis and the progress of the planned projects.

(4) Issues on FRM

1) Overall Present Conditions and Issues

Overall present conditions and issues are the same as described in sub section 4.3.3.7 (4) 1).

2) Present Conditions and Issues in the 3 Major River Basins

Present conditions and main issues in the 3 major river basins are organized based on the current FRMMPs as shown in the table below.

Table 4.4-34 Present Conditions and Main FRM Issues in the 3 Major River Basins

River Name	Present Conditions	Main Issues
Davao	• Typhoons rarely hit the river basin, but occasionally cause heavy rainfalls. • Floods occur almost every year whose magnitude is the inundation depth with less than 1m and the inundation duration with about several hours. • Davao City is highly developed over the lower flood plain, which results in high potential of flood damage. • Artificial factors such as land use change, cutting trees, sub-division development and improper waste disposal increase flood risks. • Davao River Fault lies under the upper and middle part of the basin.	• Present flow capacity in the downstream corresponds only 2-3 year scale flood, which cause frequent flood damages. • Natural retarding function is decreasing due to urbanization of riverside, swamps and depression areas. • Land acquisition for flood control projects is very difficult in the downstream. • Davao City grants the permits for land-use development in flood prone areas on the condition that the land is elevated. However, the raising of some land may increase flood risks by causing poor drainage in other areas and decreasing flood retarding effect.
Tagum-Libuganon	• Typhoons rarely hit the river basin, but occasionally cause heavy rainfalls. • Sediment transport is rather low. • Floods occur with very high frequency and abnormal long duration of inundation. • Fluvial floods are caused not only from main rivers but also from tributaries. • Part of natural river network has been modified by means of riverbed rectification (straight canals) and “simplified” as ancient river beds have been filled for agricultural purposes (especially huge banana plantation on the West of Carmen City). • Land use has drastically changed over the plain including urban zone extension to floodable areas.	• Existing embankment structures along rivers and irrigation channels work not only for original flood control purpose but also for unexpected bad effects that exacerbate inland flooding by surrounding flood plain with the embankments like polder and by disconnecting natural creeks from the hydraulic network. • As the whole plain has been cultivated and drained, hydrology or the river has been drastically modified. Such changes in land use and drainage have increased run-off rates and strongly reduced lag time so that flood peak discharge values are much higher than those in the past.

River Name	Present Conditions	Main Issues
Buayan-Malungon	• Typhoons rarely affect the river basin, but Southwest Monsoon causes flash floods and landslides in the upper and middle basin. • The middle basin is also severely affected by flood-induced riverbank erosion and sediment transport. • The lower basin suffers from river line and inland flooding. • The basin is affected by local active faults (Davao River Fault, Mindanao Fault- Daguma Extension, Tangbulan Fault) capable of producing earthquakes. • The active stratovolcano, Mt. Matutum, is located at the Buayan River headwaters.	• The upper basin suffers from flash floods and landslides aggravated by strong deforestation, principally due to illegal logging and 'kaingin' (slash-and-burn farming) ancestral practices. • Large volume of sediment inflow from the upstream accumulates in the mid-stream and makes the river course meandering and unstable, which cause riverbank erosion in the meander bends. • Most flood prone area is located around the confluence of the Buayan and Maribulan Rivers, where flood occurs even without heavy rainfall, several times a year, and may last up to three days.

Source: Prepared by JICA Survey Team based on the reviews of current FRMMPs and field surveys.

(5) Recommendation on FRM

1) Overall Recommendation

Overall recommendation is the same as described in Chapter 4.3.3.7 (5) 1).

2) Recommendation for the 3 Major River Basins

Recommendations in terms of FRM for the three major river basins are summarized as follows:

- Flood control projects should be steadily implemented in accordance with the current FRMMPs.
- No flood control dam is adopted in the current FRMMPs for the Davao River Basin due to its cost-benefit performance and environmental and social impacts. On the other hand, multi-purpose dams (Davao 2 Dam and Davao 3 Dam) are proposed as priority projects for water resource development in this survey. The proposed multi-purpose dams can be more effective by including flood control purpose to be multi-purpose dams. As described in this subsection (3), the current FRMMP plans total 7 retarding ponds to reduce the design flood peak discharge by 1,700 m^3/s. Comparing the construction cost of 7 retarding ponds with the estimated additional cost of adding flood control capacity equivalent to the total storage capacity of these 7 retarding ponds to the Davao 2 Dam, it was found that the project cost would likely be lower in the case of multi-purpose dam as this result is based on a rough estimation. Besides, the case of multi-purpose dam can be more advantageous in terms of social impacts such as resettlement and land acquisition, etc. since the number of construction sites is limited to one. On the other hand, in the case of multi-purpose dam, there will be a burden of dealing with among stakeholders the allocation of storage capacity, coordination of benefits and costs, implementation schedule, and coordination of the operation and maintenance. Aiming to optimal water resources development in terms of IWRM, a feasibility study of the multi-purpose dams should be conducted.
- Two multi-purpose dams in the Tagum-Libuganon River Basin and one multi-purpose dam in the Buayan-Malungon River Basin are proposed in their current FRMMPs not strictly within the framework of a flood risk reduction approach, but in the long-term and within a broader climate change

adaptation and mitigation plan coping also with drought and water scarcity events. Because those dams were roughly studied for flood control purpose only in the FRMMPs, feasibility studies for the multi-purpose dams should be conducted.

(6) Draft FRM Plan

As mentioned in this subsection (2), since the current FRMMPs of the three major rivers are lately formulated, steady implementation of proposed measures along the plans should be pursued. The proposed FRM measures in the FRMMPs are summarized in the table below. In addition, among the priority projects for water resources development identified in this survey, the projects that may also contribute for FRM are added in red.

Table 4.4-35 Draft FRM Plan for WRR XI

River Name	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common (Structural Measures)	• Riverbank & Bed Protection (Revetment, Spur Dike, Grounsill, etc.) • Drainage Improvement (Drainage Channel Improvement, Pumping Station, etc.) • Sabo Facility (Slope Protection, Check Dam, etc.) • Rehabilitation of Old River Structures (Weir, Revetment, Bridge, etc.)		
Common (Non-Structural Measures)	• River & Drainage Channel Maintenance (Dredging, Cleaning, etc.) • Flood Forecasting and Early Warning • Evacuation Planning & Drill • Educational Activities • Forests Conservation (regulating illegal logging, mining, unsuitable agricultural activities, etc.) • Land-use Regulation (regulating the land use in flood prone areas, etc.)		
Davao	• River Shortcuts • Retarding Basin	• River Widening • Retarding Basin	• River Widening • Retarding Basin • Multipurpose Dam (Davao 2, Davao 3)
Tagum- Libuganon	• River Improvement • Improvement of Existing Shortcut Channels • Dike	• River Improvement • Dike • Raising Existing Roads	• River Improvement • Dike • Multipurpose Dams (Locutan, Gupitan)
Buayan- Malungon	• River Improvement • Removal of Existing Dikes and a Bridge • Resettlement • Dikes at the River Mouth	• Dike • Jetties at the River Mouth	• Multipurpose Dam (Buayan)

Note:
1) Red colour indicates potential FRM measures identified in this survey.
2) River improvement includes river excavation, widening, revetment, etc.

Source: Prepared by JICA Survey Team based on the reviews of current FRMMPs and field surveys.

4.4.3.8 Water Resources Management Plan (River Basin Environmental Conservation) in WRR XI

(1) Issues and Challenges on River Basin Environment in WRR XI

1) Water Balance

In WRR XI, surface water potential is basically abundant in whole region while the risk of water shortage of groundwater is high, especially in Davao Occidental. Future shortage of groundwater is predicted due to high demands for domestic and industrial water in Metro Davao.

2) Facility Plan

Surface water development is being promoted with private funds. There are some dam plans which needs to be reviewed for these usage and feasibility. Considering feasibility of these facilities, environmental and social aspect should be considered and evaluated.

3) Sedimentation

In Davao del Sur, Miral dam operated by NIA has been almost fully silted and the outlet was clogged due to sedimentation since 2012. Cultivation in the watershed causes a large amount of soil erosions. Countermeasures against the sediment problem is needed for the effective utilization of existing facilities.

(2) Objective of the River Basin Environmental Conservation Plan in WRR XI

Objectives of the River Basin Environmental Conservation Plan in WRR XI are as follows considering the above present conditions.

- To secure good quality and enough amount of water resources in WRR XI through the environmental conservation measures
- To protect and improve waterfront environment and water quality that ensure the sustainability between natural environment and development / livelihood activities towards prosperity of communities.

(3) Strategy of the River Basin Environmental Conservation Plan in WRR XI

1) Securing Clean Water

Effective use of the water is one of the most important factors in water resources management. Water quality of the river basin in WRR XI is good; hence, sustaining and securing clean water is required for the effective use of water against the high demand of the water use in the future.

The following measures are suggested to secure the clean water.

- Source countermeasures: Treatment of wastewater generated from domestic, industries, agriculture and fisheries such as sewage system, agricultural drainage, septic tank etc.
- Purification of rivers and lakes: Installation and development of purification facility, utilization of natural purification function using plants and aquatic life and removal of sediment directly such as dredging.

- Monitoring of water quality: Formulation of water quality monitoring system to prevent contamination of water body and establishment of a close communication system between residents, LGUs and national agencies to understand the current situation and cause of the accident and to prevent the spread of damage.

2) Sustainable Basin Reservation

Sustainable maintenance of the water function and securing the water amount are very important as the long-term goal of basin reservation. The following measures are suggested to maintain the sustainable water resources.

- Appropriate forest management: Providing support for appropriate forest management according to the characteristics of water source areas based on forest planning in order to enhance the water retention function of forests such as improvement of devastated forests, avoiding unregulated conversion of forest land to land development, reforestation, forest road network development and thinning and pruning etc.
- Consideration for water retention function in development projects: Consideration of alternative measures such as rainwater infiltration, installation of water storage facilities and reforestation when there is concern that the water retention function is decline due to deforestation by development projects.
- Improvement of water retention function in urban areas: Restriction of rainwater runoff by the installation of rainwater storage and infiltration facilities, the development of permeable pavement and development of green space such as promotion of city greening etc.

3) Establishment of Interaction between Nature and People

Waterfront environments such as rivers, lakes, reservoirs and wetlands are important habitats for aquatic life and also places of recreation and relaxation for people. Creation of comfortable water area is important for both natural environment and people. The following measures are suggested to establish interaction between nature and people.

- Conservation of waterfront where diverse life grows and inhabits: Promotion of multi-natural waterfront development considering the natural environment and landscape of rivers and lakes that coexist with aquatic life.
- Conservation of biodiversity: Conservation of waterfront ecosystems with securing a place for the growth and habitat of a variety of life and forest around the water body, conservation of wetlands, conservation of aquatic life with the Red Data Book, extermination of alien species and research on aquatic life.
- Creating friendly waterfronts: Creation of opportunities to become familiar with water area.

(4) Proposal of the River Basin Environmental Conservation Plan in WRR XI

Tentative river basin environmental conservation plans in WRR XI divided to three terms (short, middle and long) based on the above strategies is shown in Table 4.4-36.

Table 4.4-36 Draft River Basin Environmental Conservation Plan for WRR XI

Strategy	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common	• Removal (dredging) of sediment directly • Monitoring of water quality at the existing monitoring stations • Consideration of alternative measures such as rainwater infiltration, installation of water storage facilities and reforestation when there is concern that the water retention function is decline by development projects. • Reforestation		
Securing the Clean Water	• Utilization of natural purification function using plants and aquatic life • Planning of water quality monitoring system and its close communication system	• Development of agricultural drainage • Development of septic tank around the water body • Formulation of water quality monitoring system and establishment of its close communication system	• Development of sewage system • Installation and development of purification facility • Updating of water quality monitoring system and its close communication system
Sustainable Basin Reservation	• Development of sustainable forest plan • Planning of green space such as city greening	• Development of forest road network • Improvement of devastated forests • Restriction of rainwater runoff by the installation of rainwater storage and infiltration facilities in urban areas • Development of green space such as city greening	• Improvement of devastated forests • Development of permeable pavement • Development of green space such as city greening
Establishment of Interaction between Nature and People	• Planning of multi-natural waterfront development • Planning of waterfront ecosystems conservation	• Promotion of multi-natural waterfront development • Development of waterfront ecosystems conservation	

Source: JICA Survey Team

4.4.3.9 Water Resources Management Plan (Organizations and Legal Frameworks) in WRR XI

(1) Introduction

In this section, the following items are summarized in order to clarify the current status and issues, recommendations for improving the organizations and legal frameworks relating to the proposed plans for water resources development and management in the Water Resources Region XI.

- ✓ Outline of the way for considering the implementation scheme
- ✓ Possible Implementation Schemes for Water Resources Development and Management Projects
- ✓ Recommendations and Plans in the aspect of organizations and legal frameworks
- ✓ Recommendations related to the proposed plans for water resources development and management

(2) Outline of the way for considering the implementation scheme

The description on "Outline of the way for considering the implementation schemes" for WRR VII can be applied for WRR XI, then please see the previous sub section of 4.3.3.9 (2).

(3) Possible Implementation Schemes for Water Resources Development and Management Project

The description on "Possible Implementation Schemes for Water Resources Development and Management Projects" for WRR VII can be applied for WRR XI, then please see the previous sub section of 4.3.3.9 (3).

(4) Recommendations and Plans for Improvement in the Aspect of Organization and Legal Framework

The description on "Plans for Improvement of the Aspect of Organizations and Legal Frameworks" for WRR VII can be applied for WRR XI except for the affair of Inabanga Dam project, then please see the previous subsection of 4.3.3.9 (4). Table 4.4-37 shows the plans for improving the issues on organizations and legal frameworks in WRR XI.

Table 4.4-37 Plans for Improving the Issues on Organizations and Legal Frameworks (WRR XI)

Items		Short Term (-2030)	Middle Term (2030-2040)	Long Term (2040-2050)
National Level				
	Creating DWR	⇒		
	Consideration of incentive scheme for rainwater storage and infiltration	⇒	⇒	⇒
Region/Basin Level				
	Preparation of plans for multipurpose dams (Davao II Dam & Davao III Dam)	⇒		
	Strengthening the functions of River Basin Committee Development of consultative scheme for Upgrading the Buhi Lake IWRMInabanga Dam project	⇒ ⇒		
	"MODEL PROJECT" of multipurpose dams	⇒ Preparation	⇒ Implementation	⇒
	Strengthening of organization and human resources of the regulatory organization	⇒		

Source: JICA Survey Team

(5) Recommendation related to enhancing multi-purpose dam projects

The contents on "Recommendation Related to Enhancing Multi-purpose Dam Project" for WRR VII can be applied for WRR XI, then please see the previous subsection of 4.3.3.9 (5).

4.4.4 Proposal for Priority Project Concept in WRR XI

4.4.4.1 Selection of Priority Project

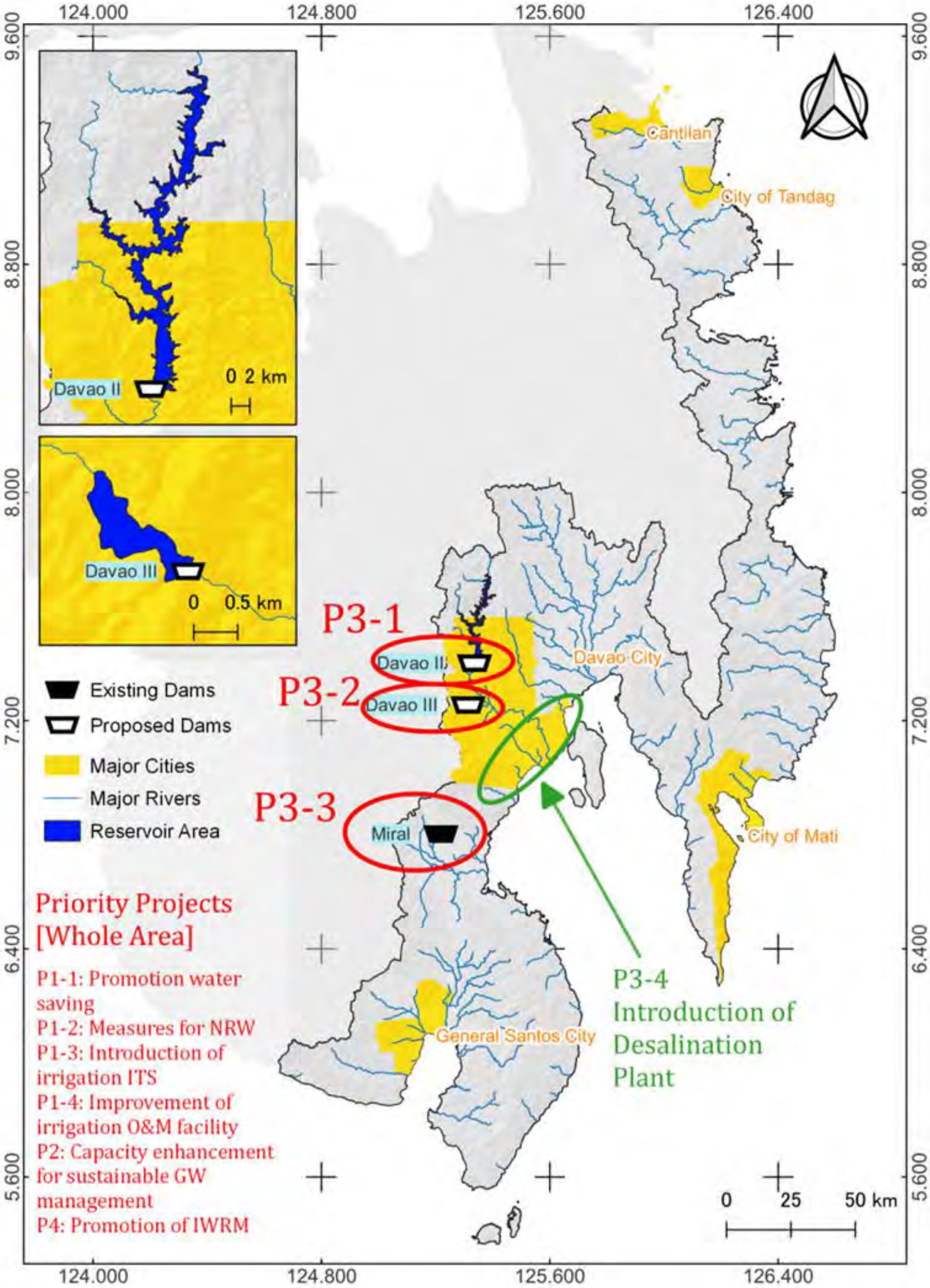
Table 4.4-38 shows the short-term (2030), medium-term (2040), and long-term (2050) project implementation schedule up to 2050 as a roadmap for the water resources development and management plan proposed in the previous section. Of these, the projects selected as short-term proposals that are of high need and urgency, will be selected as the priority projects. In addition to this, among the medium-term proposals, it is decided to include the projects with high feasibility and high importance as priority projects. These priority projects are shown in red frames in Table 4.4-38 and Figure 4.4-20 below.

Table 4.4-38 Roadmap of Water Resources Development and Management Plan (Idea) and Priority Projects in WRR XI

Priority Policy	Development Items	Short-term (2024-30)	Mid-term (2031-40)	Long-term (2041-50)
1	Demand Management	P1-1: Promotion of water-saving P1-2: Measures for NRW (20%) P1-3:Introduction of Irrigation ITS P1-4: Improvement of Irrigation O&M Facility	Promotion of water-saving Measures for NRW (15%) Introduction of Irrigation ITS Improvement of Irrigation O&M Facility	Promotion of water-saving Measures for NRW (10%) Introduction of Irrigation ITS Improvement of Irrigation O&M Facility
2	Groundwater Management	P2:Capacity Enhancement for Sustainable Groundwater Management	Monitoring and regulation of GW	Monitoring and regulation of GW
3(1)	Surface water development	P3-3 Study and Investigation of Upgrading existing dams (Miral) Promotion of mid-long term plans of Multipurpose Dams (P3-1 Davao 3 Dam, P3-2 Davao 2 Dam) ●Development of irrigation weirs and dams (SRIP)	P3-3 Upgrading existing dams (Miral) P3-1 Davao3 Dam (multi-purpose) Development of irrigation weirs and dams (SRIP)	Davao2 Dam (multi-purpose) Development of irrigation weirs and dams (SRIP)
3(2)	Water Supply and Sewerage Development	●Bulk water developments (Apo Agua, Manila Water) ●Groundwater developments (General Santos)	Bulk water developments Groundwater developments (General Santos) Installation of desalination plants	Bulk water developments Groundwater developments (General Santos) Recycle of sewerage water in Davao
4	Water Resources Management Plan	P4: Promotion of IWRM (managements of information, flood risks, watershed conservation, organization and institution)	Promotion of IWRM	Promotion of IWRM

●based on the existing / on-going plans
[red frame] Priority Projects

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.4-20 Priority Projects in WRR XI

4.4.4.2 Priority Project Concept

(1) P1: Demand Management

1) P1-1: Reduction of Non-Revenue Water

Reduction of the Non-Revenue Water (NRW) is proposed as one of the priority project concepts of the demand management. Outline of the project concept is the same as Table 4.3-50.

2) P1-2: Promotion of Water Saving Activities

Promotion of water saving is proposed as one of the priority project concepts of the demand management. Outline of the project concept is the same as Table 4.3-51.

3) P1-3: Introduction of Irrigation Telemetry System

Since there is no large irrigation dam in WRR XI, this project is not proposed in WRR XI.

4) P1-4: Improvement of O&M Facility

Several NISs are located in the remote areas from the Negros Oriental Satellite Office, where access roads are in poor conditions, no existence of pavements and difficulty of driving during the rainy season. For proper water control/ management, O&M office with operational staffs and road improvement are required in the improvement works. Outline of the project concept is the same as Table 4.3-53.

The preliminary cost estimate for introduction of irrigation telemetry system and improvement of O&M facility in WRR XI is presented in Table 4.4-39 below.

Table 4.4-39 Preliminary Cost Estimate for Introduction of Irrigation Telemetry System and Improvement of O&M Facility in WRR XI

Irrigation Telemetry System	Target System	ISA (ha)	Unit Cost (Peso/ha)	Amount (million P)
	(none)	0		0.00
Diversion Dam Sluice & Intake Gate	Gate Nos.	Gate Area (sqm)	Unit Cost (Peso/sqm)	Amount (million P)
	29.0	108	1,600,000	172.19
Concrete Flume Canal (Lateral Canals)	Target System	ISA (ha)	Unit Cost (Peso/ha)	Amount (million P)
	(All NISs)	38,814	80,000	3,105.12
Total (million P)				**3,277.31**
Total (million Yen)				**8,193**

Source: JICA Survey Team

(2) P2: Groundwater Management

All of the short-term items listed in Table 4.4-40 should ultimately be implemented on the Philippine side, and capacity strengthening through technology transfer is considered essential. Therefore, it is considered optimal to formulate and update the groundwater management plan through the implementation of the technical cooperation projects shown below as a short-term development plan.

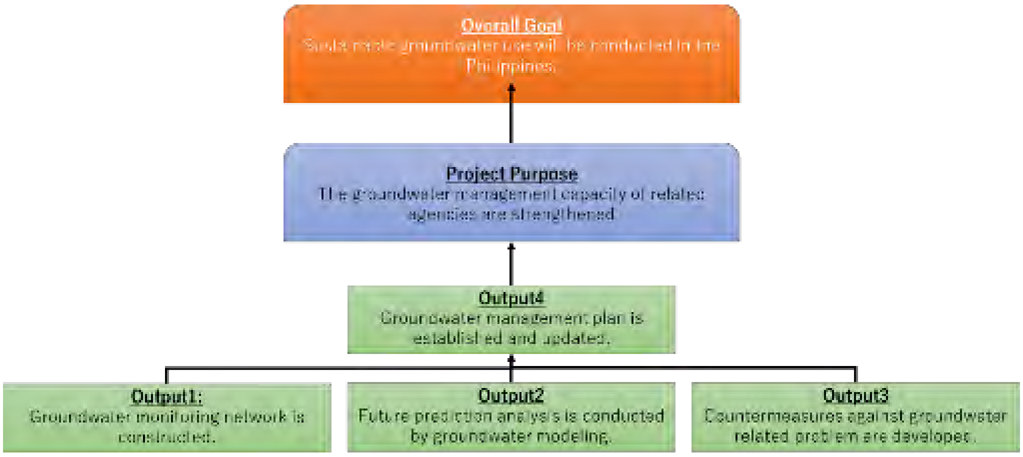
Table 4.4-40 Outline of the Project Concept (Groundwater Management Project)

Title:	Project on Capacity Enhancement for Sustainable Groundwater Management in WRR XI
Goal:	Groundwater management capacity of related agencies are strengthened.
Target:	NWRB, MGB, DCWD, etc
Location:	Davao, Tagum

Output:	Output1: Groundwater monitoring network is developed. Output2: Future prediction analysis is conducted by groundwater modeling. Output3: Countermeasures against groundwater related problem are developed. Output4: Groundwater management plan is established and updated.
Effect:	Groundwater usage will be optimized.
Approx. Cost:	Output1: 82 mil. PHP Output2: 33 mil. PHP Output3: 20 mil. PHP Output4: 20 mil. PHP

Source: JICA Survey Team

The relationship between the overall goal, project purpose, and each outcome is shown in Figure 4.4-21.



Source: JICA Survey Team

Figure 4.4-21 Proposed Overall Goal, Project Purpose, Output of Technical Cooperation Project in WRR XI

The following is a description of the activities and their contents for each of the expected outcomes.

1) **<Output 1>** Groundwater monitoring network is established

[Activity 1-1] Conduct Well Inventory Survey

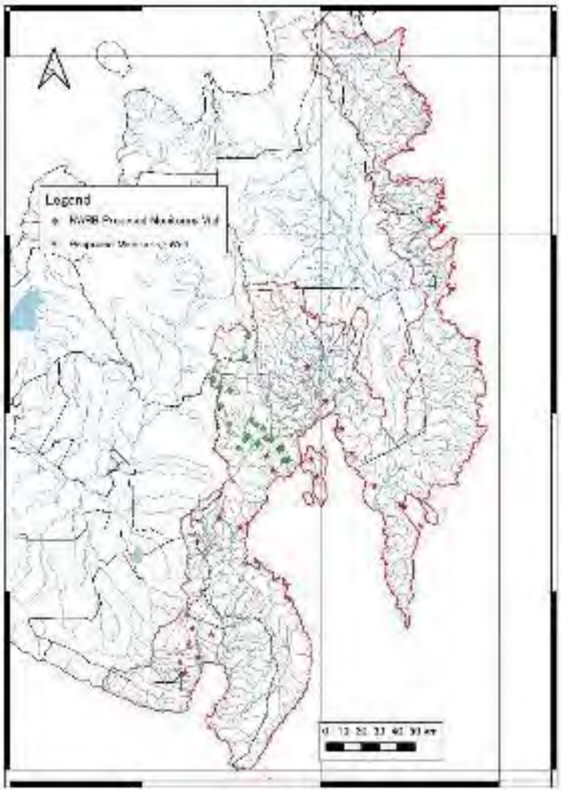
To ascertain the status of groundwater use, the use of wells for domestic, agricultural, and industrial purposes will be confirmed and organized into a list.

[Activity 1-2] Conduct hydrogeological, hydrological, and geophysical surveys

Conduct various geological surveys to determine aquifer capacity. Since NWRB and others have electrical survey equipment, it is better to include the implementation of an electrical survey to estimate the vertical structure of the aquifer. In addition, simultaneous hydrometric surveys should be conducted in the proposed wells at least twice, once in the dry season and once in the rainy season. Measurement of groundwater levels will be beneficial in understanding the distribution status of groundwater levels.

[Activity 1-3] Drilling of new observation wells, pumping tests, and installation of observation equipment

Considering the expected distribution of groundwater level drop and the proposed monitoring wells, it is necessary to establish a groundwater monitoring network that covers the entire area. Figure 4.4-22 shows proposed locations for new monitoring wells with the NWRB's proposed wells.



Source: JICA Survey Team

Figure 4.4-22 Proposal of Groundwater Monitoring Network in WRR XI

(3) P3: Surface Water Development

1) P3-1: Study/Construction of Davao-III Dam (multipurpose dam)

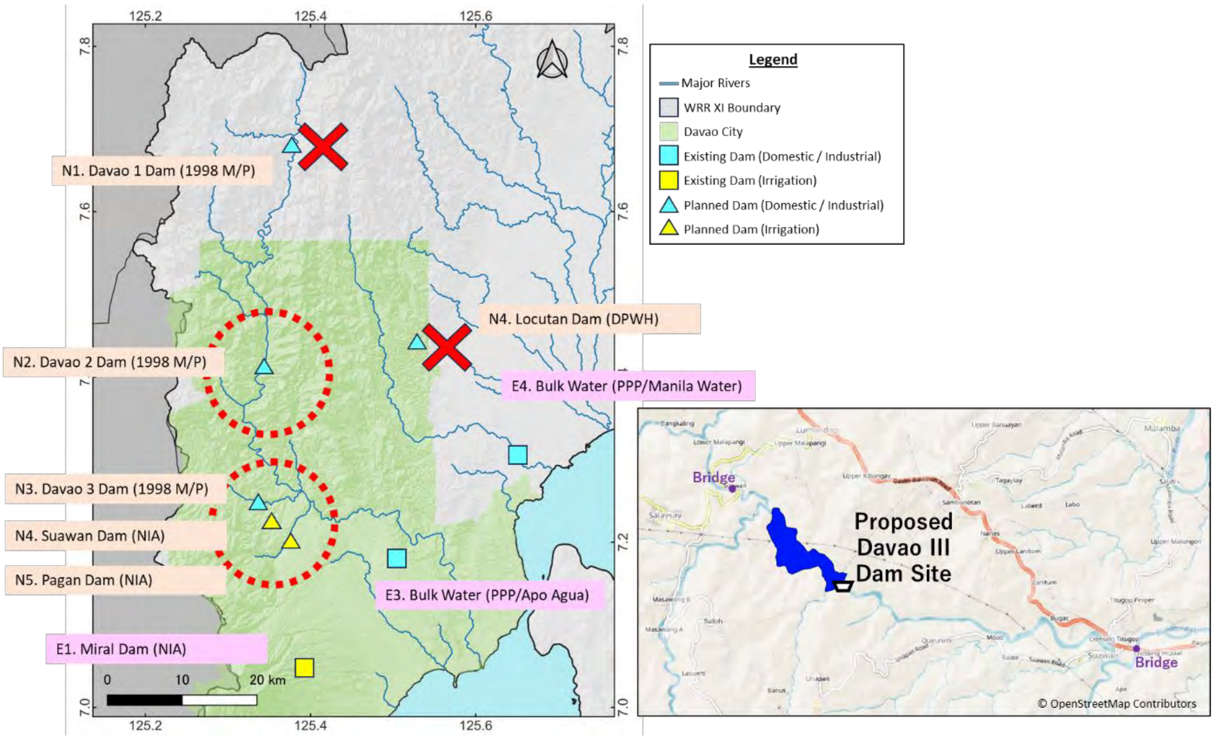
Davao-III dam was planned in the 1998 M/P. At present, near the Davao-III Dam, there are two proposed irrigation dams by NIA, namely Pagan Dam and Suawan Dam. According to NIA, the proposed plans of Pagan and Suawan Dams are still at the preliminary study level, and it was confirmed that it is possible to integrate these two dams to increase storage capacity and use for multiple purposes. Considering the current situation, Davao III dam is proposed as a priority project, to be developed as a multi-purpose dam for not only irrigation water but also water supply.

The basic conditions of the dam plan comply with those in the 1998 M/P. The location of the "Davao 3 Dam in the 1998 M/P" was proposed in the north of Davao City, in the middle reach of the Suawan River, the right tributary of the Davao River. However, it was planned at a point with a small water storage capacity, which is less efficient. Hence, the dam location is proposed to be change to 2.4 km upstream of the existing plan. In addition, as a result of the map study and the field survey shown in sub section 3.4.3.8, it was found that if the dam height is 132 m as the original plan, the scale of water resources development would be large, and relocation of main road bridges and many houses in the proposed reservoir area would be required. Therefore, in this study, the dam height is lowered to 51.5 m, the elevation at which the main road bridges are not submerged.

Table 4.4-41 Outline of the Project Concept (Study/Construction of Davao-III Dam (Low Dam))

Title:	Study/Construction of Davao 3 Dam (low dam)
Goal:	Surface water development for multipurpose use (irrigation, municipal water supply, flood control, hydro power generation)
Targe:	Irrigation water supply of NIA, Water supply system of MDWD
Location:	Suawan River (right tributary of Davao River), Davao City
Profiles:	(Basic Dimension) Dam Type: Rockfill Dam Height and Crest Length: H 51.5 m and L 270 m Catchment Area: 151 km^2 Area of Reservoir: 50.1ha Number of Affected House Holds: 2 hh Capacity of Reservoir: 11.5 MCM In addition to the dam, it is necessary to construct water intake facilities, transmission pipes, water treatment plants, water pumping stations, and water distribution mains. Sediment management facility is necessary.
Effect:	Regulated water supply by using reservoir storage of 11.5 MCM
Cost:	Approx. 2,3142 mil. PHP (for dam construction) Approx. 662 mil. PHP (for pipelines, WTPs)
Others:	Prior to implement the project, a study for design change of dam height as well as social and environmental assessment is necessary.

Source: JICA Survey Team



Source: JICA Survey Team based on NIA 11 data

Figure 4.4-23 Location Map of Davao-III Dam Site

2) P3-2: Study/Construction of Davao-II Dam (multipurpose dam)

Davao II Dam was planned in the 1998 M/P. It was planned as a large-scale water resources development project with a dam height of 112m and a water storage capacity of 436MCM. From result of the field survey shown in sub section 3.4.3.8, it was confirmed that the topography and geology of the dam construction site are suitable, and that there are almost no private houses near the dam axis.

This project is positioned as a long-term plan due to the current applicability of the plan, but in the future, Metro Davao area is expected to have further population growth and economic development, and thus expected to convert the current main water sources from groundwater to surface water. Therefore, implementation of a planning study is proposed as a priority component.

In addition, there was an alternative option to construct a flood control dam in the upstream of the Davao Rivers in the recent JICA Study for formulating a Davao River flood control master plan. However, it was rejected at the time of the first screening, and the plan to construct a retarding pond downstream from the dam site was adopted as a long-term flood control plan. This dam however was designed for flood control purposes only, and was not intended for multi-purpose, including the use and supply of municipal/industrial water and irrigation water. If a multi-purpose comparative study is conducted, the priority of the dam plan may rise. In addition, since the location of this dam plan and the plan of the retarding basin are far apart, they do not interfere physically. As a long-term plan in term of flood control, it is possible to propose both, and consider the optimization of each scale considering the benefits for both flood control and water utilization.

Table 4.4-42 Outline of the Project Concept (Study/Construction of Davao 2 Dam)

Title:	Study/Construction of Davao 2 Dam
Goal:	Surface water development for multipurpose use (irrigation, municipal water supply, flood control, hydro power generation)
Target:	Irrigation water supply of NIA, Water supply system of MDWD
Location:	Davao River, Davao City
Profiles:	(Basic Dimension) Dam Type: Rockfill Dam Height and Crest Length: H131.5 m and L 707 m Catchment Area:814 km^2 Area of Reservoir: 6,125 ha Number of Affected House Holds: ,2322 hh Capacity of Reservoir:2,538 MCM In addition to the dam, it is necessary to construct water intake facilities, transmission pipes, water treatment plants, water pumping stations, and water distribution mains.
Effect:	Regulated water supply by using reservoir storage of 2,538 MCM
Cost:	Approx. 25,684 mil. PHP (for dam construction) Approx.663 mil. PHP (for pipelines, WTPs)
Others:	Prior to implement the project, a study for design change of dam height as well as social and environmental assessment is necessary.

Source: JICA Survey Team

Site Reconnaissance to Davao 2
Dec.03, 2022

Site Reconnaissance to Davao 2 Dam Site

Source: JICA Survey Team

Figure 4.4-24 Photos of Site Condition of Davao II Dam Site

3) P3-3: Study/Upgrading Existing Dams (Miral Dam)

Miral Dam is an irrigation dam built in 1994 in the Padada River in the province of Davao Oriental. Cultivations in the upstream mountainous area has highly progressed, causing more soil erosions in the basin and more sedimentation in the reservoir than planned. As a result, the dam outlet discharge pipe was buried and blocked by sedimentation around 2012, and since then, water has continued to flow out of the spillway in a run-of-river state. At present, the actual irrigated area in the rainy season is 800 ha, which is half of the plan, and 300 ha in the dry season.

This area is suffering from water shortage in case of droughts. Upgrading of existing dams, which have less social impact in term of land acquisition and relocation, has more advantages than new dam development. Therefore, from the viewpoint of effective use of existing dam, the upgrading of the existing Miral Dam by combining dam operation improvement, sedimentation countermeasures, and power generation expansion is proposed as a priority project.

Table 4.4-43 Outline of the Project Concept (Study/Upgrading of Existing Miral Dam)

Title:	Study/Upgrading Existing Miral Dam in Davao Oriental
Goal:	Extend and strengthen of irrigation water supply function of existing Dam
Target:	Irrigation water supply system in Province of Davao Oriental, NIA 11
Location:	Padada River, Miral Dam, Davao Oriental
Profiles:	<Basic Information of Existing Dam (Miral Dam)> Dam type: Hardfill, Dam height: H=27m. Crest length: L=80m, Dam capacity: V=approx.6.3MCM, Service area: SA = 1,500ha. <Study and investigation for dam upgrading> <Implementation of candidate options for dam upgrading> (1) Safety inspection and soundness assessment, (2) sedimentation survey, measures, (3) improvement of dam operation, (4) power generation expansion, etc. <Formulation and implementation of watershed conservation plan>
Effect:	Extension of irrigation water supply function by using reservoir storage of 6.3MCM
Cost:	project cost shall be estimated based on the results of study and investigation
Others:	Prior to implementing the project, investigation and survey as well as study for dam upgrading is necessary.

Source: JICA Survey Team

Figure 4.4-25 Photos of Site Condition of Miral Dam

(4) P3(2): Water Supply System

1) P3-4: Introduction of Desalination Technology

So far Metro Davao Water District does not have any plan for construction of a desalination plant. However, due to the rapid increase of water demands in connection with the economic development of the Davao Metropolitan area, this measure might be necessary in the long-term plan. Promotion study is recommended.

2) P3-5: Introduction of Rainwater Storage and Infiltration

Same as WRR VII, introduction of rainwater storage and infiltration is recommended as a priority project.

(5) P4: Water Resources Management

Promotion or priority project of each water resources management plan (idea) such as information management, flood risk management, river basin environmental conservation and organizational and legal frameworks as mentioned in 4.4.3.6 – 4.4.3.10 are recommended to be implemented.

4.4.4.3 Implementation and Management Scheme for the Priority Project Concept

(1) Introduction

In this section, JST considers and proposes the appropriate implementation and management schemes for the priority project concepts described in section 4.4.3, divided in the items of Short Term (2023-2030) and Middle Term (2030-2040), based on the description in Section 4.3.3.9.

(2) Promotion of IWRM such as managements of information, flood risk, watershed conservation etc., (P4: Management of Water Resources)

The implementation schemes for promotion of IWRM was described in the Section 4.3.4.3 (2), and this affair is applicable for the WRR XI.

(3) Short term (2023-2030)

1) Promotion of Water Saving Activity (P1: Demand Management)

The description on “Promotion of Water Saving Activity” for WRR VII can be applied for WRR XI. Please see section 4.3.4.3. (3) 1).

2) Non-Revenue Water Improvement (P1: Demand Management)

The description on “Non-Revenue Water Improvement” for WRR VII can be applied for WRR XI. Please see section 4.3.4.3. (3) 2).

3) Introduction of Irrigation ITS (P1: Demand Management)

The description on "Introduction of Irrigation ITS" for WRR VII can be applied for WRR XI. Please see section 4.3.4.3. (3) 3).

4) Improvement of Irrigation O&M Facilities (P1: Demand Management)

The description on "Improvement of Irrigation O&M Facilities" for WRR VII can be applied for WRR XI. Please see section 4.3.4.3. (3) 4).

5) Capacity Enhancement for Sustainable Groundwater Management (P2: Groundwater Management)

The description on "Capacity Enhancement for Sustainable Groundwater Management" for WRR VII can be applied for WRR XI. Please see section 4.3.4.3. (3) 5).

6) Promotion of mid-long-Term Plans – Study of Upgrading Miral Dam (P3 (1): Surface Water Development)

Miral Dam is an irrigation water supply dam owned by NIA XI. The upgrading project of Miral Dam is expected to be implemented in the next decade (2030-2040) for recovering the reservoir capacity. Thus, NIA XI should conduct a study for the project in order to implement it in the next decade.

7) Promotion of mid-long-Term Plans – Study of Davao II Dam and Davao III Dam (P3 (1): Surface Water Development)

Both Davao II Dam and Davao III Dam include multiple purposes of 1) irrigation water for NIA, and 2) water supply for DCWD, and their construction works are expected to be implemented in the decade of 2040-2050 and the decade of 2030-2040 respectively. Thus, it is necessary to set a planning scheme suitable for multipurpose dams and a leading agency for the planning in order to implement the project in the future. Here, JST recommends the following options of the leading agency for planning;

- ✓ DWR region office if it is successfully created in the near future
- ✓ NEDA region office in cooperation with relevant agencies if DWR cannot be created

Also, JST likes to propose the option to utilize the existing River Basin Committee (The Davao River Basin Management Alliance) as the consultative framework to build consensus for implementing the projects among stakeholders. Furthermore, it is desirable if the recommendations related to multipurpose dam projects described in 4.3.3.9 (5) are taken into account when conducting the study.

8) Introduction of Rainwater Storage and Infiltration (P3 (2): Water Supply and Sewerage

Development)

The description on "Introduction of Rainwater Storage and Infiltration" for WRR VII can be applied for WRR XI. Please see section 4.3.4.3. (3) 12).

(4) Middle term (2030-2040)

1) Construction of Davao III Dam ((P3 (1): Surface Water Development)

Option 1

The purposes of the project are irrigation to NIA and water supply to DCWD, and both of them are water users.

- ✓ Implementation Scheme

  If DCWD chooses the PPP scheme to the BOT contract with a private entity (such as SPV) for the project, joint venture scheme between NIA XI and the private entity can be applied. As mentioned in section 4.3.3.9. (2), a government-owned and controlled corporation (GOCC) including NIA can establish a joint venture with private entities in the Philippines.

  JST recommends establishing a new organization suitable for multi-purpose projects, but it is usually costly and time-consuming to establish new organizational frameworks. Thus, in this case, it is desirable to apply the existing JV scheme.

- ✓ Management Scheme

  The JV between NIA XI and the private entity will oversee the management of Davao III dam.

Option 2

- ✓ Implementation Scheme

  NIA XI representatively takes the role of the implementation body of the dam construction project. DCWD will bear the appropriate part of the construction cost of the dam.

- ✓ Management Scheme

  NIA XI will be in charge of O&M of the dam after completion of the dam construction, and DCWD will bear the appropriate part of O&M cost of the dam.

Other Comment

- ✓ It is necessary to set a rule for cost allocation of the project between NIA XI and DCWD, whichever option is adopted.

2) Miral Dam Upgrading (P3 (1): Surface Water Development)

The purpose of Miral Dam is irrigation water owned by NIA XI.

Option 1

- ✓ Implementation Scheme

  NIA XI implements the project by itself with its budget.

- ✓ Management Scheme

  NIA XI manages the Miral Dam after completing the project.

Option 2

- ✓ Implementation Scheme

  ROT (Rehabilitate-Operate-Transfer) or RO (Rehabilitate-Operate) scheme can be applied for the project. In this case, a private entity will enter into ROT/RO contract with NIA XI during the limited contract period. The private entity will implement the project to remove the sedimentation.

- ✓ Management Scheme

  The private entity of the ROT/RO contract will oversee the operation and maintenance of Miral Dam during the contract period.

Other Comment

In the case that ROT/RO scheme is applied to the project, adding the hydropower generation to the dam can promote the project implementation from the viewpoint of stabilizing the revenue of the private entity.

Outline of the above proposals of implementation schemes for the priority project concept is summarized in Table 4.4-44, Table 4.4-45, and Table 4.4-46.

Table 4.4-44 Proposal of Implementation Schemes for Priority Projects in WRR XI (Short Term：2023-2030) (1)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P1: Demand Management	Water Saving	Water Supply	LGUs/DENR/WSPs	-	Relevant WSPs w/ supportive education activity from relevant LGUs or CSOs	Relevant WSPs w/ supportive education activity from relevant LGUs or CSOs
	NRW Reduction	Water Supply	LGUs/WSPs	Possible	Relevant WSPs	Relevant WSPs
	Introduction of Irrigation ITS	Irrigation	NIA	-	NIA XI (National Irrigation System (NIS) is assumed.)	NIA XI w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)
	Improvement of Irrigation O&M Facilities	Irrigation	NIA	-	NIA XI (National Irrigation System (NIS) is assumed.)	NIA XI w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)
P2: Groundwater Management	Capacity Enhancement for Sustainable Groundwater Management	Groundwater	NWRB	-	NWRB (Organization to oversee the groundwater monitoring and regulation) in cooperation with relevant WSPs and LGUs	NWRB (Organization to oversee the groundwater monitoring and regulation) in cooperation with relevant WSPs and LGUs
P3(1): Surface Water Development	Study and Investigation for Upgrading existing dams (Miral Dam)	Irrigation	NIA XI	-	NIA XI to conduct study and investigation for upgrading existing dam projects including Miral Dam, which is planned to be implemented in the next decade.	-
	Promotion of mid-long-term plans of Multipurpose Dams (Davao II and III Dams)	Water Resources	-	-	NEDA regional office (or DWR regional office) will lead to develop the plan of multipurpose dam projects and make necessary coordination to promote them in the next decade. Also, it should be considered to utilize the existing River Basin Committee as the consultative framework for consensus building among stakeholders.	
	●Development irrigation weirs and dams (SRIP)	Irrigation	NIA XI	-	NIA XI to implement the construction projects of irrigation weirs and dams in line with its development plan.	NIA XI w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)

Table 4.4-45 Proposal of Implementation Schemes for Priority Projects in WRR XI (Short Term：2023-2030) (2)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P3(2): Water Supply & Sewerage Development	●Bulk Water Developments	Water Supply	WSPs	Possible	A private entity such as SPV will enter into BOT or other types of PPP contract will implement the bulk water supply project. WSPs will purchase water as an off-taker.	In the case of BOT, a private entity such as SPV will be in charge of O&M during the contract period.
	●Groundwater Development (General Santos)	Water Supply	WSP (GSCWD)	Possible	Relevant WD (GSCWD)	Relevant WD (GSCWD)
	Introduction of rainwater storage and Infiltration	Water Supply	NEDA/NWRB/LGUs/WSPs	Possible	Entities such as households, building owners, and urban developers to set the facilities for rainwater storage and infiltration. Also, an incentive scheme such as subsidy may be considered.	

Table 4.4-46 Proposal of Implementation Schemes for Priority Projects in WRR XI (Middle Term：2030-2040)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P3 (1): Surface Water Development	Construction of Davao III Dam	Water Supply & Irrigation	DCWD & NIA XI	Possible	[Option 1] (DCWD to choose the form of bulk water supply and enter a contract with a private entity for BOT or other types of PPP.) JV among NIA XI and a private entity for bulk water supply project will implement the project.	JV among NIA XI and a private entity for bulk water supply project will be in charge of O&M.
					[Option 2] NIA XI takes a role of implementation body of the dam project. DCWD will bear some part of the construction cost of the dam.	NIA XI will be in charge of O&M and DCWD will bear some part of the O&M cost of the dam.
	Miral Dam Upgrading	Irrigation	NIA XI	Possible	[Option 1] NIA XI	[Option 1] NIA XI
					[Option 2] A private entity such as SPV, which enters into ROT/RO contract with the NIA XI, will implement the project.	[Option 2] In the case of ROT/RO, a private entity such as SPV will be in charge of O&M during the contract period.

4.4.5 Regional Collaboration among Water Utilities in WRR XI

In this section, with regard to the proposed water resources development and management plan (Section 4.4.3) and the priority project concept (Section 4.4.4), if there are multiple water utilities in the area covered by the proposed water resource, the possibility of business efficiency improvement through regional collaboration among water utilities (e.g., integration of management, joint operation of facilities, business integration, and management integration) will be considered.

In this regard, JST has not been able to find the situation suitable for the above condition in WRR XI. However, JST cannot rule out the possibility that some of the water utilities that were not included in the Survey may have issues on management improvement or efficiency or may have problems with overlapping multiple water utilities in the WRR. Thus, JST recognizes that regional collaboration among water utilities may be considered as one of the water demand management measurements in the future.

4.4.6 Initial Environmental and Social Impact Assessment in WRR XI

4.4.6.1 Necessity of the Environmental and Social Impact Assessment

Necessity of the environmental and social assessment is shown in 4.3.6.1.

4.4.6.2 Components Considered for the Environmental and Social Condition in WRR XI

Initial environmental and social impact assessment was conducted for the priority projects in WRR XI considering the necessity of assessment in the SEA stage. The selected projects are shown in Table 4.4-47.

Table 4.4-47 Profiles of the Priority Projects Selected for Assessment in WRR XI

No.	Priority Project	Location	Profile	EIA Necessity
1	P1: Demand Management	Whole area	- Reduction of Non-Revenue Water: 1) Implementing underground leakage and sectorization, aboveground leakage measures and apparent loss measures, 2) strengthening pipe materials and/or renewing pipe thorough underground leak detection - Promotion of Water Saving Activities: Spread of water-saving devices and increased awareness of water conservation - Introduction of Irrigation Telemetry System: Providing devices for establishing proper irrigation water management system - Improvement of Irrigation O&M Facility: 1) Improvement of main and lateral canals as concrete lining or flume canal and gate works of diversion dams, 2) replacement of all gates, 3) introduction of the remote-control operation system	× Adverse impacts by some improvement / upgrading works of existing facilities are expected but these impacts are not major and less than installation of new facilities so that these impacts are not evaluated here.
2	P2: Groundwater Management	Davao, Tagum	- Formulating and updating the groundwater management plan through the implementation of the technical cooperation projects	× This project is a technical assistance so major adverse impact is not expected.
3	P3-1: Construction of Davao III Dam (multipurpose dam)	Davao river, Davao City	Name of River: Davao River Dam Type: Rockfill Dam Height and Crest Length: H 51.5 m and L 770 m Area of Reservoir: 50.1 ha Capacity of Reservoir: 11.5 million cubic meters	○ Construction of new dam has a significant impact
4	P3-2: Construction of Davao II Dam (multipurpose dam)	Davao river, Davao City	Name of River: Davao River Dam Type: Rockfill Dam Height and Crest Length: H 131.5 m and L 707 m Area of Reservoir: 6,125 ha Capacity of Reservoir: 2,538 million cubic meters	○ Construction of new dam has a significant impact
5	P3-3: Upgrading Existing Dams (Miral Dam)	Padada River, Miral Dam, Davao Oriental	1) Safety inspection and soundness assessment, 2) Sedimentation survey, measures, 3) Improvement of dam operation, 4) Power generation expansion, etc.	× Adverse impacts by upgrading works of existing dams are not major and less than construction of new dams so that these impacts are not evaluated here.
6	P3-5: Introduction of Rainwater Storage and Infiltration	Water shortage areas in WRR XI	Installation of rainwater storage and infiltration	× Installation of equipment does not major adverse impact.
7	P4 Water Resources Management	Whole area	Information management, Flood risk management, River basin environmental conservation and Organizational and legal frame works	× Major adverse impact is not expected by these managements.

Source: JICA Survey Team

4.4.6.3 Environmental and Social Conditions in the Targeted Area in WRR XI

(1) Water Quality and Water Use

Source: EMB XI Regional State of Brown Environment Report, 2021

Figure 4.4-26 Monitoring Stations in Davao River

Davao River was designated as Water Quality Management Area (WQMA), which aims to improve water quality to meet the guidelines under which they have been classified or to improve its classification based on its potential use. Davao River is classified into two classifications based on its intended beneficial use and location of Davao III Dam is classified as Class A.

- Class B – Stations 1-4a (Downstream)
- Class A – Stations 5-11 (Upstream)

Based on the annual average concentration of the Davao River, the results for color, DO, nitrate, cadmium, copper, and lead are within the water quality guideline values. In contrast, results for chloride, fecal coliform, pH, phosphate, temperature, and TSS exceeded the limits.

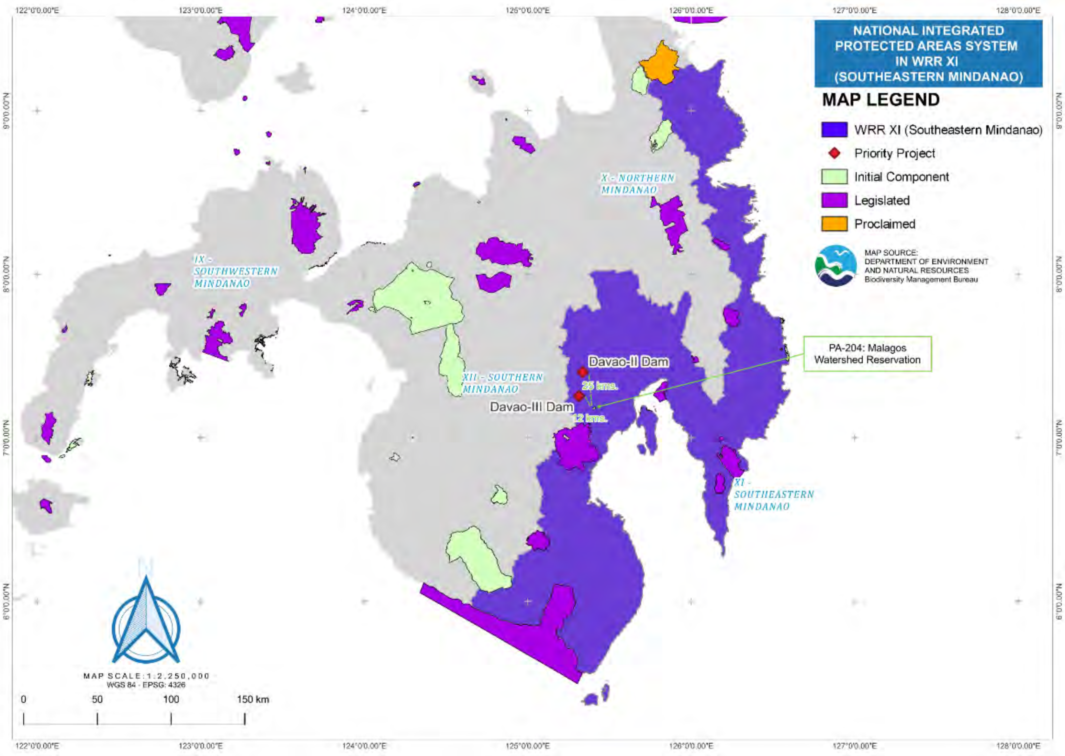
The Davao River is utilized for bathing, washing, occasional fishing, agriculture, and irrigation, as a venue for water rafting, and alternative pathway for navigation. It is also a major source of sand and gravel materials.

Anticipated factors that negatively affect the water quality are that it has been the receiving end of run-offs from rainfall and commercial, industrial, agro-industrial, and residential wastewater.

(2) Protected Area

According to DENR BMB, there are two protected areas that cover Davao City. These are the Malagos Watershed Reservation with a total area of 235 hectares located in Malagos, Baguio District and the Mt. Apo National Park covering a total area of 57,974 hectares, of which 11,137 hectares are situated within the territorial jurisdiction of Davao City. In addition, DCWD and Apo Agua Infrastuctura, Inc. are currently requesting for the declaration of the "Panigan-Tamugan Watershed" as a protected area.

Each priority project area is away from the protected area as shown in Figure 4.4-27.



Source: JICA Survey Team

Figure 4.4-27 Location Map of the Priority Project and Protected Area in WRR XI

(3) Ecosystem and Biodiversity

Davao City is home to different flora and fauna species. In the 235-hectare Malagos Protected Landscape, the DENR observed that the Flora species evenness was high while its diversity was low as of April 2016.

Latest inventory made by the CENRO bared that there are a total of 1,310 fauna species and 370 flora species particularly in the public parks.

Table 4.4-48 Animal Class found in Davao City, 2011-2015

Class	Richness	Diversity	Evenness
Birds	2.833213	High	Very High
Amphibians & Reptiles	1.609438	Very Low	High
Insects	1.946	Low	Very High
Mammals	1.098612	Very High	Very High

Source: Davao City Environment and Natural Resources Office; Davao City CLUP

(4) Resettlement / Land

Possibility of resettlement and land acquisition are summarized in Table 4.4-49.

Table 4.4-49 Possibility of Resettlement for the Priority Project Area in WRR XI

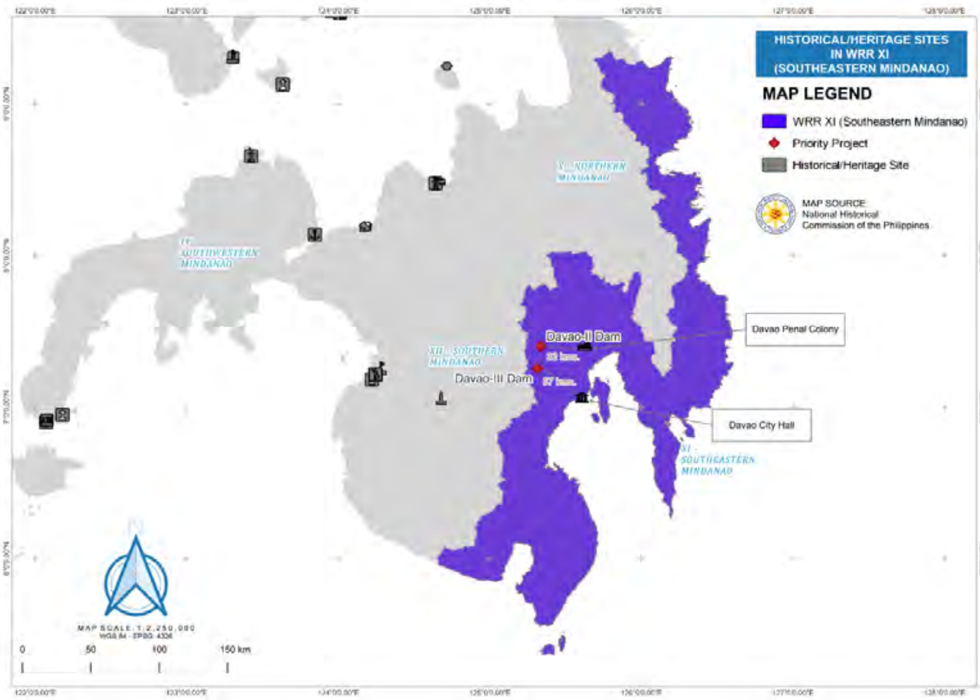
No.	Priority Project	Location	Condition for Water Quality
1	P3-1: Construction	Davao river,	In case of dam height of 52 m, there is a possibility that few

No.	Priority Project	Location	Condition for Water Quality
	of Davao III Dam (multipurpose dam)	Davao City	households need to be resettled. Land of reservoir is 50 ha, which need to be secured.
2	P3-2: Construction of Davao II Dam (multipurpose dam)	Davao river, Davao City	In case of dam height of 130 m, there is a possibility that around 2,200 households need to be resettled. Land of reservoir is 6,125 ha, which need to be secured.

Source: JICA Survey Team

(5) Heritage

The proposed sites of pilot project are away from the nearest identified cultural property, which is the Davao City Hall as shown in Figure 4.4-28.



Source: JICA Survey Team

Figure 4.4-28 Location Map of the Priority Project and Cultural Properties in WRR XI

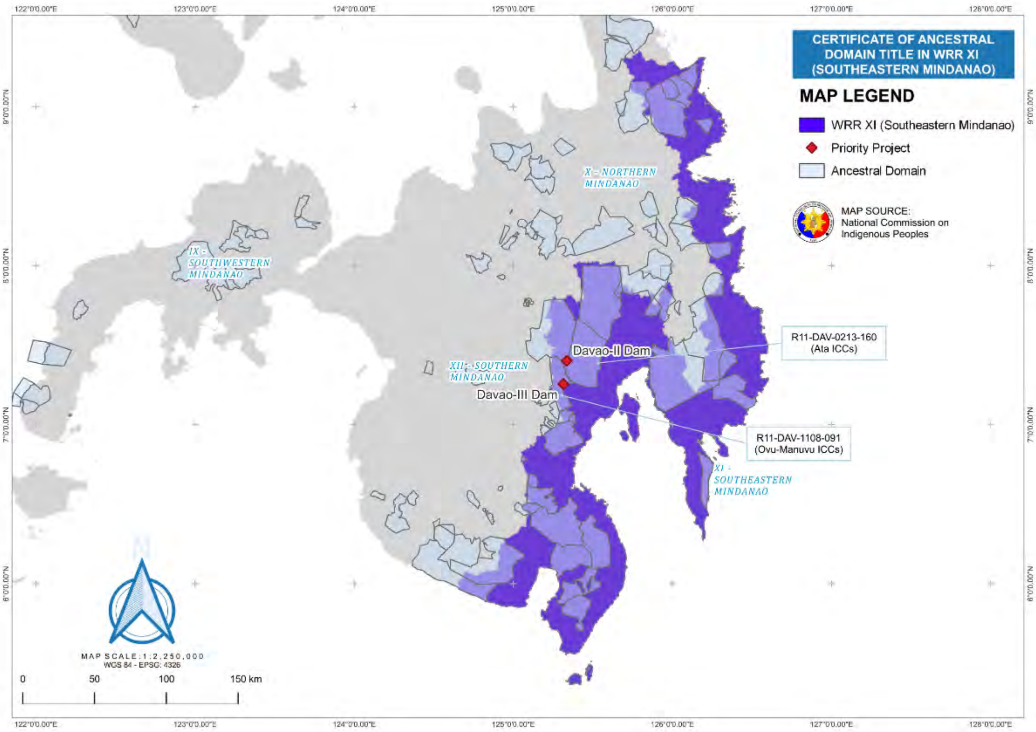
(6) Ethnic Minorities and Indigenous Peoples

The Indigenous Peoples (IPs) communities are located especially in the upstream of Davao River. According to the NCIP, there are three ancestral domains (ADs) with Certificate of Ancestral Domain Title (CADT) around the Davao river as shown in Table 4.4-50.

Table 4.4-50 Profile of CADT

CADT No.	Tribes	Area
R10-KIT-0703-0011	Matigsalug-Manobo	102,400 ha
R11-DAV-0213-160	Ata	87,800 ha
R11-DAV-1108-091	Ovu-Manuvu	35,200 ha

Source: National Commission on Indigenous Peoples



Source: JICA Survey Team

Figure 4.4-29 Location Map of the Priority Project and CADT Area in WRR XI

(7) Poverty

The PSA defines Poverty Incidence (PI) as the proportion of families/individuals with per capita income/expenditure less than the per capita poverty threshold to the total number of families/individuals. The 2021 poverty estimates show that poverty incidence in Davao del Sur province is 7.2% in 2021 against national rate as 13.2% in 2021[1].

4.4.6.4 Scoping of the Priority Projects in WRR XI

Considering the project characteristics and baseline conditions, the result of the scoping is shown in Table 4.4-51.

[1] PSA 2021 Full Year Official Poverty Statistics Tables

Table 4.4-51 Scoping of the Targeted Priority Projects in WRR XI

Items		Construction of Davao III Dam and Davao II Dam		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Pollution Control				
1	Air quality (including greenhouse gas)	✓		**<Construction>** - Air pollution by gas emission caused by construction machines and vehicles is expected - Dust caused by earth works and transportation of materials etc. is expected. - These adverse impacts will be limited around the construction site and during construction period.
2	Water quality	✓	✓	**<Construction>** - Water pollution to the water body by turbid water caused by construction works is expected. **<Operation>** - Adverse impact to water quality in the water reservoir such as eutrophication and dissolved oxygen caused by the storage of water is expected.
3	Waste	✓		**<Construction>** - Generation of construction waste and residual soil by construction works is expected. - Its impact will be limited during construction period.
4	Soil contamination	✓		**<Construction>** - Contamination caused by outflow of construction oil, fuel etc. is expected. - Its adverse impact will be limited during construction period.
5	Noise and vibration	✓		**<Construction>** - Noise and vibration caused by construction works, machines and vehicles are expected. - These adverse impacts will be limited around the construction site and during construction period.
6	Subsidence			- Subsidence is not generally expected.
7	Odor			- Odor is not generally expected.
8	Sediment		✓	**<Operation>** - Inflow and stock of sediments in the reservoir by river erosion are expected - Outflow of sediment to the downstream is changed
Natural Environment				
9	Protected areas			Adverse impact to protected areas is currently not expected.
10	Ecosystem and biodiversity	✓	✓	**<Construction>** - Adverse impact to fauna and flora around/inside the project area caused by construction work is expected. **<Operation>** - Adverse impact to fauna and flora around/inside the project area caused by changes of their habitats and river flow is expected.
11	Hydrology	✓	✓	**<Construction>** - Impact on hydrology of the downstream caused by temporarily damming and excavation of the riverbed is expected. **<Operation>** - Impact on hydrology of the downstream caused by change of water flow volume is expected.
12	Topography and geology	✓		**<Construction>** - Geographical impact caused by the earth works is expected - Its adverse impact will be limited during construction period.
Social Environment				
13	Resettlement and Land acquisition	✓		**<Pre-Construction>** - There is high possibility of resettlement at the proposed dam sites, hence, direct impact to residents is expected. - Each proposed site requires large areas of reservoir, hence, there is high possibility of land acquisition.
14	Ethnic minorities and indigenous peoples / Poverty	✓	✓	**<Construction / Operation>** - There may be some IPs groups so detail survey and frequent communication for the impact to IPs are needed.

Items		Construction of Davao III Dam and Davao II Dam		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Pollution Control				
15	Local economies	✓	✓	**<Construction>** - The project will bring some benefits such as job creation and economic opportunities to sell foods/goods to workers. **<Operation>** - Economy is expected to growth by expanding the usage of water - Compensation for the livelihood will be done if any
16	Water use	✓	✓	**<Construction>** - Temporary adverse impact for water use at the downstream caused by the construction works and generation of turbidity water is expected. **<Operation>** - Impact for water use at the downstream caused by water flow management is expected.
17	Existing social infrastructures and Services	✓	✓	**<Construction>** - Traffic impact caused by the construction vehicles is expected. **<Operation>** - After the operation, the project will contribute to efficient water use.
18	Cultural Heritage			**<Construction / Operation>** The proposed project will not have direct impacts on any identified cultural heritage sites.
19	Landscape		✓	**<Operation>** - Structural design shall consider harmonization with surroundings.
20	Gender / Children's right	✓		**<Construction>** - Gender and Children's right shall be evaluated in detail to consider the equal employment opportunities, provision of break rooms, avoidance of child labor and safety of school zone etc.
21	Working conditions / Accident	✓		**<Construction / Operation>** - Working conditions and Accident shall be evaluated in detail with construction and operation plan to consider working security, traffic safety and fall prevention to water etc.

Note: PCS: Pre-Construction Stage, CS: Construction Stage, OS: Operation Stage

Source: JICA Survey Team

4.4.6.5 Evaluation for the Impact Items in WRR XI

Initial evaluation for the impact items which may cause adverse impact in the scoping items is presented.

(1) Water Quality and Water Use

Location of Davao III Dam is classified as Class A and results for annual average of chloride, fecal coliform, pH, phosphate, temperature, and TSS exceeded the limits. In addition, the Davao River is utilized for many activities such as bathing, fishing, irrigation, etc.

To avoid impacts on above conditions, control of turbid water is mainly needed during the construction considering the seasonal climate.

In the operation phase, water quality in the reservoir may be worse in case untreated wastewater is discharged from urbanized area. Hence, prevention of inflow of wastewater is needed.

(2) Sediment

Condition of sediments will be changed by the project, hence detail survey for the impact on the sediment at downstream is needed. In case sediment causes adverse impact to surroundings, removal of sediment and design of facility to avoid the stock of sediment should be considered.

(3) Ecosystem

Detailed surveys on the vulnerable species and its habitation are needed before the construction and identified in detail. In the operation stage, their monitoring is also needed, and mitigation measures such as reforestation should be conducted as needed.

(4) Hydrology

Impact on hydrology of the downstream needs to be considered, and survey and communication with residents at the downstream area should be conducted before the construction.

(5) Resettlement and Land acquisition

Affected households are expected in the dam construction projects and there may be possibilities of resettlement and land acquisition around the project site, thus, detail survey and frequent communication with residents are needed to evaluate these impacts. Preparation of a RAP is necessary including eligibility for receiving compensation and resettlement assistance, compensation and entitlements, implementation procedures that ensure complaints are processed, public support and participation, and the provision of internal and external monitoring of the implementation of the RAP.

(6) Ethnic minorities and indigenous peoples

There may be some IPs groups around the project area, hence detail survey of the impact to IPs and frequent communication with the groups are needed to evaluate these impacts. These considerations should be planned in the RAP before the construction.

In case the project is implemented in ADs, the following procedures are needed.

- Granting of Free and Prior Informed Consent (FPIC) for projects within ancestral domains
- Participate in the public scoping
- In the process of EIA study, the socio-economic/perception surveys which shall be used as the basis for the subsequent formulation of social development plans, IEC, monitoring plans and other components of the environmental management plans are needed.
- Participate in public hearings or public consultations;
- Multi-partite monitoring

4.4.6.6 Possible Mitigation Measures and Management Plan in WRR XI

As a result of the initial evaluation above, possible mitigation measures and the environmental management plan are shown in Table 4.4-52.

Table 4.4-52 Possible Mitigation Measures and Management Plan in WRR XI

No.	Impact Item	Mitigation and Management Measures	Implementer
1	Water Quality and Water Use	<Construction> - Earth works inside and near the water body during the dry season - Temporary cofferdam method at the time of excavation works - Countermeasures for sediment and turbidity <Operation> - Direct purification of river water by filtration and vegetation purification and excavation of sediment etc. - Prevention of load inflow by protection of dam slope, wastewater treatment and reforestation etc. - Management of discharge flow considering the environmental flow	- Contractor - Manager of facility
2	Sediment	<Operation> - Excavation and dredging of sediment for renoval - Installation of sediment trap dam at the upstream to prevent its inflow. - Designing sand discharge facility	- Design consultant - Manager of facility
3	Ecosystems	<Construction> - Attention to wildlife at the time of site clearance and restricting the loss of vegetation within the project area < Construction / Operation> - Confirmation of the existence of vulnerable species and continuous monitoring - Reforestation	- Contractor - Manager of facility
4	Hydrology	<Construction> - Implementation of appropriate drainage plan <Operation> - Development and implementation of an appropriate water intake plan - Management of water intake amount according to the season change.	- Contractor - Manager of facility
5	Resettlement and Land acquisition / Ethnic minorities and indigenous peoples / Poverty	<Pre-Construction> - Secure accessibility to ancestral domains - Assistance to access social welfare and support. - Secure adequate compensation and support indicated in the RAP	- Design consultant - Manager of facility

Source: JICA Survey Team

4.5 Priority Water Resources Region (WRR V)

4.5 Priority Water Resources Region (WRR V)

4.5.1 Analysis of Present Status of Water Resources in WRR V

(1) Present Status of Water Resources

The present status of water resources development and management in the priority water resources regions and the result of the water balance analysis are summarized in Chapter 3.

(2) Summary Results of Water Balance Analysis

In the water balance analysis, the following scenarios and cases are considered for the assessment of the climate change impacts. A summary of the water balance calculation results for the current situation and climate change scenarios (4 cases: current climate and 3cases of climate change LMH) in WRR V is shown in Table 4.5-1 below.

Table 4.5-1 Examination case of Water Balance Analysis in WRR V

Scenario	Target Year of Water Demands	Cases and Scenario of Climate Change Impact (RCP8.5)	Countermeasure
Present	2020	Present climate	None
Future (w/o measures)	2050	4 cases: No impact (Present climate) & 3scenario (L, M, H)	None
Future (w/measures)	2050 (w/ demand management)	4 cases No impact (Present climate) & 3scenario (L, M, H)	Based on the case in left, water balance and combination of countermeasures is studied.

Source: JICA Survey Team

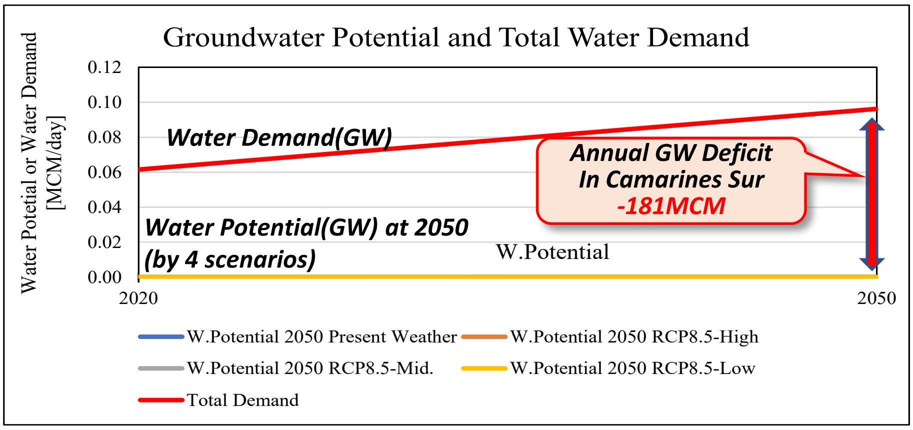
Table 4.5-2 Summary of Water Balance by Province and by Major City (2050 climate change (low), 1/5 drought year) in WRR V

Province		Annual Water Balance in 2050 (MCM)		
		Surface Water	Groundwater	Total
Albay		○ (+1,373)	× (-42)	○ (+1,330)
Camarines Norte		○ (+2,291)	× (-25)	○ (+2,267)
Camarines Sur		○ (+3,469)	× (-181)	○ (+3,288)
Catanduanes		○ (+1,039)	○ (+301)	○ (+1,340)
Masbate		○ (+719)	× (-9)	○ (+709)
Quezon		○ (+576)	○ (+12)	○ (+588)
Sorsogon		○ (+1,039)	× (-9)	○ (+1,030)
Whole Area (WRR V)		○ (+10,506)	○ (+47)	○ (+10,553)
Province(s)	Major City	Annual Water Balance (MCM)		
		Surface Water	Groundwater	Total
Albay	Legazpi	○ (+167)	× (-7)	○ (+160)
Camarines Norte	Daet	○ (+230)	× (-21)	○ (+209)
Camarines Sur	Naga	○ (+77)	× (-35)	○ (+42)
Catanduanes	Catanduanes	○ (+1,026)	○ (+302)	○ (+1,327)
Masbate	Masbate	○ (+951)	× (-6)	○ (+946)

Source: JICA Survey Team

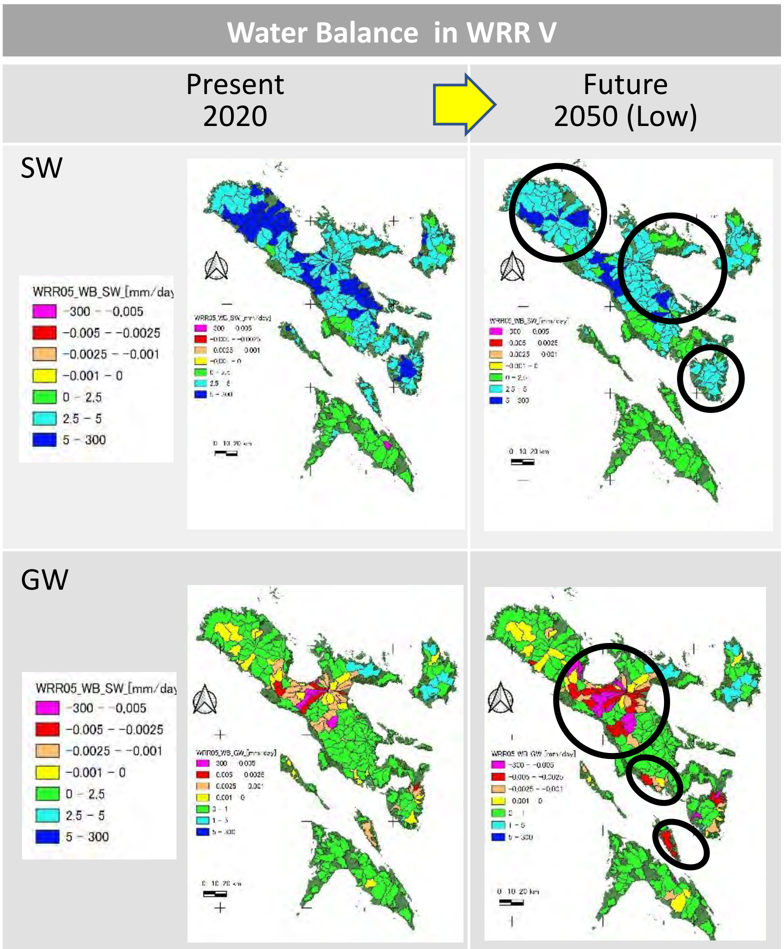
As shown in Table 4.5-2 above, there is a marked shortage of groundwater potential in the region as a whole, while surface water potential is abundant in the whole region. By municipality, the risk of water shortage in Camarines Sur is high; the estimated groundwater shortage is -181 MCM, in case of year 2050, 1/5 drought year, with climate change.

Camarines Sur (Naga City)



Source: JICA Survey Team

Figure 4.5-1 Prediction of Future Water Balance of Groundwater in Camarines Sur



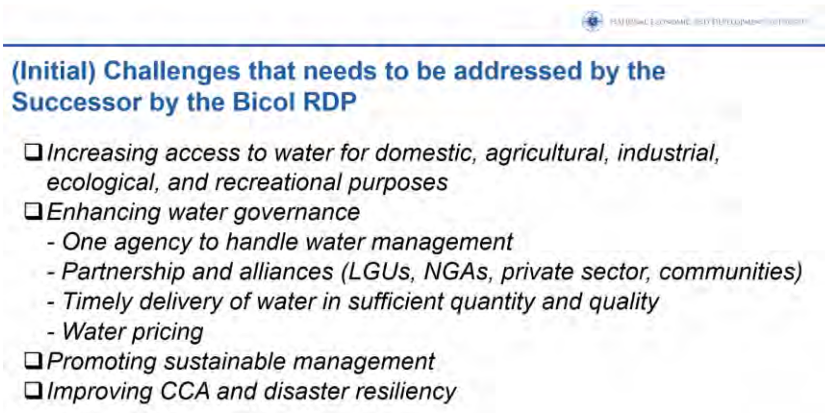
Source: JICA Survey Team

Figure 4.5-2 Overall Location Map of Water Balance Change in WRR V

(3) Current Water Resources Development Plan

In the Bicol Regional Development Plan 2017-2022 Midterm Update, strategy and policy for water resources development sector in the region were summarized in Chapter 19 Accelerating Infrastructure Development, Sub-Sector Outcomes 2: “Water security ensured and lives and property protected from floods”, and cross cutting strategies related to water resources development were described. It initially assessed the challenges that needs to be address by the successor by the Bicol RDDP as below:

Regional Development Plan 2017-2022



Source: Bicol RDP 2017-2022, NEDA RO-V

Figure 4.5-3 Current Water Resources Development Plan in Bicol Region

4.5.2 Study for Water Resources Development and Management Options in WRR V

4.5.2.1 Map Survey and Field Investigation of New Water Resources (Dams, Weirs, Possible Reservoirs)

Related information on existing plans including the 1998 M/P proposed projects and new possible water source candidate sites were collected, and a map study referring to topographic maps, geological maps, and land use maps were conducted to find candidate sites of proposed dams, weirs, water conveyance points, and construction roads. In addition, at the stage of scoping down to a more promising candidate sites for water resource, on-site investigations were conducted to check the local situation and collect information from local stakeholders.

The maximum feasible development capacity was studied while paying attention to the residential houses, land use, and rare creatures at the study site.

The following challenges and strategies in each area were considered and proposed by JST based on the results of the field investigation, but after discussions with NEDA/NWRB and at the stakeholder meetings, it was understood that it was a reasonable policy that the Philippines side could adopt.

(1) Bicol River Downstream

1) Current situation

- Rich surface water potential from the foot of Mt. Mayon
- Irrigation facility does not have a reservoir but is a weir-type intake with sediment discharge gates.
- Farm ponds and pump irrigation system are being implemented recently.

2) Challenges

- Water shortage due to problems in the operation of irrigation water: (1) insufficient flow capacity due to sediment inflow and deposition, and overgrowth of water hyacinth in irrigation canals, (2) pollution due to inflow of sewage, (3) inefficient intake and water supply due to aging of facilities, and delays in restoration after flood damages, and (4) monitoring is not possible.
- Flooding, poor drainage and sediment management problems in the Bicol River Basin
- Intrusion of salt water in irrigation areas near the estuary

3) Strategy for countermeasures

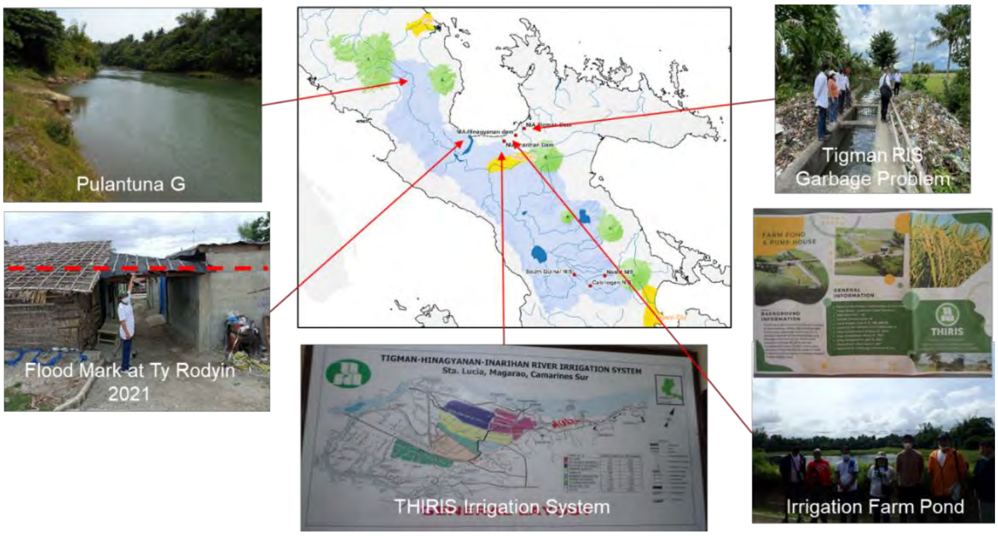
- Water shortage can be resolved by improving sediment management of intake, maintenance of waterways and facilities, and improvement of operation, as there is rich surface water potential.
- Modernization of irrigation facilities, water-saving operation, and flood control are important.

Main findings of the field investigation and results of assessment of water resources facilities in Bicol River Downstream are presented below.

Table 4.5-3 Result of Assessment of Water Resources Facilities in Bicol River Downstream

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Bicol River Downstream	■Existing Dam None (only irrigation weir)	
	■Planned Dam [NIA]: Sipcot Dam	✓ Planned Sipcot Dam was interrupted (social issue, IP)
	■Existing Water Supply [Naga WD]: Groundwater (wells)	✓ Needs for surface water development (small pond), salinity water measure, and flood and sediment management

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-4 Result of Field Investigation and Assessment of New Water Resources in Bicol River Downstream

(2) Bicol River Upstream

1) Current situation

- Irrigation area upstream of Bicol is highly dependent on the water resources of Lake Buhi (lake area: 17km^2).
- At the end of the lake, there is a Lake Buhi Control Structure (NIA). There are several villages around the lakeshore, and transportation to the villages is by boat. The lake is used as an active fish farming and tourist area.

2) Challenges

- Effective depth of Lake Buhi is only 0.5 m, between HWL 82.8 m and LWL 82.3 m, while the original one was 3.3 m with LWL of 79.5 m. This regulation is in place because lowering the WL deteriorates water quality and kills fish in the lake.

3) Strategy for countermeasure

– Effective depth can be increased by 1 m by raising HWL and/or lowering LWL to develop 17 MCM of water.

– Dredging can increase water depth of the lake and improve water quality. The dredged sediments can be used for land reclamation areas around the lake.

– With modernization of control structures, gate operation can be improved not only for irrigation intake, but also for flood control for the lakeside village and the downstream river.

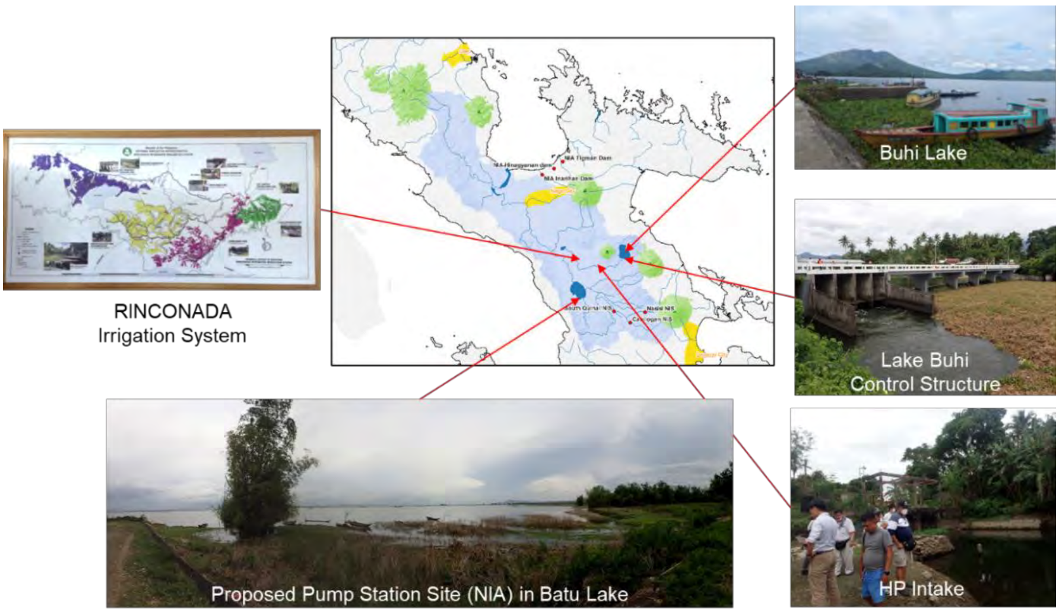
– In connection with the changing of the effective depth, bank protection works will be provided with environmental improvement along lake shore.

Main findings of the field investigation and results of assessment of water resources facilities in Bicol River Upstream are presented below.

Table 4.5-4 Result of Assessment of Water Resources Facilities in Bicol River Downstream

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Bicol River Upstream	■Existing Dam Buhi Lake, Batu Lake No dams (only irrigation weirs and hydropower intake)	✓ Sedimentation, aging and constrain of effective water depth in existing lakes ⇒Necessity of Integrated water management of existing lakes
	■Planned Dam [NIA]: Waras dam	✓ Planned Waras Dam was interrupted (social issue)
	■Existing Water Supply	✓ Needs for flood and sediment management

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-5 Result of Field Investigation and Assessment of New Water Resources in Bicol River Downstream

(3) Catanduanes

1) Current situation

- Main water source of Virac WD is surface water. Groundwater is used as a backup water source.
- Main water source of NIA is also surface water. Irrigation development is being carried out by weirs, but no dam
- Rich surface water and groundwater due to abundant forests and rainfall.

2) Challenges

- High NRW and small service rate (45%) due to small WD's budget.
- Although the facilities are dilapidated, they cannot be repaired, renewed, or expanded as desired.
- In case of serious droughts, water supply is restricted while residents use their own wells.

3) Strategy for countermeasure

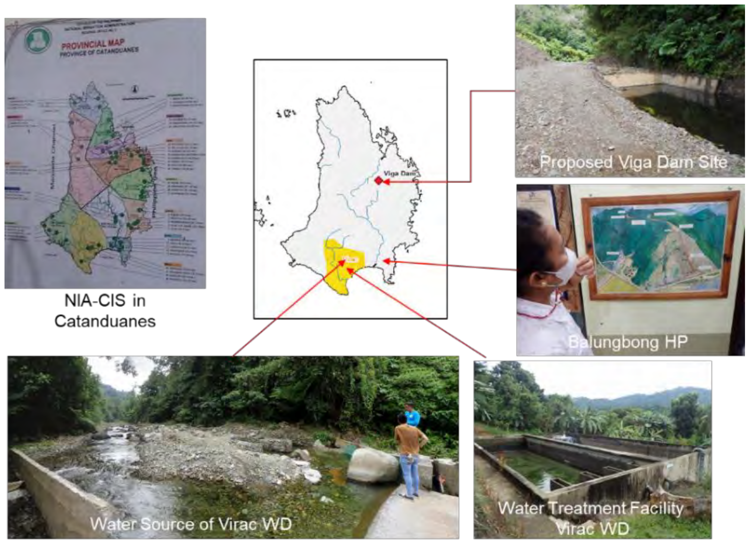
- Continuation of groundwater & surface water developments by weirs are recommended.
- Since there is not a large water demand, a large-scale dam is not considered necessary.
- However, there are topographically and hydrologically candidate dam sites. In the future, multiple uses such as power generation, irrigation, and water utilization will be considered as required.

Main findings of the field investigation and results of assessment of water resources facilities in Catanduanes are presented below.

Table 4.5-5 Result of Assessment of Water Resources Facilities in Catanduanes

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Catanduanes	■Existing Dam [for hydropower plant]: 3 dams by NAPCOR and SWECO	
	■Planned Dam [DPWH]: Viga dam	✓ Planned Viga Dam is not recommended due to hydrological and dam structural problems
	■Existing Water Supply Virac WD (GW well, SW with spring)	✓ Needs for NRW improvement and GW & SW (weir) development (⇒in progress)

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-6 Result of Field Investigation and Assessment of New Water Resources in Catanduanes

(4) Sorsogon

1) Current situation

- NIA's irrigation area has expanded, and the main water source is groundwater.
- The Ibingan Dam is under construction by NIA (82% progress, construction cost 400 M Peso). It will be the first dam in the area.
- Foundation excavation, grouting, diversion, embankment, spillway and irrigation discharge pipes have been installed. The gate (valve) and the final embankment works remain.

2) Challenges

- Watershed area of the dam is small (5km^2) as a water resource.
- Central part of the peninsula is volcanic and not much suitable for reservoir construction.

3) Strategy for countermeasure

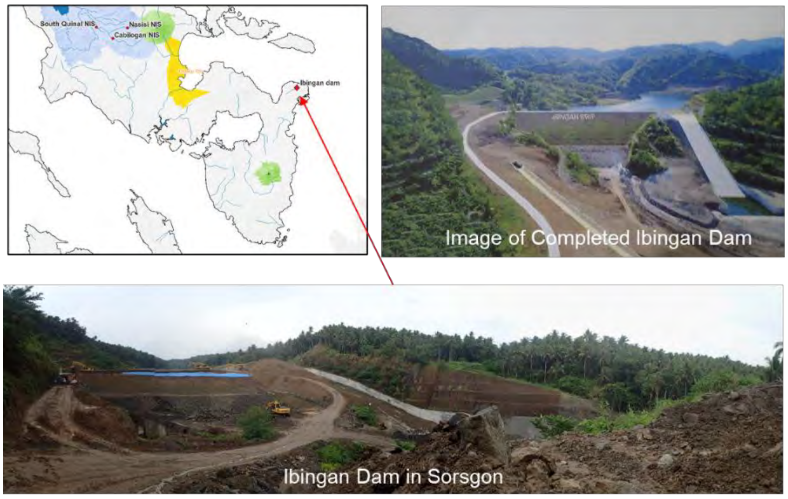
- Continuation of irrigation developments with surface water and groundwater.

Main findings of the field investigation and results of assessment of water resources facilities in Sorsogon are presented below.

Table 4.5-6 Result of Assessment of Water Resources Facilities in Sorsogon

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Sorsogon	■Existing Dam None (only irrigation weirs)	
	■Planned Dam [NIA]: Ibingan Dam (under construction)	✓ Ibingan Dam construction works (H= 27 m, Earth-fill, Progress 82%, Construction cost, P386 M)

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-7 Result of Field Investigation and Assessment of New Water Resources in Sorsogon

(5) Masbate

1) Current situation

- There is severe water shortage. In case of drought, domestic water supply is restricted (4-6 hours a day).
- There are water quality problems with turbid surface water and contaminated groundwater with iron and manganese. There are several mining areas.
- Main land use is grassland with relatively little vegetation. In the past, the land was bare due to deforestation.
- NIA implemented irrigation development by weir (CIS).
- Masbate WD supplies water to Masbate and Mobo cities with surface water of Bañadero River by 12,000 CMD, and groundwater by deep wells with 1,382-3,888 CMD. Service rate is 68%.

2) Challenges

- In the provincial government's development policy, water resources development and electric power development are given high priority, and early development is required.
- There is a proposal for a multi-purpose dam, but it has not yet been investigated.

3) Strategy for countermeasure

- Candidate dam site is in the Lanang River, the largest river in the island. The value of the multi-purpose development is high, although there are minor social problems such as resettlements and gold mining in the river.
- In the downstream of Lanang River, BSWM is constructing impounding dam for local irrigation.

– Survey and planning of Lanang dam as well as investigation of other water sources in other areas are recommended in the future.

Main findings of the field investigation and results of assessment of water resources facilities in Masbate are presented below.

Table 4.5-7 Result of Assessment of Water Resources Facilities in Masbate

Area	Water Resources Facilities	Result of Field Investigation and Assessment
Masbate	■Existing Dam None (only irrigation weirs and small ponds)	✓ Irrigation development by weirs and small ponds (⇒in progress)
	■Planned Dam [PPDO]: Lanang Dam	✓ Necessity of detailed survey/investigation for Lanang Dam plan
	■Existing Water Supply [Masbate WD]: Surface water (river) and Groundwater (deep wells)	✓ There are water quality issues for water supply

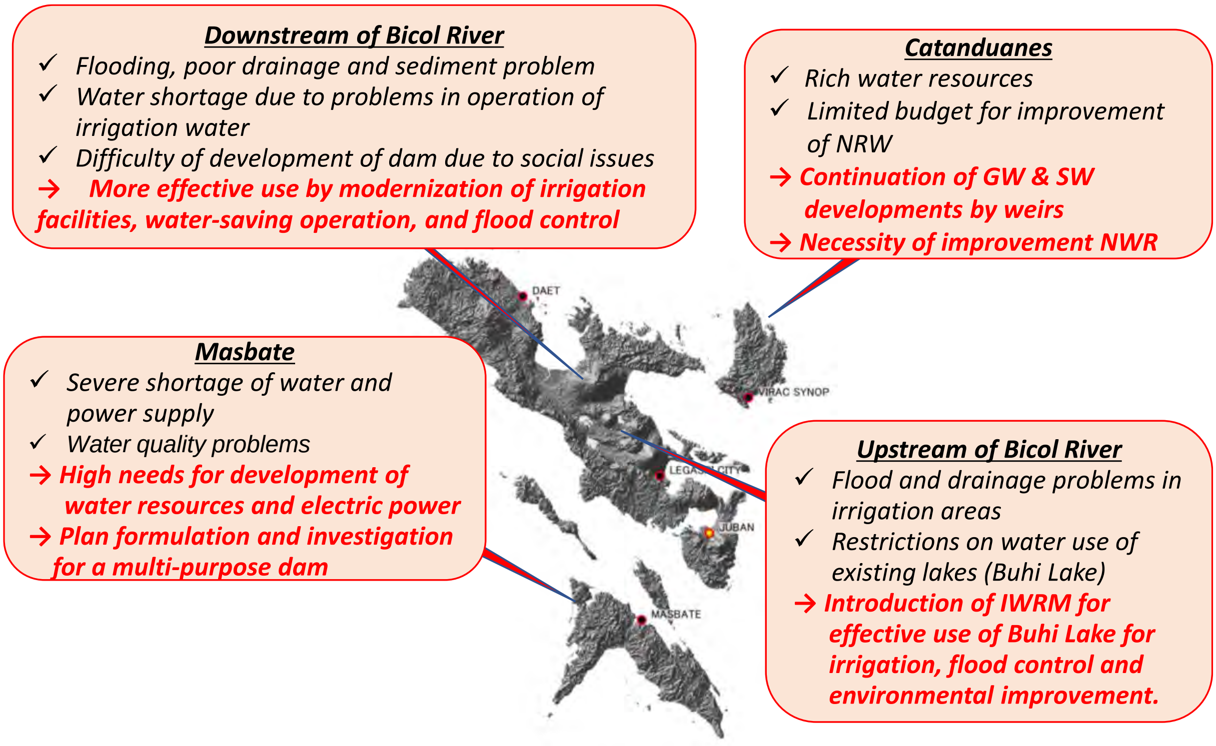
Source: JICA Survey Team

Source: JICA Survey Team

Figure 4.5-8 Result of Field Investigation and Assessment of New Water Resources in Masbate

(6) Results of Map Survey and Field Investigation

Overall results of the map survey and field investigation of water resources facilities in WRR V are summarized in the figure below.

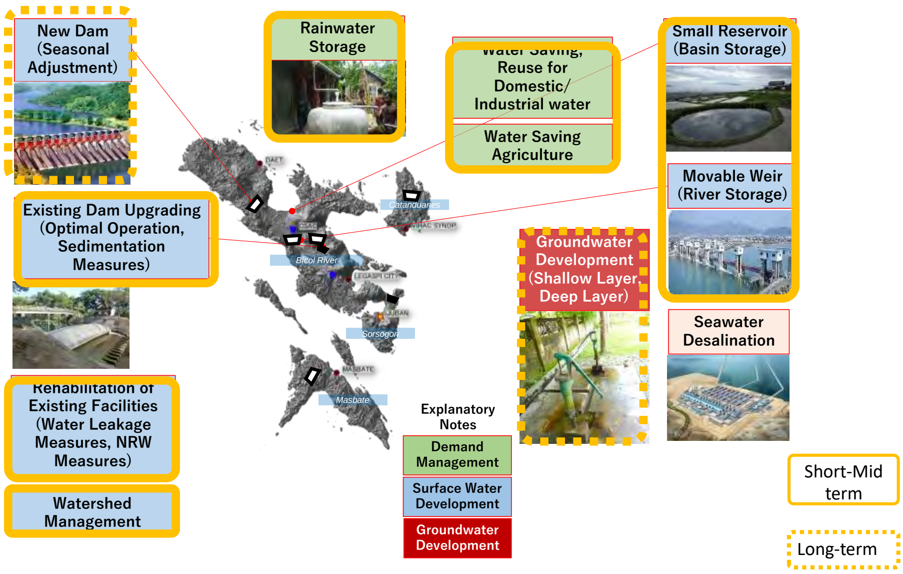


Source: JICA Survey Team

Figure 4.5-9 Result of Field Investigation and Assessment of Water Resources in WRR V

4.5.2.2 Alternative Study for New Water Resources Development Options (First Screening)

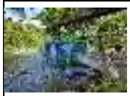
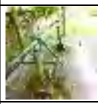
Possible individual countermeasures are formulated as shown in Figure 4.5-10 and Table 4.5-8. For these measures, primary screening is conducted to compare the adoptability based on the map survey and the field survey results to select multiple realistic plans. In the areas where water sources are limited, demand management should be included as one of the options to be considered.



Source: JICA Survey Team

Figure 4.5-10 Individual Countermeasures for Water Sources and Water Utilization Facilities in WRR V

Table 4.5-8 Result of First Screening of Countermeasures of Water Source Development Options (WRR V)

Countermeasure Plan		Surface Water Development				Groundwater Development		Seawater Desalination	Water Saving (Demand management)
		Dam/Reservoir	Movable Weir	Small Pond	Inter-basin Diversion	Shallow Layer	Deep Layer		
Overview		Control structure with seasonal discharge	Structures for bulk water and local irrigation	Structures for local irrigation	Proposed in the existing plan	Currently implemented locally	Groundwater deeper than existing wells	Complementary measures when the amount of water is low	Water-saving agriculture, water leakage, etc.
									
Adoptability	Short-term	×	◎	○	×	○	○	×	◎
	Mid-term	○ Buhi Lake IWRM	○	○	×	○	○	×	◎
	Long-term	○ (Lanang Dam in Masbate)	○	○	×	△	○	×	◎

Legend: ◎Very Effective, ○Effective, △Somewhat Effective, ×Not Subject to Consideration (based on assessment for the adaptability based on the map survey and the field survey results)

Source: JICA Survey Team

Among these countermeasures, the applicability was first evaluated "qualitatively". For those that have applicability, secondary screening is proceeded with different criterion such as the amount of water to be developed.

4.5.2.3 Water Balance Analysis of Countermeasures

Assuming basic countermeasure alternatives that combine the above options that consider the staged development for the short-term, medium-term, and long-term, water balance analysis for each alternative options are performed using the hydrological analysis model. In this way, the amount of water that can be developed and the scale of the facility can be examined.

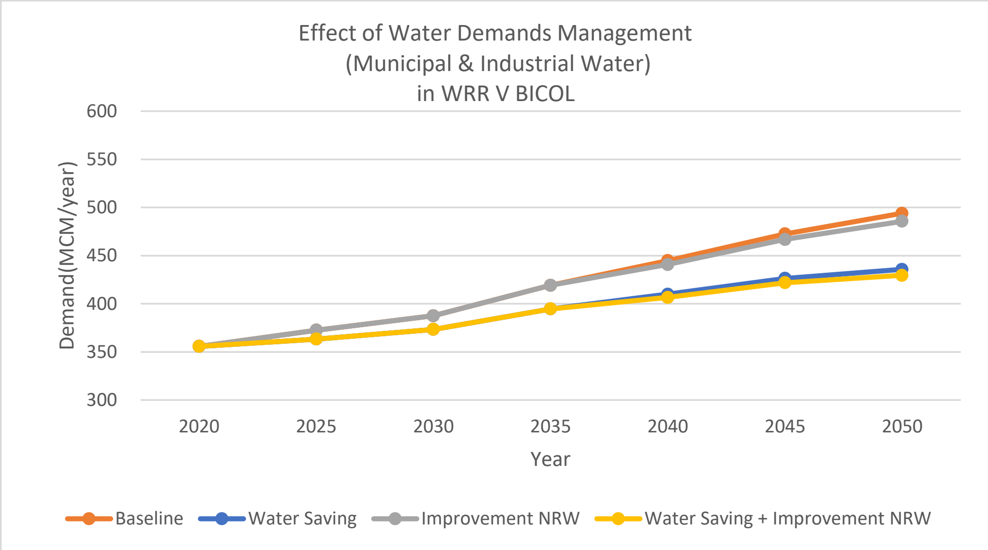
(1) Concept and Procedure for Measures to Improve Water Balance

The same concept and procedure for measures to improve the balance of water and supply in WRR VII as mentioned in Section 4.3.2.3 is applied.

(2) Measures 1 (Water Demand Managements)

1) Demand Management (Municipal and Industrial Water Use)

As for the demand management measures for municipal and industrial water use, water saving and enhancement of non-revenue water measures as described in 4.3.3.5 are considered to be applied. The reduction effect is estimated as 13% in total in whole WRR V as shown in Figure 4.5-11 below.



Water Resource Region		Municipal & Industrial Water Demand Projection (MCM/Year)							Reduction Effect in 2050
		2020	2025	2030	2035	2040	2045	2050	
WRR V - BICOL	Baseline	356	373	387	419	445	473	494	100%
	Water Saving	356	363	373	395	410	426	436	88%
	Improvement NRW	356	373	387	419	441	467	486	98%
	Water Saving + Improvement NRW	356	363	373	395	407	422	430	87%

Source: JICA Survey Team

Figure 4.5-11 Reduction Effect of Demands Management (Municipal and Industrial Water Use) in WRR V

2) Demand Management (Irrigation Water Use)

As for the demand management measures for irrigation water use, waterway leakage countermeasures, irrigation efficiency improvement by introducing ITS as described in 4.3.3.5 are considered to be applied. The reduction effect is estimated as 5.8% in total in the whole WRR V as shown in Table 4.5-9 below.

Table 4.5-9 Reduction Effect of Demands Management (Irrigation Water Use) in WRR V

WRR V (Region V and part of Region IV-A)

Province	Irrigated Area (ha)		Without measures	With measures	Without - With	
	Wet	Dry	Irrigation Water Demands in 2050 (MCM)		Reduction of Irrigation Water Demands in 2050 (MCM)	
Albay	46,059	43,273	1,096	1,034	61	5.6%
Camarines Norte	18,529	18,488	412	377	34	8.3%
Camarines Sur	86,902	83,273	2,262	2,128	134	5.9%
Catanduanes	3,080	3,138	82	81	1	1.6%
Masbate	16,247	16,543	425	396	29	6.8%
Sorsogon	12,511	12,453	295	290	5	1.7%
Queson	1,053	963	21	21	1	2.5%
Total	**184,382**	**178,131**	**4,592**	**4,327**	**265**	**5.8%**

Source: JICA Survey Team

3) Total Demand Management

The reduction of total water demand adopting both of 1) and 2) measures is summarized by each province as shown in Table 4.5-10 below.

Table 4.5-10 Reduction of Total Water Demand adopting Demand Management Countermeasures by Province in WRR V

Province	SW/GW	Without	With	Without-With	
		Total Demand	Total Demand	Reduction of Total Demand	
		[MCM/day]	[MCM/day]	[MCM/day]	[%]
Albay	SW	1,202.6	1,094.1	108.4	9%
	GW	68.4	46.4	22.0	32%
	Total	1,270.9	1,140.6	130.4	10%
Camarines Norte	SW	479.0	423.2	55.9	12%
	GW	42.8	36.8	5.9	14%
	Total	521.8	460.0	61.8	12%
Camarines Sur	SW	2,333.7	2,175.2	158.5	7%
	GW	243.6	166.2	77.4	32%
	Total	2,577.3	2,341.4	235.9	9%
Catanduanes	SW	111.0	97.6	13.4	12%
	GW	5.0	3.6	1.4	28%
	Total	116.0	101.2	14.8	13%
Masbate	SW	486.6	435.8	50.8	10%
	GW	22.1	14.2	8.0	36%
	Total	508.8	450.0	58.8	12%
Quezon	SW	56.9	53.3	3.6	6%
	GW	2.4	2.3	0.1	3%
	Total	58.4	55.6	2.8	5%
Sorsogon	SW	339.8	317.5	22.3	7%
	GW	56.8	34.4	22.3	39%
	Total	396.6	352.0	44.6	11%
WRR-V all	**SW**	**5,009.5**	**4,596.7**	**412.8**	**8%**
	GW	**440.2**	**303.9**	**136.3**	**31%**
	Total	**5,449.8**	**4,900.6**	**549.2**	**10%**

Note: Present Climate, 2050, 1/5-dry year

Source: JICA Survey Team

(3) Required Storage Volume for Reservoir Operation

In order to calculate the amount of development water necessary to cover the shortage of water supply and demand in the future 2050 even if the water demand adjustment program will be implemented, reservoir operation study is conducted assuming the proposed dam site upstream. The following conditions are applied for the calculation.

- Water safety level: 1-10 year for municipal and industrial water
- Development site: proposed dam sites in the upstream of high demand area (see section 4.5.3.2 below)
- Calculation method: Reservoir operation analysis is performed using the daily flow data for 42 years (1981 to 2022) calculated by the water balance calculation model (SHER) at the proposed dam site. Based on the result of the analysis, the amount of water supply from the reservoir is estimated to satisfy the require water safety level (developable discharge) in the downstream demand areas.

Details are given in Annex D Chapter 13.

4.5.2.4 Comparison of Alternative Options

(1) Evaluation Criteria

As mentioned in Section 4.3.2.4, the evaluation criteria for screening of WRDM Plan (idea) and priority project concepts were established through series of discussions with NEDA and NWRB.

(2) Alternative Options of Water Resources Development

Based on the results of the detailed water balance calculations in the previous chapter, as well as the results of the map studies, field surveys, and interviews with concerned organizations, the alternative options of water resources developments for each area were set and evaluated as shown in Table 4.5-11 below.

Table 4.5-11 Alternative Options for Water Resources Development and Management in WRR V

Sector	Options	Bicol	Sorsogon	Catanduanes	Masbate
Surface Water	Dam/Small Pond (WS)	-	-	Viga Dam	Lanang Dam (including irrigation)
	Dam/Small Pond (IR)	Waras Dam Sipocot Dam	Ibingan Dam (on-going)	-	
	Upgrading of Existing Dam	Upgrading Buhi Lake IWRM (including flood control)	-	Upgrading Balongbong Dam （NAPCOR)	-
	Inter-basin Diversion	none	none	none	none
	Irrigation Weir	NIA's plan (SRIP/IP)			
Groundwater Development		Deep wells Recharge facilities			
Water Supply Development		Bulk water Seawater desalination Recycle sewerage water			
Demand Management	Municipal and Industrial Water Use	Measures for non-revenue water Promotion of water saving Improvement of recycle rate of industrial water Rainwater harvesting Monitoring of groundwater			
	Irrigation Water Use	Modernization of irrigation system Measures for water leakage of irrigation canals			

Source: JICA Survey Team

(3) Results of Comparison Alternatives

Applying the afore-mentioned evaluation criteria, a comparative evaluation of the alternative options for each of the above areas was carried out. The results of comparison are shown in Table 4.5-12 below.

The alternative options listed in the Table 4.5-12 are items that were studied in past master plans and development plans in the Philippines, as well as items that were newly brought up in exchanging opinions with related organizations involved in this Survey. These proposed measures were the comprehensive ones selected through explanation and discussions with NEDA/NWRB and other related agencies and stakeholders in the Survey.

Table 4.5-12 Result of Comparison of Alternative Options in WRR V

Alternative Plans of Water Resrouces Development			Evaluation Criteria*1									
ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	1.5	1	0.5	1	2	1.5	10		
	WS	Construction of Libmanan-Cabusao Dam(Sipocot) in 1998 M/P (WS)										
	WS	Construction of Talisay Dam in 1998 M/P (WS)										
V-BR-D-1	IR	Construction of Waras Dam	2	no data	no data	3	4	1	2	12	15.5	x
V-BR-D-2	IR	Construction of Sipocot Dam	2	5	4	3	4	1	2	21	27	x
V-BR-D-3	IR/FC	Upgrading Buhi Lake IWRM	4	3	4	3	4	3	4	25	36	O
V-BR-D-4	IR	Development of Irrigation Farm Ponds	4	1	1	5	4	4	4	23	33	O
V-BR-D-5	IR	Development of Irrigation Weirs	4	2	5	5	4	4	4	28	38.5	O
V-BR-D-6	WS	Bulk Water Development	3	2	2	5	3	4	4	23	32	O
V-BR-D-7	WS	Construction of Desalination Plants	2	2	3	2	3	3	3	18	25.5	x
V-BR-D-8	GW	Recycle of Sewerage Water	2	3	2	2	3	3	3	18	26	x
V-BR-D-9	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	24	33.5	O
V-BR-D-10	GW	Groundwater Development (Recharge Facility)	2	3	2	2	3	3	3	18	26	x

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	1.5	1	0.5	1	2	1.5	10		
V-SO-D-1	IR	Construction of Ibingan Dam	4	1	1	3	4	4	3	16	30.5	on-goin
V-SO-D-2	IR	Development of Irrigation Weirs	4	2	3	5	4	4	4	22	36.5	O
V-SO-D-3	WS	Bulk Water Development	3	2	2	5	3	4	4	20	32	O
V-SO-D-4	WS	Construction of Desalination Plants	1	2	3	2	3	3	3	16	23	x
V-SO-D-5	GW	Recycle of Sewerage Water	1	3	2	2	3	3	3	16	23.5	x
V-SO-D-6	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	20	33.5	O
V-SO-D-7	GW	Groundwater Development (Recharge Facilities)	2	3	2	2	3	3	3	16	26	x

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	1.5	1	0.5	1	2	1.5	10		
V-CD-D-1	FC	Construction of Viga Dam	3	1	x	x	4	3	2	13	22	x
V-CD-D-2	IR/HP	Upgrading Balongbong Dam（NAPCOR)	4	2	2	3	2	3	3	19	29	x
V-CD-D-3	IR	Development of Irrigation Weirs	4	2	3	5	4	4	4	26	36.5	O
V-CD-D-4	WS	Bulk Water Development	3	2	2	5	3	4	4	23	32	O
V-CD-D-5	WS	Construction of Desalination Plants	1	2	3	2	3	3	3	17	23	x
V-CD-D-6	GW	Recycle of Sewerage Water	1	3	2	2	3	3	3	17	23.5	x
V-CD-D-7	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	24	33.5	O
V-CD-D-8	GW	Groundwater Development (Recharge Facility)	2	3	2	2	3	3	3	18	26	x

ID	Sector	Proposed Structural Measures	Needs, Emergency	Possible Amount of Water Intake	Unit Cost	Technical Feasibility	Implementing Organization	Environmental and Social Considerations	Sustainability	Total (w/o weight)	Total (w/ weight)	Screening
			2.5	1.5	1	0.5	1	2	1.5	10		
V-MB-D-1	IR/WS/HP	Study, Investigation & Construction of Lanang Dam	4	4	4	3	2	2	3	22	32	O
V-MB-D-2	IR	Development of Irrigation Weirs and Farm Ponds	4	2	3	5	4	4	4	26	36.5	O
V-MB-D-3	WS	Bulk Water Development	3	2	2	5	3	4	4	23	32	O
V-MB-D-4	WS	Construction of Desalination Plants	1	2	3	2	3	3	3	17	23	x
V-MB-D-5	GW	Recycle of Sewerage Water	1	3	2	2	3	3	3	17	23.5	x
V-MB-D-6	GW	Groundwater Development (Deep Wells)	4	1	4	5	3	4	3	24	33.5	O
V-MB-D-7	GW	Groundwater Development (Recharge Facility)	2	3	2	2	3	3	3	18	26	x

Note: IR: Irrigation, WS: Water Supply, GW: Groundwater, FC: Flood Control, HP: Hydro-power

Source: JICA Survey Team

(4) Selected Options

Selected water resources development options and water resource management options are shown in Table 4.5-13 and Table 4.5-14 below.

Table 4.5-13 Selected Plans for Water Resources Development in WRR V

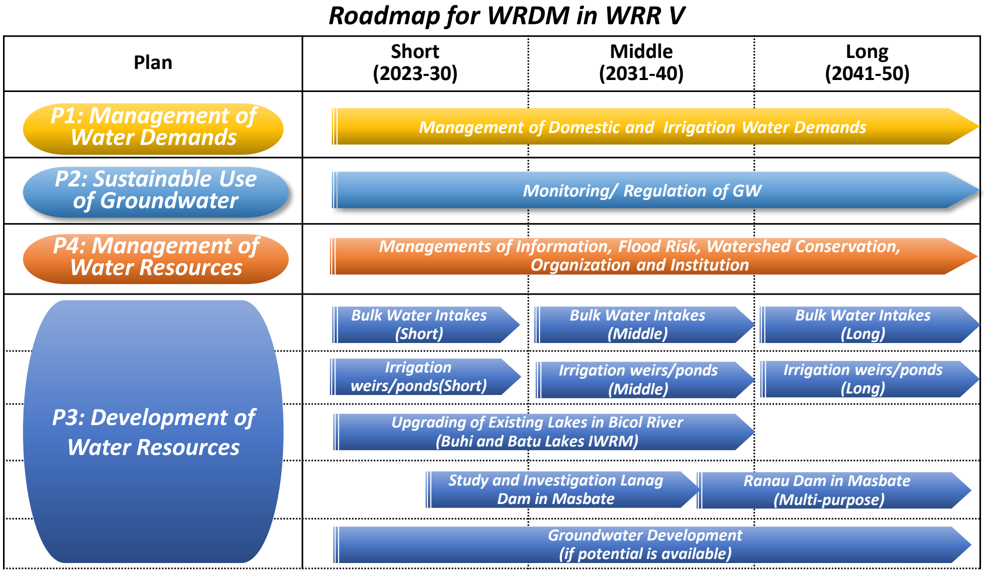
No	Proposed Measures	Location (Province)	Responsible Organization	Sector /Purpose	Implementation		
					Short	Medium	Long
1	Upgrading Buhi Lake IWRM	Camarines Sur	NIA5	Multi IR/FC	○	○	-
2	Study/Construction of Lanang Dam	Masbate	Related Water Utilities /NIA5	Multi WS/IR	Study	○	○
3	Development of Irrigation Weirs and Farm Ponds	(Whole WRR V)	NIA5	IR	●	○	○
4	Bulk Water Development	-	Related Water Utilities	WS	●	○	○
5	Groundwater Development (Deep Wells)	-	-	GW	●	○	○

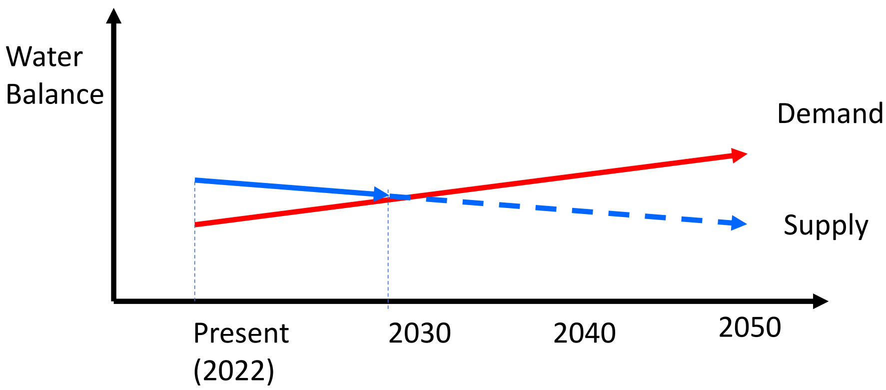
Note: ●With exiting plan, ○: Newly proposed plan, IR: Irrigation, WS: Water Supply, GW: Groundwater, FC: Flood Control
Source: JICA Survey Team

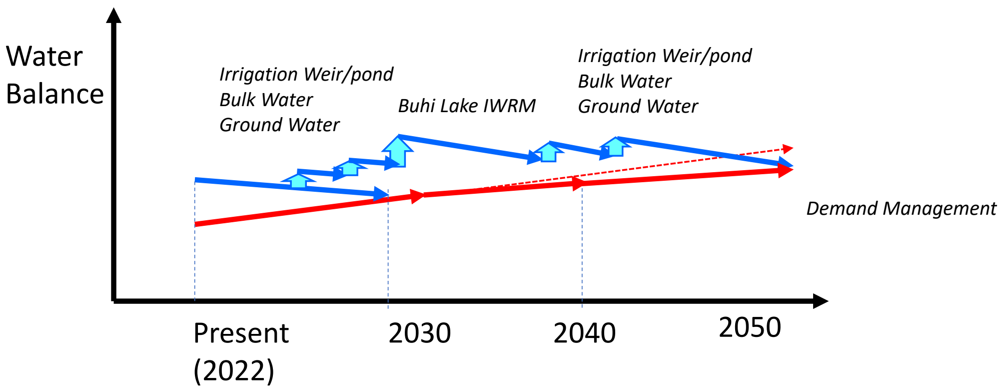
Table 4.5-14 Selected Plans for Water Resources Management in WRR V

No	Proposed Measures	Location	Responsible Organization	Sector	Implementation		
					Short	Medium	Long
1	Measures for Non-Revenue Water	all	Related Water Utilities	WS	○	○	○
2	Promotion of Water Saving	all	Related Water Utilities w/ Public Promotion Activities	WS	○	○	○
3	Improvement of Recycle Rate of Industrial Water	all	Industrial Water Users	WS	○	○	○
4	Measures for Water Leakage of Irrigation Canals	all	NIA & Related Irrigation Associations	IR	○	○	○
5	Modernization of Irrigation System	all	NIA & Related Irrigation Associations	IR	○	○	○
6	Rainwater Harvesting	all	Related Irrigation Associations	SW	○	○	○
7	Monitoring of Groundwater	all	NWRB	GW	○	○	○
8	Regulation of Groundwater Use	all	NWRB	GW	○	○	○

Note: ●With exiting plan, ○: Newly proposed plan, IR: Irrigation, WS: Water Supply, GW: Groundwater
Source: JICA Survey Team







Source: JICA Survey Team

Figure 4.5-12 Road Map (idea) for Water Resources Development and Management Plan in WRR V

4.5.3 Proposal for Water Resources Development and Management Plans (idea) in WRR V

4.5.3.1 Composition of the Plan

Composition of the water resources development and management plan (idea) in WRR V is the same contents of the one in WRR VII as described in Sub Section. 4.3.3.1.

4.5.3.2 Surface Water Development Plan in WRR V

(1) List of Priority Proposed Dams

As a surface water development plan for WRR V, the following dams were selected in the primary screening of the current and planned dams and reservoirs described in Chapter 3. These dams are reviewed for the preliminary layout, size, and estimated construction costs.

Table 4.5-15 List of Priority Proposed Dams (WRR V)

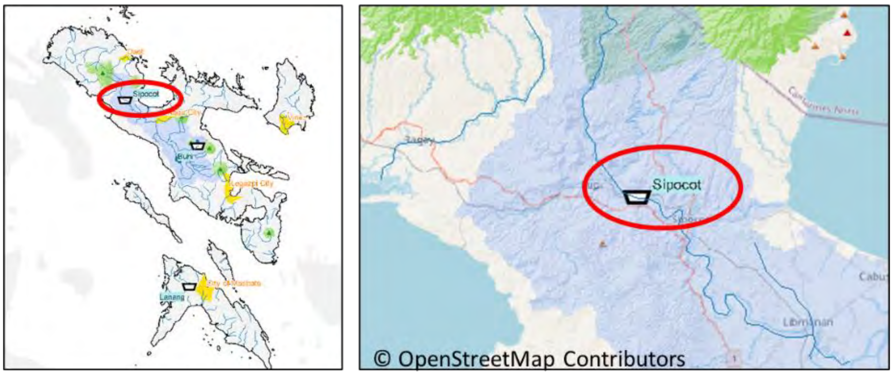
Name of Island	Luzon	Masbate	Luzon
Name of Dam	Sipocot	Lanang	Buhi
Name of River	Bicol Sipocot	Lanang	Lake Buhi
Catchment Area	470 sq.km	53 sq.km	75 sq.km
Flood Discharge (100-Yr Design)	5,030 cu.m/sec	730 cu.m/sec	1,850 cu.m/sec
Dam Type	Rockfill	Rockfill	Control Wier
Dam Height (Approximately)	40m	60m	20m
Dam Top Elevation	EL.49.5m	EL.126.5m	---
Dam Crest Length	327m	561m	(Spiliway) 50m (Gate) 10m
Dam Volume	0.8 M.cu.m	2.9 M.cu.m	7,000 cu.m
Upstream Slope ratio	1:3.0	1:3.0	垂直
Downstream Slope ratio	1:2.5	1:2.5	1:0.8
Foundation bedrock Elevation	EL.10.0m	EL.60.0m	---
Foundation bedrock properties	---	good sedimentary rock outcrops	---
Channel bottom Elevation (Crest EL. Spillway)	EL.36.5m	EL.117.5m	---
Area of Resorvoir	3,172.9 ha	657.3 ha	15～18 sq.m
Capacity of Reservoir	446.0 M.cu.m	153.8 M.cu.m	---
Minimum Operation WL. (Top of Dead Storage)	EL.29.1m	EL.110.1m	---
Dead Storage Volume (Sediment Yield 100%)	48.8 M.cu.m	76.9 M.cu.m	---
Dam Coordinates (Latitude)	13° 46' 54.611"N	12° 21'39.473"N	(Control Structure) 13° 25'58"N
Dam Coordinates (Longitude)	122° 56' 28.007"E	123° 26'23.356"E	(Control Structure) 123° 30'34"E
Total Construction Cost	**1,558 M.PHP**	**5,706 M.PHP**	**837 M.PHP**

Source: JICA Survey Team

(2) Outline of Layout Study

1) Sipcot Dam

The dam axis position is based on the basic plan shown in the 1998 M/P (Water Resources Development Study, USAID, 1976) report. It is located in the northwest of Naga City, on the right tributary of the Lib Manan River. Dam facility layout plan, cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



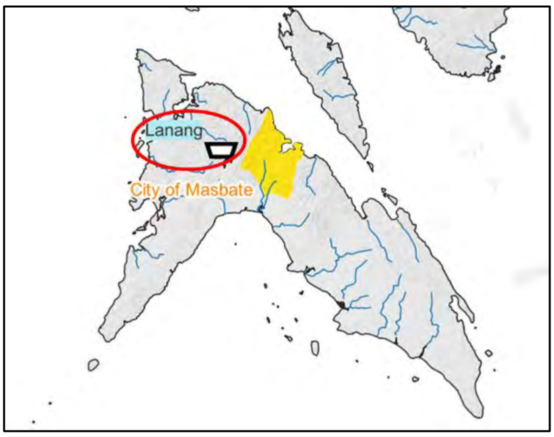
Source: JICA Survey Team

Figure 4.5-13 Location Map of Sipcot Dam

2) Lanang Dam

There is no detailed data and information of the previous dam studies in Masbate Island. For the proposed dam site, the Lanang River, which has a large catchment area, was adopted as the target river among rivers that can be used as a measure to cope with water shortages in Masbate City. The construction site of the dam was set from the topographic map study. It is located in the upper reaches of the Lanang River, west of Masbate.

Dam facility layout plan, cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



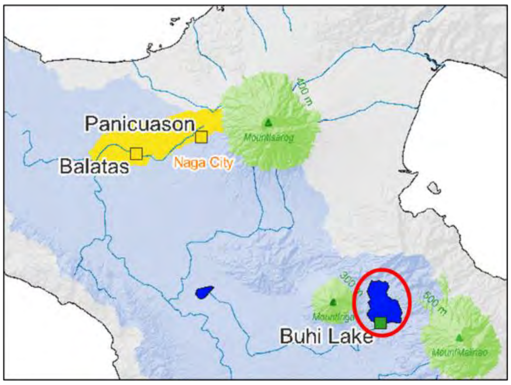
Source: JICA Survey Team

Figure 4.5-14 Location Map of Lanang Dam

3) Improvement of Lake Buhi (Control Structures)

Buhi Lake is a natural lake located in the upstream of tributary of the Bicol River. Since the difference in current operational water level is as small as 50 cm only, it is considered to be effective to improve the regulating weir and spillway that are installed at the river outlet in order to increase the effective storage capacity of Lake Buhi.

Dam facility layout plan, cross section, water utilization facility, sedimentation, resettlement and land acquisition of reservoir of the proposed dam are presented in ANNEX G.



Source: JICA Survey Team, mountain data from © OpenStreetMap Contributors

Figure 4.5-15 Location Map of Lake Buhi

4.5.3.3 Groundwater Development and Management Plan in WRR V

(1) Current Issues of Groundwater Use

Based on the results of the interviews in the field and the groundwater analysis in this study, the current issues in groundwater use in WRR V are listed as shown in Table 4.5-16.

Establishment of a monitoring system to understand the groundwater environment is essential for sustainable use of groundwater resources, but at present, there are no sufficient groundwater monitoring network in WRR V.

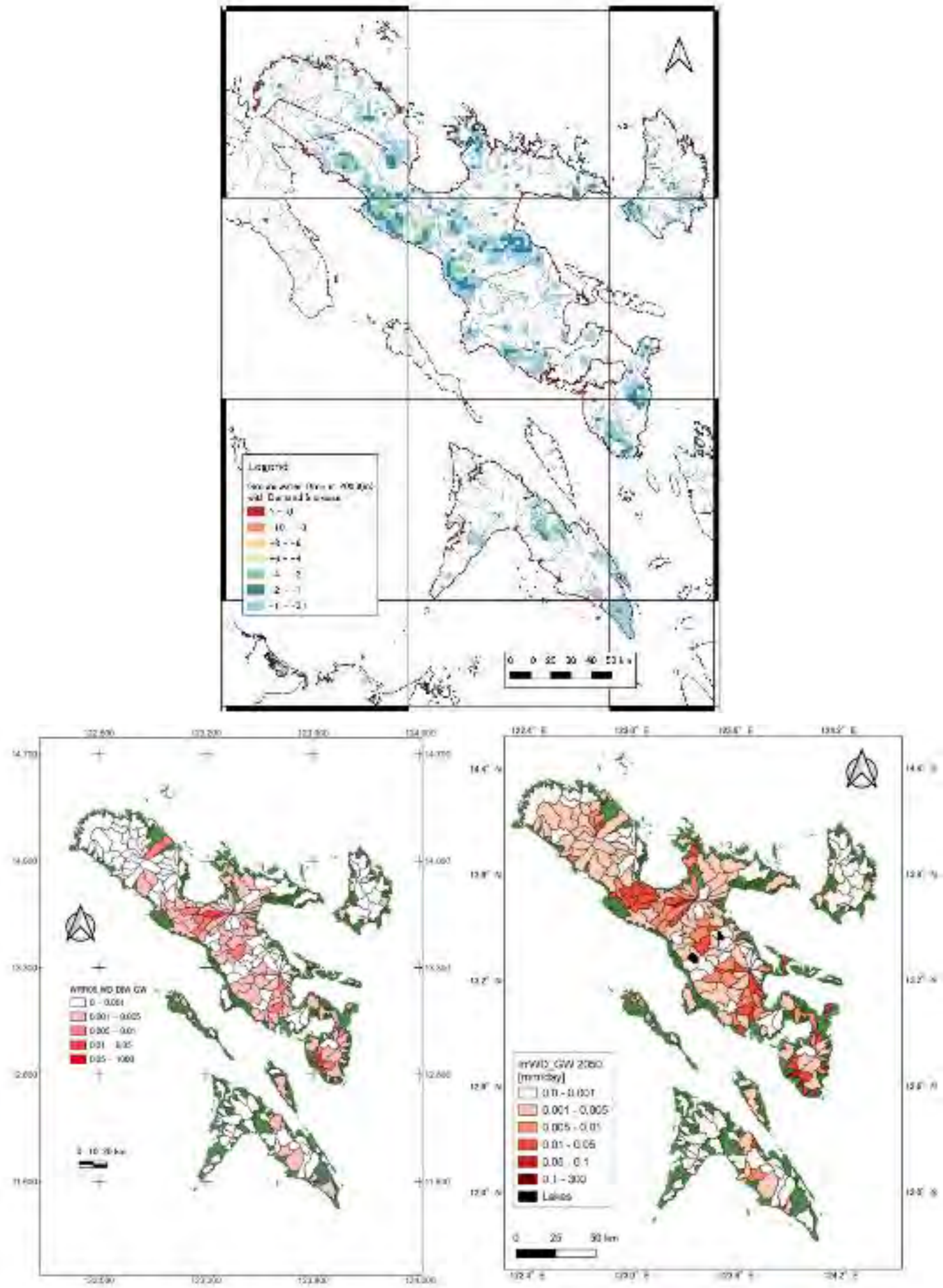
Figure 4.5-16 shows the amount of groundwater level drop from 2020 to 2050 if groundwater demand continues to increase through 2050. Although smaller than WRRs VII and XI, groundwater level drop that could be caused by over pumping are seen in the western part of Naga City, around Lake Buhi, around San Andress in Catanduanes, and in the eastern part of Masbate.

As noted in 4.3.3.3, there is also the potential for impacts to groundwater and spring systems and well failures in the event of an earthquake.

Table 4.5-16 Summary of Current Issues of Groundwater Use in WRR V

Area	Groundwater Monitoring	Groundwater Related Issues			
		Over Pumping	Saltwater Intrusion	Water Quality	Subsidence
Bicol	No specific monitoring well	None	✓ Especially in Naga Region	None	✓
Catanduanes	No specific monitoring well	None	None	✓	None
Masbate	No specific monitoring well	None	None	✓	None

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-16 Groundwater Level Drop in WRR V

(2) Basic Concept of Priority Project

Based on the issues related to groundwater described above, the proposed priority projects that can be considered at present are shown in Table 4.5-17.

Since the foremost priority is understanding the actual status of groundwater use, the short-term plan includes the development of an observation network and understanding of the current pumping amounts.

In areas where water level drops have already occurred due to over pumping, pumping regulations and relocation of water sources (surface water or wells in other areas) are also envisioned as short-term developments.

Medium-term projects could include the development of deep wells for water sources based on the understanding of the groundwater environment, or the securing of freshwater areas through artificial recharge.

Long-term projects could include securing water sources by relocating water sources and constructing deep wells, controlling saltwater intrusion by developing underground dams, and utilizing grey water and sewage (artificial recharge).

Table 4.5-17 Summary of Priority Project Concept

Development Item	Short-term (2023-30)	Mid-term (2031-40)	Long-term (2041-50)
Groundwater Management	▪ Regulation of Groundwater use ▪ Development of groundwater monitoring network ▪ Determination of the current production amount from existing well ▪ Relocation of water source ▪ Detailed analysis for prediction	▪ Relocation of water source ▪ Construction of Deep well (after investigation and study)	▪ Relocation of water source ▪ Construction of Deep well (after investigation and study)
Countermeasure for Saltwater Intrusion	▪ Observation and evaluation of saltwater intrusion	▪ Expansion of freshwater area through artificial recharge	▪ Construction of underground dams ▪ Sewage/ grey water use

Source: JICA Survey Team

4.5.3.4 Water Supply Plan (Agriculture Water Use) (Agriculture Water Supply) in WRR V

For Albay, Camarines Sur, and Camarines Norte provinces, the irrigation development plans are prepared in consideration of the target areas estimated based on the NIA financial programs. For Masbate and Sorsogon provinces, the potential irrigable areas estimated in NIMP 2020-2030, which include the

3-8% slope area, shall be assessed to clarify the suitable farmlands for paddy cultivation. The productivity of existing irrigation systems shall be maintained and upgraded through the improvement of irrigation facilities. The extension of service areas shall also be included in consideration of utilizing the water resources saved by effective irrigation water management, which could be established through the lining of main and lateral canals, introducing the mechanical operation sluice gate with electric/generator power, and introducing the irrigation telemetry system.

(1) Irrigation Development Areas

As shown in Table 4.5-18, in the Stage 1 Study, the future irrigation development areas in 2030, 2040 and 2050 were estimated based on the past NIA financial programs and NIMP 2020-2030.

Table 4.5-18 Forecasted Future Irrigation Development Areas in WRR V

Province	Potential Irrigable Area (ha)	Year 2020				Remaining Irrigable Area (ha)	Newly Developed ISA (ha) by		
		ISA (ha)	FUSA (ha)	Irrigated Area (ha)			Year 2030	Year 2040	Year 2050
				Wet	Dry				
NIA Financial Program									
Albay	54,435	31,749	30,429	23,045	21,651	22,686	7,373	14,746	22,119
Camarines Norte	22,555	9,695	9,236	6,725	6,710	12,860	4,180	8,359	12,539
Camarines Sur	123,700	77,665	55,218	34,313	32,880	46,035	14,962	29,923	44,885
Catanduanes	3,770	3,211	3,113	1,805	1,839	559	182	363	545
Masbate	19,880	6,848	6,582	3,456	3,519	13,032	4,235	8,471	12,706
Sorsogon	15,100	14,102	13,712	9,094	9,052	998	324	649	973
Total	239,440	143,270	118,290	78,438	75,651	96,170	31,256	62,511	93,767
NIMP 2020-2030									
Albay	49,323	31,749	30,429	23,045	21,651	17,574	5,260	7,768	8,947
Camarines Norte		9,695	9,236	6,725	6,710				
Camarines Sur	149,823	77,665	55,218	34,313	32,880	72,158	21,599	31,896	36,735
Catanduanes		3,211	3,113	1,805	1,839				
Masbate	129,951	6,848	6,582	3,456	3,519	123,103	36,848	54,415	62,670
Sorsogon	44,861	14,102	13,712	9,094	9,052	30,759	9,207	13,596	15,659
Total	373,958	143,270	118,290	78,438	75,651	243,594	72,915	107,675	124,011

Source: JICA Survey Team based on NIA Data

As the results of the water balance studies for the irrigation areas by the NIA financial programs, the estimated irrigation areas with 170% cropping intensity in 2050 could not be irrigated in Albay, Camarines Sur and Masbate Provinces. The irrigable areas estimated based on the results of the water balance studies in Albay, Camarines Sur and Masbate Provinces are shown in Table 4.5-19.

Table 4.5-19 Irrigable Areas by Provinces in 2050 Based on Water Balance Studies

Province	Eatimated Development Area (ha)				Irrigable Area by Water Balance (ha)		Cropping Intensity
	ISA	FUSA	Irrigated Area				
			Wet	Dry	Wet	Dry	(%)
Albay	53,868	52,548	46,059	43,273	**35,469**	**42,236**	**148** Low
Camarines Norte	22,234	21,775	18,529	18,488	*18,529*	*18,488*	170
Camarines Sur	122,550	100,103	86,902	83,273	**56,016**	**71,139**	**127** Low
Catanduanes	3,756	3,658	3,080	3,138	*3,080*	*3,138*	170
Masbate	19,554	19,288	16,247	16,543	**13,426**	**15,952**	**152** Low
Sorsogon	15,075	14,685	12,511	12,453	*12,511*	*12,453*	170
Total	237,037	212,057	183,329	177,168	139,032	163,407	

Source: JICA Survey Team

In these three provinces, the available water sources are not sufficient for the potential irrigation areas. The new irrigation development projects shall be carefully formulated considering the proper irrigable areas through detailed analysis of the available water resources.

(2) Rice Supply and Demand Forecast

The self-sufficiency of rice is one of the major indicators for the irrigation development planning. Therefore, irrigation development shall also be assessed in consideration of the rice supply and demand. Table 4.5-20 shows the per capita consumption of rice by provincial level in 2020. Except Camarines Sur Province, the per capita consumptions of other provinces are lower than the national target of 128kg, which is adopted in NIMP 2020-2030. On the regional level, the self-sufficiency of rice is attained.

Table 4.5-20 Per Capita Consumption of 2020 in Region V

Province	Palay Production (ton) in 2020			Population	Per Capita Consumption*1 (kg)		
	Irrigated	Rainfed	Total	2020	Irrigated	Rainfed	Total
Albay	186,440	29,567	216,007	1,396,090	87	14	101
Camarines Norte	70,972	37,540	108,512	622,515	74	39	113
Camarines Sur	483,608	166,798	650,406	2,059,495	153	53	205
Catanduanes	13,970	13,050	27,020	272,940	33	31	64
Masbate	41,589	106,421	148,010	937,079	29	74	103
Sorsogon	110,490	34,547	145,037	845,717	85	27	111
Total	907,069	387,923	1,294,992	6,133,836	96	41	137

Remarks *1: (Palay Production) x (0.65)/(Population), adopting 065% of milling rate
Source: JICA Survey Team based on Data from Bureau of Agricultural Statistics, Department of Agriculture

For the irrigable areas in 2050 based on the NIA financial programs, the per capita consumptions of each province in 2050 are also estimated as shown in Table 4.5-21.

Table 4.5-21 Per Capita Consumption of 2050 in Region V

Province	Irrigable Area (ha) 2050		Palay Production *1(ton)	Population 2050	Per Capita Consumption *2(kg)
	Wet	Dry			
Albay	35,469	42,236	419,607	1,893,641	144
Camarines Norte	18,529	18,488	199,892	970,241	134
Camarines Sur	56,016	71,139	686,637	2,998,232	149
Catanduanes	3,080	3,138	33,581	440,285	50
Masbate	13,426	15,952	158,641	1,407,754	73
Sorsogon	12,511	12,453	134,809	1,282,805	68
Total	139,032	163,407	1,633,166	8,992,958	118

Remarks *1: Palay unit yield = 5.4 ton/ha
Remarks *2: (Palay Production) x (0.65)/(Population), adopting 065% of milling rate
Souece: JICA Survey Team

Albay and Camarines Norte Provinces could attain self-sufficiency of rice through irrigation development areas shown in Table 4.5-21. In Catanduanes, Masbate and Sorsogon Provinces, even if full potential irrigation areas are developed, self-sufficiency of rice could not be attained. In the regional level, the per capita consumption of 118kg is lower than the national target of 128kg. However, as mentioned in Annex-F: F2.1.2, it is generally known that the more society develops, the more rice consumption decreases. The self-sufficiency of rice in regional level may be improved through irrigation development.

(3) NIA Priority Irrigation Development Projects

As of February 2022, NIA presented the priority projects in Region V as shown in Table 4.5-22.

Table 4.5-22 NIA Priority Irrigation Development Projects in Region V
(Excludes on-going projects)

	Project Name	Province	Municipality	Program		Target Area (ha)		Project Status (As of March 2022)		
				TRIP	PIP	New	Restore	Feasibility Study (FS)	Detailed Engineering and Design (DED)	Remarks
1	Ogod SRIP	Albay	Daraga	✓	✓	661		FS is ongoing		ISA is in Sorsogon
2	Bosigon NIP	Camarines Norte	Labo	✓	✓	1,250	1,035	FS is ongoing		
3	Paculago IP	Camarines Sur	Ragay	✓	✓	450		FSR approved on November 2020	Interim Report for review	ROW Problem
4	Haguimit SRIP	Camarines Sur	Lupi	✓	✓	600		Ongoing review of Final FSR by the Regional Office		
5	Bicol River Irrigation System Improvement Project	Camarines Sur	Lupi	✓	✓	1,100	2,900	Ongoing field validation by the Consultant		
6	Waras SRIP	Camarines Sur	Iriga City	✓	✓	1,595		FS approved on May 15, 2019	On-going	Indigenous people issue
7	Ibingan SRIP	Sorsogon	Prieto Diaz		✓	255		Target date of reformulation of FS is May 2022.	Completed	
	Total					**5,911**	**3,935**			

TRIP: Three-year Rolling Infrastructure Program - DBM and NEDA Joint Circular No. 2016-01
PIP: Public Investment Program - NEDA Memorandum dated May 19, 2021, Updating of the 2017-2022 PIP
Source: NIA

The above planned development areas are not sufficient for the 2030 target development areas of 31,256 ha shown in Table 4.5-18. It is necessary for NIA to identify further irrigation development projects. NIA Regional Office V gives priority to SRIP because the reservoir can contribute not only to irrigation, but also flood control. However, SRIP has several constraints for the implementation, such as the right of way and no-acceptance by the indigenous people.

In Region V, floods are the worst problem for proper irrigation operation. There are also existing canal erosion and sedimentation. NIA RO-V is taking several countermeasures. One of them is tree planting along the flooding rivers as part of watershed management. In addition, DA RO-V emphasized that it is important to conserve the watershed together with infrastructure development.

(4) Recommendations on Future Irrigation Development Plans

As a result of the above assessment and the field inspection explained in Annex-F: F3, the future irrigation development plans are recommended in consideration of the following present situations:

1) Water resources and potential irrigation areas

The Bicol River basin, mainly in Albay and Camarines Sur provinces, is the major rice granary in Region V. In 2050 however, the water resources are not sufficient for the full irrigation development areas estimated based on the past 10 years of NIA financial programs. On the other hand, in the island provinces of Masbate and Catanduanes as well as in Sorsogon province, the potential irrigation areas are not sufficient to attain self-sufficiency in rice.

The cropping intensity of actual irrigated areas in 2020 was 177% for NISs (refer to Table F-1) and 119% for small-scale irrigation systems (refer to Annex F:Table F-5). This means that NISs have large water sources and small irrigation systems have been developed with the small watershed areas. As the potential areas of large-scale irrigation development (like NIP) are not abundant, the improvement and extension of the existing NISs are the key factors of future development plans.

2) Per capita consumption of rice

The per capita consumption of rice could be improved through irrigation development. Under the limited irrigation areas and water sources, it is essential to increase productivity through not only the new irrigation development but also the improvement of the existing irrigation systems.

3) Flood problem

The territory of Region V is located in the typhoon belt; thus, flooding is the most serious problem. The construction of proper flood control facilities is of course the most important requirement. Moreover, irrigation facilities shall be also constructed and improved to prevent their damage from flooding as much as possible. Furthermore, it is essential to implement proper watershed management plans together with the irrigation projects.

4) Gate works of diversion dams

Related to the above flood problem, the gate works of the diversion dam are easily damaged without proper operation during flooding. At present, many sluice gates of diversion dams are damaged and require repair and replacement. The inventory data of NIS's gates in Region V is shown in Annex F: Table F-60. It is a common issue that the repair work and replacement cannot be timely implemented due to the financial procedures and the availability of the materials. The non-operational gates cause further serious damage in the irrigation systems.

The following future irrigation development plans are recommended in the synthetic consideration of above situations.

1) New irrigation development projects

In order to complete the new irrigation area of 93,767 ha in 2050, NIA RO V shall implement the new irrigation projects of about 3,500 ha per year from 2023 to 2050. The key factors in the formulation of the new projects are as follows:

(i) The main and lateral canals are constructed as concrete lining or flume canal from the viewpoints of water saving and the mitigation of flood damages.

(ii) The sluice gates and intake gates of diversion dams for the NISs shall be provided with the mechanical operation type with electric/generator power.

(iii) The remote-control operation system shall also be introduced in the flood prone area and in the case that the residential gatekeeper cannot be assigned.

(iv) The watershed management plans including re-forestation shall be implemented to achieve the sustainable irrigation farming. There are several improvement and recovery plans for the uncontrolled watershed, e.g. construction of sabo dam and slope protection works. The definite plans shall be formulated through the field survey and further assessment of the present situations.

For Albay, Camarines Sur, and Camarines Norte provinces, the irrigation development plans are prepared in consideration of the target areas estimated based on the NIA financial programs. For Masbate and Sorsogon provinces, the potential irrigable areas estimated in NIMP 2020-2030, which include the 3-8% slope area, shall be assessed to clarify the suitable farmlands for paddy cultivation. The assessment shall be executed in due consideration of the available water resources.

2) Improvement of the existing NISs

The productivity of existing irrigation systems shall be maintained and upgraded through the improvement of irrigation facilities. The extension of service areas shall also be programmed in consideration of utilizing the water resources saved by effective irrigation water management. The following improvement plans are mainly recommended to realize sustainable irrigation farming in WRR V:

(i) Main and lateral canals shall be improved as concrete lining or flume canal to minimize the conveyance losses.

(ii) Gate works of diversion dams shall be improved to prevent their damages from flood. As shown in Annex-F: Table F-60, there are 80 gate works for NISs in Region-V. Most of the gates are manual operation type and 39 gates require rehabilitation works. These gates shall be replaced with mechanical operation type with electric/generator power. As same as new projects, the remote-control operation system shall also be introduced in the flood prone area and in the case that the residential gate-keeper cannot be assigned.

(iii) Denudation of watersheds shall be recovered by re-forestation programs to prevent the irrigation facilities and waterways from siltation.

(iv) The Rinconada Integrated Irrigation System (RIIS) in Camarines Sur Province is operated with the main water resources of the Buhi Lake, like the reservoir irrigation system. The Camarines Sur IMO proposes to introduce automatic monitoring and control system for the remote operation of the Buhi Lake control structure. The irrigation telemetry system (ITS) utilizing information technology (IT) is considered an effective water management system for the reservoir irrigation system. The ITS is explained in the following Annex F: F-4.5.

(v) As for the rehabilitation/ improvement project of NISs, NIA had implemented the National Irrigation Systems Rehabilitation and Improvement Project (NISRIP) under JICA Loan Assistance Programs. NIA shall study whether the above-mentioned improvement works will be implemented as the NISRIP next phase.

(5) Implementation Plan

Above future irrigation development plans are proposed to be implemented by the short term (urgent), middle term and long term as shown in Figure 4.5-17.

Work Items	Short Term 2030	Middle Term 2040	Long Term 2050
New Irrigation Development			
Based on NIA Financial Program	→ 31,256 ha	→ 31,256 ha	→ 31,256 ha
Based on NIMP 2020-2030 (Mainly Masbate & Sorsogon Provinces)			
- Identification of Paddy Irrigation Area		→	
- Implementation			→
Improvement of NISs			
Lining of Main & Lateral Canals	→		
Upgrading of Gate Works in Diversion Dam	→		
Watershed Management	→	→	→
Intruducing of ITS		→	→

Source: JICA Survey Team

Figure 4.5-17 Implementation Plan of Future Irrigation Development in Region V

4.5.3.5 Water Supply Plan (Municipal and Industrial Water Use) in WRR V

(1) Proposal of Priority Project Concept

Summary of municipal and industrial water demand projection in WRR V is shown as below. The water demand is expected to increase gradually, and there are concerns about future water balance constrains. This water demand projection is defined as the "baseline" (without projects).

Table 4.5-23 Summary of Municipal and Industrial Water Demand Projection in WRR V (Baseline)

Water Resource Region	Municipal+Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR V - BICOL	356	373	387	419	445	473	494

Source: JICA Survey Team

The Proposal of priority project concept in WRR V is the same contents of the one in WRR VII as described in sub section 4.3.3.5.

(2) Reduction of Non-Revenue Water

NRW ratio for baseline is shown below.

Table 4.5-24 Non-Revenue Water Ratio in WRR V (Baseline)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	28%	20%	20%	20%	20%	20%	20%	MNWD hearing survey
	Legazpi	Legazpi	35%	23%	**20%**	**20%**	**20%**	**20%**	**20%**	LCWD hearing survey
	Virac	Virac	30%	28%	25%	24%	23%	22%	20%	VWD hearing survey
	Masbate-Mobo	Masbate, Mobo	40%	34%	28%	20%	20%	20%	20%	MWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

NRW ratio with NRW reduction case is shown below.

Table 4.5-25 Non-Revenue Water Ratio in WRR V (NRW Reduction)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	28%	20%	20%	20%	15%	13%	10%	MNWD hearing survey
	Legazpi	Legazpi	35%	23%	**20%**	**20%**	15%	13%	10%	LCWD hearing survey
	Virac	Virac	30%	28%	25%	24%	15%	13%	10%	VWD hearing survey
	Masbate-Mobo	Masbate, Mobo	40%	34%	28%	20%	15%	13%	10%	MWD hearing survey
Other cities			25%	25%	20%	20%	20%	20%	20%	NRW target by PWSSMP2018 and LWUA standard

Note: Changes from baseline condition due to NRW reduction is highlighted in red.
JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

Summary of municipal and industrial water demand projection in WRR V with NRW reduction case is shown below.

Table 4.5-26 Summary of Municipal and Industrial Water Demand Projection in WRR V (NRW Reduction)

Water Resources Region	Municipal + Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR V - BICOL	356	373	387	419	441	467	486

Note: Changes due to NRW reduction is highlighted in red.

Source: JICA Survey Team

As a result of the above, it was confirmed that if NRW measures were thoroughly implemented up to the advanced countermeasure stage, there would be a saving of 2% (8 MCM) of water demand. Very rough estimation of project cost for a similar NRW reduction project in 4 major cities can be estimated at 9.2 billion PHP.

(3) Promotion of Water Saving Activity

Water demand per capita for baseline is shown below.

Table 4.5-27 Water Demand Per Capita in WRR V (Baseline)

Water Consumption per Capita (lpcd)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	175	175	175	200	200	200	200	MNWD hearing survey
	Legazpi	Legazpi	100	146	**146**	**146**	**146**	**146**	**146**	LCWD hearing survey
	Virac	Virac	130	130	130	130	130	130	130	VWD hearing survey
	Masbate-Mobo	Masbate, Mobo	113	107	100	100	100	100	100	MWD hearing survey
Other cities in Urban Area			120	120	120	120	120	120	120	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	60	60	60	60	60	60	Domestic demand (rural) in PWSSMP2018

Note: JST setting value due to lack of data is highlighted in bold.

Source: JICA Survey Team

Water demand per capita with water saving promotion is shown below.

Table 4.5-28 Water Demand Per Capita in WRR V (Water Saving Promotion)

WRR	Water District	Municipality	2020	2025	2030	2035	2040	2045	2050	Resource
WRR V	Naga	Naga, Camaligan, Canaman, Gainza, Magarao	175	172	168	165	159	154	149	MNWD hearing survey
	Legazpi	Legazpi	100	98	96	94	91	88	85	LCWD hearing survey
	Virac	Virac	130	127	125	122	118	114	111	VWD hearing survey
	Masbate-Mobo	Masbate, Mobo	113	111	108	106	103	99	96	MWD hearing survey
Other cities in Urban Area			120	118	115	113	109	106	102	Domestic demand (urban) in PWSSMP2018
Other cities in Rural Area			60	59	58	56	55	53	51	Domestic demand (rural) in PWSSMP2018

Note: Changes from baseline condition due to water saving promotion is highlighted in red.

Source: JICA Survey Team

Summary of municipal and industrial water demand projection in WRR XI with water saving promotion is shown below.

Table 4.5-29 Summary of Municipal and Industrial Water Demand Projection in WRR V (Water Saving Promotion)

Water Resources Region	Municipal + Industrial Water Demand Projection (MCM/Year)						
	2020	2025	2030	2035	2040	2045	2050
WRR V - BICOL	356	363	373	395	410	426	436

Note: Changes from baseline condition are highlighted in red.

Source: JICA Survey Team

As a result of the above, it was confirmed that if water saving promotion were thoroughly implemented, there would be a saving of 12 % (58 MCM) of water demand. It is assumed that the cost of water saving promotion can be accounted for as part of each water utility's public relations activities and that no construction or other cost will be incurred.

(4) Comparison of Priority Project Concept

Comparison of priority project concept is shown as below.

Table 4.5-30 Comparison of Priority Project Concept in WRR V

Priority Project Concept	Reduction of NRW	Promotion of Water Saving Activity	Introduction of Desalination Technology	Recycling of Sewerage Water	Recycling of Industrial Wastewater
Target City	Large Scale Major Municipalities （Naga, Legazpi, Virac, Masbate-Mobo ）	All Municipalities	—	—	—
Reduction Effect (2050)	WRR V: 8 MCM	WRR V: 58 MCM	—	—	—
Very Rough Project Cost	9.2 billion PHP	- （It is included in municipalities public relations budget）	—	—	—
Feasibility	Low （NRW 20% is a high target, but the alternative is an even higher target of 10%.）	Middle （No typical project cost and water demand per capita is already declining in other countries.）	—	—	—

Source: JICA Survey Team

4.5.3.6 Water Resources Management Plan (Information Management) in WRR V

Water resources management plan (information management) in WRR V is same as the one for WRR VII, as described in sub section. 4.3.3.6.

The proposed composition of the information management plan is shown in Table 4.5-31 below. The Central and Regional Offices should manage the data-sharing diligently.

Table 4.5-31 Composition of Information Management Plan (Idea)

Information Management Plan (Idea)	Contents	Related Agencies
Meteorology and Hydrological Data Information Management	• River water level observation, cross-section survey of the river channel, discharge measurement, and the creation of water level-discharge curves (H-Q rating curves). • Retroactively organize short-term rainfall, water level and discharge data, and construct a display system for real-time observation data using a telemeter on real-time hourly or 10 to 15-minute basis. • Monitoring system of dams and intake weirs operations in real-time and organizing past operation record data. • Installation of telemetric ARG, telemetric AWLG, ARCM, and RSLC.	DPWH, PAGASA, DOST-ASTI, FMB, NIA, NPC, LGUs
Climate Change Data Information Management	• More detailed regional (preferably mesh data) and monthly or daily climate change data in the Philippines. Downloadable in CVS format and some graphs on the PAGASA website.	PAGASA
Groundwater and Hydrogeological Data Information Management	• Monitor and collect the groundwater level, groundwater quality data, hydrogeological data, geological data, boring data, pumping test data of wells, saturated hydraulic conductivity, porosity data, etc. • Construction of a central monitoring and management system of data and information. • Drilling of more monitoring wells is desired to increase the spatial distribution of monitoring wells for groundwater level and groundwater quality.	NWRB, DENR, LGUs
Flood Forecast and Early Flood Warning System	• Installation of telemeter-type ARGs and telemeter-type AWLGs, ARCM, and RSLC on the ground. • Installation of the real-time radar (X or C-band) rainfall gauge systems. • Develop a flood forecasting and early flood warning system. • Utilization of observed rainfall and river water levels, re-analysis rainfall forecast data by the ECMWF or satellite rainfall forecast data by USGS or other commercial satellites. • Construction of a river water level and discharge prediction system using AI technology is desired.	PAGASA, DOST-ASTI, DRRMO, DPWH, LGUs
GIS/Map Data	• To update and centrally manage more detailed digital geological maps, soil maps, hydrogeological maps, environmental maps, land use/land cover maps, satellite image, digital elevation data, river sub-basin maps and river line, and river structural location maps, etc. • For example, rapidly changing land use/land cover maps will be changed every 3 to 5 years. And once every 10 to 15 years for topographic data, etc., which do not change so much. • Capacity building for engineers of central and regional government.	DENR, NAMRIA, NWRB, PAGASA, DPWH, etc.

Source: JICA Survey Team

The proposed draft information management plan for priority WRRs is shown in table below.

Table 4.5-32 Draft Information Management Plan for the Priority WRRs

WRR	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common (Structural Measures)	• Installation of telemeter-type ARGs, telemeter-type AWLGs, ARCM, and RSLC. • Installation of the real-time radar (X or C-band) rainfall gauge systems. • Construction of a display system for real-time or short-term rainfall, WL, discharge, and GWL, SW and SW quality data, dams/intake weirs operation data using a telemeter system. • Drilling of monitoring wells of GWL and quality by telemetric system.		
Common (Non-Structural Measures)	• River WL observation, cross-section survey, discharge measurement, and to create H-Q rating curves. • Central monitoring and management system of meteorological, hydrological, and hydrogeological data and information. • Past meteorological, hydrological, and dams/weirs operation record data arrangement. • Detailed spatial-temporal climate change data website. • Monitor and collect the GWL, GW quality data, hydrogeological data, geological data, boring data, pumping test data of wells, etc. • Update and centrally manage more detailed GIS data of geological, soil, hydrogeological, environmental, land use/land cover, river structural location maps satellite images, etc. • Develop a flood forecasting and early flood warning system utilization of observed rainfall and river water levels, re-analysis, or satellite rainfall forecast data. • Construction of a river water level and discharge prediction system by AI technology. • Capacity building		
Meteorology and Hydrological Data Information Management	• Installation of ARGs, AWLGs, ARCM, and RSLC. • Real-time meteor-hydrological, dams/intake weirs operation. • Cross-section survey, discharge measurement, and H-Q rating curves.	• Installation of ARGs, AWLGs, ARCM, and RSLC, • Installation of the real-time radar (X or C-band) rainfall gauge systems.	• Installation of the real-time radar (X or C-band) rainfall gauge systems.
Climate Change Data Information Management	• Detailed spatial-temporal climate change data website.	• Updating of climate change data website.	• Updating of climate change data website.
Groundwater and Hydrogeological Data Information Management	• Past meteor-hydrological, dams/weirs operation, and GW data arrangement. • Monitoring wells. • GWL and quality, boring, pumping test data collection.	• Drilling of more monitoring wells of groundwater level and groundwater quality.	• Drilling of more monitoring wells of groundwater level and groundwater quality.
Flood Forecast and Early Flood Warning System	• Flood forecasting and early flood warning system. • Utilization of re-analysis or satellite rainfall forecast data. • River WL and discharge prediction system by AI.	• Updating flood forecasting and early flood warning system. • Utilization of re-analysis or satellite rainfall forecast data.	• Updating flood forecasting and early flood warning system. • Utilization of re-analysis or satellite rainfall forecast data.
GIS/Map Data	• Decide on a policy for centralized data management and update frequency. • Capacity building for engineers	• Regularly update data and train personnel.	• Regularly update data and train personnel.

Note: ARG: telemetric automatic rainfall gauge, AWLG: the telemetric automatic water level gauge, ARCM: the non-contact radar sensor automatic radio current meter, RSLC: the simple river surveillance live camera.

Source: JICA Survey Team

4.5.3.7 Water Resources Management Plan (Flood Risk Management) in WRR V

(1) The Objective of Draft FRM Plan

The objective is the same as described in Chapter 4.3.3.7 (1).

(2) Target of Draft FRM Plan

Due to the natural and social conditions, flood disasters frequently occur in the Philippines. Aiming to strengthen flood disaster resilience, DPWH suggests planning target design flood as 100 years in return period for the rivers with the drainage area over 40 km^2 in the Design

Guidelines, Criteria and Standards (DGCS, 2015). Because most of rivers still have a long way to achieve their goals, the implementation of structural and non-structural measures based on FRMMPs should be accelerated.

The National Water Resources Council (NWRC, the predecessor of NWRB) classifies the river basins in the Philippines by the drainage areas as 18 major river basins (larger than 1,400 km^2), 421 principal river basins (between 40 km^2 and 1,400 km^2) and others. In WRR V, there are 1 major river basin and 29 principal river basins. Since there are numerous rivers in the region, the major river, namely Bicol River, is focused considering the scale of flood risks and the importance of water resources development and management. The summary of the current FRMMP for the Bicol River Basin (BRB) is shown in Table 4.5-33 below.

Table 4.5-33 Summary of the Current FRMMP for the Bicol River Basin

River Basin Name	Bicol River Basin
Drainage Area (km^2)	3,171 *1
Estimated Population (thousand people) and Estimated Year	2,011 (2010) *1
Latest FRMMP and Formulated Year	DENR (2015) *2
Target Year	2030
Target Flood Level	5- or 10-year flood*3
Design Flood Discharge	Not clearly described.
No. of Existing Flood Control Dam	0
No. of Potential Flood Control Dam	0

*1) The values of “Drainage Area” and “Estimated Population” are quoted from the website of River Basin Control Office (https://riverbasin.denr.gov.ph/main/index)
*2) DENR, 2015, “Integrated Bicol River Basin Management and Development Master Plan”
*3) In the latest FRMMP (DENR, 2015), the target flood level is not clarified. In the previous FRMMPs (WB, 2003/ ADB, 1992), the target flood level was set at 5 or 10-year flood.

Source: JICA Survey Team

The steady implementation of proposed measures along the FRMMP is also pursued in this Draft FRM Plan. However, the current FRMMP of BRB formulated by DENR in 2015 does not include detailed hydrological and hydraulic analyses nor alternative solution analysis, and thus does not satisfy a general master plan level study. The last master plan level study for BRB would be “The Basin Plan for the Water Resources Development and Management (BPWRDM)” by NEDA and World Bank in 2003 or “Bicol River Basin Flood Control and Irrigation Development Project (FCIDP)” by DPWH and ADB in 1992. Most of the proposed structural measures in both plans, however, are still not implemented. Consequently, present conditions and issues on FRM in the BRB are studied in this survey.

(3) Potential Dams for Flood Control Purposes

Because dams can give especially large impacts among various kinds of river projects, potential dams for flood control purpose are studied. There is no existing flood control dam and planned flood control dams in the current and previous FRMMPs. On the other hand, there are three natural lakes, namely Lake Bato, Lake Baao, and Lake Buhi in the BRB, which could be utilized as natural reservoirs with the installation of flow control structures. In fact, there exists a flow control structure at the outlet of Lake Buhi, and it controls the outflow discharge for the irrigation in the downstream. It also can be utilized for flood control purpose although the effect would be limited due to the small catchment area comparing to that of BRB. Flow control structures were also proposed for Lake Bato and Lake Baao in the previous FRMMPs. ADB (1992)[2] proposed the construction of flow regulator at the downstream of Lake Baao with the aim of integrated use of Lake Bato and Lake Baao as a natural reservoir. WB (2003)[3] also proposed a Lake Bato Control Structure for utilizing Lake Bato for flood control purpose. Their proposed flow control structures will be effective to reduce flood peak discharge and to store water for drinking water or irrigation in the downstream, thus, such structures could be proposed again in the future in terms of IWRM.

(4) Issues on FRM

1) Overall Present Conditions and Issues

Overall present conditions and issues are the same as described in Chapter 4.3.3.7 (4) 1).

2) Present Conditions and Issues in the Bicol River Basins

Present conditions and main issues in the Bicol River Basin are organized by the review of the current and previous FRMMPs (DENR, 2015/ WB, 2003/ ADB, 1992) and the study in this survey as shown in Table 4.5-34 below.

Table 4.5-34 Present Conditions and Main FRM Issues in the Bicol River Basin

Present Conditions	Main Issues
• Typhoons frequently hit the river basin and cause intensive rainfall and storm surge. • Floods occur almost every year and the inundation durations tend to be long (more than 1 month in some place) especially around Lake Bato and Lake Baao. • Large volume of sediments produced by volcanic eruptions, landslides and mass movement are flown into river channels. • Three active volcanoes (Mt. Mayon, Mt. Iriga, Mt. Isarog) exist in the river basin. Large volume of volcanic sediments causes rivers to meander and change course. There is another risk of 'Lahar', pyroclastic flows. • There is a risk of mass movement induced by active faults (San Miguel Fault, Legaspi Lineament, San Vincente Linao Fault).	• Although the target flood level in the FRMMP is low, it's still not achieved mainly due to large volume of sediment inflow from the upstream and low flow capacity in the downstream. • Bato Lake and Baao Lake plays an important role to decrease flood peak discharge in the downstream as natural retarding basins, but the lakes have been shallowing by sedimentation. • The downstream is very vulnerable to high-tide, storm surge and tsunami due to the gentle slope of the riverbed. Sea level rise induced by climate change will aggravate the situation. • The uncertainty of future volcanic activities makes it difficult to formulate FRM and Sabo master plans and to invest for the implementation.

Source: Prepared by JICA Survey Team based on the reviews of current FRMMPs and field surveys.

[2] ADB, 1992, Bicol River Basin Flood Control and Irrigation Development Project

[3] WB, 2003, The Basin Plan for the Water Resources Development and Management

(5) Recommendation

1) Overall Recommendation

Overall recommendation is the same as described in Chapter 4.3.3.7 (5) 1).

2) Recommendation for the Bicol River Basin

The recommendations in terms of FRM for the Bicol River Basin are summarized as follows:

- Flood control projects should be steadily implemented in accordance with the current FRMMP. However, because the current FRMMP would not satisfy general master plan level study as described in this subsection (2), a more comprehensive master plan study for flood and sediment control at a river basin scale should be conducted.
- Upgrading of the existing flow control structure at Lake Buhi is proposed as a priority project for water resource development in this survey. Since controlling the discharge from Lake Buhi in flood season can also contribute for flood risk reduction in the downstream, the effective and efficient operation of the structure should be studied in terms of IWRM.
- In terms of IWRM, storing floods in Lake Bato and Lake Baao can greatly contribute not only for decreasing flood peak discharge in the downstream but also for increasing available fresh water in dry season. In fact, as described in this subsection (3), installation of flow control structures at the outlet of Lake Bato or Lake Baao were proposed to utilize the lakes as natural reservoirs in the old projects (ADB, 1992/WB, 2003). Although these proposals have not yet been realized, the measures have great potential for both flood and drought mitigation and may be revisited in the future. A master plan study for the integrated natural lake management including flood and sediment control, water utilization, water quality, etc. should be conducted.

(6) Draft FRM Plan

The proposed FRM measures in the FRMMPs are summarized in the table below. In addition, among the priority projects for water resources development identified in this survey, the projects that may also contribute for FRM are added in red.

Table 4.5-35 Draft FRM Plan for WRR V

River Name	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common (Structural Measures)	• Riverbank & Bed Protection (Revetment, Spur Dike, Grounsill, etc.) • Drainage Improvement (Drainage Channel Improvement, Pumping Station, etc.) • Sabo Facility (Slope Protection, Check Dam, etc.) • Rehabilitation of Old River Structures (Weir, Revetment, Bridge, etc.)		
Common (Non-Structural Measures)	• River & Drainage Channel Maintenance (Dredging, Cleaning, etc.) • Flood Forecasting and Early Warning • Evacuation Planning & Drill • Educational Activities • Forests Conservation (regulating illegal logging, mining, unsuitable agricultural activities, etc.) • Land-use Regulation (regulating the land use in flood prone areas, etc.)		
Bicol	• Retarding Basin • Dike (including Ring Dike) • Diversion Channel • Study for the integrated natural lake management	• Retarding Basin • Dike • Upgrading of the Existing Flow Control Structure at Lake Buhi	

Note: 1) Red colour indicates potential FRM measures identified in this survey.
2) River improvement includes river excavation, widening, revetment, etc.

Source: Prepared by JICA Survey Team based on the reviews of current FRMMPs and field surveys

4.5.3.8 Water Resources Management Plan (River Basin Environmental Conservation) in WRR V

(1) Issues and Challenges on River Basin Environment in WRR V

1) Water Balance in WRR V

In WRR V, surface water potential is basically abundant in the whole region; however, water shortage is caused by the inadequate management of water resources such as the aging of facilities, flooding, poor drainage, sediment management and intrusion of salt water in irrigation areas near the estuary.

2) Water Quality in Lake Buhi

Irrigation area upstream of Bicol is highly dependent on the water resources of Lake Buhi which is used as an active fish farming and tourist area.

Effective depth of Lake Buhi is currently only 0.5 m, while the original depth is 3.3 m. This regulation is due to the fact that the lowering of water level deteriorates water quality and kills fish in the lake. Improvement of water quality and dredging of sediment are needed. In connection with changing of the effective depth, bank protection works can be provided with environmental improvement along the lake shore.

3) Natural Environment in Masbate

There are severe water shortages and water quality problems with turbid surface water and contaminated groundwater with iron and manganese due to several mining areas in Masbate.

In the past, much of the land in Masbate was bare due to deforestation, and main land use was grassland with relatively little vegetation.

(2) Objective of the River Basin Environmental Conservation Plan in WRR V

Considering the above present conditions, the objectives of the river basin environmental conservation plan in WRR V are as follows.

- To secure good quality and enough amount of water resources in WRR V through environmental conservation measures
- To protect and improve waterfront environment and water quality that ensure the sustainability between natural environment and development / livelihood activities towards the prosperity of communities.

(3) Strategy of the River Basin Environmental Conservation Plan in WRR V

1) Securing Clean Water

Effective use of the water is one of the most important water resources management methods. As water quality of the river basin in WRR V is not good, securing clean water is necessary for effective use of water. The following measures are suggested to secure clean water.

- Source countermeasures: Treatment of wastewater generated from domestic use, industries, agriculture, and fisheries such as sewage system, agricultural drainage, septic tank etc.
- Purification of rivers and lakes: Installation and development of a purification facility, utilization of natural purification function using plants and aquatic life and direct removal of sediment such as with dredging.
- Monitoring of water quality: Formulation of water quality monitoring system to prevent contamination of water body and establishment of a close communication system between residents, LGUs and national agencies to understand the current situation and cause of the accident and to prevent the spread of damage.

2) Sustainable Basin Reservation

Sustainable maintenance of water function is very important as a long-term goal of basin reservation. The following measures are suggested to maintain sustainable water resources.

- Appropriate forest management: Providing support for appropriate forest management that matches the characteristics of water source area, based on forest planning, in order to enhance the water retention function of forests. Examples include improvement of devastated forests, avoiding unregulated conversion of forest land to land development, forest road network development and thinning and pruning.
- Consideration for water retention function in development projects: Consideration of alternative measures such as rainwater infiltration, installation of water storage facilities and reforestation when there is concern that the water retention function is in decline due to deforestation by development projects.

- Improvement of water retention function in urban areas: Restriction of rainwater runoff by the installation of rainwater storage and infiltration facilities, the development of permeable pavement and development of green spaces such as promotion of city greening.

3) Establishment of Interaction between Nature and People

Waterfront environments such as rivers, lakes, reservoirs and wetlands are important habitats for aquatic life and also places of recreation and relaxation for people. Creation of comfortable water area is important for both natural environment and people. The following measures are suggested to establish interaction between nature and people.

- Conservation of waterfront where diverse life grows and inhabits: Promotion of multi-natural waterfront development considering the natural environment and landscape of rivers and lakes that coexist with aquatic life.
- Conservation of biodiversity: Conservation of waterfront ecosystems with securing a place for the growth and habitat of a variety of life and forest around the water body, conservation of wetlands, conservation of aquatic life with the Red Data Book, extermination of alien species and research on aquatic life.
- Creating friendly waterfronts and promotion of tourism: Creation of opportunities to become familiar with water area and development and promotion of waterfront tourism.

(4) Proposal of the River Basin Environmental Conservation Plan in WRR V

Tentative river basin environmental conservation plans in WRR V divided to three terms (short, middle and long) based on the above strategies is shown in Table 4.5-36.

Table 4.5-36 Draft River Basin Environmental Conservation Plan in WRR V

Strategy	Short-Term (2030)	Mid-Term (2040)	Long-Term (2050)
Common	• Monitoring of water quality at the existing monitoring stations • Consideration of alternative measures such as rainwater infiltration, installation of water storage facilities and reforestation when there is concern that the water retention function is declining by development projects. • Reforestation		
Securing Clean Water	• Removal (dredging) of sediment directly • Utilization of natural purification function using plants and aquatic life • Planning of water quality monitoring system and its close communication system	• Development of agricultural drainage • Development of septic tank around the water body • Formulation of water quality monitoring system and establishment of its close communication system	• Development of sewage system • Installation and development of purification facility • Updating of water quality monitoring system and its close communication system
Sustainable Basin Reservation	• Development of sustainable forest plan • Planning of green space such as city greening	• Development of forest road network • Improvement of devastated forests • Restriction of rainwater runoff by the installation of rainwater storage and infiltration facilities in urban areas • Development of green space such as city greening	• Improvement of devastated forests • Development of permeable pavement • Development of green space such as city greening

Establishment of Interaction between Nature and People	• Planning of multi-natural waterfront development • Planning of waterfront ecosystems conservation • Planning of tourism development considering waterfront environment	• Promotion of multi-natural waterfront development • Development of waterfront ecosystems conservation • Development of tourism development considering waterfront environment

Source: JICA Survey Team

4.5.3.9 Water Resources Management Plan (Organizations and Legal Frameworks) in WRR V

(1) Introduction

In this section, the following items are summarized to clarify the current status and issues, recommendations for improving the organizations and legal frameworks relating to the proposed plans for water resources development and management in WRR V.

- ✓ Outline of the way for considering the implementation scheme
- ✓ Possible implementation schemes for water resources development and management projects
- ✓ Recommendations and plan in the aspect of organizations and legal frameworks
- ✓ Recommendations relating to the proposed plans for water resources development and management

(2) Outline of the way for considering the implementation scheme

The description on “Promotion of Water Saving Activity” for WRR VII can be applied for WRR V. Please see section 4.3.4.3. (3) 1).

(3) Possible Implementation Schemes Water Resources Development and Management Project

The description on “Possible Implementation Schemes for Water Resources Development and Management Projects” for WRR VII can be applied for WRR V. Please see section 4.3.3.9 (3).

(4) Recommendations and Plan in the Aspect of Organizations and Legal Frameworks

The description on “Recommendations and Plans for Improvement of the Aspect of Organizations and Legal Frameworks” for WRR VII can be applied for WRR V except for the affair of Inabanga Dam project. Please see the previous subsection of 4.3.3.9 (4).

On the other hand, “Upgrading Buhi Lake IWRM” is a kind of a multi-purpose project with irrigation and flood control consisting of gate facility improvement, sediment removal, and land reclamation. In addition, this project may give an impact on the biological environment of the lake and the life of residents around the lake. Thus, it is necessary to develop a consultative scheme consisting of stakeholders considering the complexity of the project. Plans for improvement in the aspect of organization and legal frameworks in WRR V is as follows.

Table 4.5-37 Plans for Improving the Issues on Organizations and Legal Frameworks (WRR V)

Items		Short Term (-2030)	Middle Term (2030-2040)	Long Term (2040-2050)
National Level				
	Creating DWR	⇒		
	Consideration of incentive scheme for rainwater storage and infiltration	⇒	⇒	⇒
Region/Basin Level				
	Preparation of plans for multipurpose dams (Lanang Dam)	⇒		
	Strengthening the functions of River Basin Committee	⇒		
	Development of consultative scheme for Upgrading the Buhi Lake IWRMInabanga Dam project	⇒		
	"MODEL PROJECT" of multipurpose dams	⇒ Preparation	⇒ Implementation	⇒
	Strengthening of organization and human resources of the regulatory organization	⇒		

Source: JICA Survey Team

(5) Recommendation related to Upgrading Buhi Lake IWRM

This project increases the available water level of Buhi Lake by reconstructing and modernizing the gates in order to secure irrigation water and flood protection in the lower reaches of the lake. The project will also increase the discharge capacity of the lake, and if necessary, the downstream river will also need to be expanded to accommodate it. In addition, Buhi Lake will be excavated and the land around the lake will be raised with dredged material to prevent flooding. The lake has also been a place for fish farming by the residents, and the use of the water and gate operations during flooding have been restricted because the rolling up of bottom soil caused by the mixing of the lake water lowers the DO and adversely affects the habitat of farmed fish.

With regard to this project, it may be assumed that NIA V will be the main implementation body to reconstruct the existing gate facility, dredge the lake, and raise the surrounding area of the lake. DPWH V will oversee the rehabilitation work of downstream rivers and the LGU will oversee the development of the surrounding area.

Many of the residents living around the lake make their living from fish farming in Buhi Lake. Since this project will affect the residents, it is necessary to proceed with caution while listening to the opinions of the residents. It is desirable to establish a consultative organization consisting of the operator (NIA), DPWH, the Province of Camarines Sur, the Municipality of Buhi, academic experts, and other concerned parties, and to implement the project with overall coordination.

4.5.4 Proposal for Priority Project Concept in WRR V

4.5.4.1 Selection of Priority Project

Table 4.5-38 shows the short-term (2030), medium-term (2040), and long-term (2050) project implementation schedule up to 2050 as a roadmap for the water resources development and management plan proposed in the previous section. Of these, the projects selected as short-term proposals that are of high need and urgency are selected as the priority projects. In addition to this, among the medium-term proposals, it is decided to include the projects with high feasibility and high importance as priority projects. These priority projects are shown in red frames in Table 4.5-38 and in Figure 4.5-18.

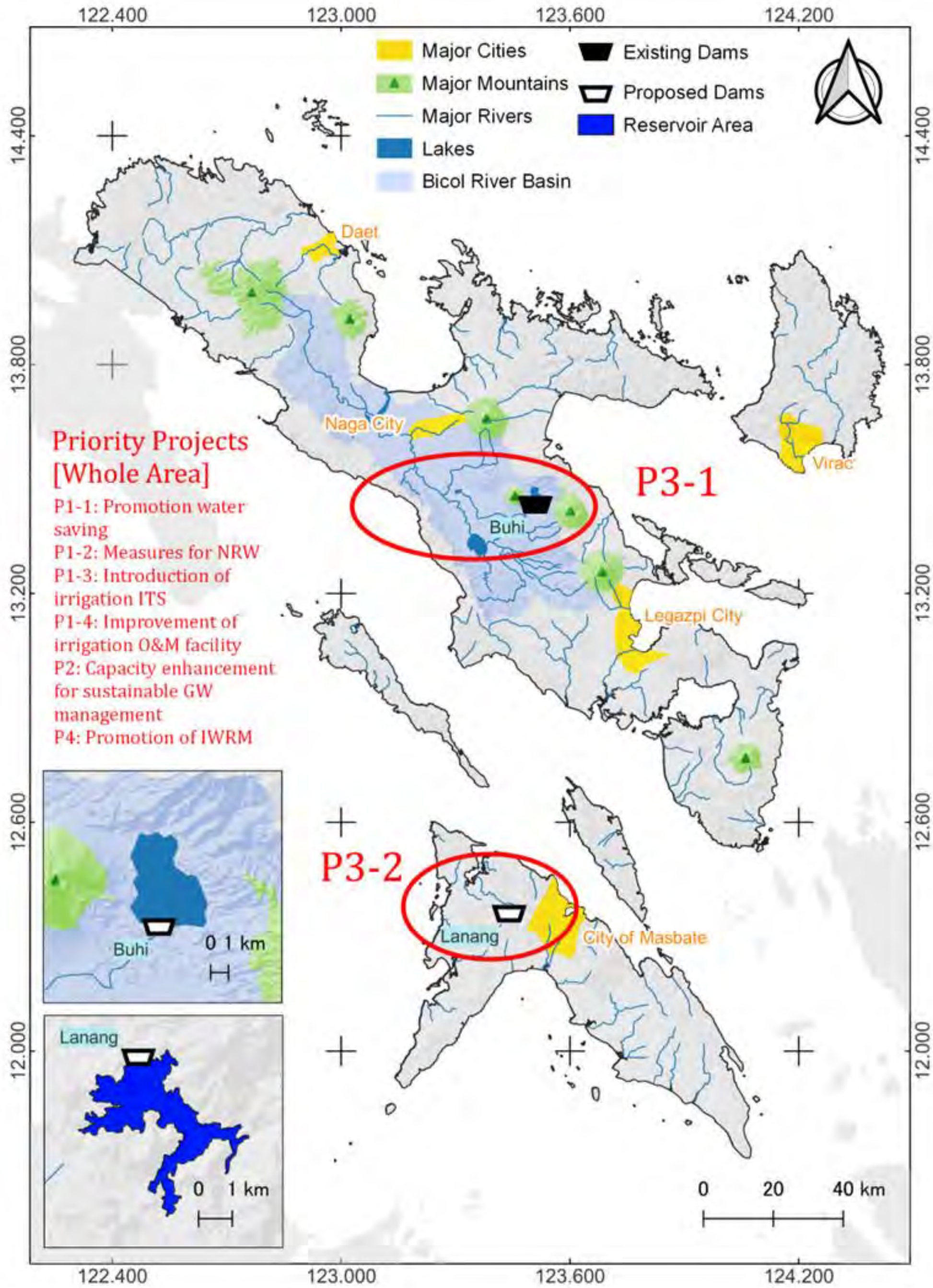
Table 4.5-38 Roadmap of Water Resources Development and Management Plan (Idea) and Priority Projects in WRR V

Priority Policy	Development Items	Short-term (2024-30)	Mid-term (2031-40)	Long-term (2041-50)
1	Demand Management	P1-1: Promotion of water-saving P1-2: Measures for NRW (20%) P1-3: Introduction of Irrigation ITS P1-4: Improvement of Irrigation O&M Facility	Promotion of water-saving Measures for NRW (15%) Introduction of Irrigation ITS Improvement of Irrigation O&M Facility	Promotion of water-saving Measures for NRW (10%) Introduction of Irrigation ITS Improvement of Irrigation O&M Facility
2	Groundwater Management	P2: Capacity Enhancement for Sustainable Groundwater Management	Monitoring and regulation of GW	Monitoring and regulation of GW
3(1)	Surface water development	P3-1: Upgrading Buhi Lake IWRM Promotion of mid-long term plans (P3-2: Lanang Dam) ●Development of irrigation weirs and dams (SRIP)	Upgrading Buhi Lake IWRM Construction of Lanang Dam (multi-purpose) in Masbate Development of irrigation weirs and dams (SRIP) Upgrading existing Balongbong Dam (NAPCOR) in Catanduanes	Development of irrigation weirs and dams (SRIP)
3(2)	Water Supply and Sewerage Development	●Bulk water developments ●Groundwater developments (Bicol, Sorsogon, Catanduanes, Masbate)	Bulk water developments Groundwater developments (Bicol, Sorsogon, Catanduanes, Masbate)	Bulk water developments Groundwater developments (Bicol, Sorsogon, Catanduanes, Masbate)
4	Water Resources Management Plan	P4: Promotion of IWRM (management of information, flood risks, watershed conservation, organization and institution)	Promotion of IWRM	Promotion of IWRM

●based on the existing / on-going plans

Priority Projects (red frame)

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-18 Priority Projects in WRR V

4.5.4.2 Priority Project Concept

(1) P1: Demand Management

1) P1-1: Reduction of Non-Revenue Water

Reduction of the Non-Revenue Water (NRW) is proposed as one of the priority project concepts of the demand management. Outline of the project concept is the same as Table 4.3-50.

2) P1-2: Promotion of Water Saving Activities

Promotion of water saving is proposed as one of the priority project concepts of the demand management. Outline of the project concept is the same as Table 4.3-51.

3) P1-3: Introduction of Irrigation Telemetry System

The ultimate goal of proper irrigation water management is to improve the agricultural productivity and farmers' economy through maximum utilization of available land and water resources. The introduction of ITS is proposed as one of the most effective tools for the establishment of proper water management system in NISs, especially NISs with reservoir dam. Outline of the project concept is the same as Table 4.3-52.

4) P1-4: Improvement of O&M Facility

Several NISs are located in remote areas, where access roads are in poor conditions, no existence of pavements and difficulty of driving during the rainy season. For proper water control/ management, O&M office with operational staffs and road improvement are required in the improvement works. Outline of the project concept is the same as Table 4.3-53.

The preliminary cost estimate for introduction of irrigation telemetry system and improvement of O&M facility in WRR V is presented in Table 4.5-39 below.

Table 4.5-39 Preliminary Cost Estimate for Introduction of Irrigation Telemetry System and Improvement of O&M Facility in WRR V

Irrigation Telemetry System	Target System	ISA (ha)	Unit Cost (Peso/ha)	Amount (million P)
	(Rinconada IIS only)	8,002	15,000	120.03
Diversion Dam Sluice & Intake Gate	Gate Nos.	Gate Area (sqm)	Unit Cost (Peso/sqm)	Amount (million P)
	39.0	454	1,600,000	727.15
Concrete Flume Canal (Lateral Canals)	Target System	ISA (ha)	Unit Cost (Peso/ha)	Amount (million P)
	(All NISs)	24,135	80,000	1,930.80
Total (million PHP)				**2,777.98**
Total (million Yen)				**6,945**

Source: JICA Survey Team

(2) P2: Groundwater Management

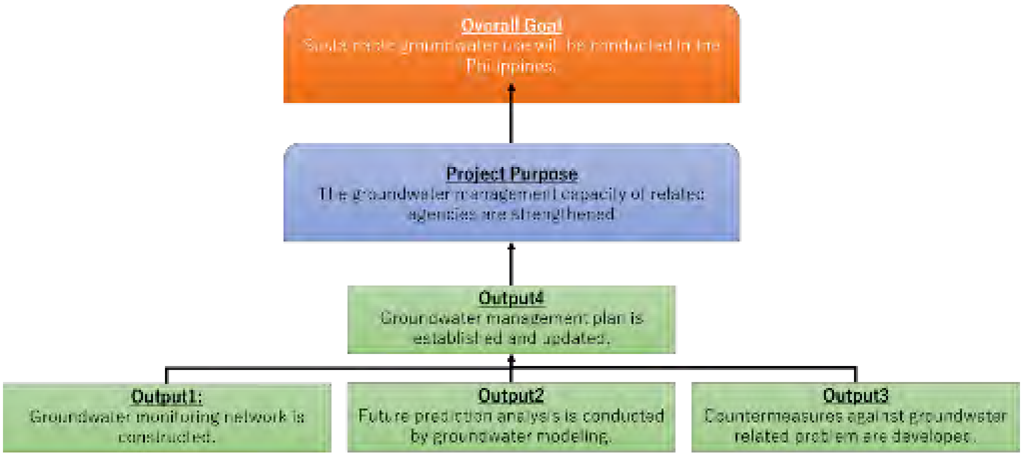
All of the short-term items listed in Table 4.5-17 should ultimately be implemented on the Philippine side, and capacity strengthening through technology transfer is considered essential. Therefore, it is considered optimal to formulate and update the groundwater management plan through the implementation of the technical cooperation projects shown below as a short-term development plan.

Table 4.5-40 Outline of the Project Concept (Groundwater Management Project)

Title:	Project on Capacity Enhancement for Sustainable Groundwater Management in WRR V
Goal:	Groundwater management capacity of related agencies are strengthened.
Target:	NWRB, MGB, etc
Location:	Naga
Output:	Output1: Groundwater monitoring network is developed. Output2: Future prediction analysis is conducted by groundwater modeling. Output3: Countermeasures against groundwater related problem are developed. Output4: Groundwater management plan is established and updated.
Effect:	Groundwater usage will be optimized.
Approx. Cost:	Output1: 103 mil. PHP Output2: 33 mil. PHP Output3: 10 mil. PHP Output4: 20 mil. PHP

Source: JICA Survey Team

The relationship between the overall goal, project purpose, and each outcome is shown in Figure 4.5-19.



Source: JICA Survey Team

Figure 4.5-19 Proposed Overall Goal, Project Purpose, Output of Technical Cooperation Project in WRR V

The following is a description of the activities and their contents for each of the expected outcomes.

1) **<Output 1>** Groundwater monitoring network is established

[Activity 1-1] Conduct Well Inventory Survey

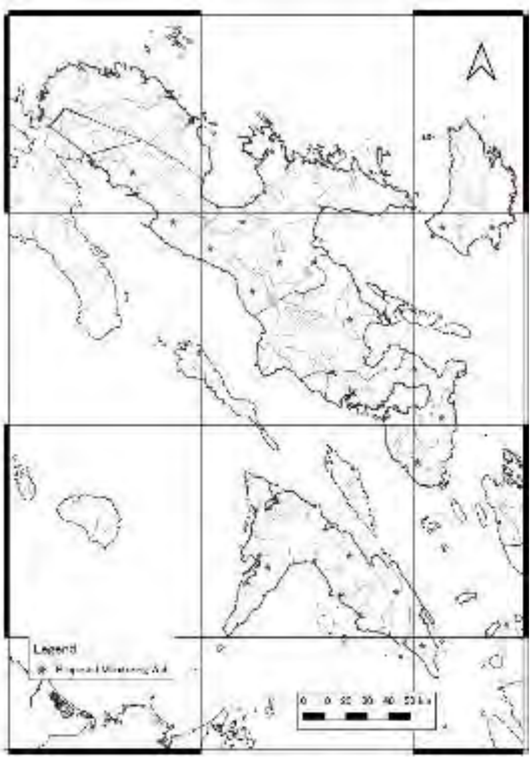
To ascertain the status of groundwater use, the use of wells for domestic, agricultural, and industrial purposes will be confirmed and organized into a list.

[Activity 1-2] Conduct hydrogeological, hydrological, and geophysical surveys

Conduct various geological surveys to determine aquifer capacity. Since NWRB and others have electrical survey equipment, it is better to include the implementation of an electrical survey to estimate the vertical structure of the aquifer. In addition, simultaneous hydrometric surveys should be conducted in the proposed wells at least twice, once in the dry season and once in the rainy season. Measurement of groundwater levels will be beneficial in understanding the distribution status of groundwater levels.

[Activity 1-3] Drilling of new observation wells, pumping tests, and installation of observation equipment

Considering the expected distribution of groundwater level drop and the proposed monitoring wells, it is necessary to establish a groundwater monitoring network that covers the entire area. Figure 4.5-20 shows proposed locations for new monitoring wells with the NWRB's proposed wells.



Source: JICA Survey Team

Figure 4.5-20 Proposal of Groundwater Monitoring Network in WRR V

2) **<Output 2>** Future Prediction Analysis is Conducted Using Groundwater Modeling

[Activity 2-1] Data collection, organization, and analysis for groundwater modeling

Various groundwater data obtained in Outcome 1 and the results of existing hydrological investigations will be collected, organized, and analyzed for groundwater modeling.

[Activity 2-2] Construction of groundwater flow model and advection-dispersion model

The groundwater analysis conducted in this survey was intended to estimate the groundwater potential of each water resource region, and because of the wide area covered, the hydrogeological structure, actual pumping conditions, and other settings were simplified. In order to conduct a more detailed study in the future, it is necessary to conduct the analysis after creating an elaborate groundwater model for each basin and city.

[Activity 2-3] Groundwater model calibration based on observed data

Using the data obtained in output 1, the groundwater model constructed in 2-2 will be calibrated to improve the accuracy of the groundwater model.

[Activity 2-4] Future Prediction Analysis

The groundwater model calibrated in activity 2-3 is used to predict future water level drop and saltwater intrusion analysis.

3) **<Output 3>** Countermeasure plans against groundwater related problem are developed

The following studies will be conducted to develop countermeasures to address the various problems caused by groundwater use that have been identified in the field investigations.

In areas where groundwater-related problems are not recognized and groundwater potential is relatively large, drilling of new production wells will be implemented as a pilot project. If further development is deemed feasible, further production wells could be developed as a water supply development project. In WRRVII, Legazpi and Catanduanes is candidate site.

[Activity 3-1] Collecting and organizing examples of countermeasures

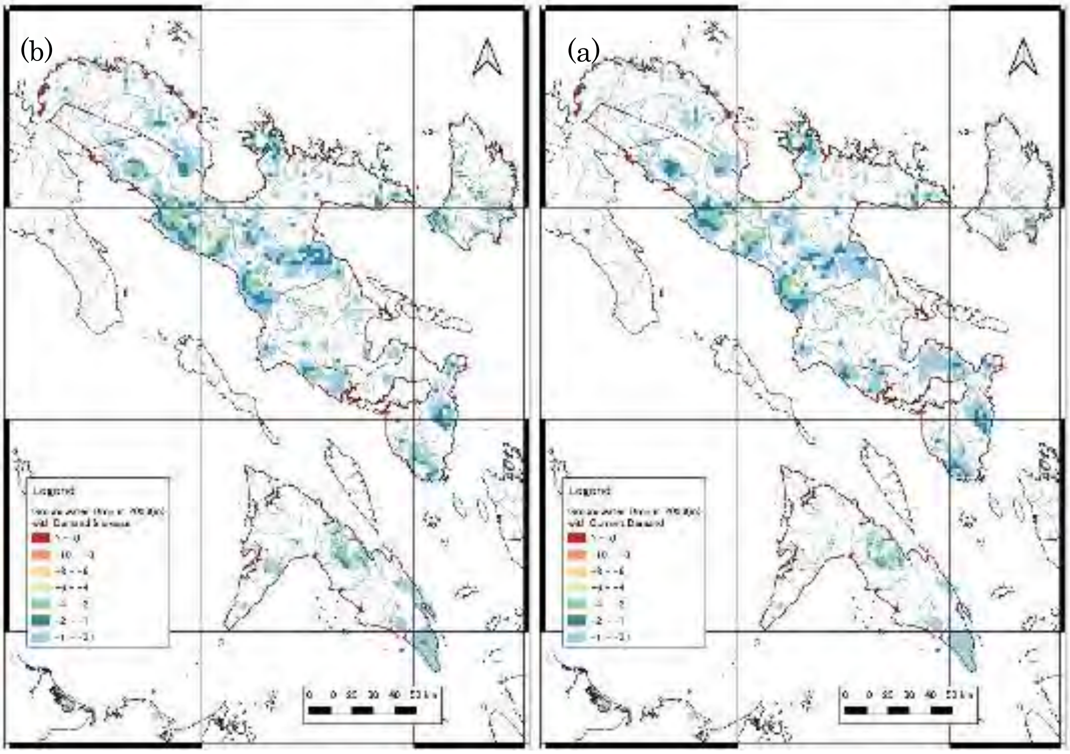
[Activity 3-2] Mapping of groundwater salinization area, subsidence and sinking risk areas

[Activity 3-3] Implementation of pilot project (production well construction)

4) **<Output 4>** Groundwater management plan is established and updated

[Activity 4-1] Acceptable Groundwater Criteria (Condition)

Based on the future prediction analysis obtained in Activity 2-4, establish an acceptable groundwater standard criterion (condition). For example, if future groundwater demand could be maintained at the current level of use, the amount of decline in groundwater levels would be as shown in Figure 4.5-21(b), thus reducing the groundwater level drop.



Source: JICA Survey Team

Figure 4.5-21 Groundwater Level Drop (2020-2050) by considering increased groundwater demand and by limiting within current groundwater demand

[Activity 4-2] Development of a regulation (mitigation) plan for groundwater use based on the results of the prediction analysis

Based on the results of the prediction analysis obtained in Activity 4-1, a feasible groundwater use regulation plan will be developed. Since the groundwater demand shortage caused by the regulation must be met by alternative water sources such as surface water, it is desirable to set a target value for groundwater use regulation after taking into account the amount of surface water and desalinated water that can be developed.

[Activity 4-3] Develop a plan to introduce the countermeasures for saltwater intrusion and artificial groundwater recharge

Develop a future plan based on Output 3.

[Activity 4-4] Development of a middle/long-term groundwater management plan and guidelines

Develop a comprehensive groundwater management plan based on all the above considerations.

(3) P3: Surface Water Development

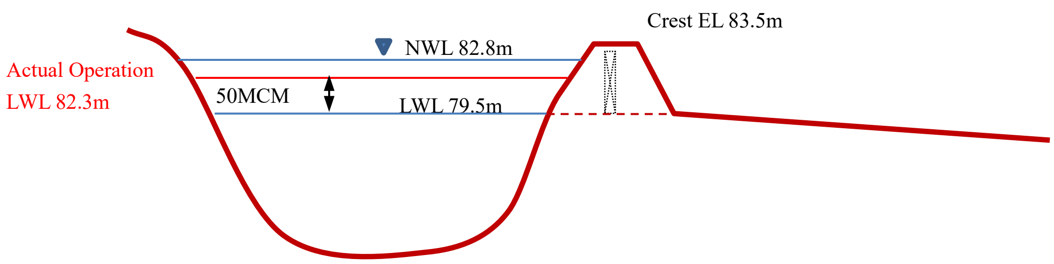
1) P3-1: Study/Upgrading Buhi Lake IWRM

Lake Buhi, located in the upper reaches of the Bicol River tributary, is a natural lake with a lake area of about 18 km^2, a maximum depth of 16 m and an average depth of about 10 m. Using this lake as a water source, NIA developed irrigating areas of approximately 7,000 ha (planned 12,923 ha) with 75 km canals in a total length in the downstream reach, named Rinconada Integrated Irrigation System (RIIS).

Four discharge control gates and a spillway (concrete overflow weir) are installed at the river outlet as a water storage control facility for Lake Buhi. Currently, the gates are malfunctioning and only one gate is working. NIA has a plan to repair and automate these gates as part of the Climate Change Modernization Fund program with the budget of 120 M Pesos.

In the initial plan, the effective water usage depth of Lake Buhi was set at 3.3 m from EL.79.5 m to 82.8 m. Currently, however, it is limited to prevent changes in the lake water level and cause adverse effects on the operation of fish cages. It has been changed to only 0.5 m from EL.82.3 m to 82.8 m. As a result, about 50 MCM of water, which is equivalent to a water depth of 2.8 m, is not being used effectively within the originally planned storage capacity. One problem with keeping the lake water level high is that there is a risk in water storage operation during floods. In addition, sediment has accumulated in the lake. NIA has carried out a bathymetric survey in the past by a sublet work, but there was a problem with the survey data and the results could not be used.

According to the local government, in order to promote the use of stored water in the lake, they are going to relax the restriction of water usage depth and remove some fish cages in accordance with the regulation of less than 10% of the lake area for fisheries.



Source: JICA Survey Team

Figure 4.5-22 Elevations of Lake Water Level and Buhi Control Gate

	
Buhi Lake Control Structure (Gate)	Buhi Lake Control Structure (Spillway)

Source: JICA Survey Team

Figure 4.5-23 Photos of Buhi Control Gate and Spillway

If the local government's plan is carried out successfully, i.e. if there is restriction on fish cage operation, more water could be used. Taking into consideration that the local government is promoting a policy to reduce the size of the fish cages and expand the depth of water use in the lake, a practical option would be to lower the minimum operating water level by about 1 m from El.82.3 m to 81.3 m (around 18 MCM in volume) as well as perform continuous monitoring of the status of water use and the condition of fish cages. If no problems arise, it is possible to expand the revised operation plan, based on the study of water development amount and benefits (water use, irrigation), and consider further expansion of the water use depth.

On the other hand, there is also another option to raise the lake water by about 1 m, but in this case, there are concerns about negative social impacts and flood risks on the land use of the lakeshore due to the rise of the lake surface.

Based on the above, this study proposes the following integrated water management improvement project as a priority project for the purpose of effective utilization of the water in Lake Buhi:

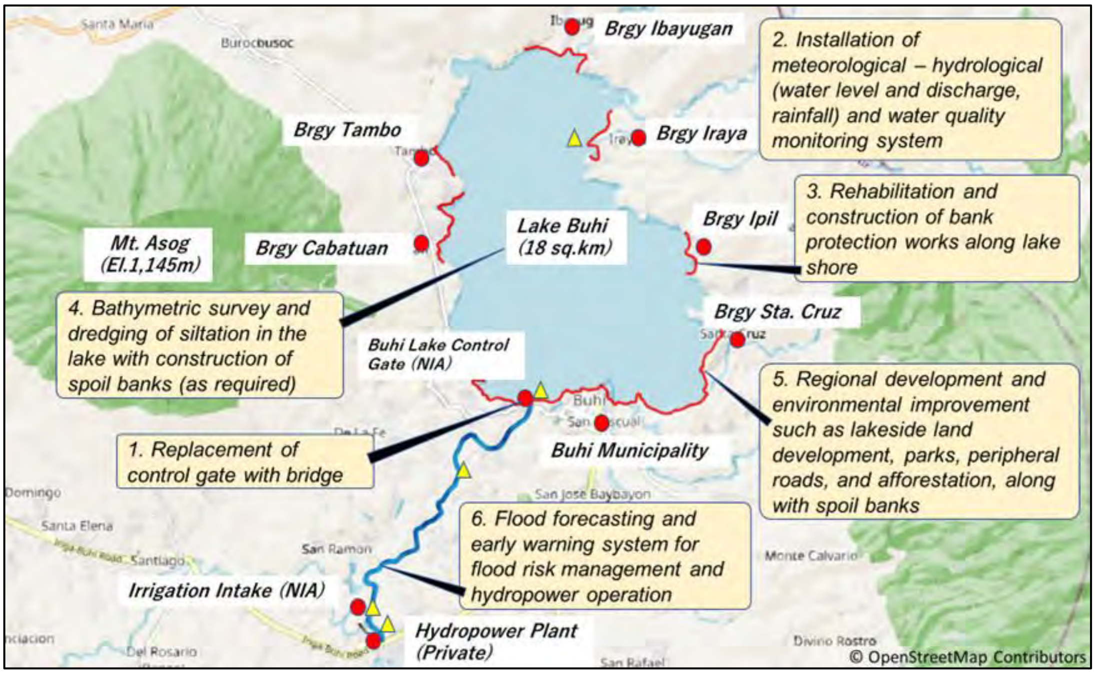
- Along with the repair/automation of the Buhi Lake control gate, revision of gate operation method, the minimum water level will be lowered by 1.0 m as a pilot basis, and the effective storage would be increased by 18 MCM.
- In addition to the repair of the gates and spillway, the existing bank protection works along the lake shore in the residential area will be repaired and raised in height, and new protection is provided to protect from high flood risk.
- Investigate the installation of meteorological and hydrological observation system in the upstream basin and gate operation system to improve the efficiency of water utilization in the lake, as well as to improve safe operation of facilities. This system would also be effectively used for the downstream rivers in terms of flood forecasting and early warning.
- Conduct a 3D bathymetric survey of the lake and, if necessary, implement dredging of sediment (procurement of dredger and spoil site development).

- If the dredged soil can be reused, it will be used for integrating land development along the lakeshore, parks, peripheral roads, afforestation, and other regional development and environmental improvement in conjunction with the development of the spoil sites.

Table 4.5-41 Outline of the Project Concept (Study/Upgrading of Buhi Lake for IWRM)

Title:	Study/Upgrading Buhi Lake for IWRM
Goal:	Surface water development for multipurpose use (irrigation, municipal water supply, flood control, hydro power generation)
Target:	Irrigation water supply of NIA, Flood risk management in surrounding areas of the lake and downstream river
Location:	Buhi Lake and Barit River (tributary of Bicol River) in the Province of Camarines Sur
Profiles:	(Basic Dimension) Lake Area: 18 km^2 Lake Depth: average 10 m Lake Water Level (FWL 82.8, LWL 82.3) Water Level and Discharge Regulating Facility: Gate 4 nos, Spillway (Crest El. 83.5m) <Upgrading Components> 1) Replacement of regulating facilities 2) Installation of automation and remote operation system 3) Installation of meteorological -hydrological (rainfall, water level and discharge) and water quality monitoring system. 4) Rehabilitation and construction of bank protection works along lake shore 5) Bathymetric survey and dredging of siltation in the lake with construction of spoil banks (as required) 6) Regional development and environmental improvement such as lakeside land development, parks, peripheral roads, and afforestation, along with spoil banks
Effect:	Regulated water supply by using reservoir storage of 18.0 MCM
Cost:	Approx. 585 mil. PHP (for replacement of regulating facilities Other costs for dredging and lake bank are necessary.
Others:	Prior to implement the project, a study for investigation, survey and design of proposed works as well as social and environmental assessment are necessary.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.5-24 Upgrading Buhi Lake for IWRM

2) P3-2: Lanang Dam (multipurpose dam)

Lanang Dam is a dam planned on the Lanang River in the northwest of Masbate Island. At present, the water sources for drinking water on Masbate Island are mainly surface water and groundwater, and irrigation water is also taken from surface water by weirs, but water shortages and power shortages are becoming more serious.

Although there is no existing dam plan, water resources development and electric power development are given high priority in the development policy of the provincial government, and early water resources development is aspired. Under these circumstances, upon a request for the proposal for the study of a multi-purpose dam raised in consultations with related organizations, field surveys and map study candidates for a dam site on the Lanang River, which is the largest river in the island, were conducted. As a result, although there are some social problems such as the relocation of residents along the river and the mining of gold in the river, the geology and topography of the dam site are considered suitable. It was confirmed that the needs for development are high, and the multi-purpose water resources development is an effective measure.

This project is proposed as a long-term plan due to the current readiness level of the plan, but in consideration of the needs for water resources development in the area, it is proposed to implement a survey and planning study of this project as a priority component.

Table 4.5-42 Outline of the Project Concept (Study/Construction of Lanang Dam (multipurpose))

Title:	Study/Construction of Lanang Dam (multipurpose)
Goal:	Surface water development for multipurpose use (irrigation, municipal water supply, flood control, hydro power generation)
Target:	Irrigation water supply of NIA, Water supply system of MMWD
Location:	Lanang River, Province of Masbate
Profiles:	(Basic Dimension) Dam Type: Rockfill Dam Height and Crest Length: H61.5m and L 561 m Catchment Area:53 km^2 Area of Reservoir: 658ha Number of Affected House Holds: 128 hh Capacity of Reservoir:154 MCM In addition to the dam, it is necessary to construct water intake facilities, transmission pipes, water treatment plants, water pumping stations, and water distribution mains.
Effect:	Regulated water supply by using reservoir storage of 154 MCM
Cost:	Approx. 5,706 mil. PHP (for dam construction) Pipeline and water treatment plant cost shall be estimated as necessary at the time of future study.
Others:	Prior to implementing the project, a study for design change of dam height as well as social and environmental assessment is necessary.

Source: JICA Survey Team

Source: JICA Survey Team

Figure 4.5-25 Photo showing Condition of Lanang Dam Site

(4) P3(2): Water Supply System

1) P3-3: Introduction of Rainwater Storage and Infiltration

Similar to WRR VII, introduction of rainwater storage and infiltration is recommended as a priority project.

(5) P4: Water Resources Management

Promotion for priority project of each water resources management plan (idea) such as information management, flood risk management, river basin environmental conservation and organizational and legal frame works as mentioned in sections 4.5.3.6 to 4.5.3.9 are recommended to implement.

4.5.4.3 Implementation and Management Scheme for the Priority Project Concept

(1) Introduction

In this section, JST considers and proposes the appropriate implementation and management schemes for the priority project concepts described in section 4.5.3, divided in the items of Short Term (2023-2030) and Middle Term (2030-2040), based on the description in Section 4.3.3.9.

(2) Promotion of IWRM such as managements of information, flood risk, watershed conservation etc., (P4: Management of Water Resources)

The implementation schemes for promotion of IWRM was described in Section 4.3.4.3 (2), and this affair is applicable for WRR XI as well.

(3) Short term (2023-2030)

1) Promotion of Water Saving Activity (P1: Demand Management)

The description on "Promotion of Water Saving Activity" for WRR VII can be applied for WRR V. Please refer to Section 4.3.4.3. (3) 1).

2) Non-Revenue Water Improvement (P1: Demand Management)

The description on "Non-Revenue Water Improvement" for WRR VII can be applied for WRR V. Please refer to Section 4.3.4.3. (3) 2).

3) Introduction of Irrigation ITS (P1: Demand Management)

The description on "Introduction of Irrigation ITS" for WRR VII can be applied for WRR V. Please refer to Section 4.3.4.3. (3) 3).

4) Improvement of Irrigation O&M Facilities (P1: Demand Management)

The description on "Improvement of Irrigation O&M Facilities" for WRR VII can be applied for WRR V. Please refer to Section 4.3.4.3. (3) 4).

5) Capacity Enhancement for Sustainable Groundwater Management (P2: Groundwater Management)

The description on "Capacity Enhancement for Sustainable Groundwater Management" for WRR VII can be applied for WRR V. Please refer to Section 4.3.4.3. (3) 5).

6) Promotion of mid-long-Term Plans – Study of Lanang Dam (P3 (1): Surface Water Development)

Lanang Dam includes multiple purposes of 1) irrigation water for NIA, and 2) water supply for MNWD, and its construction work is expected to be implemented in the next decade (2030-2040). Thus, it is necessary to conduct a study, and to set a planning scheme suitable for multipurpose dams and leading agency for the planning, in order to implement the project in the next decade. JST recommends the following options of leading agency for planning:

- ✓ DWR region office if it is successfully created in the near future
- ✓ NEDA region office in cooperation with relevant agencies if DWR cannot be created

Furthermore, it is desirable if the recommendations related to multipurpose dam projects described in 4.3.3.9 (5) are take into account when conducting the study.

7) Introduction of Rainwater Storage and Infiltration (P3 (2): Water Supply and Sewerage Development)

The description on "Introduction of Rainwater Storage and Infiltration" for WRR VII can be applied for WRR V. Please refer to Section 4.3.4.3. (3) 12).

(4) Middle term (2030-2040)

1) Upgrading Buhi Lake IWRM

"Upgrading Buhi Lake IWRM" is a kind of a multi-purpose project with irrigation and flood control consisting of gate facility improvement, removing sedimentation and land reclamation etc.; thus, it is necessary to consider a suitable implementation scheme that reflects the complexity of the project.

✓ Implementation Scheme

– NIA V will be the main implementation body to reconstruct the existing gate facility, to dredge the lake and to raise the surrounding area of the lake.

– DPWH V will be in charge of the rehabilitation work of downstream rivers.

– LGU (The Province of Camarines Sur or the Municipality of Buhi) will be in charge of development of surrounding area around the lake including road construction.

– It is desirable to establish a consultative framework consisting of NIA, DPWH, the Province of Camarines Sur, the Municipality of Buhi, academic experts, and other concerned parties, and to implement the project in a well-coordinated manner, in order to avoid conflicts with the resident fish farmers who may have adverse effects from the project.

– The regional office of NEDA or DWR (after establishment of the department) may play a leading role in forming the consultative framework.

– In addition, it will be more desirable if the existing river basin organization of Bicol River (The Bicol River Basin Committee) can be utilized for the abovementioned consultative framework for the project implementation.

✓ Management Scheme

– NIA V will be the main management body of Buhi Lake including operation and maintenance of the gate facility for fluctuating the lake water level.

– This project may give considerable effects on the residents especially related to fish farming, which should be monitored on a regular basis. It would be appropriate that the abovementioned consultative framework will be retained continuously to fulfill the monitoring function after the completion of the project.

Outline of the above proposals of implementation schemes for the priority project concept is summarized in Table 4.5-43, Table 4.5-44, and Table 4.5-45.

Table 4.5-43 Proposal of Implementation Schemes for Priority Projects in WRR V (Short Term: 2023-2030) (1)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P1: Demand Management	Water Saving	Water Supply	LGUs/DENR/ WSPs	-	Relevant WSPs w/ supportive education activity from relevant LGUs or CSOs	Relevant WSPs w/ supportive education activity from relevant LGUs or CSOs
	NRW Reduction	Water Supply	LGUs/WSPs	Possible	Relevant WSPs	Relevant WSPs
	Introduction of Irrigation ITS	Irrigation	NIA	-	NIA V (National Irrigation System (NIS) is assumed.)	NIA V w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)
	Improvement of Irrigation O&M Facilities	Irrigation	NIA	-	NIA V (National Irrigation System (NIS) is assumed.)	NIA V w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)
P2: Groundwater Management	Capacity Enhancement for Sustainable Groundwater Management	Groundwater	NWRB	-	NWRB (Organization to oversee the groundwater monitoring and regulation) in cooperation with relevant WSPs and LGUs	NWRB (Organization to oversee the groundwater monitoring and regulation) in cooperation with relevant WSPs and LGUs
P3(1): Surface Water Development	●Development irrigation weirs and dams (SRIP)	Irrigation	NIA V	-	NIA V to implement the construction projects of irrigation weirs and dams in line with its development plan.	NIA V w/ relevant irrigation associations (National Irrigation System (NIS) is assumed.)
	Promotion of mid-long-term plans of Multipurpose Dams (Lanang Dam)	Water Resources			NEDA regional office (or DWR regional office) will lead to develop the plan of multipurpose dam projects and make necessary coordination to promote them in the next decade. Also, it should be considered to utilize the existing River Basin Committee as the consultative framework for consensus building among stakeholders.	

Table 4.5-44 Proposal of Implementation Schemes for Priority Projects in WRR V (Short Term: 2023-2030) (2)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P3(2): Water Supply & Sewerage Development	●Bulk Water Developments	Water Supply	WSPs	Possible	A private entity such as SPV will enter into BOT or other types of PPP contract will implement the bulk water supply project. WSPs will purchase water as an off-taker.	In the case of BOT, a private entity such as SPV will be in charge of O&M during the contract period.
	●Groundwater developments (Bohol, Sorsogon, Catanduanes, Masbate)	Water Supply	WSPs	Possible	Relevant WSPs	Relevant WSPs
	Introduction of rainwater storage and Infiltration	Water Supply	NEDA/NWRB/ LGUs/WSPs	Possible	Entities such as households, building owners, and urban developers to set the facilities for rainwater storage and infiltration. Also, an incentive scheme such as subsidy may be considered.	

Table 4.5-45 Proposal of Implementation Schemes for Priority Projects in WRR V (Middle Term 2030-2040)

Type	Proposed Project	Sector/Purpose	Original Planning Body/Owner	Possibility for PPP	Expected Implementation Scheme/Body	Expected Management Scheme/Body
P3: Surface Water Development	Buhi Lake Upgrading IWRM	Flood Control & Irrigation	NIA V	-	NIA V: Reconstruct the existing gate facility, dredge the lake and raise the surrounding area of the lake	Each implementation body will manage the infrastructure it developed.
					DPWH V: Rehabilitation work of downstream rivers	
					LGU (The Municipality of Buhi is assumed.): Development of surrounding area around the lake including road construction.	
					It is desirable to establish a consultative framework consisting of the implementation bodies, and relevant LGUs, academic experts and concerned parties.	It would be appropriate that the consultative framework will be retained continuously to implement the monitoring function after completion of the project.
					Leading organization to form the consultive framework may be the NEDA regional office, or the DWR region office if it is established. Also, the option to utilize the existing River Basin Committee as the consultive framework should be considered for consensus building among stakeholders.	

4.5.5 Regional Collaboration among Water Utilities in WRR V

In this section, with regard to the proposed water resources development and management plan (Section 4.5.3) and the priority project concept (Section 4.5.4), if there are multiple water utilities in the area covered by the proposed water resource, the possibility of business efficiency improvement through regional collaboration among water utilities (e.g., integration of management, joint operation of facilities, business integration, and management integration) will be considered.

In this regard, JST has not been able to find the situation suitable for the above condition in the WRR V. However, JST cannot rule out the possibility that some of the water utilities that were not included in the survey may have issues on management improvement or efficiency, or may have problems with overlapping multiple water utilities in the WRR. Furthermore, some participants of the second stakeholder meeting held on 25th April 2023 in the City of Legazpi indicated the recognition of the necessity of wide-area water service crossing over the administrative boundaries. Thus, JST recognizes that regional collaboration among water utilities may be considered as one of the water demand management measurements in the future.

4.5.6 Initial Environmental and Social Impact Assessment in WRR V

4.5.6.1 Necessity of the Environmental and Social Impact Assessment

Necessity of the environmental and social assessment is shown in 4.3.6.1.

4.5.6.2 Components Considered for the Environmental and Social Condition in WRR V

Initial environmental and social impact assessment was conducted for the following priority projects in WRR V considering the necessity of assessment in the SEA stage. The selected projects are shown in Table 4.5-46.

Table 4.5-46 Profiles of the Priority Projects Selected for Assessment in WRR V

No.	Priority Project	Location	Profile	EIA Necessity
1	P1: Demand Management	Whole area	- Reduction of Non-Revenue Water: 1) Implementing underground leakage and sectorization, aboveground leakage measures and apparent loss measures, 2) Strengthening pipe materials and/or renewing pipe thorough underground leak detection - Promotion of Water Saving Activities: Spread of water-saving devices and increased awareness of water conservation - Introduction of Irrigation Telemetry System: Providing the devices for establishing the proper irrigation water management system - Improvement of Irrigation O&M Facility: 1) Improvement of main and lateral canals as concrete lining or flume canal and gate works of diversion dams, 2) Replacement of all gates, 3) Introduction of the remote control operation system	× Adverse impacts by some improvement / upgrading works of existing facilities are expected but these impacts are not major and less than installation of new facilities so that these impacts are not evaluated here.
2	P2: Groundwater Management	Davao, Tagum	- Formulating and updating the groundwater management plan through the implementation of the technical cooperation projects	× This project is a technical assistance so major adverse impact is not expected.
3	P3-1: Upgrading Buhi Lake IWRM	Lake Buhi, Municipality of Buhi	1) Replacement of regulating facilities 2) Installation of automation and remote operation system 3) Installation of meteorological - hydrological (rainfall, water level and discharge) and water quality monitoring system. 4) Rehabilitation and construction of bank protection works along lake shore 5) Bathymetric survey and dredging of siltation in the lake with construction of spoil banks (as required) 6) Regional development and environmental improvement such as lakeside land development, parks, peripheral roads, and afforestation, along with spoil banks	○ Impact by the construction and rehabilitation of facilities in/aside the water body needs to be assessed.
4	P3-2: Lanang Dam (multipurpose dam)	Lanang River, Province of Masbate	Name of River: Lanang River Dam Type: Rockfill Dam Height and Crest Length: H 61.5 m and L 561 m Area of Reservoir: 658 ha Capacity of Reservoir: 154 million cubic meters	○ Construction of new dam has a significant impact
5	P3-3: Introduction of Rainwater Storage and Infiltration	Water shortage areas in WRR V	Installation of rainwater storage and infiltration	× Installation of equipment does not major adverse impact.
6	P4 Water Resources Management	Whole area	Information management, Flood risk management, River basin environmental conservation and Organizational and legal frameworks	× Major adverse impact is not expected by these managements.

Source: JICA Survey Team

4.5.6.3 Environmental and Social Conditions in the Targeted Area in WRR V

The municipality of Buhi is located in the southeastern portion of the province of Camarines Sur. It is bounded by the Sagñay-Buhi mountain ranges to the north; Mount Malinao to the east; the municipality of Polangui, Albay to the south; by Mount Isarog and Iriga City to the west. The municipality is politically subdivided into 38 barangays.

(1) Water Quality and Water Use

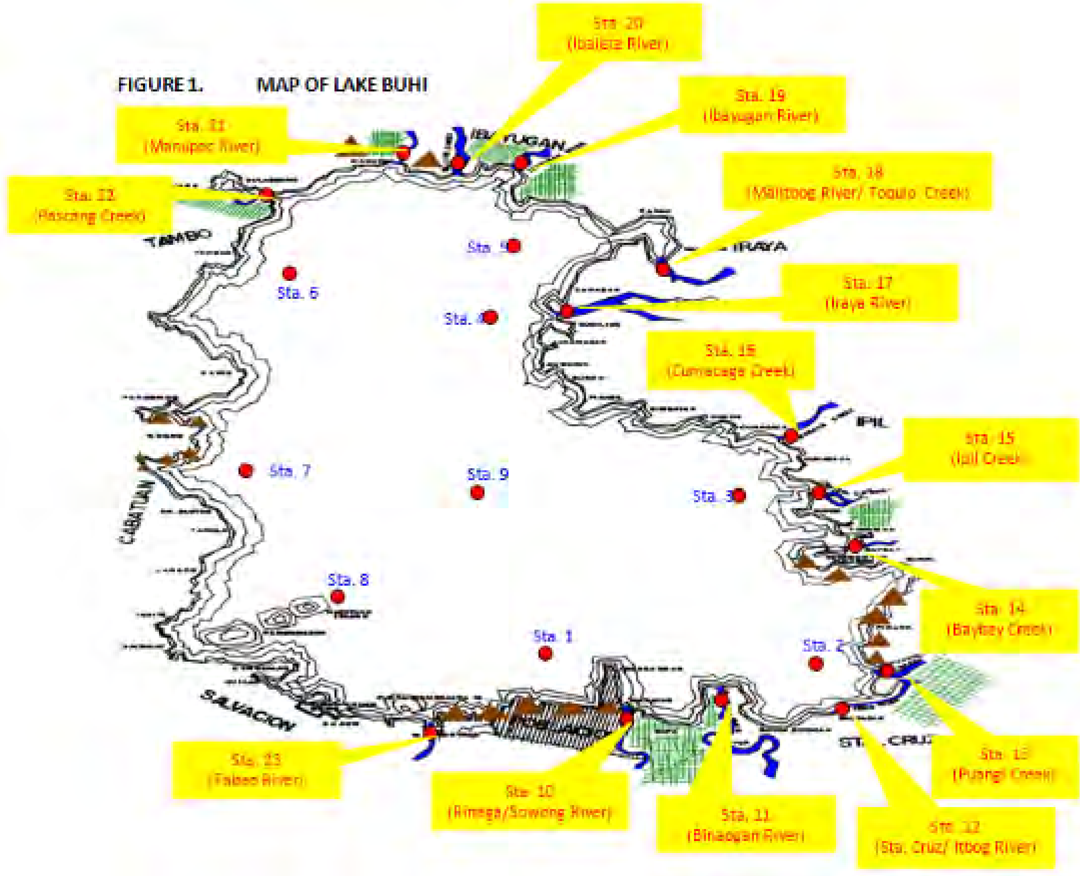
1) Lake Buhi

Lake Buhi is officially designated as a Water Quality Management Area (WQMA) and classified as Class "B". DENR Region V conducts regular water quality monitoring of the lake.

The quality of the lake is influenced by the different natural and man-made sources. These sources are based on activities undertaken by the users. Some major factors that cause the degradation of the lake are as follows:

- Domestic waste: Direct discharge of liquid/solid waste to the lake, which is the main source of water pollution. Inadequate treatment of domestic/industrial wastes could apparently lead to the degradation of the lake.
- Agriculture or aquaculture waste: Overfeeding of fish and chemicals used such as insecticides, pesticides, fertilizers, and others also contribute to the degradation of this waterbody.
- Siltation: Eroded soils from hills surrounding the lake and other solid wastes could also add to the pollution of the lake.

There are 23 sampling stations. Water Quality Monitoring for CY 2021 shows that Lake Buhi met the criteria and satisfied the parameters that have been considered for Class B Waters for pH, temperature, dissolved oxygen, biochemical oxygen demand, total suspended solids, nitrates, phosphates, lead, cadmium, zinc, mercury, and color (true). Meanwhile, for the parameters of fecal coliform, oil and grease, and copper, some stations had failed to conform to the water quality standards. Although Lake Buhi is used mainly for fishing, its water quality generally conforms to the criteria for Class B Waters.



Source: JICA Survey Team

Figure 4.5-26 Location Map of Water Quality Sampling Stations in Lake Buhi

Based on the present condition of Lake Buhi, this water body is predominantly used for:

- Fish/aqua culture: Proliferations of fish cages are very evident in the water body of Lake Buhi. Tilapia is usually the fish being cultured in this water body.
- Transport/conveyance of goods as well as residents: The common mode of transportation to the coastal barangays is through the use of the lake. This waterway helps facilitate their trade of products or the procurement of consumer products for their domestic use.
- Agriculture: Agricultural farms essentially make use of the water of Lake Buhi basically for irrigation purposes.
- Recreation: Some portion of the lake is utilized for swimming, especially for children in the lakeside barangays, and other recreational purposes.
- Source of energy: Another important use of the water from Lake Buhi is for the generation of hydroelectricity through the hydropower plant stationed at Barit, Sta. Justina that generates 12 MW and is run by a private company.

2) Lanang River

Lanang River is one of the priority rivers under the Sagip-Ilog Program of DENR as of 2019 and is classified as a Class A waterbody.

There are six (6) sampling stations established in Lanang River as shown in Figure 4.5-27. The monitoring results for CY 2021 show that the parameters pH, temperature, dissolved oxygen, biochemical oxygen demand, nitrate, color, cyanide, lead, cadmium, copper, zinc, and mercury are within the WQG value set for Class A waterbody. Total suspended solids, phosphates, fecal coliform, ammonia, oil and grease, and chloride exceeded the WQG for Class A set under DAO 2016-08 and DAO 2021-19. The exceedance may be attributed to wastewater discharges from residential houses, commercial establishments, and other domestic activities near the river.

Source: Regional State of the Brown Environment Report Bicol Region, 2021

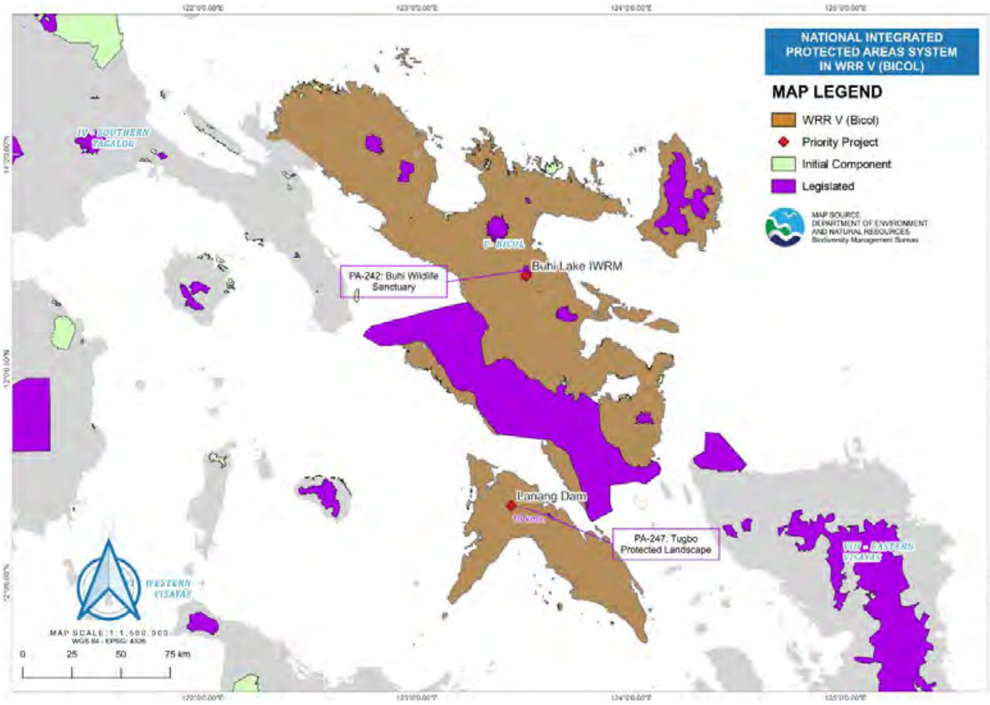
Figure 4.5-27 Location Map of Water Quality Sampling Stations in Lanang river

(2) Protected Area

There are four declared protected areas in the Municipality of Buhi, namely Barit River – Lake Buhi Forest Reserve; Lake Buhi Fish Sanctuary; Sinarapan Sanctuaries; and Buhi Wildlife Sanctuary.

Barit River – Lake Buhi Reserve or Buhi-Barit Watershed Reservation is a permanent forest reserve declared by virtue of Presidential Proclamation No. 573, Series of 1969. It has a total area of 18,379.80 hectares covering the Municipalities of Buhi, Tiwi, and Sañgay and the City of Iriga. Buhi Wildlife Sanctuary was declared as protected area under Republic Act 11038, or the Expanded National Integrated Protected Areas System (E-NIPAS) Act of 2018.

Lake Buhi is located in the Buhi Wildlife Sanctuary as shown in Figure 4.5-28.



Source: JICA Survey Team

Figure 4.5-28 Location Map of the Priority Project and Protected Area in WRR V

(3) Ecosystem and Biodiversity[4]

Lake Buhi has an estimated area of 1,517 hectares and an average depth of 8 m. Aside from the Sinarapan (Mistichthys luzonensis), 7 native fish species have been observed in the lake, including Irin - irin (Goby, Redigobius dispar), Dalag (Snakehead murrel, Channa striata), Atas, and Puyo (Climbing perch, Anabas testudines).

There are about 25 bird species observed in the surrounding forests of the lake. Endemic species were observed such as Philippine Pygmy Woodpecker, Philippine Hanging Parrot, Elegant Tit, Black-naped Monarch, White-eared Brown Dove, Philippine Mallard, Stay Breasted Rail (Tikling), White-eared Brown Fruit Dove, Van Hasselts Sunbird, Banded Rail. Other species observed are Common Bittem, Wandering Whistling duck, and White-collared Kingfisher.

(4) Resettlement / Land

Possibility of resettlement and land acquisition are summarized in Table 4.5-47.

Table 4.5-47 Possibility of Resettlement for the Priority Project Area in WRR V

No.	Priority Project	Location	Condition for Water Quality
1	P3-1: Upgrading Buhi Lake IWRM	Lake Buhi, Municipality of Buhi	Although there are some residents around the lake Buhi, this project is an upgrading project of the existing facilities etc. so resettlement and new land acquisition are currently not expected.
2	P3-2: Lanang Dam (multipurpose dam)	Lanang River, Province of Masbate	In case of dam height of 61.5m, there is a possibility that around 130 households need to be resettled. Land of reservoir is 658 ha, which need to be secured.

Source: JICA Survey Team

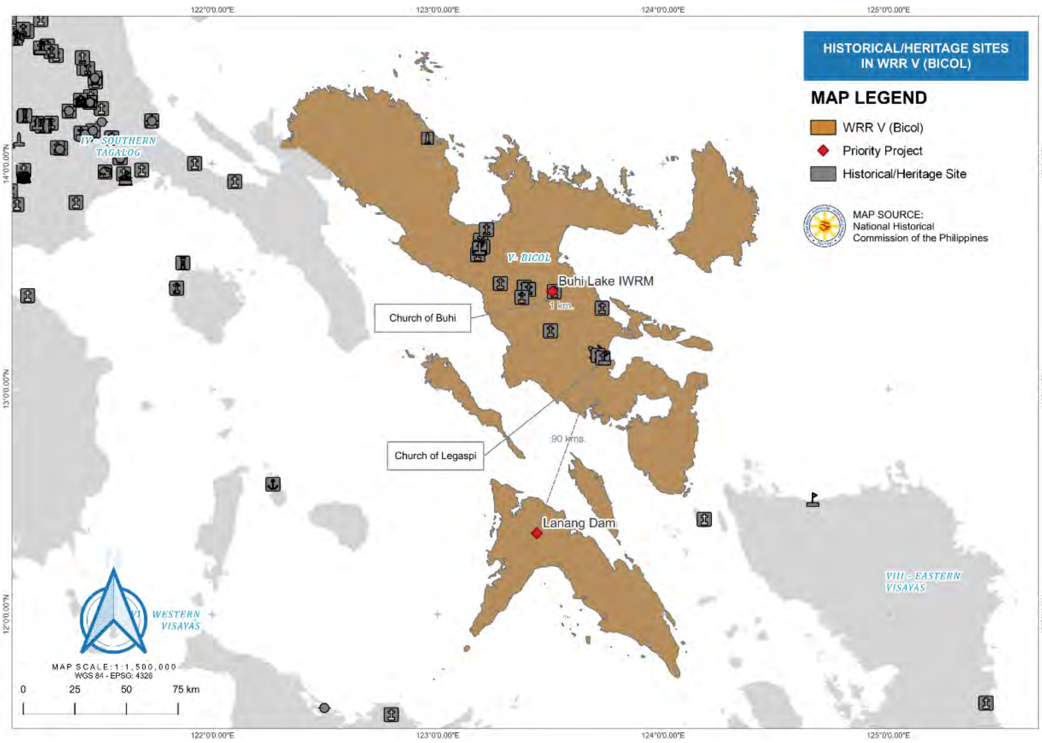
[4] Integrated Bicol River Basin Management and Development Master Plan, DENR 2015

(5) Heritage

The Municipality of Buhi hosts the Parish Church of Saint Francis of Assisi of Buhi (Church of Buhi) which is a marked structure and considered as Tangible immovable. The church is built close to the southern shore of the lake.

Moreover, based on the CLUP of Buhi, the other identified cultural heritages in the municipality are the Cementerio y Santuario del Espiritu Santo (Heritage Arch); Veterans Memorial Monument; and the Don Gregorio Ricafranca (Freedom) Park. Lake Buhi itself is considered a natural heritage by the municipality.

Location of the proposed sites of pilot project and the nearest identified cultural property are shown in Figure 4.5-29.



Source: JICA Survey Team

Figure 4.5-29 Location Map of the Priority Project and Cultural Properties in WRR V

(6) Ethnic Minorities and Indigenous Peoples

The Municipality of Buhi hosts two ancestral domains with certificates of ancestral domain titles (CADTs) recognized by the NCIP as shown in Table 4.5-48. These ancestral domains are located on the northeastern portion of Lake Buhi.

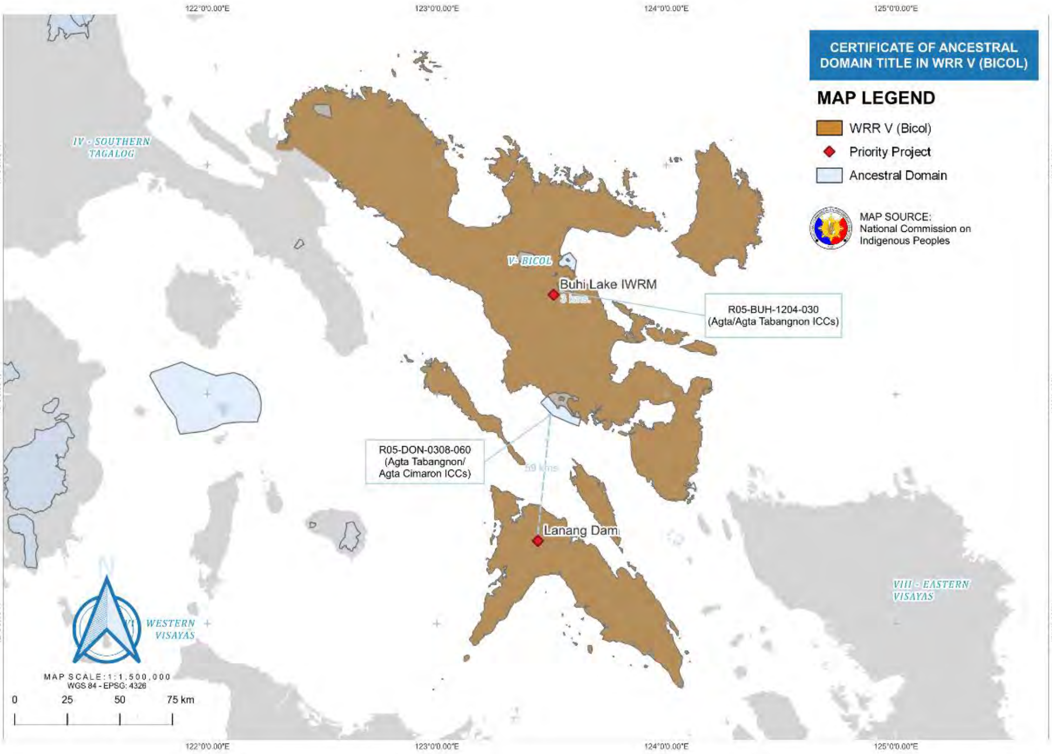
Table 4.5-48 Ancestral Domains in the Municipality of Buhi

CADT No.	Tribes	Description	Area (ha)
R05-BUH-1204-030	Agta Agta-Tabangnon	Portions of Barangays Ipil and Iraya, Municipality of Buhi, Province of Camarines Sur	1,278.1203
R05-TIW-0206-042	Agta	LOT 1: (Area = 700.5435 has) Portions of Barangays Mayong, Dapdap, Misibis, Maynonong, and Joroan, Municipality of Tiwi, Province of Albay; LOT 2: (Area = 753.3027) Portions of Barangays Sta. Cruz, Ipil, and Iraya, Municipality of Buhi, Camarines Sur province	1,453.8462

Source: Ancestral Domains Office, Recognition Division (2018)

In addition, based on the CLUP of Buhi, there are two certificates of ancestral domain claims (CADCs) covering portions of the municipality:

- CADC No. RV-CADC-065 covering a total of 1,209 hectares in barangays San Ramon, Dela Fe, and Salvacion; and
- CADC No. RV-CADC-097 covering a total of 19,970 hectares in barangays Antipolo, Burucbusoc, Cabatuan, Cagmaslog, De los Angeles, Divino Rostro, Gabas, Ibayugan, Igbac, Lourdes, Macaangcay, Monte Calvario, Namurabod, Sagrada, San Jose Salay, San Vicente, San Antonio, San isidro, San Rafael, Sta. Cruz, Sta. Isabel, Sta. Justina, and Tambo.



Source: JICA Survey Team

Figure 4.5-30 Location Map of the Priority Project and CADT Area in WRR V

4.5.6.4 Scoping of the Priority Projects in WRR V

Result of the scoping is shown in Table 4.5-49 considering the project characteristics and baseline conditions.

Table 4.5-49 Scoping of the Targeted Priority Projects in WRR V No.1

Items		Upgrading Buhi Lake IWRM		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Pollution Control				
1	Air quality (including greenhouse gas)	✓		**<Construction>** - Air pollution by gas emission caused by construction machines and vehicles is expected - Dust caused by earth works and transportation of materials etc. is expected. - These adverse impacts will be limited around the construction site and during construction period.
2	Water quality	✓		**<Construction>** - Water pollution to the water body by turbid water caused by construction works is expected.
3	Waste	✓		**<Construction>** - Generation of construction waste and residual soil by construction works is expected. - Its impact will be limited during construction period.
4	Soil contamination	✓		**<Construction>** - Contamination caused by outflow of construction oil, fuel etc. is expected. - Its adverse impact will be limited during construction period.
5	Noise and vibration	✓		**<Construction>** - Noise and vibration caused by construction works, machines and vehicles are expected. - These adverse impacts will be limited around the construction site and during construction period.
6	Subsidence			- Subsidence is not generally expected
7	Odor			- Odor is not generally expected
8	Sediment	✓		**<Construction>** - Agitation of sediment caused by excavation work is expected - Its adverse impact will be limited during construction period.
Natural Environment				
9	Protected areas	✓	✓	**<Construction / Operation>** - The proposed project is situated within protected areas; hence, direct impact on the protected area is expected from project construction and operations.
10	Ecosystem and biodiversity	✓		**<Construction>** - Adverse impact to fauna and flora around/inside the project area caused by construction work is expected.
11	Hydrology			- Hydrology is not generally expected.
12	Topography and geology	✓		**<Construction>** - Geographical impact caused by the earth works is expected. - Its adverse impact will be limited during construction period.
Social Environment				
13	Resettlement and Land acquisition	✓		- There might be no impact on resettlement and land acquisition since the proposed project is just an upgrading.
14	Ethnic minorities and indigenous peoples / Poverty	✓	✓	**<Construction / Operation>** - There may be some ancestral domains so detail survey and frequent communication for the impact to them are needed.
15	Local economies	✓	✓	**<Construction>** - The project will bring some benefits such as job creation and economic opportunities to sell foods/goods to workers. **<Operation>** - Tourism activity may be developed more due to the improvement of surrounding environment.
16	Water use	✓		**<Construction>** - Temporary adverse impact for water use at the downstream caused by the construction works and generation of turbidity water is expected.

Items		Upgrading Buhi Lake IWRM		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
17	Existing social infrastructures and Services	✓		**<Construction>** - Traffic impact caused by the construction vehicles is expected.
18	Cultural Heritage			**<Construction / Operation>** - The proposed project will not have direct impacts on the NHCP- and locally identified cultural heritage sites in the municipality.
19	Landscape		✓	**<Operation>** - Structural design shall consider harmonization with surroundings.
20	Gender / Children's right	✓		**<Construction>** - Gender and Children's right shall be evaluated in detail to consider the equal employment opportunities, provision of break rooms, avoidance of child labor and safety of school zone etc.
21	Working conditions / Accident	✓		**<Construction / Operation>** - Working conditions and Accident shall be evaluated in detail with construction and operation plan to consider working security, traffic safety and fall prevention to water etc.

Note: PCS: Pre-Construction Stage, CS: Construction Stage, OS: Operation Stage

Source: JICA Survey Team

Table 4.5-50 Scoping of the Targeted Priority Projects in WRR V No.2

Items		Construction of Lanang Dam		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
Pollution Control				
1	Air quality (including greenhouse gas)	✓		**<Construction>** - Air pollution by gas emission caused by construction machines and vehicles is expected - Dust caused by earth works and transportation of materials etc. is expected. - These adverse impacts will be limited around the construction site and during construction period.
2	Water quality	✓	✓	**<Construction>** - Water pollution to the water body by turbid water caused by construction works is expected. **<Operation>** - Adverse impact to water quality in the water reservoir such as eutrophication and dissolved oxygen caused by the storage of water is expected.
3	Waste	✓		**<Construction>** - Generation of construction waste and residual soil by construction works is expected. - Its impact will be limited during construction period.
4	Soil contamination	✓		**<Construction>** - Contamination caused by outflow of construction oil, fuel etc. is expected. - Its adverse impact will be limited during construction period.
5	Noise and vibration	✓		**<Construction>** - Noise and vibration caused by construction works, machines and vehicles are expected. - These adverse impacts will be limited around the construction site and during construction period.
6	Subsidence			- Subsidence is not generally expected.
7	Odor			- Odor is not generally expected.
8	Sediment		✓	**<Operation>** - Inflow and stock of sediments in the reservoir by river erosion are expected - Outflow of sediment to the downstream is changed
Natural Environment				
9	Protected areas			Adverse impact to protected areas is currently not expected.
10	Ecosystem and biodiversity	✓	✓	**<Construction>** - Adverse impact to fauna and flora around/inside the project area caused by construction work is expected. **<Operation>** - Adverse impact to fauna and flora around/inside the project area caused by changes of their habitats and river flow is expected.

Items		Construction of Lanang Dam		
		Scoping Result		Reason for Evaluation (PCS, CS, OS)
		PCS/CS	OS	
11	Hydrology	✓	✓	**<Construction>** - Impact on hydrology of the downstream caused by temporarily damming and excavation of the riverbed is expected. **<Operation>** - Impact on hydrology of the downstream caused by change of water flow volume is expected.
12	Topography and geology	✓		**<Construction>** - Geographical impact caused by the earth works is expected - Its adverse impact will be limited during construction period.
Social Environment				
13	Resettlement and Land acquisition	✓		**<Pre-Construction>** - There is high possibility of resettlement at the proposed dam sites, hence, direct impact to residents is expected. - Each proposed site requires large areas of reservoir, hence, there is high possibility of land acquisition.
14	Ethnic minorities and indigenous peoples / Poverty			**<Construction / Operation>** - Vulnerable people is currently not identified but detail survey is needed.
15	Local economies	✓	✓	**<Construction>** - The project will bring some benefits such as job creation and economic opportunities to sell foods/goods to workers. **<Operation>** - Economy is expected to growth by expanding the usage of water - Compensation for the livelihood will be done if any
16	Water use	✓	✓	**<Construction>** - Temporary adverse impact for water use at the downstream caused by the construction works and generation of turbidity water is expected. **<Operation>** - Impact for water use at the downstream caused by water flow management is expected.
17	Existing social infrastructures and Services	✓	✓	**<Construction>** - Traffic impact caused by the construction vehicles is expected. **<Operation>** - After the operation, the project will contribute to efficient water use.
18	Cultural Heritage			**<Construction / Operation>** - The proposed project will not have direct impacts on any identified cultural heritage sites.
19	Landscape		✓	**<Operation>** - Structural design shall consider harmonization with surroundings.
20	Gender / Children's right	✓		**<Construction>** - Gender and Children's right shall be evaluated in detail to consider the equal employment opportunities, provision of break rooms, avoidance of child labor and safety of school zone etc.
21	Working conditions / Accident	✓		**<Construction / Operation>** - Working conditions and Accident shall be evaluated in detail with construction and operation plan to consider working security, traffic safety and fall prevention to water etc.

Note: PCS: Pre-Construction Stage, CS: Construction Stage, OS: Operation Stage

Source: JICA Survey Team

4.4.6.5 Evaluation of the Impact Items in WRR V

Initial evaluation of the impact items which may cause adverse impact in the scoping items is presented.

(1) Water Quality and Water Use

Lake Buhi is classified as Class B, and fecal coliform, oil and grease, and copper had failed to conform to the water quality standards at some stations. In addition, the water of Lake Buhi is used for many usages such as fishing, transport, agriculture, recreation, and a source of hydroelectricity.

To avoid impacts on water quality and water use, control of turbid water is mainly needed during the construction considering the seasonal climate.

In the operation phase of dam project, water quality in the water reservoir may be worse in case untreated wastewater is discharged from urbanized areas so the prevention of the inflow of wastewater is needed.

(2) Sediment

The condition of the sediments will be changed by the dam project, thus a detailed survey for the impact on the sediments downstream is needed. In case sediments cause an adverse impact on the surroundings, the removal of sediments and the design of the facility to avoid the stock of sediment should be considered.

(3) Ecosystem

Detailed surveys on the vulnerable species and its habitation are needed before the construction as well as identification in detail. In the operation stage, their monitoring is also needed, and mitigation measure such as reforestation should be conducted as needed.

(4) Hydrology

In the dam project, the impact on downstream hydrology needs to be considered and a survey and communication with residents in the downstream area should be conducted before construction.

(5) Resettlement and Land acquisition

Affected households are expected in the dam construction projects and there may be possibilities of resettlement and land acquisition around the project site, thus, detail survey and frequent communication with residents are needed to evaluate these impacts. Preparation of a RAP is necessary including eligibility for receiving compensation and resettlement assistance, compensation and entitlements, implementation procedures that ensure complaints are processed, public support and participation, and the provision of internal and external monitoring of the implementation of the RAP.

(6) Ethnic minorities and indigenous peoples

There may be some ancestral domains around the project area; hence, detailed survey for the impact to them and frequent communication with the residents are needed to evaluate these impacts. These considerations should be planned in the resettlement action plan before the construction.

In case the project is implemented in ADs, the following procedures are needed.

- Granting of Free and Prior Informed Consent (FPIC) for projects within ancestral domains
- Participate in the public scoping

- In the process of EIA study, the socio-economic/perception surveys which shall be used as the basis for the subsequent formulation of social development plans, IEC, monitoring plans and other components of the environmental management plans are needed.
- Participate in public hearings or public consultations;
- Multi-partite monitoring

4.4.6.6 Possible Mitigation Measures and Management Plan in WRR V

As a result of the initial evaluation above, possible mitigation measures and the environmental management plan are shown in Table 4.5-51 and Table 4.5-52.

Table 4.5-51 Possible Mitigation Measures and Management Plan in WRR V

No.	Impact Item	Mitigation and Management Measures	Implementer
1	Water Quality and Water Use	<Construction> - Earth works inside and near the water body during the dry season - Temporary cofferdam method at the time of excavation works - Countermeasures for the sediment and turbidity <Operation> - Direct purification of river water by filtration and vegetation purification and excavation of sediment etc. - Prevention of load inflow by protection of dam slope, wastewater treatment and reforestation etc. - Management of discharge flow considering the environmental flow	- Contractor - Manager of facility
2	Protected Area and Ecosystems	<Pre-Construction> - Securing of clearance from the Protected Area Management Board (PAMB) of the Barit River – Lake Buhi Reserve or Buhi-Barit Watershed Reservation and Buhi Wildlife Sanctuary. <Construction> - Attention to wildlife at the time of site clearance and restricting the loss of vegetation within the project area < Construction / Operation> - Confirmation of the existence of vulnerable species and continuous monitoring - Reforestation	- Contractor - Manager of facility
3	Ethnic minorities and indigenous peoples / Poverty	<Pre-Construction> - Secure accessibility to ancestral domains - Assistance to access social welfare and support. - Secure adequate compensation and support indicated in the Resettlement Action Plan	- Design consultant - Manager of facility

Source: JICA Survey Team

Table 4.5-52 Possible Mitigation Measures and Management Plan for Lanang Dam Construction

No.	Impact Item	Mitigation and Management Measures	Implementer
1	Water Quality and Water Use	<Construction> - Earth works inside and near the water body during the dry season - Temporary cofferdam method at the time of excavation works - Countermeasures for the sediment and turbidity <Operation> - Direct purification of river water by filtration and vegetation purification and excavation of sediment etc. - Prevention of load inflow by protection of dam slope, wastewater treatment and reforestation etc. - Management of discharge flow considering the environmental flow	Contractor / Manager of facility
2	Sediment	<Operation> - Excavation and dredging of sediment to remove it. - Installation of sediment trap dam at the upstream to prevent its inflow. - Designing sand discharge facility	Design consultant / Manager of facility
3	Ecosystems	<Construction> - Attention to wildlife at the time of site clearance and restricting the loss of vegetation within the project area < Construction / Operation> - Confirmation of the existence of vulnerable species and continuous monitoring - Reforestation	Contractor / Manager of facility
4	Hydrology	<Construction> - Implementation of appropriate drainage plan <Operation> - Development and implementation of an appropriate water intake plan - Management of water intake amount according to the season change.	Contractor / Manager of facility
5	Resettlement and Land acquisition	<Pre-Construction> - Assistance to access social welfare and support. - Secure adequate compensation and support indicated in the RAP	Design consultant / Manager of facility

Source: JICA Survey Team

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Conclusions from the Survey are presented below.

1. For nationwide analysis, the following data pertaining to water resources were collected and organized.

   i) Primary Data: Precipitation, temperature, evapotranspiration, river water level, river discharge, topographic map, geology, soil, hydrogeology, wells, environment, land use/land cover map, satellite images, elevation, river basin maps, river centerline, etc.

   ii) Verified Data: Primary data that has been verified, filtered, corrected, or supplemented from the original data such as precipitation, river water level, river discharge, etc.

   iii) Secondary Data: Data resulting from water balance analysis using primary data as input values.

   In addition, remote sensing technologies, such as satellite data for topographic data and rainfall distribution, were utilized for data analysis in this survey. Such data-related activities can foster technological opportunity for remotely conducted rough water balance analysis from Japan.

2. Nationwide water balance assessment, taking into account the effects of climate change, were conducted with 2050 as the target year; and based on the results, 3 water resources regions (WRR V: Bicol, WRR VII: Central Visayas, WRR XI: South-eastern Mindanao), where the water balance is expected to be particularly tight in the future, were selected out of 12 regions based on a set selection criterion.

3. In the 3 priority WRRs, based on the detailed water balance analysis for sub-basin scale, the current and future monthly and annual water balance for each basin, province, municipality, and major city were quantitatively calculated.

4. In developing the Water Resources Development and Management Plan (idea), priorities for water use were established and in order to propose an effective plan, a basic policy for planning was established based on the findings and lessons learned from the review of the existing M/P. An efficient and effective Water Resources Development and Management Plan (idea) as well as its roadmap for 2050 were developed to resolve the water shortages in each priority WRRs.

5. From the roadmap, priority projects were selected based on the necessity and urgency. The concepts of the priority projects were formulated which included the project content, the effect, estimated project costs, social and environmental impacts, and implementation systems. The location maps of the priority projects in each WRRs are presented in Figure 4.3.24, Figure 4.4.20 and Figure 4.5.18.

6. In terms of environmental and social considerations, a strategic environmental assessment (SEA) was conducted for the priority project, whereas stakeholder meetings were held two times in the

three WRRs (six SHMs in total). Water demand gap and the present status of existing facilities were reported by stakeholders, and recommendations were made on the proposed plan and project concepts in order to ultimately develop consensus-built plans and project implementations.

7. On the organizational and institutional perspective, the current status and trends of the water sector were analyzed at the national level. In addition, in the priority WRRs, the implementation system of the proposed priority projects and the application for wide-area water resource development were examined, then issues and recommendations were made.

8. Two major issues have been recognized regarding organizations and legal frameworks related to water resources from the past: 1) lack of coordination due to institutional fragmentation, and 2) necessity to strengthen the regulatory functions. The situation related to these issues has not changed much, though some actions/movements to improve them are recognized in the Survey.

9. JST proposes to implement multipurpose projects in order to effectively and efficiently deal with the increasing future demand in each priority WRR; however, it is evident that there is inadequacy in organizations and legal frameworks in the Philippines for implementing multipurpose projects. Hence, it is necessary to prepare integrated plans for water resources development and management and create implementing entities at the basin level to implement multipurpose projects efficiently. .

10. Overlapping issues among multiple water service providers in the same area, which may cause inefficient water use, were found in the Survey. JST proposes the policy on regional collaboration among water utilities as one of the effective measurements to improve such situations. However, there are some issues related to organizations and legal frameworks, such as the fragmentation among regulatory organizations over water service providers, against enhancing regional collaboration among water utilities in the Philippines.

11. Through extensive discussions with the counterparts, criteria were established for the selection of priority WRRs as well as selection of priority projects. Additionally, technical training program was held for each sector by the Survey Team members for the counterpart agencies.

5.2 Recommendations

The following are recommendations given for the overall survey and for the priority WRRs.

5.2.1 Recommendations for the Overall Survey

1. Although this Survey was not intended to develop a masterplan, it was positioned to collect and analyze data and provide necessary information for the development of a master plan. As a result, a Water Resources Development and Management Plan (idea) for the 3 priority WRRs were proposed based on the comprehensive collection and analysis of information necessary for the development of a masterplan. It is recommended that the draft plan and the detailed data and information combined be used to develop a full-scale water resources development and management master plan for the 3 priority WRRs in cooperation with the implementing agencies.

2. For the remaining 9 WRRs that were not included in the detailed study, data and information for a water balance analysis at the national level were collected and analyzed to assess the degree of the water resource constraints. Using these data and information, as well as the basic policies, procedures, and methods of planning applied in the study, it is recommended that a water resources development and management plan for the 9 WRRs be conducted sequentially, and the plans be developed and updated in reference to priorities and evaluation criteria.

3. Additionally, in the 3 priority WRRs, the short-term planning component of the Water Resources Development and Management Plan (idea), and projects related to priority policies and sectors are identified as priority projects to solve water problems in the region. Those priority projects' concepts, including their goals, target agencies, target areas, outcomes, estimated costs, and environmental and social considerations, were proposed preliminarily. In order to ensure that those proposed Water Resources Development and Management Plan (idea) and priority project concepts become harmonized and integrated projects in accordance with the regional plans, it is necessary for the Philippines side to improve the level of inter-regional and inter-sectoral coordination and review, as well as promote project planning and implementation.

4. The plans and projects proposed in this study mainly focus on the major watersheds and major cities in each region, taking into account their regional importance and effectiveness. On the other hand, detailed water balance data for each local sub-basin were shared as well. Using these data to the maximum extent possible, it is recommended to extend planning and project proposals to local regions, and to promote demand management (water conservation, non-revenue water measures, irrigation channel repair, and irrigation operational efficiency) proposed in this study, as well as plans and studies for groundwater development and surface water development as needed.

5. Extensive data pertaining to water resources were collected and organized during the analysis at national and priority WRR level. It is recommended that these data be shared first with relevant agencies related to the water sector, while in future, the measurement, collection, transfer, verification, supplementation, and sharing of data and information be managed centrally. It is expected that NWRB will take the role of an/the implementing entity for centralized data management.

6. The study strongly recommends strengthening and implementing activities related to integrated water resources management based on the principle of equitable and fair water use in order to promote the development and management of water resources and practical project implementation in the future.

7. Plans pertaining to water resources are multi-sectoral and involve many stakeholders. It is recommended that Multi-Stakeholder Partnership (MSP) be established and strengthened to ensure rapid and smooth consensus building, and to formulate, approve, and implement a higher-level plan that integrates the development plans of each sector.

8. Conclusions and recommendations on the organizational and institutional aspects are described separately in subsequent sections.

5.2.2 Recommendations for Each Priority WRR

WRR VII

1. In WRR VII, priority project concepts were proposed in the Water Resources Development and Management Plan (idea) as described in Section 4.3.4.
2. In Metro Cebu, water shortages are worsening, and saltwater intrusion has already been confirmed due to low groundwater levels. Although dam development has been proposed multiple times, due to social, political, and inter-basin consensus building problems, it has not been implemented. Thus, it is necessary as proposed in the Study to diversity water sources, strengthen groundwater monitoring and management, as well as promote groundwater recharge projects, conversion of water sources from groundwater to surface water, and seawater desalination projects that have been implemented in recent years. In addition, it is recommended that various water demand management measures proposed in this study be promoted to meet the future increase in water demand with limited water resources.
3. For the "P3-1:[1] Study/Construction of Mananga II Dam (low dam)" priority project, a change to lower the dam height from the initial plan was proposed – and because of this, there will be a relatively smaller social impact. As the facility would be a valuable water source for Metro Cebu, it is recommended that the study plan be accelerated, and the project be commercialised as soon as possible.
4. The "P3-2: Study/Construction of Kotkot Dam (multipurpose use)" priority project proposes the construction of a multipurpose dam by integrating the existing multiple dam plans planned separately in the same watershed (in irrigation, flood control, and water utilization sectors), and adding hydropower development. The existing irrigation dam plan by NIA has a relatively higher maturity level, thus it is recommended that NIA's plan be used as a base, and the plan to be promoted and commercialized as soon as possible by deepening consultation and coordination among related agencies from an integrated water management perspective, including capacity allocation and construction cost sharing for multipurpose use of irrigation water and water supply.

WRR XI

1. In WRR XI, priority project concepts were proposed in the Water Resources Development and Management Plan (idea) as described in Section 4.4.4.
2. In the central cities of the region, Davao City and Tagum City located north of Davao city, the future decline of groundwater in urban areas is foreseen, thus it is recommended to strengthen

1 The number at the beginning of the priority project title corresponds to the list of the priority project set in Chapter 4.

groundwater measures and management and promote development of new surface water sources. In the Davao River basin, which flows through Davao City, flood control is also an issue, thus it is recommended to promote multipurpose water resource development plans and projects that integrate the effects and functions of water utilization and flood control in a balanced manner. In General Santos, where groundwater is abundant, promotion of the management and development of groundwater sources is recommended.

3. The “P3-1: Study/Construction of Davao-III Dam (multipurpose dam)” priority project proposes to integrate several irrigation dam development plans currently planned by NIA for the Davao River tributaries, and to construct a multipurpose dam by adding a water supply for Davao City to the plan. Because the existing dam plans are relatively high in terms of planning maturity, and because the initial plan was proposed to be changed to lower the dam height and thus the social impact is relatively small, it is recommended that the study plan be promoted and commercialized as soon as possible by deepening cooperation among related organizations and promoting the study plan.

4. The “P3-2 Study/Construction of Davao-II Dam (multipurpose dam)” priority project is a multipurpose dam planned in the middle reaches of the Davao River. It is planned to be a large-capacity water source necessary to cover future water shortages in Davao City. Furthermore, it will greatly contribute to flood control of Davao City as the plan is a comprehensive development plan for water utilization and flood control. The plan itself is still at its beginning stage, and the impact of relocation and land acquisition is expected to be relatively large. Therefore, from a long-term perspective, it is recommended that a preliminary study of technical, and environmental and social considerations be first conducted as soon as possible, followed by a basic plan afterwards.

WRR V

1. In WRR XI, priority project concepts were proposed in the Water Resources Development and Management Plan (idea) as described in Section 4.5.4.

2. It is recommended to promote plans and projects that integrate irrigation and flood control in the Bicol River basin, which flows through the center of the region; to practice efficient water development and management using abundant rainfall and groundwater in Catanduanes Island; and to develop multipurpose water resources in Masbate Island.

3. The “P3-1: Study/Upgrading Buhi Lake IWRM” priority project will make efficient use of the water resources of the existing natural lake, with relatively viable technical, financial, and environmental components (flow control weir rehabilitation, lake operational improvements, sediment dredging and disposal site improvement, etc.). The project’s benefits include irrigation development, flood risk reduction in the surrounding area, and contribution to local development and environmental improvement. Currently, NIA is working on a weir modification project, and it is recommended that based on the proposed project, consultations and cooperation among related agencies be deepened from an IWRM perspective to increase the maturity of the plan and make the project a reality as soon as possible.

4. In addition, the "P3-2: Lanang Dam (multipurpose dam)", proposed as a priority project, has project objectives that contribute to the grave problems concerning quantity and quality of water resources on Masbate Island and to the development of power sources in the area. At this time, the plan is still in preliminary stage, and thus it is recommended that the project be initiated first with the aim of formulating a basic plan based on a basic survey.

5.2.3 Recommendations regarding Organizations and Legal Frameworks

1) National Level

(1) Early establishment of the leading agency to prepare plans for water resources development and management

The Philippines aims to create DWR and its region offices as an organization reform in the water sector and has already established WRMO as the transitory body until DWR is created. In this regard, early establishment of DWR should be a priority, as is it expected to become the lead agency for planning of water resources development and management, including multipurpose dams at the basin level.

(2) Strengthening of the relationship between planning agency and implementing agency

DWR is supposed to be the organization which mainly deals with planning and regulation, and thus is not in charge of the implementation and management of water resources infrastructure projects. Hence, it will be indispensable to strengthen the relationship between DWR and implementing agencies (DPWH, NIA, WDs etc.,) in order to secure the implementation of prepared plans.

2) Region / Basin Level

(1) Form and strengthen the consultative frameworks for building consensus among stakeholders at the basin level

One of the important points in developing plans for water resources development and management at basin level is the consensus building among stakeholders in the basin. The River Basin Committees (RBCs) have been established at important basins in the Philippines, hence it is proposed to strengthen the functions of RBCs to provide a framework for consensus building and strengthen the relationship between water-related agencies.

(2) Develop organizational framework related to implementation and management of multipurpose water infrastructure projects

Given the lack of a sufficiently developed organization and legal system for the centralized implementation of multipurpose water resource development projects, it is proposed that a single entity for the implementation and maintenance of multipurpose dam projects at the basin level be established, beyond the jurisdiction of ministries and government organizations. A possible method of implementing multipurpose dam projects proposed in this study could be to identify one of them as a "model project" and then establish a single entity specialized for it in cooperation with relevant agencies.

(3) Establish and strengthen implementation systems for priority WRR priority projects

The following are proposed towards developing and strengthening the implementing scheme for multipurpose projects or similar ones.

WRR VII

Regarding Kotkot Dam project, multiple sectors (flood control, irrigation and water supply) have plans for dam construction respectively in the neighbouring areas of the same river basin. Thus, it is necessary to integrate the dam construction plans and implementing entities in order to implement it as a multipurpose project. The following are proposed:

- DWR region office or NEDA region office will lead the planning of Kotkot Dam project in cooperation with relevant agencies. The existing RBC "The Central Cebu River Basin Management Committee (CCRBMC)" will be utilized for the consultative framework of consensus building for the project. It is necessary to strengthen the function of CCRBMC for that purpose.
- After the integrated planning, an organization with engineers of expertise and knowledge from DPWH, NIA, local LGUs, etc. will be established to implement the multipurpose dam project as a "Model Project", and the dam construction project will be implemented. After the completion of the construction project, the organization will continue to function as a dam maintenance and management body.

WRR XI

Davao II Dam (Multipurpose) is expected to be for the irrigation and water supply for DCWD. It is proposed that the existing JV framework for implementing scheme of the Dam project (ex. JV between NIA XI and a private entity of bulk water project for DCWD) be utilized in the future study.

Davao III Dam (Multipurpose) is expected to be for flood control, irrigation, and water supply for DCWD. Thus, the same proposal for Kotkot Dam is suitable for Davao III Dam, except that the related RBC to Davao III Dam is" The Davao River Basin Management Alliance".

WRR V

"Upgrading Buhi Lake IWRM" is the project where multiple implementing entities (NIA, DPWH, and LGUs) may be involved, and at the same time, may give impact on the fish farming business which residents around Buhi Lake engage in. It is proposed that the DWR region office or NEDA region office lead the planning of the project and establish a consultative framework consisting of relevant parties in planning and implementation of the project to ensure consensus building and to promote it. Also, it is preferrable to utilize the existing "The Bicol River Basin

Committee" as the consultative framework. For that purpose, strengthening the function of the RBC is proposed.

3) Regional collaboration among water utilities

In this survey, existing cases of regional collaboration among water utilities could not be confirmed. Based on this, the following are proposed:

(1) Resolving the issue on overlapping of water supply areas among service providers

The situation on overlapping of water supply areas among multiple water service providers, which causes inefficiency of water supply facility management, was confirmed through the Survey. It is proposed that the regulatory agencies against water utilities (NWRB, LWUA etc.,) recognize the situation of overlapping and enhance coordination towards its resolution.

(2) Improvement of fragmentation affairs related to regulatory functions on water utilities

In the Philippines, there are different regulatory organizations with respective water service providers (Water District, LGU-run Utility and Private Service Providers); and this fragmented situation is one of the reasons causing the overlapping issue, and making regional collaboration among water utilities more difficult. It is proposed to unify the regulatory function on water utilities such as the issuance of Certificate of Public Convenience (CPC) into one agency through the creation of DWR in the future.

(3) Recognition of regional collaboration among water utilities as the measure for improving efficiency of water supply business

In addition, it is proposed that regional collaboration among water utilities should be recognized as one of the measures for improving efficiency of water supply business, and the policy for enhancing this regional collaboration (such as subsidy) is considered in the Philippines.

4) Public-Private Partnership (PPP)

In this survey, the following actual cases of water resources development projects related to WDs that utilized PPP scheme were confirmed:

- Lusaran Weir to supply water for MCWD (implemented by JE Hydro & Bio-Energy Corporation)
- Intake facility to supply water for DCWD (implemented by Apo Agua)

Utilization of PPP scheme for water resources development related to WDs is recognized to be the effective option from the following viewpoints:

- WDs might not have adequate capacity (technical knowledge and experiences) and technical experts for implementing especially surface water development projects, hence it is necessary to keep an option to utilize external resources which private sector has, and

- It is also necessary to keep an option to utilize the financial source of private sector since financial sources of public sector for large scale projects are not adequate.

Considering the above points, JST recognizes that PPP is one of the necessary and effective ways for implementing projects in the Philippines, hence PPP (BOT, JV) is proposed as the implementation scheme for some priority projects related to WDs.

In addition, from the perspective of improving the profitability of the project, it is proposed that the addition of hydropower generation be considered in conjunction with the planning of the priority projects which are technically feasible.

5) Capacities of agencies for planning and implementation

- It is recognized that the lack of project implementation capacity and financial resource are big issues, which, as indicated before, are part of the reasons why the projects proposed in 1998 M/P have not been promoted as expected. In addition, it is recognized that the lack of planning capacity related to water resources is the issue.
- The capacity of planning or project implementation cannot be improved in a short period of time. Thus, capacity development activities, such as long-term expert dispatchment, technical assistance, or training, should be continued persistently in the future. It is also noted that the counterpart agencies (NEDA and NWRB) wish to continue holding “Familiarization Program” which JST implemented in areas such as hydrology or groundwater analysis in line with the survey.
- The affairs on budget acquisition for water resources projects strongly relate to prioritization among the competitive political issues in the country. Thus, it is necessary to emphasize the importance of investment into water sector against the government leaders and fiscal authorities with utilizing the result of the survey or other relevant resources. In this regard, the present President Marcos Jr. gives priority on agriculture sector, and PDP 2023-2028 mentions the necessity for multipurpose dam projects, hence, taking this opportunity, JST recommends that the Philippines Government consider to allocate more financial resource for water resources development and management in the future.
- In deliberating the water resources M/P in the future based on the result of the survey, JST proposes that the Philippines Government should clarify the financial affairs necessary for implementing water resources projects and authorize them in the M/P.
- There are possibilities that Cost Benefit Ratio (B/C) of multipurpose projects can be higher than that of single purpose projects. This merit may be emphasized in planning the multipurpose projects, especially in the aspect of budget acquisition.

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