METROPOLITAN WATERWORKS
AND SEWERAGE SYSTEM
THE REPUBLIC OF THE PHILIPPINES

THE STUDY OF WATER SECURITY MASTER PLAN FOR METRO MANILA AND ITS ADJOINING AREAS

FINAL REPORT

WATER BALANCE STUDY

MARCH 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
THE UNIVERSITY OF TOKYO

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Location Map of the Study Area

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Abbreviations

AMRIS	Angat-Maasim River Irrigation System
AR4	Forth Assessment Report
BEMs	Business Efficiency Measures
BOT	Build-operate-transfer
BRL	Bureau of Research and Laboratories
BRS	Bureau of Research and Standards
BSWM	Bureau of Soils and Water Management
CA	Concession Agreement
CAG	Corporate Affairs Group
CARP-IC	Comprehensive Agrarian Reform Program, Irrigation Component
CIS	Communal Irrigation System
CMIIP-IC	Casecnan Multi-purpose Project - Irrigation Component
CMIP3	Phase 3 of Coupled Model Inter-comparison Project
CPC	Certificate of Public Convenience
DA	Department of Agriculture
DAO	DENR Administrative Order
DAR	Department of Agrarian Reform
DBM	Department of Budget and Management
DD	Diversion Dam
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DIAS	Data Integration and Analysis System
DILG	Department of Interior and Local Government
DOF	Department of Finance
DOH	Department of Health
DPWH	Department of Public Works and Highways
ECC	Environmental Compliance Certificate
EDITORIA	The University of Tokyo Earth Observation Data Integration and Fusion Research Initiative
EHS	Environmental Health Services
EIA	Environmental Impact Assessment
EMB	Environmental Management Bureau
EO	Executive Order
EPIRA	Electric Power Industry Reform Act
FAO	Food and Agriculture Organization
FMB	Forest Management Bureau
FPIC	Free and Prior Informed Consent
FTA	Fault-tree-analysis
GAA	General Appropriations Act
GCM	General Circulation Model
GDP	Gross Domestic Products
GIS	Groundwater Irrigation System
GOCC	Government Owned and Controlled Corporation
GOP	The Government of the Philippines
GRDP	Gross Regional Domestic Products
H-Q	Water Level - Discharge
IA	Irrigation Association
ICC	Investment Coordination Committee
ICC/IP	Indigenous Cultural Communities/Indigenous Peoples
IMT	Irrigation Management Transfer
INFRACOM	NEDA Board Committee on Infrastructure

IPCC	Inter-governmental Panel on Climate Change
IPRA	The Indigenous Peoples' Rights Act of 1997
IRA	Internal Revenue Allotment
IRR	Implementing Rules and Regulations
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KPIs	Key Performance Indicators
LAI	Leaf Area Index
LGU	Local Government Units
LLDA	Laguna Lake Development Authority
LPCD	Litter Per Capita Per Day
LWUA	Local Water Utility Administration
MCM	Million Cubic Meter
MERALCO	Manila Electric Company
MGSB	Mines and Geo-science Bureau
MLD	Million Litter per Day
MMDA	Metro Manila Development Authority
MRIIS	Magat River Integrated Irrigation System
MTPDP	Medium-term Philippine Development Plan
MWCI	Manila Water Company, Inc.
MWSI	Maynilad Water Services, Inc.
MWSS	Metropolitan Waterworks and Sewerage System
MWSS-RO	MWSS Regulatory Office
NAMRIA	National Mapping and Resource Information Authority
NAPC	National Anti-Poverty Commission
NASA	National Aeronautics and Space Administration
NCIP	National Commission on Indigenous Peoples
NCR	National Capital Region
NEDA	National Economic Development Agency
NIA	National Irrigation Administration
NIPAS	National Integrated Protected Areas
NIS	National Irrigation System
NPC	National Power Corporation
NRW	Non-revenue Water
NSCB	National Statistical Coordination Board
NSO	National Statistics Office
NWRB	National Water Resources Board
NWRMC	National Water Resources Management Council
O&M	Operation and Maintenance
OPDS	Project Development Services
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAWB	Protected Areas and Wildlife Bureau
PD	Presidential Decree
PDRIS	Pampanga Delta River Irrigation System
PhP	Philippine Pesos
PIDP	Participatory Irrigation Development Project
PIS	Private Irrigation System
PMO-MFCP	Project Management Office - Major Flood Control Projects
PMO-RWS	Project Management Office - Rural Water Supply
PMO-SWIM	Project Management Office - Small Water Impounding Projects
PNSDW	Philippine National Standards for Drinking Water
PPP	Public-private-partnership

PSALM	Power Sector Assets and Liabilities Management
RA	Republic Act
RBO	River Basin Organization
RDC	Regional Development Councils
RIS	River Irrigation System
RPFP	Regional Physical Framework Plan
RWSA	Rural Waterworks and Sanitation Associations
SAFDZ	Strategic Agriculture and Fishery Development Zone
SCWR	Sub-Committee on Water Resources
SFR	Small Farm Reservoir
SHER	Similar Elements of Hydrological Response
SPUG	Small Power Utilities Group
SRES	Emission Scenarios
SRI	System of Rice Intensification
SRIP	Small Reservoir Irrigation Project
SRTM-3	Shuttle Radar Topography Mission - 3 Seconds
STW	Small Tubewell
SWIP	Small Water Impounding Project
UP-NEC	University of the Philippines - National Engineering Center
UPRIIS	Upper Pampanga River Integrated Irrigation System
US$	United States Dollars
WD	Water District
WEB-DHM	Water and Energy Budget-based Distributed Hydrological Model
WSP	Water Security Plan
WSP	Small Water Supply Provider
WSSU	Water Supply and Sanitation Unit
WTP	Water Treatment Plant

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Metropolitan Waterworks and Sewerage System (MWSS) is the sole organization directly responsible for managing water supply systems in Metro Manila, serving a population of some 12 million. The MWSS entrusts its water supply operations to two water supply concessionaires, namely, the Manila Water Company, Inc. (MWCI) and Maynilad Water Services, Inc. (MWSI). The MWCI caters to the eastern part of Metro Manila and a part of Rizal Province, while the command area of MWSI is the western part of Metro Manila and a part of Cavite Province.

At present, the major source of water supply for Metro Manila is the Angat Reservoir located at the Angat River. The Umiray River is supplementing the inflow to the reservoir through a diversion tunnel (Angat-Umiray system). The system shares 97% of the total water source available for MWSS. Other sources are Laguna Lake and groundwater. The present total water rights granted to MWSS is 4190 MLD consisting of 4000 MLD from the Angat-Umiray system, 100 MLD from Laguna Lake and 90 MLD from groundwater extraction. According to the Metro Manila Water Security Study, July 2012, the estimated average water demand in Metro Manila in 2010 was approximately 3600 MLD considering the assumed coverage ratio of 95%. MWSS could meet the whole demand making the granted water right fully available in 2010. It is, however, anticipated that the rapid increase in demand will exceed the water right sooner or later. Further hydrologic condition of the Angat River basin could no longer provide this water allocation of 4000 MLD to Metro Manila without sacrificing other stakeholders such as AMRIS and water supply to Bulacan Province.

Consequently, development of a new water resource is urgently needed to meet the water supply requirement in Metro Manila. The Government of the Philippines (GoP), led by President Benigno S. Aquino III, who was inaugurated in 2010, instructed the MWSS to materialize a project implementation plan for water resources development within one to two years. In this respect, the GoP adopted the principle that priority for water resource development should be vested by evaluating its conformity to the regional development plans in Metro Manila and its adjoining areas. This can be undertaken through a comprehensive study on the medium- and long-term projections of water demand and supply taking into account potential impacts of climate change anticipated in the future.

Under the government’s principles, the MWSS has been carrying out the formulation of the Water Security Plan (WSP) to establish a comprehensive water resources development in Metro Manila and its adjoining areas on a medium- and long-term basis. The WSP will cover the following seven subjects:

1) Review of the MWSS and Concessionaires Business Plan
2) Water Efficiency Plan
3) Water Infrastructure Development Plan
4) Water Resources Management Plan
5) Disaster Risk Management and Mitigation Plan
6) Knowledge Management Plan

7) Stakeholder Engagement Plan

To complete the WSP by the end of 2012, the MWSS requested the World Bank and Japan International Cooperation Agency (JICA) to support its formulation. In response to the request by the MWSS, the World Bank has implemented the Metro Manila Water Security Study for the period of July 2011 to July 2012. Subsequent to the Metro Manila Water Security Study, the Study on Water Security Master Plan for Metro Manila and its Adjoining Areas (hereinafter referred to as the Study) has been initiated by JICA in February 2012 in line with the Minutes of Discussion signed by JICA and the MWSS in November 2011.

JICA has duly divided the works of the Study into two components in view of the technical complexity of the Study, inter alia:

- Water Balance Study
- Climate Change Impact Assessment and Runoff Simulation

This final report describes the results of the Water Balance Study component, comprising (i) the background of the Study, (ii) the results of demand side study, (iii) the results of supply side study, (iv) study on the influences of climate change to water resources, (v) water demand and supply balance study, (vi) preliminary diagnosis of water resources management, (vii) assessment of the effects of the projects proposed in the road map prepared by the World Bank study, and (viii) conclusions and recommendations.

1.2 Objectives of the Study

The objectives of the Study are summarized as follows:

- To carry out the water demand and supply balance analysis toward 2040 in Metro Manila and its adjoining areas in consideration of climate change impacts in the future.
- To evaluate the effects and impacts of the water resources development projects listed in the road map proposed by the Metro Manila Water Security Study on the basis of the obtained results of water demand and supply balance analysis to be carried out along the principle adopted by the government reflecting the impacts of climate change.

1.3 Study Area

The study area covers Metro Manila and its adjoining six river basins, namely the (i) Angat River basin, (ii) Pampanga River basin, (iii) Umiray River basin, (iv) Agos River basin, (v) Pasig-Marikina River basin, and (vi) Laguna Lake basin (collectively referred to as the Study Area). In this report, the adjoining areas are sometimes referred to as the ‘river basins’.

The location of the Study Area is presented in the Location Map.

CHAPTER 2 INSTITUTIONAL AND ORGANIZATIONAL STUDY

2.1 Legal Framework of the Water Sector

2.1.1 Constitution and Water Code of the Philippines

The Constitution of the Philippines (1987) stipulates that water resource is “owned by the State” and its development and utilization “shall be under the full control and supervision of the State” (Section 2, Article XII).

The basic water law is the Water Code of the Philippines (Presidential Decree No.1067, 1976), which is enacted under the same principles as those of the Constitution. The National Water Resources Board (NWRB, formerly the National Water Resources Council), as the primary enforcer, established the implementing rules and regulations (IRR) pursuant to the code in 1979. The revision of the IRR was approved by NWRB in 2005.

The objectives of the Water Code (Article 1) are provided as follows:

- To establish the basic principles and structural framework relating to the appropriation, control, and conservation of water resources to achieve the optimum development and rational utilization of these resources;
- To define the extent of the rights and obligation of water users and owners including the protection and regulation of such rights;
- To adopt a basic law governing the ownership, appropriation, utilization, exploitation, development, conservation, and protection of water resources and rights to land thereto; and
- To identify the administrative agencies which will enforce this code.

The Water Code governs the appropriation of water, i.e., the acquisition of rights over the use, taking, or diverting of water from natural sources. Such appropriation of water is legally allowed by the code for the following purposes: domestic, municipal, irrigation, power generation, fisheries, livestock raising, industrial, and recreational. The measure and limit of water appropriation is its beneficial use, which is defined in the code as the utilization of water in the right amount during the period that water is needed for producing the benefits for which the water is appropriated. Standards of beneficial use are prescribed by NWRB to the appropriators of water for different purposes and conditions. No person shall appropriate water without a water right that is acquired through issuance of a water permit as the granted water right. A water permit may be granted to: (i) a Philippine citizen, (ii) a legal entity. i.e., cooperative, corporation, etc., with at least 60% of its capital owned by Philippine citizens, or (iii) a government entity or a government-owned corporation.

The most noticeable point in the water appropriation is that the Water Code adopts the policy of “first-in time, first-in right” for the water allocation among users. In its Article 22, the code provides that in case of emergency, domestic and municipal water use is prioritized; provided, however, that “where water shortage is recurrent and the appropriator for municipal use has a lower priority in time of appropriation, then it shall be his duty to find an alternative source of supply".

2.1.2 Water Supply

In the 1970s, the Philippines made three legislations which formed the basis of today's water supply sector. Republic Act No.6324 (1971) created the Metropolitan Waterworks and Sewerage System (MWSS) and authorized it to serve water supply and sanitation needs of Metro Manila. The Provincial Water Utilities Act (1973) was enacted to form local water districts for densely populated areas outside of Metro Manila. The act also created the Local Water Utility Administration (LWUA) to supervise water districts nationwide. Presidential Decree No.1206 (1977), known as the Public Service Law, authorizes NWRB to supervise water supply services and regulate water tariffs, except those under the control of MWSS and LWUA.

2.1.3 Sanitation

The Sanitation Code promulgated as Presidential Decree No.856 (1975) is a comprehensive legal basis which broadly covers various activities related to health and sanitation. Its Chapter XVII regulates sewage collection and disposal. The Department of Health (DOH) issued the IRR for Chapter XVII in 1995 (and supplemented in 2004) establishing the requirements on collection, treatment, and disposal of sewage and domestic sludge.

2.1.4 Project Implementation

Environmental assessment is necessary to implement a water resources project in accordance with the Environmental Code as described in Chapter 4. In addition to environmental protection, social consideration is required for project implementation. The law governing land acquisition procedure for infrastructure projects is Republic Act No.8974 of 2000 entitled "An Act to Facilitate the Acquisition of Right-of-Way, Site or Location for National Government Infrastructure Projects and for Other Purposes". In light of the relevant provision stipulated in the Constitution, private property shall not be taken for public use without just compensation. Towards this end, the State shall ensure that owners of real property acquired for national government infrastructure projects are promptly paid just compensation. The act also provides the guidelines for expropriation proceedings including compensation of the property which shall be appraised through determining the market values of lands and improvements. Section 8 of the act stipulates that the implementing agency shall take into account the ecological and environmental impact of the project.

Section 5 of the act provides that compensation for private land can be based on 100% of zonal value or, if this is not agreed to, on fair market value. The latter is assessed by the Provincial or Municipal Assessor.

The Urban Development and Housing Act (Republic Act No.7279 of 1992) provides the government policy to undertake, in cooperation with the private sector, a comprehensive and continuing urban development and housing program. The program is aimed to uplift the conditions of the underprivileged and homeless citizens in urban and resettlement areas by making available to them decent housing at affordable cost, with basic services and employment opportunities. The program covers lands in urban and urbanizable areas, including existing areas for priority development, zonal improvement sites, slum improvement, and resettlement sites. Under this act, eviction and demolition are allowed in danger areas such as railroad tracks, garbage dumps, riverbanks, shorelines, waterways, and other public places. Pursuant to Section 28 and Section 44 of the act, the Department of Interior and Local Government and the Housing and Urban Development Coordinating Council have adopted "the Implementing Rules and Regulations to Ensure the Observance of Proper and Resettlement Procedures Mandated by the Urban Development and Housing Act of 1992" to establish the procedures to follow when involuntary resettlement must inevitably take place in an infrastructure project.

If infrastructure projects that involves involuntary resettlement are prepared and implemented with donor assistance, they must prepare Resettlement Action Plan by following the donor's social consideration guidelines such as JICA's "Guidelines for Environmental and Social Considerations" (2010) and World Bank's Safeguard Policies (Operational Policies 4.12: Involuntary Resettlement).

2.1.5 Public-Private Partnership (PPP) and Privatization

Promoting PPP is one of the pillars that the new administration relies on to pursue its infrastructure development goals in the face of fiscal constraints. The Medium-Term Philippine Development Plan (MTPDP) 2011-2016 issued in mid-2011 states that the "government shall rely on the public-private partnership scheme to implement the bulk of its infrastructure programs". As of April 26, 2012, the PPP Center of the Philippine government has identified 21 priority PPP projects in various sectors; one of which is the "New Water Supply Source Project"[1]. This is a water source development project that intends to construct a dam, a water treatment plant (WTP) and an associated main pipeline to deliver water from the project location to Metro Manila, thereby providing water supply security. A number of potential water source projects have been proposed and prepared under the PPP scheme so far.

The first attempt to establish the legal framework of infrastructure privatization is Executive Order No.215 of 1987 for electric power plants. Republic Act No.6959, or the former Build-Operate-Transfer (BOT) Law, was enacted in 1990 to enable private sector participation in infrastructure development, including water source development and water supply. The present BOT Law, which was enacted as Republic Act No.7718 of 1994 amending the former BOT Law, allows more flexibility in the implementation of projects in such sectors as road, airport, water, and information technology. The law stipulates different PPP modalities that are allowed, the nationality restriction, PPP project approval process, solicited and unsolicited modes, government guarantee and support, etc. There is no specific legislation for water source development in the PPP modalities; thus, new water source projects under PPP are supposed to follow the BOT Law for their preparation and implementation. The National Economic Development Authority (NEDA) issued the IRR of the BOT Law in 2005 for detailed procedures to be followed by project implementing agencies.

On the other hand, the privatization of water supply and sewerage systems of Metro Manila became in force by a specific law entitled the National Water Crisis Act of 1995 (Republic Act

[1] The PPP Center list does not indicate a specific location of the project and is interpreted that any feasible PPP projects for such purpose are prioritized

No.8041). The concession of Metro Manila waterworks was granted by MWSS to two private concessionaires in 1997 based on the said legislation.

The PPP-related legislation is still at the developing stage. Due to the BOT Law's requirements for approval of project implementation, a number of small-scale water supply projects nationwide were implemented under other PPP legal basis i.e., the Joint Venture (JV) guidelines established by NEDA in 2008 or the Procurement Law (Republic Act No.9184 of 2003).

Relevant legislations and orders are summarized in Table 2.1 below.

Table 2.1 Major Water-related Legislations and Orders

Category	Legislation/Orders		Salient Provision
Water Resource Management Principles and Governance	Constitution of the Philippines (1987)		Stipulates that all water resources in the Philippines belong to, and under the control of the State.
	PD No.1067 (1976)	Water Code of the Philippines, as amended	Provides the framework for water resource development and management including the rules governing the water use and its rights and obligations as well as government agency for enforcement (former NWRC, or NWRB). It adopts the water appropriation policy of "first in-time, first in-right".
	PD No.424 (1974)	NWRC Charter	Creation of NWRC (now NWRB) for coordination and planning of water resource management.
	RA No.6324 (1971)	-	Creation of MWSS for water supply and sanitation services for Metro Manila.
Water Supply	PD No.198 (1973)	Provincial Water Utilities Act, as amended	Creation of LWUA as supervising government body and water districts as local water supply service providers at the provincial level. The act also enables LWUA to provide lending facility and technical assistance to water districts.
	PD No.1206 (1977)	Public Service Law	Mandates NWRB to supervise and regulate all water supply services except those under the jurisdiction of MWSS and LWUA.
	PD No.856 (1975)	Sanitation Code of the Philippines	Establishes various sanitation policies and standards for water supply, food processing, sanitary facilities, sewerage and sewage management, etc.
Land Acquisition and Involuntary Resettlement	RA No.8974 (2000)	-	Known as "An Act to Facilitate the Acquisition of Right-of-Way, Site or Location for National Government Infrastructure Projects and for Other Purposes", it provides policy on land acquisition and compensation thereof in infrastructure projects implemented by the national government.
	IRR for Proper and Humane Relocation Procedures (1992)	-	Pursuant to relevant provisions of RA No.7279 (Urban Development and Housing Act), this IRR is set forth to provide detailed rules and regulations on resettlement procedures.
	EO No.215 (1987)		First legal framework established for privatization of public infrastructure, resulting in the implementation of about 20 power sector projects.
PPP/ Privatization	RA No.6957 (1990)	Former BOT Law	Authorizes the financing, construction, operation and maintenance of infrastructure projects by the private sector (amended by RA No.7718 of 1994).
	RA No.7718 (1994)	BOT Law	Amendment of RA No.6957 of 1990, known as the current BOT Law of the Philippines, under which only two projects have been implemented actually.
	RA No.8041 (1995)	National Water Crisis Act	Privatization of MWSS water facilities

Notes PD: Presidential Decree, RA: Republic Act, EO: Executive Order, DAO: DENR Administrative Order

Source: Prepared by the JICA Study Team

2.2 Water-Related Organizations

2.2.1 National Water Resources Board (NWRB)

This government institution is primarily involved in coordinating and regulating the water-related activities consistent with the principles of Integrated Water Resource Management (IWRM), issuing water permits, supervising, and regulating operations of water utilities in the entire country. Its regulatory function for water utilities is limited by the exclusion of areas under the jurisdiction of LWUA, MWSS, LGU-managed water systems, and Rural Waterworks and Sanitation Associations (RWSAs).

As an attached agency to DENR with the DENR Secretary as Chairman of its Board, NWRB is essentially responsible for the formulation and recommendation of policies on water resources. As mentioned in Section 2.1.1 above, NWRB is the primary agency mandated by the Water Code to lead the sector development. It advises NEDA on issues related to water resources development projects and programs.

Despite its broad mandate mentioned above, NWRB has very limited resources. Its current staff is around 100 without regional offices; and it has an annual operating budget of only around 50 million pesos. NWRB has no residential office in the field even though its command area covers the whole country.

In this respect, an ongoing development in inter-agency discussions has proposed to replace NWRB with a new National Water Resources Management Council (NWRMC) to reinforce governance of the water sector. The recommendation for an Executive Order in this regard has been submitted to President Benigno C. Aquino III for approval. This proposed change is further discussed in Section 2.5.1.

2.2.2 Department of Public Works and Highways (DPWH)

The DPWH acts as the engineering and construction arm of the government. It is tasked to plan, design, construct, and maintain infrastructure particularly the national roads, flood control, and small-scale water impounding and supply projects, among other projects financed and constructed by the government. Majority of these DPWH projects are highway construction whereas flood control projects accounted for 6.4% of its entire capital outlay budget in 2010. It also establishes the technical standards for the conduct of engineering surveys, designs, as well as operation and maintenance.

The agency undertakes water resources development initiatives through its following offices: (a) Bureau of Research and Standards (BRS) that conducts hydrological surveys and data gathering; (b) Project Management Office-Major Flood Control Projects (PMO-MFCP) that oversees the major flood control projects; (c) Project Management Office-Rural Water Supply (PMO-RWS) that is responsible for foreign-assisted rural water supply projects; and (d) Project Management Office-Small Water Impounding Projects (PMO-SWIM) that supervises locally-funded and foreign-assisted SWIM projects. DPWH is also the lead agency for flood control activities of the government.

In addition to implementing projects in Level I (point source) and Level II (fixed communal faucets), DPWH also extends technical assistance concerning rural water supply systems to

LGUs as requested. An attached agency to DPWH is the Metropolitan Waterworks and Sewerage System (MWSS).

2.2.3 Department of Environment and Natural Resources (DENR)

The DENR is tasked with the protection, conservation, and management of the environment and natural resources of the country that include forests and watershed areas. It is also responsible for the promulgation of the policies and guidelines for the control of water, air, and land pollution. The department has four bureaus and three attached agencies that are involved in water resources management.

The Environmental Management Bureau (EMB) designs plans and programs as well as environment quality standards to prevent and control pollution (e.g., water, air) and sees to it that these are being implemented. The approval of the Environmental Impact Statements and the issuance of Environmental Compliance Certificate (ECC) are among the responsibilities of the EMB.

The promotion of sustainable mineral resources development through proper management, utilization, and conservation of the country's mineral reserves is the main task of the Mines and Geosciences Bureau (MGB). It also undertakes the monitoring and mapping of groundwater resources throughout the country.

The Forest Management Bureau (FMB) ensures the effective protection, development, and conservation of forestlands and watersheds, including the improvement of water resource use and development through the formulation and recommendation of appropriate policies and programs.

The Protected Areas and Wildlife Bureau (PAWB) is mandated to establish, manage, and develop the National Integrated Protected Areas System (NIPAS) in the country. An important function is the protection and conservation of wetlands (e.g., swamps, lakes) through the proper management of the coastal biodiversity and wetlands ecosystem.

The National Mapping and Resources Inventory Authority (NAMRIA) undertakes the surveying and mapping of the land and water resources in the country. Another attached agency to DENR is the NWRB as described in Section 2.2.1 above.

The other attached agency is Laguna Lake Development Authority (LLDA), a quasi-government agency that has been given the mandate of leading, promoting, and accelerating sustainable development in the Laguna de Bay Region. It exercises regulatory and law enforcement functions on environmental management and community-based natural resource management including surface water resource allocation that is exercised by NWRB for other regions. The geographical scope of LLDA includes the towns in the provinces of Rizal, Laguna, Cavite (Silang, General Mariano Alvarez, Carmona, and Tagaytay City), Quezon (Lucban) as well as selected sites in Metro Manila (cities of Marikina, Pasig, Taguig, Muntinlupa, Pasay, Caloocan, and the town of Pateros).

2.2.4 National Economic Development Authority (NEDA)

NEDA is the economic development and planning agency of the Philippines as mandated by the Constitution. It is headed by the President as chairman of the NEDA Board, with the

Secretary of Socio-Economic Planning, concurrently NEDA Director-General, as vice-chairman. In water sector governance, the agency is mainly responsible for the formulation of policies on water resources and its subsequent approval. Through its Regional Development Councils (RDCs), the direction of economic and social development in each region, including that of water resources development, is determined by how the regional development endeavors are integrated. The evaluation, appraisal, and approval of major development projects and policies, including those related to the water sector, is being undertaken by the Investment Coordination Committee (ICC) of the NEDA Board while the Sub-Committee on Water Resources (SCWR) of the NEDA Board Committee on Infrastructure (INFRACOM) enables the stakeholders from both government and non-government organizations to share data, coordinate, and provide advices on the conduct of studies as well as policy recommendations to the NEDA Board.

2.2.5 National Irrigation Administration (NIA)

NIA is a government-owned and controlled corporation (GOCC). It has the mandate of overseeing the sustainable development and management of irrigation systems nationwide that is supportive of the agricultural development program of the government.

Presently an attached agency of the Department of Agriculture, NIA constructs multi-purpose projects primarily intended for irrigation as well as for other uses that include hydraulic power development, domestic water supply, flood control, drainage, reforestation, roads and highway construction. NIA has strengthened its decentralized regional office operation. Operational budget for each irrigation system is planned based on its own irrigation service fee collection. Budget for capital outlay is appropriated from the Department of Budget and Management (DBM) directly to Regional Irrigation Offices of NIA for their implementation of irrigation projects through Irrigation Management Offices. Two integrated irrigation systems, namely the Upper Pampanga River Integrated Irrigation System (UPRIIS) and Magat River Integrated Irrigation System (MRIIS), are each operated by respective special regional office headed by an Operations Manager.

2.2.6 National Power Corporation (NPC)

An attached agency of the Department of Energy, NPC is another GOCC that functions as the main power provider for the Manila Electric Company (MERALCO), the sole power distributor in Metro Manila.

NPC, through its Small Power Utilities Group (SPUG) is now mainly involved in the electrification of off-grid areas (those not connected to the main transmission grid) also known as Missionary Areas as a result of the passage of the Electric Power Industry Reform Act (EPIRA) in 2011. The EPIRA Law created the Power Sector Assets and Liabilities Management (PSALM) Corporation, a wholly-owned and controlled government entity that took over the ownership of all existing generation assets of NPC.

In addition to this function, NPC is tasked to be the steward of watershed areas where hydroelectric power plants are located. It also manages the generation assets that have been transferred to the PSALM Corporation until their disposal.

NPC presently performs "non-power" functions that include the conduct of regular technical audit to ensure compliance of the winning bidder to the terms and conditions of the operation and maintenance agreement related to power generation assets. The agency is also responsible for the flood forecasting and warning activities for dam operation.

Angat Dam, which supplies mostly the domestic water requirements of Metro Manila, has been privatized, however, since the turn over of the dam assets including the power plant to the winning bidder has not yet materialized, NPC continues to manage the Angat Dam operation for PSALM.

2.2.7 Metropolitan Waterworks and Sewerage System (MWSS)

The Metropolitan Waterworks and Sewerage System (MWSS) is the main agency responsible for water and sewerage services in Metro Manila as well as its neighboring towns and cities. It is mandated "to ensure an uninterrupted and adequate supply and distribution of water for domestic and other purposes at just and equitable rates." This is being undertaken at present by the MWSS through its private water concessionaires.

In 1997, the passage of Republic Act No.8041 of 1995 (Water Crisis Act) led to the privatization of the MWSS. A 25-year concession agreement was formalized between the government and the two private concessionaires after the bidding process was completed. The operational responsibility for the East Zone was given to the Manila Water Co., Inc. and that of the West Zone was awarded to the Maynilad Water Services, Inc. The MWSS, however, retains its economic regulatory functions in the National Capital Region (NCR). It continues to review water supply and sewerage rates (tariff) and to implement extraordinary price adjustment and rate rebasing provision. The MWSS, through its Regulatory Office, closely monitors and regulates the water tariffs being charged by its private concessionaires. On the other hand, the Corporate Office of the MWSS acts as the owner of the water supply and sewerage assets under the concession agreements. It is also mandated to prepare and implement water source development projects for the water supply to the two concessionaires.

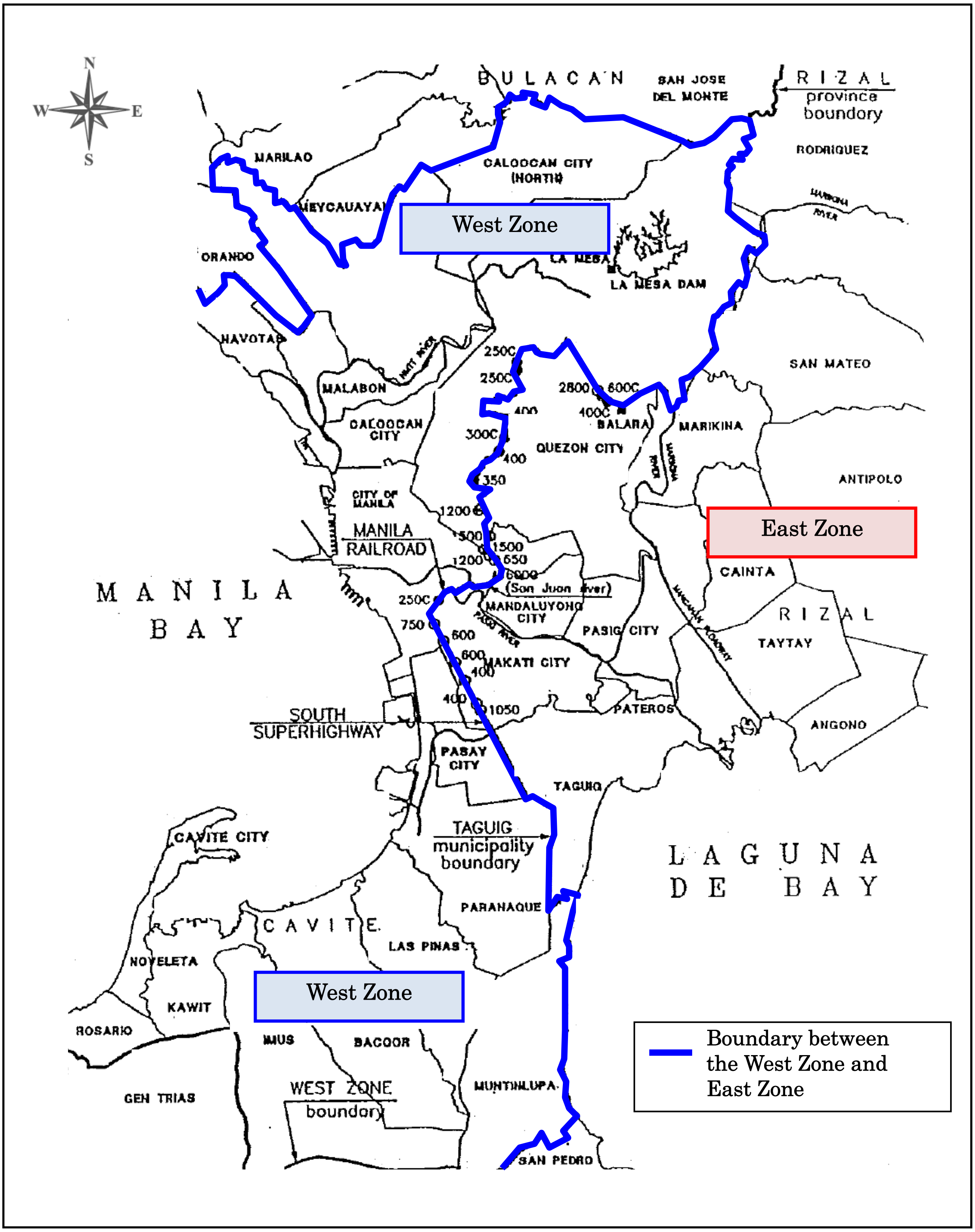
2.2.8 Manila Water Co. Inc. (MWCI) and Maynilad Water Services, Inc. (MWSI)

The MWCI and MWSI are private water concessionaires responsible for supplying water, managing the distribution system, and improving and expanding the service area in Metro Manila during the period of the concession agreement.

The service area of MWCI comprises 23 cities/municipalities in eastern Metro Manila (Mandaluyong, Marikina, Pasig, Pateros, San Juan, Taguig, Makati, and parts of Quezon City and Manila), and Rizal (Angono, Baras, Binangonan, Cainta, Cardona, Jala-Jala, Morong, Pillilia, Rodriguez, San Mateo, Tanay, and Taytay), including Antipolo City.

The MWSI covers 17 cities/municipalities in the West Zone (parts of Manila except San Andres, Pasay, Paranaque, Caloocan, Muntinlupa, Las Pinas, Valenzuela, parts of Makati, Quezon City, Navotas, and Malabon), Cavite City, and some towns of Cavite (Bacoor, Imus, Kawit, Noveleta, and Rosario).

Figure 2.1 shows the boundary and coverage areas of both companies.



Source: Maynilad Water Services Inc. Concession Agreement (West Side Area)

Figure 2.1 Coverage Areas of the Two Companies

2.2.9 Local Water Utilities Administration (LWUA)

This GOCC has been given the mandate of promoting and overseeing the development of water supply systems in provincial cities and municipalities outside of Metro Manila, as provided for by Presidential Decree No.198 or the Provincial Water Utilities Act of 1973. The said law also facilitated the creation of water districts at the provincial cities and municipalities that would be responsible for the operation and maintenance of local water supply systems.

LWUA exercises regulatory functions over urban water supply aside from Metro Manila. It formulates and implements quality and performance standards of service for water districts. The agency extends financial and advisory services to the water districts and LGU-managed utilities as part of its institutional development initiatives for the water service providers (WSPs). Recently in October 2011, Executive Order No.62 was issued by the President to order the transfer of LWUA from DOH to DPWH.

2.2.10 Local Government Units (LGUs)

The Local Government Code of 1991 (Republic Act No.7160) has devolved the powers and functions from the national government to the LGUs to include the delivery of basic services and facilities such as safe potable water to their constituents. The responsibility for policy formulation, planning, and regulatory functions on water, sewerage, and sanitation is among the tasks that have been devolved to local government units.

In providing reliable water supply to the community, the LGUs may have the option to (a) both directly provide and finance these services; (b) encourage the involvement of the private sector in both provision and financing through management, service contract or concession arrangements, and (c) enter into a joint venture agreement with a private party. The LGUs could also use their Internal Revenue Allotment (IRA) and other locally generated income in financing or securing external borrowings for water supply development.

With the exception of areas with water districts, the LGUs have the authority to exercise regulatory powers over local water utilities to ensure customer satisfaction on the services being provided. The LGUs are also responsible for the overall supervision of the Barangay and Rural Waterworks and Sanitation Associations (BWSAs/RWSAs) that have been formed to operate and manage Level I and Level II systems.

2.2.11 Other Related Organizations

(1) Department of Interior and Local Government (DILG)

The DILG extends general administration and capacity-building support in all aspects of local governance to the LGUs, including water and sanitation concerns. Its Office of the Project Development Services (OPDS), through the Water Supply and Sanitation Unit (WSSU), is presently managing the provision of Water Supply Program or the so-called "*Sagana at Ligtas na Tubig Para sa Lahat (Salintubig)*". An undertaking of DOH, DILG, and the National Anti-Poverty Commission (NAPC), the program aims at providing water supply systems to identified waterless municipalities and waterless thematic areas (*barangays*, health centers, and resettlement sites) all over the country. The program management was transferred to OPDS-DILG effective 2012 after its initial implementation by NAPC.

(2) Department of Health (DOH)

The Department of Health is mandated to regulate water supply quality and set standards on water testing, treatment and sanitation. These functions are being undertaken through the Environmental Health Services (EHS) and the Bureau of Research Laboratories (BRL). EHS is responsible for water supply and sanitation programs and implementing intervention to avert environment-related diseases while BRL undertakes monitoring activities on the quality of water.

(3) Department of Budget and Management (DBM) and Department of Finance (DOF)

The Department of Budget and Management (DBM) is an executive body under the Office of the President which is mandated to promote the sound and efficient use of government resources. Its functions include formulating the overall resource allocation strategy and the medium-term expenditure plan, and preparing annual national budgets. One of the requirements for an implementing agency is to obtain budgetary clearance from DBM to process a proposed infrastructure project using the national budget.

The Department of Finance (DOF) is responsible for national fiscal policy and management. Its Corporate Affairs Group (CAG) undertakes the supervision over GOCCs such as MWSS.

2.3 Water Resource Management Practice

2.3.1 Water Resource Allocation

As mentioned earlier, NWRB is the primary government agency mandated to issue water rights on both surface water and groundwater upon the requests from water users in accordance with the Water Code. However, in the case of the Angat-Umiray system, water allocation was made in an irregular manner. The Technical Working Group consisting of NPC, NIA, PAGASA, MWSS, and NWRB prepared the draft water allocation to be approved through an NWRB resolution. The Technical Working Group also monitors the hydrological conditions and instructs NPC on the daily dam operation.

Shortage in water inflow and increasing water supply demand cause conflict among water users. Water allocation to MWSS has been gradually increased and currently reached 46 m^3/s. This allocation includes 15 m^3/s, which is granted for “conditional use” for irrigation. However, since MWSS constantly requires water and does not have an alternative water source, there is no water to be supplied when NIA claims for the use of this 15 m^3/s.

In 2004, the Angat-Umiray system had experienced severe drought, and water supply for irrigation of AMRIS was suspended for four months. NIA submitted to NWRB in 2005 the claim for compensation of loss of irrigation service fee (ISF) and agricultural production. MWSS insisted that the scarcity of water is caused by force majeure. The Water Code stipulates that water supply for municipal use is prioritized. NWRB recommended for NIA to file its claim in the Office of the Government Corporate Council, which is the office mandated for settlement of claims and disputes among government-owned corporations.

2.3.2 River Basin Management

In its Medium-term Philippine Development Plan, the government has adopted the Integrated Water Resource Management (IWRM) by the river basin approach as a comprehensive strategy for water resource management. Creating river basin organizations (RBOs) is planned as authorities to manage specific water basins. However, only four RBOs have been established in the Philippines to date, in the form of authority, council, board, or commission. Their institutional functions differ from the statutory body for the basin development and infrastructure management (e.g., LLDA) to coordinating body for multiple organizations concerned (e.g., Bohol IWRM Board). Not all the water basins are covered by RBOs.

2.3.3 Water Quality and Watershed Management

The Clean Water Act (Republic Act No.9275) of 2004 provides comprehensive water quality management in all water bodies and the control against water source pollution from land-based sources. The DENR, in coordination with NWRB, is responsible for the water quality control. The Forest Management Bureau under DENR formulates and implements the policies and programs for the protection and management of forest lands and watersheds. NIA, NPC, MWSS, and the Water Districts as well as the Philippine National Oil Company cooperate with DENR to protect and preserve the watersheds in their respective responsible areas. For the soil and water resources for agriculture, the Bureau of Soils and Water Management of the Department of Agriculture is also responsible for the assessment, management, and preservation of watersheds.

2.3.4 Water Resource Assessment

Several government agencies are involved in the assessment of water resources. Primarily responsible agencies for collecting the stream flow data are the Bureau of Research and Standards (BRS) of DPWH, NIA, and NPC. BRS records and processes data collected at 274 monitoring stations managed by DPWH regional offices nationwide. NIA and NPC are also involved in gathering stream flow data at their water resource facilities.

2.4 Investment in Water Source Development Projects

2.4.1 Overview

Historically, most of the existing large water source facilities such as large-scale dams were planned and constructed by NIA and NPC. However, according to a JICA Study (2011)[2], there is no unified planning and design standard established for dams and auxiliary structures nationwide, and NPC has customarily applied the United States Bureau of Reclamation Standards.

Currently, large-scale water source projects in the study area such as those mentioned in the "Metro Manila Water Security Study" (World Bank, 2012) are prepared and implemented by (i) MWSS for municipal water supply in Metro Manila; (ii) NIA for irrigation; and (iii) private sector investment for bulk water supply and hydropower generation. For municipal and domestic water supply, LGUs and Water Districts may be engaged in small-scale groundwater development or surface water intake facilities but are not capable of implementing larger-scale projects that can substantially account for the water security situation in the study area. NPC is now involved in the sector as an operator of major dams such as Angat and is not considered an implementing agency of water source projects since

[2] JICA "Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin" (2011)

private sector investment has taken this primary role in the power source development after privatization.

Budget constraints greatly affect investment in water resource development of the country. National budget allocated for water source-related infrastructure development projects is mostly limited to irrigation (NIA) and flood control (DPWH) purposes. The capital outlay budget appropriated for irrigation and flood control in 2010 was 14.29 billion pesos and 7.44 billion pesos, respectively (See Table 2.2). Most recently, the increased budget amounting to 25 billion pesos has been allocated to NIA for 2012 to generate, restore and rehabilitate irrigation systems all over the country to support the urgent attainment of the country's goal of self-sufficiency in rice.

Table 2.2 National Budget Allocated to Projects for Water Source Infrastructure Development

(Unit: Billion Pesos)

	2009	2010			
		Total	*Foreign-assisted*	*Locally Funded*	*Inter-agency Projects*
Irrigation	12.55	14.26	*4.14*	*9.46*	*0.66*
Flood Control	6.93	7.44	*N/A*	*N/A*	-
Total	19.48	21.70	-	-	-

Source: JICA Study (2011), NIA and DPWH

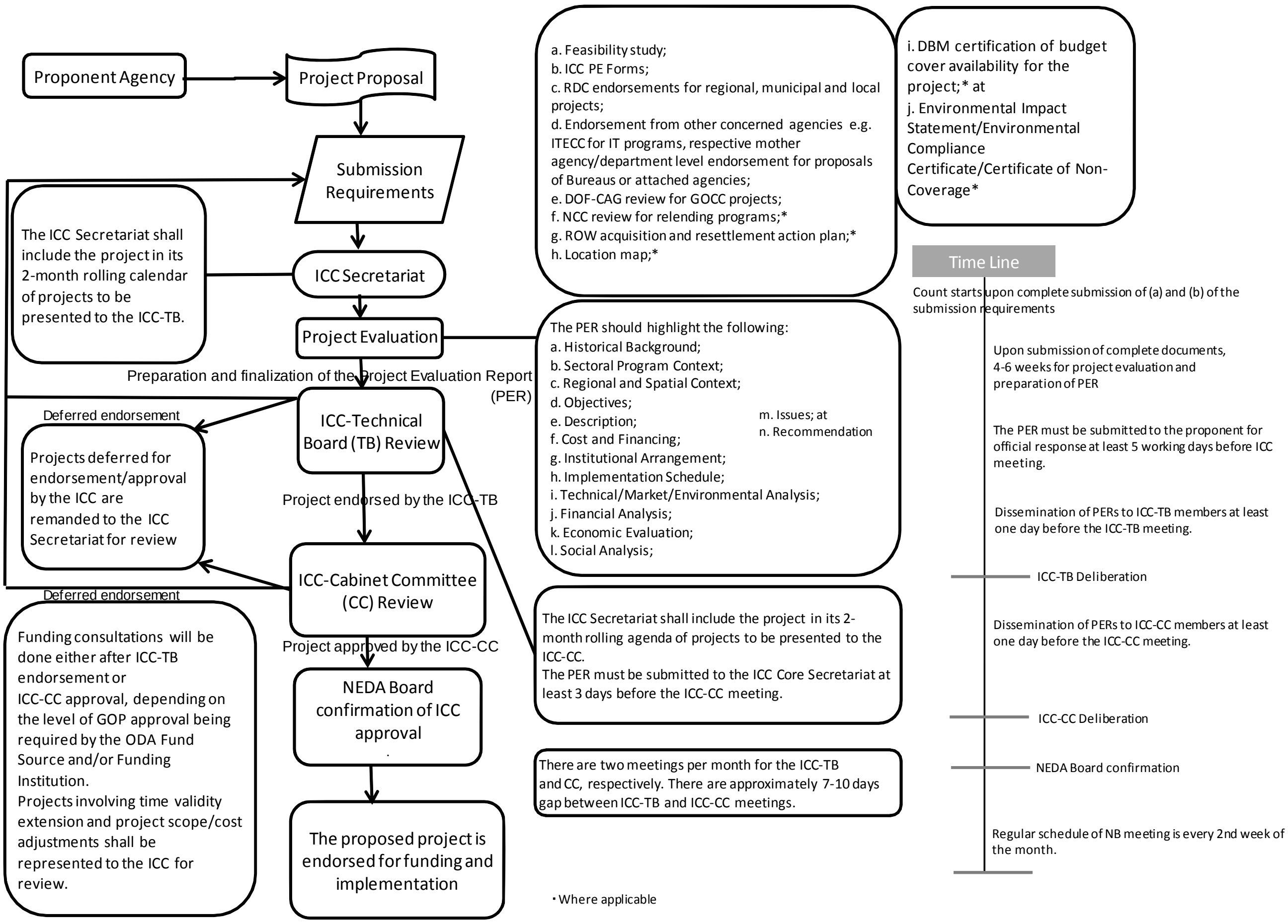
For municipal water supply, the water source projects to be implemented by MWSS rely on financing by various financial institutions, including donor lending. The debt service and operational costs incurred in the project implementation will be transferred to the concession fees borne by the concessionaires, and eventually paid by end consumers as water tariffs; thereby the full cost recovery of water supply services is ensured.

A number of water source projects are also proposed to be implemented through PPP mode with private sector participation, where the bulk water price charged to the concessionaires will cover all the capital and operational expenses incurred. The private investment in water source development such as raw water transmission and WTP construction can also be undertaken through the concessionaires' own implementation under their respective concession agreements.

2.4.2 Project Formation and Implementation Process

(1) Investment Coordination Committee Approval Process

The Investment Coordination Committee (ICC) was created by Executive Order No.230 of 1987 as one of the five committees under the NEDA Board. According to the ICC guidelines and procedures revised in March 2005, its functions include reviewing the fiscal, monetary, and balance of payments implications of major capital projects (over 500 million pesos), and recommending to the President the timetable of the implementation of these projects and programs. The ICC-Cabinet Committee, the highest decision-making body of ICC, consists of several cabinet members chaired by the Secretary of Finance. Figure 2.2 illustrates the typical ICC project approval process.



Source: NEDA

Figure 2.2 ICC Project Approval Process

(2) Public-Private Partnership

As described in the previous section, the Public-Private Partnership (PPP) scheme is considered as a primary funding and implementing modality for water resource development projects. The PPP Center of NEDA provides specific guidance and assistance for implementing agencies and LGUs to prepare and implement PPP projects, including procedures set forth such as the ICC approval process mentioned earlier. The PPP Center offers various technical supports to the agencies from preparation through bidding and closing of PPP project contracts, including providing a Project Development and Monitoring Fund (PDMF) for pre-investment studies. For water resource development, the PPP Center has approved funding for technical and business development studies and preparation of bidding documents for the Agos Dam project of MWSS.

2.5 Issues and Recent Developments

2.5.1 Water Sector Governance and Institutional Reform

(1) Recent Development for Institutional Reform

In response to the weak and dispersed governance in water-related sectors, the President designated the Secretary of DPWH in October 2011 by Executive Order No. 62 to be the one responsible for the water sector. By the same Executive Order, it was decided to transfer the LWUA from DOH to DPWH and establish an inter-agency committee for institutional reform in the sector.

Related to this development, the "Policy Brief on the Status, Challenges, and Proposed National Water Resources Management Council for Philippine Water Resources Sector Development Plan" was commissioned by NEDA with the support of the Asian Development Bank (ADB). Dr Guillermo Q Tabios, III and Ms Rosario Aurora L. Villaluna prepared the policy brief.

The necessity of institutional reform in the water sector governance explained in the policy brief is summarized as follows: Among other issues such as limited water availability, inadequate access to safe water and sanitation, increasing water pollution and recent climate change causing drought and floods, the policy brief focuses on "the weak leadership and fragmented institutions." Government functions such as policy planning, data monitoring, and infrastructure development are separately done by many different agencies. Some of them have financing (e.g., LWUA) and economic regulatory functions (e.g., MWSS-RO). However, there is no integrated platform for these organizations in order to avoid duplication, deficiency, and conflicts. As mentioned earlier, NWRB is originally supposed to take the major role to push forward such integration, but its limited resources do not allow it to fully function as the lead organization in water resource development and management for the whole country. NWRB's current operation merely focuses on resource regulation.

(2) Proposed National Water Resources Management Council

To cope with the issues stated above, the said policy brief recommends the creation of the National Water Resource Management Council (NWRMC) by transforming and scaling up the existing NWRB with merger of several agencies[3]. It will be managed by a governing board consisting of the President as chair, and council members composed of DPWH, DA, DILG, DENR, NEDA, etc. The daily management will be carried out by an executive management body headed by the Executive Director, a cabinet-level appointee with about 640 staff including regional offices.

The NWRMC's major functions are summarized as follows:

- Planning and policy recommendation
- Data collection and monitoring
- Scientific and decision support systems
- Infrastructure and program development[4]
- Strategic development of water facilities and operations
- Regulatory functions (economic and resource regulation including extraction and water permits, quantity, quality, monitoring, and enforcement and conflict resolution)
- Water economics studies
- Public relations and capacity development
- River Basin Organization (RBOs) development

[3] The policy brief mentions NWRB, LWUA (except WDs financing body), DPWH-BRS, DPWH-DS, DPWH-Flood Control Center, etc. to be integrated into the new NWRMC.

[4] Project preparation and implementation function will be retained by each line agency such as MWSS and NIA.

It is also proposed to establish the inter-governmental panel and the multi-stakeholder water advisory board to work with government line agencies, LGUs, NGOs, and private sector partners.

(3) Current Status

The Secretary of DPWH submitted the recommendation of the inter-agency committee along with the abovementioned policy brief to the President on April 4, 2012. Further development for the proposed institutional reform is still to be monitored.

2.5.2 Investment in Water Resources

Acceleration of investment in water resource development is a challenge to ease the tight water balance in Metro Manila and adjacent areas. In the course of discussions with NEDA officials, the following were pointed out as major issues faced by the proposed water source projects:

- Heavy investment cost: Large financing requirement for private sector in water source projects limits the project's viability by increasing off-take price for water supply. Certain mechanisms to utilize public funding, including donor assistance, would be necessary to fill in such viability gap.
- Social and environmental consideration process: Implementing agencies and proponent companies are sometimes not capable of the project preparation procedures, especially obtaining the ECC, National Commission on Indigenous Peoples (NCIP) certificates, and right of way, causing delays and deficiency in the process.
- Cooperation with LGUs: In water source development, it is inevitable to obtain consent from the host LGUs. The direct beneficiaries of water source projects are located in the water consumption points in Metro Manila and no benefits are expected for the host LGUs and their residents. Therefore, it is required to reach an agreement with host municipalities and communities on the compensation and mitigation measures well before project planning starts. For instance, in the Kaliwa Low Dam project, the previous project's deficient compensation arrangement for the host municipality caused the municipality to refuse the consultation process for the proposed project, thereby affecting its NCIP certificate process (JICA 2012)[5]. In order to avoid such problems, it is necessary for the implementing agency to conduct the consultation process on the compensation and mitigation package in a timely manner along with the project planning process. According to the interviews conducted by the said JICA survey with provincial offices of NCIP, it is hard to obtain the consent of host municipalities unless the project includes community activities beneficial to the residents, such as infrastructure development, capacity building, and health care facilities construction.

[5] , The Kaliwa Low Dam case is referred to in the JICA Study entitled "Information Collection Survey on Water Supply for Metro Manila" (2012).

2.6 Institutional Interventions

2.6.1 Water Conservation

Since water source development is facing challenges in financing and social acceptance for project implementation, it is crucial to promote water consumption-saving on the demand side to ensure the water supply-demand balance of the region in the long term.

The combined non-revenue water (NRW) rate of Metro Manila's water supply systems accounted for 32.8% in 2010; majority of which is caused by physical water loss in the distribution network. Especially, the NRW in the west area was as high as 43.0% and its physical loss was estimated at around 30% in 2010. It is crucial to reduce this huge physical loss in the distribution network to control excessive water demand. The business plans of the water service concessionaires have set the gradual reduction of NRW down to 12% in the east area and 20% in the west area by 2037 along with their capital expenditure plans to invest in network rehabilitation to decrease water losses. Although these works are planned as private sector investment by the concessionaires, if further loss reduction is required to meet future water scarcity, public funding including donor assistance should be considered for water loss reduction as an alternative to water source development.

Another measure for water conservation on the demand side is improving water use among consumers. It will be necessary to involve public outreach campaigns to raise domestic consumers' awareness, application of more progressive water tariff system, and promotion of household applications for water saving such as low-flush toilets and low-flush showers.

2.6.2 Participation of the Host LGUs and Communities

In order to obtain consent of the host LGUs for water source projects, their participation and that of their communities should be ensured in the project planning process. The implementing agencies as well as government leaders backing the project should initiate careful and timely communication with the stakeholders concerning the project's necessity based on scientific rationale, implementation methods, environmental impacts and their mitigation measures. Honest and deliberate approach must be taken in such communication. As summarized in Chapter 2, the current institutional reform proposes to establish a multi-stakeholder water advisory board to work with the LGUs, NGOs, and private sector partners.

Along with the EIS process required by law, the project plan must have a compensation and mitigation package, including funding for community activities beneficial to the residents, revenue-sharing for long-term compensation to LGUs, etc. In particular, sharing the revenue of the project that diverts water to Metro Manila with the affected people is a challenge to achieve equitable water utilization. It is the most realistic measure to obtain consensus of the stakeholders for the project as well.

CHAPTER 3 SOCIO-ECONOMIC FEATURES OF THE STUDY AREA

3.1 Administrative Composition of the Study Area

The Study Area comprises the command area of MWSS and six basins, that of the Angat River, Pampanga River, Pasig-Marikina River, Agos River, Umiray River, and Laguna Lake. Administratively, the areas cover the NCR and 12 provinces. The areas depend on their water sources of five river basins and a lake basin. The water sources and their respective relevant provinces are presented in Table 3.1 below;

Table 3.1 Water Sources and Provinces

Water Sources (Basin)	Provinces	Total Number of Municipalities
Angat, Umiray, and Laguna Lake	NCR (17), Cavite (6), Rizal (2)	25
Angat River	Bulacan (17)	17
Pampanga River	Aurora (2), Bulacan (5), Nueva Ecija (32), Nueva Viscaya (5), Pampanga (22), Pangasinan (1), Tarlac (10)	77
Pasig-Marikina River	Bulacan (2), Rizal (3)	5
Agos River	Quezon (3), Rizal (1)	4
Umiray River	Aurora (1)	1
Laguna Lake	Batangas (4), Cavite (5), Laguna (30), Quezon (5), Rizal (8)	52

Note: Figures in parenthesis show the number of cities or municipalities
Source: JICA Study Team

3.2 Population of the Study Area

The population data analyzed by the National Statistics Office (NSO) is available. The NSO has projected the respective provincial population and its growth rates. The Study confirmed the growth rates of medium growth scenario are appropriate for the Study because the trend of the growth rates assimilates the past population trends of the census data in 1995, 2000, and 2007 (see Annexes 3.1 and 3.3).

The Study projected future provincial populations on the basis of obtained growth rates and census data in 2007. The estimated population of the Philippines was 94,013,200 in 2010. while that of the study area is estimated at 29,038,931. This comprises the MWSS service area of 15,683,803 and the adjoining areas of 13,355,128. The population in the Study Area shares about 31% of the total population of the whole Philippines.

The projected future population in the Study Area is shown in the following tables. The population projection per municipality is shown in Annexes 3.2 and 3.4.

Table 3.2 Projected Population in the Service Area of MWSS

Area	Population based on NSO Medium Assumption								
	2010	2011	2012	2015	2020	2025	2030	2035	2040
West Zone	9,203,882	9,325,211	9,448,372	9,829,182	10,380,518	10,855,275	11,247,921	11,539,073	11,716,258
Easst Zone	6,479,921	6,573,421	6,668,373	6,962,175	7,392,551	7,768,943	8,084,300	8,325,824	8,486,621
Total	**15,683,803**	**15,898,632**	**16,116,745**	**16,791,357**	**17,773,069**	**18,624,217**	**19,332,221**	**19,864,896**	**20,202,879**

Source: JICA Study Team

Conditions and assumptions adopted

- Population growth rate: Official provincial growth rates prepared by NSO
- Base population: 2007 Census Data

Table 3.3 Projected Population in the River Basins

	Provice	NSO	Projected Population								
		2007	2010	2011	2012	2015	2020	2025	2030	2035	2040
1	AURORA (part)	81,047	87,483	89,468	91,498	97,868	108,610	119,431	129,500	139,489	148,962
2	BATANGAS (part)	557,940	595,348	606,365	617,586	652,510	709,008	762,977	812,630	857,327	895,589
3	BULACAN	2,822,216	3,084,443	3,158,928	3,235,211	3,475,292	3,870,169	4,261,122	4,636,994	4,989,419	5,311,064
4	CAVITE (part)	1,022,526	1,132,317	1,162,565	1,193,621	1,291,855	1,456,602	1,625,040	1,789,437	1,946,605	2,092,347
5	LAGUNA	2,473,530	2,634,056	2,678,142	2,722,965	2,861,987	3,077,714	3,274,484	3,445,323	3,587,071	3,699,184
6	NUEVA ECIJA	1,804,497	1,903,635	1,932,229	1,961,253	2,050,968	2,189,117	2,312,668	2,417,561	2,503,892	2,570,211
7	NUEVA VIZCAYA (part)	95,452	102,943	104,946	106,988	113,356	123,240	132,530	140,891	148,124	154,115
8	PAMPANGA	2,229,349	2,367,002	2,405,313	2,444,243	2,564,857	2,752,145	2,925,242	3,077,828	3,203,792	3,299,404
9	PANGASINAN (part)	62,497	67,068	68,400	69,758	73,995	80,820	87,446	93,880	99,970	105,571
10	QUEZON (Part)	419,276	443,468	450,767	458,185	481,182	518,386	553,268	584,390	611,862	636,038
11	TARLAC (part)	886,167	937,365	951,853	966,565	1,012,079	1,082,105	1,146,125	1,201,428	1,246,695	1,281,708
	TOTAL	**12,454,497**	**13,355,128**	**13,608,974**	**13,867,873**	**14,675,948**	**15,967,916**	**17,200,333**	**18,329,861**	**19,334,247**	**20,194,194**

Source: JICA Study Team

Conditions and assumptions adopted

Population growth rate: Official provincial growth rates prepared by NSO

- Population growth rate: Official provincial growth rates prepared by NSO
- Base population: 2007 Census Data

3.3 Economy of the Study Area

The municipalities in the Study Area belong to five regions, namely, NCR, Regions I, II, III, and IV-A. The economic activities in the Study Area represent the national economy culminated by that of NCR.

The estimated annual gross domestic product (GDP) was PHP 7,679 billion in 2009 according to the statistics of National Statistical Coordination Board (NSCB). The estimated annual gross regional domestic product (GRDP) of NCR is PHP 2,814 billion and it shares more than 36% of the GDP. The GRDP of Region IV-A is PHP 803 billion or more than 10% of the GDP. The total GRDP of these regions shares approximately 60% of the national GDP, including those of Regions I, II, and III.

The said high economic share indicates high economic activities in the Study Area. It should be noted that a high economic activity is accordingly related to intensive water consumption for both domestic and non-domestic users for commercial and industrial consumptions.

The service sector shares substantial GRDP in the Philippines. It is more than 70% in NCR and more than 50% in the adjoining areas. The share of the industrial sector follows the service sector. It is more or less 30%. The remainder is the agricultural sector share, which is almost nil in NCR.

A GRDP growth rate reflects the economic activity and development in each region at that time. The historical data of each region from 2001 to 2010 are summarized in Table 3.4. The GDP of the whole Philippines shows the growth rate of 4.8% and the NCR demonstrates the highest rate at 5.1%. Meanwhile, the figures in the adjoining areas show lower rates, from 3.0% in Cagayan Valley Region to 3.7% in the Ilocos Region.

The following table presents the GRDP growth rates from 2001 to 2010 prepared by the National Statistics Coordination Board.

Table 3.4 Trend of GRDP at Constant 1985 Prices in the Study Area (%)（**from 2001 to 2010**）

Region		**Province**	**Current Price in 2009 (PHP billion)**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Ave**
Whole Philippines		-	7,679	3.0	4.3	4.6	6.2	4.9	5.4	7.1	3.7	1.1	7.6	**4.8**
NCR	Metro Manila	NCR (National Capital Region)	2,814	3.1	3.1	5.2	8.4	7.4	6.7	7.8	4.7	-0.4	**	5.1
I	Ilocos Region	Pangasinan	215	2.1	4.3	3.3	5.4	5.2	6.1	5.7	2.0	-1.0	**	3.7
II	Cagayan Valley	Nueva Vizcaya	139	3.2	-1.2	1.2	10.4	-4.3	7.4	6.4	1.7	1.9	**	3.0
III	Central Luzon	Aurora, Bulacan, Nueva Ecija, Pampanga, Tarlac	577	4.0	3.7	3.4	1.8	2.7	4.8	5.9	3.7	-1.4	**	3.2
IVA	Calabarzon	Batangas, Cavite, Laguna, Quezon, Rizal	803	2.8	6.5	2.8	4.0	2.6	4.6	5.3	1.9	1.6	**	3.6

NSCB: National Statistical Coordination Board

CHAPTER 4 EXISTING ENVIRONMENTAL CONDITION

4.1 Government Policy for Environmental Protection

All policies are based on the 1987 Constitution of the Republic of the Philippines.

Article II, Section 16 thereof provides that the State shall protect and advance the right of the people to a balanced and healthful ecology in accord with the rhythm and harmony of nature.

Article III of the Constitution stipulates the social issues in Section 9 stating that private property shall not be taken for public use without just compensation. In addition, Article XIII, Section 10 mentions that urban and rural poor dwellers shall not be evicted nor their dwelling demolished, except in accordance with law and in a just and humane manner.

Republic Act No. 7279 is the "Urban Development and Housing Act of 1992", and its corresponding Implementing Rules and Regulation (IRR) is designed to provide a comprehensive and continuing urban development and housing programs. A component of the act is to ensure the adherence to proper and humane relocation and resettlement procedures. In Article II, Section 22, the State recognizes and promotes the rights of indigenous cultural communities within the framework of national unity and development.

Republic Act No. 8371 is "The Indigenous Peoples' Rights Act of 1997" (IPRA). This policy recognizes and promotes all individual and collective rights of indigenous cultural communities/indigenous peoples (ICC/IP), especially the right to manage their own ancestral domain.

Pursuant to sections of RA No.8371, is the National Commission on Indigenous Peoples (NCIP) Administrative Order No. 01, Free and Prior Informed Consent (FPIC) Guidelines of 2006. This includes the commission's advocating the intent of the law in requiring FPIC of the ICCs/IPs concerning applications for lease, license, permit, agreement, and/or concession for implementation and/or operation of programs, projects, or activities affecting ancestral domains.

Other policies created to protect the natural environment include:

Presidential Decree No. 1586 established an Environmental Impact Statement (EIS) system: the system shall reconcile the exigencies of socio-economic undertakings with the requirements of environmental quality.

Republic Act No. 7586 is the "National Integrated Protected Areas System Act of 1992" (NIPAS). This is a comprehensive system made to secure for the present and future generation of Filipinos the perpetual existence of all native plants and animals. Meanwhile, Republic Act No. 9147 is an act that provides for the conservation and protection of wildlife resources and their habitats.

The Department of Environment and Natural Resources (DENR) issued Administrative Order No. 30, Series of 2003. This is the Implementing Rules and Regulations (IRR) of Presidential Decree No. 1586, establishing the Philippine Environmental Impact Statement System. Part of this is the Environmental Impact Assessment (EIA) that examines the adverse impacts of a proposed activity to people, properties, livelihoods, and other projects. Then, mitigation measures are determined and ways to improve the sustainability of the project are recommended.

4.2 Environmental Issues Vulnerable to Water Resources Development

4.2.1 Indigenous People

The Philippines is culturally rich and diverse. Indigenous people (IP) are part of the 110 ethno-linguistic groups in the Philippines, with an estimated population of 14 to 17 million (as of February 2010, United Nations Development Program) in the entire country. The Metro Manila Water Security Master Plan study covers Regions IV-A (Calabarzon), III (Central Luzon) and the periphery of Nueva Vizcaya in Region II.

There are about 15,869 (as of 2011, National Commission on Indigenous People, Main Office) indigenous people in Region IV-A. Of the five provinces in Calabarzon, Quezon Province has the most number of IPs at 67% of the total population, next is the province of Rizal at 32%. Only 1% of the IP population is in the regions of Laguna and Batangas while there is none in Cavite. The region is home to the Dumagats, Remontado, Aetas, and only a few Badjaos.

In Central Luzon, the IP population was estimated at 182,206 (as of 2011, National Commission on Indigenous People, Regional Office No. III). IPs in the region are mostly found in Zambales at 29%, closely followed by Nueva Ecija at 28%. The provinces' percentage shares to total IP population are as follows: Tarlac (20%), Pampanga (10%), Aurora (7%), Bulacan (3%), and Bataan (3%). There are 15 tribes who live in Region III; among them are Abelling, Aeta, Applai, Bago, Baluga, Bugkalot, Dumagat, Gaddang, Ibaloi, Igorot, Ilonggot, Kalanguya, Kalinga, Kankanaey, and Remontado.

In Region II, there are ancestral domains in the towns of Aritao and Santa Fe, Nueva Vizcaya with a combined IP population of 10,442.

Despite the approval of the landmark law, Republic Act No. 8371, Indigenous Peoples' Rights Act (IPRA) of 1997, a foundation of national policies for the recognition, protection, and support of indigenous peoples' rights; they remain to be the poorest and most vulnerable regardless of where they live. Careful examination is necessary in advance to develop water resources to harmonize with the protection of these indigenous cultures.

Annex 4-1 presents the details of the estimated indigenous population.

4.2.2 Natural Environment

In the natural environment, habitats in the protected areas are vulnerable to water resources development. There are 14 protected areas in the Study Area. One is located in the Angat River basin, seven in Pampanga, one in the Pasig Marikina area, two in Laguna Lake basin and three in Agos-Umiray River basin. Table 4.1 presents the defined protected areas.

Table 4.1 Protected Areas in the River Basins

River Basin	Protected Areas
Angat	(1)Angat Watershed Forest Reserve
Pampanga	(1) Aurora National Memorial Park, (2) Candaba Swamp, (3) Casecnan Protected Landscape, (4) Manila Bay, (5) Mt. Dingalan, (6) Mt. Arayat, (7) South Central Sierra Madre Mountains
Pasig-Marikina	(1) Pasig River
Laguna Lake	(1) Mount Makiling Forest Reserve, (2) Mts. Banahaw-San Cristobal National Park
Agos-Umiray	(1) Uplands Grants(Pakil and Real), (2) Mts. Irid-Angilo and Binuang, (3) Umiray River

Source: JICA Study Team

There are some habitats defined as vulnerable species in these protected areas, except for Mt. Arayat and South Central Serra Madre Mountains in the Pampanga River basin, Pasig River in the Pasig-Marikina River basin and Umiray River in the Agos-Umiray River basin. The following table lists the numbers of species defined to be vulnerable.

Table 4.2 Numbers of Vulnerable Species

River Basin	Protected Areas	Specific Forms								
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Angat	Angat Watershed Forest Reserve	1	10	1	-	-	2	-	-	14
Pampanga	Aurora Memorial National P.	9	7	4	8	-	-	1	-	29
	Candaba swamp	-	4	-	-	-	-	-	-	4
	Casecnan Protected Landscape	3	8	-	-	-	-	2	-	13
	Manila Bay	-	4	-	-	1	-	-	-	5
	Mt. Dingalan	2	9	4	-	-	1	3	-	19
	Mt. Arayat	-	-	-	-	-	-	-	-	-
	S.C. Sierra Madre Mts	-	-	-	-	-	-	-	-	-
Pasig-Marikina	Pasig River	-	-	-	-	-	-	-	-	-
Laguna Lake	Mt. Makiling Forest Reserve	1	7	1	1	-	-	3	3	16
	Mts. Banahau-S. Cristobal NP	4	4	6	-	-	-	3	-	17
Agos-Umiray	Uplands Grants	-	6	-	-	-	1	-	-	7
	Mts. Irid-Angilo and Binuang	4	11	2	2	-	2	3	-	24
	Umiray River	-	-	-	-	-	-	-	-	-

Note: Specific Forms - (1) Mammalia, (2) Birds, (3) Amphibia, (4) Reptilia, (5) Fish, (6) Insect, (7) Tree, (8) Plant, (9) Total
Source: JICA Study Team

The Philippine Eagle is a critically endangered species which inhabit in the Angat River basin and Mt. Dingalan in the Pampanga River basin. Chinese Crested Tern is another bird inhabiting in Manila Bay and defined as critically endangered species. The other critically endangered bird in the Study Area is the Yakal-Kailot in the mountains of the Agos River basin and Laguna Lake basin. White Lauan, Daling lingan Mangga Chapui are critically endangered trees growing in the mountains of Laguna Lake basin.

Endangered birds in the Study Area are Black-faced Spoonbill, Mottle-Winged Flying Fox, and Giant Golden Crowned Flying Fox. Polillo Forest Frog and Spotted Greenshark are endangered species as well. Meanwhile, Ulas and Malapaho are trees defined as endangered species in the Study Area.

Special care is necessary in developing water resources in the Study Area so as not to disturb the habitats of these species.

The details of the ecological conditions are presented in Annex 4-2.

4.3 Measures Provided to Protect the Environment

DENR's Administrative Order No. 30, Series of 2003 provides the rules and procedures for the establishment of the Philippine Environmental Impact Statement System. One of the highlights of this administrative order is the stipulation for Environmental Impact Assessment (EIA) that examines the adverse impacts of proposed activity to people, properties, livelihoods, and other projects. Then, mitigation measures are determined and ways to improve the sustainability of the project are recommended.

Concept of integrated water resources management is fundamental to assess impacts of an intervention to develop water resources to secure a reasonable and equitable utilization among stakeholders including all creatures that depend on water resources. The concept envisages a multi-disciplinary approach in water resources management.

CHAPTER 5 DEMAND SIDE STUDY
WATER SUPPLY

5.1 Present Water Use in MWSS Service Area

- Brief History of the Concession Agreement of Water and Sewerage Service in Metro Manila

The state-owned Metropolitan Waterworks and Sewerage System (MWSS) operated the water and sewerage service in Metro Manila until the year 1997. MWSS could only provide water for an average of 16 hours per day to two-thirds of its coverage area. In 1995, former President Ramos pushed the Philippine Congress to pass the National Water Crisis Act, which enabled the private sector to enter into water and sewerage management services in Metro Manila.

For enhancing service competitiveness, the service area was divided into two zones, i.e., the west and east, and service rights were awarded to different concessionaires whose proposals have the lowest tariff level.

The concession agreements for the two areas were signed in 1997, and the service operation was handed over to the concessionaires for 25 years (1997-2023, original period) from MWSS to Maynilad Water Services Inc. (MWSI, West Zone) and Manila Water Company Inc. (MWCI, East Zone).

After the concession started, MWSI (West Zone) nearly went bankrupt in 2002 because of the low tariff rate and the doubled concession fee caused by the depreciation of the Philippine peso against the US dollar as an effect of the Asian Economic Crisis. MWSI and MWSS went through a long arbitration process. Afterwards, the dispute between the GoP (MWSS) and MWSI was resolved after the company was filed under the Corporate Rehabilitation Law, and the parties entered into a Debt and Capital Restructuring Agreement (DCRA). The service was handed back to MWSS in 2005 and MWSS awarded the West Zone concession to the Joint Venture of Metro Pacific Investment Corporation (MPIC) and DMCI Holdings in 2007 again by public bidding.

In contrast, the financial condition of MWCI (East Zone) improved, especially after the year 2002 because of an increase in revenue influenced from tariff rate increase and supply area expansion. Subsequently, MWCI became a publicly listed company in 2005.

In 2009, the concession agreements were extended for another 15 years from 2023 to 2037 to alleviate the increasing tariff rate covering the projected capital investment cost in the future.

5.1.1 Billed Water Volume

The MWSS has entrusted two concessionaires for its water supply operation in its service areas that include Metro Manila as iterated before. The concessionaires treat the raw water, distribute the treated water to the consumers, and bill and collect the tariffs. The records of billing reflect well the water uses in the service areas. The concessionaires classified and recorded the billed water volumes by four categories and made it available to the public. Tables 5.1 to 5.2 present the billed water records.

Table 5.1 Billed Water Volume in the West Zone (MWSI) (unit: million m^3 /year)

Year	Residential	Semi-Business	Commercial	Industrial	Total
2000	167.41	12.74	72.60	19.29	272.04
2001	174.62	14.90	72.26	20.78	282.56
2002	165.31	13.81	66.27	18.75	264.14
2003	162.00	13.00	64.00	16.00	255.00
2004	162.00	16.00	61.00	16.00	255.00
2005	161.00	16.00	59.00	15.00	251.00
2006	174.96	16.61	56.53	14.45	262.55
2007	191.95	19.69	59.55	15.65	286.84
2008	209.34	24.78	63.69	17.38	315.19
2009	238.82	27.48	65.70	18.22	350.24
2010	257.82	30.01	67.23	18.79	373.85
Average	187.75	18.64	64.35	17.30	288.04

Source: Report on the Metro Manila Water Security Study

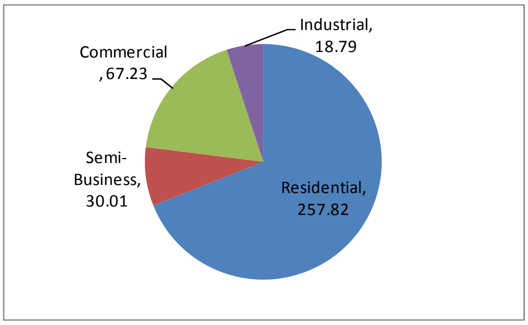
Table 5.2 Billed Water Volume in the East Zone (MWCI) (unit: million m^3 /year)

Year	Residential	Semi-Business	Commercial	Industrial	Total
2000	147.99	6.65	76.59	15.63	246.86
2001	164.85	7.99	78.13	25.35	276.32
2002	171.71	7.71	73.50	16.49	269.41
2003	169.96	15.02	72.90	15.10	272.98
2004	179.60	19.65	76.25	14.24	289.74
2005	196.14	22.29	78.60	18.25	315.28
2006	216.50	24.88	82.66	11.17	335.21
2007	242.09	26.43	94.62	11.15	374.29
2008	258.52	26.75	92.46	9.97	387.70
2009	263.09	30.64	91.06	9.25	394.04
2010	271.96	33.86	91.99	8.94	406.75
Average	207.49	20.17	82.61	14.14	324.42

Source: Report on the Metro Manila Water Security Study

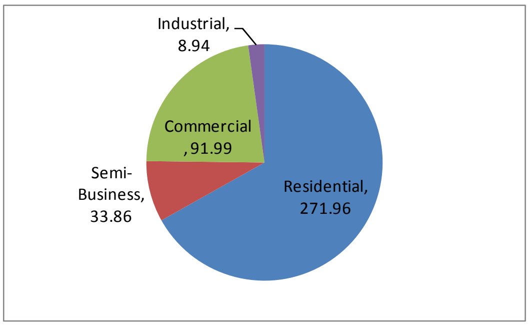
For this demand forecast, the consumed water under the categories of residential and semi-business are for domestic use in general. Meanwhile, the billed water volumes under the commercial or industrial categories are to be classified as non-domestic use.

The shares of domestic use are almost 3/4 of the total consumption both in the East and the West zones. The share of commercial use in the East Zone, which includes Makati City, is larger than that in the West Zone. The following charts present the features of demands in both areas (see Figures 5.1 to 5.2).



Source: MWSS

Figure 5.1 Composition of Tariff Categories in the West Zone in 2010



Source: MWSS

Figure 5.2 Composition of Tariff Categories in the East Zone in 2010

The total billed amount of the MWSS service area in 2000 was 519 million m^3/year. The amount has increased to 781 million m^3/year in 2010. Increase in domestic use is distinctive. The estimated average increase rate is about 5.7% in the ten years from 2000 to 2010.

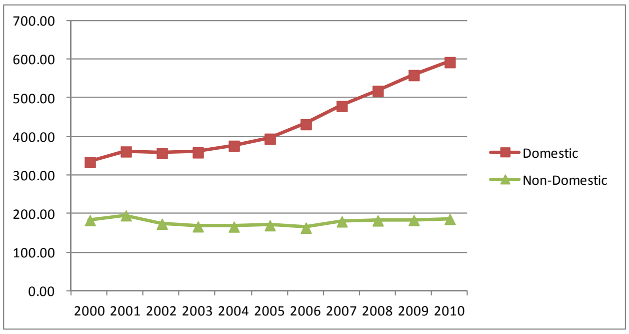
This high rate of increase is attributed to the increase in service ratio for domestic use as well as the increase in population. The decrease in non revenue water (NRW) is the main cause of high rate because the decrease in NRW surely increased the volume of billed water although details of NRW were not clarified by the concessionaires. The existing studies reported that there is no significant change in per capita consumption in these years.

The volume consumed by non-domestic uses is rather constant in general. Although commercial demands demonstrate a slight increasing trend, the decrease in industrial demands has stopped the trend in the period. Table 5.3 and Figure 5.3 demonstrate the historical trends.

Table 5.3 Summary of Billed Volume in the MWSS Service Area

Year	Domestic	Non-Domestic
2000	334.79	184.11
2001	362.36	196.52
2002	358.54	175.01
2003	359.98	168.00
2004	377.25	167.49
2005	395.43	170.85
2006	432.95	164.81
2007	480.16	180.97
2008	519.39	183.50
2009	560.03	184.23
2010	593.65	186.95
Average	434.05	178.40

Source : MWSS



(Unit: million m^3 /year)

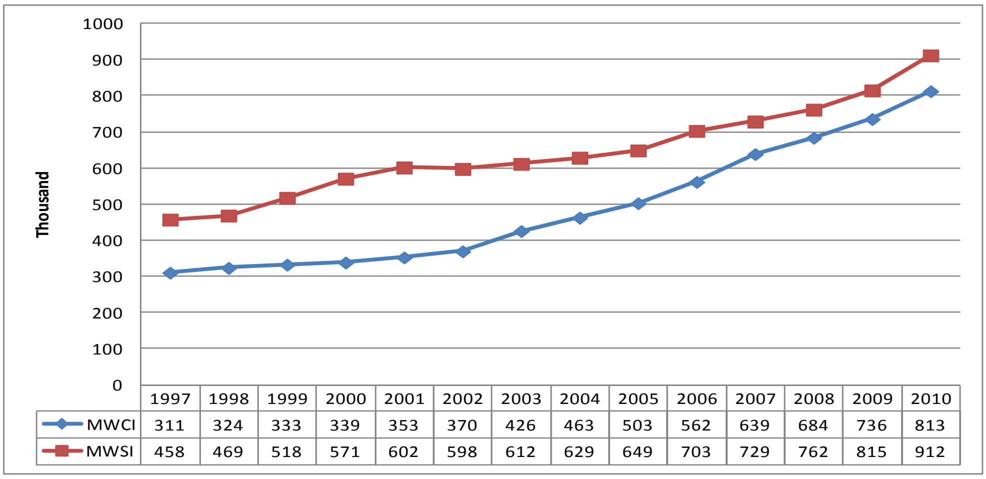
7.5.1 Source: MWSS

Figure 5.3 Historical Trend of Billed Water Volume (million m3 /year)

5.1.2 Number of Connections

Compared with the figure in 1997, the total number of water connections increased by 161%

in the East Zone (MWCI) and 99% in the West Zone (MWSI). The present compositions of domestic connections out of total connections are approximately 94% and 93%, respectively in the East and West zones.



Source: Evaluation on KPIs/BEMs 2012, MWSS

Figure 5.4 Total Number of Water Service Connections

5.1.3 Per Capita Consumption

Based on the figures mentioned above, present daily per capita consumption (lpcd: liter per capita per day) is estimated through the following formula:

lpcd = "(i) daily billed water amount for domestic use"; "(ii) average number of people per domestic connection"; and "(iii) number of domestic connection".

The assumptions applied in the equation above are summarized below.

(i) Daily billed water amount for domestic use:	Figures in Table 5.3
(ii) Average number of people per domestic connection:	8.10 in the East Zone (MWCI) and 7.07 in the West Zone (MWSI) (PAWS report which evaluated the service condition in 2003)
(iii) Number of domestic connection =(iii)-1 x (iii)-2	
(iii)-1 Total connection (Figure 5.4): The sum of (ii) and (iii) represents the served population.	813,000 and 912,000 in the East and West zones, respectively in 2010 as shown in Table 5.4
(iii)-2 Assumed shares of domestic connection:	94% in the East Zone and 93% in the West Zone, number of connections

The average lpcds from 2000 to 2010 are estimated at 156 lpcd in the East Zone and 124 lpcd in the West Zone. Population in Table 5.4 is obtained by (ii) item above.

Table 5.4 Estimation of the Present LPCD in the East Zone (MWCI)

Year	Billed Volume (MCM/year)	Billed Volume (LPD)	Total Connection	Domestic Connection	Population	LPCD (liter/capita /day)
2000	154.64	423,671,233	339,000	318,660	2,581,146	164.14
2001	172.84	473,534,247	353,000	331,820	2,687,742	176.18
2002	179.42	491,561,644	370,000	347,800	2,817,180	174.49
2003	184.98	506,794,521	426,000	400,440	3,243,564	156.25
2004	199.25	545,890,411	463,000	435,220	3,525,282	154.85
2005	218.43	598,438,356	503,000	472,820	3,829,842	156.26
2006	241.38	661,315,068	562,000	528,280	4,279,068	154.55
2007	268.52	735,671,233	639,000	600,660	4,865,346	151.21
2008	285.27	781,561,644	684,000	642,960	5,207,976	150.07
2009	293.73	804,739,726	736,000	691,840	5,603,904	143.60
2010	305.82	837,863,014	813,000	764,220	6,190,182	135.35
Average	-	-	-	-	-	**156.09**

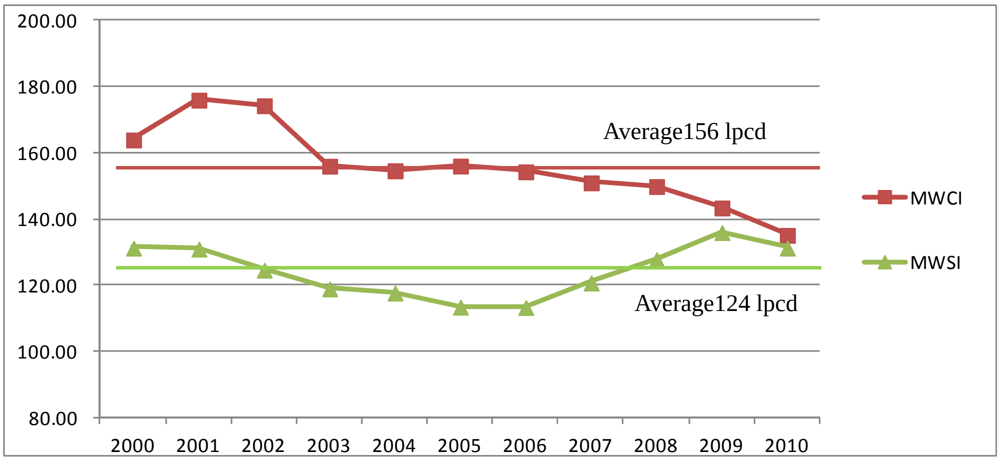
Source: JICA Study Team

Table 5.5 Estimation of Present LPCD in West Area (MWSI)

Year	Billed Volume (MCM/year)	Billed Volume (LPD)	Total Connection	Domestic Connection	Population	LPCD (liter/per capita /day)
2000	180.15	493,561,644	571,000	531,030	3,754,382	131.46
2001	189.52	519,232,877	602,000	559,860	3,958,210	131.18
2002	179.12	490,739,726	598,000	556,140	3,931,910	124.81
2003	175.00	479,452,055	612,000	569,160	4,023,961	119.15
2004	178.00	487,671,233	629,000	584,970	4,135,738	117.92
2005	177.00	484,931,507	649,000	603,570	4,267,240	113.64
2006	191.57	524,849,315	703,000	653,790	4,622,295	113.55
2007	211.64	579,835,616	729,000	677,970	4,793,248	120.97
2008	234.12	641,424,658	762,000	708,660	5,010,226	128.02
2009	266.30	729,589,041	815,000	757,950	5,358,707	136.15
2010	287.83	788,575,342	912,000	848,160	5,996,491	131.51
Average	-	-	-	-	-	**124.40**

Source: JICA Study Team

As presented in Figure 5.5 below, the domestic consumption of water per capita shows a relatively constant trend in both West and East zones during the last ten years.



Source: Report on the Metro Manila Water Security Study

Figure 5.5 Per Capita Consumption in LPCD

5.2 Present Water Use in Adjoining Areas

5.2.1 Water Supply Service Providers

Small water supply providers (WSPs) such as water districts (WD), local government units (LGUs) and Certificate of Public Convenience (CPC) grantees have supplied water to consumers in the adjoining areas of Metro Manila.

Domestic and non-domestic water demands depend on water supplied by relevant water districts in urbanized areas. Meanwhile, LGUs serve water demands in rather small-scale urban areas and in rural areas. There are private consumers who have their own water facilities and being operated by themselves. Those users are classified as CPC grantees. Uses of water supplied by WDs and LGUs are classified as domestic and non-domestic. However, the business scale is small and combined with domestic use. Meanwhile, water use by CPC category is more or less for business use.

There are 55 WDs in the adjoining areas. The WDs in these areas supply piped water to end users (Level 3). The total number of LGUs in the adjoining areas is 181. The main service of LGU is also to provide safe piped water to end users (Level 3) but there are some who supply water through community faucets (Level 1). The NWRB has granted water rights to 883 CPCs in the adjoining areas.

The data compiled by NSO provide the provincial ratio on the main source of drinking water categorized per water service level in 1990 and 2000. Meanwhile, the provincial health offices have undertaken a sample survey on the population who could access the water supply service. The results of the sample survey were used to estimate the existing water service level ratios for each municipality in the Study Area for 2010.

Table 5.6 shows the coverage ratios of Level 3 facilities per province as shown below;

Table 5.6 Coverage Ratio of Level 3 Facility per Province and Increase Ratio

	Provinces	1990			2000			PHO 2010 Level 3 Service coverage	Coverage increase in 20 years (1990-2010)	Estimated coverage increase in 30 years
		Total HH	No. Of HH with Level3	%	Total HH	No. Of HH with Level3	%			
1	Aurora	26,127	4,489	17%	35,024	6,348	18%	30%	13%	20%
2	Batangas	272,116	82,403	30%	374,767	176,512	47%	54%	23%	35%
3	Bulacan	287,890	77,839	27%	463,886	187,200	40%	61%	34%	51%
4	Cavite	222,151	77,343	35%	428,879	198,482	46%	79%	44%	67%
5	Laguna	269,342	100,427	37%	417,932	185,307	44%	53%	16%	24%
6	N. Ecija	250,978	38,849	15%	340,158	61,300	18%	26%	10%	15%
7	Nueva Viscaya	58,558	4,991	9%	74,402	11,347	15%	*		20%
8	Pampanga	268,007	73,665	27%	307,639	83,675	27%	35%	8%	12%
9	Pangasinan	366,908	54,684	15%	477,819	77,026	16%	*		4%
10	Quezon	265,762	45,011	17%	299,662	55,849	19%	29%	12%	19%
11	Rizal	189,190	58,858	31%	356,578	110,246	31%	81%	50%	76%
12	Tarlac	159,344	25,091	16%	215,395	42,787	20%	26%	10%	15%
	Total	**2,636,373**	**643,650**	**24%**	**3,792,141**	**1,196,079**	**32%**			

* The estimated Level 3 service coverage is lower than in 2000. The increase from 1990 to 2000 was considered instead.
Source: JICA Study Team

Figures in the table present the trend of Level 3 coverage ratios against the total provincial population from year 1990 to 2010.

5.2.2 Per Capita Consumption

Measured per capita consumption for Levels 1 and 2 are not available in the adjoining areas. However, the DPWH design standards for rural water supply projects are available and considered to reflect the actual consumption. Per capita consumption for Levels 1 and 2 are thus assumed to be 30 lpcd and 60 lpcd, respectively. The unit consumptions are supposed to be constant in recent years.

The WD data list published by LWUA is available to estimate the per capita consumption in the case of LGUs with WD. The details of the data are presented in Annex 5.2. For LGUs without WD, the provincial average of WDs in the Study Area is adopted. For a province without any WD (Aurora, Nueva Vizcaya), 120 lpcd is used as the base year consumption.

Table 5.7 shows the average lpcd per province.

Table 5.7 Unit Water Demand for Domestic Use (lpcd: liter/capita/day)

	Province	2010	2011	2012	2015	2020	2025	2030	2035	2040
1	AURORA (part)	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
2	BATANGAS (part)	132.9	133.5	134.2	136.2	139.7	143.2	146.8	150.5	154.3
3	BULACAN	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
4	CAVITE (part)	139.8	140.3	140.8	142.3	144.9	147.6	150.3	153.0	155.9
5	LAGUNA	133.1	133.8	134.4	136.3	139.6	143.0	146.4	150.0	153.6
6	NUEVA ECIJA	121.2	121.8	122.3	124.1	127.1	130.1	133.3	136.5	139.8
7	NUEVA VIZCAYA (part)	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
8	PAMPANGA	137.4	138.1	138.8	140.9	144.4	148.1	151.8	155.6	159.6
9	PANGASINAN (part)	112.7	113.2	113.8	115.5	118.4	121.4	124.5	127.6	130.9
10	QUEZON (Part)	97.6	98.1	98.6	100.1	102.6	105.2	107.8	110.5	113.3
11	TARLAC (part)	111.2	111.7	112.3	114.0	116.9	119.8	122.8	125.9	129.1

Note: The above figures are the average of municipalities located in the Study Area
Source: JICA Study Team

5.2.3 Non-domestic Consumption

Non-domestic demand includes consumptions in commercial areas, government offices, industrial, and recreation uses.

Preliminary estimate of non-domestic water demand is based on the water permits granted by NWRB. According to the CPCs list obtained from NWRB, there are 883 CPCs existing in the Study Area as mentioned above. Actual operation data is unavailable, therefore, non-domestic water demand is assumed to be equal to the current granted water rights. The granted water rights of whole CPCs are categorized into six river basins after recognizing its location.

The whole amount per basin and water source type is summarized in Table 5.8. Approximately, two thirds of whole consumption is derived from the surface water coming from Laguna Lake.

Water districts (WDs) of respective LGUs supply non-domestic water uses as well. The data supplied by 55 WDs as obtained from the LWUA homepage were used for analyses. Generally, surface water is not used in rural areas in the Philippines, and the source of water supplied by WDs is assumed to be coming from groundwater. The NRW rate applied to domestic demand (35% in 2012, 25% in 2040) was also applied to the non-domestic demand of WDs. The estimated amount became much smaller compared with the above predicted consumption of CPCs.

Table 5.8 shows the present non-domestic demand of CPCs and WDs calculated per river basin.

Table 5.8 Estimated Non-domestic Use

River Basin		Granted Water Right for Non-Domestic Use				Non-domestic Use of Existing WDs	Total
		Surface Water		Underground Water			
		l/s	m^3/s	l/s	m^3/s	m^3/s	m^3/s
1	Angat	22.47	0.02	336.44	0.34	0.09	0.45
2	Pampanga	1,391.30	1.39	2,663.01	2.66	0.14	4.19
	- PAM-1	95.00	0.10	194.42	0.19	0.00	0.29
	- PAM-2	965.00	0.97	30.48	0.03	0.01	1.01
	- PAM-3	0.00	0.00	844.27	0.84	0.00	0.84
	- PAM-4	166.00	0.17	36.61	0.04	0.04	0.25
	- PAM-5	60.26	0.06	1.13	0.00	0.00	0.06
	- COR	0.00	0.00	0.00	0.00	0.00	0.00
	- PAN	25.00	0.03	237.74	0.24	0.00	0.27
	- RCH	4.00	0.00	900.19	0.90	0.04	0.94
	- PEN	0.00	0.00	0.00	0.00	0.00	0.00
	- PAS	76.04	0.08	418.17	0.42	0.06	0.56
3	Agos	553.00	0.55	105.79	0.11	0.00	0.66
4	Umiray	0.00	0.00	0.00	0.00	0.01	0.01
5	Pasig-Marikina	242.75	0.24	757.20	0.76	0.01	1.01
6	Laguna*	3,493.89	3.49	3,281.54	3.28	0.47	7.24
	Total	5,703.41	5.69	7,143.98	7.15	0.72	13.56

* Water rights granted to LDDA (for fisheries) and Sierra Madre Water Corporation (service not started) are excluded from the amount in the Laguna River basin.
Source: JICA Study Team (as of March 2012)

5.3 Summary of Water Demand Projections in the MWSS Service Area (by the UP-NEC and World Bank Study)

The University of the Philippines, National Engineering Center (UP-NEC) study, which was completed in September 2011, has projected water demand in the MWSS service area. The purpose of this study is to provide the basic data of water demand projection for the processing of tariff rebasing among the MWSS and two concessionaires.

The Metro Manila Water Security Study (World Bank Study), completed in July 2012, projected water demands in the service areas of the MWSS to prepare the roadmap of water resource development plan towards 2040. Based on the reasons mentioned above, both studies are recognized as quite important. In addition to the above studies, the JICA Study Team also conducted the demand projection to confirm the results.

The following table presents the assumptions adopted in these projections;

Table 5.9 Comparison of Assumptions for Demand Projection

		UP-NEC	World Bank Study	JICA Study
Published Date		September 2011	February 2012	March 2012
Methodology		i) Sectoral analysis and ii) Spatial analysis	Sectoral analysis	Sectoral analysis
Domestic Consumption	Base Data	Population data of NSO 2007	Population data of NSO 2007	Population data of NSO 2007
	lpcd (l/capita/day)	East 151, West 125 lpcd in average of respective data of municipalities based on the study in 2011.	i) 150 (East 143, West 155) based on the actual water consumption from 2000 to 2010. *1 ii) 138 based on the weighted mean of UP-NEC	East 156 lpcd, West 124 lpcd based on the actual consumption and number of domestic connections from 2000 to 2010.
	Increase Rate of lpcd	Constant (0%)	Constant (0%)	i) Constant (0%) ii) Increase of 0.5 lpcd per year
Non-domestic Consumption	Base Data	Actual consumption amount in 2010	Actual consumption amount from 2000 to 2010	Actual consumption amount from 2000 to 2010
	Increase Rate	5.3% based on the past record	i) Constant(0%, historical consumption data) ii) 4.0% (GDP growth rate)	Constant(0%, historical consumption data)
Other Assumptions	Coverage Rate	Target rate of each concessionaire	Target rate of each concessionaire based on the first tariff rebasing in 2008	Target rate of each concessionaire based on the tariff rebasing process in 2012
	NRW Rate	Target rate of each concessionaire	Target rate of each concessionaire based on the first tariff rebasing in 2008	i) Target rate of each concessionaire based on the tariff rebasing process in 2012, ii) 50% improvement of NRW rate of the target figure since 2012
	Buffer	15% to 30% under negotiation with concessionaires (Daily fluctuation and El Nino influence)	10% (for loss of raw water transmission and water treatment)	10% (for loss of raw water transmission and water treatment)

*1 The JICA Study Team could not reaffirm the lpcd number calculated in the World Bank report as the assumptions ares unclear as well as the numbers described in Table 8.4.

Source: JICA Study Team

The results of projections are summarized in the following table;

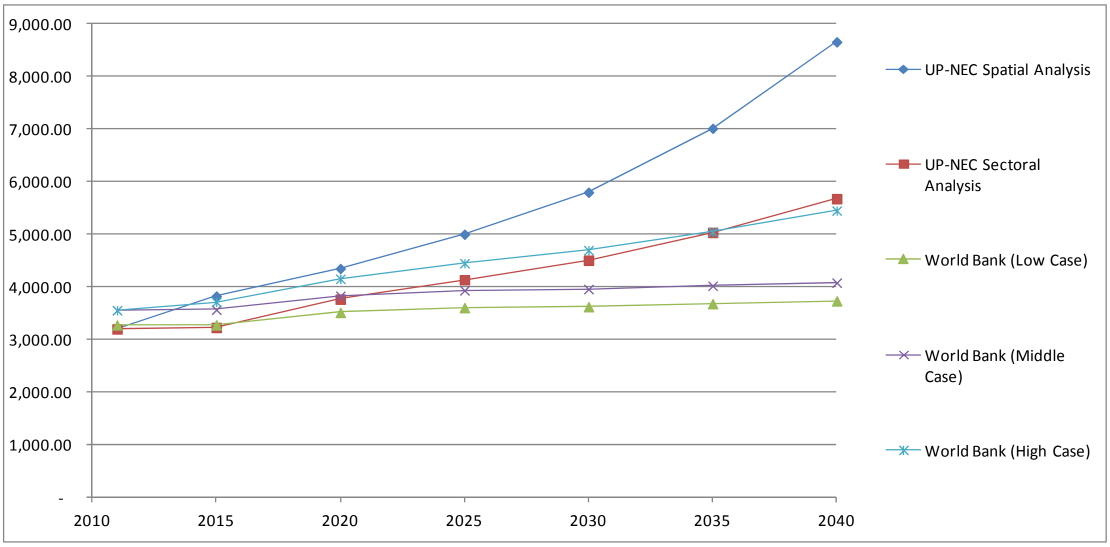
Table 5.10 Water Demand Projections by UP-NEC and World Bank Study (MLD)

Year	2011	2015	2020	2025	2030	2035	2037
UP-NEC Spatial	3,213.00	3,828.00	4,351.00	5,002.00	5,800.00	7,014.00	8,658.35
UP-NEC Sectoral	3,202.00	3,231.00	3,768.00	4,138.00	4,508.00	5,036.00	5,678.78
WB (low case) *	3,278.54	3,279.09	3,517.27	3,606.36	3,626.36	3,682.73	3,735.22
WB (middle case) *	3,557.82	3,567.27	3,833.64	3,935.45	3,960.00	4,022.73	4,082.08
WB (high case) *	3,557.82	3,715.45	4,154.55	4,450.91	4,699.09	5,049.09	5,451.51

*The buffer ratio (10% of total demand) is excluded from the figures.

Source: JICA Study Team

The following Figure 5.6 demonstrates the different projections and assumed scenarios.



Source: JICA Study Team

Figure 5.6 Comparison of Demand Projection by UP-NEC and World Bank Study

Regarding the UP-NEC study, two simulations were made 1) Sectoral analysis and ii) Spatial analysis. The sectoral analysis projected the demands on the basis of real consumption data, while the spatial analysis projected the future land use in the MWSS service area. In conclusion, the result of sectoral analysis is recognized to be more realistic than the spatial analysis as the demand is based on the real consumption especially for short term forecast until 2031.

In the report of the Metro Manila Water Security Study, three alternative cases were simulated based on the assumed per capita consumption and the annual increase rate at 3% of non-domestic demand. Conclusively, the "middle case result" is considered to be the most probable among the three alternative cases, because the future trend is predicted by the real billed water amount.

Both studies recommended reviewing the demand forecast at least every five years to update the latest condition.

5.4 Water Demand Projection in the MWSS Service Area (by the JICA Study Team)

5.4.1 Projection of the Domestic Water Demand

(1) Assumptions and Result of the Base Case Projection

The domestic water demand is calculated using the following formula:

Domestic Water Demand (MLD)
= "Population" x "Coverage Ratio" x "Daily Consumption per Capita" / (1- "NRW Ratio")

The conditions and assumptions applied to the formula are summarized below.

<u>Population:</u> Population is presented in Section 3.2. The summary of the total population in the MWSS service area is shown in Table 5.11.

Table 5.11 Population Projection in the MWSS Service Area

	2010	2015	2020	2025	2030	2035	2040
West	9,203,882	9,829,182	10,380,518	10,855,275	11,247,921	11,539,073	11,716,258
East	6,479,921	6,962,175	7,392,551	7,768,943	8,084,300	8,325,824	8,486,621
Total	**15,683,803**	**16,791,357**	**17,773,069**	**18,624,217**	**19,332,221**	**19,864,896**	**20,202,879**

Source: JICA Study Team

Daily domestic consumption per capita: Daily domestic consumption per capita is assumed to be 156 lpcd and 124 lpcd in the East and West service zones as estimated in Chapter 5.1.3.

Coverage Ratio and NRW Ratio: The target number of i) coverage ratio and ii) NRW ratio which are set by MWSS and the two concessionaires are adopted for the projection. The figures are decided after a precise evaluation from the technical and financial points of view under the tariff rebasing process done every five years. The achievement of the said target number is being monitored by the MWSS every month during the concession period, whereas, the two concessionaires may be penalized if the target is not met. Hence, said figures reflect the most reliable service condition.

Table 5.12 Target Figure of Coverage Ratio in the MWSS Service Area

	2010	2015	2020	2025	2030	2035	2040
West	89.0%	96.0%	98.0%	99.0%	100.0%	100.0%	100.0%
East	73.0%	81.0%	92.0%	98.0%	100.0%	100.0%	100.0%

Source: MWSS

Table 5.13 Target Figure of NRW Ratio in the MWSS Service Area

	2010	2015	2020	2025	2030	2035	2040
West	43.0%	34.0%	25.0%	20.0%	20.0%	20.0%	20.0%
East	15.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%

* The target figures of the latest business plan agreed by MWSS and the two concessionaires are used as of September 2012.
Source: MWSS

The demand forecast is indicated in the table below.

Table 5.14 Projection of Domestic Water Demand in the MWSS Service Area under Base Case

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
West	1,782	1,773	1,682	1,666	1,743	1,789	1,816
East	868	1,000	1,206	1,350	1,433	1,476	1,504
Total	**2,650**	**2,773**	**2,888**	**3,016**	**3,176**	**3,265**	**3,320**

Source: JICA Study Team

(2) Demand Projection in Alternative Cases

In addition to the above demand forecast, the JICA Study Team projected the demand under three alternative cases in order to prepare for the risk in case of demand increase.

Alternative Case 1 is when lpcd increases slightly in accordance with the living level improvement. Alternative Case 2 is a scenario where the improvement of NRW ratio in the West Zone is delayed due to financial or management problems. Alternative Case 3 (high demand case) is when the previous two cases happen simultaneously.

The assumptions of each case are described below.

Alternative Case 1 (lpcd increase)

Regarding Figure 5.5, there is a constant trend of LPCD shows constant. However, there is the uncertainty in the reliability of the said figure especially in the recent years.

In addition, the lpcd amount is known to be increasing in developing country with an approximate amount up to 180 along with the improvement of the living environment, in general.

Regarding the above conditions, this Study simulated the demand forecast in case the lpcd is slightly increasing at 0.5 lpcd each year. The lpcd becomes 139 (West) and 171 (East) in 2040 based on the assumption.

Table 5.15 Per Capita Consumption of Alternative Case 1 (lpcd Increase)

(Unit: lpcd)

	2010	2015	2020	2025	2030	2035	2040
West	124.0	126.5	129.0	131.5	134.0	136.5	139.0
East	156.0	158.5	161.0	163.5	166.0	168.5	171.0

Source: JICA Study Team

Table 5.16 Projection of Domestic Water Demand under Alternative Case 1 (lpcd Increase)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
West	1,782	1,809	1,750	1,766	1,884	1,969	2,036
East	868	1,016	1,244	1,415	1,525	1,594	1,649
Total	**2,650**	**2,824**	**2,994**	**3,181**	**3,409**	**3,563**	**3,685**

Source: JICA Study Team

Alternative Case 2 (Delay in NRW Reduction)

As the historical trend of NRW rate is shown in Figure 7.3.4, NRW ratio in the East Zone improved rapidly from 51% in 2003 to 13% in 2010. The MWSS expected the MWSI to reduce the NRW similar to MWCI achievement. However, the service area of MWSI is located in the old city, and hence, the pipe exchange construction is more difficult and costly. The NRW rate will retain higher than expected. Taking these conditions under consideration, the JICA Study Team ought to notice the risk when the improvement of NRW ratio in the West Zone incurs delays.

The NRW ratio in the West Zone is assumed to be 5% higher than planned. The figures are as follows:

Table 5.17 NRW Ratio of Alternative Case 2 (Delay in NRW Reduction)

	2010	2015	2020	2025	2030	2035	2040
Base Case	43.0%	34.0%	25.0%	20.0%	21.0%	20.0%	20.0%
Alt. Case 2	43.0%	39.0%	30.0%	25.0%	25.0%	25.0%	25.0%

Source: JICA Study Team

Table 5.18 Projection of Domestic Water Demand under Alternative Case 2 (Delay in NRW Reduction)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
West	1,782	1,918	1,802	1,777	1,860	1,908	1,937
East	868	1,000	1,206	1,350	1,433	1,476	1,504
Total	**2,650**	**2,918**	**3,008**	**3,127**	**3,293**	**3,384**	**3,442**

Source: JICA Study Team

Alternative Case 3 (High Demand Case)

If the "lpcd increases (Case 1)" and a "delay of NRW improvement (Case 2)" happen simultaneously, there is an demand projection becomes highest as shown in Table 5.19.

Table 5.19 Projection of Domestic Water Demand under Alternative Case 3

(High Demand Case)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
West	1,782	1,957	1,875	1,884	2,010	2,100	2,171
East	868	1,016	1,244	1,415	1,525	1,594	1,649
Total	**2,650**	**2,973**	**3,119**	**3,299**	**3,535**	**3,694**	**3,821**

Source : JICA Study Team

5.4.2 Projection of Non-domestic Water Demand

The non-domestic water demand is calculated by using a simpler method as defined in the following formula:

Non-Domestic Water Demand
= "Present Consumption Amount (as of 2010)" x (1 + "Annual Increase Ratio") ^{n}
where,
n: Number of years spent after 2010

Present non-domestic consumption amount is indicated in Table 5.3. As evaluated in Figure 5.3, the historical trend of non-domestic consumption is kept stable for the last ten years. Therefore, the increase rate is basically set at 0% for the projection. The estimation of the increase rate at 4.0% is calculated reflecting the average gross regional domestic product (GRDP) of 3.0%–5.1% in the Study Area. (Refer to Table 3.4)

Table 5.20 Projection of Non-Domestic Water Demand (0% Increase)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
West	276.5	276.5	276.5	276.5	276.5	276.5	276.5
East	235.7	235.7	235.7	235.7	235.7	235.7	235.7
Total	**512.2**	**512.2**	**512.2**	**512.2**	**512.2**	**512.2**	**512.2**

Source: JICA Study Team

Table 5.21 Projection of Non-Domestic Water Demand (4% Increase)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
West	276.5	336.4	409.3	498.0	605.9	737.2	896.9
East	235.7	286.8	348.9	424.5	516.5	628.4	764.5
Total	**512.2**	**623.2**	**758.2**	**922.5**	**1122.4**	**1365.6**	**1661.4**

Source: JICA Study Team

Table 5.22 Combined NRW Rate of Two Zones

	2010	2015	2020	2025	2030	2035	2040
NRW Rate in West	43.0%	34.0%	25.0%	20.0%	20.0%	20.0%	20.0%
NRW Rate in East	15.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Combined NRW Rate *	32.8%	25.4%	19.5%	16.5%	16.5%	16.5%	16.5%

* The composition of West and East zones is based on the actual billed volume of non-domestic water in 2010.
Source: JICA Study Team

As influenced by the NRW ratio of each year, the demand forecast of non-domestic consumption is indicated in Table 5.23.

Table 5.23 Projection of Non-Domestic Water Demand (NRW included)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
Total of 0% Increase	762.4	686.7	636.5	613.4	613.4	613.4	613.4
Total of 4% Increase	762.4	835.6	942.2	1104.9	1344.3	1635.6	1989.9

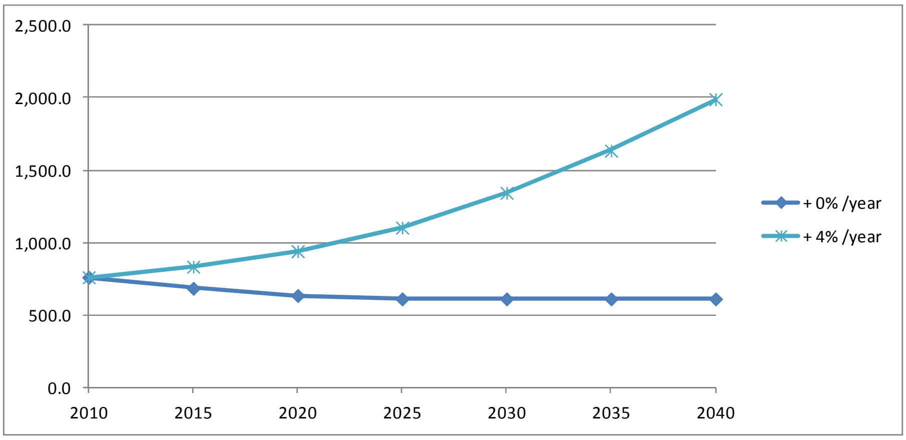


Figure 5.7 Projection of Non-Domestic Water Demand (NRW included)

5.4.3 Projection of Total Water Demand

(1) Total Water Demand

Combining the domestic water demand with non-domestic water demand, the total water demand results are presented in Table 5.24 and Figure 5.8. Total domestic consumption is estimated using four different cases. The increase ratio of non-domestic water consumption is assumed at 0% as the actual billed volume does not show the increasing trend.

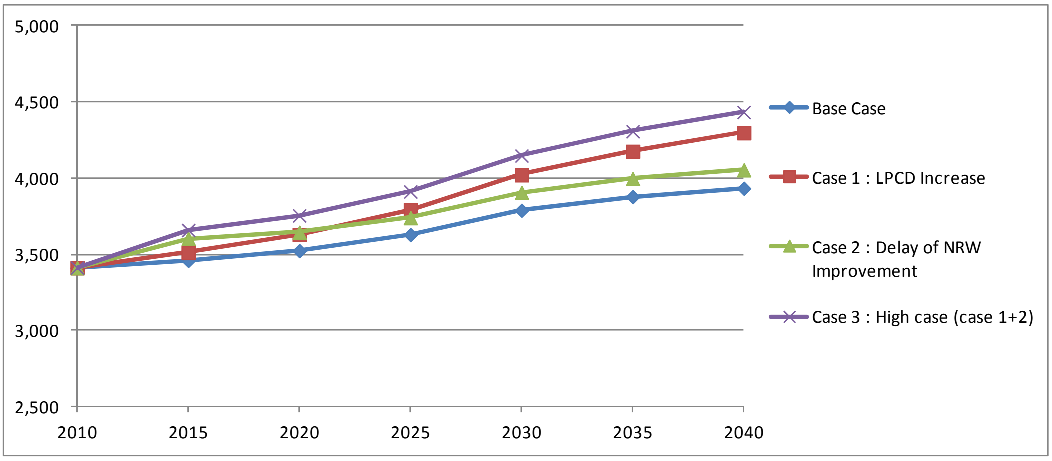
The impact of demand increase by Alternative Case 1 (annual lpcd increase at 0.5 liters per capita) and Alternative Case 2 (delay of NRW rate reduction) becomes similar until 2025. The influence on the total demand in 2040 will be 365 MLD (+9.3%) and 121 MLD (+3.0%). In the high demand case, the lpcd increase and delay of NRW reduction happened simultaneously, the total demand increases to 500 MLD (+12.5%).

Table 5.24 Total Water Demand Projection in the MWSS Service Area

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
Base Case	3,412	3,460	3,525	3,629	3,789	3,878	3,933
Case 1 : LPCD Increase	3,412	3,512	3,631	3,794	4,022	4,176	4,298
Case 2 : Delay of NRW Rate Reduction	3,412	3,605	3,645	3,740	3,906	3,997	4,054
Case 3 : High case	3,412	3,660	3,756	3,912	4,148	4,307	4,433

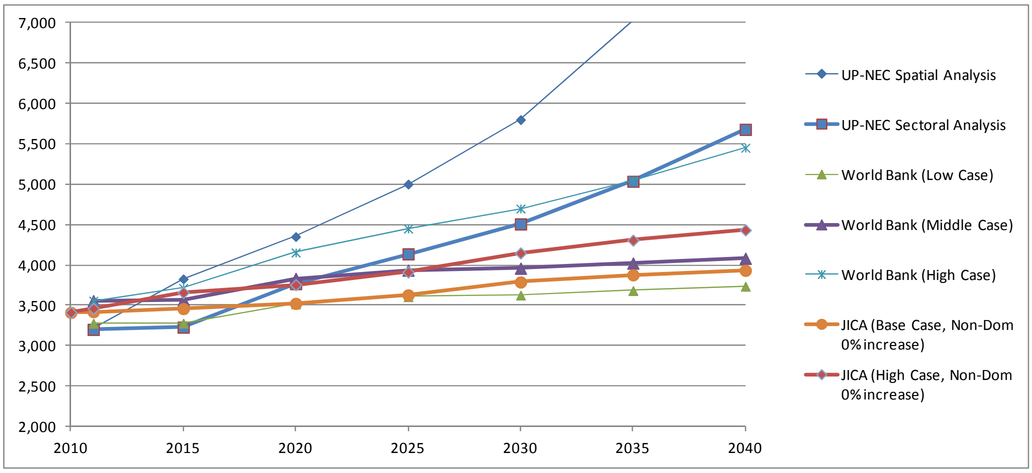
Source: JICA Study Team



Source: JICA Study Team

Figure 5.8 Projection of Total Water Demand in the MWSS Service Area

The projection of the base case and high demand case made by the JICA Study Team is compared with other projections made by the UP-NEC and World Bank studies. The whole figures do not include the buffer water amount which is generally added to absorb the fluctuation of daily demand and operational water loss under treatment process.



Source: JICA Study Team

Figure 5.9 Comparison of Total Water Demand Projection in the MWSS Service Area

(2) Buffer

The buffer rate is added to the above predicted total demand. The definition of buffer differs from the World Bank Study and UP-NEC.

The buffer ratio at 10% is added in the World Bank study as it is defined as the amount for pure "loss of raw water transmission and water treatment". Whereas, the buffer in UP-NEC study is set at 15%–30% in the latest business plan submitted to the MWSS from two concessionaires in March 2012, which is defined as "the fluctuation of daily use and retainment of water security". As the MWSS and two concessionaires used the result of UP-NEC study under the tariff rebasing process, the buffer rate is treated more seriously as it influences significantly the future tariff level and the business profitability.

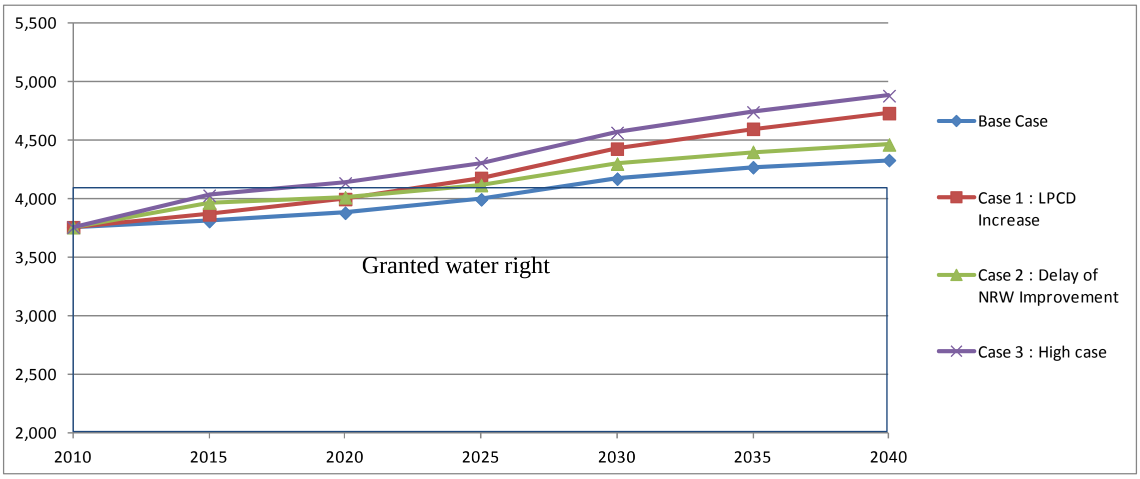
For JICA study, 10% of total consumption is adopted as the buffer rate same as the World Bank study because the definition is simpler and more reasonable for the actual demand estimation of raw water. Including the buffer amount, the total water demand is predicted as follows;

Table 5.25 Total Water Demand in the MWSS Service Area (with buffer)

(Unit: million liters per day)

	2010	2015	2020	2025	2030	2035	2040
Base Case	3,754	3,806	3,877	3,992	4,168	4,266	4,327
Case 1 : LPCD Increase	3,754	3,863	3,994	4,174	4,425	4,594	4,728
Case 2 : Delay of NRW Improvement	3,754	3,965	4,009	4,114	4,297	4,397	4,460
Case 3 : High case	3,754	4,026	4,131	4,304	4,563	4,738	4,877

Source: JICA Study Team



Source: JICA Study Team

Figure 5.10 Projection of Total Water Demand in the MWSS Service Area (with buffer)

5.5 Water Demand Projection in the Adjoining Areas

5.5.1 Coverage of Water Supply

The actual coverage ratios of Levels 1, 2, and 3 facilities against total relevant municipality population in the Study Area in 2010 are estimated on the basis of the surveyed data by PHO for each province. The following table presents the estimated coverage ratios together with the projected coverage ratios towards 2040.

The Level 3 service coverage of each municipality is assumed to increase in line with the provincial ratio of increases in 30 years (2010-2040). Correspondingly, Level 2 is assumed to be upgraded to Level 3 relative to the increase in Level 3 service area. Then, the Level 1 projected ratio will consequently be adjusted relative to the Levels 3 and 2 service coverage. Table 5.26 shows the summary of the average water level service ratio per province. Annex 5.1 shows the water service level of each municipality.

Table 5.26 Service Coverage Projection of Levels 1, 2, and 3 Facility in the Study Area

	Provice	2010			2020			2030			2040		
		lv1	lv2	lv3	lv1	lv2	lv3	lv1	lv2	lv3	lv1	lv2	lv3
1	AURORA (part)	19%	0%	81%	16%	0%	84%	13%	0%	87%	9%	0%	91%
2	BATANGAS (part)	20%	4%	76%	18%	0%	82%	12%	0%	88%	6%	0%	94%
3	BULACAN	34%	0%	66%	24%	0%	76%	14%	0%	86%	4%	0%	96%
4	CAVITE (part)	1%	3%	96%	1%	2%	98%	1%	1%	99%	0%	0%	100%
5	LAGUNA	35%	14%	51%	32%	10%	58%	28%	6%	65%	24%	4%	73%
6	NUEVA ECIJA	67%	9%	24%	64%	6%	29%	61%	5%	34%	57%	4%	39%
7	NUEVA VIZCAYA (part)	43%	36%	21%	41%	31%	28%	40%	25%	35%	39%	20%	41%
8	PAMPANGA	61%	4%	35%	58%	3%	39%	54%	2%	43%	51%	2%	47%
9	PANGASINAN (part)	93%	0%	7%	91%	0%	9%	90%	0%	10%	89%	0%	11%
10	QUEZON (Part)	20%	21%	59%	20%	17%	64%	18%	14%	68%	16%	11%	73%
11	TARLAC (part)	81%	0%	19%	76%	0%	24%	71%	0%	29%	66%	0%	34%

Note: The above figures are the average of municipalities located in the Study Area
Source: Study Team

5.5.2 Per Capita Consumption

Per capita consumption is calculated based on the average water usage for each level.

<u>Levels 1 and 2</u>

As mentioned before, the per capita daily consumptions of 30 lpcd and 60 lpcd were assumed for Levels 1 and 2, respectively, in line with the design standards of DPWH. So far, there are no reasons to modify the figures and the per capita daily consumption rates are assumed to be constant up to 2040.

<u>Level 3</u>

As mentioned before, WD data list prepared by LWUA is used to estimate per capita water consumption for each WD. The provincial average of per capita water consumption of WDs in the Study Area is assumed for the per capita consumption of LGUs where no WD is established. In the case of a province without any WD (Aurora, Nueva Vizcaya), 120 lpcd was adopted as the base year consumption.

The LWUA recommended the increase rate of lpcd at 1% per year in its guideline for demand forecast of WDs. JICA Study adopted the rate of 1% per year if the lpcd is below 100 and 0.5% per year if the lpcd is 100 and above because there is a case of 1% growth rate increase per capita consumption as high as more than 125 lpcd which is the assumed figure for Metro Manila.

Table 5.27 shows the average lpcd per province and Annex 5.2 shows the lpcd of each municipality.

Table 5.27 Unit Water Demand for Domestic Use (lpcd)

	Province	2010	2011	2012	2015	2020	2025	2030	2035	2040
1	AURORA (part)	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
2	BATANGAS (part)	132.9	133.5	134.2	136.2	139.7	143.2	146.8	150.5	154.3
3	BULACAN	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
4	CAVITE (part)	139.8	140.3	140.8	142.3	144.9	147.6	150.3	153.0	155.9
5	LAGUNA	133.1	133.8	134.4	136.3	139.6	143.0	146.4	150.0	153.6
6	NUEVA ECIJA	121.2	121.8	122.3	124.1	127.1	130.1	133.3	136.5	139.8
7	NUEVA VIZCAYA (part)	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
8	PAMPANGA	137.4	138.1	138.8	140.9	144.4	148.1	151.8	155.6	159.6
9	PANGASINAN (part)	112.7	113.2	113.8	115.5	118.4	121.4	124.5	127.6	130.9
10	QUEZON (Part)	97.6	98.1	98.6	100.1	102.6	105.2	107.8	110.5	113.3
11	TARLAC (part)	111.2	111.7	112.3	114.0	116.9	119.8	122.8	125.9	129.1

Source: JICA Study Team

5.5.3 Non-Revenue Water (NRW)

The NRW is another form of water consumption. According to LWUA, in most cases, NRW is generated from pipe leakages, unmetered connections, unregistered users, and other forms of water loss. NRW is necessary to be accounted in the demand projection.

The estimated NRW ratio is 35% at present. The ratio is assumed to decrease by 25% in 2040 considering an improved operation and maintenance in the system.

5.5.4 Projection of Domestic Water Demand

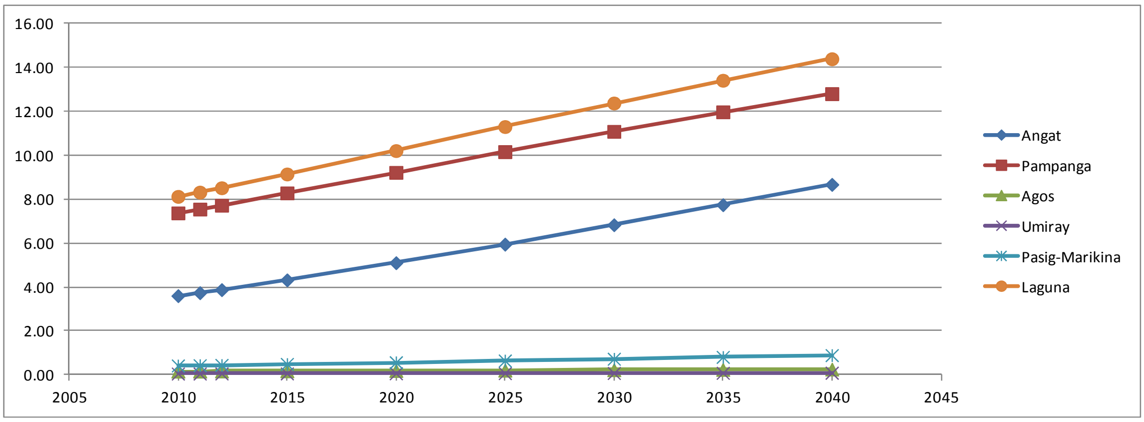
Based on the above assumptions and projected population in Table 3.3, the domestic demand is calculated, as shown in Table 5.28. Water source in a river basin could meet the demand therein and no transbasin water supply is conceivable in the adjoining areas. The consumption of Laguna, Pampanga and Angat River basins shows higher amount reflecting the high population figures. The projected water demand of each municipality is indicated in Annex 5.3.

Table 5.28 Projection of Domestic Water Demand in Adjoining Areas per River Basin

(Unit: m^3/s)

	2010	2015	2020	2025	2030	2035	2040
Angat	3.87	4.32	5.10	5.94	6.83	7.74	8.67
Pampanga	7.72	8.28	9.22	10.16	11.09	11.97	12.80
Pampanga (PAM-1)	0.85	0.91	1.03	1.14	1.25	1.36	1.46
Pampanga (PAM-2)	0.65	0.73	0.87	1.02	1.19	1.35	1.53
Pampanga (PAM-3)	0.10	0.11	0.12	0.14	0.15	0.17	0.18
Pampanga (PAM-4)	1.00	1.06	1.14	1.23	1.30	1.37	1.43
Pampanga (PAM-5)	0.02	0.02	0.03	0.03	0.04	0.04	0.05
Pampanga (COR)	0.14	0.15	0.16	0.18	0.19	0.21	0.23
Pampanga (PAN)	0.21	0.22	0.25	0.28	0.30	0.33	0.36
Pampanga (RCH)	2.26	2.42	2.69	2.96	3.22	3.47	3.70
Pampanga (PEN)	0.04	0.05	0.05	0.05	0.06	0.06	0.07
Pampanga (PAS)	2.44	2.60	2.86	3.13	3.38	3.62	3.83
Agos	0.16	0.17	0.19	0.20	0.22	0.24	0.25
Umiray	0.05	0.06	0.06	0.07	0.07	0.08	0.09
Pasig-Marikina	0.44	0.49	0.56	0.64	0.72	0.81	0.89
Laguna	8.51	9.14	10.21	11.30	12.38	13.41	14.39
Total	20.76	22.45	25.34	28.32	31.31	34.25	37.09

Source: JICA Study Team



Source: JICA Study Team

Figure 5.11 Projection of Domestic Water Demand in the Adjoining Areas per River Basin

5.5.5 Projection of Non-domestic Water Demand

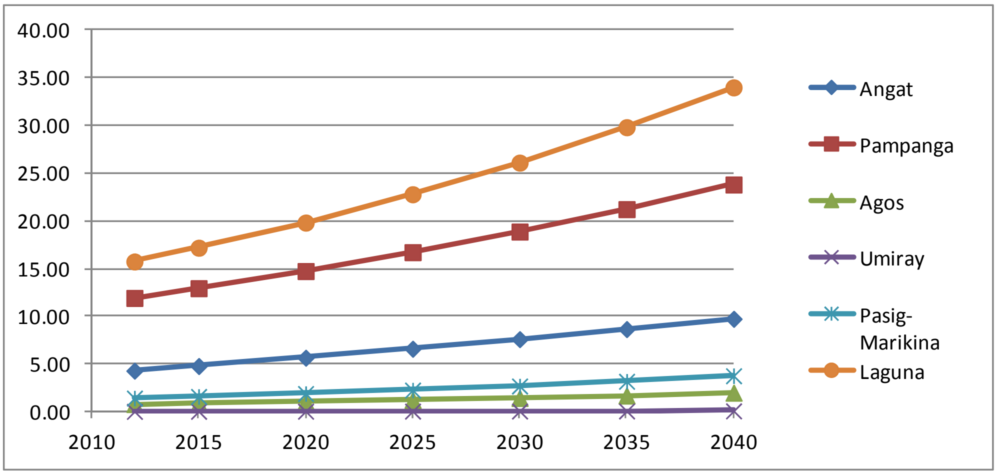
The future water demand is projected assuming that the consumption increases along with the increase in GRDP which vary from 3.0% to 5.1% in the Study Area as shown in Table 3.4. The following table demonstrates the results of demand projection per river basin;

Table 5.29 Projection of Non-domestic Water Demand in the Adjoining Areas per River Basin

(Unit: m^3/s)

	Average Increase Rate	2012	2015	2020	2025	2030	2035	2040
Angat	**3.20%**	**0.45**	**0.49**	**0.58**	**0.68**	**0.79**	**0.93**	**1.09**
Pampanga	**3.55%**	**4.22**	**4.67**	**5.54**	**6.57**	**7.80**	**9.26**	**11.01**
Pampanga (PAM-1)	3.20%	0.29	0.32	0.37	0.44	0.51	0.60	0.70
Pampanga (PAM-2)	3.22%	1.01	1.11	1.30	1.52	1.79	2.09	2.45
Pampanga (PAM-3)	3.20%	0.84	0.92	1.08	1.27	1.48	1.73	2.03
Pampanga (PAM-4)	3.57%	0.25	0.28	0.33	0.39	0.47	0.56	0.67
Pampanga (PAM-5)	3.60%	0.06	0.07	0.08	0.10	0.11	0.14	0.16
Pampanga (COR)	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pampanga (PAN)	5.06%	0.27	0.31	0.40	0.51	0.66	0.84	1.08
Pampanga (RCH)	3.55%	0.94	1.04	1.24	1.48	1.76	2.10	2.50
Pampanga (PEN)	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pampanga (PAS)	3.39%	0.56	0.62	0.73	0.86	1.02	1.21	1.42
Agos	**3.58%**	**0.66**	**0.73**	**0.87**	**1.04**	**1.24**	**1.48**	**1.77**
Umiray	**3.20%**	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**
Pasig-Marikina	**3.84%**	**1.01**	**1.13**	**1.37**	**1.65**	**1.99**	**2.40**	**2.90**
Laguna	**3.62%**	**7.24**	**8.06**	**9.62**	**11.49**	**13.73**	**16.40**	**19.60**
Total	-	**13.59**	**15.10**	**17.99**	**21.45**	**25.58**	**30.50**	**36.38**

Source: JICA Study Team



Source: JICA Study Team

Figure 5.12 Projection of Non-domestic Water Demand in the Adjoining Areas per River Basin

5.5.6 Projection of Total Water Demand

The following table presents the total demand projection in the adjoining areas;

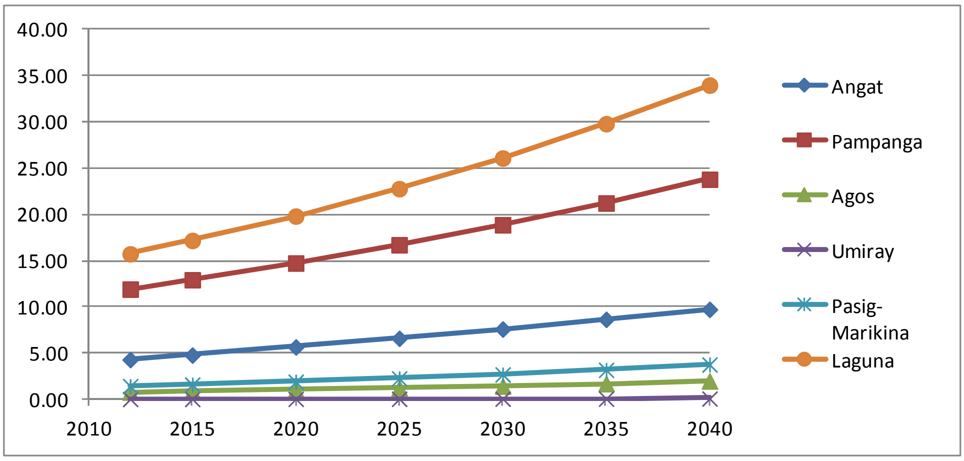
Table 5.30 Projection of Total Water Demand in the Adjoining Areas per River Basin

(Unit: m^3/s)

River Basin	2012	2015	2020	2025	2030	2035	2040
Angat	**4.32**	**4.81**	**5.68**	**6.62**	**7.62**	**8.67**	**9.76**
Pampanga	**11.94**	**12.95**	**14.76**	**16.73**	**18.89**	**21.24**	**23.81**
Pampanga (PAM-1)	1.14	1.23	1.40	1.57	1.76	1.96	2.16
Pampanga (PAM-2)	1.66	1.84	2.17	2.55	2.97	3.45	3.98
Pampanga (PAM-3)	0.94	1.03	1.20	1.40	1.63	1.90	2.21
Pampanga (PAM-4)	1.25	1.33	1.47	1.62	1.77	1.93	2.09
Pampanga (PAM-5)	0.08	0.09	0.11	0.13	0.15	0.18	0.21
Pampanga (COR)	0.14	0.15	0.16	0.18	0.19	0.21	0.23
Pampanga (PAN)	0.48	0.54	0.65	0.79	0.96	1.17	1.43
Pampanga (RCH)	3.20	3.47	3.94	4.44	4.98	5.56	6.19
Pampanga (PEN)	0.04	0.05	0.05	0.05	0.06	0.06	0.07
Pampanga (PAS)	3.00	3.22	3.60	3.99	4.40	4.82	5.25
Agos	**0.82**	**0.91**	**1.06**	**1.25**	**1.46**	**1.72**	**2.02**
Umiray	**0.06**	**0.07**	**0.07**	**0.08**	**0.09**	**0.10**	**0.11**
Pasig-Marikina	**1.45**	**1.62**	**1.93**	**2.29**	**2.71**	**3.21**	**3.79**
Laguna	**15.75**	**17.20**	**19.83**	**22.80**	**26.11**	**29.82**	**33.99**
Total	**34.35**	**37.55**	**43.33**	**49.78**	**56.89**	**64.76**	**73.48**

Source: JICA Study Team

Figure below shows the increase in raw water demand per river basin;



Source: JICA Study Team

Figure 5.13 Projection of Total Water Demand in the Adjoining Areas per River Basin

5.5.7 Alternative Surface Water Demand

Both surface water and groundwater are reliable water sources to meet the existing demands in the adjoining areas. The Study, however, could not obtain information regarding a policy that defines the future shares of surface water and groundwater. It is crucial to define surface water demand in the conduct of the Study to review the impacts of the projects in the roadmap that envisions an inter-basin water diversion from the river basins to Metro Manila.

The recorded present groundwater exploitations are shown in Table 7.2.1 of Chapter 7. Consequently, the present surface water demand is approximated by estimating the balance of the total demand and groundwater shares or the exploitation recorded in December 2011 as shown in Table 5.31.

Table 5.31 Assumed Surface Water Demand in 2012

(Unit: m^3/s)

River Basin	Total Demand	Share of Groundwater	Surface Water Demand
Angat	4.3	1.1	3.2
Pampanga	11.9	3.2	8.7
Pasig-Marikina	1.4	0	1.4
Agos	0.8	0	0.8
Umiray	0.1	0	0.1
Laguna Lake	15.7	3.7	12.0

Source: JICA Study Team
Note: Table 7.2.1 shows actual exploitation recorded by LWUA

Meanwhile Table 7.2.2 of Chapter 7 presents the preliminarily estimated potentials of groundwater. Accordingly, the following two alternative cases are conceived:

1) Share of groundwater will not change in the future and figures in Table 5.31 will be maintained (Case 1)

2) Groundwater exploitation increases and will reach to the maximum safe yields in 2040 (Case 2)

The estimated surface water demand for Case 1 and Case 2 in 2040 are presented in Tables 5.32 to 5.33, respectively.

Table 5.32 Projected Surface Water Demand in 2040 for Case-1

(Unit: million liters per day)

River Basin	Ground Water	Source	2010	2020	2030	2040
Angat	91	Total	372	491	657	847
		Surface	281	400	566	756
Pampanga	273	Total	1,028	1,279	1,633	2,056
		Surface	755	1,006	1,360	1,783
Agos	0	Total	69	92	130	173
		Surface	69	92	130	173
Umiray	0	Total	5	6	8	10
		Surface	5	6	8	10
Pasig-Marikina	0	Total	121	164	233	328
		Surface	121	164	233	328
Laguna Lake	320	Total	1,365	1,711	2,255	2,938
		Surface	1,045	1,391	1,935	2,618

Source: JICA Study Team

Table 5.33 Projected Surface Water Demand in 2040 for Case-2

(Unit: million liters per day)

River Basin	Water Source	2010	2020	2030	2040
Angat	Total	372	491	657	847
	Ground water	91	199	307	416
	Surface water	281	292	350	431
Pampanga	Total	1,028	1,279	1,633	2,059
	Ground water	273	798	1,324	1,849
	Surface water	755	481	309	210
Agos	Total	69	92	130	173
	Ground water	0	65	130	173
	Surface water	69	27	0	0
Umiray	Total	5	6	8	10
	Ground water	0	6	8	10
	Surface water	5	0	0	0
Pasig-Marikina	Total	121	164	233	328
	Ground water	0	17	35	52
	Surface water	121	147	198	276
Laguna Lake	Total	1,365	1,711	2,255	2,939
	Ground water	320	373	425	477
	Surface water	1,045	1,338	1,830	2,462

Source: JICA Study Team

The increase in the groundwater exploitation towards 2040 is assumed constant from present exploitations to maximum safe yields.

5.6 Official Demand Projection Presented by MWSS

The MWSS presented the official demand projection to the JICA Study Team for planning the future water source development in October 2012. The figures are approved as the official number to be used for future tariff setting between MWSS and the two concessionaires.

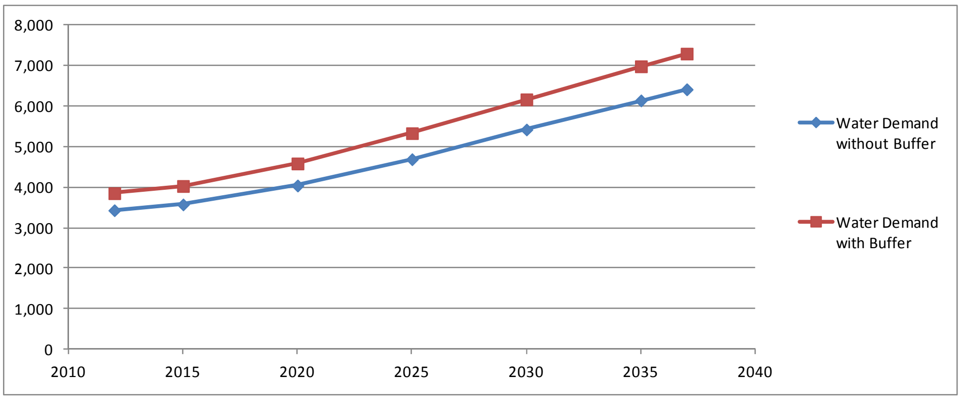
The presented demand amount is shown in Table. 5.34.

Table 5.34 Official Demand Projection Presented by MWSS

(Unit: million liters per day)

	2012	2015	2020	2025	2030	2035	2037
Water Demand without Buffer	3,412	3,460	3,525	3,629	3,789	3,878	3,933
Water Demand with Buffer	3,412	3,512	3,631	3,794	4,022	4,176	4,298

Source: MWSS



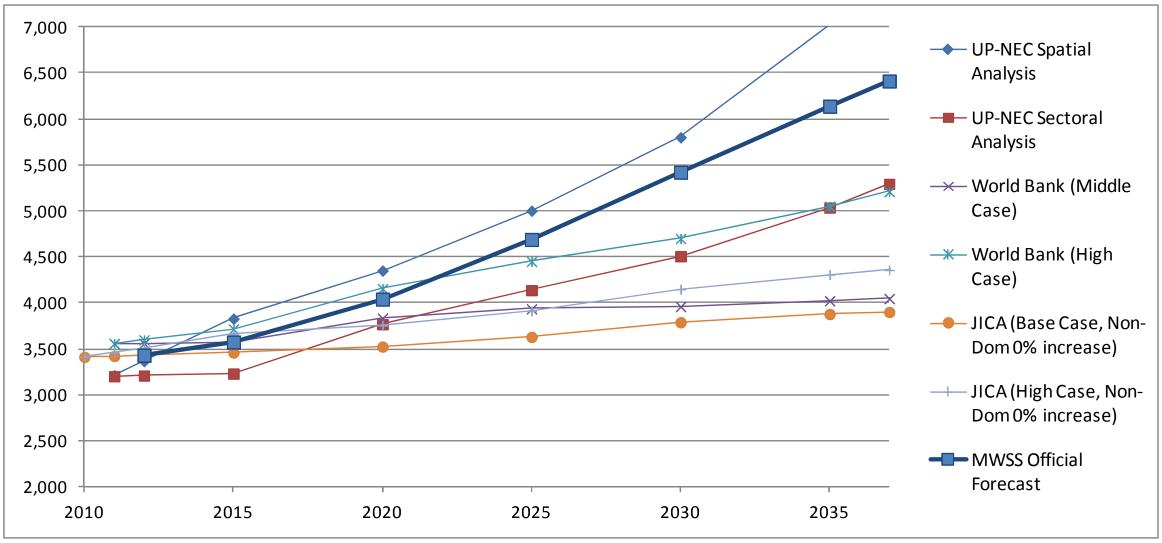
Source : MWSS

Figure 5.14 Official Demand Projection Presented by MWSS

The forecast is basically calculated based on the demand projection of UP-NEC which has been explained previously. The result showed a high demand in the future as the lpcd is assumed to increase each year, while the non-domestic consumption will continue to increase more than 5% per year, and the buffer rate is set at approximately 15%.

The comparison of the forecast figures excluding buffer by MWSS, UP-NEC (Spatial Analysis, Sectoral Analysis), World Bank (Middle Case, High Case), and JICA Study Team (Base Case, High Case) is indicated in Figure 5.15.

The result exceeded the other forecasts (JICA and World Bank) except for the "Spatial Analysis" of UP-NEC.



Source : JICA Study Team

Figure 5.15 Comparison of Each Demand Projection

Before the year 2020, the demand projection by MWSS showed similar trend with other projections, though the demand amount increases sharply afterwards.

As the service regulator of the water supply, MWSS needs to promote the water source development in order to avoid future water shortage. Hence, it is considered to be natural that the official demand projection of MWSS tends to be higher. In consideration of the said condition, the JICA Study Team agreed to use the projection figures used by MWSS in finalizing the Water Security Plan.

However, it should be noticed that the detailed and periodical study of water demand, including household survey and climate change review, should be conducted to avoid excess spending on the investment of water source facility. The JICA Study Team recommends that the said study should be conducted at least every five years.

CHAPTER 6 DEMAND SIDE STUDY AGRO-FISHERIES

6.1 Agricultural Sector in the Philippines

6.1.1 Background

The agricultural sector in the Philippines remains an important part of and contributor to the economy, sharing 18.4% to GDP. The sector employed almost 35% of the total work force in 2010. The Government of the Philippines (GoP) emphasizes poverty reduction and the strategic policies to improve agricultural productivity in the Philippine Development Plan 2011-2016.

More than 12 million ha or about 75% of the country's alienable and disposable lands are agricultural areas. Arable land devoted to temporary crops is about 5.7 million ha or 47% of the total agricultural areas. Paddy area is estimated at about 4.5 million ha in 2008. Self-sufficiency in rice was achieved in the late 1970s. However, it was short-lived due to natural calamities and reduced public investments in research and development, extension, and irrigation development. Rice production increased to 16.8 million tons in 2008, however, during the global food crisis that year, the Philippines imported some 2.4 million tons of rice valued at USD 1.9 billion. For the period 2004-2010, domestic rice production has met only 85% of the country's annual average rice requirement.

6.1.2 Government's Policy

(1) Philippine Development Plan 2011-2016

The Philippine Development Plan 2011-2016 was issued in the beginning of 2012. The plan centers on five key strategies, as follows;

(a) To boost competitiveness in the productive sectors to generate massive employment;

(b) To improve access to financing to address the evolving needs of a diverse public;

(c) To invest massively in infrastructure;

(d) To promote transparent and responsive governance; and

(e) To develop human resources through improved social services and protection.

In the plan, the development strategies for the agriculture sector are anchored on three primary goals: (i) Food security improved and income increased; (ii) Sector resilience to climate change risks increased, and (iii) Policy environment and governance enhanced. Strategies to achieve the first goal are: (i) Raise productivity and incomes of agriculture and fishery-based households and enterprises and (ii) Increase investments and employment across an efficient value chain. Self-sufficiency in rice production continues to be the key of the agriculture productivity goal.

(2) Philippine Rice Master Plan 2009-2013

An ambitious Philippine Rice Master Plan 2009-2013 was drawn up, and was enforced in 2008 with the issuance of an Executive Order 725. This plan aims to increase paddy production from 16.2 million tons in 2007 to 21.6 million tons in 2013, with a focus on increasing provincial productivity of 49 provinces, where location- specific interventions will be provided to help the farmers achieve higher yields. The basic strategies in implementing the program are: (i) Irrigation system repair, restoration, and rehabilitation; and (ii) Clustering approach through LGU-centered planning and implementation to facilitate the delivery of support services, market, and credit assistance.

In the Philippines, production from irrigated areas has contributed to 78% of the total rice production. However, each province known for growing rice has different productivity levels. To improve yield production, this plan pursues the extension and increase of irrigation service area by 2013 through construction, rehabilitation, and restoration of irrigation systems, and the increase of cropping intensity from the current average cropping intensity of 135% to 170%. Extended or reactivated irrigation service area is planned to reach approximately 1.2 million ha through four major irrigation development and rehabilitation programs, such as: (i) irrigation construction projects, (ii) new small water impounding projects, (iii) shallow tube well development in rain-fed area, and (iv) irrigation rehabilitation projects. Harvested area to be attained by 2013 is about 2 million ha with cropping intensity of 170%. The program plans to allot an estimated budget of PhP 76.7 billion to support its intervention activities for the period of 2009 to 2013.

(3) Regional Policy for Agriculture Sector

In the Updated Central Luzon Regional Physical Framework Plan (RPFP), 2005-2030, one of the focal points is improvement of productivity, profit, and resiliency of the region’s agriculture, which include post-harvest handling, processing marketing networks, and supporting crop production on sloping area. Concerning land resources, conversion of prime agricultural land to non-agricultural uses should be subject to social benefit-cost analysis under intensity promotion of program supporting the development of areas identified as Strategic Agriculture and Fisheries Development Zones. Irrigated areas where significant public investment has taken place should not be subject for conversion.

In the RPFP, it is emphasized that the government should continue allocating funds in support of the development of the agricultural sector, and construction of irrigation and drainage facilities, farm to market roads, and farm mechanization. The priority is given to the development of new irrigation systems and rehabilitation of existing systems in order to expand coverage of production areas and increase their efficiency. For water resource and irrigation development in Central Luzon, the following plans were proposed, i.e., (i) Casecnan Multipurpose Project, (ii) Balintingon Multipurpose Project, (iii) Rehabilitation of Angat Afterbay Regulator Dam, (iv) Improvement of National Irrigation System, (v) Communal Irrigation Development Program, and (vi) Development of Pump Irrigation Systems.

(4) Strategic Agriculture and Fishery Development Zone (SAFDZ)

In accordance with Republic Act 8435 (Agriculture and Fisheries Modernization Act), the Department of Agriculture defined the area for the acceleration and modernization of agriculture and fisheries sector in support to the country's food security and to realize and sustain rural development. The Bureau of Soils and Water Management has completed the basic development resource information and map for the Strategic Agriculture and Fisheries Development Zone (SAFDZ), which represents the various categories for strategic agricultural and fishery development.

In this act, it is noted that all irrigated lands, irrigable lands already covered by irrigation projects with firm funding commitments, and lands with existing or having the potential for growing high value crops so delineated and included within the SAFDZ shall not be converted for a period of five years from the time the act is effective: provided however, that not more than 5% of the said lands located within the SAFDZ may be converted upon compliance with existing laws, rules, regulations, executive orders and issuances, and administrative orders relating to land use conversion.

(5) Projects on Agriculture/Irrigation and Fishery

Taking the national and regional strategy into consideration, the following goals are set up for the agriculture/irrigation and fishery sectors. This sector goal is based on condition that the primary agricultural lands be preserved and the government continues to support the development of irrigation infrastructures both for new construction and rehabilitation/ improvement of existing irrigation systems. Also, new technologies shall be developed, demonstrated, and widely disseminated in order to improve the efficiencies and to increase agricultural productivity with competitive cost for production.

For the fishery sector, the government agencies including LGUs are supporting the increase and improvement of productivity in fishery, especially for aquaculture in the region, while no specific projects/programs are identified on water resource development and management relating to the fishery sector except for water quality. In this Study, sector goals are set up as shown below;

- Rehabilitate and develop the irrigation system;
- Enhance the new agricultural technology on water management sustainability; and
- Fishery under the integrated water resource management.

Ongoing and proposed projects are referred to in the NIA Indicative Irrigation Development Program (2010-2019), the NIA Regional Irrigation Development Program (2010-2019) and information obtained from the Bureau of Soil and Water Management, and the Bureau of Fisheries & Aquatic Resources.

Major areal development strategy in the Pampanga River basin is categorized as presented below.

- Bulacan
  - Water allocation at the Angat Storage Dam
  - Rehabilitation and improvement of AMRIS
  - Sustainable aquaculture production in Pampanga Delta
- Nueva Ecija
  - Implementation of CMIIP-IC - II and BMRP
  - Rehabilitation of UPRIIS
  - Small water impounding in hilly areas

- Pampanga - Rehabilitation of Pampanga Delta RIS, Porac-Gumain RIS and CISs
- Tarlac - Implementation of BBMP-II
  - Rehabilitation of TASMORIS
  - Expansion and rehabilitation of groundwater irrigation
- All Provinces - Development and restoration of CISs and small-scale irrigation
  - Improvement of irrigation efficiency

6.1.3 Irrigation Sector

(1) Outline of irrigation sector

Irrigation plays a vital role in the development of agriculture as well as in the attainment of food security. As of the end of 2009, irrigated agriculture comprised about 1.54 million ha of land, or about 49% of the estimated irrigable area of 3.13 million ha. Around 765,000 ha are served by national irrigation systems (NISs), while communal irrigation systems (CISs) and private irrigation systems (PISs) serve around 558,000 ha and 217,000 ha, respectively.

The main institutions involved in irrigation system management are the National Irrigation Administration (NIA) as the water supplier and Irrigators Associations (IAs) as the water users.

The NIA rationalization plan is an ongoing government reform aiming to improve the quality and efficiency of government service delivery. This plan seeks to streamline functions and responsibilities of NIA through the elimination of overlapping units and redundant functions among its staff, and will be implemented over a 5-year period from 2009 to 2014. Under the approved plan, the number of personnel will be reduced from 4816 at present to 3813 by April 2013. The reduction of personnel would lead to annual cost reductions of about PhP 90 million at the end of 2014. To deal with problems on O&M performance of IAs, management of NIA, and recommendations of strengthening IA's functionality, the irrigation management transfer (IMT) programs were prepared. The IMT policy supports the engagement of the various levels of IA's organization on O&M activities to develop capacity in system management. IAs will also be trained on appropriate accounting and auditing procedures.

Major technical problems on NISs are: (i) severe sedimentation and siltation in irrigation and drainage canals, (ii) accelerated deterioration of irrigation and drainage facilities, and (iii) poor/insufficient water flow regulation, control, conveyance, and delivery capacity of irrigation systems. These problems are principally caused by flood damages due to typhoons and frequent heavy rainfall, as rapid deforestation activities in the watershed areas of the irrigation systems have reduced their capacity to retain rain water to a considerable extent. Moreover, shortage of budget in carrying out repair and rehabilitation of damaged/malfunctioning facilities trigger reduction of irrigation service areas. Under such situation, NIA has identified the necessity for rehabilitation and restoration of NISs in each region throughout the country.

(2) NIA Corporate Plan 2010-2020

In contributing to increase paddy production, NIA proposed to carry out irrigation development in strategic areas of the country within a period of ten years, aiming to achieve:

(i) new area generation of 300,114 ha; (ii) rehabilitation of 1.3 million ha; and (iii) restoration of 251,000 ha. By 2020, it is expected that the total area provided with irrigation facilities would increase to around 1.90 million ha from its current development level of about 1.44 million ha. The additional area of around 0.46 million ha targeted to be developed within the planned period would increase the nationwide coverage rate of irrigated area to 61% from the present level of 50%.

To achieve the above targets, NIA plans to launch new projects to generate additional areas and/or expand the service area of existing irrigation systems wherein water supply is not a constraint. In addition, rehabilitation works will be carried out for irrigation facilities which have deteriorated due to normal wear and tear, or to prevent further deterioration due to lack of funds for partial repairs. Restoration of damaged facilities, usually caused by floods and other natural calamities, will be undertaken to put back into operation the service area affected by non-functional facilities. For the 10-year irrigation program, the total amount required is estimated at PhP 219 billion or an average capital outlay of about PhP 22 billion per year.

6.2 Agriculture in the Study Area

6.2.1 Conditions of the Study Area

The Study Area (excluding Metro Manila) covers six river basins (total area of 17,904 km^2) located in seven provinces as follows:

Table 6.2.1 Features of the Study Area

	River Basin	Area (km^2)	Region	Province
1	Angat	1,085	III	Bulacan
2	Pampanga	10,981	III	Bulacan, Nueva Ecija, Tarlac, and Pampanga
3	Agos	940	IV	Quezon
4	Umiray	538	IV	Quezon
5	Pasig-Marikina	540	IV	Rizal
6	Laguna Lake	3,820	IV	Laguna
Total		17,904		

Source: Prepared by the JICA Study Team

Pampanga River basin is the largest river basin in Luzon Island and is one of the major granaries in the country, especially in production of paddy.

6.2.2 Agriculture in the Study Area

The Study Area is the highest producer of paddy in the country. In 2008, 2,675,000 tons of paddy (16% of the country’s total rice production) are harvested in around 583,000 ha in total, for both wet and dry seasons. The province of Nueva Ecija is the highest producer among all 80 provinces in the country and other provinces in the Study Area are also among top producers in terms of harvested area and production of paddy. Most of paddy products are marketed to major consuming areas such as Metro Manila because of the proximity.

In the Study Area, the agriculture sector accounts for 24% of the region’s GRDP in 2003. Out of the total workers, 22% are working in agriculture sector as cultivators and agriculture laborers. Majority of work force are engaged in agriculture and this trend is prominent especially in rural areas. Thus, the agriculture sector especially irrigation to paddy production in the Study Area is most important both in terms of country's strategy on food security and for the farm economy in rural areas.

The agricultural lands lie at the central portion of the Study Area, mostly in the flat lands of the river basins of Pampanga and its major tributaries. Around 45% of the Study Area is agricultural land, in which around 38% is paddy field. The region's primal agricultural crop is paddy followed by corn. Paddy is planted in both irrigated and rain fed fields, while vegetables and fruits are planted mainly in the upland.

In the Study Area, farmers plant paddy twice a year with limited vegetables planted in irrigated area. There are two cropping seasons, i.e., the wet and dry seasons. In general, wet cropping season is from June to September/November and the dry cropping is from October/November to April/May, while some areas are optionally planted with third crops, such as vegetables and beans which are planted in between dry and wet seasons. To meet the requirement for the above double cropping, irrigation operation is carried out based on the pre-fixed irrigation schedule. For the upland areas without irrigation facilities, farmers plant string beans, eggplant, tomato, okra, and others during dry season.

6.3 Present Irrigation Development in the Study Area

6.3.1 General

Irrigation system including national, communal, and private ones is most developed in vast plains and low land areas of the Pampanga River basin. As of 2009, irrigation development covers around 240,000 ha or 60% of the total paddy field in the Study Area. Irrigation development is spearheaded mainly by the National Irrigation Administration (NIA), which is the national government agency mandated to plan, construct, and operate irrigation systems to support agriculture production in the country. The Bureau of Soils and Water Management (BSWM) under the Department of Agriculture (DA) is also a government agency tasked to promote small-scale irrigation or water-harvesting system utilizing small local catchments. Other existing irrigation systems are either privately-owned or constructed by other government agencies through various programs.

The irrigation systems are categorized as follows;

1. National Irrigation System (NIS): constructed and operated by NIA
    - River Irrigation System (RIS)
    - Pump Irrigation System (PIS)
    - Groundwater Irrigation System (GIS)
    - Small Reservoir Irrigation Project (SRIP)
2. Communal Irrigation System (CIS): constructed by NIA and turned over to IA
    - Communal Irrigation System (CIS)
    - Pump Irrigation System (PIS)
3. Small Scale Irrigation (SSI): managed by BSWM/DA
    - Diversion Dam (DD)
    - Small Water Impounding Project (SWIP)

- Small Farm Reservoir (SFR)
- Shallow Tubewell (STW)

4. Private Irrigation System

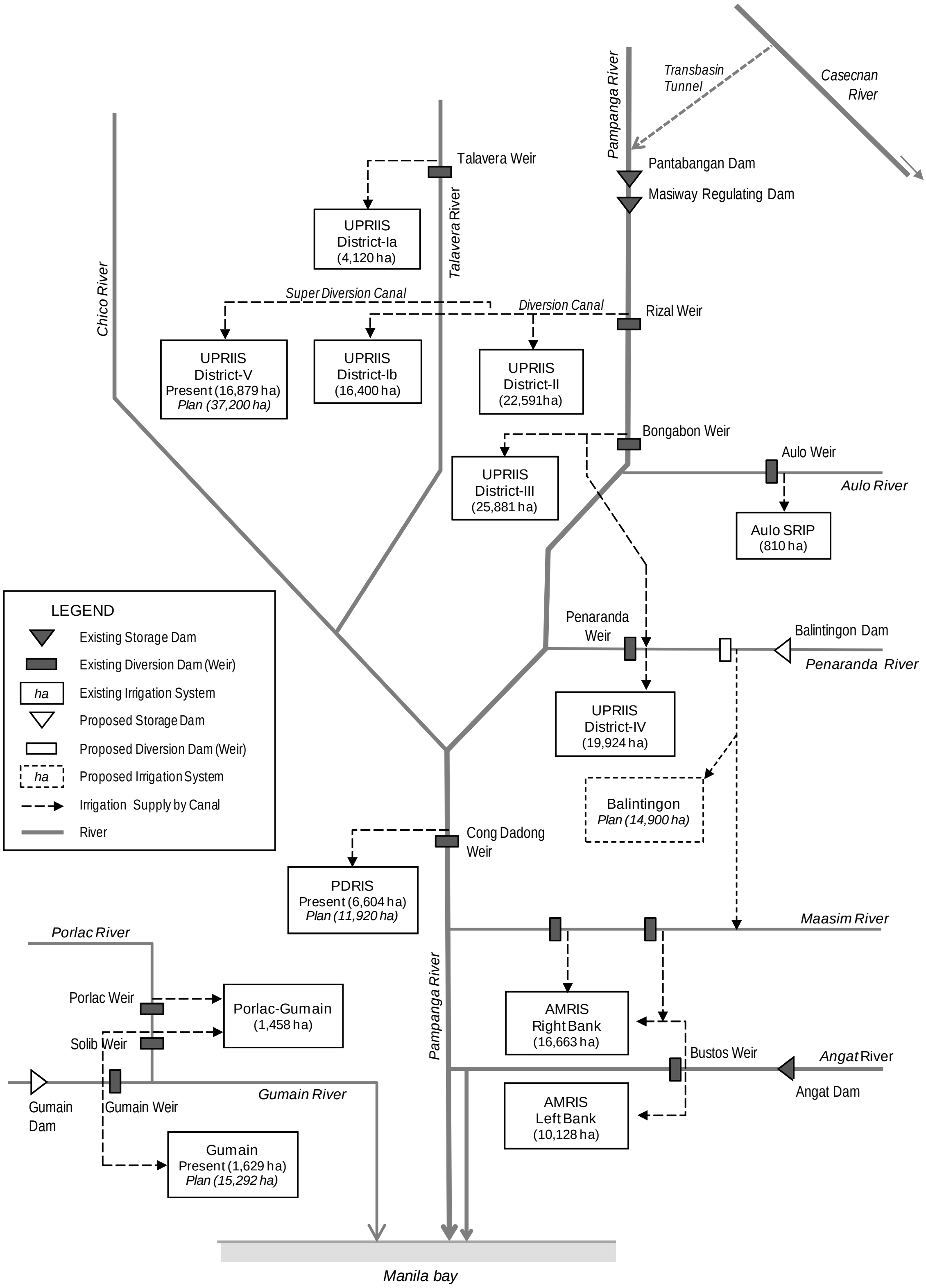
6.3.2 National Irrigation System (NIS) in the Study Area

Under NIA, irrigation systems are either national or communal. A national irrigation system (NIS), of which the service area is generally more than 1000 ha, is constructed, operated, and maintained by NIA. There are eight NISs in the Study Area with a total service area of 178,000 ha, including groundwater systems as shown in Table 6.3.1 of which locations and schematic flow diagram are shown in Figure 6.3.1. The Upper Pampanga River Integrated Irrigation System (UPRIIS) is the largest in the Study Area and also in the entire country. It has a total service area of 119,000 ha at present divided into five divisions, covering the province of Nueva Ecija and some areas in Bulacan and Tarlac. Tarlac-San Miguel-O'Donnel River Irrigation System (RIS) located in the province of Tarlac is diverting water from Agno River, however, its service area lies in the Study Area and its drained water flows into the Pampanga River basin.

Table 6.3.1 Existing NISs in the Study Area

River Basin	Name of System	Sub-system	Irri. Area (ha)	Water Source
Angat	Angat-Maasim (AMRIS)		26,000	Angat R.+Maasim R.
Pampanga	Upper Pampanga River Integrated Irrigation System (UPRIIS)	District-I	20,520	Pampanga R.+Talavera R.
		District-II	22,591	Pampanga R.
		District-III	25,881	Pampanga R.
		District-IV	19,924	Penaranda R.
		District-V	16,879	Pampanga R.
	Aulo SRIP		810	Aulo R.
	Pampanga Delta (PDRIS)		6,604	Pampanga R.
	Porac-Gumain		3,087	Gumain R.+Porac R.
	Total for Pampanga		117,609	
Laguna	Cabuyao East		348	Diversion dam
	San Cristobal		413	Diversion dam
	Diezmo		852	Diversion dam
	Macabling		418	Diversion dam
	San Juan		341	Diversion dam
	Sta. Maria		974	Diversion dam
	Mayor		375	Diversion dam
	Sta. Cruz		2,185	Diversion dam
	Mabacan		272	Diversion dam
	Balanac		1,000	Diversion dam
	Lumban		57	Intake
	Malaunod		227	Diversion dam
	Total for Laguna		7,462	
Quezon	Agos		1,234	Intake
	Dumacaa		1,893	Diversion dam
	Hanagdong		274	Diversion dam
	Lagnas		639	Diversion dam
	Total for Quezon		4,040	
Total for the Whole Study Area			155,902	

Source: NIA



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 6.3.1 Schematic Layout of Major Irrigation Systems in the Pampanga River Basin

The following table shows the ongoing project activities of NISs reported in the NIA COPLAN 2009-2018.

Table 6.3.2 Summary of Ongoing National Irrigation Projects

Name of Project	Province Covered	Schedule	
		Start	End
Rehabilitation of AMRIS	Bulacan	2009	2010
Along-along Creek Irrigation Project (In UPRIIS Div-3)	Nueva Ecija	2010	2019
Comprehensive Agrarian Reform Program, Irrigation Component, Project-II	Nationwide	1993	-
Repair, Rehabilitation of Existing Groundwater Irrigation Systems, Establishment of Groundwater Pump Project	Nationwide	-	-
Repair, Rehabilitation, Restoration & Preventive Maintenance of Existing National & Communal Irrigation Facilities	Nationwide	-	-
Balikatan Sagip Patubig Program (BSPP)	Nationwide	2010 -	2019
Repair, Rehabilitation, Restoration & Preventive Maintenance of Existing National & Communal Irrigation Facilities (RRENIS/CIS)	Nationwide	2010 -	2019
Restoration/Rehabilitation of Existing NIA Assisted Irrigation System (PRE-NIA-AIS)	Nationwide	2010 -	2019
Participatory Irrigation Development Project (PIDP)	Nationwide	2010 -	2019
Rehabilitation of Small Water Impounding Projects / Diversion Dam	Nationwide	2009-	2011
Upper Tabuating SRIP	Nueva Ecija	2010-	2010-

Source: NIA COPLAN, 2009-2018, NIA: Indicative Irrigation Development Program, 2010-2019 and BSWM

In addition to the proposed projects mentioned in NIA COPLAN, the updated Central Luzon Regional Physical Framework Plan (RPFP) covering 2005-2030, envisioned the development of the Balintingon Multipurpose Project, of which feasibility study was made in 1983 and reviewed and updated in 2008. This project was proposed to irrigate new area of 14,900 ha of its own service area and to divert water to the AMRIS area.

Table 6.3.3 Summary of Proposed National Irrigation Projects

Name of Projects	Province Covered	Service Area (ha)	Expected Funding
Participatory Irrigation Development Project	Nationwide	26,791	GAA / IBRD
Procurement of Pumps, Drilling Rigs & Related Equipment	Nationwide	3,900	GAA / Spanish Loan
Balog-balog Multipurpose Project Phase 2	Tarlac	34,410	GAA / ODA
Sector Loan on Rehabilitation of Irrigation Facilities	Nationwide		GAA / JICA
Casecnan Multipurpose Power & Irrigation Project Irrigation Component - Phase II	Nueva Ecija / Bulacan	61,000	GAA / ODA
Irrigation Water Resources Augmentation Pump Establishment Project	Nationwide	2,361	-
Appropriate Irrigation Technologies for Enhanced Agricultural Production	Include. Regions III	4,000	GAA / ODA
Central Luzon Groundwater Irrigation Systems Reactivation Project	Nueva Ecija	5,000	-
Gumain Reservoir Project	Pampanga	16,750	-

Source : NIA COPLAN, 2009-2018 and Indicative Irrigation Development Program, 2010-2019
Note : GAA : General Appropriations Act, IBRD : International Bank for Reconstruction and Development

6.3.3 Communal Irrigation System (CIS) in the Study Area

Most of CISs have service area of less than 1000 ha which are constructed and turned over by NIA to an organized group of farmer-beneficiaries called Irrigators Association (IA). The construction cost of CISs are borne by NIA and later amortized by the beneficiaries after the turnover. Some CISs are privately owned and operated. There are 218 functional CISs with 37,522 ha of service area as shown below.

Table 6.3.4 Existing Communal Irrigation System (CIS) in the Study Area

River Basin	Functional CIS				Total	
	CIS (Gravity)		PIS (Pump System)			
	Nos	Area (ha)	Nos	Area (ha)	Nos	Area (ha)
Angat	7	219	0	0	7	219
Pampanga	137	25,712	31	7,427	168	33,139
Umiray	0	0	0	0	0	0
Agos	1	224	0	0	1	224
Pasig-Marikina	3	206	0	0	3	206
Laguna Lake	39	3,734	0	0	39	3,734
Total	187	30,095	37	7,427	224	37,522

Source:

Around one-third of the existing CISs are not operational at the moment. One of the reasons is that some CISs firmed up area have been integrated into new large NIS such as UPRIIS, etc., so that the previous intake systems were abandoned, and hence, functional CISs area was reduced. The other reasons of reducing CIS service area include the urbanization in the farm land and/or deterioration of the old systems. Especially, some existing pump irrigation systems are not operational due to the high operation and maintenance cost.

6.3.4 Small-Scale Irrigation (SSI) in the Study Area

In addition to NISs and CISs, there are various small scale irrigations under the Bureau of Soils and Water Management (BSWM) of the Department of Agriculture (DA). These systems are developed to increase cropping intensity and production by providing small-scale irrigation and rainwater-harvesting infrastructure utilizing small local catchments or shallow groundwater. These small-scale irrigations are categorized into (i) diversion dams (DD), (ii) small farm reservoir (SFR), (iii) small water impounding project (SWIP), and (iv) shallow tubewell (STW). In most of these systems, dry season crops are planted without, or with limited supplementary irrigation due to insufficient water source in the small catchment area.

Table 6.3.5 Summary of Small-Scale Irrigations under BSWM in the Study Area

Type of System	Nos	Area (ha)	
		Wet Season	Dry Season
Diversion Dam (DD)	32	1,108	735
Small Water Impounding Project (SWIP)	14	681	108
Small Farm Reservoir (SFR)	1	37	0
Total	47	1,826	843

Source : Prepared by the JICA Study Team based on the BSWM GIS database

New construction or rehabilitation of existing CISs will be implemented under the nationwide programs. The proposed project to be implemented by BSWM is summarized below.

Table 6.3.6 Summary of Proposed Small Scale Irrigations under BSWM

	Nos	Service Area (ha)
Diversion Dam (DD)	18	1959
Small Water Impounding Project (SWIP)	24	1,635
Small Farmers Reservoir (SFR)	4	112
Total	46	2,706

Source : Estimated by the JICA Study Team based on the BSWM database

6.4 Future Irrigation Projects in the Study Area

6.4.1 General

In the "COPLAN, 2010-2020" and "Indicative Irrigation Development Program, 2010-2019" prepared by NIA, ongoing and proposed national irrigation projects to be implemented until 2020 are listed including nationwide program.

There are various projects to improve water shortage situation in existing irrigation areas, which are categorized into; (i) NIA regular programs, (ii) rehabilitation of NISs, (iii) development of large scale irrigation projects, and (iv) development of small scale irrigation projects.

6.4.2 Rehabilitation and Development of NIA Assisted Irrigation System

NIA's nationwide regular programs are on-going by allocating the budget for new development and rehabilitation of CISs and some rehabilitation works of NISs. These are:

- Repair, Rehabilitation of Existing Groundwater Irrigation Systems,
- Establishment of Groundwater Pump Project (REGIP),
- Balikatan Sagip Patubig Program (BSPP),
- Repair, Rehabilitation, Restoration & Preventive Maintenance of Existing National & Communal Irrigation Facilities (RRENIS/RRECIS), and
- Restoration/Rehabilitation of Existing NIA Assisted Irrigation System (RRE-NAIS).

The financial sources for these projects are generally the national budget (GAA; General Appropriations Act) except some are foreign assisted. Rehabilitation of CISs is conducted in case that the required works is beyond the capacity of IAs, while normal maintenance should be managed by IAs. Rehabilitation/repair and improvement of groundwater pump irrigation system to sustain the operation of existing wells are also done. Construction and installation of new deep and shallow tube wells are also included.

6.4.3 Comprehensive Agrarian Reform Program, Irrigation Component (CARP-IC)

The program is a nationwide program to support the Comprehensive Agrarian Reform Program (CARP) of the Department of Agrarian Reform (DAR) in providing rural infrastructure necessary to enhance farm productivity and income of CARP beneficiaries. The CARP involves pre-engineering, construction/rehabilitation of irrigation and drainage facilities, farm roads, marketing facilities, and institutional development. The irrigation component covers development of CISs/CIPs and strengthening of the IAs through the irrigation development projects, which are conducted by NIA in the same manner as that of other NIA projects in the construction of CISs, except that their financial source is under DAR's budget.

6.4.4 Rehabilitation of NIS

(1) Participatory Irrigation Development Project (PIDP), APL1- Infrastructure Development (for Rehabilitation of AMRIS)

The PIDP financed by the World Bank seeks to improve NIA's financial viability through institutional reform and capability building including better service delivery to farmers, enhance farmers participation, and their capability to manage NIS transferred from NIA to IA. APL1 under PIDP involves the infrastructure improvement and sustenance of national irrigation systems, policy instruments, and institutional development for improved IMT in O&M, capacity building for IAs, and organization and financial corporate strengthening. Under this PIDP-APL-1, rehabilitation of AMRIS is selected to cover the whole existing area with 49,000 beneficiaries. Proposed works includes; (i) rehabilitation of the North and South constant gates, (ii) repair and improvement of control house, (iii) construction of measuring device, (iv) canal lining, (v) replacement of steel gates, and (vi) manual and mechanized desisting in the canals.

(2) Rehabilitation of AMRIS

The rehabilitation work of the Bustos Diversion Dam in AMRIS including the downstream apron and its foundation is an urgent necessity and has been recognized. Its project components and implementation plans were prepared by NIA.

6.4.5 Development of National Irrigation Projects

(1) Along-Along Creek Irrigation Project

This project located in San Antonio, Nueva Ecija includes construction of check gate, new construction and rehabilitation of irrigation and drainage facilities, raising of embankment and dredging, which are under implementation to generate additional service area of 2500 ha for UPRIIS District III.

(2) Upper Tabuating SRIP

The project located in General Tinio, Nueva Ecija involves construction of a new zoned earthfill dam with a height of 25 m and a reservoir area of 71.5 ha, targeting new irrigable area of 700 ha, flood control, and aquaculture. The project works of irrigation facilities were commenced in March 2010, while budget allocation for the dam construction is still being awaited from the central office.

(3) Balintingon Reservoir Multipurpose Project (BRMP)

The project envisions the construction of a rock fill center-core dam and its appurtenant structures across the Sumacbao River in Neva Ecija. The project works include construction of a diversion weir and new irrigation facilities in the command area of about 14,900 ha and hydropower plant with an installed capacity of 30 MW.

To overcome financial affordability, BOT investors have been invited to implement the project. The MOA was signed on February 17, 2010 between NIA and the investor to undertake a full-blown feasibility study to determine its financial, socio-economic, and technical viabilities.

There is an idea to send a portion of the reservoir's regulated water to the AMRIS area so that it would be utilized to supplement the water used in AMRIS and MWSS. However, if the water is utilized for such purpose, the available water for irrigation in the project area may be reduced.

(4) Casecnan Multi-purpose Project - Irrigation Component (CMIPP-IC), Phase 2

The CMIPP-IC, Phase 2 is the continuation project of CMIPP-IC, Phase 1. Construction of the new intake in Rizal and the Super Diversion Canal (SDC) has already been completed, taking into consideration the water requirements of the entire 37,200 ha of new area (UPRIIS District-V). However, the facilities in the new area constructed under the Phase 1 are only for 16,879 ha, and the remaining area is scheduled to be constructed in Phase 2. In order to maximize the utilization and economic benefits of the water delivered by the Casecnan BOT Project (Transbasin diversion) and the irrigation facilities already constructed under Phase 1, the immediate implementation of the Phase 2 project is proposed to cover the remaining 20,321 ha of new area as well as rehabilitation of about 40,000 ha in UPRIIS.

The project components of Phase-2 include the: (i) extension of SDC and construction of additional lateral and sub-lateral canals, drainage canals, and related structures in 20,321 ha, and (ii) rehabilitation/improvement of UPRIIS area, such as rehabilitation of the PENRIS main and lateral canals, and related structures. The project will benefit 11,931 farmers within the new area.

(5) Gumain Reservoir Project

Feasibility study of the Gumain Reservoir: Project was conducted in 1985, however, updating of the study has not been made since then. In the F/S conducted in 1985, construction of a 108-m high, zoned embankment dam was proposed to store irrigation water to serve 11,000 ha of paddy and 5200 ha of sugarcane area, including the existing Porac-Gumain and Caulaman RIS. Due to the possibility of change caused by the eruption of Mt. Pinatubo, it is necessary to study again its feasibility including the technical and economic viabilities.

6.4.6 Development of Communal and Small-Scale Irrigation Projects

(1) Irrigation Water Resources Augmentation Pump Establishment Project

These are two new regular programs of NIA with nationwide coverage. The Program of the Procurement of Pumps, Drilling Rigs and Related Equipment (PPDRRE) was scheduled to start in 2011, while the Irrigation Water Resources Augmentation Pump Establishment Project (IWRAPEP) will start in 2013, according to the NIA Indicative Irrigation Development Program. These are summarized in Table 6.4.1 below.

Table 6.4.1 Summary of NIA Planned Regular Program

	Number of Pump Unit	Beneficiaries	Target Area
PPDRRE	1,000 units	3,900 families	3,900 ha
IWRAPEP	1,330 units 1,029 units (surface water) 301 units (shallow tubewells)	1,333 families	2,360 ha 1,437 ha (new) 924 ha (rehab)

Source: NIA Indicative Irrigation Development Program, 2010-2019

(2) Central Luzon Groundwater Irrigation Systems Reactivation Project

In the NIA Indicative Irrigation Development Program, this project is planned to start in 2015 in continuation of the previous groundwater irrigation development in Tarlac Province, The project involves the construction of 100 deep well pump systems covering 5000 ha. Provision of rural water supply in selected barangays and procurement of equipment in the definite plan and design of this project has not been made available. According to NIA Region III, the project area in the CMIPP-IC, Phase 2 should be excluded.

(3) Rehabilitation of Small Water Impounding Projects/Diversion Dams

The small scale irrigation projects including small water impounding projects contribute not only in the increasing rice production in the region but also in the strengthening of livelihood especially in the upland and hilly areas where the development is not covered by large scale development. Though there are many small water impounding systems, some of them are not functioning. Under the regular program of the Bureau of Soil and Water Management (BSWM), rehabilitation of seven small water impounding projects (SWIPs) in Nueva Ecija and Bulacan, with an area of 235 ha to be restored, is ongoing.

(4) Construction of Priority Small-Scale Irrigation Systems/Small Water Impounding Projects (SWIP), Small Diversion Dam Projects (SDD)

The priority projects are identified by DA Region III. The detailed design has been completed, however the implementation has been delayed since around 2002, because of limited budget allocation. According to DA Region III, the following projects are given higher priority.

- Bulacan (1SWIP and 2SDD, service area = 125 ha)
- Nueva Ecija (1SWIP, service area = 95 ha)
- Pampanga (1SWIP and 3SDD, service area = 195 ha)
- Tarlac (1SWIP, service area =45 ha)

In addition, the PPDO in Nueva Ecija has prepared its own list of priority small scale irrigation development projects as below. Though, the list has been submitted to BSWM with the estimated cost, the implementation has also been delayed due to limited budget.

(5) New Construction of Small Scale Irrigation Project under BSWM

There are various potentials of small-scale irrigation identified by BSWM which are not covered by the ongoing and planned priority projects. These potentials are to be exploited through various projects consisting of (i) diversion dams (18 dams for 959 ha), (ii) small farmers reservoir (4 nos for 112 ha), (iii) small water impounding project (24 nos for 1,635 ha) and (iv) shallow tubewell (STW). The high and urgent necessity of such small-scale irrigation development is recognized from the viewpoints of well-balanced, equitable development of agricultural activity in the Study Area, which was also pointed out by several stakeholders through the technical working group meetings and stakeholders meetings. The potential small scale irrigation project was further estimated from the information given by BSWM as one of necessary conceptual projects and plans.

6.4.7 Projects to Address Low Irrigation Efficiency

Improving irrigation efficiency is vital for the integrated water resources management to effective and optimum use of limited water sources in the basin as well as improving agricultural productivity with less water, which was also raised from the stakeholders. In the Study Area, aside from the ongoing and planned structural projects, there have been several potential activities which are related to enhancement of the irrigation efficiency from the viewpoints of water management and water-saving technology for irrigation as described below.

(1) Appropriate Irrigation Technologies for Enhanced Agricultural Production

This is a nationwide project covering Region III, VI, IV, XI and XII. The project involves the use of innovative and appropriate technology including photovoltaic energy in power generation and drip tape for water dispersion. Irrigation technology to be implemented includes drip sprinkler and flood irrigation facilitated by solar power. The target area in Central Luzon is estimated at 4,000 ha and beneficiaries are approximately 2,000 families.

(2) Introduction of Water-Saving Irrigation Technology

Water-saving irrigation is one of the key issues on effective water use in irrigation systems as well as improvement of related facilities. Also, new technology is highly required under the situation caused by possible climate change in future. Ongoing activities are being jointly undertaken by NIA-UPRIIS and PhilRice for Upscaled Technology Demonstration and Adoption of water saving irrigation since 2007 in order to improve equitable distribution in UPRIIS. These activities aim at trial, research, demonstration and dissemination of implementing the adoption of “Alternate Wet and Dry (AWD)” by means of intermittent irrigation and rotational water supply. PhilRice is also conducting trial on System of Rice Intensification (SRI), which is a set of new farming practices developed to increase the productivity of land, water, and other farm input.

The above-mentioned activities are proposed to be more enhanced, integrated and disseminated to the entire Study Area. Project components include; (i) trial and research, (ii) demonstration farm operation, (iii) training to trainers and technical campaign to IAs, and (iv) monitoring with close coordination among related agencies such as DA, NIA, PhilRice, IRRI, and JICA technical cooperation project. The project also requires capacity development of IAs, because more sustainable and equitable water distribution within irrigation schemes can be achieved through farmers' participation.

(3) Monitoring System and Capacity Development for Proper Water Management in NISs and CISs

In most of the existing major irrigation systems, water discharge at the intake and in some control points in canals is monitored periodically. However, their reliability and quantity are observed to be not sufficient to properly control the system and also, these are not well-utilized to improve water delivery planning. The reasons are due to the following: (i) Discharge measuring devices are insufficient at necessary points, (ii) Measuring devices have deteriorated or are not well-functioning as designed because of sediment in the canals, etc, (iii) Conversion tables (H-Q curve) of water discharge against water level and gate opening heights are not sufficiently calibrated and updated, (iv) Communication systems are insufficient among the sites and offices, and so on.

In addition, timely reactions such as gate adjustment corresponding to unexpected rainfall are not fully controlled due to insufficient monitoring and control system, which is causing certain amount of water loss. To utilize the limited water sources more efficiently, it is necessary to monitor the water flow in the systems, which is also vital for further adoption of water-saving technology. This project will also contribute to the inter-sector surface water monitoring system.

6.5 Present and Future Irrigation Areas in the Study Area

The present and future irrigation areas are clarified based on the latest information and future development plan listed in the previous section. The major change in irrigation areas in the Study Area will occur by the implementation of the following projects;

Balintingon Dam and Irrigation Project in the Pampanga River Basin:

> New irrigation area of 14,900 ha will be developed with water supply coming from the Balintingon Multipurpose Dam to be constructed on the Penaranda River.

Gumain Dam and Irrigation Project in the Gumain River Basin:

> The existing Porac-Gumain irrigation system (3087 ha) will be expanded to 16,750 ha through the construction of the Gumain Dam. Project feasibility was confirmed in 1985 by JICA. However, due to the volcanic eruption of Mt. Pinatubo in June 1991, volcanic debris accumulated in the Gumain River basin, and overall review study should be conducted.

Extension of UPRIS Division V:

> The super diversion canal to convey water from the Rizal Diversion Dam (weir) to UPRIS Division V area has already been completed, but the present irrigation area is limited to 16,879 ha. It is planned to develop the system’s full potential to irrigate 37,200 ha in the future.

Extension of Pampanga Delta Development Project (PDRIS):

> A diversion dam on the Pampanga River and irrigation canal system were completed in 2002. The project was designed to irrigate 11,920 ha. However, present irrigation area is 6604 ha. It is planned to extend the irrigation area up to the system’s full potential in the future.

Development of Small Irrigation System (CIS and WRMP):

> In the Study Area, small irrigation systems (CIS and WRMP) are planned to increase by 49 CISs (9914 ha) by NIA and 56 WRMPs (2993 ha) by DA.

The present and future irrigation areas to estimate diversion water demands are presented in Annex 6.5.1 for NIS, and Annexes 6.5.2 and 6.5.3 for small irrigation systems (CIS and WRMP). Features of present and future irrigation areas are summarized as shown in Table 6.5.1 below:

Table 6.5.1 Present and Future Irrigation Areas for Water Demand Estimation

River Basin	Category	Change of Irrigation Scheme					
		Present		Future		Balance	
		Scheme(no)	Area (ha)	Scheme(no)	Area (ha)	Scheme(no)	Area (ha)
Angat	NIS	1	26,000	1	26,791	0	791
	CIS	7	219	13	515	6	296
	WRMP	2	62	4	117	2	55
Pampanga	NIS	5	117,609	6	171,809	1	54,200
	CIS	168	32,139	209	42,213	41	10,074
	WRMP	41	1,764	95	4,702	54	2,938
Agos	NIS	4	4,040	4	4,040	0	0
	CIS	1	224	6	523	5	299
	WRMP	0	0	0	0	0	0
Umiray	NIS	0	0	0	0	0	0
	CIS	0	0	0	0	0	0
	WRMP	0	0	0	0	0	0
Pasig-Marikina	NIS	0	0	0	0	0	0
	CIS	3	206	3	206	0	0
	WRMP	4	84	4	84	0	0
Laguna Lake	NIS	12	7,462	12	7,462	0	0
	CIS	39	3,734	42	3,979	3	245
	WRMP	23	779	23	779	0	0
Total	NIS	22	155,902	23	210,102	1	54,200
	CIS	218	37,522	273	47,436	55	9,914
	WRMP	70	2,689	126	5,682	56	2,993
Grand Total		310	196,113	422	263,220	112	67,898

Source: NIA

6.6 Problems on the Existing Irrigation System

6.6.1 General

The current problems and issues on irrigation systems are identified and evaluated through clarification of available data, field reconnaissance, and interview and discussions with various stakeholders during the Study period. Although the agriculture and fishery sectors consist of various aspects including land resources, productivity, post harvesting, marketing, and so on, this Study focuses only on water resources development and management in the river basins.

The major problems and issues are categorized into:

1) Water shortage relating to irrigation water development;
2) Low irrigation efficiency as irrigation management;
3) Implementation of irrigation development projects;
4) Maintenance, rehabilitation, restoration, and upgrading of irrigation systems;
5) Irrigation water management such as improvement of irrigation efficiency and water-saving technology; and
6) Small scale irrigation development, including small water impounding and shallow tubewells.

The inter-sectoral issues include:

1) Water allocation among other sectors;

2) Development and management of multi-purpose dam projects; and
3) Water quality management, both of surface water and groundwater, among the other sectors.

6.6.2 Water Shortage

(1) Water Shortage and Existing Irrigation Systems

In many paddy fields, including existing irrigation systems both of national and communal irrigation, water shortage is observed and considered due to: (i) recent climate change causing unstable rainfall pattern, (ii) limited water resource development, (iii) deterioration of irrigation facilities due to insufficient maintenance, and (iv) lack of small scale irrigation including water impounding facilities. In addition, degradation of watershed due to illegal logging and slash and burn agriculture is also one of the reasons of unstable water resource for irrigated cultivation.

(2) Delay of Large Scale Irrigation Development Projects

In the Pampanga River basin, there are various irrigation development plans including large scale development of national irrigation systems, communal irrigation systems, and small scale irrigation developments. Major large scale projects are; 1) Casecnan Multipurpose Irrigation & Power Project - Irrigation Component (CMIPP-IC), Phase-2, 2) Balintingon Reservoir Multipurpose Project (BRMP), and 3) Balog-Balog Multipurpose Project (BBMP), Phase-II. However, their implementation has been suspended or delayed mainly due to insufficient budgetary arrangement because of the rapid escalation of prices of construction materials. For the BBMP, it was reported in the workshop during the stakeholders' meeting that unstable security conditions due to NPA activities had also cause delay on the project implementation.

(3) Water Shortage in AMRIS

At present, most serious problems on irrigation water source in the existing irrigation system is the case of the AMRIS due to the water allocation of the Angat Multipurpose Dam. Water resources development and management in detail of the inadequate reliability of water supply in Angat-Umiray, the priority of water distribution from the Angat Dam is given to the municipal water supply, and hence, the irrigation operation in the AMRIS has been facing chronic water shortage. In addition, as the effective storage capacity of 1.5 MCM of the existing Bustos Dam is not enough to regulate the daily fluctuation of the water through the hydropower plants during peak power generation, the AMRIS cannot effectively utilize the full water from the Angat Dam.

6.6.3 Low Irrigation Efficiency

(1) Insufficient and Deterioration of Irrigation Facilities

Low irrigation efficiency is caused by various reasons. Physically, these are; (i) deterioration of canals and related facilities due to lack of maintenance, (ii) insufficient water control facilities including discharge measuring devices, and (iii) high water conveyance loss in the unlined canal. The low irrigation efficiency causes the low collection efficiency on irrigation service fees.

(2) Insufficient Water Management

The low irrigation efficiency is also caused by lack of proper water management activities both by the farmers and related agencies, which requires capacity development and introduction and dissemination of new water-saving technologies. In the workshop, it was pointed out that the role of LGUs is weak in terms of the implementation and operation of communal irrigation systems.

6.6.4 Other Problems and Issues

(1) Water Quality

The Pampanga Delta is the biggest aquaculture area in the nation, and hence aquaculture being done in the fishponds is one of the most important industries in this region. Major issue in the fishpond is the water quality, which consists of two aspects, i.e., a) water pollution in the fishpond areas due to contamination by effluents and garbage from the other sectors such as factories, urbanization, and livestock industry, and b) pollution load given by fishponds causing water pollution in Manila Bay. In addition, it was pointed out in the workshop that sulfate in the groundwater has increased due to the Mount Pinatubo eruption.

(2) Depletion of Groundwater

Depletion of groundwater is reported in Bulacan, Pampanga, and Nueva Ecija provinces due to increasing pump installation of irrigation, fishpond, and domestic water supply, which is also caused by insufficient implementation of groundwater use regulation, including lack of inventory of pump irrigation facilities. Depletion of groundwater has caused salt intrusion in pump irrigation systems in some areas in the provinces of Pampanga and Bulacan.

(3) Flood Damage to Irrigation System and Fishpond

Frequent flood damages and poor drainage conditions due to degradation of drainages and related facilities in the existing agricultural land are the reasons behind the low and unstable production, especially in lower Pampanga and its tributaries. Flood damage in the fishpond area is also reported in the workshop. From the view point of conservation of agricultural and fishery lands, mitigation of flood damage is required.

6.7 Irrigation Water Demand

6.7.1 Estimation of Water Demand

Estimation of irrigation water demand includes (a) surface irrigation, (b) groundwater irrigation, (c) fishery, and (d) livestock. Present and future water demands are estimated by river basin.

(1) Irrigation Water Demand for NISs

The irrigation water demand has been estimated for the water balance analysis of the Study Area (six river basins) both for the existing and future firmed-up service area. For NISs whose water source is surface water, the data on the firmed-up service area was taken from the information given by NIA, and the water demands have been estimated at the intake points. Meanwhile, the estimated water demands for CISs whose water source is surface water are assumed.

The irrigation water demands are determined on an average monthly basis.

In NIA's existing and proposed irrigation systems, only the definite development plan for the Casecnan Multipurpose Project estimated the detailed water requirement in all divisions of the UPRIIS in order to conduct water balance study for their expansion and improvement of the system. Therefore, taking the assumption that the cropping pattern, cropping intensity, water consumption at the field, and irrigation efficiency are similar in all systems in the basin, water demands are preliminarily estimated applying the unit diversion water requirement per hectare in UPRIIS, except for the case that the planned water demand is available in the previous studies. The proposed projects, including the data on their service area, are determined based on the NIA COPLAN covering the years of 2009-2018.

In the past, there are many estimates on diversion water demand for AMRIS as shown in Annex 6.7.1. In this Study, it is estimated based on NIA's estimate for 2009/10 operation, but taking the effective rainfall of 80% dependability into account. The irrigation area is assumed to be 26,000 ha for the wet season cropping and 20,335 ha for the dry season cropping.

For the irrigation water demand in UPRIIS, the re-use rate, which is defined as the ratio (a/b) between the (a) amount of irrigation water to return to the river and (b) amount of irrigation water diverted at intake, is assumed, referring to the Casecnan project, and the net diversion water requirement is computed by subtracting the re-use water volume from the demand. The re-use rate is assumed as follows (Annexes 6.7.2 and 6.7.3):

- Rizal Diversion Dam (weir) point: 0.106
- Bongabon Diversion Dam (weir) point: 0.180
- Penaranda Diversion Dam (weir) point: 0.041

The estimated diversion water demands at each intake point for the existing NISs are summarized in Annex 6.7.2 for present demands and Annex 6.7.3 for future water demands.

For the entire Study Area, the diversion water demand for National Irrigation Systems (NISs) is shown in Annex 6.7.4 for present condition and Annex 6.7.5 for the future condition.

(2) Irrigation Water Demand for Small Irrigation Systems (CISs and SSIs)

The program for future development of CISs is not available, therefore it is assumed that the existing non-functional CISs will be mostly rehabilitated at the target year, which may be implemented under the NIA's nationwide programs.

The CISs located within the future potential large-scale NISs, such as the UPRIIS Division-V and Balintingon Project will be integrated into these systems. If these projects are not operational at present, these systems may not be rehabilitated. However, CISs, which are operational at present, will also utilize local supplementary sources and/or re-use intakes in the future. Therefore, the diversion water demands are included in the water balance study for the case of future irrigation system.

It is assumed that the actual irrigated area is 62.5% of the firmed-up service area in the dry season on the basis of the figure reported by NIA, if the water source is local flow which may be limited in the dry season.

The NIA COPLAN includes the development of the Upper Tabuating Small Reservoir Irrigation Project. However, the service area of this project is designed within the proposed area of the above-mentioned Balintingon Project, and therefore, it is excluded from the water balance study to avoid double counting of water demand.

Pump irrigation systems (PISs) which are operational at present and located in the future large-scale NISs as mentioned above, will be abandoned due to the high O&M cost, and hence, water demands at such PIS are not included in the water balance study for the future case.

Standard procedure for unit diversion water requirement employed by NIA is as follows;

a) Diversion Water Requirement

Unit diversion water requirement was estimated by the following formula;

DWRo = (LSIR + LPIR + CU + P - Re) / EF / 8.64

Where,
DWRo: Unit diversion water requirement (lit/sec/ha)
LSIR: Land soaking irrigation requirement (mm/day)
LPIR: Land preparation irrigation requirement (mm/day)
CU: Consumptive water use (mm/day)
P: Percolation (mm/day)
Re: Effective rainfall (mm/day)
EF: Overall irrigation efficiency

b) Proposed Cropping Pattern

Major crop for CISs and SSIs is paddy for both wet and dry seasons, and diversified crops are limited. Therefore, the proposed cropping pattern was assumed to be a double cropping of paddy per year as a necessary demand. Based on the present cropping pattern prevailing in each province, nine types of cropping pattern have been set as shown in Annex 6.7.6.

c) Criteria in Preparing the Cropping Pattern

The following criteria were applied in preparing the cropping pattern.

(a) The staggering period is one month.
(b) The land soaking period is one week.
(c) The growing period of paddy is four months.
(d) The fallow period is one month.
(e) Drainage starts two weeks before harvest.

d) Representative Pan-Evaporation (PE)

Representative PE for each province was selected from 30 meteorological observation stations.

e) Land Soaking Irrigation Requirement (LSIR)

LSIR = Sn/t + Ep x 0.8

Where,
Sn: Soil saturation requirement (150 mm: common practice of NIA)
t: Land soaking period (7.5 days or 1/4 month: common practice of NIA)
Ep: Pan-evaporation (mm/day)

f) Land Preparation Irrigation Requirement (LPIR)

LPIR = Ep x 0.8

Where:

Ep: Pan-evaporation (mm/day)

g) Consumptive Water Use (CU)

CU = Ep x K

Where,
Ep: Pan-evaporation (3.5-5.0 mm/day)

K: Consumptive use coefficient of paddy by growing stage (% : NIA standard)

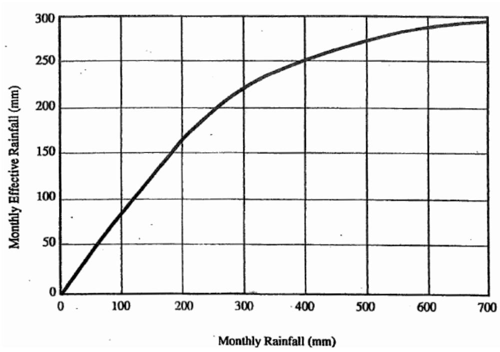
Stage	0	10	20	30	40	50	60	70	80	90	100
K	0.80	0.95	1.05	1.15	1.20	1.30	1.30	1.20	1.10	0.90	0.50

h) Percolation (P)

Since almost all areas are formed by silt and/or loam, P was assumed at 2.5 mm/day based on the standard of NIA.

i) Effective Rainfall (Re)

Re was estimated on a monthly basis by multiplying monthly rainfall with monthly effective rainfall coefficient obtained from the "monthly effective rainfall curve" as shown in Figure 6.7.1.



Source: The Master Plan Study on the Small –Scale Irrigation Development Project (JICA/NIA, 1992)

Figure 6.7.1 Effective Rainfall Curve

j) Overall Irrigation Efficiency (EF)

Irrigation efficiency in small schemes is higher than in large schemes. Overall irrigation efficiency was assumed to be 58% by adopting the following assumption;

Conveyance efficiency (90%), operation efficiency (80%), and on-farm efficiency (80%).

In accordance with NIA's standard procedure mentioned above, the estimation of a nationwide unit diversion requirement by province classifying the climate type and assuming cropping pattern type therein is shown in Table 6.7.1. The table shows the standard monthly unit diversion water requirement.

Table 6.7.1 Unit Diversion Water Requirement for Small Irrigation System

Region / Province	Climate Type	Cropping Pattern	Monthly Unit Diversion Water Requirement (lit/s/ha)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Region III														
Nueva Ecija-1	1 (4)	8	1.4	1.8	0.8	0.0	0.0	1.0	0.0	0.0	0.0	0.1	0.1	0.9
Nueva Ecija-2	3	8	1.2	1.6	0.8	0.0	0.0	1.2	0.2	0.1	0.4	0.0	1.0	0.3
Tarlac	1	4	1.7	0.4	0.0	0.0	1.3	0.1	0.0	0.0	0.0	1.1	0.8	1.4
Pampanga	1	6	1.6	1.6	0.0	0.0	0.0	0.9	0.0	0.0	0.1	0.0	1.5	1.2
Bulacan	1	7	1.7	1.8	0.7	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.3	1.1
Region IVa														
Rizal	1 (4)	8	1.4	1.7	1.2	0.0	0.0	1.0	0.0	0.0	0.0	0.1	1.1	0.4
Laguna	1	7	1.3	1.7	11.0	0.0	0.0	1.0	0.1	0.3	0.2	0.0	1.0	0.4
Quezon	1	8	0.1	0.1	0.0	0.0	1.6	0.4	0.5	0.4	0.0	0.3	0.0	0.0

Source: The Master Plan Study on the Small –Scale Irrigation Development Project (JICA/NIA, 1992)

For the entire Study Area, the diversion water demand for communal irrigation system (CIS) is shown in Annex 6.7.7 for present condition and Annex 6.7.8 for future projection. The diversion water demand for small-scale irrigation (SSI) is shown in Annex 6.7.9 for present condition and Annex 6.7.10 for future projection. These are summarized below.

(3) Groundwater Irrigation Demand

The water demand for irrigation whose water source is groundwater is preliminarily estimated based on the water use permit granted by NWRB. It is assumed that the present and future peak water demand is equal to the current water quantity granted by NWRB. The monthly variation of the demand is estimated based on the crop water requirement determined in the Tarlac Groundwater Irrigation System Reactivation Project. Since there are no measured water use data available, consumptive use for wet/dry season paddy was estimated on a monthly basis following the procedure employed in the Master Plan Study on the Small-Scale Irrigation Development Project, conducted by JICA in 1992.

The present and future irrigation water demand for groundwater source in the Study Area is estimated as shown in Annex 6.7.11.

(4) Fishery Water Demand

The water demand for fisheries is estimated as follows;

- The unit water demand for fisheries which is used as standard criterion or procedure for water permit granted by NWRB is employed. Assuming that there is minimal prawn cultivation, the unit water demand of 0.926 lit/s/ha is applied.
- The area for fishponds as well as the ratio of freshwater fishpond at present for each city/municipality is given by BFAR.

- It is assumed that the areas for fishponds will be kept in the future.

The estimated water demand for fisheries in the Study Area is shown in Annex 6.7.12.

(5) Livestock Water Demand

The water demand for livestock is estimated as follows;

- The unit water demand for livestock which is used as standard criterion or procedure for water permit granted by NWRB (0.00024 l/s/head for cattle and swine, 0.00000146 l/s/head for poultry) is employed.
- City/municipality data for number of livestock is used for the present water demand.

The increasing rate in the number of livestock is assumed to be proportional to the increasing share rate of agriculture in the GRDP. In the Philippines, the proportional coefficient is assumed to be 0.282 for livestock and 0.151 for poultry, based on the relationship between the average increasing rate for the total number of livestock and poultry and that share of agricultural sector in the country's GDP for the last five years, according to the statistical data prepared by NSCB. It is also observed that the annual increasing rate of agriculture sector in the GRDP in Region III for the last five years is 8.2% per year on the average, according to the statistical data prepared by NSCB. The increasing rate in number is therefore set at 2.3% per year for livestock and 1.2% for poultry.

The estimated water demand for livestock in the Study Area is shown in Annex 6.7.13.

6.7.2 Summary of Water Demand Estimation

(1) Water Demand for National Irrigation System

Table 6.7.2 Present Diversion Water Demand for NIS

River Basin	NIS	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	AMRIS	41.3	41.7	32.0	9.7	0.0	25.5	9.9	1.2	5.4	10.1	18.8	34.2
Pampanga	UPRIIS	125.8	142.7	107.4	25.5	12.2	78.9	46.1	16.0	18.7	41.7	74.6	108.9
	Aulo	1.1	1.2	0.6	0.0	0.2	0.7	0.3	0.1	0.2	0.4	0.7	0.9
	PDRIS	8.7	9.4	5.3	0.0	1.5	5.7	2.1	1.2	1.3	3.4	5.9	7.0
	Porac-Gumain	4.1	4.8	4.0	1.3	0.1	2.7	1.6	0.5	0.5	1.3	2.1	3.7
	Total	139.7	158.1	117.3	26.8	14.0	88.0	50.1	17.8	20.7	46.8	83.3	120.5
Umiray		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agos	4 NISs	6.2	6.3	4.9	1.5	0.0	3.8	1.5	0.2	0.8	1.5	2.8	5.2
Pasig-Marikina		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laguna Lake	12 NISs	11.5	11.6	9.0	2.7	0.0	7.1	2.8	0.3	1.5	2.8	5.2	9.5
Grand Total		198.7	217.7	163.2	40.7	14.0	124.4	64.3	19.5	28.4	61.2	110.0	169.4

Source: Prepared by the JICA Study Team

Table 6.7.3 Future Diversion Water Demand for NIS

River Basin	NIS	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	AMRIS	42.5	43.0	33.2	10.0	0.0	26.3	10.2	1.2	5.6	10.4	19.4	35.2
Pampanga	UPRIIS	150.7	171.4	131.6	33.1	12.9	92.7	56.8	18.9	22.2	49.3	88.4	131.1
	Aulo	1.1	1.2	0.6	0.0	0.2	0.7	0.3	0.1	0.2	0.4	0.7	0.9
	Balintingon	19.5	21.2	11.9	0.0	3.3	12.8	4.8	2.7	3.0	7.7	13.3	15.8
	PDRIS	15.7	16.9	9.5	0.0	2.7	10.3	3.8	2.2	2.3	6.1	10.6	12.6
	Porac-Gumain	12.9	12.9	7.6	6.3	6.7	6.2	4.3	6.0	5.3	2.8	8.8	12.5
	Total	180.4	202.5	149.3	39.4	22.5	109.8	65.2	27.2	30.0	58.6	108.5	157.1
Umiray		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agos	4 NISs	6.2	6.3	4.9	1.5	0.0	3.8	1.5	0.2	0.8	1.5	2.8	5.2
Pasig-Marikina		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laguna Lake	12 NISs	11.5	11.6	9.0	2.7	0.0	7.1	2.8	0.3	1.5	2.8	5.2	9.5
Grand Total		240.6	263.4	196.4	53.6	22.5	147.0	79.7	28.9	37.9	73.3	135.9	207.0

Source: Prepared by the JICA Study Team

(2) Water Demand for Communal Irrigation Systems

Table 6.7.4 Present Diversion Water Demand for CIS

River Basin	CIS (nos)	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	7	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.2
Pampanga	168	29.1	31.5	17.8	0.0	7.3	28.5	10.6	6.0	6.6	17.2	19.7	23.5
Umiray	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
Agos	1	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.2
Pasig-Marikina	3	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1
Laguna Lake	39	2.3	2.5	1.4	0.0	0.6	2.2	0.8	0.5	0.5	1.4	1.6	1.9
Total	218	32.0	34.6	19.5	0.0	7.9	31.3	11.7	6.5	7.1	18.9	21.6	25.9

Source: Prepared by the JICA Study Team

Table 6.7.5 Future Diversion Water Demand for CIS

River Basin	CIS (nos)	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	13	0.6	0.6	0.3	0.0	0.1	0.6	0.2	0.1	0.1	0.3	0.4	0.5
Pampanga	209	41.2	44.6	25.1	0.0	10.3	40.3	15.1	8.4	9.4	24.4	28.0	25.4
Umiray	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
Agos	6	0.1	0.1	0.0	0.8	0.2	0.3	0.2	0.0	0.2	0.0	0.0	0.0
Pasig-Marikina	3	0.4	0.6	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.1
Laguna Lake	42	3.5	3.8	2.1	0.0	0.9	3.4	1.3	0.7	0.8	2.1	2.4	2.8
Total	273	45.8	49.7	27.8	0.8	11.5	44.9	16.8	9.2	10.5	26.8	31.1	28.8

Source: Prepared by the JICA Study Team

(3) Water Demand for Small-Scale Irrigation

Table 6.7.6 Present Diversion Water Demand for SSI

River Basin	WRMP (nos)	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	2	0.05	0.06	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.04	0.04
Pampanga	41	1.55	1.68	0.95	0.00	0.39	1.52	0.56	0.32	0.35	0.92	1.05	1.25
Umiray	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agos	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pasig-Marikina	4	0.07	0.08	0.05	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.05	0.06
Laguna Lake	23	0.68	0.74	0.42	0.00	0.17	0.67	0.25	0.14	0.16	0.41	0.46	0.55
Total	70	2.35	2.56	1.45	0.00	0.59	2.31	0.86	0.49	0.54	1.40	1.60	1.90

Source: Prepared by the JICA Study Team

Table 6.7.7 Future Diversion Water Demand for SSI

River Basin	WRMP (nos)	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	4	0.10	0.11	0.06	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.07	0.08
Pampanga	95	4.13	4.47	2.52	0.00	1.03	4.04	1.51	0.84	0.94	2.45	2.80	3.34
Umiray	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agos	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pasig-Marikina	4	0.07	0.08	0.05	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.05	0.06
Laguna Lake	23	0.68	0.74	0.42	0.00	0.17	0.67	0.25	0.14	0.16	0.41	0.46	0.55
Total	126	4.98	5.40	3.05	0.00	1.25	4.88	1.83	1.02	1.14	2.96	3.38	4.03

Source: Prepared by the JICA Study Team

(4) Water Demand for Groundwater Use, Fishery, and Livestock

Table 6.7.8 Water Demand for Groundwater Use, Fishery, and Livestock

Water Demand for Groundwater Use

	Water Demand (m^3/s) by River Basin						Total (m^3/s)
	Angat	Pampanga	Umiray	Agos	P-Marikina	Laguna	
Present	0.00	0.58	0.00	0.00	0.00	0.00	0.58
Future	0.00	2.25	0.00	0.00	0.08	0.19	2.52

Water Demand (Fresh Water) for Fishery

	Water Demand (m^3/s) by River Basin						Total (m^3/s)
	Angat	Pampanga	Umiray	Agos	P-Marikina	Laguna	
Present	0.2	6.4	0.0	0.0	0.0	0.0	6.6
Future	0.2	6.4	0.0	0.0	0.0	0.0	6.6

Water Demand for Livestock

	Livestock Water Demand (m^3/s) by River Basin						Total (m^3/s)
	Angat	Pampanga	Umiray	Agos	P-Marikina	Laguna	
Present	0.02	0.27	0.00	0.00	0.01	0.01	0.31
Future	0.04	0.38	0.00	0.00	0.01	0.02	0.45

Source: Prepared by the JICA Study Team

6.7.3 Influence of Climate Change and Proposed Alternative Scenario for the Projection of Water Demand

As can be seen in the above discussions, climate is a key factor that defines irrigation water requirement. Change in climate due to the change in the concentration of greenhouse gases surely affects the irrigation water requirements presented in the previous section. A decrease in effective rainfall in the dry season increases the diversion requirement to secure the planned production. A heightening of air temperature increases consumptive use of crops, such as paddy. It increases evaporation from surfaces like paddy farms as well, and consequently, increases irrigation water requirement. Thus, assessment of climate change calls for coming up with an alternative scenario for the projection of irrigation water requirement to conduct water demand and supply balance study.

Schedule of irrigation development including additional scheme planning is another key factor that defines the alternative scenario for irrigation water demand projection in most of the countries. However, the following views impeded the development schedule to be a key factor to formulate the alternative scenario in the Study Area.

Irrigation development is not feasible in addition to the schemes discussed in the previous sections due to limited suitable land resources available.

Although the completion year of each scheme is not defined yet, all the schemes are to be implemented by 2040 according to the project plan. It is not realistic to assume that implementation of any scheme is postponed until 2040 considering the policy of the government concerning attainment of self-sufficiency in paddy. Meanwhile, acceleration of the implementation is not realistic as well, considering the allocations of budget for investment.

The other key factor is the operation of irrigation that defines water requirement, as can be seen in the procedures to estimate diversion requirement discussed in the previous sections. The figures based on the common practice of NIA have governed the estimation of irrigation water requirement. The International Rice Research Institute (IRRI) is now promoting Alternate Wet and Dry Operation as a component of System for Rice Intensification (SRI). The operation is expected to save water for about 10% to 20% from the common practice. Along this line, an alternative scenario that the promotion made by IRRI becomes effective and irrigation water requirement is reduced by 10% in 2040 is proposed.

6.8 Irrigation Water Demand Affected by Climate Change

6.8.1 General

Climate change projection in this study showed a tendency to increase in maximum air temperature at a rate of 2°C in the future. These changing conditions may affect on irrigation water demand by increasing in crop evapotranspiration caused by air temperature increase. Though available data on changing condition are limited, projection of irrigation water demand affected by climate change may suggest the broad direction how to meet the changing situation in the future.

(1) Estimation of Change in Crop Evapotranspiration

For estimation of water requirement by crops, usually, the FAO Penman-Monteith equation is adopted. Required data to use this equation are 5 kinds of climate data, i.e. (a) maximum and minimum air temperature, (b) humidity, (c) wind velocity, (d) sunshine hours, and (e) radiation at the crop surface.

The FAO Penman-Monteith equation is as follows:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

where	ET_o	reference evapotranspiration [mm $hour^{-1}$],
	R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
	G	soil heat flux density [MJ m^{-2} day^{-1}],
	T	air temperature at 2 m height [°C],
	u_2	wind speed at 2 m height [m s^{-1}],
	e_s	saturation vapour pressure [kPa],
	e_a	actual vapour pressure [kPa],
	$e_s - e_a$	saturation vapour pressure deficit [kPa],
	Δ	slope vapour pressure curve [kPa $°C^{-1}$],
	γ	psychrometric constant [kPa $°C^{-1}$],

This equation determines the evapotranspiration from the hypothetical grass surface and provides a standard to which evapotranspiration in different periods of the year. Detail of calculation procedure is described in FAO Irrigation and Drainage Paper 56 "Crop Evapotranspiration – Guidelines for Computing Crop Water Requirement" 1998.

Climate change projection indicates only the change in temperature among the above climate records. Therefore, in this study trial calculation will be carried out assuming that all climate data except for air temperature are constant (no change).

Assumptions are as follows.

- Humidity = 80%
- Wind speed = 70 km per day (0.8 m/s)
- Sushine hours = 6 hours

CHAPTER 7 SUPPLY SIDE STUDY

7.1 Meteorology and Hydrology

7.1.1 Meteorology

(1) Climate Types

The climate in the Philippines is broadly characterized as tropical monsoon and tropical rainforest. The “Climate Map of the Philippines” published by PAGASA indicates that there are four climate types occurring in the country. In the Study Area, the Sierra Madre Mountains form a watershed ranging from the north to the south. The river basins of Angat (lower), Pampanga (lower), Pasig-Marikina (lower) and the west of the Laguna Lake basin are located west of the watershed. These watersheds belong to the zone of Climate Type I. The river basins of Umiray and Agos (lower) are located to the east of the watershed. These belong to the zone of Climate Type II. High altitude regions along the Sierra Madre Mountains, corresponding to the river basins of Angat (upper), Pampanga (upper), Pasig-Marikina (upper) and the east of the Laguna Lake basin, belong to the zone of Climate Type III (see Table 7.1.1).

Table 7.1.1 Climate Types in the Study Area

Climate Type	Description	Study Area
I	Two pronounced seasons, dry from November to April and wet during the rest of the year. Maximum rain period is from June to September.	Angat River basin (lower) Pampanga River basin (lower) Pasig-Marikina River basin (lower) Laguna Lake basin (west)
II	No dry season. Very pronounced maximum rain period from December to February. There is not a single dry month. Minimum monthly rainfall occurs during the period from March to May.	Umiray River basin Agos River basin (lower)
III	No very pronounced maximum rain period with a dry season lasting only from one to three months, either during the period from December to February or from March to May. This type resembles Type I since it has a short dry season.	Angat River basin (upper) Pampanga River basin (upper) Pasig-Marikina River basin (upper) Laguna Lake basin (east)
IV	Rainfall is more or less evenly distributed throughout the year. This type resembles Type II since it has no dry season.	(Not applicable)

Source: Climate Map of the Philippines, PAGASA

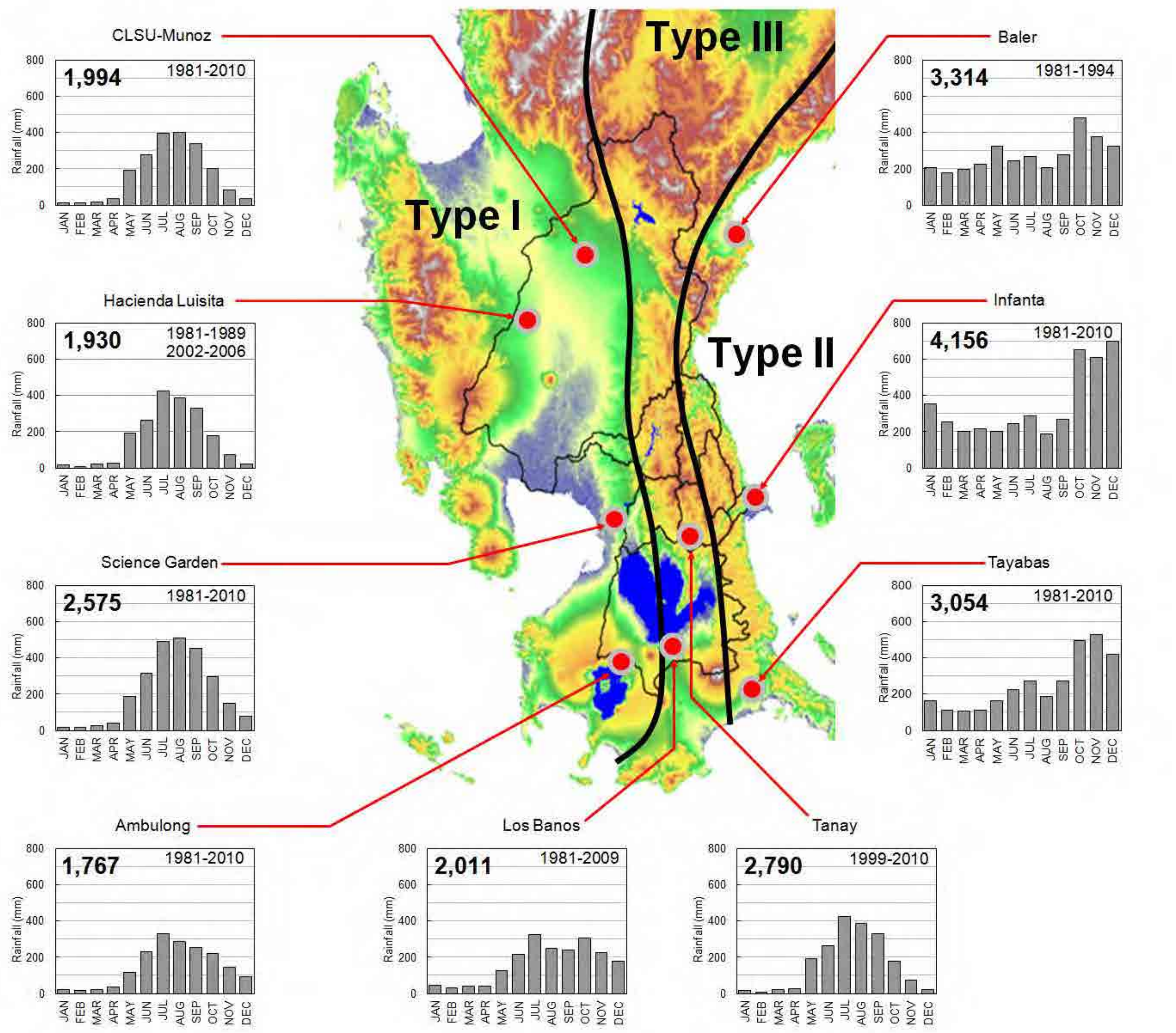
(2) Rainfall (Refer to Figure 7.1.1)

The major causes of rainfall in the Philippines are monsoons, tropical depressions and trade winds. The southwest monsoon prevails from May to October and the northeast monsoon becomes dominant from November to April. Therefore, the Sierra Madre Mountains have important influences over the climate of the Study Area. In addition, tropical depressions born in the Pacific Ocean frequently pass by the territories of the Philippines. About 20 typhoons pass by the Philippines every year, which brings half of the country’s annual rainfall amount.

The climate in regions located west of the Sierra Madre Mountains is classified as Climate Type I. The mean annual rainfall is 1994 mm at CLSU-Munoz, 1930 mm at Hacienda Luisita in the Pampanga River basin, 2575 mm at the Science Garden (Quezon City) in Metro Manila, and 1767 mm at Ambulong located around the watershed boundary on the southwest of the Laguna Lake basin. Monthly rainfall reaches its peak during the months of July-August. About 80% to 90% of the annual rainfall occurs during the wet season from May to October.

The climate in regions located east of the Sierra Madre Mountains is classified as Climate Type II. The mean annual rainfall in the area is 3314 mm at Baler located northeast of the Pampanga River basin, 4156 mm at Infanta in the lower reaches of the Agos River, and 3054 mm at Tayabas located around the watershed boundary on the southeast part of the Laguna Lake basin. Monthly rainfall reaches its peak in October to December.

The climate of the remaining regions along the Sierra Madre Mountains is classified as Climate Type III. Recent study reports suggest that the mean annual rainfall in the area ranges from 2500 to 3000 mm in the upper basin of the Pampanga, 4000 to 6000 mm in the upper basins of the Angat, Umiray and Agos, and 2000 to 3000 mm in the central to west of the Laguna Lake basin.



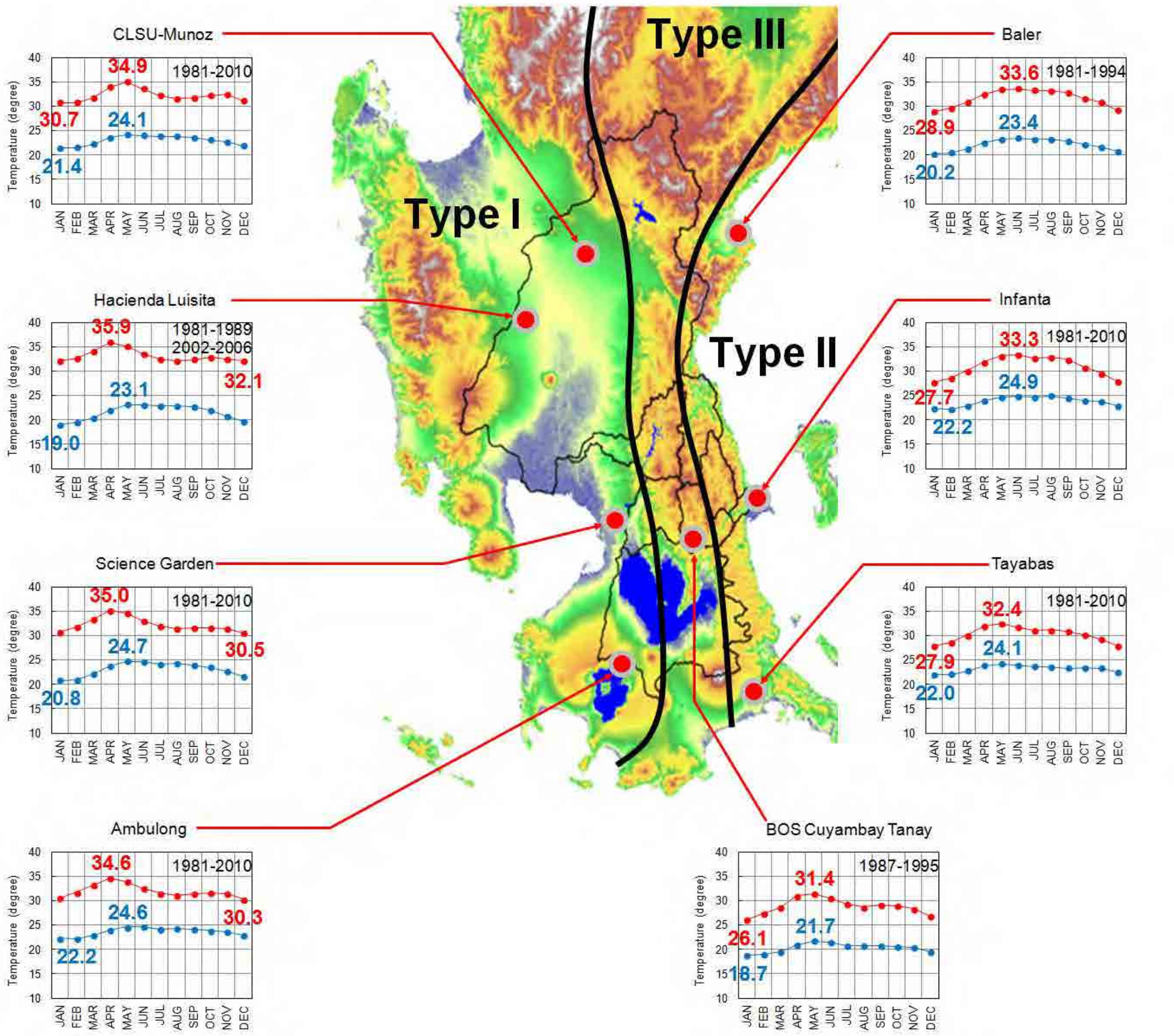
Source: Prepared by the JICA Study Team, using meteorological records collected from PAGASA

Figure 7.1.1 Annual Rainfall along the Sierra Madre Mountains

(3) Air Temperature (refer to Figure 7.1.2)

There is a common seasonal variation of the air temperature that has been observed at the Pampanga River basin, Metro Manila, and along the western part of the Laguna Lake basin. The mean daily maximum temperature by month ranges from 30.7°C to 34.9°C at CLSU-Munoz, where the highest temperature takes place in May. The mean daily minimum temperature ranges from 21.4°C to 24.0°C at CLSU-Munoz and the lowest temperature takes place in January.

A seasonal variation of the air temperature is different from the above in regions located east of the Sierra Madre Mountains. The mean daily maximum temperature by month ranges from 27.7°C to 33.3°C at Infanta and the highest takes place in June. The mean daily minimum temperature ranges from 22.2°C to 24.9°C at Infanta and the lowest takes place in January.



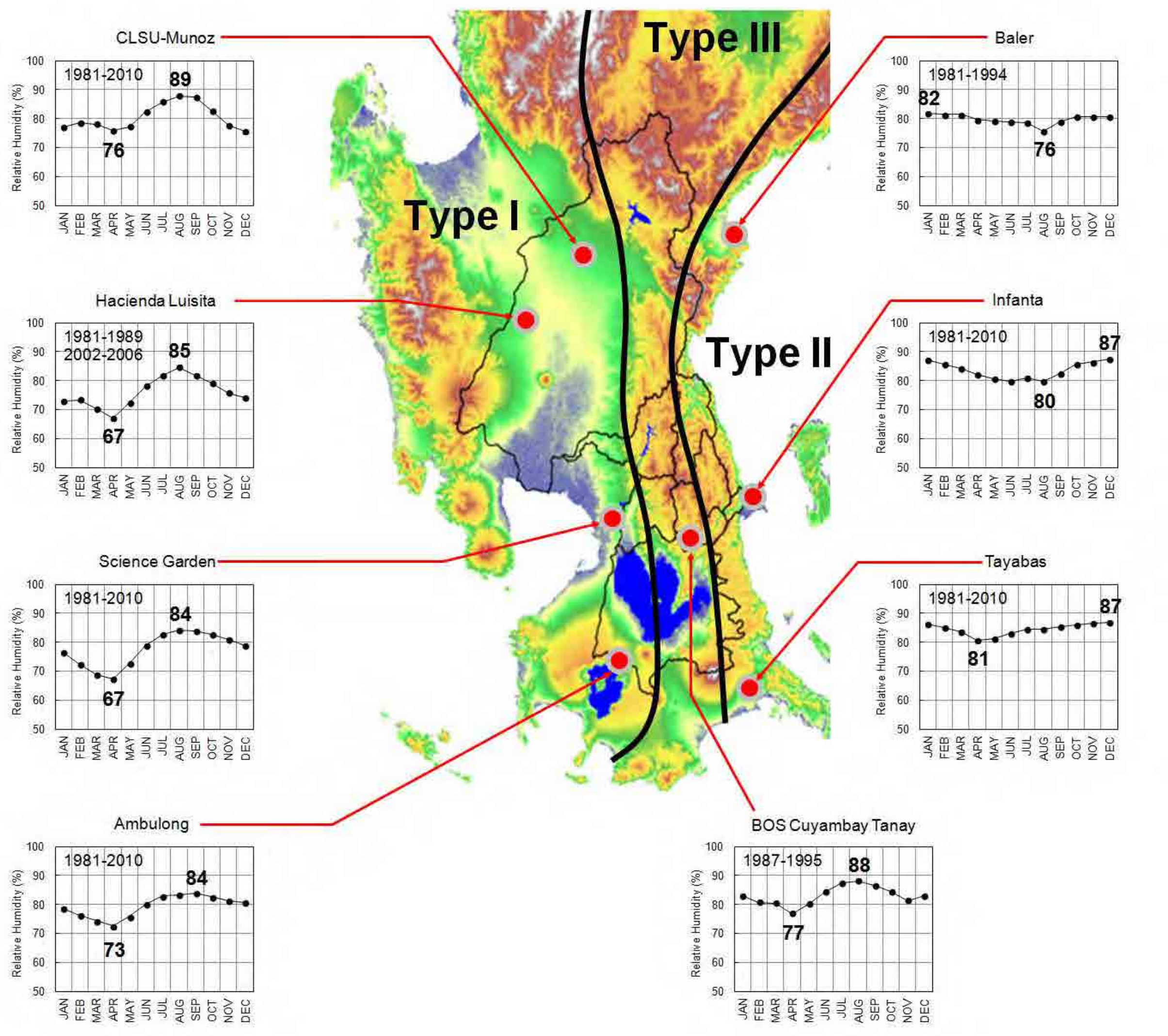
Source: Prepared by the JICA Study Team, using meteorological records collected from PAGASA

Figure 7.1.2 Annual Air Temperature along the Sierra Madre Mountains

(4) Relative Humidity (Refer to Figure 7.1.3)

At CLSU-Munoz, the mean daily relative humidity by month ranges from 75% to 77% in the dry season of November-April and it is highest in August with a value of 89%. The mean daily relative humidity at Science Garden varies with a wider range with the highest value reaching 84% in September and the lowest at 66% in April. The seasonal variation at Ambulong is similar with Science Garden and ranges from 81% in September and 69% in April.

The mean daily relative humidity at Infanta and Tayabas stations stays above 80% throughout the year. The mean daily relative humidity at Infanta ranges from 86% in December to 80% in August, while humidity in Tayabas reaches 87% in December and 81% in April.



Source: Prepared by the JICA Study Team, using the meteorological records collected from PAGASA

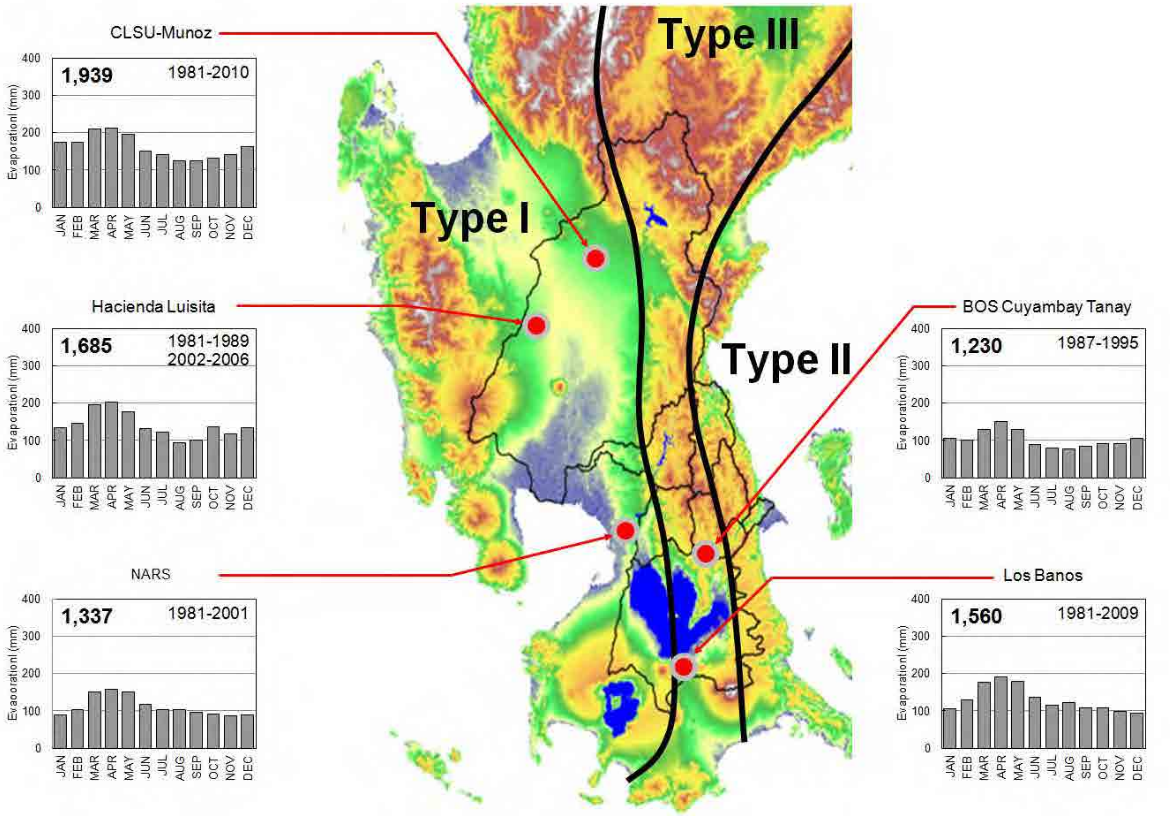
Figure 7.1.3 Annual Relative Humidity along the Sierra Madre Mountains

(5) Pan Evaporation (refer to Figure 7.1.4)

The mean annual evaporation were recorded at 1939 mm at CLSU–Munoz, 1685 mm at Hacienda Luisita in the Pampanga River basin, 1337 mm at National Agromet Research

Center (Quezon City) in Metro Manila, 1230 mm at the Bureau of Soils, Cuyambay Tanay located around the boundary of the Agos River basin and Laguna Lake basin, and 1560 mm at Los Banos located south of the Laguna Lake basin.

Monthly evaporation is highest in April for all stations mentioned above. Monthly evaporation falls lowest in the middle of the wet season for CLSU-Munoz, Hacienda Luisita, and Cuyambay Tanay, with others having recorded its lowest evaporation during the post wet season (at NARS and Los Banos).



Source: Prepared by the JICA Study Team, using meteorological records collected from PAGASA

Figure 7.1.4 Pan Evaporation along the Sierra Madre Mountains

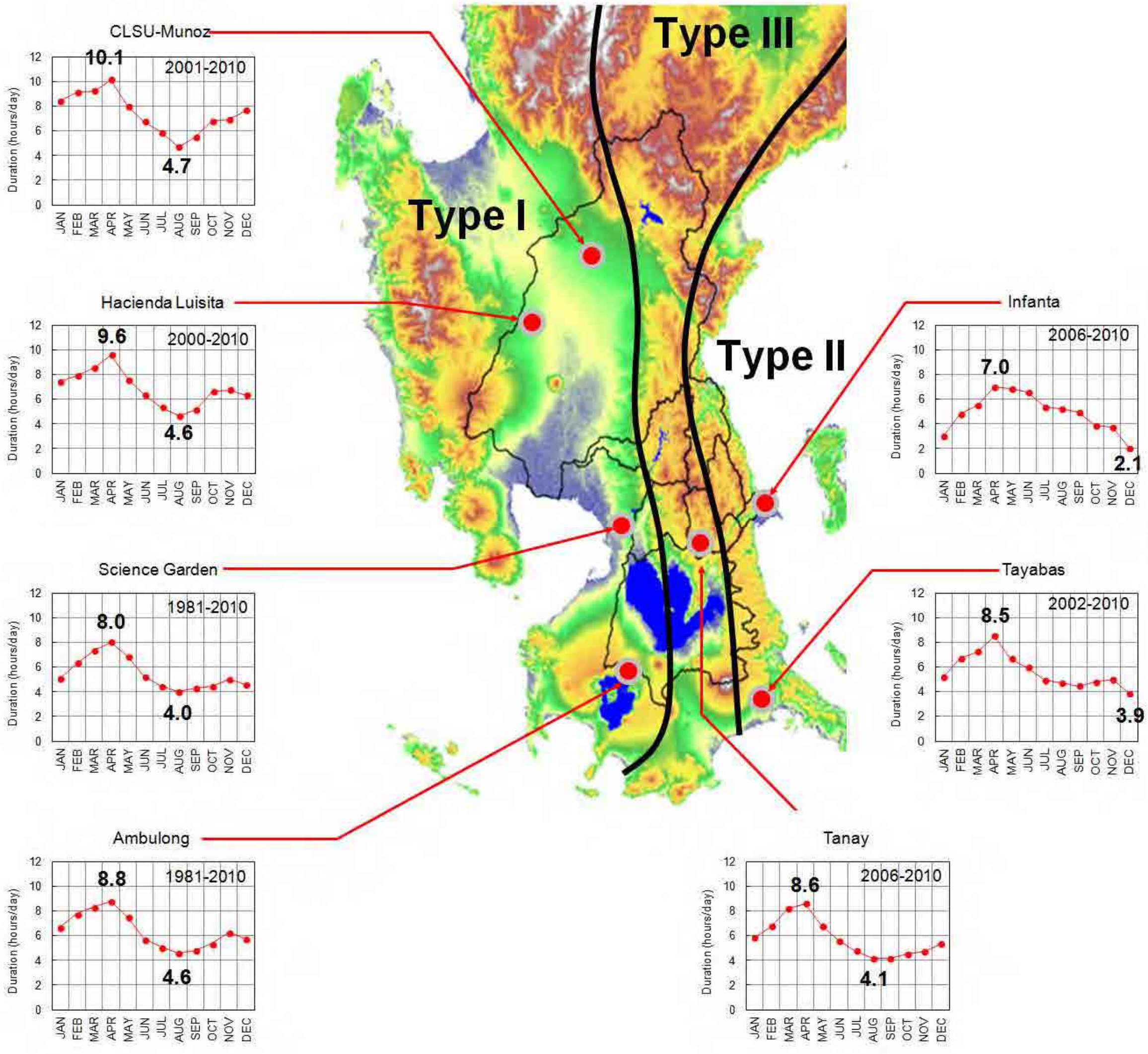
(6) Sunshine Duration (refer to Figure 7.1.5)

The maximum mean daily sunshine duration corresponds with the peak of the dry season while the minimum sunshine duration takes place during the peak of the wet season.

In the Pampanga River basin, the mean daily sunshine duration by month is maximum in April and minimum in August. The mean maximum daily sunshine duration were recorded at 10.1 hrs/d at CLSU–Munoz and 9.6 hrs/d at Hacienda Luisita in April. Mean minimum daily sunshine duration at CLSU–Munoz and at Hacienda Luisita in August are 4.7 hrs/d and 4.6 hrs/d, respectively.

The mean daily sunshine duration indicated a similar monthly variation as the above records for Metro Manila and the Laguna Lake basin. The mean maximum daily sunshine duration is 8.0 hrs/d at Science Garden and 8.8 hrs/d at Ambulong in April, while the minimum sunshine duration is 4.7 hrs/d at Science Garden and 4.6 hrs/d at Ambulong in August.

At Infanta, a monthly variation of the mean daily sunshine duration is different from the above. The mean daily sunshine duration by month varies from 7.0 hrs/d in April and 2.1 hrs/d in December.



Source: Prepared by the JICA Study Team, using meteorological records collected from PAGASA

Figure 7.1.5 Annual Sunshine Duration Along the Sierra Madre Mountains

7.1.2 Hydrology

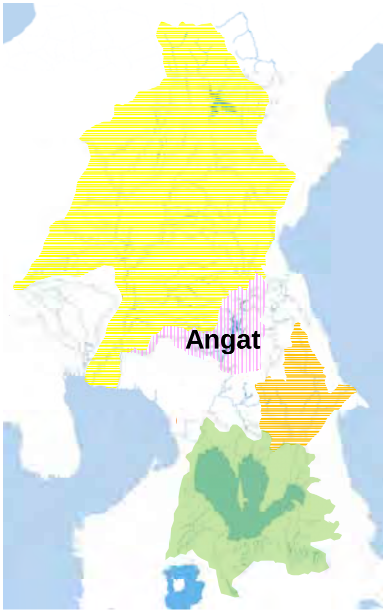
(1) Angat River Basin

The Angat River basin is located on the western slope of the Sierra Madre Mountains. The basin is bounded by the Umiray River basin in the east and the Marikina River basin in the south as shown in Figure 7.1.6.

The estimated basin mean rainfall in each of the sub-divided catchment areas is shown in Table 7.1.2. The upstream catchment from the Angat Reservoir (546 km^2) is mostly mountainous and is one of the regions receiving heaviest rainfall in the Philippines. According to the Study on Integrated Water Resources Management for Poverty Alleviation and

Economic Development in the Pampanga River Basin (JICA/NWRB, 2009-2011), the basin mean annual rainfall in the upstream catchment of the Angat Reservoir is estimated at 4391 mm.

In the downstream reaches of the reservoir, the gradient of the Angat River gradually becomes gentle toward the Pampanga Delta. Then, the river pours into the Manila Bay through the Labangan Floodway. The residual catchment between the Angat Reservoir and the Labangan Floodway is 346 km^2. The basin mean annual rainfall in the residual catchment is estimated at 2425 mm.



Source: Prepared by the JICA Study Team

Figure 7.1.6 Location of the Angat River Basin

Table 7.1.2 Basin Mean Annual Rainfall in the Angat River Basin

Reaches	Catchment Area (km^2)	Basin Mean Annual Rainfall (mm)
Upstream of Angat Reservoir	546	4391
From Angat Reservoir to Labangan Floodway	346	2425
From Labangan Floodway to Manila Bay	194	1806
Total	1,085	3303

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2009-2011) estimated the mean monthly flows at different locations of the river basins of Pampanga, Angat and Pasac using runoff analysis and simulation for the period of 50 years from 1958-2007. For evaluating the water resources potential, the said study simulated the monthly flows on the condition of a "quasi-natural", assuming that the flow control effects of existing dam reservoirs, transbasin diversions, and water intakes had not taken place.

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 7.1.7 Locations of Estimated Monthly Flows in the Angat River Basin

The locations where the monthly flows were estimated are shown in Figure 7.1.7 and the estimated average flows at each location are listed in Table 7.1.3. The average flow estimated at the Angat Reservoir is 58.3 m^3/s (5037 MLD or 1839 MCM/yr). The average flow estimated at the confluence with the Labangan Floodway is 74.7 m^3/s (6454 MLD or 2356 MCM/yr).

Table 7.1.3 Average Flows in the Angat River Basin

No.	Location	Catchment Area (km^2)	Average Flow (m^3/s)	Specific Runoff ($m^3/s/ km^2$)
A4	Angat Reservoir	546	58.3	0.107
A3	Ipo Dam	618	63.7	0.103
A2	Bustos Dam	846	73.5	0.087
A1	Confluence with Labangan Floodway	892	74.7	0.084

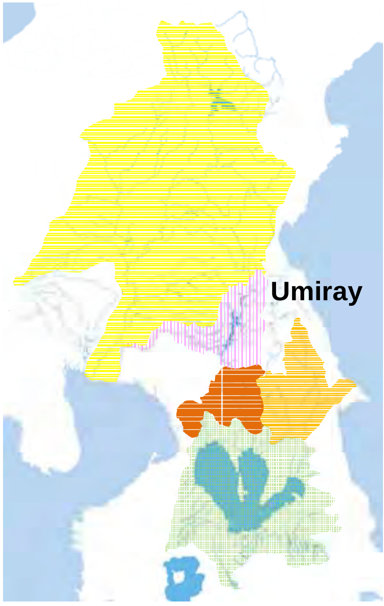
Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

(2) Umiray River Basin

The Umiray River flows down toward the north through a gorge formed between the Angat River basin to the west and the Kanan River basin to the east. The Umiray River then pours into the Pacific Ocean as shown in Figure 7.1.8. The catchment area of the Umiray River is 538 km^2.

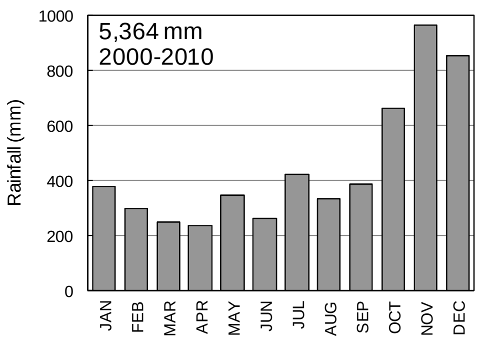
The upper basin of the Umiray River is one of the regions that receive the heaviest rainfalls in the Philippines. Based on the abundant runoff in the upper basin, a part of the Umiray River runoff is transferred to the Angat Reservoir through the Umiray-Angat transbasin diversion which was commissioned in 2000.

The mean annual rainfall of the Angat River basin would be 5000 mm or more, as suggested by the rainfall records at the inlet of the Umiray-Angat transbasin diversion shown in Figure 7.1.9.



Source: Prepared by the JICA Study Team

Figure 7.1.8
Location of the Umiray River Basin



Source: Prepared by the JICA Study Team, using records collected from MWSS

Figure 7.1.9
Rainfall at Water Diversion Facility of Umiray River

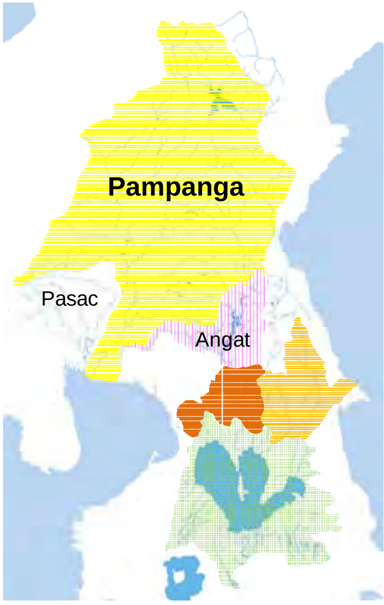
According to the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2009-2011), the catchment area at the inlet of the transbasin diversion is 130 km^2 and the average flow diverted to the Angat Reservoir is reported to be 11.7 m^3/s (1,011 MLD or 370 MCM/yr). These data were considered on the basis of the recorded daily flows diverted. The Feasibility Study Report on the Umiray-Angat transbasin Diversion (1992) suggests that 85% to 90% of the river flow could be diverted.

(3) Pampanga River Basin

The Pampanga River originates from the Caraballo Mountains. The river flows down to the south and joins the tributaries coming from the Sierra Madre Mountains. The Chico River, the largest tributary, drains the western part of the Pampanga River basin and joins the Pampanga River around the Candaba Swamp. The Pampanga River flows toward the south and eventually reaches Manila Bay.

The catchment area of the Pampanga River is 7978 km^2. The total area of the Pampanga River basin is sometimes regarded at 10434 km^2 comprising of its own catchment, the Angat River basin (1085 km^2) in the southeast and the Pasac River basin (1371 km^2) in the southwest (see Figure 7.1.10).

The Pantabangan Reservoir is located in the upstream reach of the river. Inflow into the Pantabangan Reservoir is augmented by means of the Casecnan transbasin diversion from the Cagayan River on the north.



Source: Prepared by the JICA Study Team

Figure 7.1.10
Location of the Pampanga River Basin

The basin mean annual rainfall is estimated to be 2183 mm in the upstream catchment of the Pantabangan Reservoir. In the northeastern catchments on the western slope of the Sierra Madre Mountains, the basin mean annual rainfall is 2460 mm in the Coronell River basin and 2638 mm in the Penaranda River basin. The catchment of the Chico River draining the western part of the Pampanga River basin receives 1926 mm. The remaining lower catchments receive 1700 to 1800 mm (see Table 7.1.4).

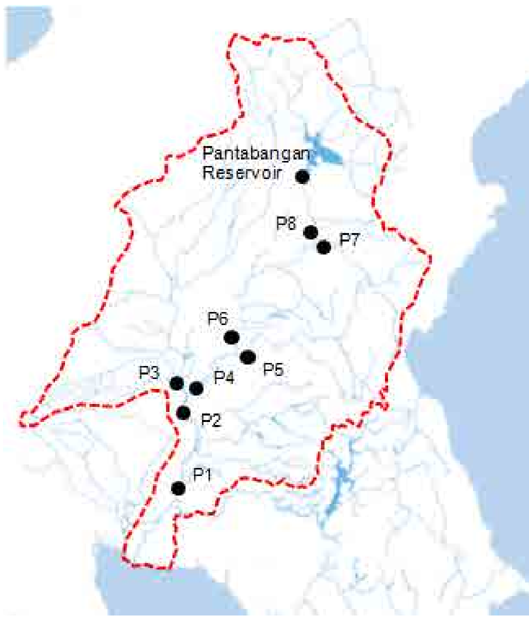
Table 7.1.4 Basin Mean Annual Rainfall in the Pampanga River Basin

River	Reaches	Catchment Area (km^2)	Rainfall (mm)
Pampanga	Upstream of Pantabangan Reservoir	849	2,183
Pampanga	Pantabangan Reservoir - Coronell River Confluence	437	2,016
Coronell	Upstream of Pampanga River Confluence	712	2,460
Pampanga	Coronell River Confluence - Penaranda River Confluence	799	1,724
Penaranda	Upstream of Pampanga River Confluence	570	2,638
Pampanga	Penaranda River Confluence - Chico River Confluence	40	1,509
Chico	Upstream of Pampanga River Confluence	2,895	1,926
Pampanga	Chico River Confluence - Calumpit	1,517	1,811
Pampanga	Calumpit - Manila Bay	159	1,731
	Total	7,978	2,009

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

The average flows estimated at the time of the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2009-2011) are shown in Table 7.1.5. The locations of the estimated monthly flows are shown in Figure 7.1.11.

On the condition of a "quasi natural" as explained before, the average flow estimated at the Pantabangan Reservoir (P9) is 33.4 m^3/s (2886 MLD or 1053 MCM/yr). The average flow estimated at Calumpit is 289.8 m^3/s (25039 MLD or 9139 MCM/yr).



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 7.1.11
Locations of Estimated Monthly Flows in the Pampanga River Basin

Table 7.1.5 Average Flows in the Pampanga River Basin

No.	River	Location	Catchment Area (km^2)	Average Flow (m^3/s)	Specific Runoff ($m^3/s/ km^2$)
P9	Pampanga	Pantabangan Reservoir	849	33.4	0.039
P8	Pampanga	Upstream of Coronell River Confluence	1,286	47.8	0.037
P7	Coronell	Upstream of Pampanga River Confluence	712	33.3	0.047
P6	Pampanga	Upstream of Penaranda River Confluence	2,797	105.0	0.038
P5	Penaranda	Upstream of Pampanga River Confluence	570	31.3	0.055
P4	Pampanga	Upstream of Chico River Confluence	3,406	137.2	0.040
P3	Chico	Upstream of Pampanga River Confluence	2,895	105.2	0.036
P2	Pampanga	Cong Daong Weir	6,308	242.6	0.038
P1	Pampanga	Calumpit	7,819	289.8	0.037

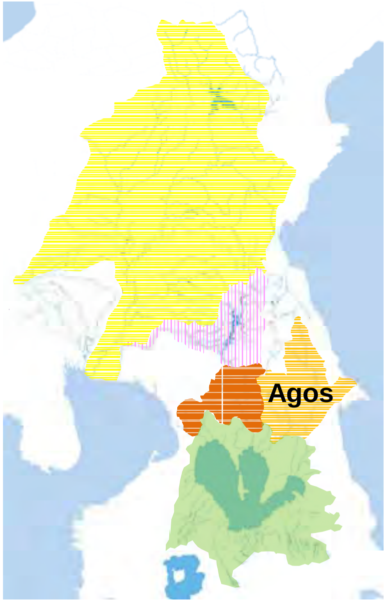
Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

(4) Agos River Basin

The Agos River basin is located east of the Sierra Madre Mountains. The river is bounded by the Umiray River basin to the north, the Marikina River basin to the west, and the Laguna Lake basin to the south (see Figure 7.1.12). Its mountainous catchment area is 940 km^2. The upper catchment is one of the regions that receive the heaviest rainfall in the Philippines (see Figure 7.1.13).

The Study on Water Resources Development for Metro Manila (JICA/NWRB, 2001-2003) estimated rainfalls in the sub-basins. The estimated basin mean annual rainfall is about 5700 mm in the Kanan River basin located in the northeast and about 3300 mm in the Kaliwa River basin in the southwest. After the Kaliwa River and Kanan River join together, the mainstream is named as the Agos River flowing eastward and then entering into the Pacific Ocean around the city of Infanta.

The Study on Water Resources Development for Metro Manila (JICA/NWRB, 2001-2003) compiled the recorded and estimated monthly flows at different locations in the Agos River basin using runoff analysis and simulation for a 39-year period from 1950-1988. The locations of the site where monthly flows were estimated are shown in Figure 7.1.14 and the estimated average flows are listed in Table 7.1.6. The average flow is 37.4 m^3/s (3231 MLD or 1179 MCM/yr) in the Kaliwa River basin and is 74.5 m^3/s (6435 MLD or 2349 MCM/yr) in the Kanan River basin.



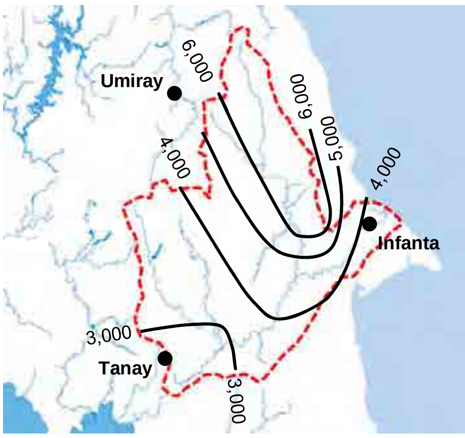
Source: Prepared by the JICA Study Team

Figure 7.1.12
Location of the Agos River Basin

Table 7.1.6 Average Flows in the Agos River Basin

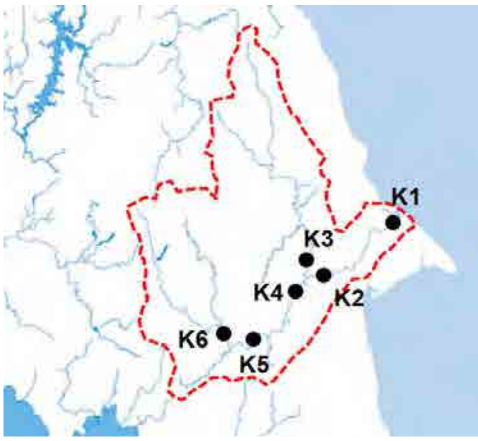
No.	River	Location	Catchment Area (km^2)	Average Flow ($m^{3/s}$)	Specific Runoff ($m^3/s/ km^2$)
K6	Kaliwa	Laiban Dam Site	276	23.4	0.085
K5	Kaliwa	Kaliwa Low Dam Site	366	27.9	0.076
K4	Kaliwa	Upstream of Kanan River Confluence	465	37.4	0.080
K3	Kanan	Upstream of Kaliwa River Confluence	393	74.5	0.190
K2	Agos	Downstream of Kaliwa-Kanan Confluence	858	111.9	0.130
K1	Agos	Banugao Gauging Station	908	120.5	0.133

Source: The Study on Water Resources Development for Metro Manila, Final Report (JICA/NWRB, 2003)



Source: The Study on Water Resources Development for Metro Manila, Final Report (JICA/NWRB, 2003)

Figure 7.1.13
Annual Rainfall in the Agos River Basin



Source: The Study on Water Resources Development for Metro Manila, Final Report (JICA/NWRB, 2003)

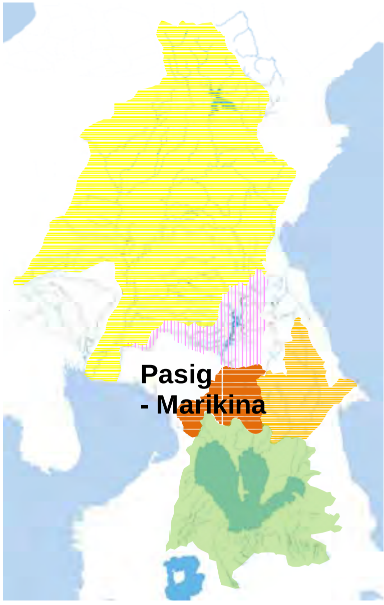
Figure 7.1.14
Locations of Estimated Monthly Flows in the Agos River Basin

(5) Pasig-Marikina River Basin

According to the information published in the Master Plan for Flood Management in Metro Manila and Surrounding Areas (World Bank, 2011-2012), the catchment area of the Pasig-Marikina River is 635 km^2, with the downstream end of the catchment area regarded as the confluence of the Pasig-Marikina River and the San Juan River. Therefore, the 635 km^2 catchment area consists of the catchment areas of the Pasig-Marikina River (544 km^2) and the San Juan River (91 km^2) (see Figure 7.1.15 and Figure 7.1.17).

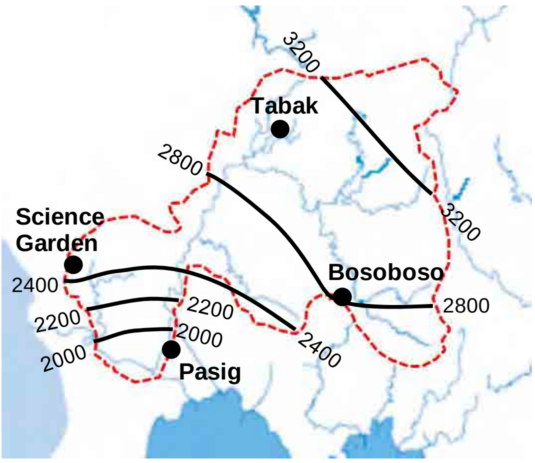
The Pasig-Marikina River connects with the Laguna Lake through the Manggahan Floodway and the Napindan Channel. The drainage areas along these waterways are not inclusive of the Pasig-Marikina River basin defined above.

The mean annual rainfall in the Pasig-Marikina River basin is shown in Figure 7.1.16. The annual rainfall in the upper Marikina River basin ranges from 3200 mm in the northeast to 2800 mm in the west to south areas. In the lower Marikina River basin and the San Juan River basin, the annual rainfall ranges from 2000 to 2400 mm.



Source: Prepared by the JICA Study Team

Figure 7.1.15
Location of the Pasig-Marikina River Basin



Source: River Catalogue, Vol-5 (The University of Kyoto, 2004)

Figure 7.1.16
Annual Rainfall in the Pasig-Marikina River Basin

Source: The Basic Design Study on the Project for Rehabilitation of the Flood Control Operation and Warning System in Metro Manila, Final Report (JICA/DPWH, 2000)

Figure 7.1.17
Locations of Hydrological Gauging Stations

The locations of the hydrological gauging stations at San Jose and Wawa Dam are shown in Figure 7.1.17 and the average flows are shown in Table 7.1.7. Based on an average specific runoff (0.057 m^3/s/km^2), the average flow of the Marikina River basin (535 km^2) is estimated at 30.6 m^3/s (2644 MLD or 965 MCM/yr).

Table 7.1.7 Average Flows in the Pasig-Marikina River Basin

Gauging Station	Catchment Area (km^2)	Average Flow (m^3/s)	Specific Runoff ($m^3/s/km^2$)	Record Period
Wawa Dam	281	14.8	0.053	1993-2002
San Jose	381	23.5	0.062	1996-2005

Source: Prepared by the JICA Study Team, using the hydrological records collected from DPWH.

The Flood Modeling in Pasig-Marikina River Basin (Roy A. Badilla, 2008) describes the functions of the Manggahan Floodway and the Napindan Channel given below. The locations of the Manggahan Floodway and the Napindan Channel are shown in Figure 7.1.18

Manggahan Floodway:

The Manggahan Floodway was constructed in 1986 in order to divert excess flood water from the Marikina River to the Laguna Lake. The design capacity of the channel is 2400 m^3/s. The inflow to the Manggahan Floodway is controlled by the Rosario Weir, which is located at the Manggahan Floodway near the junction with the Marikina River. Excess flood water from the Marikina River is introduced to the Manggahan Floodway by opening the gates of the Rosario Weir and then discharged into the Laguna Lake for temporary storage. When the water level of the Marikina River subsides, water stored in the Laguna Lake is released to the Pasig River through the Napindan Channel.

Besides the flood control operation originally planned above, water is discharged from the Laguna Lake to the Marikina River through the Manggahan Floodway at present when the water level of the Laguna Lake rises to cause the inundation in the lakeshore areas.

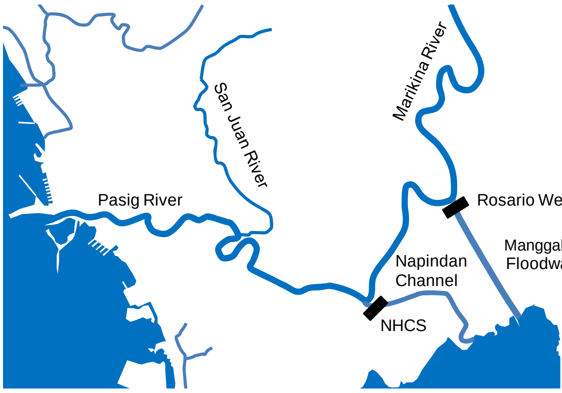
Napindan Channel:

The Napindan Hydraulic Control Structure (NHCS) is located at the Napindan Channel near the junction with the Marikina River. NHCS was constructed in 1984 in order to control the reverse flow from the Marikina River to Laguna Lake, preventing saltwater and associated pollution to flow into Laguna Lake.

At present, NHCS is operated for the purpose of flood control. Through the Napindan Channel, excess water from the Marikina River is diverted to the Laguna Lake and is released back to the Marikina River afterwards. The water from Laguna Lake is discharged to the Marikina River through the channel in order to mitigate inundation in the lakeshore areas.

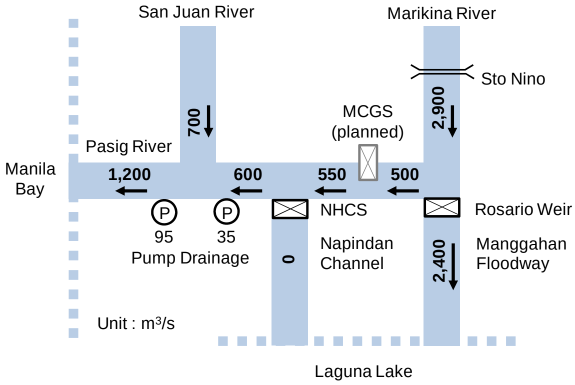
The design flow of the Pasig-Marikina River Channel Improvement Project is 2900 m^3/s corresponding to a return period of 30 years as shown in Figure 7.1.19. With a planned Marikina Control Gate Structure (MCGS) having a design flow of 2400 m^3/s, it aims to divert flood water to the Manggahan Floodway. At present, a possible diversion to the Manggahan Floodway is 1800 m^3/s without MCGS.

A principal function of NHCS is to prevent the incoming flow into the Pasig River by closing NHCS during flood. On the other hand, there are discussions on NHCS to keep it open from the viewpoints of alleviating the inundation in the lakeshore areas and sustaining the fisheries in the brackish water of the Laguna Lake.



Source: The Preparatory Study for Pasig-Marikina River Channel Improvement Project (Phase III), Final Report (JICA/DPWH, 2011)

Figure 7.1.18
Locations of Manggahan Floodway and Napindan Channel



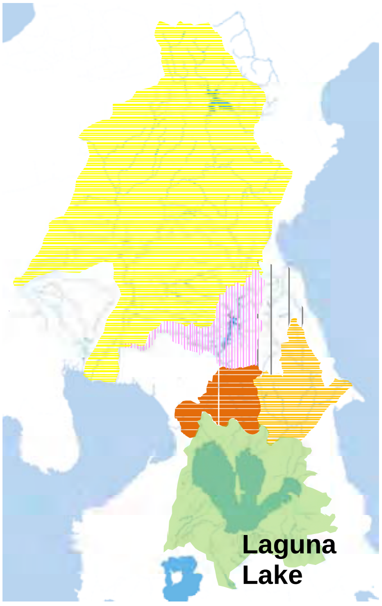
Source: The Preparatory Study for Pasig-Marikina River Channel Improvement Project (Phase III), Final Report (JICA/DPWH, 2011)

Figure 7.1.19
Design Flows for Pasig-Marikina River Channel Improvement Project

(6) Laguna Lake Basin

According to the Laguna de Bay, Experiences and Lessons Learned Brief (LLDA, 2006), the water surface area of the Laguna Lake is about 900 km^2 with an average depth of 2.5 m and water volume of 2250 MCM. The lake's catchment area is 2920 km^2 excluding the water surface area. More than 100 rivers flow into the Laguna Lake and are classified into 24 river basins. The Pasig River is only an outgoing river from the Laguna Lake, although saltwater intrusion from Manila Bay through the Pasig River takes place when the lake water level becomes lowest in the dry season.

Based on the descriptions of the above-mentioned document, the catchment area of the Laguna Lake is 3820 km^2 (900 + 2920), which would include the Marikina River basin (535 km^2). On the other hand, the information published in the Master Plan for Flood Management in Metro Manila and Surrounding Areas (World Bank, 2011-2012) defines the Laguna Lake basin to have an area of 3280 km^2, excluding the Marikina River basin (see Figure 7.1.20).

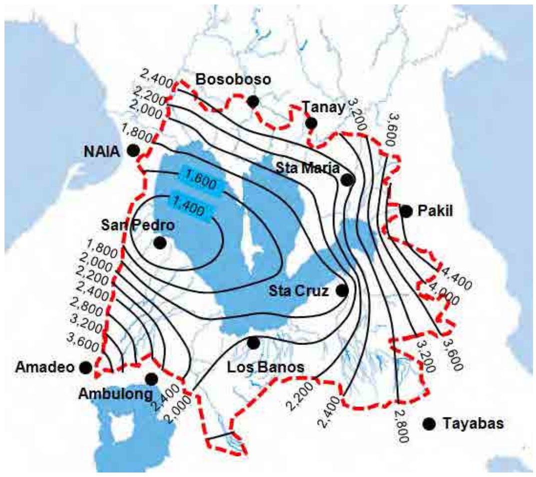


Source: Prepared by the JICA Study Team

Figure 7.1.20
Location of the Laguna Lake Basin

The mean annual rainfall in the Laguna Lake basin is shown in Figure 7.1.21. The annual rainfall is less in the west of the basin, ranging from 1400 to 2000 mm, but exceeds 3000 mm locally around the southwestern boundary. The annual rainfall ranges from 2000 to 2400 mm around the northern boundary and southern boundary and 3,000 mm or more in the eastern boundary.

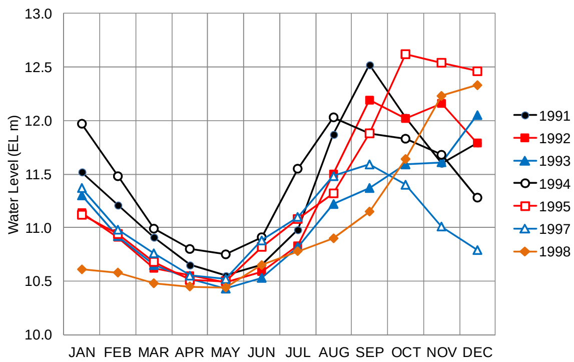
The water level of the Laguna Lake varies from the lowest at the end of the dry season (May) to the highest in the late wet season (September-December) as shown in Figure 7.1.22. An Environmental Impact Assessment for the 300 MLD Laguna Lake Bulk Water Supply Project (MWSS, 2002) describes the general figures with an average low water level of EL 10.5 m and average high water level of EL 12.5 m. The average low water level is almost the same as the mean sea level of Manila Bay. Saltwater intrusion takes place during high tide when the lake water level stays around the lowest in the dry season.



Source: River Catalogue, Vol-5 (The University of Kyoto, 2004)

Figure 7.1.21
Annual Rainfall in the Laguna Lake Basin

According to the Study on Flood Control and Drainage Project in Metro Manila (JICA/DPWH, 1990), the historical highest water level reached EL 14.03 m (1972), followed by EL 13.58 m (1978), EL 13.17 m (1960) and EL 13.08 m (1952). The water level approached the historical highest when Typhoon Ondoy hit Metro Manila in September 2009. The recorded highest water level was EL 13.90 m, according to Needs Assessment for the Disasters by Ondoy and Pepeng (JICA, 2009).



Source: LLDA

Figure 7.1.22
Water Level of the Laguna Lake (at Looc, Cardona, Rizal)

The data received from LLDA indicate a summary of water balance in the Laguna Lake basin as shown in Table 7.1.8. The total incoming water discharge to Laguna Lake is estimated at around 16000 MLD (5840 MCM/yr). Of this amount, 80% is drained to the Manila Bay through the Pasig River and 16% is drained through evapo-transpiration. The amount utilized for the purposes of water supply and irrigation is only 4%. The Kalayaan Hydropower Station is located near Sta Cruz, west of the Laguna Lake basin. The station is a pump storage hydropower facility that is operated using the Laguna Lake as lower reservoir and the Caliraya Lake as upper reservoir.

Table 7.1.8 Water Balance of the Laguna Lake

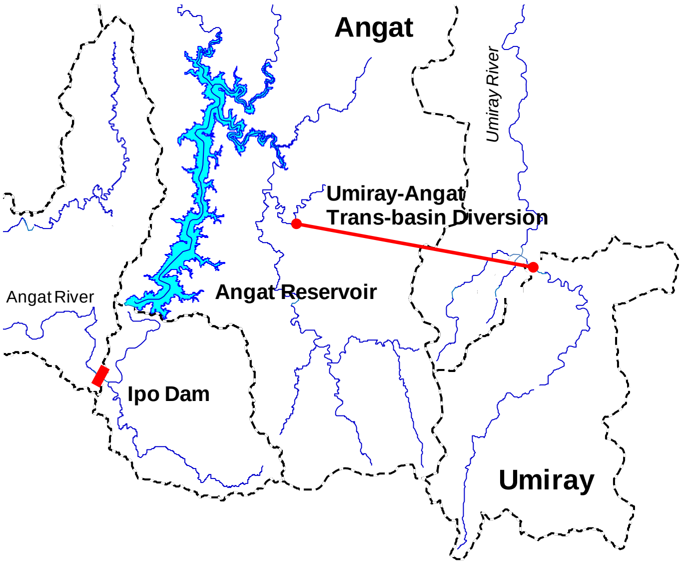
Incoming Water	MLD	Outgoing Water	MLD
Inflow from 23 River Basins	10,800	Drained through Pasig River	12,960
Rainfall	3,283	Evapo-transpiration	2,505
Groundwater Recharge	1,382	Water Supply	50
Hydropower (released)	432	Irrigation	173
		Hydropower (pumped)	432
Total	15,897	Total	16,120

Source: LLDA

7.1.3 Angat Reservoir

(1) General

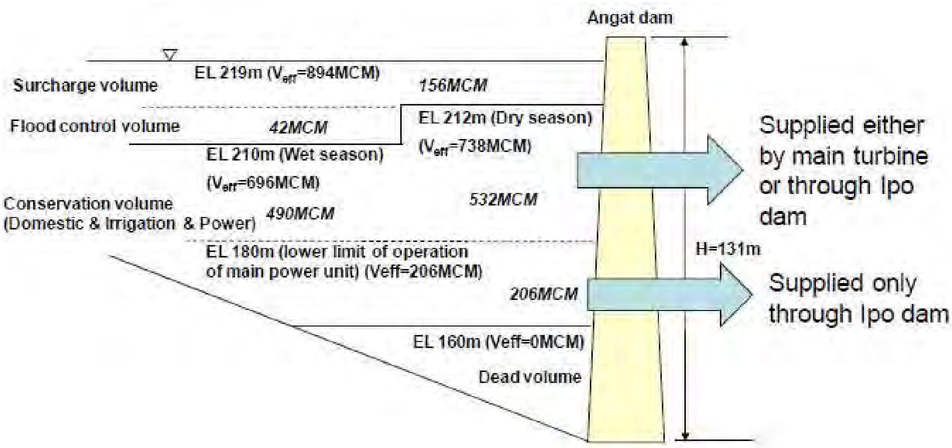
The commissioning of the Angat Reservoir was in 1968 for the purpose of urban water supply, irrigation, hydropower generation, and flood control. The catchment area upstream from the reservoir is 546 km^2. In addition, the transbasin diversion from the Umiray River was commissioned in 2000. The catchment area of the water diversion facility on the Umiray River is 130 km^2 (see Figure 7.1.23). The average inflow to the Angat Reservoir consists of 59.3 m^3/s (= 1869 MCM/yr) from the upstream catchment and 11.7 m^3/s (= 370 MCM/yr) from the Umiray River. The effective storage of the Angat Reservoir is 894 MCM (see Figure 7.1.24). The technical features of the Angat Reservoir are compiled in Annex 7.1.1.



Completion	September 1967
Purpose	Urban water supply, irrigation, hydropower generation and flood control
Dam Type	Earth / Rockfill
Dam Height	131m
Catchment Area	Angat River Basin: 546 km^2 Umiray River : 130 km^2
Inflow	Angat River Basin: 59.3 m^3/s (= 1,869 MCM/yr) Umiray River: 11.7 m^3/s (= 370 MCM/yr)
Effective Storage	894 MCM

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin , Final Report (JICA/NWRB, 2011)

Figure 7.1.23 General Location Map of Angat Reservoir



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 7.1.24 Angat Reservoir–Utilization of Storage

According to the project completion report on the Umiray-Angat Transbasin Project (ADB, 2004), the project was completed in 2000, which includes the following components.

- Diversion weir
- Diversion tunnel: 13.1 km long and 4.3 m in diameter
- Mini-hydropower plant at the outlet of the main tunnel: 970 KW
- Power transmission line: 18 km

The final report on the Metro Manila Water Security Study (World Bank, July 2012) indicates that the design discharge of the diversion tunnel is 30 m^3/s.

(2) Operation Records

The National Power Corporation (NPC) records the reservoir level, inflow and outflow of the Angat Reservoir. The JICA Study Team received the daily records from the consultant team that are working on the Project for Capacity Development on Flood Forecasting and Warning System for Dam Operation (JICA/PAGASA, 2009-ongoing). The availability of the daily records is shown in Table 7.1.9.

Table 7.1.9 Daily Operation Records of Angat Reservoir

Daily Records	19xx																					
	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Reservoir Level	○	●	●	●	●	●	●	●		●	●	●	○			○	●	●	○	●	●	●
Total Inflow										○	●	●	○				●	●	○	●	●	●
Outflow to Bustos Dam (IDR)	○	●	●	●	●	●	●	●		●	●	●	○			○	●	●	○	●	●	●
Outflow to Ipo Dam (MWSS / SPILL / BYPASS)	○	●	●	●	●	●	●	●		●	●	●	○			○	●	●	○	●	●	●

Daily Records	19xx										20xx											
	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11
Reservoir Level	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○
Total Inflow	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Outflow to Bustos Dam (IDR)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Outflow to Ipo Dam (MWSS / SPILL / BYPASS)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	

● Record Mostly Completed ○ Record Not Completed Blank: No Record

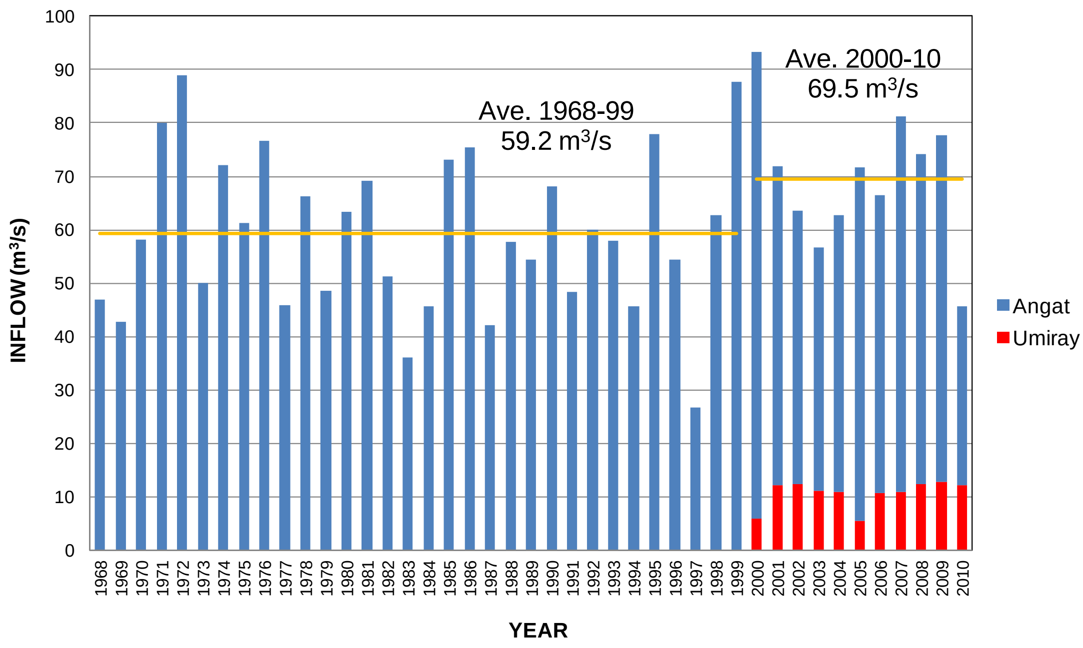
Source: Prepared by the JICA Study Team

In order to fill the gaps in the daily records, the monthly records for the period of 1968-2008 are also utilized for the purpose of the Study. These monthly records were collected at the time of the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin (JICA/NWRB, 2009-2011).

MWSS provides the daily records of water diversion from the Umiray River (for the period 2000-2010) and the monthly records of water production at four water treatment plants using the water transferred from the Angat Reservoir (for the period 1997-2010).

(3) Inflow

The mean annual inflow of the Angat Reservoir is shown in Figure 7.1.25. The average flow for the period of 1968-1999 is 59.2 m^3/s. The average flow has then increased to 69.5 m^3/s for the period of 2000-2010 mainly due to the commissioning of the Umiray-Angat transbasin diversion in 2000. The mean monthly inflows for the entire period (1968-2010) are shown in Annex 7.1.2.



Source: Refer to (2) Operation Records

Figure 7.1.25 Annual Inflows to Angat Reservoir

(4) Reservoir Level

The Angat Reservoir is operated in accordance with two rule curves as shown in Table 7.1.10.

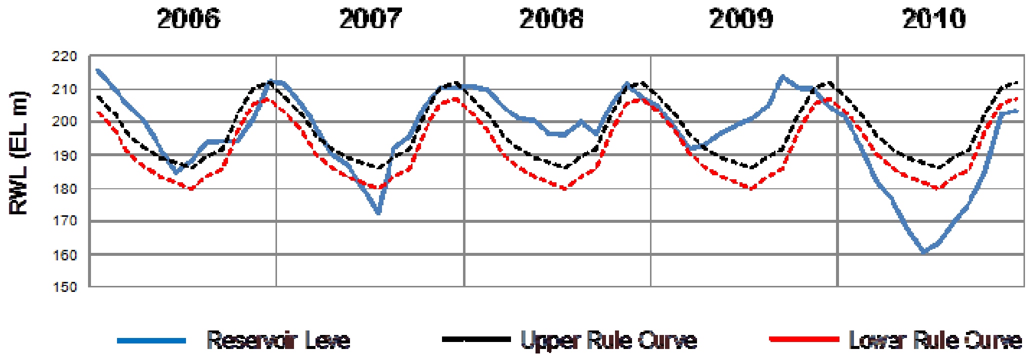
Table 7.1.10 Operation Rule for Angat Reservoir

Reservoir Level	Water Usage
Above Upper Rule Curve	Possible to request additional allocation for domestic use and irrigation
Between Upper Rule Curve and Lower Rule Curve	Allocation to satisfy both domestic use and irrigation
Below Lower Rule Curve	Priority allocation for domestic use Allocation for irrigation to be subject for NWRB decision
Below Lowest (EL 180 m) of Lower Rule Curve	Only for domestic use No allocation for irrigation

Source: Data received from the consultant team for working on the Project for Capacity Development on Flood Forecasting and Warning System for Dam Operation (JICA/PAGASA, 2011)

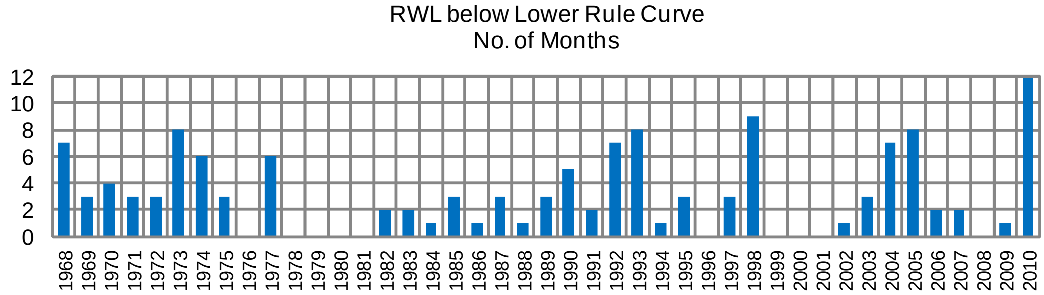
The records of reservoir level at the end of month (for the period 2006-2010) are shown in Figure 7.1.26. The reservoir levels below lower rule curve took place in 2007. In 2010, reservoir levels stayed below the lower rule curve throughout the year and had remained below EL 180 m for a duration of six months. Daily records indicate that the historical lowest of EL 157.55 m occurred on July 14, 2010.

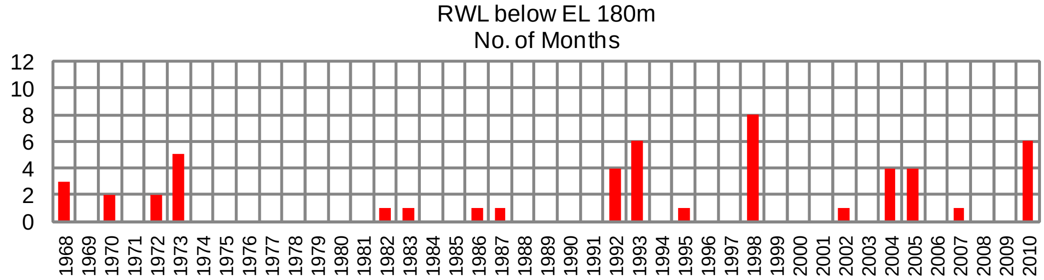
For the period of 1968-2010, the number of months is counted by year when the reservoir level stays below the lower rule curve and further lowers below EL 180 m as shown in Figure 7.1.27. In 43 years from 1968 to 2010, the reservoir levels below the lower rule curve took place in 33 out of 43 years. Reservoir levels that fell below EL 180 m occurred in 17 out of 43 years. The reservoir levels for the entire period (1968-2010) are shown in Annex 7.1.2.



Source: Reservoir Level - Refer to (2) Operation Records
Rule Curve - Data received from the consultant team for working on the Project for Capacity Development on Flood Forecasting and Warning System for Dam Operation (JICA/PAGASA, 2011)

Figure 7.1.26 Angat Reservoir Levels (2006-2010)





Source: Prepared by the JICA Study Team

Figure 7.1.27 Reservoir Level Below Lower Rule Curve / EL 180 m–Number of Months by Year

(5) Outflow

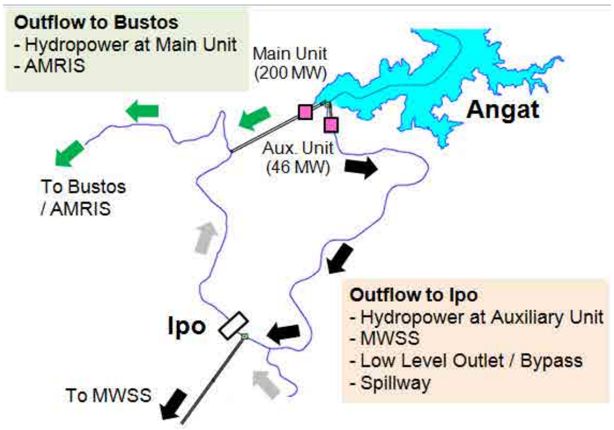
The Angat Reservoir shares 95.5% of the total water source available for MWSS. Furthermore, the Angat Reservoir needs to serve water for the Angat-Maasim River Irrigation System (AMRIS), having a total area of 26,000 ha in the lower river basin.

There are two routes for the outflow from the Angat Reservoir as shown in Figure 7.1.28. One route is the outflow discharged for the main hydropower station (200 MW). After hydropower generation, the water outgoing from the main hydropower station goes through the main diversion tunnel which flows into the Angat River and is caught at the Bustos Dam for AMRIS.

Another route consists of discharges used for the auxiliary hydropower station (46 MW). It is then released through the low level outlet and spilled out during flood. All outflow discharges go down toward the Ipo Dam that has a gross storage capacity of 7.5 MCM. A major part of the outflows received by the Ipo Dam is transferred to MWSS.

The mean annual outflows from the Angat Reservoir are shown in Figure 7.1.29. It is recognized that the outflow toward the Bustos Dam decreased from 1968 to 2000 while the outflow toward the Ipo Dam increased during the same period.

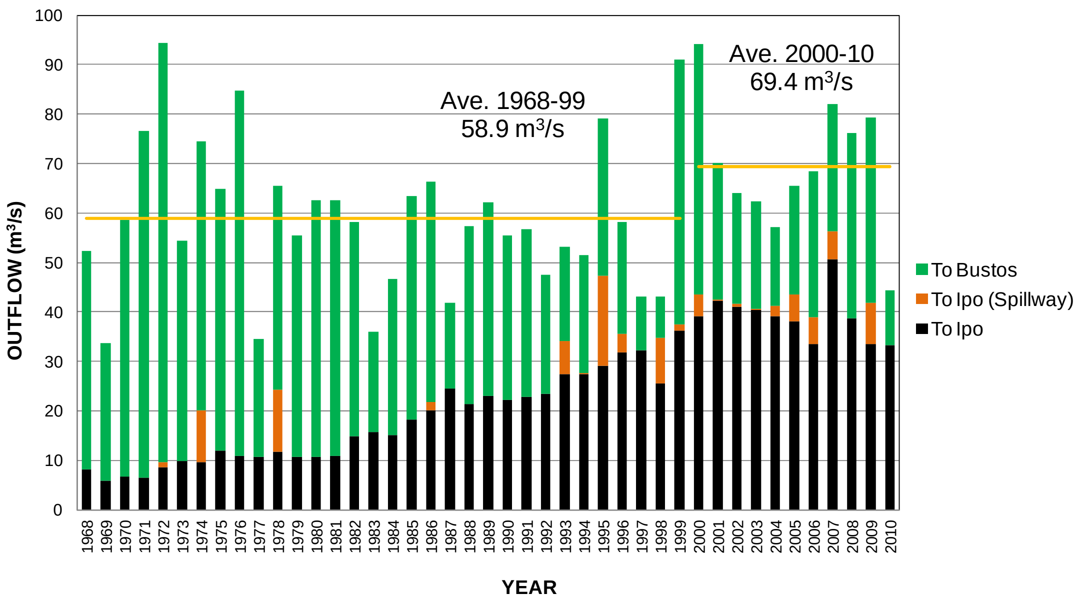
The increase of outflows toward the Ipo Dam suggests that water transferred to MWSS should have incremented year by year to cope with the increasing water demand in Metro Manila. After the commissioning of the Umiray-Angat transbasin diversion in 2000, the mean annual outflows toward the Ipo Dam have constantly stayed at around 40 m^3/s.



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 7.1.28 Outflows from Angat Reservoir

The mean monthly outflows for the entire 43-year period (1968-2010) are shown in Annex 7.1.2.



Source: Refer to (2) Operation Records

Figure 7.1.29 Annual Outflows to Angat Reservoir

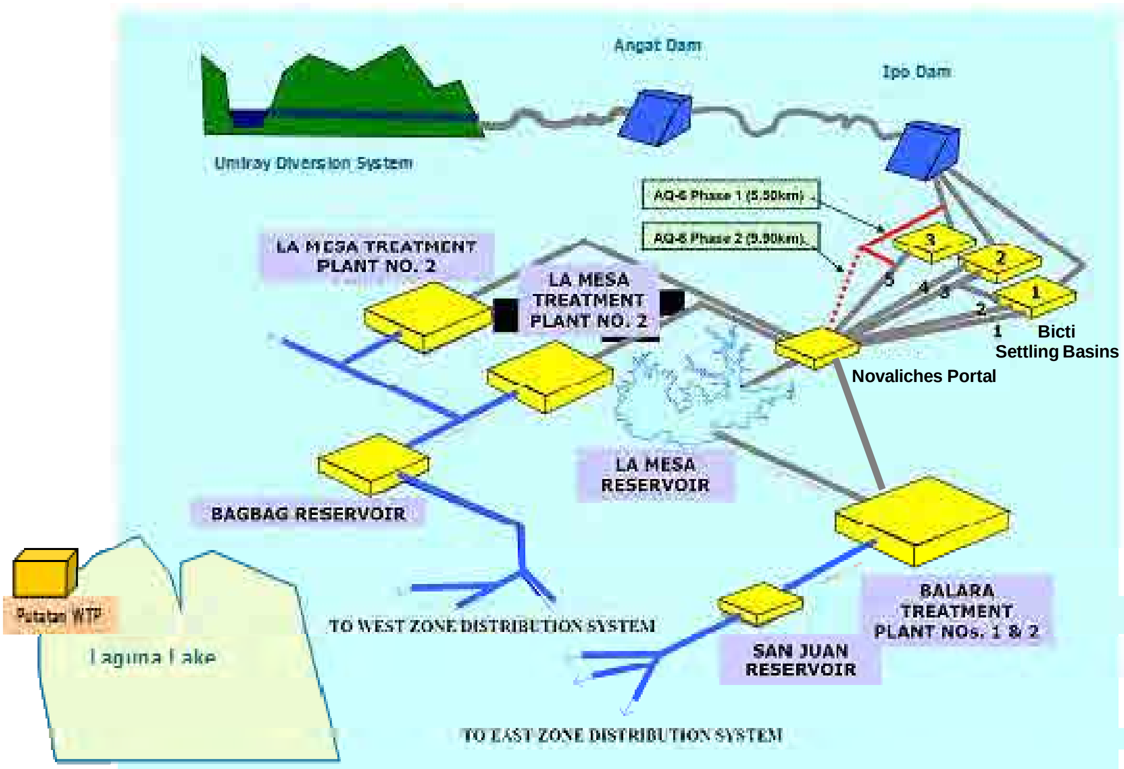
For the water allocation from the Angat Reservoir to the water users, a technical working group (TWG) is organized with the chairmanship of NWRB and the presence of MWSS, NIA, NPC and PAGASA. The TWG discussions are held monthly to decide the water allocation to MWSS and NIA. NPC operates the Angat Reservoir and hydropower stations as instructed by the TWG. In case of a drought, MWSS has the priority to be given water allocation. Water allocation to NIA is dependent on the remaining water available.

Hydropower plant discharges are dependent on reservoir outflows that are allocated to MWSS and NIA respectively. The reservoir outflow for NIA (AMRIS) through the main tunnel is used as a hydropower plant discharge for the main unit (200 MW), while the reservoir outflow for MWSS is used at the auxiliary unit (46 MW).

(6) Water Conveyance System

A conceptual diagram of the water conveyance system from the Angat Reservoir to Metro Manila is shown in Figure 7.1.30. A series of water conveyance facilities from the Ipo Dam to the La Mesa Reservoir are so-called common purpose facilities (CRF). The concessionaires Maynilad (MWSI) and Manila Water (MWCI) are jointly operating the CRF.

Water released from the Angat Reservoir is received at the Ipo Dam and then transferred to the La Mesa Reservoir which has a storage capacity of 50.5 MCM in Metro Manila. The technical features of the Ipo Dam and La Mesa Dam are shown in Annex 7.1.3.



Source: MWSS

Figure 7.1.30 Conceptual Diagram of Water Conveyance from Angat Reservoir to Metro Manila

The water abstracted at the Ipo Dam is conveyed to the Bicti Settling Basin located 6.4 km downstream by three tunnels. From the Bicti Settling Basin, the water is further conveyed to the Novaliches Portal for a distance of 15 km through six aqueducts. At the Novaliches Portal, the water is distributed to the La Mesa WTPs (No.1 and 2) and the Balara WTPs (1 and 2) through open channels. Excess water at the Novaliches Portal is released to the La Mesa Lake. There are three water intakes at the La Mesa Lake and the water tapped from these intakes are also transferred to the Balara WTPs (1 and 2).

MWSI is operating the La Mesa WTPs to distribute the treated water to the west of Metro Manila. On the other hand, MWCI is operating the Balara WTPs to distribute the treated water to the east of Metro Manila.

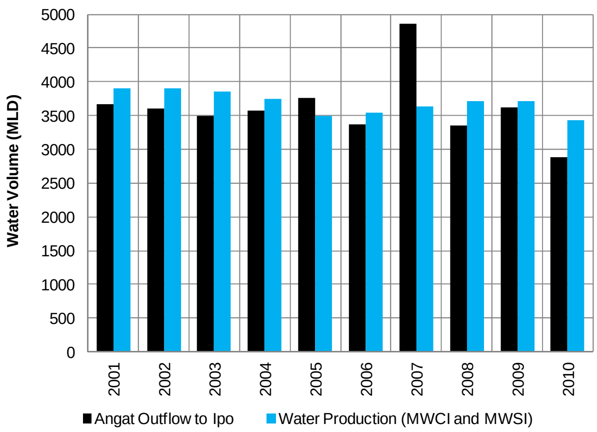
MWSS has been implementing the Angat Water Utilization and Aqueduct Improvement Project. The first phase involved the construction of a 5.5-km bypass for the deteriorated section of the existing Aqueduct No. 5, which was completed on February 2006. Phase 2 consists of the construction of a new 9.9-km aqueduct (Aqueduct No. 6) and the rehabilitation of the deteriorated section of Aqueduct No. 5. It is reported that the second phase has been inaugurated in July 2012.

(7) Preliminary Water Balance Analysis - Water Conveyance System

Records from 2001 to 2010 indicate that the total treated water produced by Maynilad and Manila Water have been larger than the water that was released from the Angat Reservoir to the Ipo Dam in almost every year (except for 2005 and 2007) as shown in Figure 7.1.31. The Metro Manila Water Security Study (World Bank/MWSS, 2011-2012) suggests that the water usable at the WTPs that are operated by Maynilad and Manila Water would be incremented with the inflows from the residual catchments: the upstream catchment of the Ipo Dam (36 km^2) and the upstream catchment of the La Mesa Lake (25 km^2).

Based on the daily outflow records from the Angat Reservoir, the mean annual outflows to the Ipo Dam from 2001 to 2010 is 41.9 m^3/s. Figure 7.1.32 shows the mean monthly outflows fluctuating by season. The red line in the figure indicates the water rights granted to MWSS (at 46.0 m^3/s).

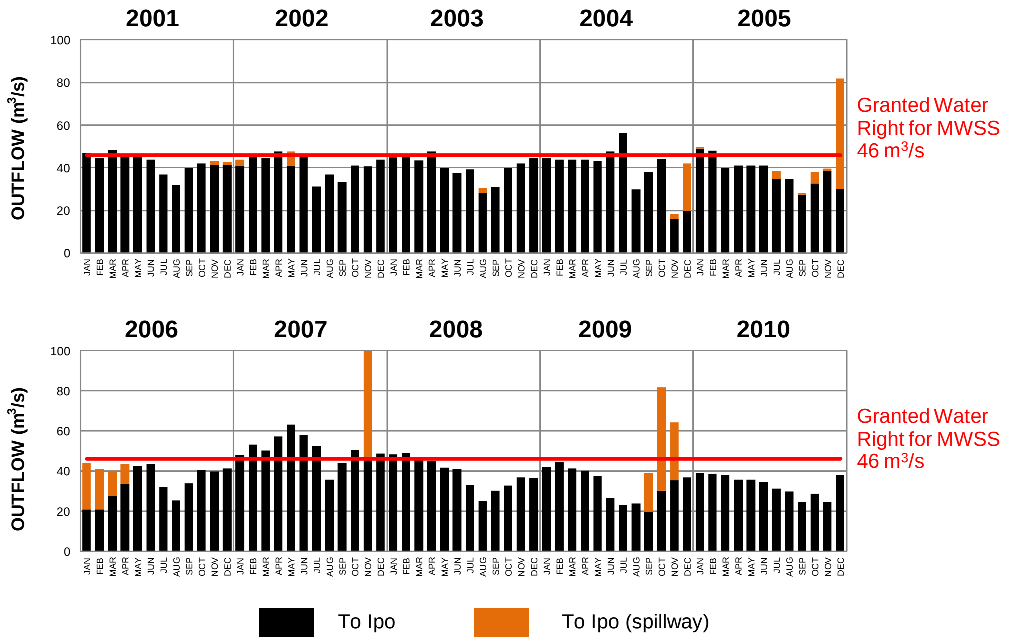
On the other hand, the mean annual total treated water production is 42.7 m^3/s, consisting of 26.0 m^3/s by Maynilad (La Mesa 1 and 2 WTPs), and 16.7 m^3/s by Manila Water (Balara 1 and 2 WTPs). Monthly records indicate that the treated water production has almost stabilized as shown in Figure 7.1.33.



Source: Refer to (2) Operation Records

Figure 7.1.31
Comparison between Outflow from Angat Reservoir and Treated Water Production

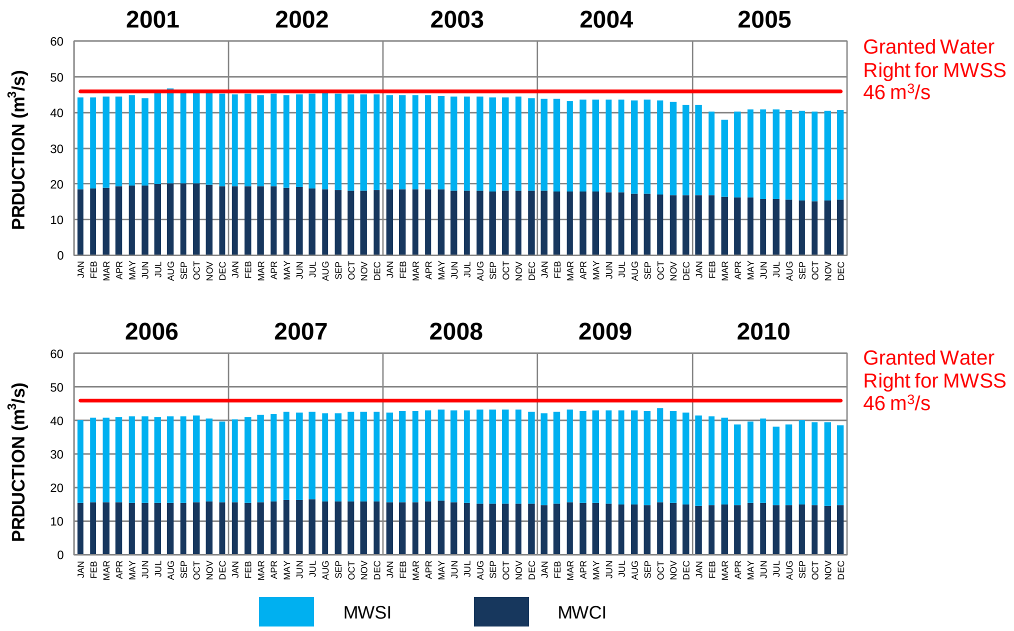
The monthly data for 2001-2010 such as Angat reservoir level, total inflow, total outflow, outflow to Bustos Dam, outflow to Ipo Dam, and total of treated water production at the WTPs, are shown in Annex 7.1.4.



Source: Refer to (2) Operation Records

Figure 7.1.32 Mean Monthly Outflows from Angat Reservoir to Ipo Dam

There is a possibility that the regulating capacities of both the Ipo Dam and La Mesa Dam have contributed to the stabilization of water production. The possibility will be confirmed by collating the inflow and outflow data of the Ipo Dam when the data are provided.



Source: MWSS

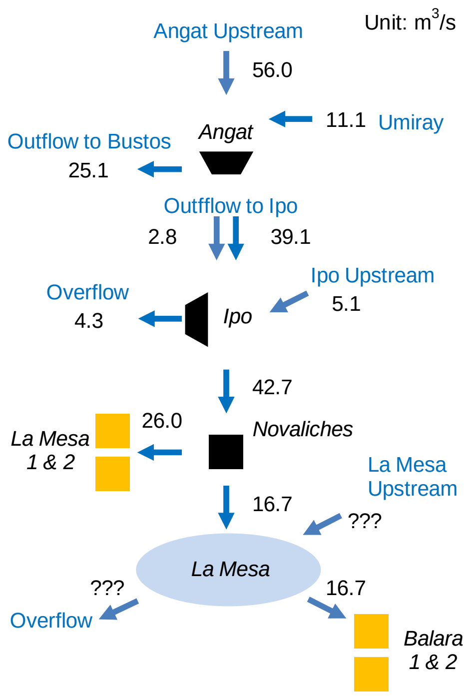
Figure 7.1.33 Mean Monthly Treated Water Production

The data described above suggest the actual conditions of the water conveyance to MWSS as follows (see Figure 7.1.34).

The inflow into the Ipo Dam consists of the outflow from the Angat Reservoir to the Ipo Dam and the incoming flow from upstream of the Ipo Dam. Most of the inflow into the Ipo Dam is transferred to the Novaliches Portal. Out of the flow received at the Novaliches Portal, 26.0 m^3/s is supplied to the La Mesa WTPs (Nos. 1 and 2). The remaining flow is supplied to the Balara WTPs (Nos. 1 and 2) or goes into the La Mesa Lake.

The available flow for the Balara WTPs (Nos. 1 and 2) consists of the flow that has exceeded 26.0 m^3/s at the Novaliches Portal and the inflow into La Mesa Lake from the remaining catchment area. This available flow fluctuates by season but the water taken to the Balara WTPs is stabilized with a 50-MCM storage capacity from the La Mesa Lake.

The inflow and outflow data of the Ipo Dam for 2001 to 2010 are crucial to confirm the distribution mentioned above.

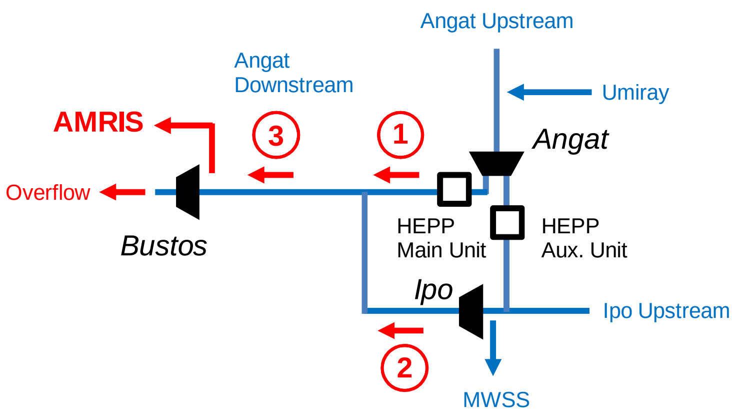


Source: Prepared by the JICA Study Team

Figure 7.1.34
Water Conveyance System for MWSS–Suggested Water Balance

(8) Preliminary Water Balance Analysis - AMRIS

The outflow from the Angat Reservoir to the main hydropower station is firstly used for hydropower generation and is released to the Angat River afterwards for the use of AMRIS. River flow at the Bustos Dam consists of the (i) outflow from the Angat Reservoir to the main hydropower station, (ii) overflow at the Ipo Dam, and (iii) runoff from the remaining catchment area along the downstream reaches of the Angat River as shown in Figure 7.1.35.

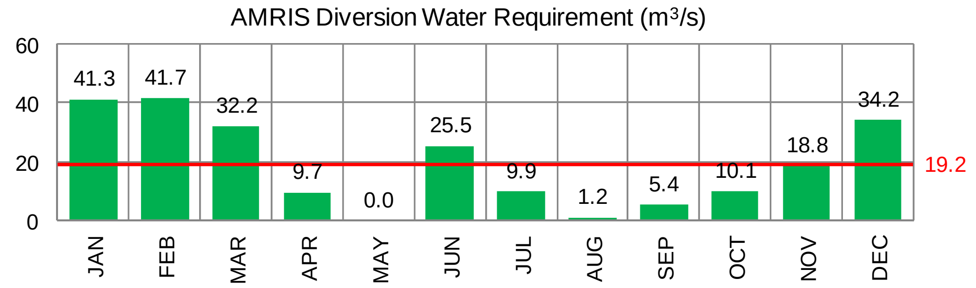


Source: Prepared by the JICA Study Team

Figure 7.1.35 River Flow at Bustos Dam

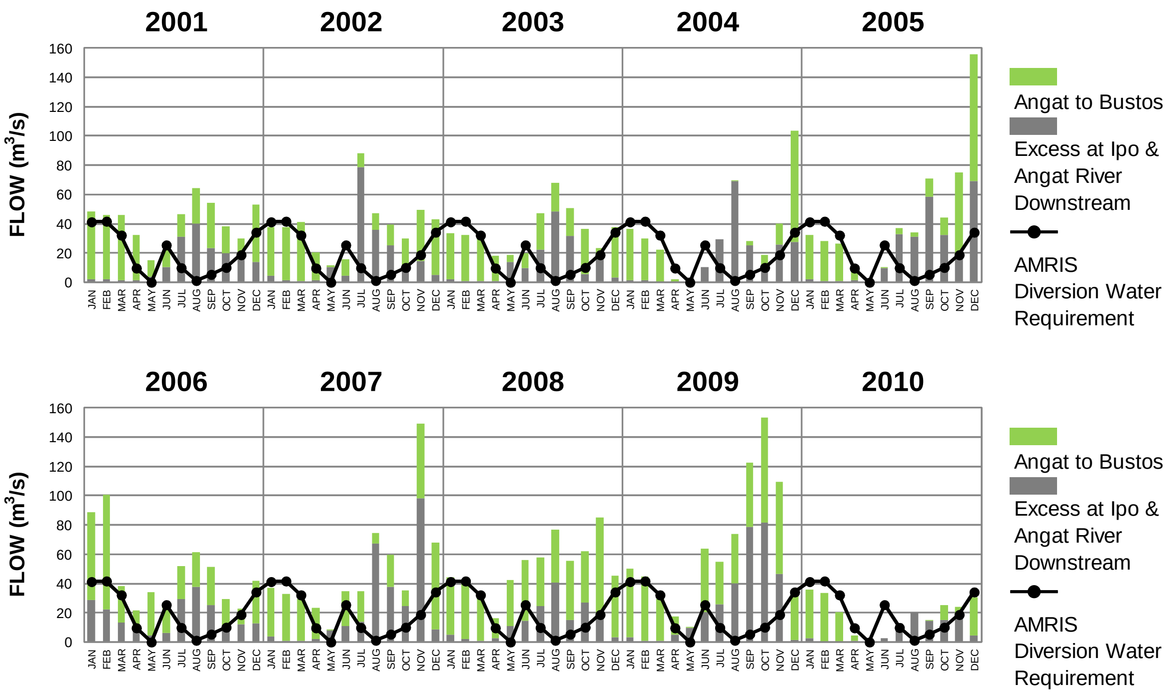
For the purpose of the preliminary analysis discussed in this subsection, the (i) outflow from the Angat Reservoir to the main hydropower station is compiled using the daily outflow records of the Angat reservoir, (ii) overflow at the Ipo Dam were estimated, and (iii) runoff into the downstream reaches of the Angat River are based on the results of the runoff simulation by the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin (JICA/NWRB, 2009-2011).

The estimated mean annual diversion water requirement of AMRIS is 19.2 m^3/s (600 MCM/yr), although it fluctuates by season as shown in Figure 7.1.36. Therefore, the water balance between the available flows at the Bustos Dam for the diversion water to AMRIS should be checked on a monthly basis. An example is shown in Figure 7.1.37 for the period of 2001-2010. The water balance for the entire period (1968-2010) is shown in Annex 7.1.5.



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB、2011)

Figure 7.1.36 Diversion Water Requirement of AMRIS



Source: Prepared by the JICA Study Team

Figure 7.1.37 River Flow at Bustos Dam and Diversion Water Requirement of AMRIS

The water balance is computed under the following assumptions.

- When the river flow at the Bustos Dam exceeds the diversion water requirement of AMRIS, the diversion water requirement of AMRIS is fully satisfied and the excess water flow is to be spilled out to the downstream.
- When the river flow at the Bustos Dam is smaller than the diversion water requirement of AMRIS, the available river flow is diverted to AMRIS but water deficit takes place.

Water balance computations are carried out in the following manner.

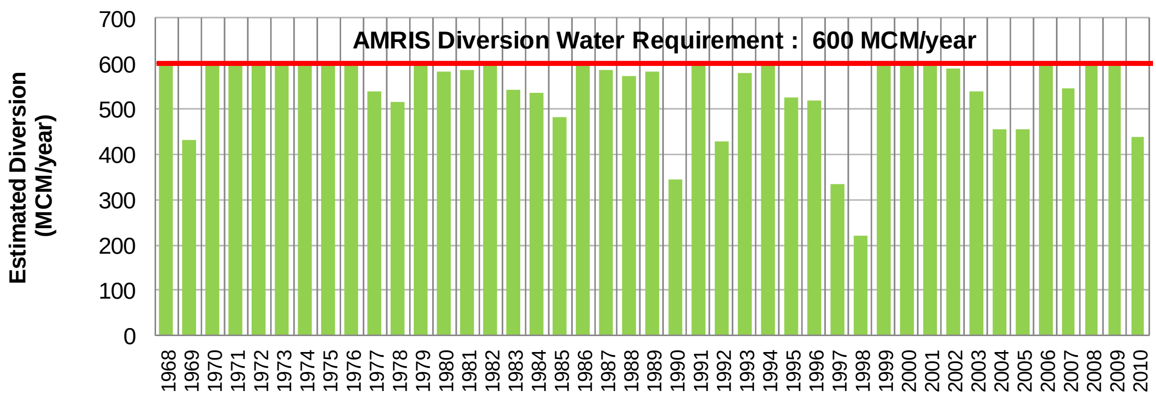
When:
Qd-AMRIS = Q-DWR; Q-Bustos > Q-DWR
Qd-AMRIS = Q-Bustos; Q-Bustos < Q-DWR

where,

Qd-AMRIS:	Water diversion to from Bustos Dam AMRIS (computed)
Q-DWR:	Diversion water requirement from Bustos Dam to AMRIS (planned)
Q-Bustos:	River flow at Bustos Dam (recorded)

The computed annual amount of water diversion to AMRIS by year is compared with the planned annual water diversion requirement of 600 MCM/yr as shown in Figure 7.1.38.

In the computations, it should be noted that the timing of the monthly diversion water requirement (planned) would not coincide exactly with the actual monthly water diversion (recorded) depending on the different climate conditions by year. In consideration of the said possible differences in timing between planned and recorded figures, the computations by month would cause an over-estimate in the annual deficit. Therefore, the computations of excess or deficit are carried out by three months (see Annex 7.1.6) in order to minimize a possible overestimate of the annual deficit.



Source: Prepared by the JICA Study Team

Figure 7.1.38 Water Diversion for AMRIS–Computed Results

The results of the computations are summarized in Figure 7.1.38 suggesting that the water shortage for AMRIS became outstanding in the 1990s. According to the daily records of the Angat Reservoir, it indicates that the outflow toward the Bustos Dam was stopped for 10 months in 1998. The computed diversion water is 37% of the requirement in 1998. The computed results are shown in Table 7.1.11. The table suggests that the outstanding water shortage for AMRIS also took place in 2004, 2005 and 2010 even after the commissioning of the Umiray-Angat transbasin diversion in 2000.

Table 7.1.11 Outstanding Water Shortage for AMRIS–Computed Results

Year	Requirement (MCM)	Computed Diversion (MCM)	Percentage
1969	600	431	72%
1990		346	58%
1992		427	71%
1997		333	56%
1998		219	37%
2004		455	76%
2005		455	76%
2010		437	73%

Source: Prepared by the JICA Study Team

According to the 'Water Allocation Between Irrigation and Municipal Use' (Dominador D. Pascua, NIA), the water allocation from the Angat Reservoir to AMRIS was cut off. Also, dry crop operations in AMRIS were suspended from November 1997 to June 1998 with the reallocation of NIA's water rights to sustain municipal water supply in Metro Manila. It was reported that 22000 farmers were affected and a loss in paddy production amounted to PHP 968 million. NIA also lost income from irrigation service fees amounting to PHP 29 million. NIA made a compensation claim for loss of ISF and agricultural production to NWRB, but the issue remained unresolved as MWSS kept its standpoint that the reallocation of the water rights was a result of force majeure.

(9) Water Balance Simulation by Metro Manila Water Security Study

The Metro Manila Water Security Study (World Bank/MWSS, 2011-2012) made a water balance simulation for MWSS and AMRIS served by the Angat Reservoir, based on the hydrological records for a period of 40 years from November 1968 to October 2008.

According to the study report, the water balance simulation was carried out under the following conditions:

Supply Side

- The records of the monthly inflow to the Angat Reservoir from 1968 to 2008 were used.
- In the simulation, transbasin diversion flows from the Umiray River were assumed to be 11.0 m^3/s (constant) based on the recorded diversion flows during 2001-2008. The recorded monthly diversion flows were used in the simulation for the period of 2001 to 2008.
- Reservoir operation rule follows the utilization of storage as shown in Figure 7.1.24.

Demand Side

- Water demand of MWSS is 46 m^3/s.
- Water diversion requirement of AMIRS is 19.2 m^3/s on average and varies by month as shown in Figure 7.1.36.

The results of the water balance simulation are summarized in Table 7.1.12. The Angat Reservoir coupled with the transbasin diversion from the Umiray River could not cope with the water demand of MWSS and AMRIS at the same time. A trade off is taking place between MWSS and AMRIS at present.

Table 7.1.12 Summary of Water Balance Simulation–MWSS and AMRIS

Case	Water Allocation Setting (m^3/s)		No. of Years Subject to Water Deficit		Recurrence Probability of Water Deficit	
	MWSS	AMRIS	MWSS	AMRIS	MWSS	AMRIS
(1)	33.0	19.2	0	8	0 (= 0/40)	1/5 (= 8/40)
(2)	46.0	19.2	10	24	1/4 (= 10/40)	1/1.7 (= 24/40)
(3)	46.0	8.4	4	8	1/10 (= 4/40)	1/5 (= 8/40)
(4)	60.0	---	4	---	1/10 (= 4/40)	---

Source: Metro Manila Water Security Study (World Bank/MWSS, 2012)

Conclusions from the water balance simulations carried out by the Metro Manila Water Security Study are summarized below:

Case (1): When the Angat-Umiray system is assumed to fulfill the diversion water requirement of 19.2 m^3/s for AMRIS with its recurrence probability of water deficit at 1/5 (8 in 40 years), the dependable water supply for MWSS is estimated at 33.0 m^3/s without any deficit for the simulation period of 40 years (0 in 40 years).

Case (2): The recurrence probabilities of water deficit are estimated at 1/4 (10 in 40 years) for MWSS and 1/1.7 (24 in 40 years) for AMRIS when both of the water demand of 46 m^3/s for MWSS and the diversion water requirement of 19.2 m^3/s are assumed to be maintained.

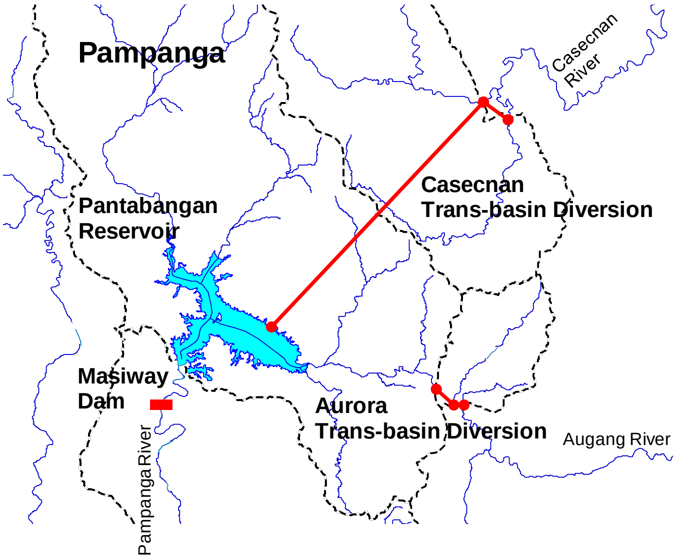
Case (3): When the Angat-Umiray system is assumed to fulfill the water demand of 46 m^3/s for MWSS with its recurrence probability of water deficit at 1/10 (4 in 40 years), the diversion water for AMRIS is reduced to 8.4 m^3/s with its recurrence probability of water deficit at 1/5 (8 in 40 years) and is equivalent to 44% of the diversion water requirement of 19.2 m^3/s.

Case (4): If the Angat-Umiray system could be exclusively used for MWSS, the system would promise a water supply capacity of 60 m^3/s for MWSS with its recurrence probability of water deficit at 1/10 (4 in 40 years).

7.1.4 Pantabangan Reservoir

(1) General

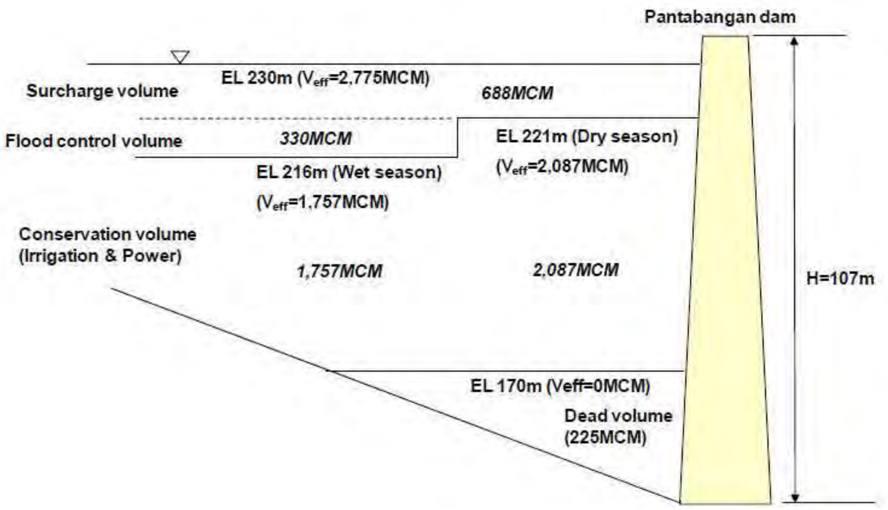
The Pantabangan Reservoir was commissioned in 1974, aiming at hydropower generation, irrigation and flood control. The catchment area upstream of the reservoir is 869 km^2. The reservoir also collects water conveyed by the Aurora transbasin diversion located east of the reservoir and having its catchment area of 68 km^2. In addition, the Casecnan transbasin diversion located to the northeast has a catchment area of 573 km^2 and was commissioned in 2001 (see Figure 7.1.39). The sum of the average inflows from the catchment area upstream of the reservoir and the Aurora transbasin diversion is 38.4 m^3/s (1195 MCM/yr). The average inflow from the Casecnan transbasin diversion is 23.8 m^3/s (751 MCM/yr). The effective storage of the Pantabangan Reservoir is 2775 MCM (see Figure 7.1.40). The technical features of the Pantabangan Reservoir are described in Annex 7.1.7



Completion	February 1974
Purpose	Hydropower, irrigation and flood control
Dam Type	Earth Fill
Dam Height	107 m
Catchment Area	Pampanga River Basin: 937 km^2 Aurora Transbasin Diversion: 68 km^2 Casecnan Transbasin Diversion: 570 km^2
Inflow	Pampanga River Basin + Aurora Transbasin Diversion: 38.4 m^3/s (1195 MCM/yr) Casecnan Transbasin Diversion: 23.8 m^3/s (751 MCM/yr)
Effective Storage	2775 MCM

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2011)

Figure 7.1.39 General Location Map of Pantabangan Reservoir



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 7.1.40 Pantabangan Reservoir–Utilization of Storage

(2) Operation Records

The National Irrigation Administration (NIA) records the reservoir level, inflow and outflow of the Angat Reservoir. The JICA Study Team received the daily records from the consultant team working on the Project for Capacity Development on Flood Forecasting and Warning System for Dam Operation (JICA/PAGASA, 2009-ongoing). The availability of the daily records is shown in Table 7.1.13.

Table 7.1.13 Daily Operation Records of Pantabangan Reservoir

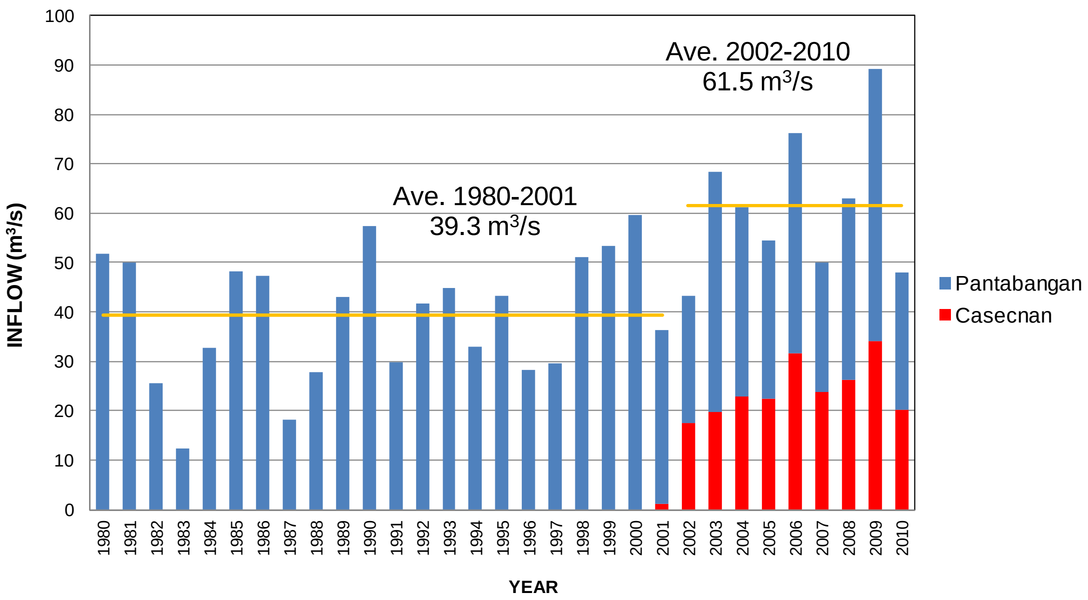
Daily Records	19xx																					20xx										
	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11
Reservoir Level, Pantabangan	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Total Inflow, Pangatabangan	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□	■	□
Inflow, Casecnan Transbasin Diversion																						□	□	■	■	■	■	■	■	■	■	□
Inflow, Aurora Transbasin Diversion																				□	□	■	■	■	■	■	■	■	■	■	■	□
Total Outflow (Irrigation / Power / Spillout), Pantabangan	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Evaporation, Pantabangan																						□	□	■	■	■	■	■	□	□	□	□
Seepage, Pantabangan																						□	■	■	■	■	■	■	■	□	□	□
Reservoir Level, Masiway	■	■	■	■	■	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Total Outflow (Power / Spillout), Masiway	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□	□	□

■ Record Mostly Completed　　□ Record Not Completed　　Blank: No Record

Source: Prepared by the JICA Study Team

(3) Inflow

Mean annual inflows to the Pantabangan Reservoir are shown in Figure 7.1.41. The average flow for the period of 1980-2001 is 39.3 m^3/s; consisting of the inflows from the upstream catchment and the Aurora transbasin diversion. The average flow has then increased up to 61.5 m^3/s for the period of 2002-2010 because of the commissioning of the Casecnan transbasin diversion in December 2001. Mean monthly inflows for the entire period (1980-2010) are shown in Annex 7.1.8.



Source: Refer to (2) Operation Records

Figure 7.1.41 Annual Inflows to Pantabangan Reservoir

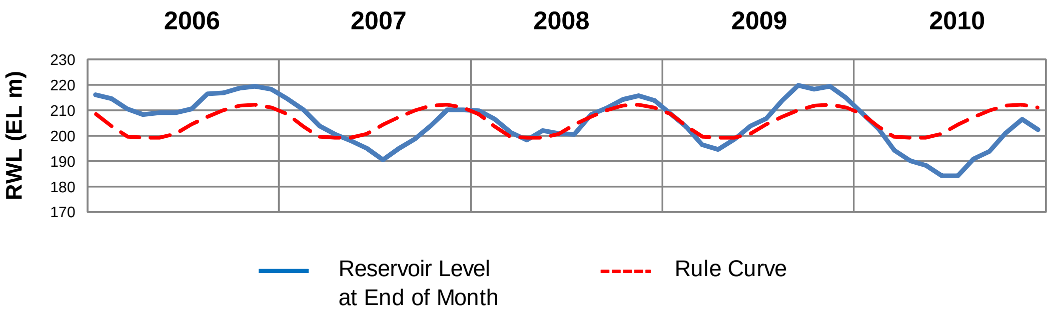
(4) Reservoir Level

According to a document relevant to the Casecnan Multipurpose Irrigation and Hydropower Project by NIA, the operation rule for the Pantabangan Reservoir is described as shown in Table 7.1.14. The records of reservoir level at the end of month (2006-2010) with the rule curve are shown in Figure 7.1.42. The reservoir levels for the entire period (1980-2010) are shown in Annex 7.1.8.

Table 7.1.14 Operation Rule for Pantabangan Reservoir

Reservoir Level		Water Utilization from Reservoir
Normal Zone	Above EL 213 m (Dry Season) Above EL 198 m (Wet Season)	100% of Water Diversion Requirement for Irrigation
Conservation Zone 1	EL 206 to 213 m (Dry Season) EL 188 to 198 m (West Season)	90% of Water Diversion Requirement for Irrigation
Conservation Zone 2	EL 200 to 206 m (Dry Season) EL 173 to 188 m (West Season)	80 % of Water Diversion Requirement for Irrigation
Conservation Zone 3	EL 170 to 200 m (Dry Season) EL 170 to 173 m (West Season)	60 % of Water Diversion Requirement for Irrigation

Source: The Casecnan Multipurpose Irrigation and Hydropower Project (NIA, 2008)



Source: Reservoir Levels - (2) Operation Records
Rule Curve - The Casecnan Multipurpose Irrigation and Hydropower Project (NIA, 2008)

Figure 7.1.42 Pantabangan Reservoir Levels (2006-2010)

The reservoir operation rule described above is applicable with the Casecnan trasnbasin diversion that enables the expansion of the Upper Pampanga River Integrated Irrigation System (UPRIIS).

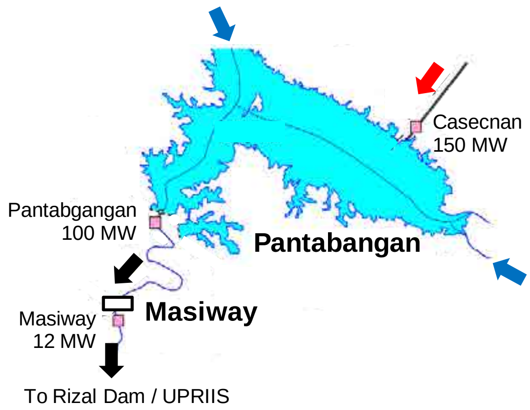
Before the commissioning of the Casecnan transbasin diversion, reservoir levels did not reach EL 213 m (corresponding with the present rule curve in the dry season) for the period of 1980-2001. After the commissioning, the reservoir level reached the normal high water level of EL 216 m during the wet season on August 27, 2006 for the first time and afterwards, becomes highest at EL 220.83 m on November 14, 2006. According to daily outflow records, the release from the spillway took place in October 2009 for the first time and the highest reservoir level in this month was EL 220.64 m (October 9).

Reservoir levels lower than EL 170 m took place for the period of 22 days from May to June 1983 only. The historical lowest is EL 169.87 m on May 23, 1983.

(5) Outflow

The Casecnan Hydropower Station (150 MW) is located at the outlet of the transbasin tunnel. The Pantabangan Hydropower Station (100 MW) is operated along with the reservoir. The Masiway Regulating Pond and its associated hydropower station (12 MW) are located downstream of the reservoir (see Figure 7.1.43).

At the downstream of the Masiway Regulating Pond, the Rizal Dam is operated for diverting water to the divisions Ib, II and V of UPRIIS (see Figure 7.1.45 later).

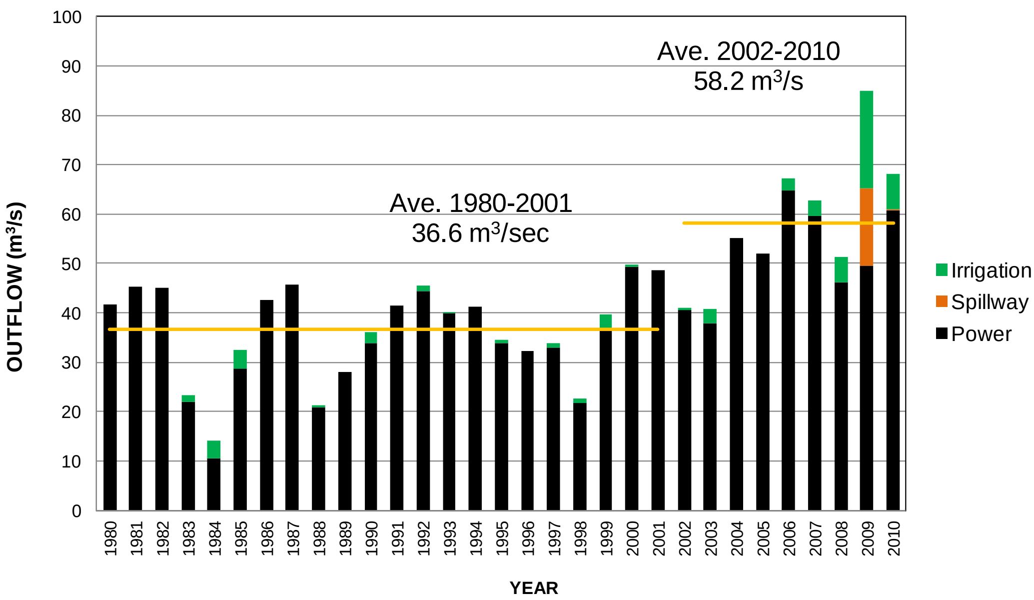


Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2011)

Figure 7.1.43 Hydropower Stations Associated with the Pantabangan Reservoir

The mean annual outflow from the Pantabangan Reservoir is shown in Figure 7.1.44. The average outflow changes from 36.6 m^3/s for 1980-2001 to 58.2 m^3/s for 2002-2010 after the commissioning of the Casecnan. Mean monthly outflows for the entire period (1980-2010) are shown in Annex 7.1.8.

Outflow from the Pantabangan Reservoir are mostly recorded for hydropower use, which also covers most of the water diversion requirement of UPRIIS. Some increases of the outflow were recorded as irrigation use is observed in 2009 and 2010 as the completion of the project to develop the Division V of UPRIIS in 2008.



Source: Refer to (2) Operation Records

Figure 7.1.44 Annual Outflows to Pantabangan Reservoir

(6) Preliminary Analysis of Water Balance - UPRIIS

A conceptual diagram of the National Irrigation System in the Pampanga River basin is shown in Figure 7.1.45. UPRIIS consists of five divisions with an existing area of 105,795 ha in total. The Pampanga Delta River Irrigation System (PDRIS) has an existing area of 6604 ha and the Aulo Small Reservoir Irrigation Project (SRIP) has an existing area of 810 ha as shown in Table 7.1.15.

Water is taken from the Talavera River, a tributary of the Chico River, draining the west of the Pampanga River basin and is diverted to Division Ia of UPRIIS. The water taken from the mainstream of the Pampanga at the Rizal Dam is diverted for the Divisions Ib, II and V of UPRIIS (16400 ha + 22591 ha + 16879 ha).

The Casecnan transbasin diversion makes it possible to develop Division V of UPRIIS with an increment of usable outflows from the Pantabangan Reservoir. The project for the development of Division V of UPRIIS was implemented until 2008 for completing the super diversion canal and the irrigation area of 16879 ha.

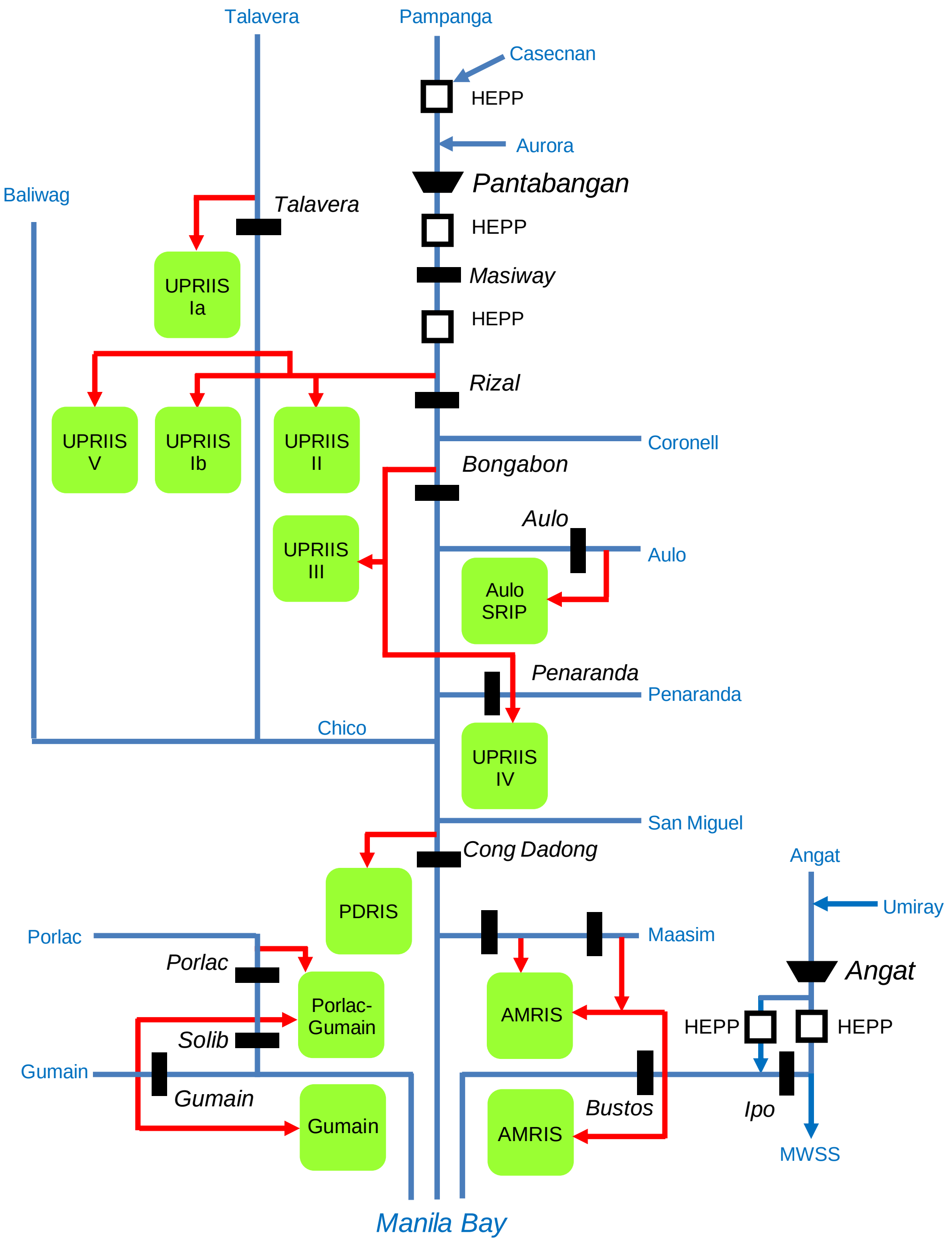
Downstream of the Rizal Dam, the water taken from the Bongabon Dam on the mainstream of Pampanga is diverted to Divisions III and IV of UPRIIS (25881 ha + 19924 ha), with supplemental water diversion from the Penaranda River to Division IV.

PDRIS is located in the Pampanga Delta. It is served from the water that is diverted from the Cong Dadong Dam. The existing irrigation area of PDRIS is 6604 ha.

Table 7.1.15 NIS in the Pampanga River Basin

Intake	NIS	Area	Present Diversion Water Requirement (m^3/s)											
		(ha)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pampanga														
Talavera	UPRIIS Ia	4,120	2.1	2.3	0.7	0.0	0.1	2.0	2.0	0.6	0.7	1.9	1.6	1.6
Rizal	UPRIIS Ib	16,400	20.1	23.2	19.5	6.2	0.6	11.2	8.7	2.3	2.8	6.2	11.2	17.9
Rizal	UPRIIS II	22,591	27.7	31.9	26.9	8.5	0.8	15.4	11.9	3.2	3.8	8.5	15.4	24.7
Rizal	UPRIIS V	16,879	20.6	23.8	20.0	6.3	0.6	11.4	8.9	2.5	2.9	6.3	11.4	18.3
Aulo	Aulo SRIP	810	1.1	1.2	0.6	0.0	0.2	0.7	0.3	0.1	0.2	0.4	0.7	0.9
Bongabon	UPRIIS III	25,881	30.3	34.4	25.0	4.5	5.9	22.5	8.5	4.0	4.7	8.9	18.0	26.1
Penaranda	UPRIIS IV	19,924	25.0	27.1	15.3	0.0	4.2	16.4	6.1	3.4	3.8	9.9	17.0	20.3
Cong Dadong	PDRIS	6,604	8.7	9.4	5.3	0.0	1.5	5.7	2.1	1.2	1.3	3.4	5.9	7.0
Total,	**Pampanga**	**113,209**	**135.6**	**153.3**	**113.3**	**25.5**	**13.9**	**85.3**	**48.5**	**17.3**	**20.2**	**45.5**	**81.2**	**116.8**
Porac														
Porlac-Solib	Porlac	1,458	1.9	2.3	1.9	0.6	0.0	1.3	0.8	0.2	0.2	0.6	1.0	1.7
Gumain	-Gumain	1,629	2.2	2.5	2.1	0.7	0.1	1.4	0.8	0.3	0.3	0.7	1.1	2.0
	Total, Porac	**3,087**	**4.1**	**4.8**	**4.0**	**1.3**	**0.1**	**2.7**	**1.6**	**0.5**	**0.5**	**1.3**	**2.1**	**3.7**
Angat														
Bustos	AMRIS	26,000	41.3	41.7	32.2	9.7	0.0	25.5	9.9	1.2	5.4	10.1	18.8	34.2
	Total, Angat	**26,000**	**41.3**	**41.7**	**32.2**	**9.7**	**0.0**	**25.5**	**9.9**	**1.2**	**5.4**	**10.1**	**18.8**	**34.2**

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)



Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

Figure 7.1.45 Conceptual Diagram of NIS in the Pampanga River Basin

For the purpose of preliminary analysis discussed in this subsection, the outflow from the Masiway Regulating Pond is compiled using daily records. Estimates of the river flow downstream of the pond were based on the results of the runoff simulation by the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2009-2011).

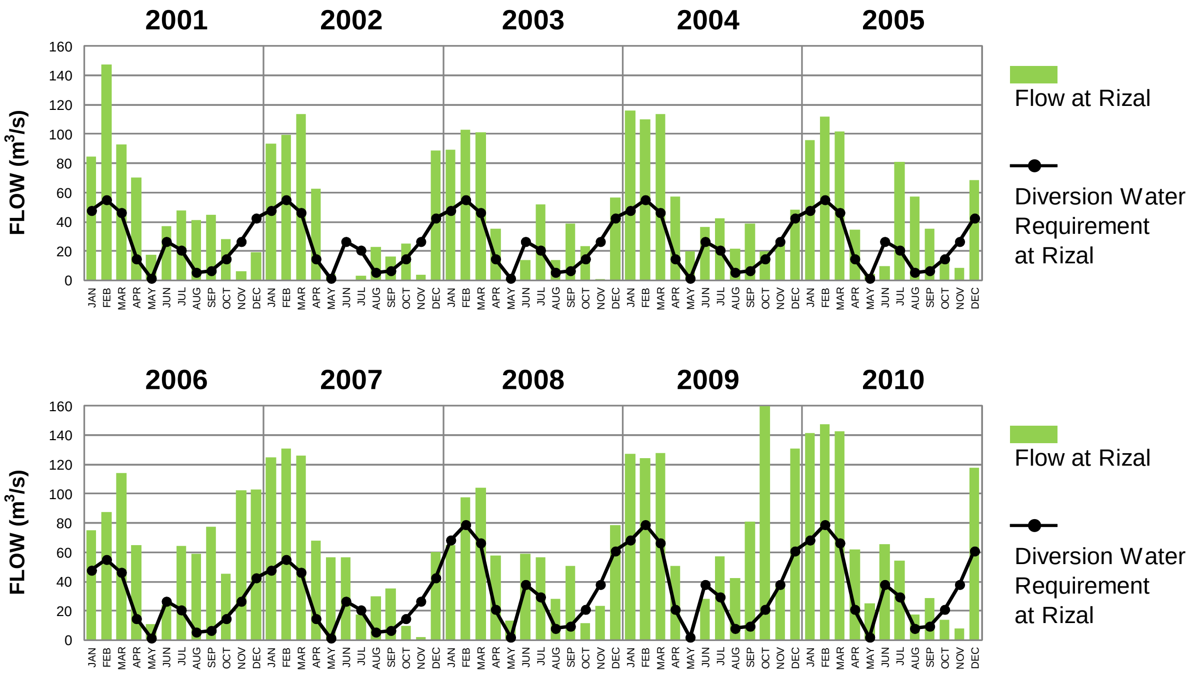
The diversion water requirement at the Rizal Dam is shown in Table 7.1.16. The water taken from the Rizal Dam is diverted to Divisions Ib, II and V of UPRIIS, with an irrigation area of 55870 ha. Of the total irrigation area, 16879 ha from Division V was developed in 2008. The previous irrigation area served by the Rizal Dam before 2008 was 38991 ha of the Divisions Ib and II.

Table 7.1.16 Diversion Water Requirement at Rizal Dam

Period	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Before 2008 38,991 ha	47.8	55.1	46.4	14.7	1.4	26.6	20.6	5.5	6.6	14.7	26.6	42.6
Since 2008 55,870 ha	68.4	78.9	66.4	21.0	2.0	38.0	29.5	8.0	9.5	21.0	38.0	60.9

Source: The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin, Final Report (JICA/NWRB, 2011)

The water balance between available flow at the Rizal Dam for the diversion water requirement of Divisions Ib, II and V of UPRIIS is shown in Figure 7.1.46 for the period of 2001-2010. The water balance for the entire period (1980-2010) is shown in Annex 7.1.9.



Source: Prepared by the JICA Study Team

Figure 7.1.46 River Flow at Rizal Dam and Diversion Water Requirement of UPRIIS

Water balance is computed under the following assumptions.

- When the river flow at the Rizal Dam exceeds the diversion water requirement of UPRIIS, the diversion water requirement of UPRIIS is fully satisfied and the excess flow spills out to the downstream.
- When the river flow at the Rizal Dam is smaller than the diversion water requirement of UPRIIS, the available river flow is diverted to UPRIIS but water deficit takes place.

Computations are carried out in the following manner.

When:
Qd-UPRIIS = Q-DWR; Q-Rizal > Q-DWR
Qd-UPRIIS = Q-Rizal; Q-Rizal < Q-DWR

where,

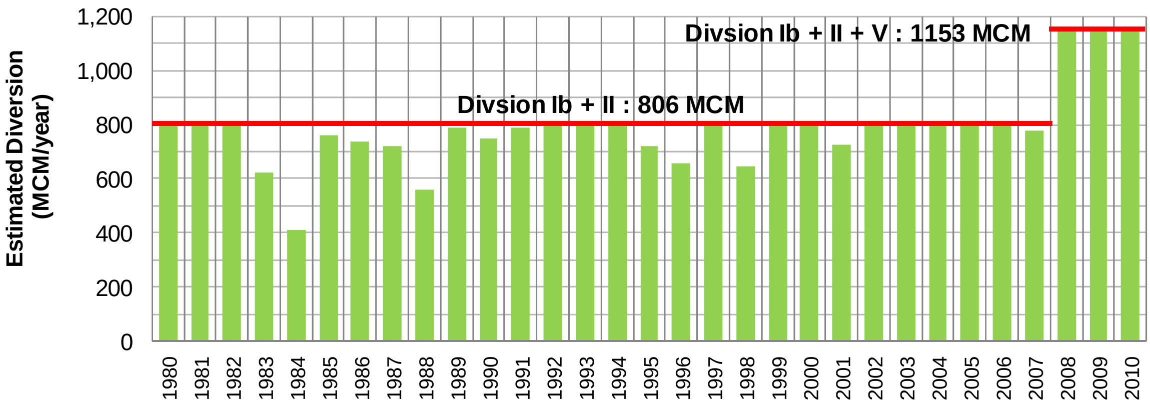
Qd- UPRIIS: Water diversion from Rizal Dam to UPRIIS divisions Ib, II and V (computed)

Q-DWR: Diversion water requirement from Rizal Dam to UPRIIS divisions Ib, II and V (planned)

Q-Rizal: River flow at Rizal Dam (recorded)

The computed annual amount of water diversion to UPRIIS Divisions Ib, II and V by year is compared with the planned annual water diversion requirement of 806 MCM/yr until 2007 and 1153 MCM/yr since 2008 as shown in Figure 7.1.47.

In the computations, it should be noted that the timing of the monthly diversion water requirement (planned) would not coincide exactly with the actual monthly water diversion (recorded), depending on the different climate conditions by year. In consideration of the said possible differences in timing between the planned and recorded figures, the computations of by month would cause an overestimate of the annual deficit. Therefore, the computations of excess or deficit are carried out by three months (see Annex 7.1.10) in order to minimize a possible overestimate of the annual deficit.



Source: Prepared by the JICA Study Team

Figure 7.1.47 Water Diversion at Rizal Dam to UPRIIS–Computed Results

The results of the computations summarized in Figure 7.1.47 suggest that the water shortage occurred frequently in 1980-1990s but was alleviated after the commissioning of the Casecnan in 2001.

(7) Water Balance Simulation by Pampanga IWRM Study

The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2009-2011) has made a water balance simulation in the Pampanga river basin based on the hydrological records for a 50-year period from 1958 to 2007. Under the hydrological conditions from 1958 to 2007 with the Pantabangan Reservoir (with the Aurora transbasin diversion) and the Casecnan transbasin diversion, the results of the water balance simulation relating to the diversion water requirements for NIS are outlined.

Present (Year 2008)

- The total irrigation area of UPRIIS is 105,795 ha comprising of Divisions I, II, III, IV and V. No deficit in the diversion water requirements of UPRIIS has taken place for 50 years.
- Deficit in the diversion water requirement of PDRIS (6,604 ha) took place twice of years out of 50 years.

Future (Year 2025)

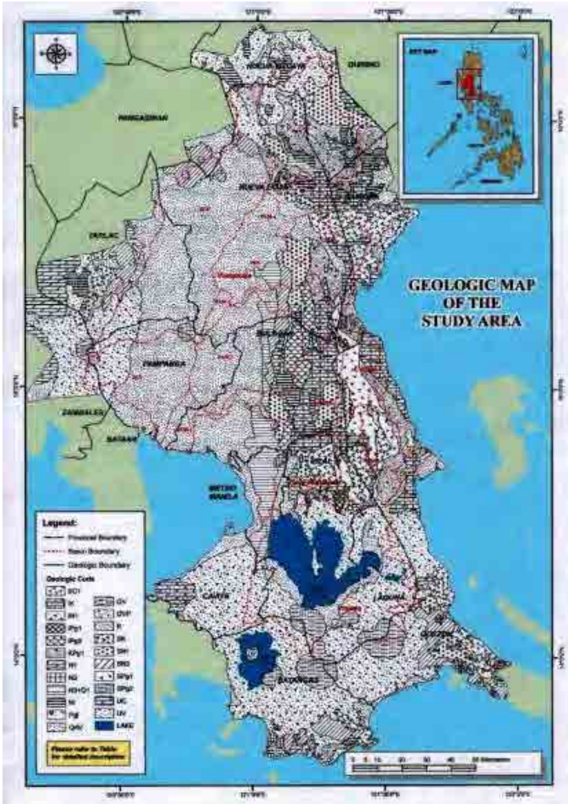
- The total of the irrigation areas of UPRIIS is 126,116 ha with an expansion of Division V from 16,870 ha (existing) to 37,200 ha (planned). For the expanded diversion water requirements of UPRIIS, a drought safety level of 1/5 is ensured. It means that the diversion water requirements are ensured in the case of a drought taking place once in five years.
- When the proposed Balintingon Reservoir with an effective storage of 488 MCM has been developed in the upstream of the Penaranda River, the water to be diverted for Division IV of UPRIIS is augmented and a new irrigation area of 14,900 ha can be developed. For the diversion water requirements of the entire UPRIIS (including the newly expanded areas), the drought safety level should be greater than 1/5.
- Under the development conditions above, a drought safety level for PDRIS also becomes greater than 1/5.

7.2 Hydrogeology

7.2.1 Hydrogeologic Conditions of the Study Area

Metro Manila and its immediate vicinity is underlain by quaternary (recent) alluvial deposits, a clastic sequence of conglomerates, mudstones, sandstones (Alat Conglomerate) and a pyroclastic-sedimentary unit (Diliman Tuff). The Alat Conglomerate and Diliman Tuff are considered members of the Pleistocene Guadalupe formation which extend from the Province of Bulacan to the North all the way to the Province of Cavite in the South.

Quaternary alluvial deposits are made up of unconsolidated and poorly sorted pebbles/cobbles and boulders of older rocks, sand, silt and mud. These were deposited along the Manila deltaic plain and Marikina Valley alluvial plain. The thicknesses of these alluvial deposits vary from 50 m along coastal areas of the Manila deltaic plain to over 130 m in the Marikina area and even up to 200 m in the Cainta-Pasig area.



Source: NWRB

Figure 7.2.1 Geologic Map of the Study Area

For the Pleistocene Guadalupe formation, most of the deposits are believed to be water-laid. The Alat Conglomerate which is about 100 m thick, is mapped to be made up of massive conglomerates, deeply weathered silty mudstone and tuffaceous sandstone. The Diliman tuff, with thickness of 1,300 m to 2,000 m, is composed predominantly of fine-grained vitric tuff and welded volcanic breccia with subordinate amount of fine to medium-grained tuffaceous sandstone.

The eastern portion of Metro Manila, covered by the Angat River basin, is underlain by Angat Ophiolitic Complex sediments composed of basalts, diabases and gabbros.

Quaternary volcanics consisting of the Guadalupe formation, the Laguna formation and the Taal tuff, form the main aquifers of Metro Manila and its surrounding areas. These quaternary volcanic sediments consist of intercalations of clay, silt, sand, and gravel lenses that have been described to dip gently toward the west in the central portion of the Study Area.

The level plains of the Pampanga River basin was formerly a sea that was filled with several hundred meters of marine and continental sedimentary deposits. Its lower geologic formations are composed of marine tertiary limestone, shale, and sandstones that outcrop along the margins of the plains. Tertiary undifferentiated rocks cover the mountains in the northern part while tertiary and later effusive rocks of rhyolites, dacites, andesites and basalts can be found in the eastern section of the basin. Rocks found within Central Luzon generally consist of large areas of metamorphic basement rocks, thick overlying deposits of tertiary volcanics and intrusive rocks, and a thin mantle of upper tertiary and quaternary deposits in the foothills and along the rivers. Alluvial deposits which cover the majority of the basin are a major source of groundwater.

In the Laguna Lake basin, the eastern side is covered by alluvial deposits, mostly sand, gravel and silt. Quaternary pyroclastic deposits and/or volcanic debris overlay the northern part of the basin that includes the towns in Laguna down to the southern and southwestern portion of the basin. Non-active cones of the Pliocene quaternary age are likewise prominent in the southern part of the basin. Significant quantities of groundwater are available in the areas of Los Baños-Bay-Calauan and Cabuyao-Sta. Rosa- Biñan as evidenced by high-yielding wells and springs.

7.2.2 Existing Groundwater Usage in the Study Area

Several reports from previous studies were collected and used as references to estimate existing groundwater usages in the Study Area.

The former service area of MWSS was divided and is currently being served by two private concessionaires, Maynilad Water Services, Inc. (MWSI) and Manila Water Co., Inc. (MWCI). In the West Zone under the Maynilad concession, 12 deepwells, producing approximately 9 MLD (104 L/s), provide water to communities in Quezon City, Malabon, Imus, Bacoor and Cavite City. According to MWSI, these wells shall only be used as stand-by sources as soon as water from surface water sources is available in the said areas. In the East Zone, Manila Water has 64 operational active/on-standby deepwells producing a total yield of about 113 MLD (1305 l/s).

In adjoining areas of Metro Manila, the use of groundwater through wells is the main water supply source for domestic and industrial water systems (Bulacan, Laguna, Cavite). Some irrigation systems are using groundwater as well. Medium to high capacity wells have been drilled and developed to support the water requirements of existing local water districts, residential subdivisions and industrial plants. Other areas rely from springs for their water supply needs.

Production data of the existing wells in the Study Area including Metro Manila were collected from the Local Water Utilities Administration (LWUA) website to estimate existing groundwater exploitation. The eventual estimated actual exploitations by the end of December 2011 are listed in Table 7.2.1 as follows.

Table 7.2.1 Existing Exploitation

River Basin	Average Exploitation in l/s
Metro Manila, Rizal and Cavite	2,782
Angat	1,052
Pampanga	3,163
Agos-Umiray	0
Pasig-Marikina	453
Laguna	3,709

Source: JICA Study Team

7.2.3 Estimated Groundwater Safe Yields

The final report on the Master Plan Study on the National Water Resources Management in the Republic of the Philippines, conducted by NWRB through JICA's technical cooperation in August 1998 was used as one of the main references in this Study to estimate safe groundwater yields of river basins. The rainfall data and the ratio of available groundwater area were used in the formulation of the succeeding table.

PAGASA provided relevant data to estimate mean areal annual rainfall depths in the table. Meanwhile areas covered by quaternary volcanic deposits or alluvial deposits were measured to estimate the ratio of GW available area.

Water permits issued by the National Water Resources Board (NWRB) were utilized in the preliminary assessment of groundwater availability in the Study Area as well. NWRB preliminarily estimated groundwater potential assuming several parameters as shown in Table 7.2.2 below.

Table 7.2.2 Groundwater Potential in the Study Area

River Basin	A Land Area (Km^2)	B Rainfall (mm/Year)	C Assumed Recharge (5% of AxB)	Ratio of GW Available Area (%)	GW Potential (l/s)
Angat	2,146	2,409	259	58.7	4,812
Pampanga	13,031	1,874	1,221	58.5	21,397
Pasig-Marikina	494	1,761	44	42.2	601
Agos	1,767	2,079	184	38.9	2,265
Umiray	788	2,429	96	38.9	1,181
Laguna lake	5,259	1,667	448	38.9	5,520

Source: NWRB Master Plan Study-National Water Resources Management in the Republic of the Philippines, March 1998

The cities of Las Piñas, Makati, Muntinlupa, Parañaque, Pasay and Taguig and the municipality of Pateros were included in the Laguna Lake basin. Meanwhile, the cities of Caloocan, Malabon, Mandaluyong, Manila, Marikina, Navotas, Pasig, Quezon, San Juan and Valenzuela were included in the Pasig-Marikina Basin. The estimated land area of Metro Manila is 630 km^2 covering 17 cities. The estimated average annual rainfall is 1631 mm. Meanwhile, the ratio of available groundwater area is estimated to be 38.9 %. The eventual total groundwater potential for Metro Manila is estimated to be 630 l/s.

The following can be deduced from the above tables:

a) The total volume of groundwater extraction of 2782 l/s in Metro Manila is more than the groundwater potential of 620 l/s. The overall potential of Laguna Lake with capacity of 5520 l/s is close to the groundwater extraction of 3709 l/s. Some specific sites could have caused overexploitation.

b) Except for Metro Manila where the amount exploited is more than the groundwater potential, the rest of the basins show that the groundwater potential of the basin is still sufficient to allow extraction by additional groundwater users. However, this has to be verified yet since other groundwater users have not secured water permits from the NWRB or are illegally extracting groundwater. Further analysis and evaluation are necessary to check the influence of urbanization to groundwater recharge because groundwater been mostly exploited in urban areas.

7.2.4 Records of Groundwater Exploitation and Land Subsidence in Each Area

The uncontrolled development and excessive pumping of groundwater had caused the decline in water levels in artesian aquifers resulting in saltwater intrusion, most especially in coastal areas.

In a study conducted by CEST, Inc. in 2004 for NWRB, it was detected that continuous groundwater withdrawal in Metro Manila, Bulacan and Cavite by private and public wells caused the water level to drop to 80 m below sea level. This was observed in the areas of Guiguinto, Bocaue, Marilao and Meycauayan in Bulacan; North Caloocan City, Navotas City-Valenzuela City, South Caloocan City; west Quezon City, Mandaluyong City-Pasig City-Makati City, Parañaque City-Pasay City-Las Piñas in Metro Manila; and in Dasmariñas in the province of Cavite. Figure 7.2.2 shows the areas affected by the decline in groundwater surface.

Source: NWRB

Figure 7.2.2 Groundwater Surface Map around Metro Manila

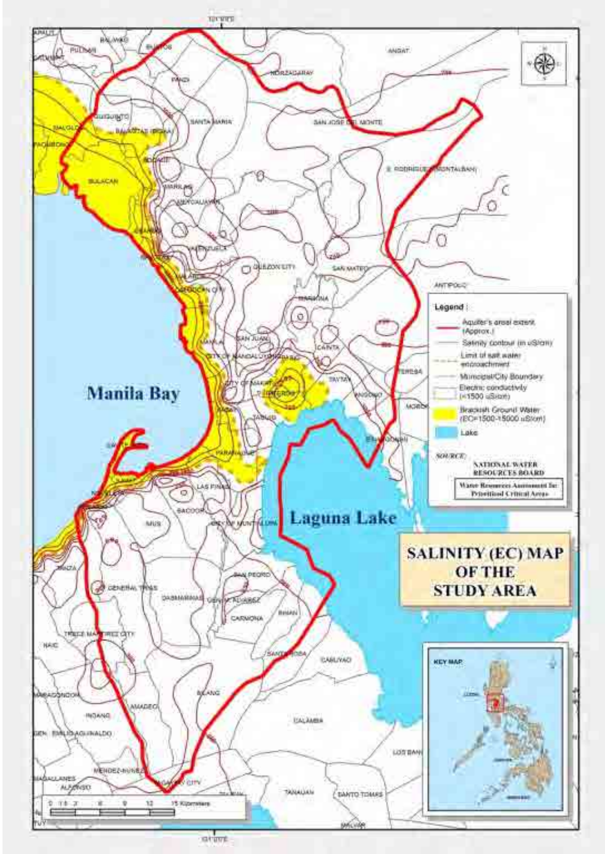
The geologic formation combined with the excessive abstraction of groundwater could be the possible causes of land subsidence in a particular area. The JICA study in 2002 and the study conducted by Kelvin S. Rodolfo and Fernando P. Siringan in 2006 stated that the annual average rate of the land subsidence in coastal areas of Pampanga was preliminarily presumed to be in the range of 0.5 cm/yr from inland to 8 cm/yr at the coastal side.

7.2.5 Water Quality of Groundwater

Since groundwater is the primary source of potable water in areas outside Metro Manila, the quality of water is of primary importance.

In the study[1] conducted by CEST, Inc. in 2004 for NWRB, the following information are deduced from the salinity (electric conductivity) map:

- Brackish water (electric conductivity = 1,500 to 15,000 μS/cm) has already encroached 12 km in the Province of Bulacan, particularly the City of Malolos and in the municipalities of Bulacan, Guiguinto, Balagtas, Marilao, Meycauayan and Obando.
- Brackish water is present in a 2-3 km strip from Malabon City in the north to Pasay City in the south
- Brackish water has affected Parañaque City that extended towards Las Piñas and Muntinlupa
- Brackish water was also detected in the towns of Kawit, Noveleta, Tanza and Cavite City in the Province of Cavite
- High salinity area was also mapped in Pateros and south of Pasig City



Source: NWRB

Figure 7.2.3 Salinity (Electric Conductivity) Map around Metro Manila

Based on the JICA study on the Pampanga River Basin[2], the chloride content of water in some wells of the water districts in Baliwag, Malolos, San Ildefonso and San Miguel as well as the water service provider in Guiguinto, all in the province of Bulacan, exceeded the permissible limit set by the Philippine National Standards for Drinking Water (PNSDW).

7.2.6 Well Test

MWSI has conducted a deep well test in its service area in May 2005 to examine the soundness of groundwater exploitation. The location of the test well is at Phase 9, Package 5, Barangay Bagong Silang, Caloocan City; 5 km north from the western edge of La Mesa Reservoir. The tests that were conducted are the step down test (SDT) and constant discharge/recovery test (CD/RT).

The step-drawdown test (SDT) was carried out on May 5, 2005. It consists of four steps at 120 minutes per step. The results of the SDT showed that the specific capacities for each step range from 0.77 to 0.94 l/s per meter of drawdown. The calculated formation loss factor (B) is

[1] Final Report on the Water Resources Assessment for Prioritized Critical Areas (Phase 1), conducted by CEST, Inc. for National Water Resources Board (NWRB), August 2004

[2] Final Report on the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin in the Republic of the Philippines, conducted for JICA & NWRB by CTI Engineering International Co., Ltd. in association with Nippon Koei Co., Ltd, January 2011

1.1963 m/l/s (aquifer loss coefficient) while well loss factor (C) is at 0.0089 m/l/s2 (well loss coefficient). The well loss during the last step (Q=13.88 l/s) was 9.36%. The estimated aquifer loss, well loss and the well efficiencies are listed in Table 7.2.3 as follows.

Table 7.2.3 Estimated Well Efficiency

Loss or Efficiency	Step 1	Step 2	Step 3	Step 4
Aquifer Loss (m)	9.18	11.47	13,03	16.61
Well Loss (m)	0.52	0.82	1.06	1.71
Total Loss (m)	9.70	12.29	14.09	18.32
Well Loss (%)	5.40	6.66	7.50	9.36
Well Efficiency (%)	94.60	93.34	92.50	90.64

Source: MWSI

The estimated well efficiencies are rather normal, however, the rapid decrease along the steps should be noted for continuous exploitation.

Constant discharge test (CDT) was conducted at 6:00 AM from May 6 to 8, 2005 for 2880 minutes (48 hours) at an average discharge rate of 13.92 l/s (221 gal/min). Static water level and maximum pumping water level were measured at 65.26 meters below ground level (m bgl) and 83.38 m bgl, respectively, or a drawdown of 18.12 m. The groundwater level was 82.3 m bgl at 7:00 AM or after one hour. The groundwater level reached 83.38 m below ground level at 6:00 AM on May 8, 2005 or after 48 hours.

Recovery test (RT) was performed for eight hours starting at 6:00 AM on May 8, 2005 immediately after pump shut off for CDT. The water level was 83.38 bgl and the residual drawdown was 18.12 m. The groundwater level was 70.39 bgl and the residual drawdown was reduced to 5.13 m at 7:00 AM on May 8. The groundwater level was 68.35 bgl at 2:00 PM on the same day when the test was terminated.

The average transmissivity coefficient estimated by the results of the constant discharge test is 5.07 x $10^{-3} m^2/s$. Meanwhile the estimated specific capacity is 0.767 l/s per meter of drawdown. The estimated values indicate that the well has medium to good aquifer yielding properties.

7.2.7 Proposed Countermeasures to Alleviate the Identified Problems

As a consequence of the findings and recommendations in the CEST Inc. study, the NWRB Board of Trustees issued Resolution No. 001-0904 entitled “Policy Recommendations for Metro Manila Critical Areas” on September 22, 2004. With this, the NWRB resolved to adopt the following policies:

1. To revoke or suspend water permits or reduce authorized volume extraction of existing deep wells in areas adequately served by MWSS, regardless of whether or not the well is located in critical areas, after due notice and hearing, except for vital services as provided under Policy No. 3 below.
2. To proceed with the processing of pending and new water permit applications as follows:

Table 7.2.4 Processing of Water Permits

	CRITICAL	NON-CRITICAL
Areas Adequately Serviced by MWSS	Process permits only for vital services as provided in Paragraph 3	Process permits only for back-up purposes and hours of operation shall be limited only during periods when commercial supply is not available
Areas Not Adequately Serviced by MWSS	Process only temporary permits that will be valid until connection becomes available in the area	To proceed with the processing of water permits

Source: NWRB

3. Groundwater extraction may be allowed to ensure that operation of vital services are not duly hampered (e.g. hospitals, fire fighting, etc.) provided that extraction shall be made only as back-up to commercial water supply.

According to the NWRB personnel that were interviewed during the course of the study, no additional measurements or studies were made since 2004 to validate the positive effects of the board resolution (e.g. halt in the encroachment of saltwater intrusion and reversal in the lowering of the water level in wells in areas identified as critical). It is imperative, therefore, that subsequent measurements/studies should be done to determine whether the 2004 condition, with regards to saline intrusion and decline in water level in Metro Manila, has improved or even worsened. The land subsidence in the province of Pampanga also needs subsequent studies.

For the areas covered by water districts or water supply providers which have problems in saline intrusion, reduction in groundwater pumping as well as tapping alternative source of water such as surface water, can help mitigate the identified problems.

7.3 Municipal Water Supply

7.3.1 Municipal Water Supply in the Study Area

In the MWSS service area, water supply and sewerage service is operated by two private companies as the service rights are handed over by the concession agreement (CA) after 1997. In contrast, the adjoining area of Metro Manila is managed by relatively smaller water supply providers (WSPs) such as the water district (WD), local government units (LGUs) and certificate of public onvenience (CPC) grantees.

7.3.2 Metro Manila (MWSS Service Area)

There are two service providers for water supply and sewerage. The estimated total service population is more than 13 million, and the estimated coverage area is 2370 km^2. The service areas of two concessionaires are shown in the Figure 7.3.1.

Source: JICA Study Team

Figure 7.3.1 Service Area of Two Concessionaires and Location of Main WTPs

The following table presents the commanding areas and the population being served with water;

Table 7.3.1 Outline of Services by Two Concessionaires

	Area (km2)	Administrative Area	Served Population
MWSI (west)	540	Cities of Manila, Pasay, Paranaque, Caloocan, Muntinlupa, Las Pinas, Malabon, Navotas, Valenzuela and parts of Makati and Quezon Cities in National Capital Region, and Cavite City, and the municipalities of Bacoor, Imus, Kawit, Noveleta and Rosario in Cavite Province.	7.40 Million
MWCI (east)	1,830	Cities of Makati, Mandaluyong, Marikina, Pasig, Pateros, SanJuan, Taguig, and parts of Quezon City and Manila in National Capital Region, and Antipolo City and the municipalities of Angono, Baras, Binangonan, Cainta, Cardona, Jalajala, Morong, Pililia, Rodriguez, Tanay, Taytay and San Mateo in Rizal Province.	5.90 Million
Total	2,370		13.30 Million

Source: MWSS (as of December 2010)

Main facilities provided for the services are briefed as follows:

Water Source

Presently, the water supply in the MWSS service area relies on the Angat-Umiray System, Laguna Lake and groundwater. The granted water rights of these water sources is estimated at about 4190 MLD (48 m^3/s) in total as shown in the Table 7.1.2. The allocation of the main water source of Angat-Umiray system to two concessionaires is decided to be 60% to MWSI and 40% to MWSI based on the CA.

Table 7.3.2 Current Raw Water Sources for MWSS Service Area

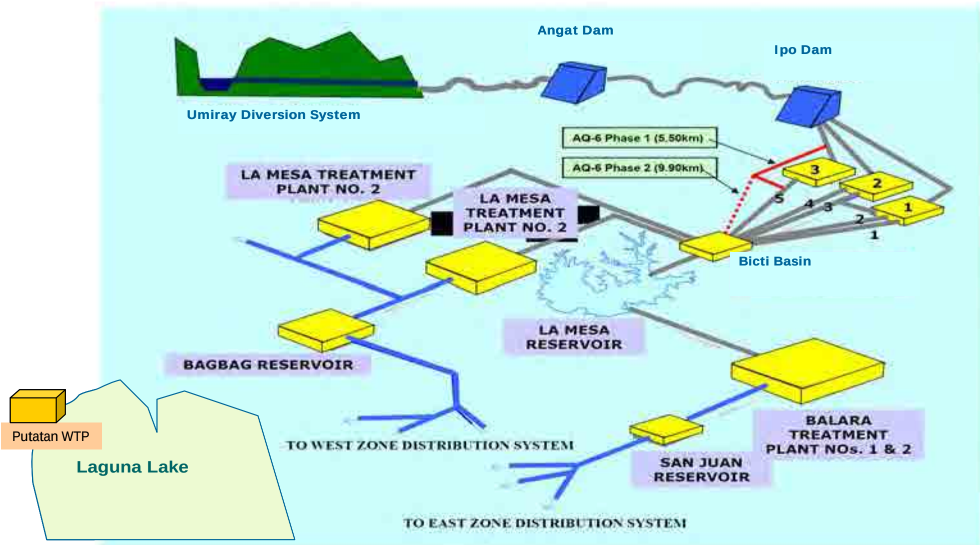
Name of Water Source	Granted Water Right	Share
Angat-Umiray System	4000MLD (46 m^3/s) (MWCI:1600, MWSI:2400)	95.5%
Laguna Lake	100MLD (1 m^3/s)	2.4%
Groundwater *	90MLD (1 m^3/s)	2.1%
Total	4190MLD (48 m^3/s)	100.0%

Note: * Extraction of underground water is terminated in 2003 by MWCI and in 2009 by MWSI. The wells shall be used only during emergency cases.

Source: MWSS

Water Transmission System

Raw water released from the Angat Dam is stored in two regulation dams, namely Ipo Dam and Bustos Dam. The raw water that came from Ipo Dam is delivered through three tunnels to the Bicti Basin (interconnection structure) and further to either the La Mesa Treatment Plant of the MWSI or the La Mesa Reservoir through five aqueducts as shown in the Figure 7.1.2. The raw water from La Mesa Reservoir flows into the Balara Treatment Plant of MWCI.



Source: MWSS

Figure 7.3.2 Raw Water Transmission System in MWSS Service Area

Water Treatment Plant

There are seven water treatment plants (WTP) that are being operated by MWSI and MWCI. The general outline of these WTPs is summarized in the below Table 7.1.3.

Table 7.3.3 General Outline of WTPs

Company	Name of WTP	Capacity	Actual Production	Treatment Procedure	Used Chemical	Construction Year
-	-	MLD	MLD	-	-	Year
MWSI	La Mesa-1	1,500	2143 (average in 2011) 86% of total capacity	Screen, Coagulation, Flocculation, Sedimentation, Rapid Filtration, Disinfection	Hypochlorite, Hydrated Lime, Caustic Soda, Liquid Alm, Ferric Chloride, PAC, Coagulant Aid, Flocculent	1984
	La Mesa-2	900		Screen, Coagulation, Flocculation, Sedimentation, Rapid Filtration, Disinfection	Hypochlorite, Hydrated Lime, Caustic Soda, Liquid Alm, Ferric Chloride, PAC, Coagulant Aid, Flocculent	1994
	Putatan	100		Screen, Coagulation, Mixing and Floculation (Dissolved Air Flotation), Skimming, Micro-Filtration (MF), Reverse Osmosis (RO), Disinfection	Aluminum Chlorhydrate, Potassium Permanaganate, Gas Chlorine	2009
MWCI	Balara-1	470	1277 (average in 2011) 79% of total capacity	Screen, Pre chlorination, Coagulation, Flocculation, Sedimentation, Rapid Filtration, Disinfection	Aluminum Sulphate, Poly Aluminum Chloride, Polymer, Chlorine	1936
	Balara-2	1,130		Screen, Pre chlorination, Coagulation, Flocculation, Sedimentation, Rapid Filtration, Disinfection	Aluminum Sulphate, Poly Aluminum Chloride, Polymer, Chlorine	1958
	Jala Jala	10		Reverse Osmosis (RO)	-	-
	San Rafael	0.6		Reverse Osmosis (RO)	Chlorine Dioxicide	-

Source: Asset Condition Report as of December 2011, Evaluation on KPIs/BEMs 2012

The JICA Study Team confirmed that the operation and management (O&M) of the above WTPs are conducted properly, and that the WTP facility keeps the designed treatment capacity without any significant technical problems. The representatives of companies mentioned that, under the influence of the recent reduction of water loss, the actual production amount of the above main WTPs is controlled below the designed capacity. The operation rate in 2011 for each concessionaire is 86% in MWSI and 79% in MWCI. This implies that the demand of the present service area can be satisfied by the present raw water amount at 4000 MLD of the Angat-Umiray System.

Even though the total demand can be satisfied by the present supply, MWCI and MWSI are trying to increase the available water source supplied from the Laguna Lake. Relatively low investment costs for transmission facilities would attract them if the new WTP could be located near the lake where the urbanization proceeds.

The outline of other distribution facilities for water supply is summarized as follows;

Table 7.3.4 Outline of Distribution Facilities

	MWSI	MWCI
Pump Station	16 Pump Stations (Commonwealth, Fairview-3, La Mesa, Novaliches, Fairview-4, Caloocan, D. Tuazon, Algeciras, Ermita, Espiritu, Tondo, Noveleta, Pasay, Villamor, Pagcor)	19 Pump Stations (Balara, Cubao, Fort Bonifacio, Makati, Maybunga, Pasig, San Juan, N. Domingo-1, N. Domingo-2, 21st, Kingsville, Lucban-1, Lucban-2, Siruna, Brookside, Celina, Curayao, Dalos Santos, San Rafael)
Reservoirs	17 Reservoires (Binuksuk 30ML, Sacred Heart 10ML, Fairview-3 1.5ML, La Mesa 50ML, Novaliches 7ML, Fairview-4 1.1ML, Bagbag 200ML, Caloocan 18.9ML, D. Tuazon 18.9ML, Algeciras 38.7ML, Ermita 18.9ML, Espiritu 18.9ML, Tondo 18.9ML, Noveleta 8ML, Paysay 18.9ML, Villamor 10ML, Pagcor 23ML,	8 Reservoires (Balara 44 ML, Fort Bonifacio 29 ML, Makati 19 ML, Pasig 80 ML, San Juan 167.8ML, Siruna 24 ML, Lucban-1 15 ML, Lucban-2 6.5 ML)
Distribution Network	5444 km (PVC 3567 km, ACP 506 km, CIP 389 km, GSP 349 km, Steel Pipe 324 km, HDPE 100 km, Others 210km)	4466km (HDPE 2131 km, PVC 1818 km, Steel Pipe 312 km, DIP 98 km, Others 107 km)

Source: MWCI, MWSI (as of April 2012)

<u>Cross Border Water Transmission Between Two Concessionaires</u>

In regards with the water allocation system, there are several cross border pipes installed between two concession areas at present. The cross border water transmission of two areas has been continued until 2002. The connection was shut by control valves afterward so that the two companies can manage the business separately. In emergency cases, when one of the two concessionaires lacks treated water, it is recommended that the two companies cooperate to provide water to the other area with a negotiated unit cost.

<u>Service Indicators</u>

MWSS is controlling the services of two concessionaires by monitoring several key indicators called key performance indicators (KPIs) and business efficiency measures (BEMs). The target figure during the concession period is decided every tariff rebasing procedures which is held every 5 years. Basing on the output of these indicators, the concessionaires can be rewarded or penalized by the regulator during the next rebasing period through a unit tariff setting process. For the monitoring purpose, two concessionaires are obliged to report these service indicators to MWSS-RO (Regulatory Office) every month. The presently used indicators are summarized in Table 7.3.5 below.

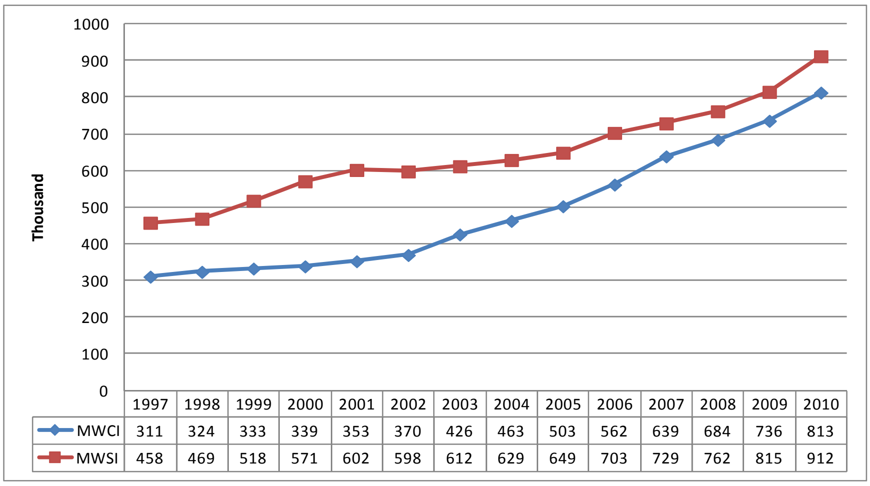
Table 7.3.5 Summary of KPIs and BEMs

Category		ID	Description	Unit
Key Performance Indicators (KPIs)	Water Service	W1	Domestic Connections	Thousand
		W2	Continuity of Water Supply	%
		W3	Pressure of Water Supply	%
		W4	Water Quality at Plant Outlet	%
		W5	Water Quality in Distribution	%
		W6	Sampling	%
	Sewerage and Sanitation	S1	Sewerage Connections	Thousand
		S2	Sanitation (Emptied Septic Tank, Actual Number/Target Number)	%
		S3	Wastewater Effluent Standards	%
	Customer Service	C1	Response to CS Complaints (within 10 days)	%
		C2	Response to Billing Complaints (within 10 days)	%
		C3	Response to Request for New Connections (within 5 days)	%
		C4	Installation of New Water Service Connections (within 7 days)	%
		C5	Response to Disruptive Mains Failure (within 24 hours)	%
Business Efficiency Measures (BEMs)	Income	IN1	Billed Volume	PHP
		IN2	Revenue Collection Rate	PHP
	OPEX	OP1	Labor Cost	PHP
		OP2	Power Cost	PHP
		OP3	Total OPEX	PHP
	CAPEX	CA1	Total CAPEX Expenditure	PHP
		CA2	Physical Accomplishment	PHP
		CA3	Financial Accomplishment	PHP
	Non-Revenue Water	NR1	NRW amount per connection	l/connec./day

Source: Evaluation on KPIs/BEMs 2012

The historical data of main technical and financial indicators are summarized in Annex 7.3.1 and 7.3.2. Historical trend of several technical indicators are evaluated below to overview the service conditions.

Number of total connection increased rapidly after 2002 in east area (MWCI). The NRW and total income of MWCI correspondingly improved during the same period of service expansion from 2002 to 2012. Compared with the figure in 1997, the total domestic connection number increased by 161% in the east area (MWCI) and by 99% in the west area (MWSI). The composition of domestic connection from the total connection is reported to be approximately 94% and 93% respectively in the east and west area (refer to Figure 7.3.3).

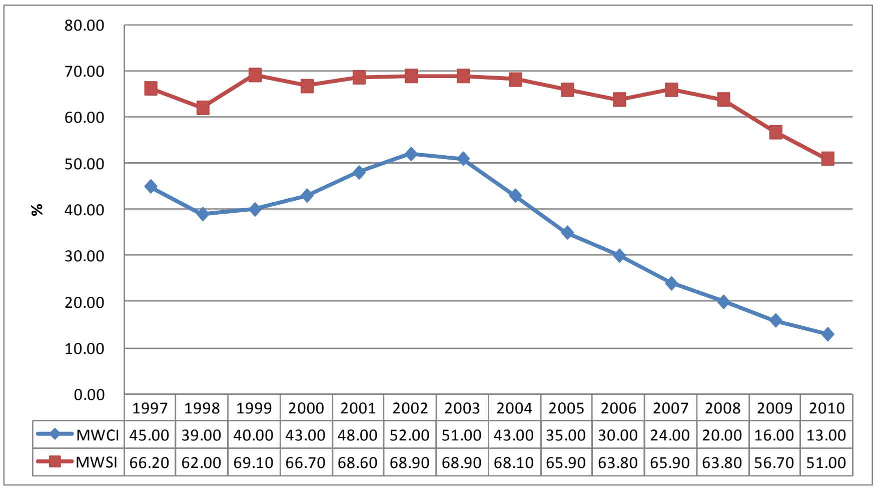


Source: MWSS

Figure 7.3.3 Total Connection Numbers

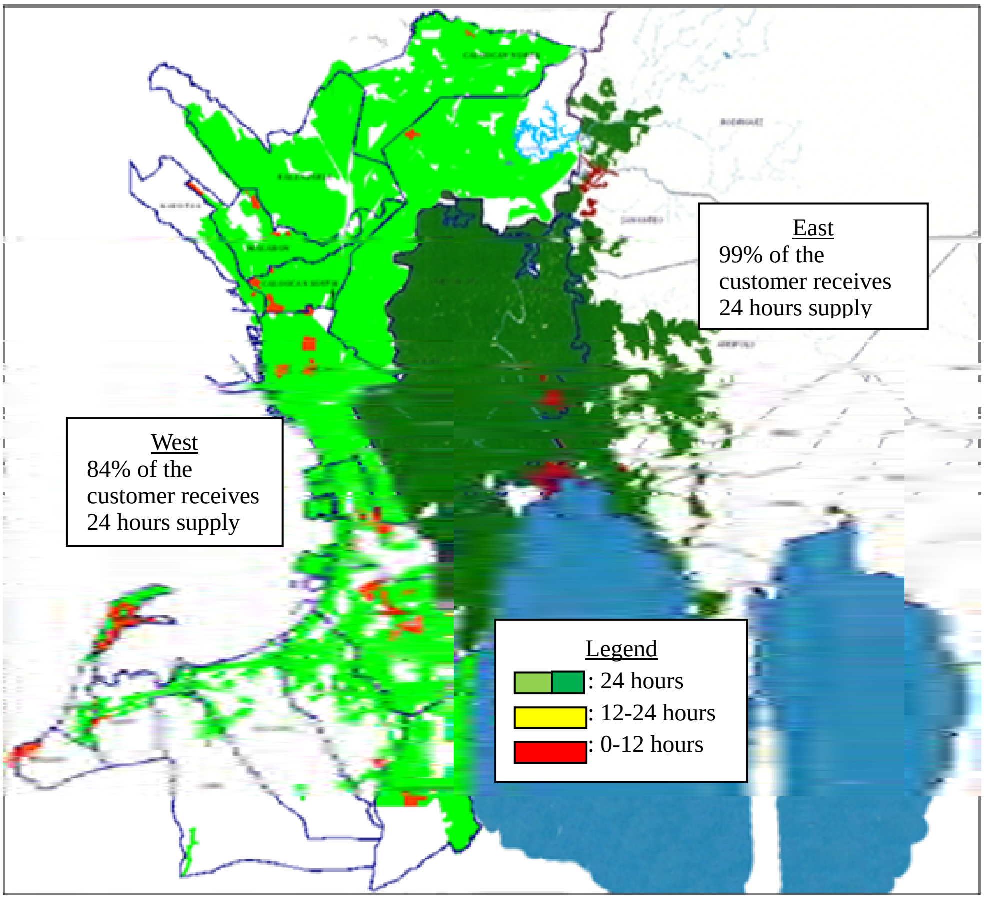
The NRW rates have improved rapidly from 52% in 2002 to 13% in 2010 in the east zone as shown in Figure 7.3.4 below. It implies that a heavy investment on pipe facilities was made by MWCI from 2002 to 2010. The reduction of NRW amount directly contributed to the increase of billed water volume as shown in Figure 7.3.4. Whereas, in the west zone, the water loss is gradually decreasing after 2007 and the present NRW rate is reduced to 51%. MWSS have set the target NRW rate in the west zone at 20% to be fulfilled until 2035 to achieve efficient services.

The supply's water pressure is substantially at 7 psi and above (refer to Figure 7.3.5).



Source: MWSS

Figure 7.3.4 Rate of Non Revenue Water



Source: Evaluation on KPIs/BEMs 2012

Figure 7.3.5 Map of Water Pressures (December 2011)

Issues Regarding Water Supply

(1) Cooperation of Two Concessionaires in Case of Water Shortage

One of the common understandings regarding the influence of climate change is an amplified fluctuation of the annual precipitation. Hence, the water source shortage in Agos-Umiray system will become more frequent. There was a case when the west zone suffered from water shortage more significantly than the east. In that case, cooperation between the two concessionaires could alleviate the problem. Technically, the existing water supply system is designed to control the allocation of water before treating at WTPs and at distribution network.

Firstly, the allotment of water source which is defined by CA at 40% (east) to 60% (west) can be modified tentatively if MWSS and both concessionaires agree. The operation is only to control the inflow amount of raw water to La Mesa WTP (west area). The rest of the water from the Agos-Umiray system automatically goes to the Balara WTP (east area).

Secondly, even cross-border transmission is possible to utilize the existing cross-border transmission pipes. As it has been explained previously, both companies transfer water until 2002 through connecting pipes. The two companies need to negotiate beforehand how to fix the details and rules for water transfer such as water allocation, price of the transferred water, and actual operation process to adapt to emergency cases.

(2) Improvement of NRW Rate in the MWSI Service Area

About 63% of the total produced water in Metro Manila is distributed to the west zone. The NRW rate is as high as 51% in 2010, although the causes thereof are not clarified yet. This means that 32% of the total produced water is wasted by leakages or commercial loss in the west area. Hence, the progress of the NRW ratio reduction in west zone influences significantly on the total demand in the Study Area.

Generally, the replacement costs of existing pipes are high. It takes time to recover the said cost by the additional revenue charged on saved water. Therefore, whether the service is managed by public or private companies, the progress of NRW reduction activity often delays if they consider the benefit and cost from a short term viewpoint.

To achieve the target NRW reduction of MWSI, the MWSS needs to have the close look on their plan, the output and actual expenditure for NRW reduction activity. In case if the accomplishment delays, MWSS as the regulator needs to find the way to incentivize MWSI to catch up to the plan.

7.3.3 Adjoining Areas

(1) **Types of Water Supply Facilities**

In the Philippines, there are three water service categories from level 1 to level 3 depending on their facility type. The definitions are as follows:

Table 7.3.6 Definition of Facility Level for Water Supply Service

Level	Facility Type	Definition
Level 1	Point source	A protected well or a developed spring with an outlet but without a distribution system as it is generally adaptable for rural areas where houses are thinly scattered serving an average of 15 households with people having to fetch water from up to 250 m distance
Level 2	Communal faucet system or stand post	A piped system with communal or public faucets usually serving 4-6 households within 25 meters distance.
Level 3	Waterworks system	A fully reticulated system with individual house connections based on a daily water demand of more than 100 liters per person.

Source: Philippine Water Supply Sector Roadmap (2nd edition)

In rural areas of the Philippines, surface water is rarely used for water supply service. Approximately a whole water source is taken from ground water.

(2) **Present Water Supply Providers (WSPs)**

In the Study Area, there are three different kinds of WSPs called Water Districts (WDs), LGU units and CPC grantees. The outline of each kind is explained below.

- Water Districts (WDs)

In the Study Area, there are 55 WDs. The WDs supply water to households in larger cities by the use of piped water connections (known as Level III water supply system), except for Metro Manila and other cities managed by private entities. WDs are able to supply water to several municipalities. The WDs are declared as government-owned and controlled corporations (GOCCs) on the grounds that these companies are managed as independent corporations without any subsidy.

- LGUs

In the Study Area, 181 LGUs exists. LGUs provide water services in rural areas where WDs are not founded. Services from LGUs are rather small as compared to those of WDs and the service level varies from level 1 to level 3. Currently, water supply services run by LGUs are legislatively managed by the Department of Interior and Local Government (DILG), however, in reality, the service is not sufficiently monitored at present.

- Certificate of Public Convenience (CPC) Grantees

There are 883 CPC grantees that exist in the Study Area. The CPC grantees are recipients of certificates issued by the NWRB. These are mainly small private companies or NGOs providing water in small lots for domestic and industrial use. By granting CPC, NWRB permits them to operate and maintain waterworks supply services and impose penalties for violations of the rules and regulations if necessary.

(3) **National Development Plan**

As the national level sector plan for water supply service, the "Philippine Water Supply Sector Roadmap (2nd edition)" was published in 2010 by the National Economic and Development Authority (NEDA). The purpose of making this roadmap is to achieve "Access to safe, adequate and sustainable water supply for all."

The roadmap is composed of three main phases.

- By 2010, 432 waterless municipalities shall have been accommodated to more than 50% of the access coverage and sustaining utility operations. Existing formal/legal utilities are expanding to coverage to areas not being served, and that 60% of water service providers shall have been regulated from the current 40% level.
- By 2015, the water supply sector shall achieve the MDG target of halving the proportion of the population without sustainable access to safe drinking water and basic sanitation.
- By 2025, universal access coverage and sustained utility operations shall be attained. Existing formal/legal utilities shall continue to expand coverage in par with the population growth and that all water service providers shall have been regulated.

The Government of the Philippines announced that the MDG of water supply would be attained without problem in 2015. The main outcomes and outputs during the medium term until 2025 are summarized as shown in Table 7.3.7 below.

Table 7.3.7 Outcome/Outputs of the Philippine Water Supply Sector Roadmap (Medium Term)

Outcome	Output
Outcome 1: Strengthened Institutions Harmonized and mainstreamed institutional and regulatory framework for a decentralized and enabling policy environment	Output 1.1: Jointly formulated policies and legislation clarifying agency mandates, advocated and promulgated by concerned agencies and institutions
	Output 1.2 : Strengthened sector coordination mechanisms for effective management (planning, implementation, monitoring evaluation) and regulation
	Output 1.3 : Established financing support mechanisms
Outcome 2: Developed Capacities Developed capacities of key LGUs, WSPs and NGAs for the sustainable management of water supply and wastewater management sector	Output 2.1: LGUs are capacitated on local policy formulation, water services planning, monitoring and evaluation
	Output 2.2 : WSPs capacity needs effective and efficient service delivery identified, and appropriate interventions designed and delivered
	Output 2.3 : NGAs' capacity needs to improve support services to LGUs and WSPs identified, and appropriate interventions designed and delivered
	Output 2.4:Established NGA support services and mechanisms promoting management and technological innovations accessible by LGUs and WSPs
Outcome 3: Built Strategic Alliances Broad community support in the development of water supply and wastewater management sector is effectively mobilized	Output 3.1: Organized and operating broad community support focused on the development of the water supply and wastewater management sector
	Output 3.2 : Identified and sector-informed champions in the national and local legislative and executive bodies
	Output 3.3 : Established effective collaboration mechanisms
	Output 3.4: Active participation of water supply and wastewater management sector stakeholders in collective localized action for IWRM
Outcome 4: Adequate Infrastructure Provision Infrastructure provided (from source development to water supply distribution) is sustainable developed in identified priority areas	Output 4.1: Installed water systems in priority areas (preferably Level 3 water systems or Level 2 water systems upgradable to Level 3)
	Output 4.2: Bulk water supply from developed water sources delivered to priority areas
	Output 4.3: Sanitation facilities installed with constructed water supply systems

Source: Philippine Water Supply Sector Roadmap (2nd edition)

Based on the above medium-term plan, the Government of the Philippines is providing technical and financial support especially in rural areas to expand the service coverage and improve the service level of their water supply. Several provinces have also made their own development plan to optimize their limited budget as prioritizing several important projects out of any kinds of infrastructure projects.

Overviewing future projects in the Study Area, the JICA Study Team found out that there is no cross-basin water delivery in the Study Area except for the “Bulacan Bulk Water Supply Project”.

- Bulacan Bulk Water Supply Project

Referred to past JICA study entitled “The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin” in 2011, the groundwater in the part of Bulacan and Panpanga provinces contain high TDS and chloride as affected by saline water intrusion.

In order to solve this problem, MWSS and the Provincial Government of Bulacan agreed for a bulk water supply to existing water districts in Bulacan province. In referral to one of its memorandum, the provision of 2.7 m^3/s bulk water would be delivered to priority cities in the Bulacan province by MWSS. The exact water source of the said supplied water is not yet confirmed, though the Angat-Umiray system and Sumag intake could be the possible resources.

(4) **Issues and Its Countermeasures in the Adjoining Area**

- Low Tariff Level

In general, the water services in the rural area are managed under weak financial conditions. The main reason is the low income due to low tariff settings considering low income users.

An LGU conducts water supply as mandate under its budget. The water tariff are calculated and controlled by the LGU council or the local barangay council. However, collected tariff is not used for water supply activity. WDs are a financially independent body. However, they sometimes receive partial subsidies from the central and local governments.

Collected tariff should cover actual expenditures for O&M and amortize capital investment cost of facilities in order to secure sustainability, depending on the residents and their capacity to pay. Transparent rules and procedures are necessary for the local government to subsidize the water supplier. In this respect, there are guidelines prepared by NWRB and LWUA. Effective application of the guidelines is crucial.

- Knowledge Management Among Stakeholders

The regulation of water services in the Philippines is quite fragmented. The NWRB, LWUA, DILG, NEDA and LGUs are planning their projects depending on their own mandates and rarely share any latest important information they receive. To make water supply effective, a centralized information system is necessary among stakeholders. In this addition, a centralized decision making system is required as well.