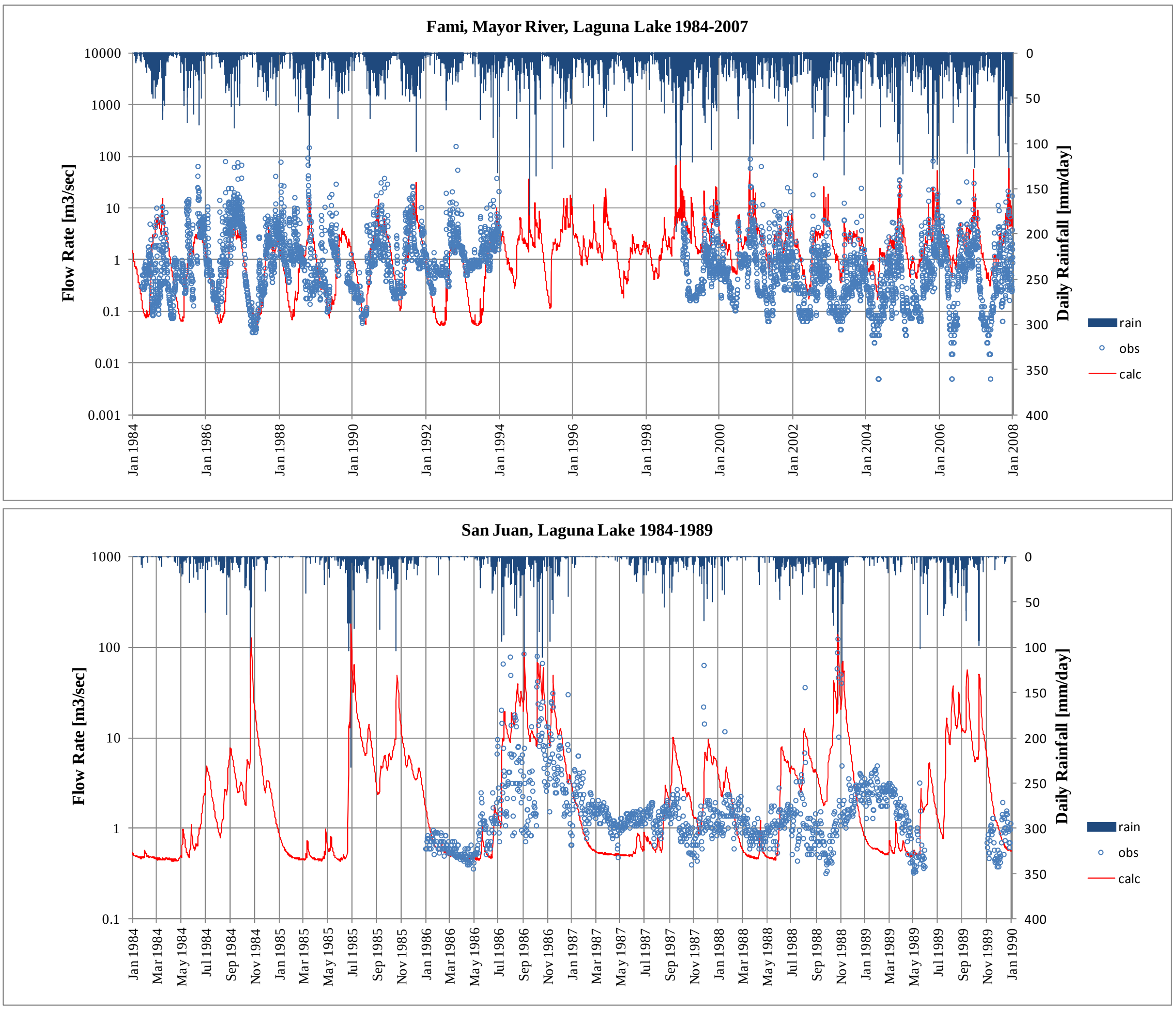
(6) Model Parameters

The simulation of rainfall-runoff model was carried out with the prepared grid rainfall and the potential evapotranspiration for the present climate condition to estimate the naturalized flow for assessment of renewable water resources. The parameters of the model were calibrated by comparing the observed discharge record at the selected river gauging stations and the simulation results. The values of saturated hydraulic conductivity of surface soil and aquifer depended on the calibration in the SHER model. The comparison of the simulated discharge of the calibrated model and observed records are shown in Figure 9.21. The calibrated parameter list is shown in Table 9.21.

The parameters for the soil type were calibrated to be consistent with the principles of soil mechanics. It is possible to apply the developed rainfall-runoff model for evaluation of the water resources for ungauged rivers, since the parameters calibrated has physically-based results. Similarly, the model also can be applied for the evaluation of future hydrological conditions and water resources with bias-corrected GCMs data.



Source: JICA Study Team

Figure 9.21 Comparison of Simulated River Discharge and Observed Record

Table 9.21 Soil Parameters of the Calibrated Model for Laguna Lake Basin

No	Name	Depression Depth [mm]	θ0 Saturated Water Content	θs Residual Water Content	Morlem's n	Saturated Hydraulic Conductivity for Vertical Direction K0[cm/sec]	Saturated Hydraulic Conductivity for Slope Direction iK0[cm/sec]
1	ForestNITOSOLS_RechargingArea	10	0.438	0.069	4.00	3.85E-04	3.85E-03
2	ForestACRISOLS_RechargingArea	10	0.464	0.072	4.00	6.80E-04	6.80E-03
3	ForestCAMBISOLS_RechargingArea	10	0.447	0.076	4.00	2.49E-04	2.49E-03
4	ForestGLEYSOLS_RechargingArea	10	0.449	0.079	4.00	2.45E-04	2.45E-03
5	ForestLUVISOLS_RechargingArea	10	0.432	0.070	4.00	3.15E-04	3.15E-03
6	ForestVERTISOLS_RechargingArea	10	0.454	0.086	4.00	1.92E-04	1.92E-03
7	GlassNITOSOLS_RechargingArea	5	0.438	0.069	4.00	3.85E-04	3.85E-03
8	GlassACRISOLS_RechargingArea	5	0.464	0.072	4.00	6.80E-04	6.80E-03
9	GlassCAMBISOLS_RechargingArea	5	0.447	0.076	4.00	2.49E-04	2.49E-03
10	GlassGLEYSOLS_RechargingArea	5	0.449	0.079	4.00	2.45E-04	2.45E-03
11	GlassLUVISOLS_RechargingArea	5	0.432	0.070	4.00	3.15E-04	3.15E-03
12	GlassVERTISOLS_RechargingArea	5	0.454	0.086	4.00	1.92E-04	1.92E-03
13	CLAY	50	0.446	0.241	4.00	1.00E-06	1.00E-05
14	BuiltUp_NITOSOLS	5	0.438	0.069	4.00	3.85E-05	3.85E-04
15	BuiltUp_ACRISOLS	5	0.464	0.072	4.00	6.80E-05	6.80E-04
16	BuiltUp_CAMBISOLS	5	0.447	0.076	4.00	2.49E-05	2.49E-04
17	BuiltUp_GLEYSOLS	5	0.449	0.079	4.00	2.45E-05	2.45E-04
18	BuiltUp_LUVISOLS	5	0.432	0.070	4.00	3.15E-05	3.15E-04
19	BuiltUp_VERTISOLS	5	0.454	0.086	4.00	1.92E-05	1.92E-04
20	ForestNITOSOLS_DischargingArea	10	0.438	0.069	4.00	3.85E-05	3.85E-04
21	ForestACRISOLS_DischargingArea	10	0.464	0.072	4.00	6.80E-05	6.80E-04
22	ForestCAMBISOLS_DischargingArea	10	0.447	0.076	4.00	2.49E-05	2.49E-04
23	ForestGLEYSOLS_DischargingArea	10	0.449	0.079	4.00	2.45E-05	2.45E-04
24	ForestLUVISOLS_DischargingArea	10	0.432	0.070	4.00	3.15E-05	3.15E-04
25	ForestVERTISOLS_DischargingArea	10	0.454	0.086	4.00	1.92E-05	1.92E-04
26	GlassNITOSOLS_DischargingArea	5	0.438	0.069	4.00	3.85E-05	3.85E-04
27	GlassACRISOLS_DischargingArea	5	0.464	0.072	4.00	6.80E-05	6.80E-04
28	GlassCAMBISOLS_DischargingArea	5	0.447	0.076	4.00	2.49E-05	2.49E-04
29	GlassGLEYSOLS_DischargingArea	5	0.449	0.079	4.00	2.45E-05	2.45E-04
30	GlassLUVISOLS_DischargingArea	5	0.432	0.070	4.00	3.15E-05	3.15E-04
31	GlassVERTISOLS_DischargingArea	5	0.454	0.086	4.00	1.92E-05	1.92E-04

Source: JICA Study Team

9.4 Runoff Simulation

9.4.1 Workflow

The runoff simulations were conducted using the developed basin models through the following steps:

1) Simulations under the present and future meteorological conditions,
2) Development of annual flow duration curve,
3) Projection of simulated river discharge to target year of 2040s, and
4) Adjustment of duration curve.

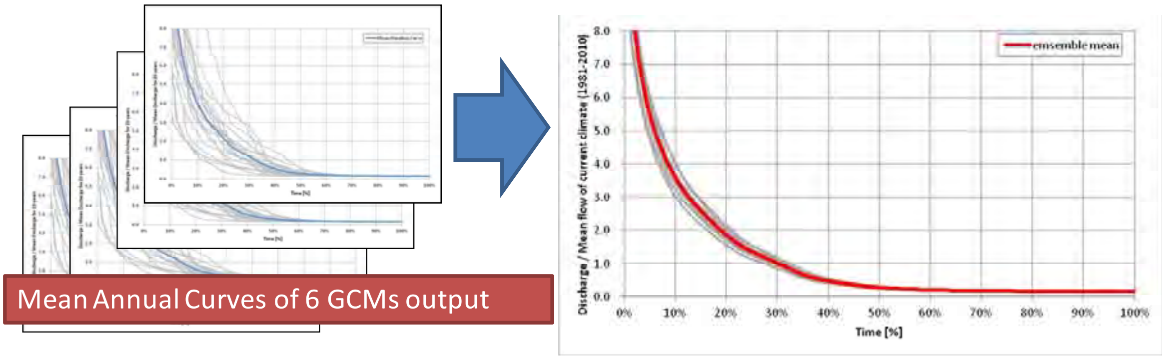
The detailed descriptions of these four steps are given below.

(1) Simulations under Present and Future Meteorological Conditions

Three types of simulations were conducted, namely OBS, 20C3M, and A1B2055. The OBS represents simulated flows from 1981 to 2000 driven by meteorological observations. The 20C3M represents simulated flows from 1981 to 2000 driven by bias-corrected present meteorological conditions of GCMs. The A1B2055 represents simulated flows for 2046 to 2065 driven by future meteorological conditions which were obtained by bias-corrected GCMs outputs. In addition, A1B2040 represents projected flows for 2031 to 2050 derived from A1B2055. As mentioned earlier, the six GCMs which were selected in priority of rainfall performance were applied for the rainfall-runoff analysis.

(2) Development of Flow Duration Curve

Flow duration curve was made to summarize long flow records. The curve was made by ranking all the flows in a year in a sequence and plotting flows with corresponding exceedance probability. Then, the mean annual duration curve was calculated from 20 annual curves. Finally, the ensemble mean of annual duration curve was made from the annual mean duration curves of the six GCMs.



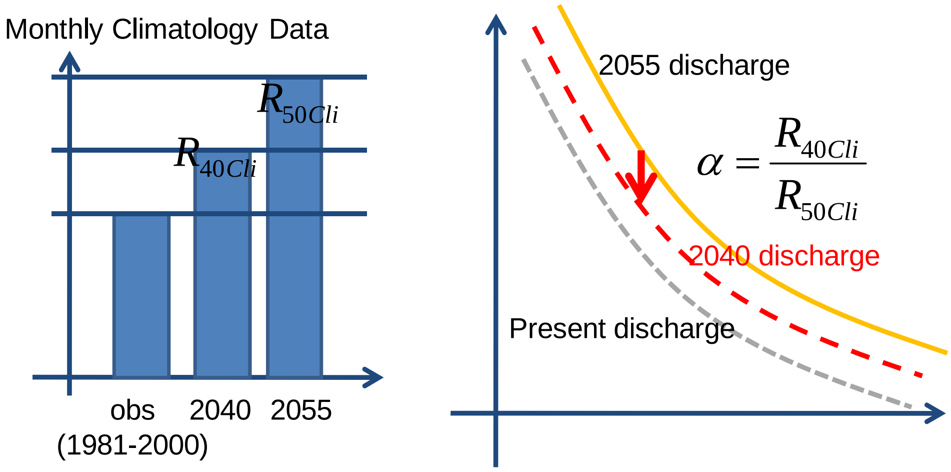
Source: JICA Study Team

Figure 9.22 Schematic Diagram for Making Annual Flow Duration Curve

(3) Projection to Target Year of 2040s

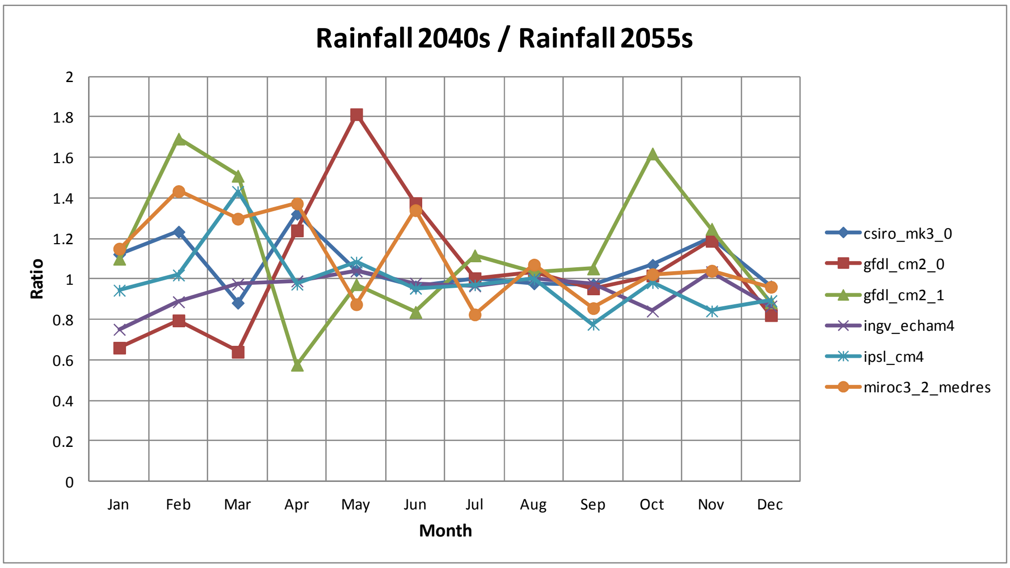
The period of the simulation for future condition was 2046-2065, since the simulation was carried out in another report, which was conducted by the University of Tokyo,(Climate Change Impact Assessment and Hydrological Simulation). In order to evaluate the hydrological conditions for the target year, the simulated discharge for 2046-2065 (or the 2055s) were projected to 2031-2040 (or the 2040s). The methodology is itemized as follows:

1) Monthly precipitation data for the period from 2031 to 2050 was obtained from IPCC Data Distribution Center.
2) Climatology of monthly mean rainfall for the 2040s and 2055s were calculated.
3) The ratios of monthly rainfall for the 2040s to 2055s were applied to the project duration curve to the target year.



Source: JICA Study Team

Figure 9.23 Schematic Diagram of Projection to Target Year of 2040s

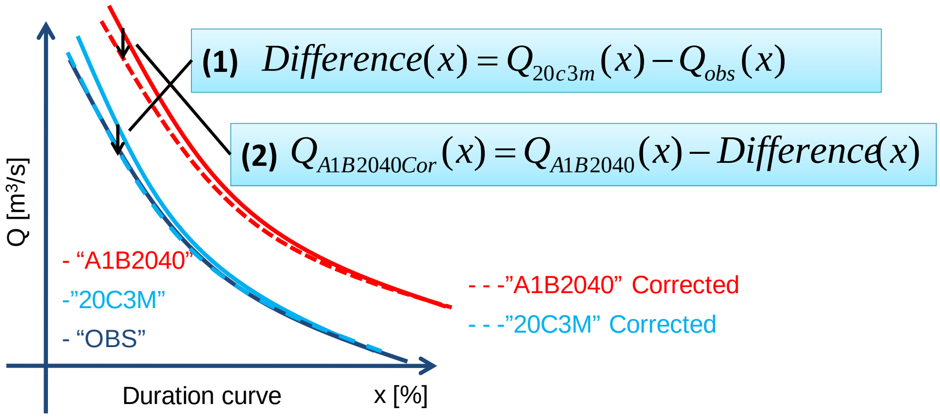


Source: JICA Study Team with CMIP3 multi-model dataset

Figure 9.24 Ratio of Climatological Monthly Mean Rainfall of 2040s (2031-2040) to 2055s (2046-2065)

(4) Adjustment of Duration Curve to OBS

The duration curve of 20C3M was slightly different from the OBS simulation, since the rainfall frequency and temporal sequence are different between observed data and simulated data. The difference between OBS and 20C3M is involved in A1B2040. In order to adjust 20C3M to OBS and dissolve the difference in A1B2040, the gap between 20C3M and OBS for particular rankings was applied to 20C3M and A1B2040. The procedures of bias correction for the difference between OBS and 20C3M are illustrated in Figure 9.25.



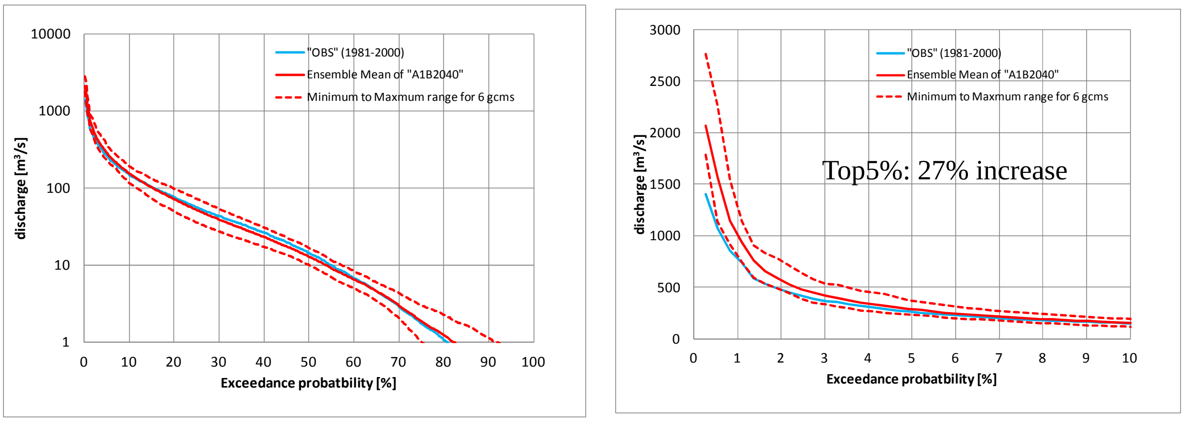
Source: JICA Study Team

Figure 9.25 Schematic Diagram for Adjusting the Flow Duration Curve

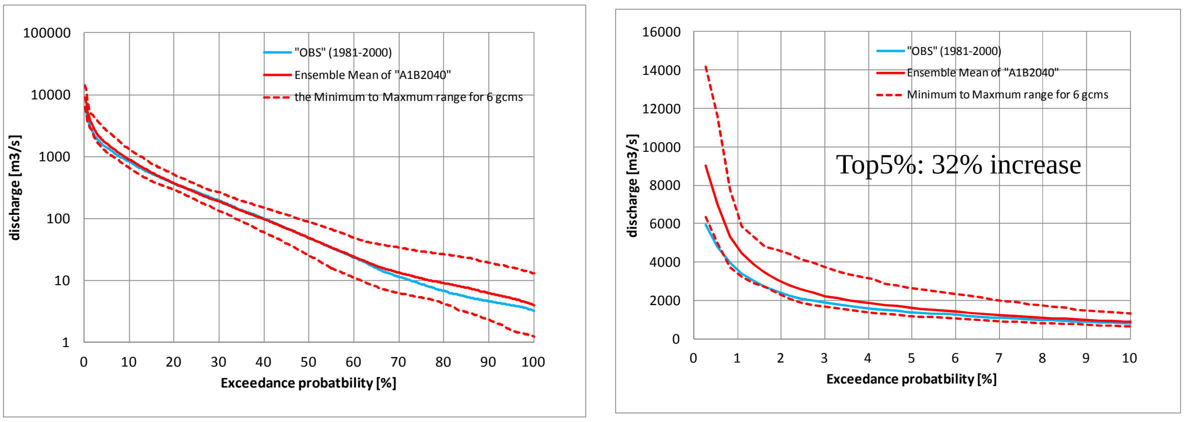
9.4.2 Evaluation of Climate Change Impact on Hydrological Condition

Annual duration curve was made for each year of the model output and is shown in Figure 9.26. Flood flows of A1B2040 are expected to be higher than that of the present condition, and the increasing rate of the top 5% values are estimated at 27% for Angat, 32% for Pampanga, 22% for Pasig-Marikina, 27% for Umiray, 32% for Agos, and 62% for Laguna basin. Meanwhile, the difference of low water of A1B2040 from the present condition is very little. The evaluation of low water condition is significant for this Study, and further detailed evaluation was conducted as discussed in Chapter 9.5.

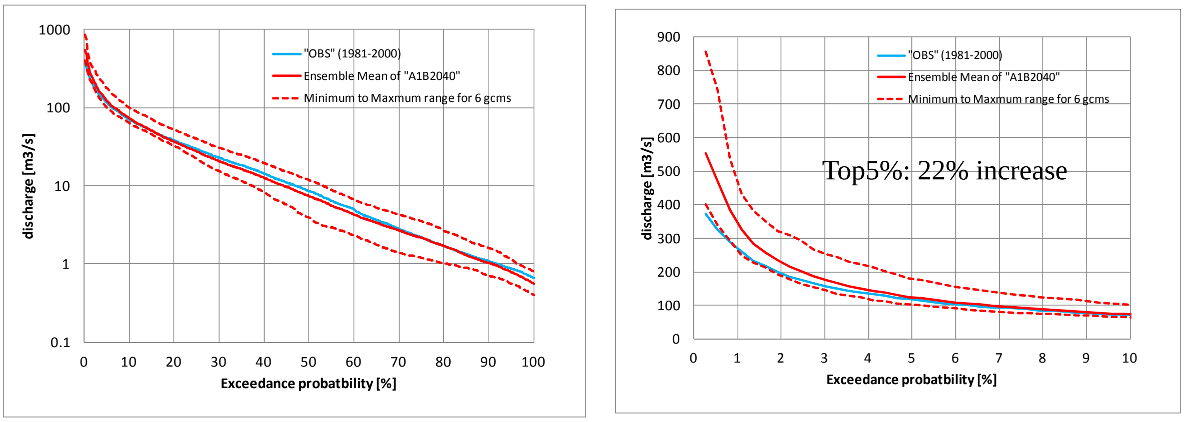
Angat River Basin



Pampanga River Basin



Pasig-Marikina River Basin

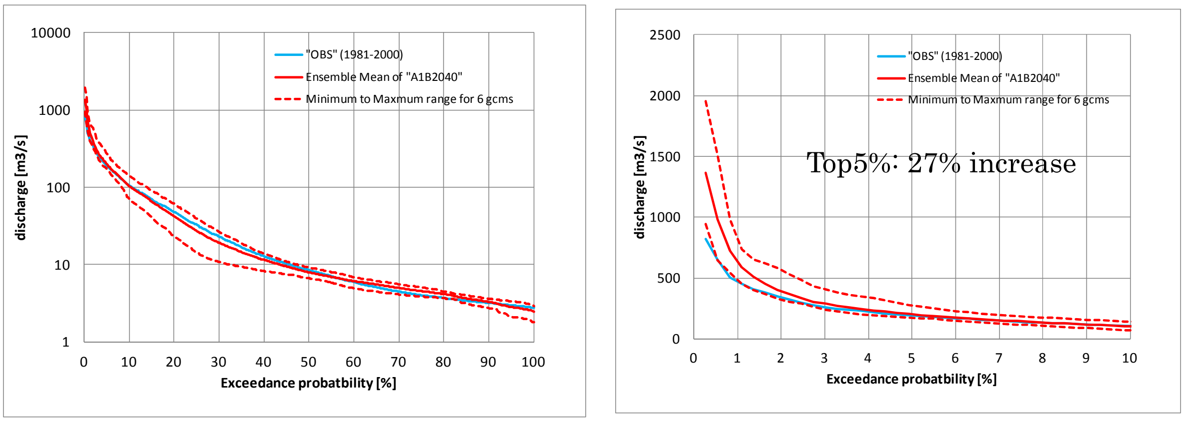


Note: The blue line shows the duration curve for the years 1981-2000 based on simulation driven by meteorological observations. The red solid line shows the ensemble mean of duration curve for the years 2031-2050 based on simulation driven by predicted meteorological data. The red dashed line shows the minimum to maximum range of models. The right panel shows a close-up of the top 10% of exceedance probability.

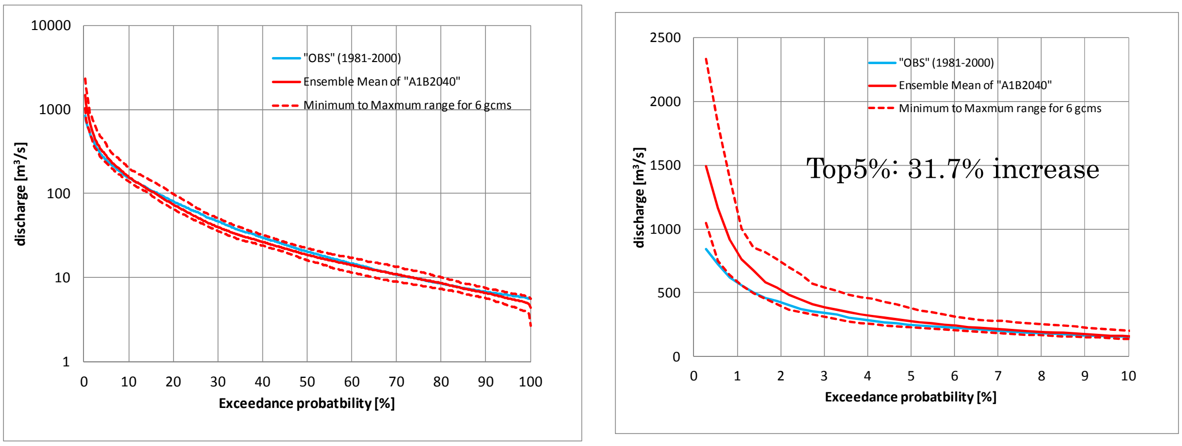
Source: JICA Study Team

Figure 9.26 (1/2) Changes in Mean Annual Duration Curves for Angat, Pampanga, and Pasig-Marikina River Basins

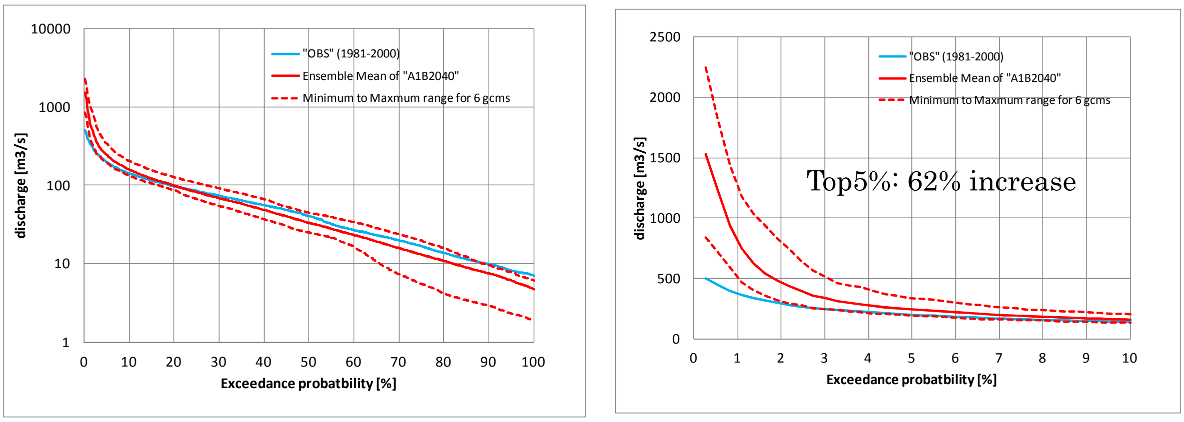
Umiray River Basin



Agos River Basin



Laguna Lake Basin



Note: The blue line shows the duration curve for the years 1981-2000 based on simulation driven by meteorological observations. The red solid line shows the ensemble mean of duration curve for the years 2031-2050 based on simulation driven by predicted meteorological data. The red dashed line shows the minimum to maximum range of models. The right panel shows a close-up of the top 10% of exceedance probability.

Source: JICA Study Team

Figure 9.26 (2/2) Changes in Mean Annual Duration Curves for Agos River Basin, Umiray River Basin, and Laguna Lake Basin

9.5 Vulnerability Assessment of the Water Resources to Climate Change

In order to understand the vulnerability of water resources to climate change impacts, it is important to estimate the change of hydrological conditions. Vulnerability of water resources is conceived when climate change causes adverse effects in view of the management of water resources. For example, if the runoff volume of dry season is assessed to be degraded in the future, the vulnerability of the water resources during the dry season can be estimated by the difference between the present and future runoff volume. The change in hydrological conditions will be unequal in view of time and space. The assessment of vulnerability shall be done by area and by season, separately.

9.5.1 Drought Index

The climate change impact of drought is one of the most important concerns. In order to evaluate drought trends, drought indices which are itemized and evaluated as follows (see also Table 9.22 to Table 9.25).

a) Annual drought discharge (the average of the 355th rank of daily discharge);
b) Number of days when base flow is below the present drought discharge;
c) The 10% non-exceedance probability of drought discharge (the 10th percentile of 355th rank of daily discharge); and
d) Number of days when base flow used below the present drought discharge of the 10% non-exceedance probability.

According to the evaluation results, about 2/3 of GCMs showed trend of increasing drought risk, while the remaining 1/3 showed decreasing trend. From these evaluations of drought indices, it is difficult to present assured assessment of drought risk. In order to formulate water resources management plan, it is necessary to prepare the possible increase of drought risk in the future.

9.5.2 Seasonal Analysis

The mean monthly discharge of the present and 2040s period are calculated and shown in Figures 9.27 to 9.30. The monthly discharges of the drought year for each month are also shown in the said figures. The average monthly flows are expected to increase slightly, while the flows during drought year are expected to decrease.

9.5.3 Inter-Annual Variation

The coefficient of variation (CV) is a useful statistic index in comparing the degree of variation from one data series to the other. It represents the ratio of the standard deviation to the mean, as shown in formula below. The CVs for the target basins are shown in Figure 9.31. The inter-annual variation will be larger in the whole range of the flow duration curve. This will be a threat for water resources management.

$$CV = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(Q_i - \overline{Q})^2}}{\overline{Q}}$$

Where: Q_i is discharge of a certain year; $\overline{Q}$ is discharge averaged over the total years; and N is the total number of subjected years.

9.5.4 Conclusion of Assessment of Vulnerability

(1) River Flow in Normal Year

The river flows in normal years will not change drastically for all target basins. This agrees with the result that the monthly rainfall for normal years will not have significant changes towards the future.

(2) River Flow of Rainy Season for Drought Year

The river flow during rainy season will suffer from drought. The decreasing amount of drought flow towards the future during rainy season was found to be larger than that during the dry season. The river flow of Pasig-Marikina River in August of drought year was assessed at 33 m^3/s at present, and will decrease to 14 m^3/s, which is almost 40% of present condition as shown in item b) of Figure 9.27. For the Laguna Lake basin, the river flow in October of drought year was evaluated at 47 m^3/s at present, and will reduce to 30 m^3/s in the future, which is about 60% of present condition as shown in item b) of Figure 9.30. Similarly, the river flow of the Agos River in September of drought year was calculated at 41 m^3/s at present and 16 m^3/s in the future, as shown in item b) of Figure 9.29.

Items a) and b) of Figures 9.27-9.30 show the ensemble mean of monthly discharges at the downstream end of modeled area for a) 20-year average and b) 10% non-exceedance probability of drought discharge. Items c) and d) of the same figures show the ensemble mean of basin averaged precipitation minus potential evapotranspiration (P-E) for c) 20-year average and d) P-E of drought year for 10-year return period. The blue line represents the present and recent years (1981-2000) while the red line represents the years 2031-2050. The red dashed line shows range of models.

Table 9.22 Drought Index in the Pasig-Marikina River Basin

GCM Model	Annual Drought Discharge (m3/s) (average 355th rank)		# of days/year that baseflow < present drought discharge		10% Non Exceedance Probability of Annual Drought Discharge(m^3/s) (10th percentile of 355th rank)		# of days/year that baseflow < present 1/10 drought discharge		Longest # of days for each year below average drought discharge	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
CSIRO	1.51	1.38	42	48	0.47	0.30	3	5	104	148
GFDL_0	1.00	0.84	49	77	0.32	0.23	5	8	141	179
GFDL_1	0.90	0.68	32	44	0.34	0.24	2	9	113	96
INGV	0.90	1.06	36	35	0.38	0.46	3	1	97	81
IPSL	0.52	0.69	32	27	0.20	0.34	2	1	108	68
MIROC	0.81	0.56	38	51	0.38	0.23	2	12	92	123

※The index was evaluated for the daily discharges at the downstream end of modeled area.
Red = drier in the future; more frequent below drought discharge
Blue = wetter in the future; less frequently below drought discharge

Source: JICA Study Team

Table 9.23 Drought Index in the Umiray River Basin

GCM Model	Annual Drought Discharge (m3/s) (average 355 th rank)		# of days/year that baseflow < present drought discharge		10% Non Exceedance Probability of Annual Drought Discharge(m^3/s) (10 th percentile of 355 th rank)		# of days/year that baseflow < present 1/10 drought discharge		Longest # of days for each year below average drought discharge	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
CSIRO	2.91	2.92	29	25	2.44	2.34	3	10	97	90
GFDL_0	2.68	2.32	38	44	2.05	1.92	4	10	137	125
GFDL_1	2.67	1.86	27	52	2.00	1.43	2	25	97	106
INGV	2.74	2.85	20	18	2.40	2.34	3	6	66	149
IPSL	2.57	2.89	26	26	2.21	2.36	4	1	103	72
MIROC	2.70	2.39	22	33	2.36	1.86	3	21	68	62

※ The index was evaluated for the daily discharges at the downstream end of modeled area.
Red = drier in the future; more frequent below drought discharge
Blue = wetter in the future; less frequently below drought discharge

Source: JICA Study Team

Table 9.24 Drought Index in the Agos River Basin

GCM Model	Annual Drought Discharge (m3/s) (average 355 th rank)		# of days/year that baseflow < present drought discharge		10% Non Exceedance Probability of Annual Drought Discharge(m^3/s) (10 th percentile of 355 th rank)		# of days/year that baseflow < present 1/10 drought discharge		Longest # of days for each year below average drought discharge	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
CSIRO	5.85	5.45	44	39	4.00	4.07	3	1	119	112
GFDL_0	4.41	4.33	37	41	3.08	2.85	3	8	115	168
GFDL_1	5.12	3.51	39	60	3.07	2.25	3	13	158	210
INGV	5.38	4.79	23	61	4.26	3.70	4	11	100	128
IPSL	4.46	4.81	36	19	3.21	3.92	2	0	102	70
MIROC	5.16	3.65	37	56	3.98	2.82	3	32	111	124

※ The index was evaluated for the daily discharges at the downstream end of modeled area.
Red = drier in the future; more frequent below drought discharge
Blue = wetter in the future; less frequently below drought discharge

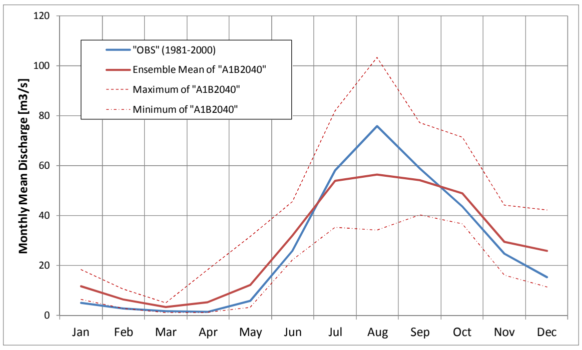
Source: JICA Study Team

Table 9.25 Drought Index in the Laguna Lake Basin

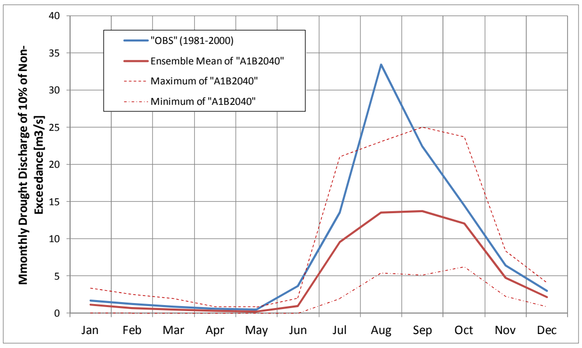
GCM Model	Annual Drought Discharge (m3/s) (average 355 th rank)		# of days/year that baseflow < present drought discharge		10% Non Exceedance Probability of Annual Drought Discharge(m^3/s) (10 th percentile of 355 th rank)		# of days/year that baseflow < present 1/10 drought discharge		Longest # of days for each year below average drought discharge	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
CSIRO	8.16	6.17	68	69	0.71	0.51	3	7	197	164
GFDL_0	7.36	7.02	71	82	2.02	0.94	2	6	199	238
GFDL_1	7.15	5.20	70	69	0.63	0.34	3	4	179	194
INGV	7.29	7.37	59	93	0.50	0.20	3	5	168	221
IPSL	7.73	7.80	38	37	4.75	5.69	2	1	148	77
MIROC	6.93	2.14	68	122	0.63	0.36	4	6	165	227

※ The index was evaluated for the daily discharges at the downstream end of modeled area.
Red = drier in the future; more frequent below drought discharge
Blue = wetter in the future; less frequently below drought discharge

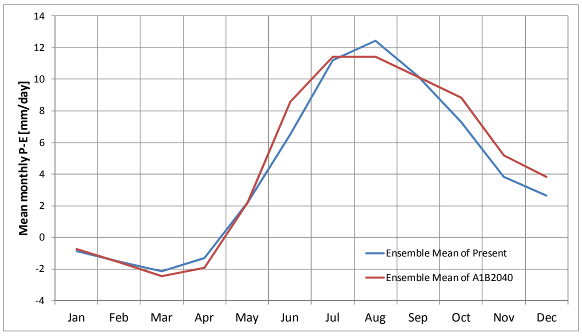
Source: JICA Study Team



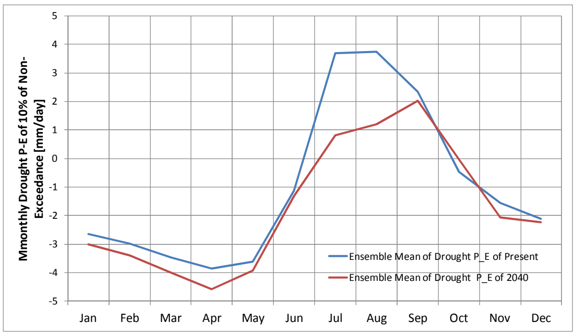
a) Monthly Mean Discharge



b) Monthly Drought Discharge



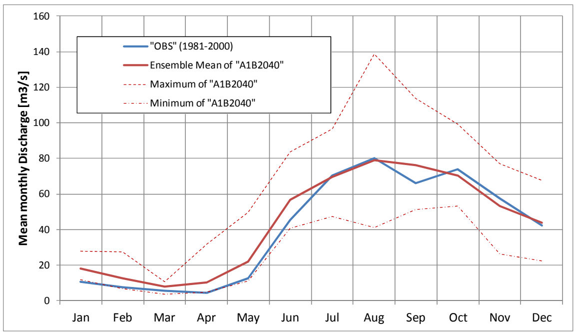
c) Monthly Mean P-E



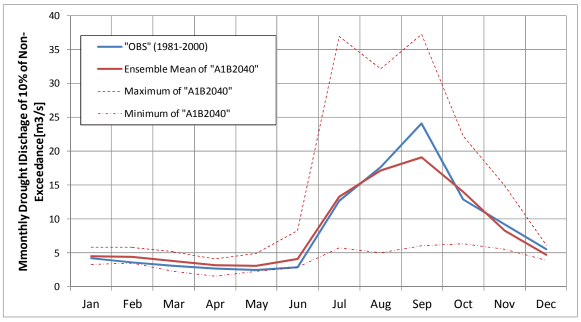
d) Monthly Drought P-E

Source: JICA Study Team

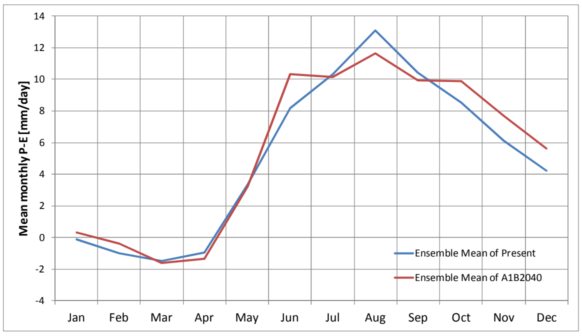
Figure 9.27 Changes in Monthly Mean Discharges and P-E in the Pasig-Marikina River Basin



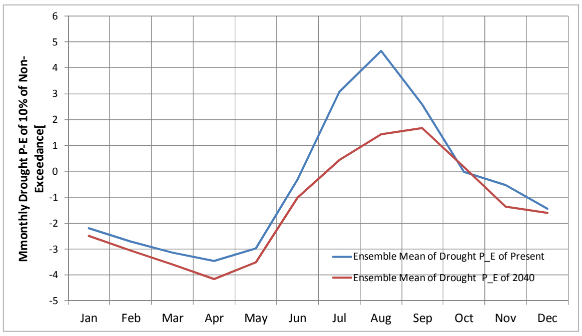
a) Monthly Mean Discharge



b) Monthly Drought Discharge



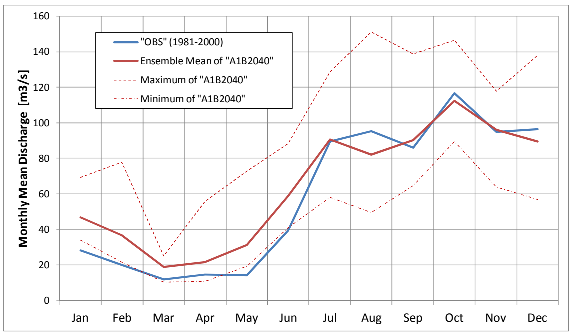
c) Monthly Mean P-E

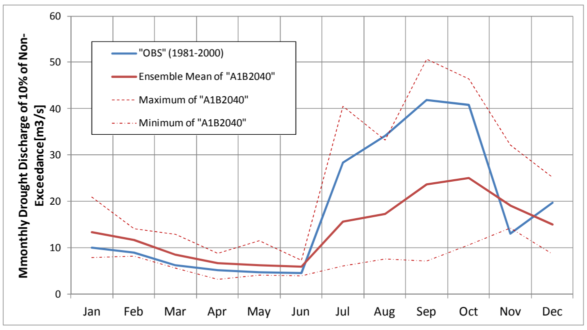


d) Monthly Drought P-E

Source: JICA Study Team

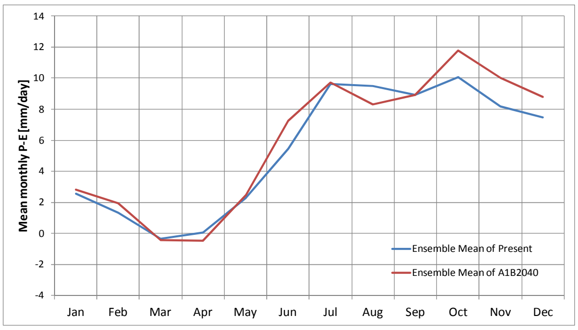
Figure 9.28 Changes in Monthly Mean Discharges and P-E in the Umiray River Basin

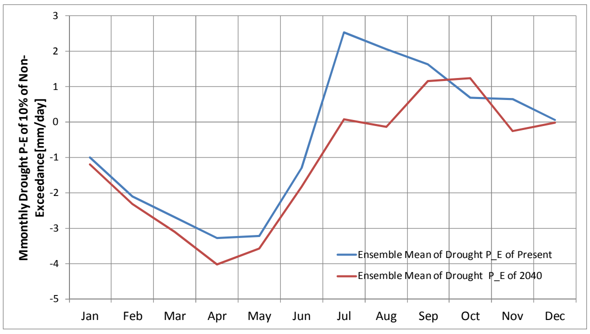




a) Monthly Mean Discharge

b) Monthly Drought Discharge



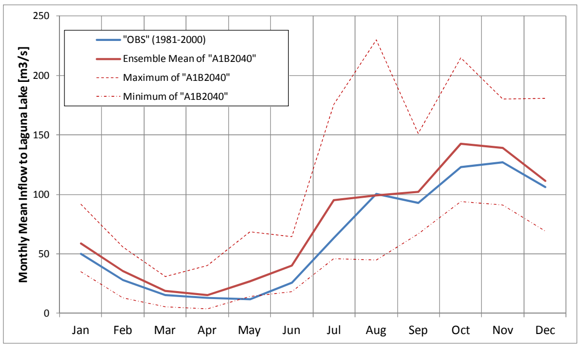


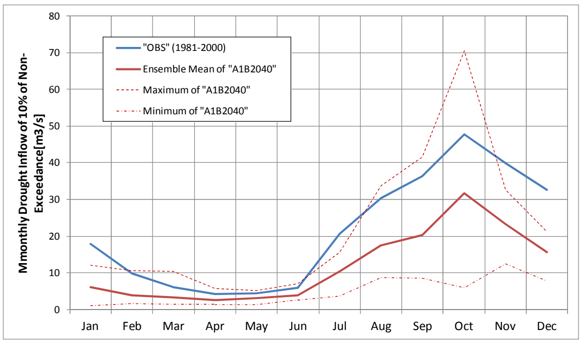
c) Monthly Mean P-E

d) Monthly Drought P-E

Source: JICA Study Team

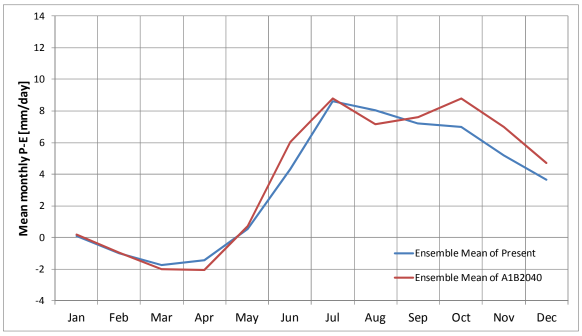
Figure 9.29 Changes in Monthly Mean Discharges and P-E in the Agos River Basin

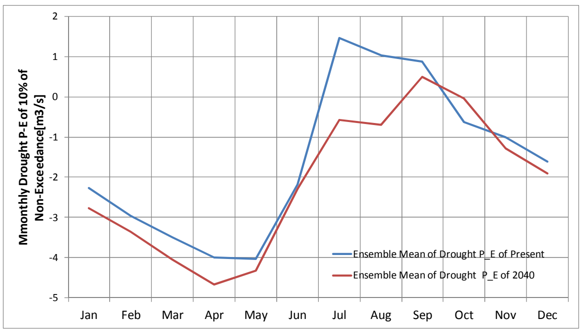




a) Monthly Mean Discharge

b) Monthly Drought Discharge





c) Monthly Mean P-E

d) Monthly Drought P-E

Source: JICA Study Team

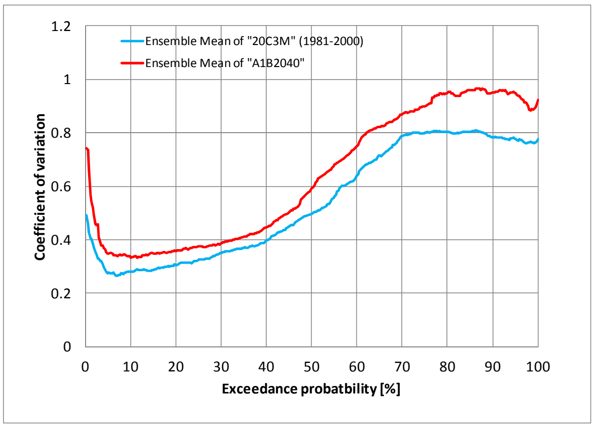
Figure 9.30 Changes in Monthly Mean Discharges and P-E in the Laguna Lake Basin

(3) Increasing Variability by Years

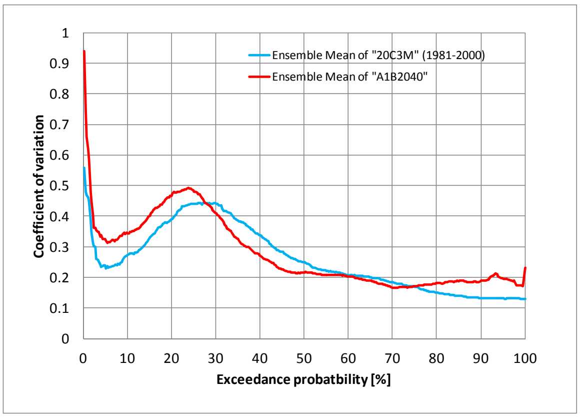
The CV shown in Figure 9.31 can be compared among the target basins, since the index is normalized by the average value. A larger value of CV means that the variance of river flow is wider by years.

The types of the chart shown in Figure 9.31 can be grouped into two due to similarities: the first type defines the inland area of the Southern Luzon Island, where the Pasig-Marikina River and Laguna Lake basins are located; and the second defines the land facing the Pacific Ocean and are experiencing heavier rainfall, where the Umiray and Agos River basins are located. The variability of Pasig-Marikina River and Laguna Lake will increase, and the management of these water resources will be more difficult. On the other hand, the variability by year of Umiray and Agos rivers will not change much towards the future. The strategy of integrated water resources management of multiple basins will be one of the hopeful methods in the future.

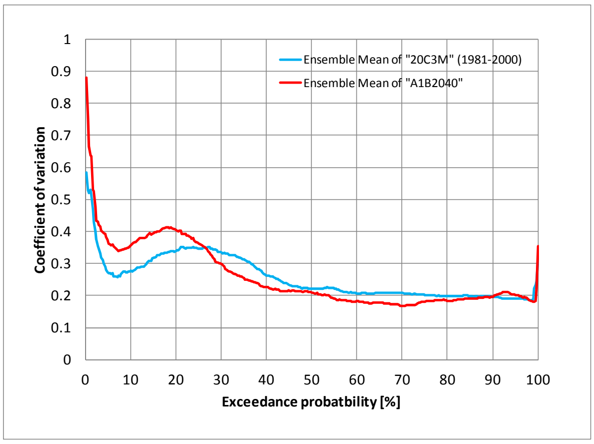
Pasig Marikina River Basin



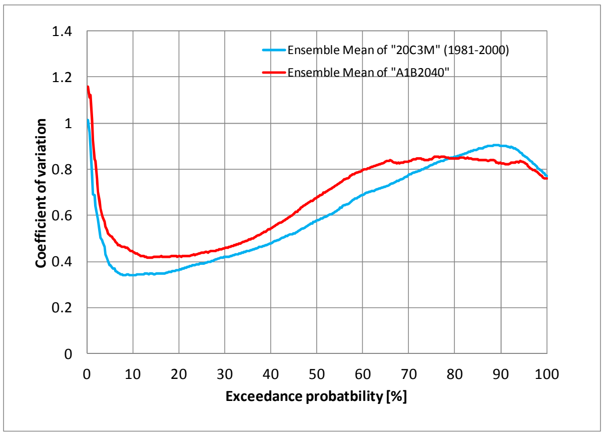
Umiray River Basin



Agos River Basin



Laguna River Basin



Note: The blue line represents the present (1981-2000) while the red line represents the years 2031-2050.

Source: JICA Study Team

Figure 9.31 Changes in Coefficient of Variation of the Annual Flow Duration Curve

CHAPTER 10 WATER DEMAND AND SUPPLY STUDY

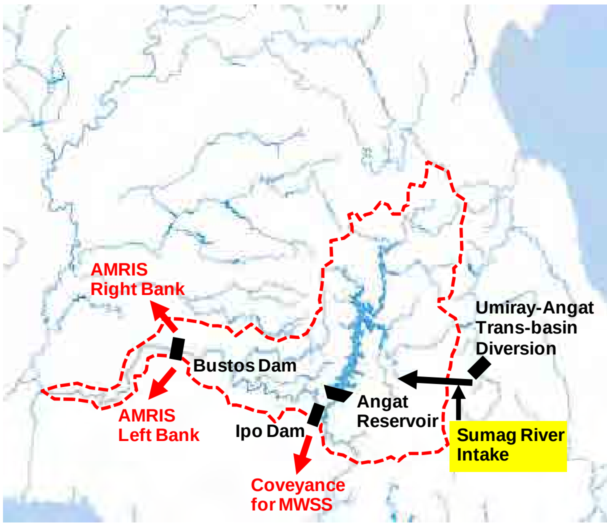
10.1 Angat River Basin

10.1.1 Water Resources

(1) Surface Water

The principal water resources in the Angat River basin are the Angat Reservoir and the Umiray-Angat transbasin diversion at present.

In the roadmap proposed by the Metro Manila Water Security Study, the Umiray-Angat transbasin diversion is to be augmented with the construction of the Sumag River intake as shown in Figure 10.1.1. The Sumag River intake aims at supplying an additional of 2.17 m^3/sec (= 188 MLD) for MWSS.



Source: Prepared by the JICA Study Team

Figure 10.1.1
Water Resources in the Angat River Basin

Table 10.1.1 shows the availability of the water resources in the Angat River basin for 'Existing' and 'With Project' conditions, respectively, resulting from the water balance calculations (Case 01 and Case 04) based on the hydrological data set for the period of 1968-2010 (43 years).

Table 10.1.1 Water Resources Availability in the Angat River Basin

Water Resources: 'Existing'	Basin Area (km^2)	Average Flow (m^3/s)	Dependable Flow (m^3/s) 80%	90%	95%
Angat Reservoir	546	70.4	51.2	50.8	32.0
Umiray-Angat transbasin diversion	(130)				
Sub-basins downstream from Angat Reservoir to Bustos Dam	846	15.1	0.7	0.4	0.2
Total		85.5	51.9	51.2	32.2

Water Resources, 'With Project'	Basin Area (km^2)	Average Flow (m^3/s)	Dependable Flow (m^3/s) 80%	90%	95%
Angat Reservoir	546	73.1	51.2	51.2	39.3
Umiray-Angat transbasin diversion with Sumag River Intake	(161)				
Sub-basins downstream from Angat Reservoir to Bustos Dam	846	15.1	0.7	0.4	0.2
Total		88.2	51.9	51.6	39.5

Source: Prepared by the JICA Study Team

(2) Groundwater

An exploitable groundwater yield in the Angat River basin is estimated at 4812 l/s (416 MLD) as described in Sub-section 7.2.3 of this report.

10.1.2 Water Demands

(1) Surface Water

The water demands to be served with the surface water resources in the Angat River basin are shown in Table 10.1.2 and Figure 10.1.2.

Table 10.1.2 Water Demands to be served with the Surface Water Resources of Angat River Basin

Water Demand	Present (2012)		Future (2040)	
	m^3/s	MLD	m^3/s	MLD
Municipal and Industrial Water (Metro Manila)	46.3	4,000	46.3	4,000
Municipal and Industrial Water (Local)	3.3	285	8.8	760
Agriculture (AMRIS)	19.0	1,642	19.6	1,693
Agriculture (Local)	0.3	24	0.6	52
Total	68.9	5,951	75.3	6,505

Source: Prepared by the JICA Study Team

The water rights of 4000 MLD (46.3 m^3/s) granted to MWSS is regarded substantially as the municipal and industrial water demands in Metro Manila at present (year 2012). The water demand in Metro Manila is projected to increase over 4000 MLD in the future. But it should be noted that an issue on the water allocation from Angat Reservoir to MWSS and NIA still remains unresolved. Therefore, the water demand and supply balance discussed in this chapter considers that the water allocation from the Angat Reservoir to MWSS would not exceed 4000 MLD towards the future (year 2040).

The present and future water demands by month are shown in Figure 10.1.2. As described in Sub-section 5.5.7, the municipal and industrial water demands to be served with the surface water resources in the Angat River basin is estimated at 3.3 m^3/s (285 MLD) at present and will be 8.8 m^3/s (760 MLD) in the future.

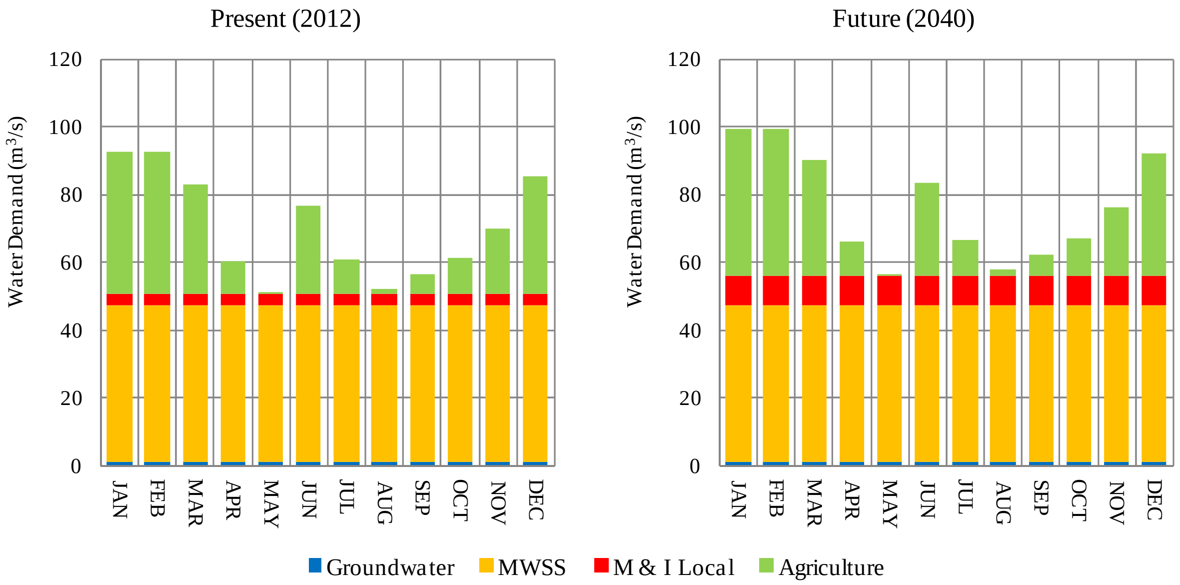
The annual average of the water diversion requirement for the Angat-Maasim River Irrigation System (AMRIS) is 19.0 m^3/s at present (year 2012) and 19.6 m^3/s in the future (year 2040). The monthly water diversion requirement ranges from 0.2 to 42.1 m^3/s at present and will be from 0.3 to 43.4 m^3/s in the future. The total water demand for the remaining local agriculture consisting of CIS, SSI, fishery, and livestock is 0.3 m^3/s at present and will be 0.6 m^3/s in the future.

Compared with the water resources availability in the Angat River basin as shown in Table 10.1.1, the present total water demand is 68.9 m^3/s and is approaching the average outflow of 70.4 m^3/s in the Angat Reservoir under the 'Existing' condition. The future total water demand is 75.3 m^3/s and is projected to exceed the average outflow of 73.1 m^3/s from the Angat Reservoir which is under the 'With Project' condition.

The sum of the municipal and industrial water demands is 49.6 m^3/s (46.3 + 3.3) at present and projected to be 55.1 m^3/s (46.3 + 8.8) in the future. It is generally recognized that the municipal and industrial water supply needs to be ensured with a reliability of higher than 95%. However, 95% dependable outflow from the Angat Reservoir is 32.0 m^3/s (2765 MLD) under the 'Existing' condition and 39.5 m^3/s (3413 MLD) under the 'With Project' condition. It is anticipated that the total water demand would already exceed the dependable water supply capacity of the Angat Reservoir.

(2) Groundwater

The present groundwater exploitation in the Angat River basin is estimated at 1052 l/s (91 MLD) as described in Sub-section 7.2.2 of this report. In the water balance calculations discussed in this chapter, it is assumed that the present groundwater exploitation would be fully utilized for the municipal and industrial water supplies and maintained towards the future.



Source: Prepared by the JICA Study Team

Figure 10.1.2 Water Demands to be served with the Water Resources in the Angat River Basin

10.1.3 Main Issues

At present, the Angat Reservoir with the Umiray-Angat transbasin diversion represents 95.5% of the water resources available for MWSS. The granted water rights for MWSS in the Angat Reservoir is 46.3 m^3/s (4000 MLD) that includes 15.0 m^3/s (1296 MLD) of the conditional allocation. This conditional allocation of 15 m^3/s is defined originally as a possible water allocation to MWSS utilizing irrigation water not used by AMRIS. Under the actual water allocation, however, the conditional allocation is granted substantially for the regular use by MWSS to maintain the stable water supply in Metro Manila. Such conditional allocation would be a major cause of water shortage at AMRIS in case of drought.

To seek a solution to the problem arising from the conditional allocation, different project proposals have been presented to date. These are broadly classified into the following two categories. The Metro Manila Water Security Study carried out by the World Bank reviewed these project proposals in the process of preparing the roadmap of water resources development for the future water supply of Metro Manila.

1) New water resources are to be developed in the neighboring areas (e.g., Angat River basin or Pampanga River basin) for supplementary water allocation to AMRIS.

According to the final report of the Metro Manila Water Security Study (World Bank, July 2011), the Balintingon Reservoir was studied as one of the promising project proposals. The Balintingon Reservoir was planned originally to expand the Upper Pampanga River Integrated Irrigation System (UPRIIS) and was also expected as a water resource for supplementary water allocation for AMRIS.

However, the final report of the Metro Manila Water Security Study describes that the discussions among MWSS, NIA, and other stakeholders have made a conclusion that the Balintingon Reservoir will be developed exclusively for the benefit of the locals of the province of Nueva Ecjia and then the solution to the conditional allocation of 15 m^3/s will not be materialized by the Balintingon Reservoir.

2) New water resources are to be developed in other river basins (e.g., Agos River basin) to cope with the present and future water demands of MWSS.

As a conclusion of the Metro Manila Water Security Study, the roadmap of water resources development was prepared to cope with the growth of water demand in Metro Manila. The roadmap consists of the following projects expected to be implemented to meet the water demand by the year 2037 as shown in Table 10.1.3 below.

Table 10.1.3 Projects Listed in the Roadmap by the World Bank Study

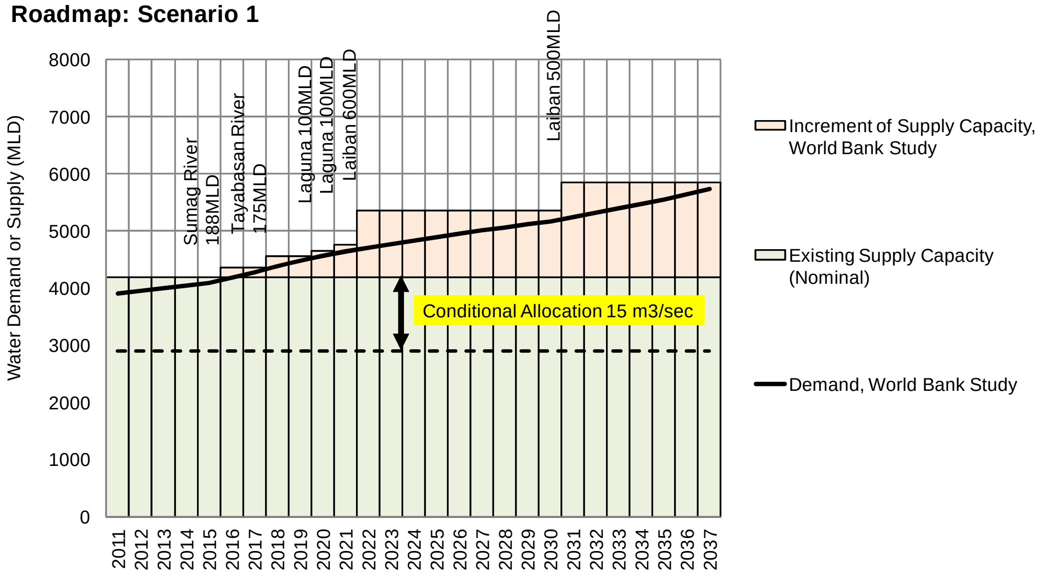
Project	Capacity (MLD)	Year of Commissioning
Sumag River	188	2016
Tayabasan River	175	2017
Laguna Lake	100	2020
Laguna Lake	100	2021
Laiban Reservoir (or Agos Reservoir)	600	2022
Laiban Reservoir (or Agos Reservoir)	500	2031

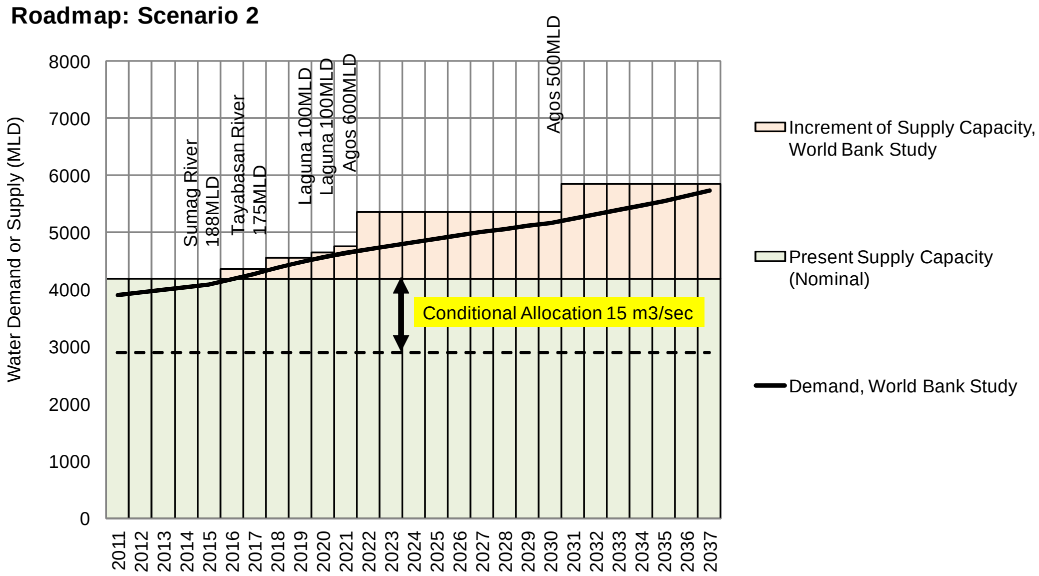
Source: Metro Manila Water Security Study, Final Report (World Bank, 2012)

The Metro Manila Water Security Study presented two roadmap scenarios. Both scenarios comprise the projects to be implemented by year 2021; Sumag River (188 MLD), Tayabasan River (175 MLD), and Laguna Lake (200 MLD). The first scenario envisages the development of the Laiban Reservoir with a total capacity of 1100 MLD while the second scenario considers developing the Agos Reservoir as an alternative.

For the purpose of preparing the roadmap, the Metro Manila Water Security Study defined the existing water resources available for MWSS as 4190 MLD comprising 4000 MLD of the Angat Reservoir with the Umiray-Angat transbasin diversion and 190 MLD of other reservoirs. The roadmap indicates that the water resources development will be implemented to increase the 4190 MLD in the future as shown in Figure 10.1.3.

It should be noted that the existing 4000 MLD (46.3 m^3/s) of the Angat Reservoir with the Umiray-Angat transbasin diversion includes the conditional allocation of 15 m^3/s as mentioned in the preceding subsection. After finalization of the Metro Manila Water Security Study, the need for a solution on the conditional allocation still remains as a main issue on the water resources management for the Angat River basin accordingly.





Source: Metro Manila Water Security Study, Final Report (World Bank, 2012)

Figure 10.1.3 Roadmap by the World Bank Study (Scenarios 1 and 2)

10.1.4 Angat Reservoir

Elevation-storage curve of the Angat Reservoir as shown in Table 10.1.4 is given in the final report of the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin (JICA/NWRB, 2011). The same is used for the water balance calculations discussed in this Study.

The effective storage of the Angat Reservoir is 737 MCM between full supply level (FSL) of EL 212 m and minimum operation level (MOL) of EL 160 m for the period of November to April. FSL is kept lower at EL 210 m from May to November in order to have a flood control storage.

The irrigation water required for AMRIS can be released when the reservoir level is above EL 180 m.

As previously described in Sub-section 7.1.3 of this report, the actual reservoir operation is based on two rule curves (upper rule curve and lower rule curve).

On the other hand, the water balance calculations discussed hereunder test different cases of water allocation for municipal and industrial (M & I) water supply and agriculture.

As the present reservoir operation rule is established with the present water allocation, it would not be appropriate that water allocation options are changed from the present water allocation.

For the purpose of the water balance calculations, it is assumed that the Angat Reservoir would be operated between FSL of EL 212 m (or EL 210 m) and MOL of EL 160 m in conformity with each of the water allocation options to be tested.

Table 10.1.4
Elevation-Storage Curve of Angat Reservoir

Elevation (EL m)	Gross Storage (MCM)	Effective Storage (MCM)	Area (km^2)
140	100.0		4.0
150	110.0		6.5
160	180.0	0.0	8.3
170	273.0	93.0	10.1
180	386.0	206.0	12.2
184	437.0	257.0	13.5
188	492.3	312.3	14.2
192	552.0	372.0	15.5
196	616.0	436.0	16.5
200	684.0	504.0	17.7
204	758.4	578.4	18.7
208	836.1	656.1	19.9
210	876.0	696.0	
212	818.0	638.0	21.3
214	861.0	681.0	21.9
216	1005.4	825.4	22.7
217	1030.0	850.0	

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

Hydropower plant discharge is assumed to be dependent on the reservoir outflows for MWSS and AMRIS, respectively. The reservoir outflow for AMRIS through the main tunnel could be used as hydropower plant discharge for the main unit (200 MW) while the reservoir outflow for MWSS could be used at the auxiliary unit (46 MW).

10.1.5 Minimum Stream Flow Requirement

According to the final report of the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin (JICA/NWRB, 2011), NWRB defined the minimum stream flow as 10% of the dependable flow (Resolution No.01-0901 on September 24, 2001). The dependable flow is regarded as a discharge rate at 80% of a flow duration curve in a quasi-natural flow condition.

In this Study, the same rates are applied in estimating the minimum stream flow requirement. Quasi-natural flows are estimated through the runoff simulation on the condition that the existing flow control effects of the reservoir and transbasin water diversion are excluded. The dependable stream flows in the Angat River basin are listed in Table 10.1.5 below.

Table 10.1.5 Minimum Stream Flow Requirement in the Angat River Basin

Location	Basin Area (km^2)	Minimum Stream Flow Requirement (m^3/s)
Angat Reservoir	546	1.75
Ipo Dam	618	1.85
Bustos Dam	846	1.95

Source: Prepared by the JICA Study Team

10.1.6 Drought Safety Level

The water balance calculations are carried out to seek an appropriate method for water allocation from the Angat Reservoir to the municipal and industrial water supply (MWSS and Local) and agriculture (AMRIS and Local). Such water allocation method needs to satisfy both of the following requirements:

1) Drought safety level of 1/10 should be ensured for municipal and industrial (M & I) water supply. Water allocation for M & I water supply should be adequate during a drought year that would probably occur once in ten years (1/10 drought year). During a 1/10 drought year, there should be no deficit in allocating water to M & I water supply.

2) Drought safety level of 1/5 should be ensured for agriculture. Water allocation for agriculture should be adequate during a drought year that would probably occur once in five years (1/5 drought year). During a 1/5 drought year, there should be no deficit in allocating water to agriculture.

10.1.7 Water Balance Calculations

(1) Calculation Cases

The water balance calculations in the Angat River basin are performed using the hydrological data set for the period of 1968-2010 (43 years).

The cases tested by water balance calculations are listed in Table 10.1.6 and outlined below.

1) Cases 01 and 04 are based on the present reservoir operation rule of the Angat Reservoir as described in Sub-section 10.1.4.

2) Cases 02 and 05 are based on the precondition to ensure a drought safety level of 1/10 for the projected water allocation for M & I water supply.

3) Cases 03 and 06 are based on the precondition to ensure a drought safety level of 1/5 for the projected water allocation for agriculture.

Table 10.1.6 Water Balance Calculation Cases–Angat River Basin

Case	Water Resources	Water Demand	Projected Water Allocation	
			M & I Water Supply	Agriculture
01	Existing	Present (2012)	MWSS 46.3 m³/s Local 3.3 m³/s Drought Safety Level: Not Specified	AMRIS 19.0 m³/s Local 0.3 m³/s Drought Safety Level: Not Specified
02A			MWSS 46.3 m³/s Local 3.3 m³/s Drought Safety Level: 1/10	AMRIS 19.0 m³/s Local 0.3 m³/s Drought Safety Level: Not Specified
02B			MWSS 46.3 m³/s Local 3.3 m³/s Drought Safety Level: 1/10	Water allocation dependability with drought safety level of 1/5
03A			MWSS 46.3 m³/s Local 3.3 m³/s Drought Safety Level: Not Specified	AMRIS 19.0 m³/s Local 0.3 m³/s Drought Safety Level: 1/5
03B			Water allocation dependability with drought safety level of 1/10	AMRIS 19.0 m³/s Local 0.3 m³/s Drought Safety Level: 1/5
04	With the Project	Future (2040)	MWSS 46.3 m³/s Local 8.8 m³/s Drought Safety Level: Not Specified	AMRIS 19.6 m³/s Local 0.6 m³/s Drought Safety Level: Not Specified
05A			MWSS 46.3 m³/s Local 8.8 m³/s Drought Safety Level: 1/10	AMRIS 19.6 m³/s Local 0.6 m³/s Drought Safety Level: Not Specified
05B			MWSS 46.3 m³/s Local 8.8 m³/s Drought Safety Level: 1/10	Water allocation dependability with drought safety level of 1/5
06A			MWSS 46.3 m³/s Local 8.8 m³/s Drought Safety Level: Not Specified	AMRIS 19.6 m³/s Local 0.6 m³/s Drought Safety Level: 1/5
06B			Water allocation dependability with drought safety level of 1/10	AMRIS 19.6 m³/s Local 0.6 m³/s Drought Safety Level: 1/5

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

(2) Results of Case 01 and Case 04

The water balance calculations of Case 01 and Case 04 are based on the present reservoir operation rule as described in subsection 10.1.4. The results are summarized in Table 10.1.7 and explained below.

Case 01 - Calculation Conditions:

- Water Resource: 'Existing' as described in Table 10.1.1
- Water Demand: 'Present (2012)' as described in Table 10.1.2
- Projected Water Allocation: drought safety level not specified

Case 04 - Calculation Conditions:

- Water Resource: 'With Project' as described in Table 10.1.1
- Water Demand: 'Future (2040)' as described in Table 10.1.2
- Projected Water Allocation: drought safety level not specified

Table 10.1.7 Results of Water Balance Calculations–Case 01 and Case 04

Case	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand (Drought Year)				
									1/2	1/5	1/10	1/20	1/43
01	Existing (2012)	Present (2012)	M & I Water Supply	MWSS 46.3	Local 3.3	Not Specified	91.3%	(471 / 516)	100.0%	94.0%	87.0%	80.8%	64.4%
			Agriculture	AMRIS 19.0	Local 0.3	Not Specified	77.5%	(400 / 516)	86.2%	56.5%	44.7%	42.5%	31.6%
04	With Project (2040)	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	87.2%	(450 / 516)	98.5%	92.2%	83.3%	78.3%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	72.7%	(375 / 516)	81.9%	43.4%	36.4%	33.1%	31.5%

Note: Cells shown with [ ] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

Results - Case 01:

The projected water allocation for M & I water supply is satisfied for 471 months out of 516 months (12 months×43 years) and dependability of supply is regarded as 91.3% (471/516). The ratio of annual supply to annual demand is 87.0% in a drought year that would probably occur once in ten years (1/10 drought year).

The projected water allocation for agriculture is satisfied for 400 months out of 516 months and dependability of supply is regarded as 77.5%. The ratio of annual supply to annual demand is 56.5% in a drought year that would probably occur once in five years (1/5 drought year).

Results - Case 04:

The projected water allocation for M & I water supply is satisfied for 450 months out of 516 months and dependability of supply is regarded as 87.2%. The ratio of annual supply to annual demand is 83.3% in a 1/10 drought year.

The projected water allocation for agriculture is satisfied for 375 months out of 516 months and then dependability of supply is regarded as 72.7%. The ratio of annual supply to annual demand is 43.4% in a 1/5 drought year.

(3) Results of Case 02 and Case 05

Water balance calculations of Case 02 and Case 05 are based on the precondition that ensures a drought safety level of 1/10 for the projected water allocation for M & I water supply. The results are summarized in Table 10.1.8 and Table 10.1.9 and explained below.

Case 02A and Case 02B - Calculation Conditions:

- Water Resource: 'Existing' as described in Table 10.1.1
- Water Demand: 'Present (2012)' as described in Table 10.1.2
- Projected Water Allocation: Water allocation for M & I water supply is prioritized to ensure a drought safety level of 1/10.

Table 10.1.8 Results of Water Balance Calculations–Case 02

Case	Water Resource	Water Demand	Projected Water Allocation: Supply (m^3/sec)			Projected Water Allocation: Drought Safety Level	Results of Water Balance Analysis: Dependability of Supply		Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20	1/43
02A	Existing (2012)	Present (2012)	M & I Water Supply	MWSS 46.3	Local 3.3	1/10	97.9%	(505 / 516)	100.0%	100.0%	100.0%	99.3%	66.6%
			Agriculture	AMRIS 19.0	Local 0.3	Not Specified	50.8%	(262 / 516)	51.9%	44.2%	38.1%	31.8%	30.5%
02B	Existing (2012)	Present (2012)	M & I Water Supply	MWSS 46.3	Local 3.3	1/10	97.9%	(505 / 516)	100.0%	100.0%	100.0%	99.3%	66.6%
			Agriculture	AMRIS 5.2	Local 0.1	1/5	97.3%	(502 / 516)	100.0%	100.0%	90.8%	79.5%	34.4%

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).

Source: Prepared by the JICA Study Team

Results:

Case 02A ensures a drought safety level of 1/10 for the projected water allocation for M & I water supply. The projected water allocation is satisfied for 505 months out of 516 months and dependability of supply is regarded as 97.9%. The ratio of annual supply to annual demand is 100% in a 1/10 drought year.

Case 02A does not specify any drought safety level for the projected water allocation for agriculture. The projected water allocation is satisfied for 262 months out of 516 months and dependability of supply is regarded as 50.8%. The ratio of annual supply to annual demand is 44.2% in a 1/5 drought year.

Case 02B calculates the dependable water allocation for agriculture with a drought safety level of 1/5. The calculated annual mean water allocation is 5.3 m^3/s (5.2 + 0.1), which is greatly lower than a demand of 19.3 m^3/s (19.0 + 0.3).

Case 05A and Case 05B - Calculation Conditions:

- Water Resource: 'With Project' as described in Table 10.1.1
- Water Demand: 'Future (2040)' as described in Table 10.1.2
- Projected Water Allocation: Water allocation for M & I water supply is prioritized to ensure a drought safety level of 1/10.

Table 10.1.9 Results of Water Balance Calculations–Case 05

Case	Water Resource	Water Demand	Projected Water Allocation: Supply (m^3/s)			Projected Water Allocation: Drought Safety Level	Results of Water Balance Analysis: Dependability of Supply		Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20	1/43
05A	With Project (2040)	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	1/10	97.9%	(505 / 516)	100.0%	100.0%	100.0%	98.5%	64.4%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	48.8%	(252 / 516)	39.7%	31.4%	23.0%	21.8%	18.2%
05B	With Project (2040)	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	1/10	97.9%	(505 / 516)	100.0%	100.0%	100.0%	98.5%	64.4%
			Agriculture	AMRIS 2.2	Local 0.1	1/5	97.1%	(501 / 516)	100.0%	100.0%	89.6%	83.6%	39.8%

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).

Source: Prepared by the JICA Study Team

Results:

Case 05A ensures a drought safety level of 1/10 for the projected water allocation for M & I water supply. The projected water allocation is satisfied for 505 months out of 516 months and dependability of supply is regarded as 97.9%. The ratio of annual supply to annual demand is 100% in a 1/10 drought year.

Case 05A does not specify any drought safety level for the projected water allocation for agriculture. The projected water allocation is satisfied for 252 months out of 516 months and dependability of supply is regarded as 48.8%. The ratio of annual supply to annual demand is 31.4% in a 1/5 drought year.

Case 05B calculates the dependable water allocation for agriculture with a drought safety level of 1/5. The calculated annual mean water allocation is 2.3 m^3/s (2.2 + 0.1), which is far lower than a demand of 20.2 m^3/s (19.6 + 0.6).

(4) Results of Case 03 and Case 06

Water balance calculations of Case 03 and Case 06 are based on the precondition that ensures a drought safety level of 1/5 for the projected water allocation for agriculture. The results are summarized in Table 10.1.10 and Table 10.1.11 and explained below.

Case 3A and Case 3B - Calculation Conditions:

- Water Resource: 'Existing' as described in Table 10.1.1
- Water Demand: 'Present (2012)' as described in Table 10.1.2
- Projected Water Allocation: Water allocation for Agriculture is prioritized to ensure a drought safety level of 1/5. Within the water demand for M & I water supply, the demand in the Angat River basin (Local) is prioritized.

Table 10.1.10 Results of Water Balance Calculations–Case 03

Case	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand				
									Drought Year				
									1/2	1/5	1/10	1/20	1/43
03A	Existing (2012)	Present (2012)	M & I Water Supply	MWSS 46.3	Local 3.3	Not Specified	28.5%	(147 / 516)	82.3%	78.5%	76.6%	73.5%	64.7%
			Agriculture	AMRIS 19.0	Local 0.3	1/5	97.1%	(501 / 516)	100.0%	100.0%	89.5%	85.1%	31.7%
03B	Existing (2012)	Present (2012)	M & I Water Supply	MWSS 31.3	Local 3.3	1/10	98.4%	(508 / 516)	100.0%	100.0%	100.0%	99.1%	82.6%
			Agriculture	AMRIS 19.0	Local 0.3	1/5	97.1%	(501 / 516)	100.0%	100.0%	89.5%	85.4%	31.7%

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

Results:

Case 03A does not specify any drought safety level for the projected water allocation for M & I water supply. The projected water allocation is satisfied for 147 months out of 516 months and dependability of supply is regarded as 28.3%. The ratio of annual supply to annual demand is 76.6% in a 1/10 drought year.

Case 03A ensures a drought safety level of 1/5 for the projected water allocation for agriculture. The projected water allocation is satisfied for 501 months out of 516 months and dependability of supply is regarded as 97.1%. The ratio of annual supply to annual demand is 100% in a 1/5 drought year.

Case 03B calculates the dependable water allocation for M & I water supply with a drought safety level of 1/10. The calculated water allocation is 34.6 m^3/s (31.3 + 3.3), which is subject to a reduction from a demand of 49.6 m^3/s (46.3 + 3.3).

Case 06A and Case 06B - Calculation Conditions:

- Water Resource: 'With Project' as described in Table 10.1.1
- Water Demand: 'Future (2040)' as described in Table 10.1.2
- Projected Water Allocation: Water allocation for agriculture is prioritized to ensure a drought safety level of 1/5. Within the water demand of M & I water supply, the demand in the Angat River basin (Local) is prioritized.

Table 10.1.11 Results of Water Balance Calculations–Case 06

Case	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand				
									Drought Year				
									1/2	1/5	1/10	1/20	1/43
06A	With Project (2040)	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	24.4%	(126 / 516)	78.6%	73.7%	71.2%	68.2%	63.1%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	96.7%	(499 / 516)	100.0%	100.0%	89.3%	84.9%	31.6%
06B	With Project (2040)	Future (2040)	M & I Water Supply	MWSS 27.1	Local 8.8	1/10	98.4%	(508 / 516)	100.0%	100.0%	100.0%	98.8%	85.2%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	97.3%	(502 / 516)	100.0%	100.0%	89.2%	85.2%	31.6%

Note: Cells shown with [box] denote the priority water allocation (preconditioned).

Source: Prepared the by JICA Study Team

Results:

Case 06A does not specify any drought safety level for the projected water allocation for M & I water supply. The projected water allocation is satisfied for 126 months out of 516 months and dependability of supply is regarded as 24.4%. The ratio of annual supply to annual demand is 71.2% in a 1/10 drought year.

Case 06A ensures a drought safety level of 1/5 for the projected water allocation for agriculture. The projected water allocation is satisfied for 499 months out of 516 months and dependability of supply is regarded as 96.7%. The ratio of annual supply to annual demand is 100% in a 1/5 drought year.

Case 06B calculates the dependable water allocation for M & I water supply with a drought safety level of 1/10. The calculated water allocation is 35.9 m^3/s (27.1 + 8.8), which is subject to a reduction from a demand of 55.1 m^3/s (46.3 + 8.8).

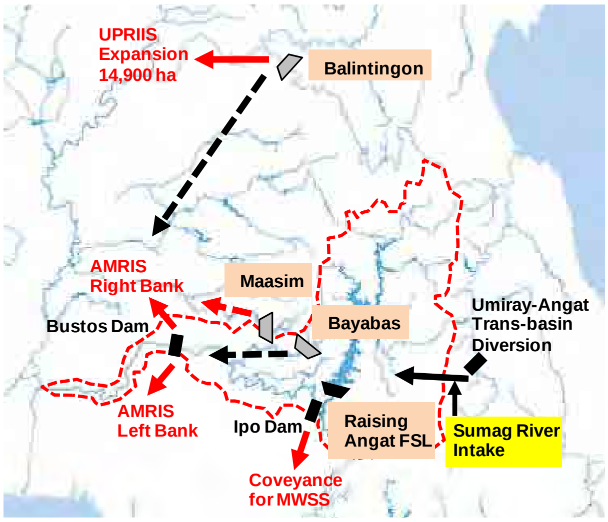
10.1 8 Water Resources Development Options in Neighboring Areas

The historical records of outflow from the Angat Reservoir suggest that the water shortage for AMRIS would become prominent along with the increase of water allocation from the Angat Reservoir to MWSS as described in Sub-section 7.1.3 of this report.

MWSS, NIA, and the concessionaires (MWCI and MWSI) are seeking solutions for the problems on water allocation from the Angat Reservoir.

Among the different project proposals, the Metro Manila Water Security Study elaborated by the World Bank evaluated the projects shown in Figure 10.1.4 to substitute for 15 m^3/s of the conditional water allocation for MWSS.

However, it should be noted that none of these are listed in the conclusion of the roadmap proposed by the Metro Manila Water Security Study.



Source: Prepared by JICA Study Team

Figure 10.1.4
Water Resources Development Options in Neighboring Areas

1) Water resources development in neighboring areas for supplementary water allocation to AMRIS (Table 10.1.12)

The Bayabas Reservoir and/or Maasim Reservoir are single purpose projects that will supply water to AMRIS when the irrigation water outflow from the Angat Reservoir to Bustos Dam falls insufficient. The main purpose of the Balintingon Reservoir is to supply water to 14,900 ha of the new irrigation development of UPRIIS. In the water balance calculations described in this subsection, it is assumed that the supplementary water allocation from the Balintingon Reservoir to AMRIS could be provided by using the excess water after the irrigation water requirement for 14,900 ha is assured.

Table 10.1.12 Water Resources Development in Neighboring Areas for Supplementary Water Allocation to AMRIS

Project	River Basin	Catchment Area (km^2)	Average Flow (m^3/s)	Effective Storage (MCM)
Bayabas Reservoir	Angat	52	3.0	144
Maasim Reservoir	Pampanga	53	2.4	95
Balintingon Reservoir	Pampanga	224	17.6	488

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

2) Raising FSL of Angat Reservoir

An increase on the effective storage of Angat Reservoir is being planned as part of the Angat Dam Rehabilitation Project to ensure the stability of the dam body. MWSS envisages raising FSL of the Angat Reservoir from EL 212/210 m to EL 217/215 m. The increase on the effective storage will be 110 MCM.

10.1.9 Water Balance Calculations for Water Resources Development Options in Neighboring Areas

(1) Calculation Cases

The cases tested by the water balance calculations are listed in Table 10.1.13 below.

1) Cases 07, 10, 13, and 16 are based on the present reservoir operation rule of the Angat Reservoir as described in Sub-section 10.1.4.

2) Cases 08, 11, 14, and 17 are based on the precondition that ensures a drought safety level of 1/10 for the projected water allocation for M & I water supply.

3) Cases 09, 12, 15, and 18 are based on the precondition that ensures a drought safety level of 1/5 for the projected water allocation for agriculture. Within the water allocation for M & I water supply, the demand in the Angat River basin (Local) is prioritized.

Table 10.1.13 Water Balance Calculation Cases–Water Resources Development Options in Neighboring Areas

Bayabas Reservoir: Cases 07, 08, and 09 Balintingon Reservoir: Cases 13, 14, and 15
Maasim Reservoir: Cases 10, 11, and 12 Rasing Angat FSL: Cases 16, 17, and 18

Case	Water Resources	Water Demand	Projected Water Allocation	
			M & I Water Supply	Agriculture
07, 10, 13, 16	With Project + Option	Future (2040)	MWSS 46.3 m^3/s Local 8.8 m^3/s Drought Safety Level: Not Specified	AMRIS 19.6 m^3/s Local 0.6 m^3/s Drought Safety Level: Not Specified
08A, 11A, 14A, 17A			MWSS 46.3 m^3/s Local 8.8 m^3/s Drought Safety Level: 1/10	AMRIS 19.6 m^3/s Local 0.6 m^3/s Drought Safety Level: Not Specified
08B, 11B, 14B, 17B			MWSS 46.3 m^3/s Local 8.8 m^3/s Drought Safety Level: 1/10	Water allocation dependability with drought safety level of 1/5
09A, 12A, 15A, 18A			MWSS 46.3 m^3/s Local 8.8 m^3/s Drought Safety Level: Not Specified	AMRIS 19.6 m^3/s Local 0.6 m^3/s Drought Safety Level: 1/5
09B, 12B, 15B, 18B			Water allocation dependability with drought safety level of 1/10	AMRIS 19.6 m^3/s Local 0.6 m^3/s Drought Safety Level: 1/5

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

(2) Results

The results of the water balance calculations for the optional cases are shown in Table 10.1.14. Compared with the results of Cases 04, 05, and 06, each of the options indicate some improvements on the water allocation. But none of the options provide a complete solution on the present problem on the water allocation between M & I water supply and agriculture.

Table 10.1.14 Results of Water Balance Calculations–Water Resources Development Options in Neighboring Areas (1/2)

Bayabas Reservoir

Case	Water Resource	Water Demand	Projected Water Allocation: Supply (m^3/s)			Projected Water Allocation: Drought Safety Level	Results of Water Balance Analysis: Dependability of Supply		Ratio of Annual Supply to Annual Demand, Drought Year: 1/2	1/5	1/10	1/20	1/43
07	With Project + Bayabas	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	87.2%	(450 / 516)	98.5%	92.2%	83.3%	78.3%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	84.1%	(434 / 516)	100.0%	61.1%	47.9%	39.2%	31.4%
08A			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	97.9%	(505 / 516)	100.0%	100.0%	100.0%	99.0%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	60.9%	(314 / 516)	60.4%	38.0%	31.9%	25.7%	21.1%
08B			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	97.9%	(505 / 516)	100.0%	100.0%	100.0%	99.0%	64.1%
			Agriculture	AMRIS 7.0	Local 0.2	1/5	95.5%	(493 / 516)	100.0%	100.0%	78.2%	56.3%	48.1%
09A			M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	26.9%	(139 / 516)	84.3%	80.9%	79.3%	75.6%	70.2%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	95.7%	(494 / 516)	100.0%	100.0%	87.4%	81.1%	31.8%
09B			M & I Water Supply	MWSS 31.8	Local 8.8	1/10	98.6%	(509 / 516)	100.0%	100.0%	100.0%	96.1%	86.0%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	96.7%	(499 / 516)	100.0%	100.0%	91.2%	81.3%	32.0%

Maasim Reservoir

Case	Water Resource	Water Demand	Projected Water Allocation: Supply (m^3/s)			Projected Water Allocation: Drought Safety Level	Results of Water Balance Analysis: Dependability of Supply		Ratio of Annual Supply to Annual Demand, Drought Year: 1/2	1/5	1/10	1/20	1/43
10	With Project + Maasim	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	87.2%	(450 / 516)	98.5%	92.2%	83.3%	78.3%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	83.3%	(430 / 516)	100.0%	58.3%	47.1%	40.4%	32.1%
11A			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	99.6%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	57.9%	(299 / 516)	54.6%	37.9%	32.1%	24.0%	21.7%
11B			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	99.6%	64.1%
			Agriculture	AMRIS 5.4	Local 0.2	1/5	96.3%	(497 / 516)	100.0%	100.0%	77.6%	66.7%	59.9%
12A			M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	26.2%	(135 / 516)	83.7%	80.3%	78.7%	73.2%	68.1%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	95.9%	(495 / 516)	100.0%	100.0%	87.8%	83.2%	32.1%
12B			M & I Water Supply	MWSS 31.6	Local 8.8	1/10	98.6%	(509 / 516)	100.0%	100.0%	100.0%	96.2%	86.6%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	96.1%	(496 / 516)	100.0%	100.0%	86.0%	81.4%	32.2%

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).

Source: Prepared by the JICA Study Team

Table 10.1.15 Results of Water Balance Calculations–Water Resources Development Options in Neighboring Areas (2/2)

Balintingon Reservoir

No.	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand, Drought Year				
									1/2	1/5	1/10	1/20	1/43
13	With Project + Balintingon	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	87.2%	(450 / 516)	98.5%	92.2%	83.3%	78.3%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	94.6%	(488 / 516)	100.0%	90.2%	66.6%	51.6%	48.7%
14A			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	97.8%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	81.8%	(422 / 516)	92.1%	61.4%	46.6%	36.8%	31.9%
14B			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	99.2%	64.1%
			Agriculture	AMRIS 9.7	Local 0.3	1/5	96.3%	(497 / 516)	100.0%	100.0%	70.8%	58.3%	51.2%
15A			M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	29.8%	(154 / 516)	89.1%	86.8%	85.8%	82.7%	69.0%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	95.3%	(492 / 516)	100.0%	100.0%	83.0%	53.7%	46.3%
15B			M & I Water Supply	MWSS 35.4	Local 8.8	1/10	98.3%	(507 / 516)	100.0%	100.0%	100.0%	97.8%	79.0%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	95.7%	(494 / 516)	100.0%	100.0%	83.3%	54.3%	47.6%

Raising Angat FSL

Case	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand, Drought Year				
									1/2	1/5	1/10	1/20	1/43
16	With Project + Angat FSL Raising	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	89.0%	(459 / 516)	100.0%	92.2%	84.7%	79.4%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	76.4%	(394 / 516)	89.2%	50.7%	36.4%	33.1%	31.5%
17A			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	98.9%	66.7%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	49.0%	(253 / 516)	49.5%	38.8%	32.1%	30.0%	28.1%
17B			M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	98.9%	66.7%
			Agriculture	AMRIS 4.4	Local 0.1	1/5	96.7%	(499 / 516)	100.0%	100.0%	86.8%	73.8%	35.0%
18A			M & I Water Supply	MWSS 46.3	Local 8.8	Not Specified	25.2%	(130 / 516)	83.2%	79.6%	78.0%	76.6%	66.0%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	97.3%	(502 / 516)	100.0%	100.0%	85.3%	81.4%	31.6%
18B			M & I Water Supply	MWSS 29.8	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	97.4%	77.3%
			Agriculture	AMRIS 19.6	Local 0.6	1/5	97.5%	(503 / 516)	100.0%	100.0%	95.9%	92.6%	31.6%

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

(3) Maximized Water Resources Development in Neighboring Areas

This case considers that a supplemental water allocation for agriculture (AMRIS and Local) is performed with the combination of the 'With Project' condition (Angat Reservoir with Umiray-Angat transbasin diversion + Sumag River intake) and all of the options mentioned above; Bayabas Reservoir, Maasim Reservoir, Balintingon Reservoir, and raising FSL of Angat Reservoir.

The results of the water balance calculations are summarized in Table 10.1.16 below. With the maximized water resources development in neighboring areas, a drought safety level of 1/5 for agriculture is attained together with a drought safety level of 1/10 for M & I water supply. In this case, the sum of supplemental water allocation from the reservoirs of Bayabas, Maasim, and Balintingon to agriculture (AMIS and Local) is 8.5 m^3/s on average. The supplemental water allocation accounts for 44% of the total water allocation of 19.4 m^3/s as shown in Table 10.1.17.

Table 10.1.16 Results of Water Balance Calculations–Maximized Water Resources Development in Neighboring Areas

No.	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand – Drought Year				
									1/2	1/5	1/10	1/20	1/43
19	With Project + All of 4 Options	Future (2040)	M & I Water Supply	MWSS 46.3	Local 8.8	1/10	98.1%	(506 / 516)	100.0%	100.0%	100.0%	99.2%	64.1%
			Agriculture	AMRIS 19.6	Local 0.6	Not Specified	95.7%	(494 / 516)	100.0%	100.0%	75.2%	63.8%	54.1%

Note: Cells shown with [box] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

Table 10.1.17 Average Water Allocation by Source (Case 19, 1968-2010)

Unit: m^3/s

	Angat	Bayabas	Maasim	Balintingon	Total
M & I Water Supply	54.6				54.6
Agriculture	10.9	3.1	2.0	3.4	19.4
Total	65.5	3.1	2.0	3.4	74.0

Source: Prepared by the JICA Study Team

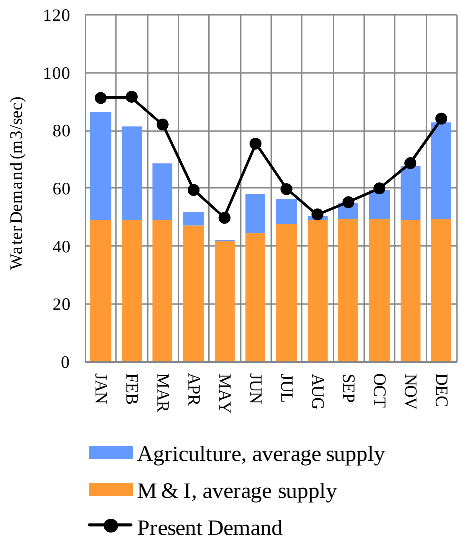
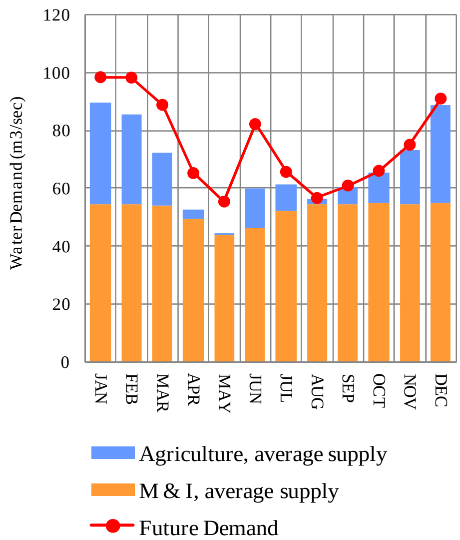
10.1.10 Summary and Conclusion of Water Balance Calculations–Angat River Basin

(1) Case 01 and Case 04 (Table 10.1.18)

It is anticipated that the water shortage on both M & I water supply (MWSS and Local) and agriculture (AMRIS and Local) would be more frequent and critical under the present manner of water allocation and reservoir operation.

The results of the water balance calculations suggested the need to change the present manner of water allocation in order to find out an appropriate water allocation for M & I water supply and agriculture.

Table 10.1.18 Summary of Water Balance Calculations–Case 01 and Case 04

Case 01:	Case 04:
● Water Resources: Existing ● Water Demand: Present (2012) ● Preconditioned Water Allocation: None The water allocation for M & I water supply (MWSS and Local) falls to 87.0% of the present demand (2012) in a 1/10 drought year. The water allocation for agriculture drops to 56.5% of the present demand (2012) in a 1/5 drought year	● Water Resources: With Project ● Water Demand: Future (2040) ● Preconditioned Water Allocation: None The water allocation for M & I water supply (MWSS and Local) falls to 83.3% of the future demand (2040) in a 1/10 drought year. The water allocation for agriculture drops to 43.4% of the future demand (2040) in a 1/5 drought year
	

Source: Prepared by the JICA Study Team

(2) Case 02 and Case 05 (Table 10.1.19)

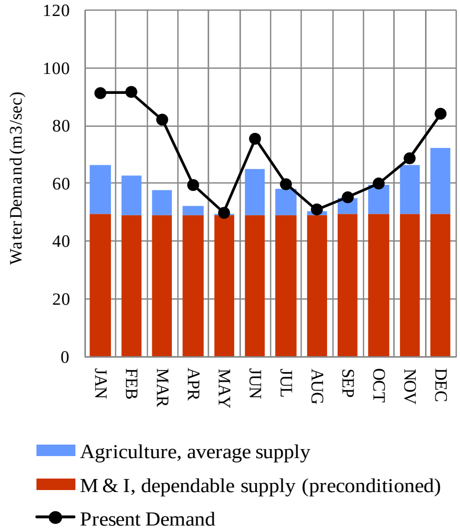
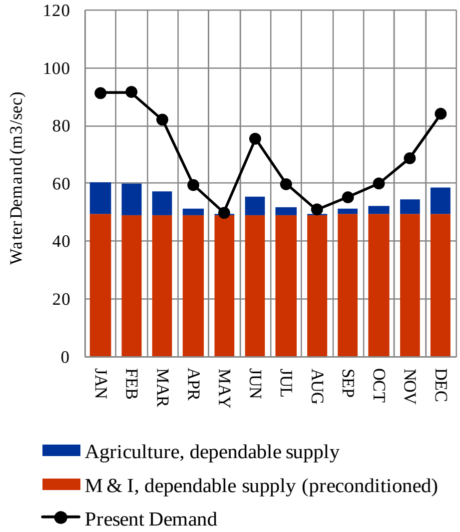
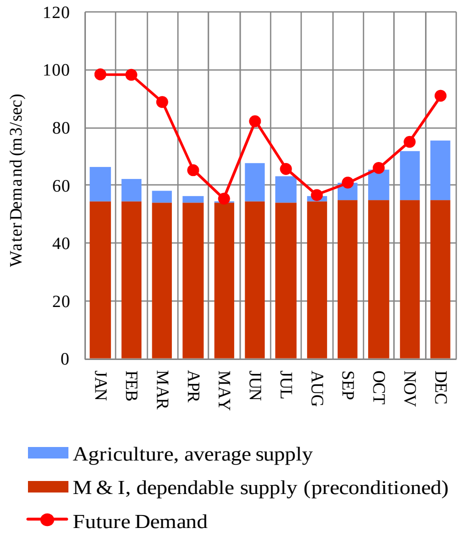
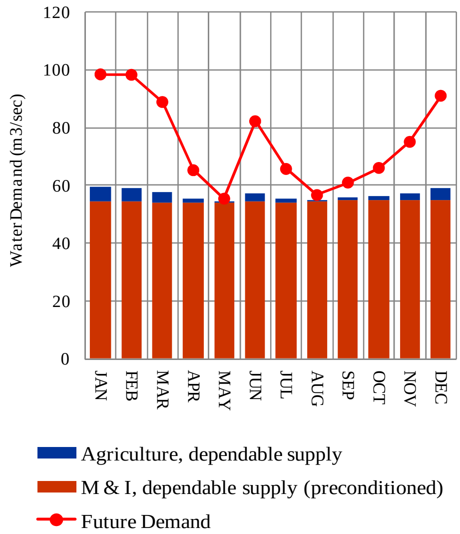
If the precondition with 49.6 m^3/s (MWSS 46.3 + Local 3.3) at present and 55.1 m^3/s (46.3 + 8.8) in the future as dependable supply with a drought safety level of 1/10 is given to ensure the demand for M & I water supply, the water allocation for agriculture becomes highly critical.

The calculations of the dependable water allocation for agriculture result in 5.3 m^3/s (AMRIS 5.2 + 0.1) at present and 2.3 m^3/s (2.2 + 0.1) in the future, which are far lower than the water demands.

(3) Case 03 and Case 06 (Table 10.1.20)

If the precondition with an average of 19.3 m^3/s (AMRIS 19.0 + Local 0.3) at present and an average of 20.2 m^3/s (19.6 + 0.6) as dependable supply with a drought safety level of 1/5 is given to ensure the demand for agriculture water supply, the water allocation for M & I water supply is subject to reduction. Assuming that the demand in the Angat River basin (Local) would be prioritized, the calculations of the dependable water allocation will result in 34.6 m^3/s (MWSS 31.3 + Local 3.3) at present and 35.9 m^3/s (27.1 + 8.8) in the future.

Table 10.1.19 Summary of Water Balance Calculations–Case 02 and Case 05

Case 02A: ● Water Resources: Existing ● Water Demand: Present (2012) ● Preconditioned Water Allocation: Drought Safety Level of 1/10 for M & I water supply The water allocation for agriculture drops to 44.2% of the present demand (2012) in a 1/5 drought year.	Case 02B: ● Water Resources: Existing ● Water Demand: Present (2012) ● Preconditioned Water Allocation: Drought Safety Level of 1/10 for M & I water supply The average of dependable water allocation for agriculture with a drought safety level of 1/5 is 5.3 m^3/s (AMRIS 5.2 + Local 0.1).
	
Case 05A: ● Water Resources: With Project ● Water Demand: Future (2040) ● Preconditioned Water Allocation: Drought Safety Level of 1/10 for M & I water supply The water allocation for agriculture drops to 31.4% of the future demand (2040) in a 1/5 drought year.	Case 05B ● Water Resources: Existing ● Water Demand: Future (2040) ● Preconditioned Water Allocation: Drought Safety Level of 1/10 for M & I water supply The average of dependable water allocation for agriculture with a drought safety level of 1/5 is 2.3 m^3/s (AMRIS 2.2 + Local 0.1).
	

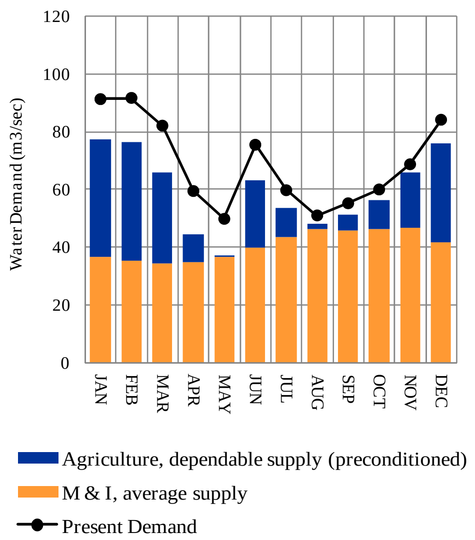
Source: Prepared by the JICA Study Team

Table 10.1.20 Summary of Water Balance Calculations–Case 03 and Case 06

Case 03A:

- Water Resources: Existing
- Water Demand: Present (2012)
- Preconditioned Water Allocation: Drought Safety Level of 1/5 for agriculture

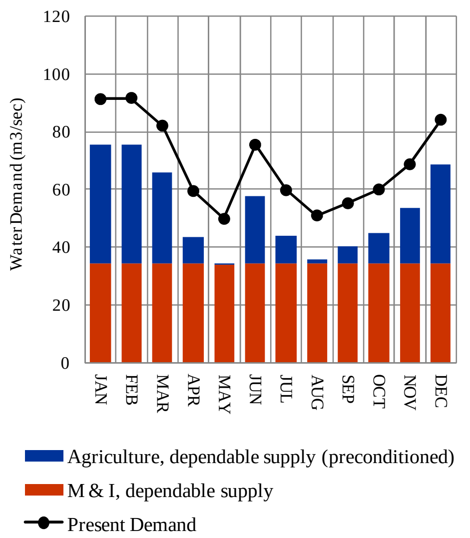
The water allocation for M &I water supply drops to 76.6% of the present demand (2012) under the ‘Existing’ condition in a 1/10 drought year



Case 03B:

- Water Resources: Existing
- Water Demand: Present (2012)
- Preconditioned Water Allocation: Drought Safety Level of 1/5 for agriculture

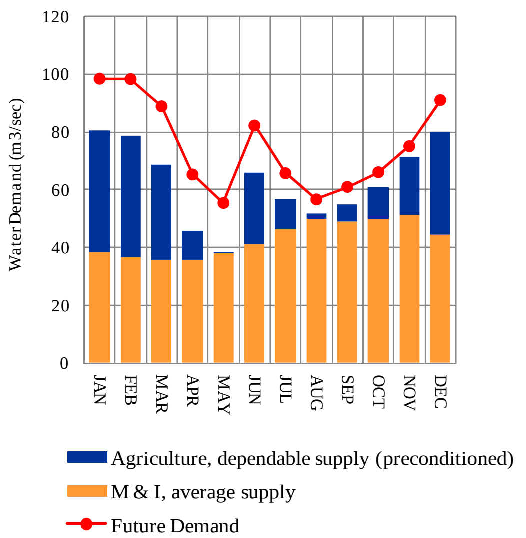
The dependable water allocation for M & I water supply with a drought safety level of 1/10 is 34.6 m^3/s (MWSS 31.3 + Local 3.3).



Case 06A:

- Water Resources: With Project
- Water Demand: Future (2040)
- Preconditioned Water Allocation: Drought Safety Level of 1/5 for agriculture

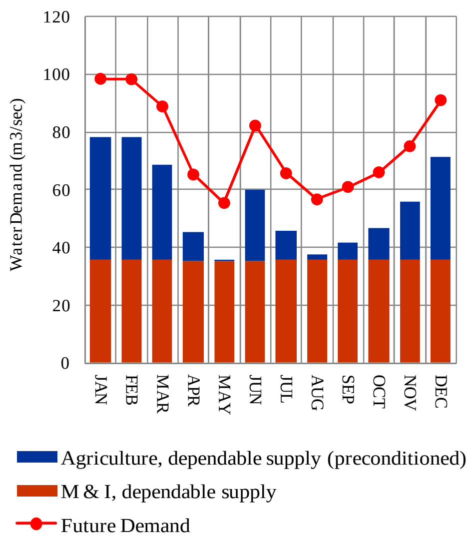
The water allocation for M &I water supply drops to 71.2% of the future demand (2040) under the ‘With Project’ condition in a 1/10 drought year.



Case 06B:

- Water Resources: With Project
- Water Demand: Future (2040)
- Preconditioned Water Allocation: Drought Safety Level of 1/5 for agriculture

The dependable water allocation for M & I water supply with a drought safety level of 1/10 is 35.9 m^3/s (MWSS 27.1 + Local 8.8).



Source: Prepared by the JICA Study Team

The above summarized results of water balance calculations indicated that the water demand exceeds the water supply capacity in any of the cases.

Table 10.1.21 shows the dependable supply capacity of the water resources in the Angat River basin.

Under the 'Existing' condition, the average dependable supply capacity is 55.7 m^3/s in a 1/5 drought year and 52.0 m^3/s in a 1/10 drought year. On the other hand, the average of the present water demand is 68.9 m^3/s.

Under the 'With Project' condition, the average dependable supply capacity is 57.9 m^3/s in a 1/5 drought year and 53.8 m^3/s in a 1/10 drought year. On the other hand, the average of the present water demand is 75.3 m^3/s.

It is obvious that such difference between demand and dependable water allocation is attributed to the conditional allocation of 15 m^3/s, which is defined originally as unused irrigation water of AMRIS. But the conditional allocation becomes substantially the regular use of MWSS and is a major cause of water shortage in AMRIS in case of drought. A solution to the conditional allocation is the main issue in the water resources management in the Angat River basin.

Table 10.1.21 Water Resources in the Angat River Basin–Dependable Supply Capacity

Present (2012)

Water Resources - Existing Dependable Supply Capacity	Angat Reservoir + Umiray-Angat Trans-basin Diversion	**55.7 m^3/s**	**(4,812 MLD)**	1/5 Drought Year
		52.0 m^3/s	**(4,493 MLD)**	1/10 Drought Year
Present Water Demand (2012)	M & I Water Supply - MWSS	46.3 m^3/s	(4,000 MLD)	
	M & I Water Supply - Local	3.3 m^3/s	(285 MLD)	
	Agriculture - AMRIS	19.0 m^3/s	(1,642 MLD)	
	Agriculture - Local	0.3 m^3/s	(26 MLD)	
	Total	**68.9 m^3/sec**	**(5,953 MLD)**	

Future (2040)

Water Resources - With Project Dependable Supply Capacity	Angat Reservoir + Umiray-Angat Trans-basin Diversion + Sumag River	**57.9 m^3/s**	**(5,003 MLD)**	1/5 Drought Year
		53.8 m^3/s	**(4,648 MLD)**	1/10 Drought Year
Future Water Demand (2040)	M & I Water Supply - MWSS	46.3 m^3/s	(4,000 MLD)	
	M & I Water Supply - Local	8.8 m^3/s	(760 MLD)	
	Agriculture - AMRIS	19.6 m^3/s	(1,693 MLD)	
	Agriculture - Local	0.6 m^3/s	(52 MLD)	
	Total	**75.3 m^3/sec**	**(6,506 MLD)**	

Source: Prepared by the JICA Study Team

(4) Water Resources Development Options in Neighboring Areas

The water resources development options in neighboring areas; Bayabas Reservoir, Maasim Reservoir, Balintingon Reservoir, and raising Angat FSL, indicate some improvements in the water allocation for M & I water supply and agriculture. But any individual option does not provide a complete solution to the present problem on the water allocation between M & I water supply and agriculture.

When a supplemental water allocation for agriculture (AMRIS and Local) is performed with the combination of the four water resources development options in neighboring areas, a drought safety level of 1/5 for agriculture is attained together with a drought safety level of 1/10 for M & I water supply. In this case, the sum of supplemental water allocation for agriculture (AMRIS and Local) is 8.5 m^3/s on average and accounts for 44% of the total water allocation of 19.4 m^3/s for agriculture.

The Metro Manila Water Security Study by the World Bank studied the Balintingon Reservoir as one of the promising project proposals for a solution to the conditional allocation. However, the Metro Manila Water Security Study finally reported that the Balintingon Reservoir should be developed exclusively for the benefit of the locals in the province of Nueva Ecjia and could not be considered as a solution to the conditional allocation.

(5) A Solution to the Conditional Allocation

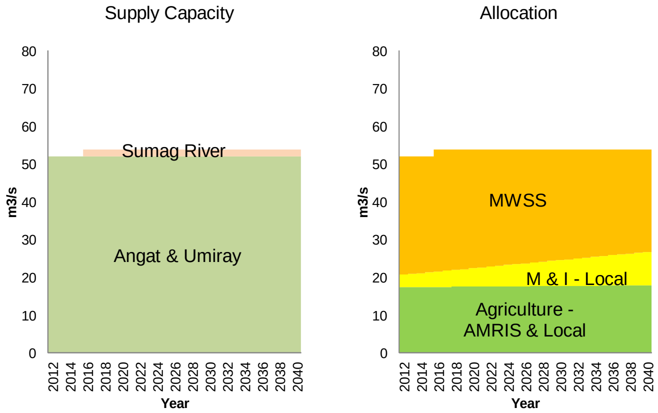
For the purpose of the water demand and balance study discussed in this chapter, the water allocation from Angat Reservoir needs to be assumed in an appropriate manner.

As a result of the water balance calculations for the water resources development options in the neighboring areas, any solution on the conditional allocation by these options is not expected for the time being because of the following points:

- None of the individual options provide a complete solution to the present problem on water allocation.
- Supplemental water allocation by the combination of four options enables to provide dependable supply for both M & I water supply and agriculture. However, the World Bank study reported that the Balintingon Reservoir, envisioned as a promising solution to the conditional allocation, could not be considered as a solution.

Therefore, a solution to the conditional allocation should be considered with other water resources development that would primarily take place in the Agos River basin in the future. To identify the scale of the water resources development in the Agos River basin, the water allocation from the Angat Reservoir is assumed to provide a solution to the conditional allocation as shown in Figure 10.1.5.

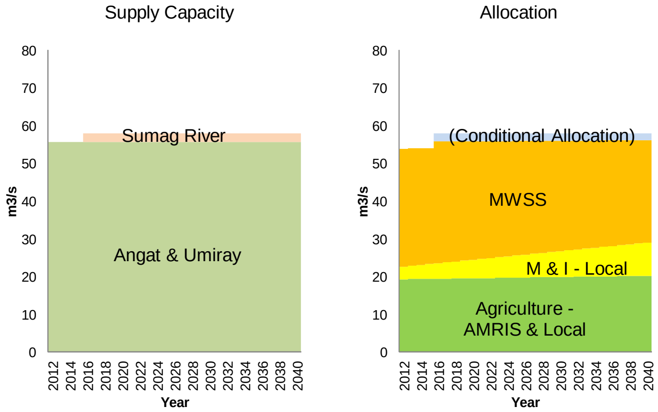
It is assumed that the water allocation would be initially made to meet the local water demands for M & I water supply and agriculture and the remaining water supply could be allocated to MWSS.



1/10 Drought Year

Unit: m^3/s

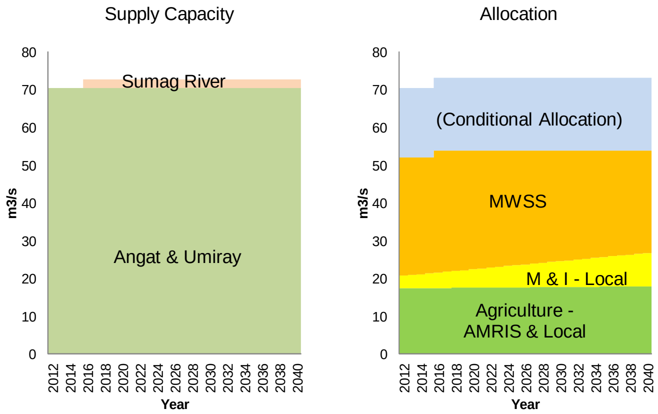
		Year	2012	2040
Supply Capacity			52.0	53.8
Allocation	MWSS		31.3	27.1
	M & I - Local		3.3	8.8
	Agriculture		17.4	17.9



1/5 Drought Year

Unit: m^3/s

		Year	2012	2040
Supply Capacity			55.7	57.9
Allocation	MWSS		33.1	28.9
	M & I - Local		3.3	8.8
	Agriculture		19.3	20.2



Average

Unit: m^3/s

		Year	2012	2040
Supply Capacity			70.4	73.1
Allocation	MWSS		47.8	44.1
	M & I - Local		3.3	8.8
	Agriculture		19.3	20.2

Source: Prepared by the JICA Study Team

Figure 10.1.5 Water Allocation from Angat Reservoir–A Solution to Conditional Allocation

10.2 Agos River Basin

10.2.1 Water Resources

(1) Surface Water

The Agos River has always been recognized as a potential water resource to cope with the growing water demand in Metro Manila. The project plans are already available such as Laiban Reservoir, Agos Reservoir, and Kanan No. 2 Reservoir, but none of these has been realized yet.

In the roadmap proposed by the Metro Manila Water Security Study, two alternative scenarios are presented. One is the Laiban Reservoir and the other is the Agos Reservoir as shown in Figure 10.2.1

Source: Prepared by the JICA Study Team

Figure 10.2.1 Water Resources Development in the Agos River Basin-Alternative Scenarios Presented by the World Bank Study

Table 10.2.1 shows the availability of the water resources in the Agos River basin. The 'Existing' condition represents the natural flows and the 'With Project' condition is the result of the water balance calculations (Case 101 and Case 105) based on the hydrological data set for the period of 1981-2010 (30 years).

Table 10.2.1 Water Resources Availability in the Agos River Basin

Existing — Unit: m^3/s

Water Resources	Basin Area (km^2)	Average	Dependable Flow		
			80%	90%	95%
Location of Laiban Reservoir	276	24.6	8.5	5.9	3.9
Location of Agos Reservoir	858	118.7	43.7	29.6	21.7

With Project — Unit: m^3/s

Water Resources	Basin Area (km^2)	Average	Dependable Flow		
			80%	90%	95%
Laiban Reservoir (Case 101)	276	24.6	21.4	21.4	21.4
Agos Reservoir (Case 105)	858	118.7	59.7	59.7	39.6

Source: Prepared by the JICA Study Team

(2) Groundwater

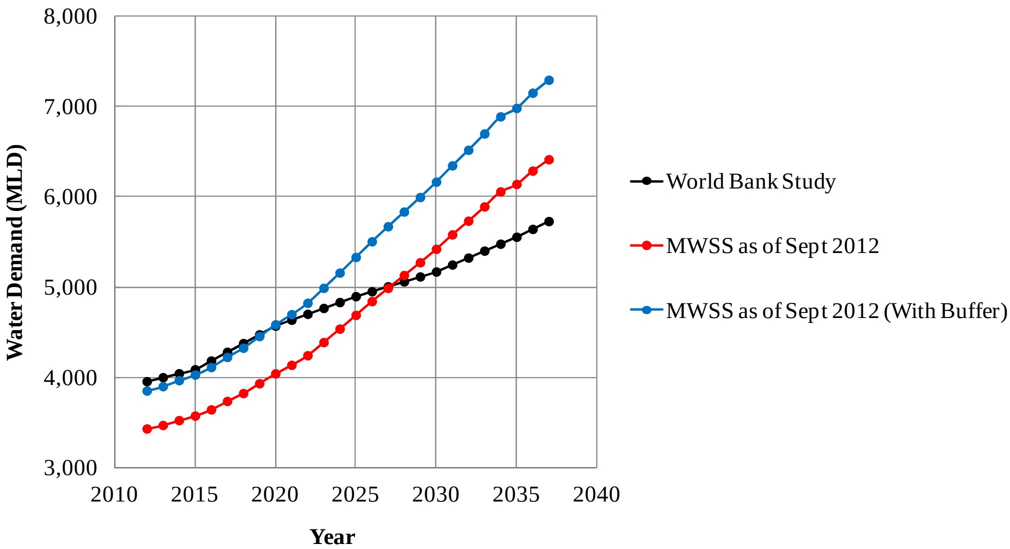
As described in Sub-section 7.2.2, no data is available for the groundwater exploitation in the Agos River basin. On the other hand, an exploitable groundwater yield is estimated to be 2265 liter/s (196 MLD) as described in Sub-section 7.2.3.

10.2.2 Water Demand in Metro Manila

At the first Steering Committee Meeting of this Study held in March 2012, it was confirmed that this Study could refer to the water demand projection elaborated in the Metro Manila Water Security Study carried out by the World Bank. The JICA Study Team made the analysis on the water demand of Metro Manila by primarily reviewing the water demand projection as elaborated in the Metro Manila Water Security Study.

Subsequently, in September 2012, MWSS informed the JICA Study Team that the water demand projection in Metro Manila was officially finalized and could be used for the purpose of this Study.

Figure 10.2.2 shows the comparison of the water demand projections. Compared with the water demand projection by the Metro Manila Water Security Study, the finalized water demand projection (without buffer) indicates lower figures until 2027 and higher figures after 2027. The water demand projection by the Metro Manila Water Security Study gives 5727 MLD (66.3 m^3/s) in 2037, while the finalized water demand projection (without buffer) showed 6472 MLD (74.2 m^3/s) in 2037.



Source: Prepared by the JICA Study Team, based on the finalized water demand by MWSS and the roadmap prepared by the Metro Manila Water Security Study

Figure 10.2.2 Comparison of Water Demand Projections in Metro Manila

10.2.3 Required Water Resources Development in the Agos River Basin

(1) Updated Water Demand and Supply Balance in Metro Manila

As earlier described in Section 10.1 of this report, the water demand in Metro Manila will not be satisfied solely with the Angat Reservoir. To cope with the water demand exceeding the water allocation from the Angat Reservoir to MWSS, the water resources development in the Agos River basin will be inevitable in the future.

As a solution to the present problem on water allocation from the Angat Reservoir, the water allocation to MWSS should be dependent on the local water demands of M & I water supply and agriculture (AMRIS and others) in the Angat River basin. Resulting from the water balance calculations for this solution, the water allocation for MWSS is 31.3 m^3/s (2704 MLD) in year 2012 and will decrease in the future due to the increase in local water demands. The water allocation for MWSS is estimated to be 25.6 m^3/s (2210 MLD) in 2037.

Table 10.2.2 shows the water demand and supply balance for MWSS, incorporating (a) updated water demand in Metro Manila, (b) projected water allocation from the Angat Reservoir to MWSS as mentioned above, and (c) projects listed in the roadmap proposed by the Metro Manila Water Security Study.

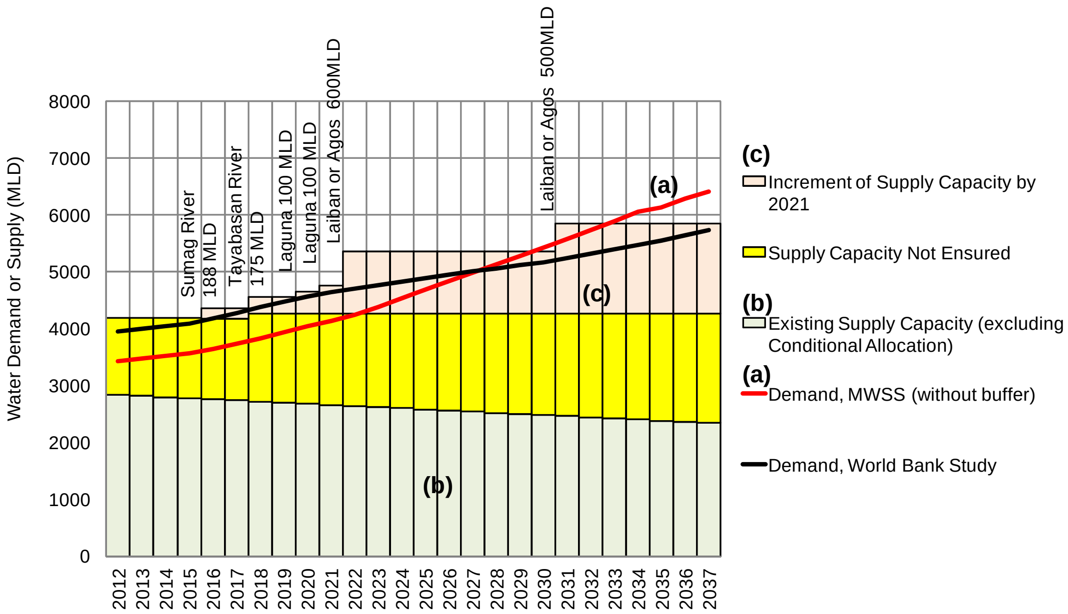
Table 10.2.2 Updated Water Demand and Supply Balance in Metro Manila

Year	(a) MWSS Demand		Supply Capacity										Balance
			Existing			(c) Roadmap Projects							
			(b) Angat & Umiray	(b) Laguna & Others	Conditional Allocation	Sumag River	Tayabasan	Laguna	Laguna	Laiban or Agos	Laiban or Agos	Total	
	MLD	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
2012	3,431	39.7	31.3	1.5	15.0							47.8	8.1
2013	3,470	40.2	31.1	1.5	15.1							47.7	7.6
2014	3,524	40.8	30.8	1.5	15.3							47.7	6.9
2015	3,574	41.4	30.6	1.5	15.4							47.6	6.2
2016	3,642	42.2	30.4	1.5	15.6	2.2						49.7	7.6
2017	3,736	43.2	30.2	1.5	15.7	2.2						49.6	6.4
2018	3,823	44.3	29.9	1.5	15.9	2.2	1.2					50.8	6.5
2019	3,932	45.5	29.7	1.5	16.0	2.2	1.2					50.7	5.2
2020	4,041	46.8	29.5	1.5	16.2	2.2	1.2	1.2				51.8	5.0
2021	4,136	47.9	29.2	1.5	16.3	2.2	1.2	1.2	1.2			52.8	5.0
2022	4,242	49.1	29.0	1.5	16.5	2.2	1.2	1.2	1.2	6.9		59.7	10.6
2023	4,388	50.8	28.8	1.5	16.6	2.2	1.2	1.2	1.2	6.9		59.6	8.8
2024	4,536	52.5	28.6	1.5	16.8	2.2	1.2	1.2	1.2	6.9		59.6	7.1
2025	4,689	54.3	28.3	1.5	16.9	2.2	1.2	1.2	1.2	6.9		59.5	5.2
2026	4,841	56.0	28.1	1.5	17.1	2.2	1.2	1.2	1.2	6.9		59.4	3.4
2027	4,988	57.7	27.9	1.5	17.2	2.2	1.2	1.2	1.2	6.9		59.3	1.6
2028	5,130	59.4	27.6	1.5	17.4	2.2	1.2	1.2	1.2	6.9		59.2	-0.1
2029	5,272	61.0	27.4	1.5	17.5	2.2	1.2	1.2	1.2	6.9		59.2	-1.9
2030	5,420	62.7	27.2	1.5	17.7	2.2	1.2	1.2	1.2	6.9		59.1	-3.6
2031	5,580	64.6	27.0	1.5	17.8	2.2	1.2	1.2	1.2	6.9	5.8	64.8	0.2
2032	5,731	66.3	26.7	1.5	18.0	2.2	1.2	1.2	1.2	6.9	5.8	64.7	-1.6
2033	5,890	68.2	26.5	1.5	18.1	2.2	1.2	1.2	1.2	6.9	5.8	64.6	-3.5
2034	6,056	70.1	26.3	1.5	18.3	2.2	1.2	1.2	1.2	6.9	5.8	64.6	-5.5
2035	6,138	71.0	26.0	1.5	18.4	2.2	1.2	1.2	1.2	6.9	5.8	64.5	-6.6
2036	6,286	72.8	25.8	1.5	18.6	2.2	1.2	1.2	1.2	6.9	5.8	64.4	-8.4
2037	6,412	74.2	25.6	1.5	18.7	2.2	1.2	1.2	1.2	6.9	5.8	64.3	-9.9

Source: Prepared by the JICA Study Team, based on the finalized water demand by MWSS and the roadmap prepared by the Metro Manila Water Security Study

According to the final report of the Metro Manila Water Security Study (July 2012), the Laiban Reservoir (or Agos Reservoir) is expected to be commissioned in year 2022. The roadmap proposed by the Metro Manila Water Security Study indicates that the increment of water supply capacity of MWSS with the Laiban Reservoir (or Agos Reservoir) will be 6.9 m^3/s (600 MLD) in 2022 and 5.8 m^3/s (500 MLD) in 2031. However, these increments are based on the water demand projection done by the Metro Manila Water Security Study and do not satisfy the finalized water demand of MWSS.

The required water resources development in the Agos River basin needs to be modified to cope with the finalized water demand of MWSS as well as the solution to the present problem on water allocation from the Angat Reservoir.



Source: Prepared by the JICA Study Team, based on the finalized water demand by MWSS and the roadmap prepared by the Metro Manila Water Security Study

Figure 10.2.3 Updated Water Demand and Supply Balance in Metro Manila

(2) Modified Water Demand and Supply Balance in Metro Manila

The following Table 10.2.3 is a modification of Table 10.2.2 above, excluding the conditional allocation and the increments by the Laiban Reservoir (or Agos Reservoir) in order to recalculate the required increments from year 2022 onwards. It is assumed that with the projects listed in the roadmap by the World Bank study until 2021 the water supply capacity would increase by 5.7 m^3/s (493 MLD).

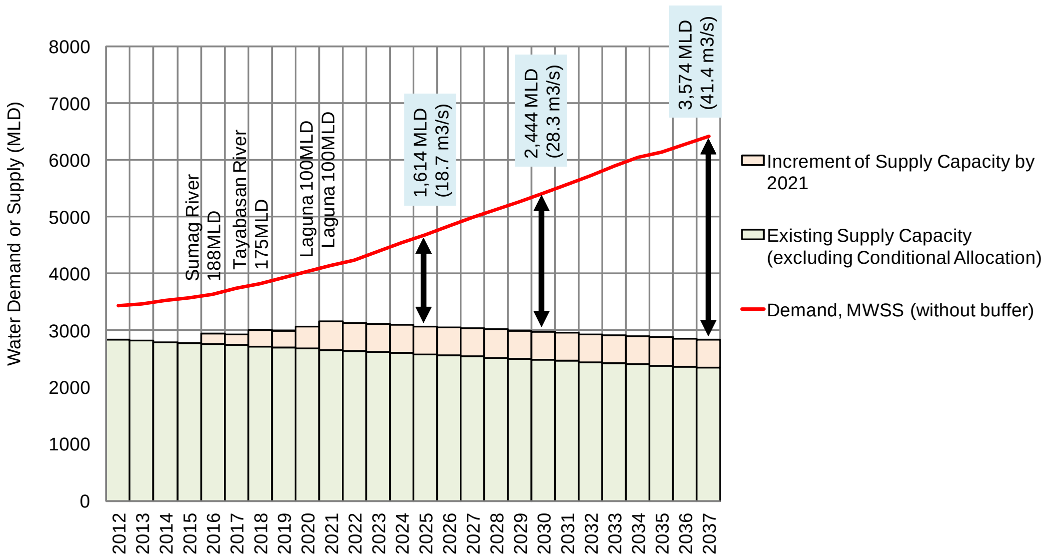
The water demand and supply balance indicates that a deficit of 11.4 m^3/s (983 MLD) is anticipated in year 2021 due to the need of a solution to the present problem on water allocation from the Angat Reservoir.

The required increments are 18.7 m^3/s (1614 MLD) by 2025, 28.3 m^3/s (2,444 MLD) by 2030, and 41.4 m^3/s (3574 MLD) by 2037.

Table 10.2.3 Updated Water Demand and Supply Balance in Metro Manila (Modified)

Year	MWSS Demand		Supply Capacity										Balance
			Existing			Roadmap Projects							
			Angat & Umiray	Laguna & Other	Conditional Allocation	Sumag River	Tayabasan	Laguna	Laguna	Laiban or Agos	Laiban or Agos	Total	
	MLD	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
2012	3,431	39.7	31.3	1.5								32.8	-6.9
2013	3,470	40.2	31.1	1.5								32.6	-7.6
2014	3,524	40.8	30.8	1.5								32.4	-8.4
2015	3,574	41.4	30.6	1.5								32.1	-9.2
2016	3,642	42.2	30.4	1.5		2.2						34.1	-8.0
2017	3,736	43.2	30.2	1.5		2.2						33.9	-9.4
2018	3,823	44.3	29.9	1.5		2.2	1.2					34.9	-9.4
2019	3,932	45.5	29.7	1.5		2.2	1.2					34.6	-10.9
2020	4,041	46.8	29.5	1.5		2.2	1.2	1.2				35.6	-11.2
2021	4,136	47.9	29.2	1.5		2.2	1.2	1.2	1.2			36.5	-11.4
2022	4,242	49.1	29.0	1.5		2.2	1.2	1.2	1.2			36.3	-12.8
2023	4,388	50.8	28.8	1.5		2.2	1.2	1.2	1.2			36.0	-14.7
2024	4,536	52.5	28.6	1.5		2.2	1.2	1.2	1.2			35.8	-16.7
2025	4,689	54.3	28.3	1.5		2.2	1.2	1.2	1.2			35.6	-18.7
2026	4,841	56.0	28.1	1.5		2.2	1.2	1.2	1.2			35.4	-20.7
2027	4,988	57.7	27.9	1.5		2.2	1.2	1.2	1.2			35.1	-22.6
2028	5,130	59.4	27.6	1.5		2.2	1.2	1.2	1.2			34.9	-24.5
2029	5,272	61.0	27.4	1.5		2.2	1.2	1.2	1.2			34.7	-26.3
2030	5,420	62.7	27.2	1.5		2.2	1.2	1.2	1.2			34.4	-28.3
2031	5,580	64.6	27.0	1.5		2.2	1.2	1.2	1.2			34.2	-30.4
2032	5,731	66.3	26.7	1.5		2.2	1.2	1.2	1.2			34.0	-32.3
2033	5,890	68.2	26.5	1.5		2.2	1.2	1.2	1.2			33.8	-34.4
2034	6,056	70.1	26.3	1.5		2.2	1.2	1.2	1.2			33.5	-36.6
2035	6,138	71.0	26.0	1.5		2.2	1.2	1.2	1.2			33.3	-37.7
2036	6,286	72.8	25.8	1.5		2.2	1.2	1.2	1.2			33.1	-39.7
2037	6,412	74.2	25.6	1.5		2.2	1.2	1.2	1.2			32.8	-41.4

Source: Prepared by the JICA Study Team, based on the finalized water demand by MWSS and the roadmap prepared by the Metro Manila Water Security Study



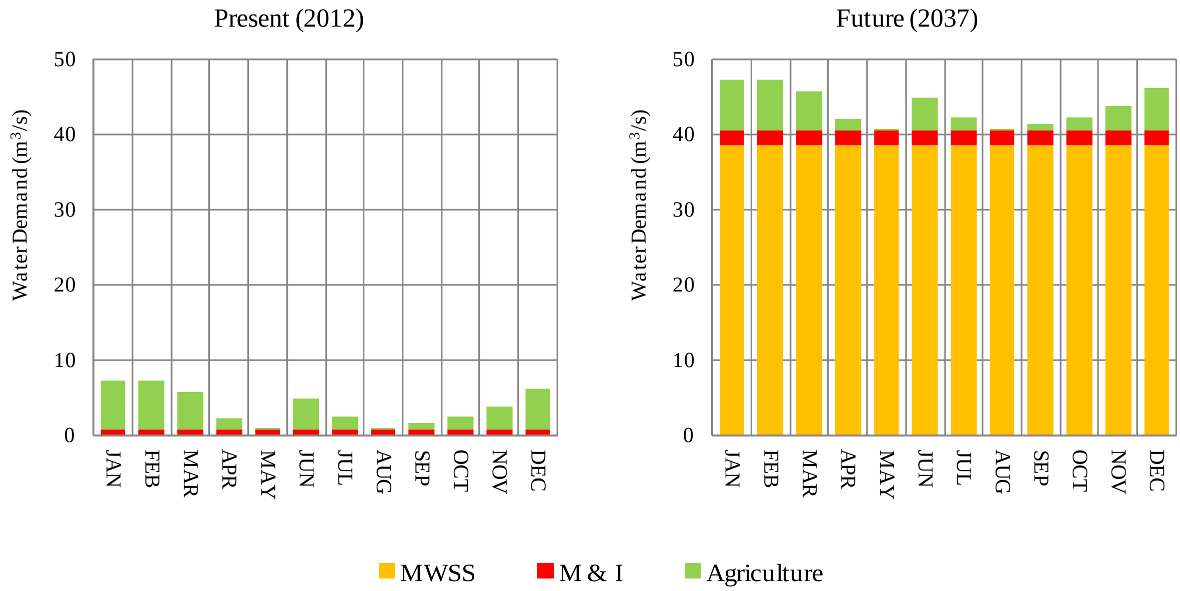
Source: Prepared by the JICA Study Team, based on the finalized water demand by MWSS and the roadmap prepared by Metro Manila Water Security Study

Figure 10.2.4 Updated Water Demand and Supply Balance in Metro Manila (Modified)

10.2.4 Water Demands in the Agos River Basin

M & I water demand from the Agos River basin is estimated at 0.8 m^3/s (69 MLD) at present (year 2012) and 1.9 m^3/s (165 MLD) in the future (year 2037).

Averaged agriculture water demand in the Agos River basin is estimated at 3.0 m^3/s (258 MLD) at present (year 2012) and 3.1 m^3/s (271 MLD) in the future (year 2037).



Source: Prepared by the JICA Study Team

Figure 10.2.5 Water Demands–Agos River Basin and MWSS

It is assumed that the water demands within the Agos River basin would be served with surface water. In the water balance calculations, the water demand within the Agos River basin is satisfied with the natural flow and/or outflow from the reservoir as preconditions. Water allocation to MWSS is calculated under such preconditions.

10.2.5 Reservoirs

Elevation-storage curves of the reservoirs are given in the final report of the Study on Water Resources Development for Metro Manila (JICA/NWRB, 2003) as shown in Table 10.2.4 below.

Table 10.2.4 Elevation-Storage Curves of Reservoirs Planned in the Agos River Basin

Laiban Reservoir

Elevation (EL m)	Storage (MCM)	Area (km^2)
174	0.00	0.00
180	0.30	0.10
190	2.80	0.40
200	10.30	1.10
210	28.30	2.50
220	63.30	4.50
230	120.80	7.00
240	204.30	9.70
250	316.80	12.80
260	464.30	16.70
270	648.80	20.20
280	869.80	24.00
290	1127.30	27.50
300	1421.80	31.40

Agos Reservoir

Elevation (EL m)	Storage (MCM)	Area (km^2)
42	0.00	0.00
60	12.20	1.36
80	55.70	2.99
100	140.12	5.45
120	281.25	8.67
140	422.03	12.72
160	733.22	18.40
180	1176.87	25.97
200	1805.46	37.89

Kanan No.2 Reservoir

Elevation (EL m)	Storage (MCM)	Area (km^2)
160	0.00	0.00
180	4.00	0.40
200	17.00	1.00
220	47.00	2.00
240	101.50	3.50
260	200.50	6.70
280	385.00	12.20
300	714.00	21.00
320	1233.00	31.00
340	1967.00	42.60

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

Effective storage of each reservoir is defined as a storage between full supply level (FSL) and minimum operation level (MOL). The figures of FSL, MOL, and effective storage of each reservoir are also given in the final report of the Study on Water Resources Development for Metro Manila (JICA/NWRB, 2003) as shown in Table 10.2.5. For the purpose of the water balance calculations, it is assumed that each reservoir would be operated in a simple manner between the FSL and MOL.

Table 10.2.5 FSL, MOL, and Effective Storage of Reservoirs Planned in the Agos River Basin

	FSL (EL m)	MOL (EL m)	Effective Storage (MCM)
Laiban Reservoir	270	237	470
Agos Reservoir	159	133	345
Kanan No. 2 Reservoir	310	270	607

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

10.2.6 Minimum Stream Flow Requirement

The Agos River basin remains almost in its natural condition. The dependable flow is regarded as a discharge rate at 80% of a flow duration curve and the minimum stream flow is defined as 10% of the dependable flow. The minimum flow requirements in the Agos River basin are listed in Table 10.2.6 below.

Table 10.2.6 Minimum Stream Flow Requirement in the Agos River Basin

Location	Basin Area (km^2)	Minimum Stream Flow Requirement (m^3/s)
Laiban Reservoir	276	0.85
Kaliwa Low Dam	366	1.02
Kanan No. 2 Reservoir	289	2.15
Agos Reservoir	858	4.37

Source: Prepared by the JICA Study Team

10.2.7 Drought Safety Level

Drought safety level of 1/10 should be ensured for M & I water supply. Water allocation for M & I water supply should be adequate during a drought year that would probably occur once in ten years (1/10 drought year). During a 1/10 drought year, there should be no deficit in allocating water to M & I water supply.

Drought safety level of 1/5 should be ensured for agriculture. Water allocation for agriculture should be adequate during a drought year that would probably occur once in five years (1/5 drought year). During a 1/5 drought year, there should be no deficit in allocating water to agriculture.

10.2.8 Water Balance Calculations–Laiban Reservoir and Associated Developments

(1) Calculation Cases

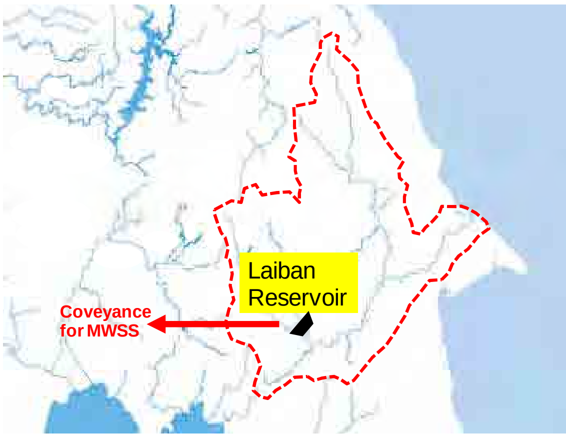
Water balance calculations for the Laiban Reservoir and associated developments were performed in Cases 101, 102, 103, and 108a as shown in Table 10.2.7 and Figure 10.2.6 below.

Table 10.2.7 Water Balance Calculation Cases–Laiban Reservoir and Associated Developments

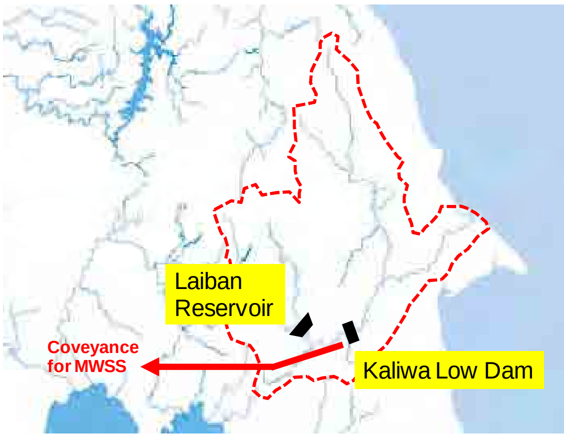
Case	Water Resource	Water Demand	Projected Water Allocation
101	With Project ● Laiban Reservoir	Future (2040)	Preconditions: ● Drought safety level of 1/10 is ensured for the projected water allocation for M & I water supply within the Agos River basin. ● Drought safety level of 1/5 is ensured for the projected water allocation for agriculture within the Agos River basin. Water allocation dependability with drought safety level of 1/10 for MWSS is calculated under the preconditions above. Water conveyance from the Kanan No. 2 Reservoir to the Laiban Reservoir is 38.3 m^3/s (3310 MLD). As an option of future development, the Agos Reservoir receives firm-up water flows of 20.1 m^3/s (1740 MLD) released from the Laiban Reservoir. The development of the Agos Reservoir consists of the water intake/conveyance for MWSS as well as the hydropower. Besides the water allocation to MWSS, 25.6 m^3/s (2210 MLD) is used for the hydropower with a dependability of 90%.
102	With Project ● Laiban Reservoir ● Kaliwa Low Dam		
103	With Project ● Laiban Reservoir ● Kaliwa Low Dam ● Kanan No. 2 Reservoir		
108a	With Project ● Laiban Reservoir ● Kaliwa Low Dam ● Kanan No. 2 Reservoir ● Agos Reservoir		

Source: Prepared by the JICA Study Team

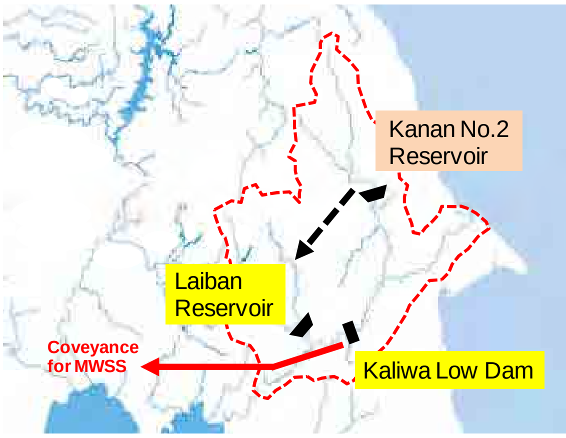
Case 101



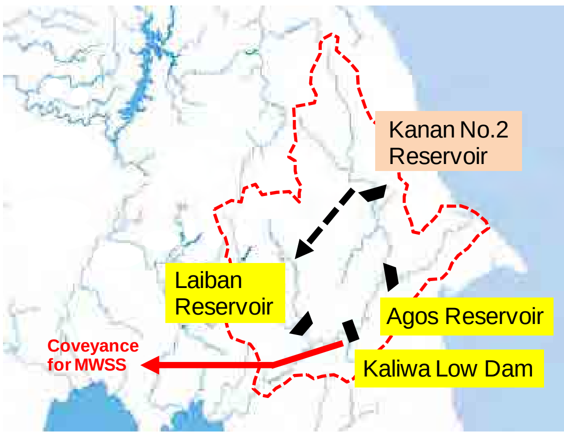
Case 102



Case 103



Case 108a



Source: Prepared by the JICA Study Team

Figure 10.2.6 Laiban Reservoir and Associated Developments

(2) Results

The results of the water balance calculations for the Laiban Reservoir and associated developments are summarized in Table 10.2.8. Each of the cases calculates the dependable water allocation for MWSS with a drought safety level of 1/10.

Case 101 examines the water conveyance solely from the Laiban Reservoir. The dependable water allocation for MWSS is 20.1 m^3/s (1740 MLD). Case 102 envisages the water conveyance from the Kaliwa Low Dam that receives water released from the Laiban Reservoir. The dependable water allocation for MWSS is 20.4 m^3/s (1760 MLD).

The dependable water allocation for any of Case 101 or Case 102 is sufficient to cope with the anticipated water deficit of MWSS until the year 2026. Accordingly, additional development will be required afterward. Case 103 is an augmentation of Case 102 by means of the water conveyance of 38.3 m^3/s (3310 MLD) from the Kanan No. 2 Reservoir to the Laiban Reservoir. The water allocation for MWSS is augmented up to 58.6 m^3/s (5060 MLD), that is enough to cope with the anticipated water deficit of MWSS until the year 2037.

Case 108a considers maximizing the water allocation for MWSS with the combination of the planned developments of Laiban Reservoir, Kanan No. 2 Reservoir, and Agos Reservoir. This case results in a possible water allocation of 68.8 m^3/s (5940 MLD) for MWSS with a drought safety level of 1/10.

Table 10.2.8 Results of Water Balance Calculations–Laiban Reservoir and Associated Developments

Case	Project (MLD)	Projected Water Allocation in 2040				Results of Water Balance Analysis					
		Supply (m^3/sec)			Drought Safety Level	Dependability of Supply	Ratio of Supply to Envisaged Water Allocation – Drought Year				
							1/2	1/5	1/10	1/20	1/30
101	Laiban Reservoir	M & I Water Supply	MWSS	20.1	1/10	97.8% (352 / 360)	100.0%	100.0%	100.0%	89.2%	84.0%
			Local	2.0	1/10	99.7% (359 / 360)	100.0%	100.0%	100.0%	100.0%	99.8%
	1740	Agriculture	NIS Local	2.9 0.3	1/5	99.7% (359 / 360)	100.0%	100.0%	100.0%	100.0%	99.6%
102	Laiban Reservoir Kaliwa Low Dam	M & I Water Supply	MWSS	20.4	1/10	98.1% (353 / 360)	100.0%	100.0%	100.0%	89.9%	89.5%
			Local	2.0	1/10	100.0% (360 / 360)	100.0%	100.0%	100.0%	100.0%	99.8%
	1760	Agriculture	NIS Local	2.9 0.3	1/5	99.4% (358 / 360)	100.0%	100.0%	100.0%	99.6%	99.4%
103	Laiban Reservoir Kaliwa Low Dam Kanan 2 Reservoir	M & I Water Supply	MWSS	58.5	1/10	96.9% (349 / 360)	100.0%	100.0%	100.0%	85.9%	79.7%
			Local	2.0	1/10	99.7% (359 / 360)	100.0%	100.0%	100.0%	100.0%	99.8%
	5060	Agriculture	NIS Local	2.9 0.3	1/5	98.9% (356 / 360)	100.0%	100.0%	99.6%	96.0%	88.8%
108a	Laiban Reservoir Kaliwa Low Dam Agos Reservoir Kanan 2 Reservoir	M & I Water Supply	MWSS	68.8	1/10	96.9% (349 / 360)	100.0%	100.0%	100.0%	86.5%	78.8%
			Local	2.0	1/10	99.7% (359 / 360)	100.0%	100.0%	100.0%	100.0%	99.8%
	5940	Agriculture	NIS Local	2.9 0.3	1/5	96.9% (349 / 360)	100.0%	100.0%	98.4%	92.1%	91.1%

Source: Prepared by the JICA Study Team

10.2.9 Water Balance Calculations–Agos Reservoir and Associated Developments

(1) Calculation Cases

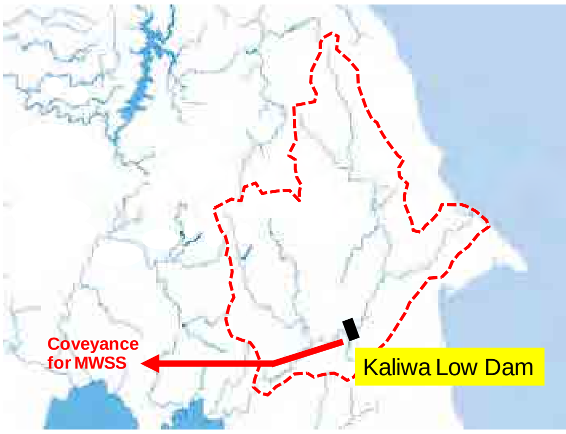
The water balance calculations for the Agos Reservoir and associated developments are performed in Cases 104, 105, 106, 107, and 108b as shown in Table 10.2.9 and Figure 10.2.5 below.

Table 10.2.9 Water Balance Calculation Cases–Agos Reservoir and Associated Developments

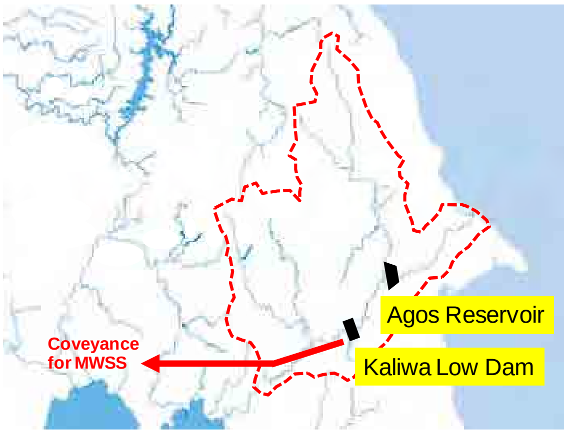
<table>
<tr><th>Case</th><th>Water Resource</th><th>Water Demand</th><th>Projected Water Allocation</th></tr>
<tr><td>104</td><td>With Project
● Kaliwa Low Dam</td><td rowspan="5">Future
(2040)</td><td rowspan="5">Preconditions:
● Drought safety level of 1/10 is ensured for the projected water allocation for M & I water supply within the Agos River basin.
● Drought safety level of 1/5 is ensured for the projected water allocation for agriculture within the Agos River basin.
The development of the Agos Reservoir consists of the water intake/conveyance for MWSS as well as the hydropower. Besides the water allocation to MWSS, 25.6 m^3/s (2210 MLD) is used for the hydropower with a dependability of 90%.
As future development, the Agos Reservoir receives firm-up water flows of 38.3 m^3/s (3310 MLD) released from the Kanan No. 2 Reservoir.
As an option of future development, the Agos Reservoir receives firm-up water flows of 20.1 m^3/s (1740 MLD) released from the Laiban Reservoir.</td></tr>
<tr><td>105</td><td>With Project
● (Kaliwa Low Dam)
● Agos Reservoir</td></tr>
<tr><td>106</td><td>With Project
● (Kaliwa Low Dam)
● Agos Reservoir
● Kanan No. 2 Reservoir</td></tr>
<tr><td>107</td><td>With Project
● Laiban Reservoir
● (Kaliwa Low Dam)
● Agos Reservoir</td></tr>
<tr><td>108b</td><td>With Project
● Laiban Reservoir
● (Kaliwa Low Dam)
● Agos Reservoir
● Kanan No. 2 Reservoir</td></tr>
</table>

Source: Prepared by the JICA Study Team

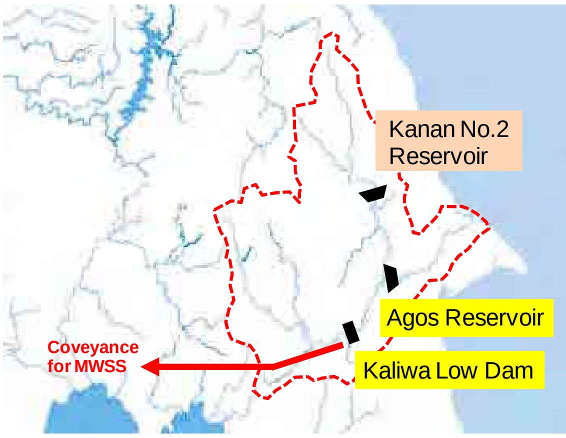
Case 104



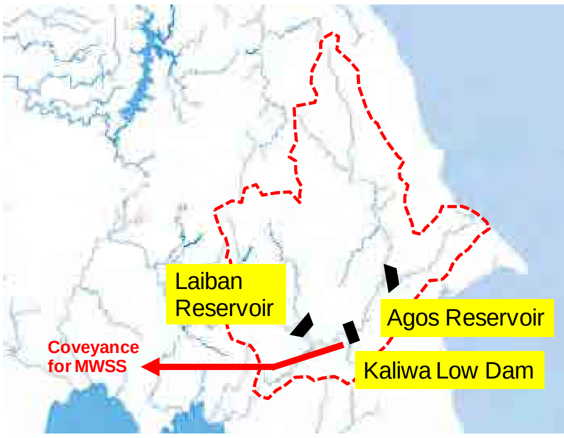
Case 105



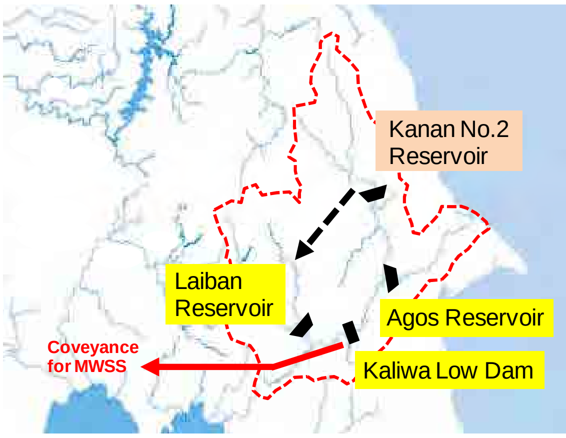
Case 106



Case 107



Case 108



Source: Prepared by the JICA Study Team

Figure 10.2.7
Agos Reservoir and Associated Developments

(2) Results

The results of water balance calculation for the Agos Reservoir and associated developments are summarized in Table 10.2.10. Case 104 represents the sole Kaliwa Low Dam that is regarded as a provisional development towards the development of the Agos Reservoir and that does not ensure a drought safety level of 1/10 for the projected water allocation for MWSS. The remaining cases calculate the dependable water allocation for MWSS with a drought safety level of 1/10.

Case 105 consisting of the Kaliwa Low Dam and the Agos Reservoir result in a dependable water allocation of 34.1 m^3/s (2950 MLD) for MWSS with a drought safety level of 1/10. This water allocation is sufficient to cope with the anticipated water deficit of MWSS until the year 2032. After year 2032, the water allocation for MWSS needs to be augmented by means of further development such as the Kanan No. 2 Reservoir (Case 106) or the Laiban Reservoir (Case 107).

Case 108b considers maximizing the water allocation for MWSS with the combination of the planned developments of Agos Reservoir, Kanan No. 2 Reservoir, and Laiban Reservoir. This case results in a possible water allocation of 68.8 m^3/s (5940 MLD) for MWSS with a drought safety level of 1/10.

Table 10.2.10 Results of Water Balance Calculations–Agos Reservoir and Associated Developments

Case	Project (MLD)	Projected Water Allocation in 2040				Results of Water Balance Analysis						
		Supply (m^3/sec)			Drought Safety Level	Dependability of Supply		Ratio of Supply to Envisaged Water Allocation				
								Drought Year				
								1/2	1/5	1/10	1/20	1/30
104	Kaliwa Low Dam	M & I Water Supply	MWSS	6.4	1/10	85.6%	(308 / 360)	95.5%	84.5%	81.9%	78.1%	77.7%
			Local	2.0	1/10	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.5%
	550	Agriculture	NIS Local	2.9 0.3	1/5	99.4%	(358 / 360)	100.0%	100.0%	100.0%	99.4%	98.3%
105	Kaliwa Low Dam Agos Reservoir	M & I Water Supply	MWSS	34.1	1/10	99.2%	(357 / 360)	100.0%	100.0%	100.0%	93.8%	93.4%
			Local	2.0	1/10	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.5%
	2950	Agriculture	NIS Local	2.9 0.3	1/5	98.1%	(353 / 360)	100.0%	100.0%	97.8%	96.4%	94.1%
106	Kaliwa Low Dam Agos Reservoir Kanan 2 Reservoir	M & I Water Supply	MWSS	55.8	1/10	98.1%	(353 / 360)	100.0%	100.0%	100.0%	90.4%	82.7%
			Local	2.0	1/10	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.5%
	4820	Agriculture	NIS Local	2.9 0.3	1/5	98.1%	(353 / 360)	100.0%	100.0%	97.8%	96.4%	94.1%
107	Laiban Reservoir Kaliwa Low Dam Agos Reservoir	M & I Water Supply	MWSS	47.6	1/10	99.2%	(357 / 360)	100.0%	100.0%	100.0%	96.5%	91.8%
			Local	2.0	1/10	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.8%
	4110	Agriculture	NIS Local	2.9 0.3	1/5	98.1%	(353 / 360)	100.0%	100.0%	98.1%	96.3%	94.0%
108b	Laiban Reservoir Kaliwa Low Dam Agos Reservoir Kanan No.2 Reservoir	M & I Water Supply	MWSS	68.8	1/10	96.9%	(349 / 360)	100.0%	100.0%	100.0%	82.4%	79.2%
			Local	2.0	1/10	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.8%
	5940	Agriculture	NIS Local	2.9 0.3	1/5	96.9%	(349 / 360)	100.0%	100.0%	97.9%	92.1%	91.1%

Source: Prepared by the JICA Study Team

10.2.10 Summary and Conclusion of Water Balance Calculations–Agos River Basin

The water demand in Metro Manila will not be solely satisfied by the Angat Reservoir. To cope with the water demand exceeding the water allocation from the Angat Reservoir to MWSS, the water resources development in the Agos River basin will be inevitable in the future.

The required water resources development in the Agos River basin is updated on the basis of the following conditions:

- The water demand and supply balance needs to be modified in accordance with the finalized water demand by MWSS in 2012.
- As a solution to the present problem on water allocation from the Angat Reservoir, the water allocation for MWSS should be dependent on the local water demands of M & I water supply and agriculture (AMRIS and others) in the Angat River basin. Resulting from the water balance calculations for this solution, the water allocation for MWSS is 31.3 m^3/s (2704 MLD) in year 2012 and will decrease in the future due to the increase in local water demands. The water allocation for MWSS is estimated to be 25.6 m^3/s (2210 MLD) in 2037.
- The water supply capacity would increase by 5.7 m^3/s (493 MLD) with the projects listed in the roadmap by the World Bank study until 2021. The water resources development in the Agos River basin will be implemented afterward to cope with the further increase in the water demand.

Based on the updated water demand for MWSS (without buffer), the required increments are 18.7 m^3/s (1614 MLD) by 2025, 28.3 m^3/s (2444 MLD) by 2030, and 41.4 m^3/s (3574 MLD) by 2037.

In the water balance calculations, the water demand within the Agos River basin is satisfied with the natural flow and/or outflow from the reservoir as preconditions. Water allocation for MWSS is calculated under such preconditions.

The dependable water allocation for MWSS with a drought safety level of 1/10 is calculated for the Laiban Reservoir and associated developments as shown below.

Laiban Reservoir	20.1 m^3/s	(1740 MLD)
Laiban Reservoir + Kaliwa Low Dam	20.4 m^3/s	(1760 MLD)
Laiban Reservoir + Kaliwa Low Dam + Kanan No. 2 Reservoir	58.6 m^3/s	(5060 MLD)

The dependable water allocation for MWSS with a drought safety level of 1/10 is calculated for the Agos Reservoir and associated developments as shown below.

Kaliwa Low Dam (90% dependable capacity)	4.7 m^3/s	(410 MLD)
Kaliwa Low Dam + Agos Reservoir	34.1 m^3/s	(2950 MLD)
Kaliwa Low Dam + Agos Reservoir + Kanan No. 2 Reservoir	55.8 m^3/s	(4820 MLD)

10.3 Water Demand and Supply Balance–Metro Manila Water Supply

10.3.1 Water Supply Capacity Resulting from Water Balance Calculations

(1) Angat Reservoir with Umiray-Angat Transbasin Diversion

The water supply capacity is estimated based on the hydrological data set for the period of 1968-2010 compiled by the Study. The average supply capacity of the Angat Reservoir with Umiray-Angat transbasin diversion augmented by the Sumag River is 73.1 m^3/s (6316 MLD). On the other hand, the dependable supply capacity of 53.8 m^3/s (4648 MLD) will be allocated to MWSS (27.1 m^3/s=2341 MLD), M & I water supply (Local, 8.8 m^3/s=760 MLD) and agriculture (AMRIS and Local, 17.9 m^3/s=1547 MLD).

(2) Tayabasan River

The Tayabasan River is a tributary of the Marikina River. As suggested from the location of the planned water intake shown in the final report of the Metro Manila Water Security Study (World Bank, July 2012), the catchment area of the water intake would be around 75 km^2. Since the size of the catchment area is small, the planned supply capacity of 175 MLD (2.03 m^3/s) will not be reliable for a year.

Based on the water balance calculations described in Section 10.5, the average river flow at the location of the planned intake is estimated to be 4.13 m^3/s. But the river flow during dry season is much lower than the planned supply capacity. This scheme is regarded as a run-of-river and the dependability of the supply capacity of 2.03 m^3/s (175 MLD) is 70.6%. A flow rate with 90% dependability is estimated at 1.22 m^3/s (105 MLD).

(3) Laguna Lake

The existing Putatan WTP is operated with a capacity of 1.16 m^3/s (100 MLD) through water purification process which includes dissolved air flotation (DAF), micro filtration (MF), and reverse osmosis (RO). The Metro Manila Water Security Study carried out by the World Bank shows that the capacity of the WTP is scheduled to be expanded up to 3.47 m^3/s (300 MLD) by year 2021 to utilize the water from the Laguna Lake.

Resulting from the water balance calculations described in Section 10.7, the water supply of 300 MLD from Laguna Lake to Metro Manila is regarded as dependable in terms of the quantity of the available water resources. Meanwhile, it is anticipated that sea water intrusion would be more frequent due to the increase in the volume of water taken from the Laguna Lake in the future as well as the drought accelerated by climate change. The results of the water balance calculations suggested the need for measures to be taken to ensure the dependability of supply in terms of water quality.

Table 10.3.1 Water Supply Capacity–Water Resources for Metro Manila

Water Resources	JICA Study 2003 (MLD)	World Bank Study 2012 (MLD)	Present Study (MLD)	Remarks
Angat Reservoir with Umiray-Angat Transbasin Diversion		(4,000)	2,150 760 1,750	MWSS (2040) M & I Local (2040, preconditioned) Agriculture (2040, preconditioned)
Sumag River		188		
Angat Reservoir with Umiray-Angat Trans-basin Diversion + Sumag River		(4,188)	2,340 760 1,750	MWSS (2040) M & I Local (2040, preconditioned) Agriculture (2040, preconditioned)
Tayabasan River		175	105	Run-of-river Dependability 90%
Laguna Lake		300	300	Existing 100 MLD Planned 200 MLD
Laiban Reservoir	1,830	1,900	1,740	
Laiban Reservoir + Kaliwa Low Dam			1,760	
Kanan No.2 Reservoir	3,310	3,300		
Laiban Reservoir + Kaliwa Low Dam + Kanan No.2 Reservoir			5,060	
Kaliwa Low Dam	550	550	410	Run-of-river Dependability 90%
Kaliwa Low Dam + Agos Reservoir	3,000	3,000	2,950	
Kaliwa Low Dam + Agos Reservoir + Kanan No.2 Reservoir			4,820	

Source: Prepared by the JICA Study Team

(4) Laiban Reservoir

The Metro Manila Water Security Study carried out by the World Bank refers to a project document named the ‘Final Report for Laiban Dam Project, March 2007’, which was used in the process of preparing the roadmap. The final report describes a water supply capacity of 1900 MLD (22.0 m^3/s) with the development of the Laiban Reservoir which is to be allocated to MWSS.

The final report of the Study on Water Resources Development for Metro Manila (JICA/NWRB, 2003) describes a development scale of the Laiban Reservoir as a dependable 1830 MLD (21.2 m^3/s) with a drought safety level of 1/10, resulting from the hydrological analysis based on the hydrological data from the 1950s to 1980s.

The World Bank study proposes solely the Laiban Reservoir (the same as Case 101 described in Sub-section 10.2.8) in the roadmap. Further, MWSS entrusts the National Hydraulic Research Center (NHRC) of the National Engineering Center of the University of the Philippines to carry out the Hydrological Study, Reliability, and Sustainability Analysis for the New Water Supply Source Project in 2012. This study proposes a long-term development in the Agos River basin in following sequence from Kaliwa Low Dam to Laiban Reservoir, Kanan No. 2 Reservoir, and Agos Reservoir.

With regards to the results of the study by NHRC, the subsequent study in this chapter considers Cases 102 and 103 described in Sub-section 10.2.8 as the Laiban Reservoir and associated developments. Based on the hydrological data set for the period of 1981-2010 prepared by this Study, the dependable supply capacity of the Laiban Reservoir with the Kaliwa Low Dam is estimated to be 20.4 m^3/s (1760 MLD).

(5) Kaliwa Low Dam

The Kaliwa Low Dam is regarded as a provisional development towards the development of the Agos Reservoir. The final report of the Study on Water Resources Development for Metro Manila (JICA/NWRB, 2003) describes the Kaliwa Low Dam as a run-of-river scheme with a development scale of 6.4 m^3/s (550 MLD) and 90% dependable supply capacity, resulting from the hydrological analysis based on the hydrological data from the 1950s to 1980s.

The Metro Manila Water Security Study refers to this supply capacity as well.

Based on the hydrological data set for the period of 1981-2010 prepared by this Study, the dependability of the supply capacity 6.4 m^3/s (550 MLD) is found to be 85.6%. A flow rate with 90% dependability is estimated at 4.7 m^3/s (410 MLD).

(6) Agos Reservoir

For the planned features of the Agos Reservoir, the Metro Manila Water Security Study carried out by the World Bank refers to the final report of the Study on Water Resources Development for Metro Manila (JICA/NWRB, 2003). The World Bank study proposes solely the Agos Reservoir (without Kaliwa Low Dam) in the roadmap.

The study by JICA (2003) presents the development of the Agos Reservoir for the water conveyance of 3000 MLD (34.7 m^3/s), dependable with a drought safety level of 1/10 resulting from the hydrological analysis based on the hydrological data from the 1950s to 1980s. The overall development of the Agos Reservoir consists of the water conveyance to Metro Manila (3000 MLD) and hydropower generation (2210 MLD) in the downstream side.

The study by JICA (2003) indicates a long-term development in the Agos River basin in the sequence from Kaliwa Low Dam to Agos Reservoir and Laiban Reservoir or Kanan No. 2 Reservoir. With regards to the results of the study by JICA (2003), the subsequent study in this chapter considers Cases 104, 105, and 106 described in Sub-section 10.2.8 as the Agos Reservoir and associated developments. Based on the hydrological data set for the period of 1981-2010 prepared by this Study, a dependable supply capacity for the water conveyance to Metro Manila is estimated to be 34.1 m^3/s (2950 MLD) on the condition that the hydropower generation is operated with 90% dependable flow of 25.6 m^3/s (2210 MLD).

(7) Kanan No. 2 Reservoir

The Metro Manila Water Security Study also refers to the final report of the Study on Water Resources Development for Metro Manila (JICA/NWRB, 2003) describing the planned features of the Kanan No. 2 Reservoir. The study by JICA (2003) indicates a development scale of the Kanan No. 2 Reservoir of 3310 MLD (38.3 m^3/s), dependable with a drought safety level of 1/10 resulting from the hydrological analysis based on the hydrological data from the 1950s to 1980s.

For the purpose of the water conveyance to Metro Manila, the Kanan No. 2 Reservoir should be considered in combination with the Laiban Reservoir or Agos Reservoir and the results of dependable supply capacity are described earlier in Sub-section 10.2.10.

10.3.2 Water Demand and Supply Balance of MWSS towards 2037 (without buffer)

(1) Laiban Reservoir and Associated Developments

The required increment of water supply capacity is 47.1 m^3/s (4067 MLD) towards 2037. The roadmap proposed by the World Bank study includes the projects to be implemented by 2021 with the total supply capacity of 5.7 m^3/s (493 MLD). The remaining 41.4 m^3/s (3574 MLD) needs to be developed later on in the Agos River basin. Resulting from the water balance calculations, the Laiban Reservoir and associated developments increase the capacity to 51.5 m^3/s (4453 MLD) towards 2037 as shown in Table 10.3.2 below.

Table 10.3.2 Water Resources Development for Metro Manila Water Supply (without Buffer), Laiban Reservoir and Associated Developments

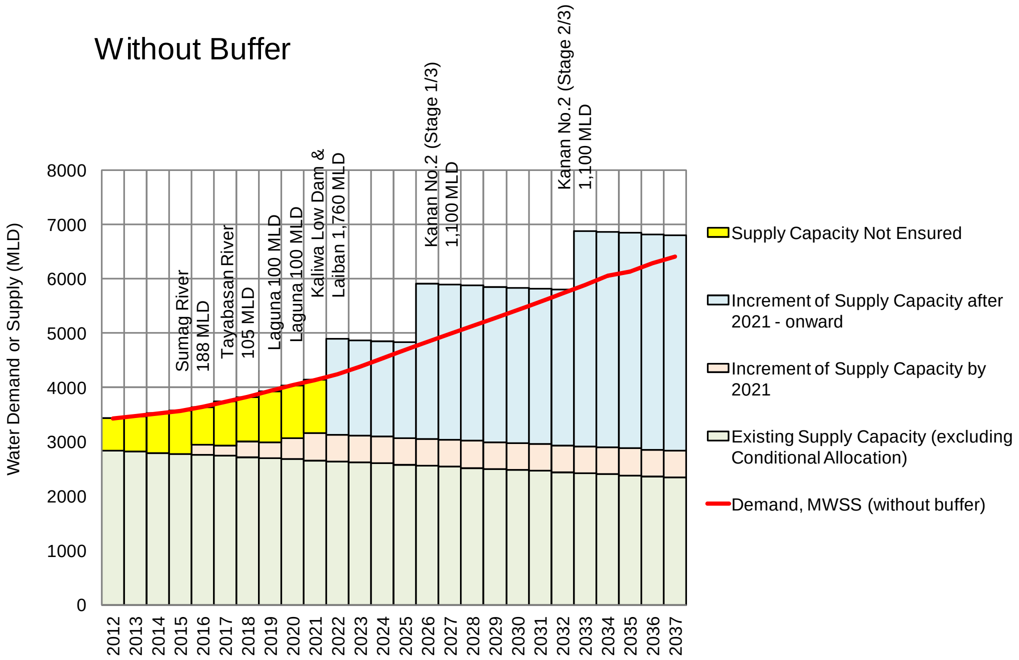
	Project	Year	Capacity (MLD)	Remarks
	Angat & Umiray	(Existing)	(2,211)	Allocation to MWSS in 2037
	Laguna & Other	(Existing)	(132)	
(1)	Sumag River	2016	188	
(2)	Tayabasan River	2018	105	Dependability 90%
(3)	Laguna Lake	2020	100	
(4)	Laguna Lake	2021	100	
(5)	Laiban Reservoir + Kaliwa Low Dam	2022	1,760	
(6)	Kanan No.2 Reservoir, 1/3	2026	1,100	
(7)	Kanan No.2 Reservoir, 2/3	2033	1,100	
(8)	Kanan No.2 Reservoir, 3/3	(After 2037)	(1,100)	(5) + (6) + (7) + (8) = 5,060 MLD
	Total (1) to (7)		4,453	

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team

Due to the conditional allocation of 15 m^3/s excluded from the existing supply capacity of the Angat Reservoir, the supply capacity is not ensured by 2021. Anticipated annual gaps are in the range of 6.9 m^3/s to 11.4 m^3/s (595 MLD to 984 MLD).

According to the Metro Manila Water Security Study carried out by the World Bank, the Laiban Reservoir and the Kaliwa Low Dam will be implemented for a period of ten years. The earliest commissioning of the Laiban Reservoir coupled with the Kaliwa Low Dam (20.4 m^3/s=1760 MLD) is expected to take place in 2022 accordingly.

To cope with the increase of water demand afterward, the succeeding water resources developments will need to be completed by 2026 and onwards. The Metro Manila Water Security Study considers that the Kanan No. 2 Reservoir will be developed in the manner of a stage-wise implementation with 12.7 m^3/s (1100 MLD) × three stages and the first stage implementation will take 13 years. Therefore, the first stage of the Kanan No. 2 Reservoir will be able to start its operation in 2026. Subsequently, the second stage of the Kanan No. 2 Reservoir will need to start its operation in 2033.



Source: Prepared by the JICA Study Team

Figure 10.3.1 Water Demand and Supply Balance–Metro Manila Water Supply (without Buffer), Laiban Reservoir and Associated Developments

(2) Agos Reservoir and Associated Developments

A required increment of water supply capacity is 47.1 m^3/s (4067 MLD) towards 2037. The roadmap proposed by the World Bank study includes the projects to be implemented by 2021 with the total supply capacity of 5.7 m^3/s (493 MLD). The remaining 41.4 m^3/s (3574 MLD) needs to be developed later on in the Agos River basin. Resulting from the water balance calculations, the Agos Reservoir and associated developments will increment the capacity of 50.7 m^3/s (4378 MLD) towards 2037 as shown in Table 10.3.3 below.

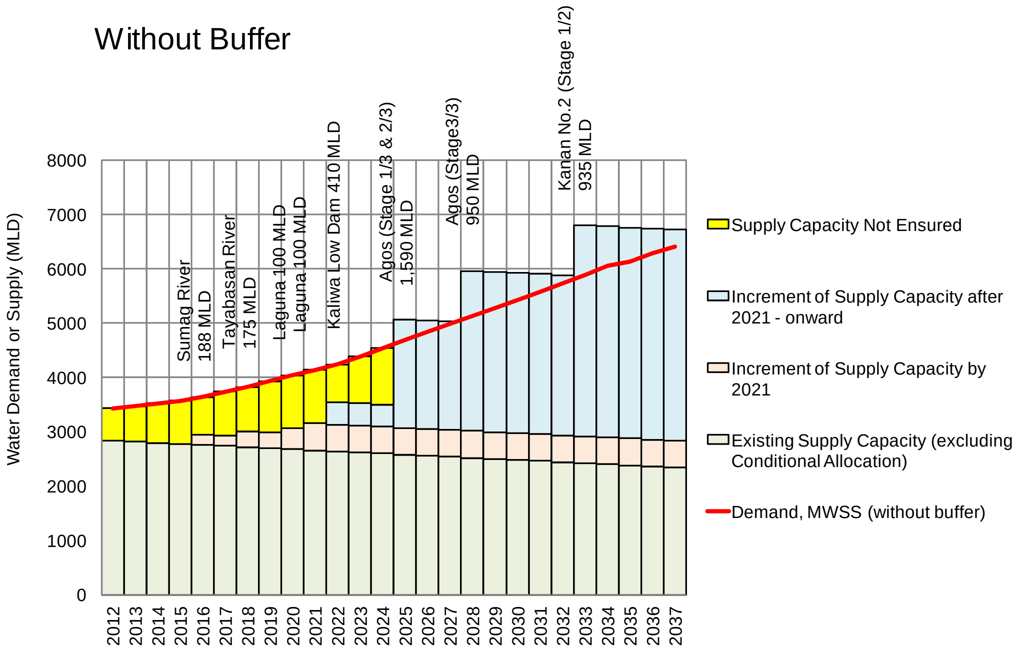
Table 10.3.3 Water Resources Development for Metro Manila Water Supply (without Buffer), Agos Reservoir and Associated Developments

Project	Year	Capacity (MLD)	Remarks
Angat & Umiray	(Existing)	(2,211)	Allocation to MWSS in 2037
Laguna & Other	(Existing)	(132)	
(1) Sumag River	2016	188	
(2) Tayabasan River	2018	105	Dependability 90%
(3) Laguna Lake	2020	100	
(4) Laguna Lake	2021	100	
(5) Laiban Reservoir + Kaliwa Low Dam	2022	1,760	
(6) Kanan No.2 Reservoir, 1/3	2026	1,100	
(7) Kanan No.2 Reservoir, 2/3	2033	1,100	
(8) Kanan No.2 Reservoir, 3/3	(After 2037)	(1,100)	(5) + (6) + (7) + (8) = 5,060 MLD
Total (1) to (7)		4,453	

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team

Due to the conditional allocation of 15 m^3/s excluded from the existing supply capacity of the Angat Reservoir, the supply capacity is not ensured by 2024. Anticipated annual gaps are in the range of 6.9 m^3/s to 12.0 m^3/s (595 MLD to 1034 MLD).

According to the Metro Manila Water Security Study carried out by the World Bank, the Kaliwa Low Dam will be implemented for a the period of ten years. The earliest commissioning of the Kaliwa Low Dam (4.7 m^3/s=410 MLD) is expected to take place in 2022 accordingly.



Source: Prepared by the JICA Study Team

Figure 10.3.2 Water Demand and Supply Balance–Metro Manila Water Supply (without Buffer), Agos Reservoir and Associated Developments

The Metro Manila Water Security Study considers that the development of the Agos Reservoir will be phased into three stages and the first stage implementation will take 13 years. The first stage of the Agos Reservoir (11.5 m^3/s=1000 MLD; consisting of 410 MLD by the Kaliwa Low Dam and the increment of 590 MLD) will start its operation in 2025 accordingly. To cope with the water demand, the second stage (11.5 m^3/s=1000 MLD) will be accelerated in the early commissioning together with the first stage.

The third stage of the Agos Reservoir (11.0 m^3/s=950 MLD) will start its operation in 2028. Afterward, the first stage of the augmentation by the Kanan No. 2 Reservoir will start its operation in 2033.

10.3.3 Water Demand and Supply Balance of MWSS towards 2037 (with buffer)

(1) Laiban Reservoir and Associated Developments

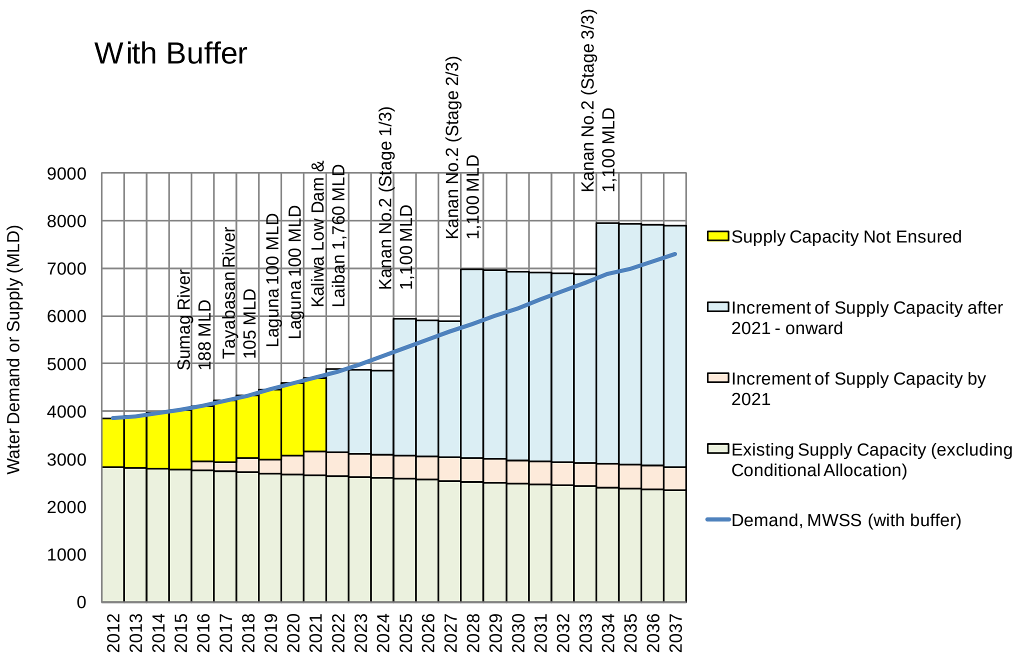
The required increment of water supply capacity is 57.3 m^3/s (4949 MLD) towards 2037. The roadmap proposed by the World Bank study includes the projects to be implemented by 2021 with the total supply capacity of 5.7 m^3/s (493 MLD). The remaining 51.6 m^3/s (4456 MLD) needs to be developed afterward in the Agos River basin. Resulting from the water balance calculations, the Laiban Reservoir and associated developments will increase the capacity to 64.3 m^3/s (5553 MLD) towards 2037 as shown in Table 10.3.4 below.

Table 10.3.4 Water Resources Development for Metro Manila Water Supply (with Buffer), Laiban Reservoir and Associated Developments

Project	Year	Capacity (MLD)	Remarks
Angat & Umiray	(Existing)	(2,211)	Allocation to MWSS in 2037
Laguna & Other	(Existing)	(132)	
(1) Sumag River	2016	188	
(2) Tayabasan River	2018	105	Dependability 90%
(3) Laguna Lake	2020	100	
(4) Laguna Lake	2021	100	
(5) Laiban Reservoir + Kaliwa Low Dam	2022	1,760	
(6) Kanan No.2 Reservoir, 1/3	2025	1,100	
(7) Kanan No.2 Reservoir, 2/3	2028	1,100	
(8) Kanan No.2 Reservoir, 3/3	2034	1,100	(5) + (6) + (7) + (8) = 5,060 MLD
Total (1) to (8)		5,553	

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team

Anticipated annual gaps in 2021 are in the range of 11.7 m^3/s to 17.9 m^3/s (1015 MLD to 1545 MLD). The earliest commissioning of the Laiban Reservoir coupled with the Kaliwa Low Dam is expected to take place in 2022. Subsequently, the Kanan No. 2 Reservoir will be fully developed by 2037; first stage by 2025, second stage by 2028, and third stage by 2034.



Source: Prepared by the JICA Study Team

Figure 10.3.3 Water Demand and Supply Balance–Metro Manila Water Supply (with Buffer), Laiban Reservoir and Associated Developments

(2) Agos Reservoir and Associated Developments

A required increment of water supply capacity is 57.3 m^3/s (4949 MLD) towards 2037. The roadmap proposed by the World Bank study includes the projects to be implemented by 2021 with the total supply capacity of 5.7 m^3/s (493 MLD). The remaining 51.6 m^3/s (4456 MLD) needs to be developed afterward in the Agos River basin. Resulting from the water balance calculations, the Laiban Reservoir and associated developments will increase the capacity to 61.5 m^3/s (5313 MLD) towards 2037 as shown in Table 10.3.5 below.

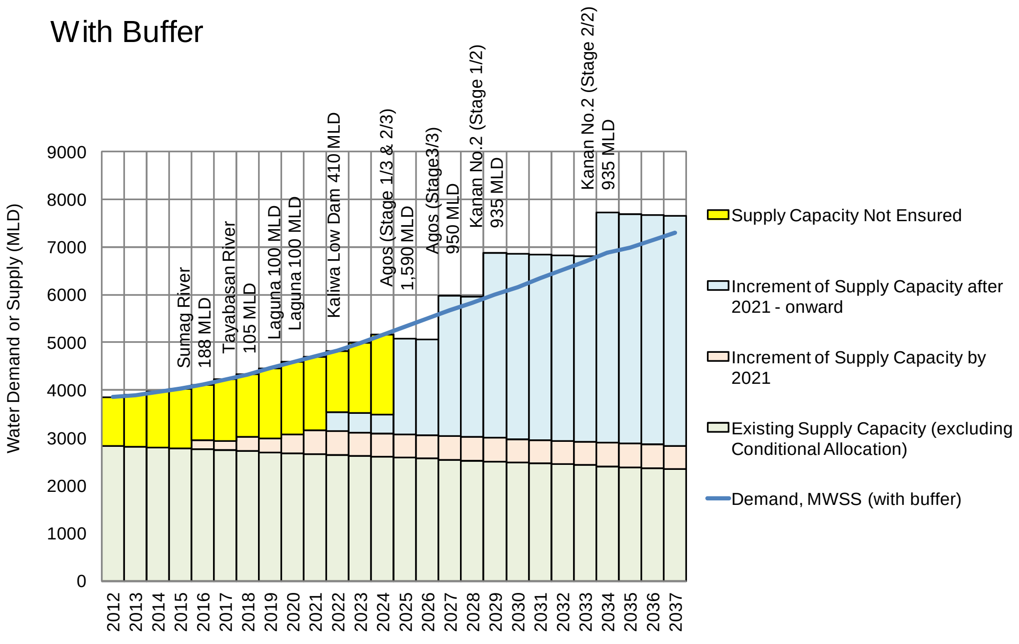
Table 10.3.5 Water Resources Development for Metro Manila Water Supply (with Buffer), Agos Reservoir and Associated Developments

Project	Year	Capacity (MLD)	Remarks
Angat & Umiray	(Existing)	(2,211)	Allocation to MWSS in 2037
Laguna & Other	(Existing)	(132)	
(1) Sumag River	2016	188	
(2) Tayabasan River	2018	105	Dependability 90%
(3) Laguna Lake	2020	100	
(4) Laguna Lake	2021	100	
(5) Kaliwa Low Dam	2022	410	Dependability 90%
(6) Agos Reservoir, Stage 1/3 and 2/3	2025	1,590	(5) + (6) = 2,000 MLD
(7) Agos Reservoir, Stage 3/3	2027	950	(6) + (7) = 2,950 MLD
(8) Kanan No.2 Reservoir, Stage 1/2	2029	935	
(9) Kanan No.2 Reservoir, Stage 2/2	2034	935	(5) + (6) + (7) + (8) + (9) = 4,820 MLD
Total (1) to (9)		5,313	

Note: Capacity is estimated as of 2037.

Source: Prepared by the JICA Study Team

Anticipated annual gaps by 2024 are in the range of 11.7 m^3/s to 19.3 m^3/s (1015 MLD to 1665 MLD). The earliest commissioning of the Kaliwa Low Dam is expected to take place in 2022. The first and second stages of the Agos Reservoir (23.1 m^3/s=2000 MLD; consisting of 410 MLD by the Kaliwa Low Dam and the increment of 1590 MLD) will start its operation in 2025. The third stage of the Agos Reservoir will be developed by 2027. Afterward, the augmentation by the Kanan No. 2 Reservoir will be fully developed before 2037; first stage by 2029 and second stage by 2034.



Source: Prepared by the JICA Study Team

Figure 10.3.4 Water Demand and Supply Balance–Metro Manila Water Supply (with Buffer), Agos Reservoir and Associated Developments

10.4 Metro Manila Water Supply–Impact Assessment under Climate Change Conditions

10.4.1 Angat River Basin

(1) Calculation Cases

The water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change impact assessment and runoff simulation for each of the river basins. Based on the results of Case 06 corresponding the assumed water allocation from the Angat Reservoir (refer to Figure 10.1.5 before), six cases under the climate change conditions are tested to assess the climate change impact as shown in Table 10.4.1.

Table 10.4.1 Water Balance Calculation Cases–Angat River Basin (under Climate Change Conditions)

Case	Water Resource	Water Demand	Projected Water Allocation	
27 28 29	With Project	Future (2040)	MWSS 27.1 m^3/s Local 8.8 m^3/s Drought Safety Level: Not Specified	AMRIS 19.6 m^3/s Local 0.6 m^3/s Drought Safety Level: 1/5
30 31 32			Water allocation dependability with drought safety level of 1/10	AMRIS 19.6 m^3/s Local 0.6 m^3/s Drought Safety Level: 1/5

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).
Source: Prepared by the JICA Study Team

(2) Results–Dependability

Table 10.4.2 and Figure 10.4.1 show the change in the dependability of the projected supply in six cases under the climate change conditions.

Table 10.4.2 Results of Water Balance Calculations: Dependability–Angat River Basin (under Climate Change Conditions)

M & I Water Supply 35.9 m^3/s (3,100 MLD)

Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand – Drought Year 1/2	1/5	1/10	1/20
06B	(Recorded Climate)	1968-2010	98.4%	100.0%	100.0%	100.0%	98.8%
27	csiro_mk3_0	2031-2050	99.2%	100.0%	100.0%	99.3%	98.3%
28	gfdl_cm2_0	2031-2050	99.6%	100.0%	100.0%	100.0%	99.6%
29	gfdl_cm2_1	2031-2050	99.2%	100.0%	100.0%	100.0%	94.3%
30	ingv_echam4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
31	ipsl_cm4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
32	miroc3_2_medres	2031-2050	96.7%	100.0%	100.0%	96.0%	92.5%

Agriculture 20.2 m^3/s (1,750 MLD)

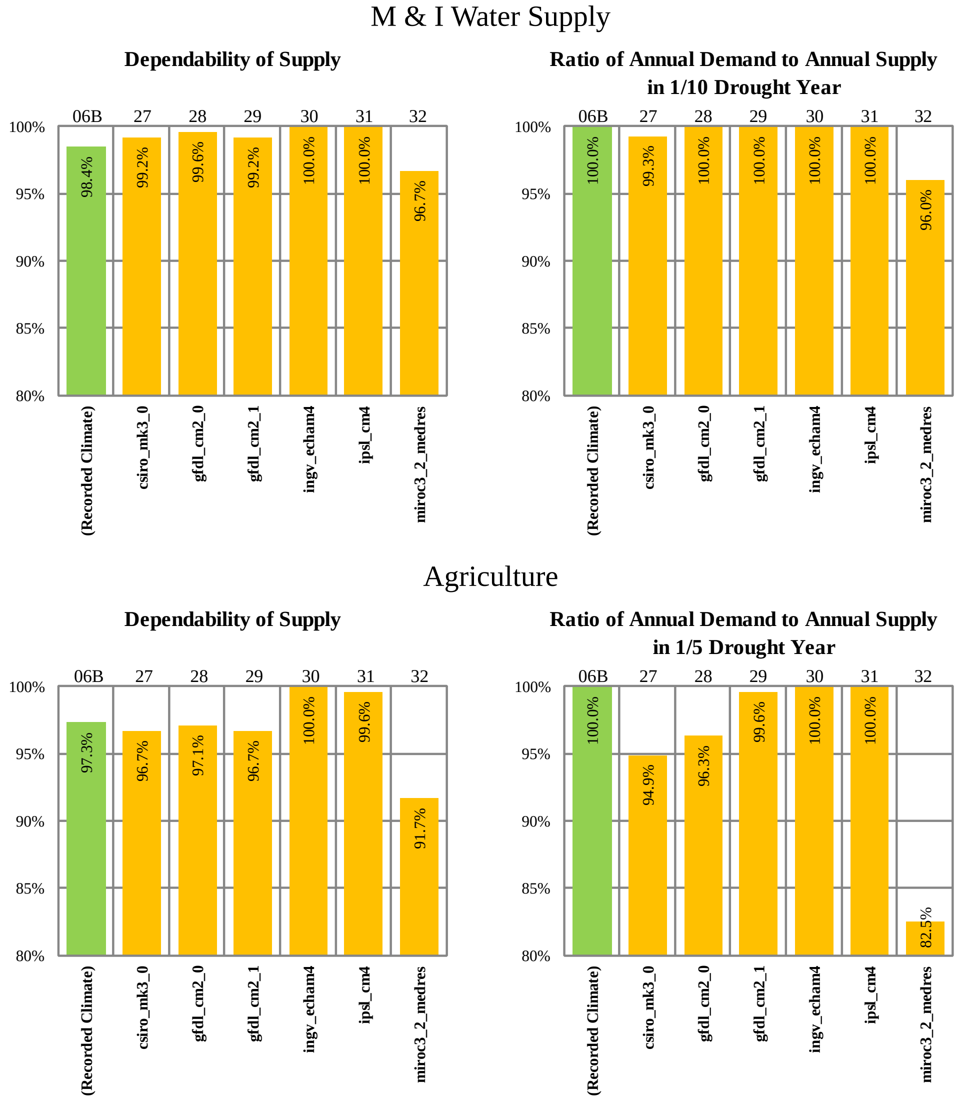
Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand – Drought Year 1/2	1/5	1/10	1/20
06B	(Recorded Climate)	1968-2010	97.3%	100.0%	100.0%	89.2%	85.2%
27	csiro_mk3_0	2031-2050	96.7%	100.0%	94.9%	91.4%	90.5%
28	gfdl_cm2_0	2031-2050	97.1%	100.0%	96.3%	90.9%	53.5%
29	gfdl_cm2_1	2031-2050	96.7%	100.0%	99.6%	93.2%	54.6%
30	ingv_echam4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
31	ipsl_cm4	2031-2050	99.6%	100.0%	100.0%	100.0%	99.9%
32	miroc3_2_medres	2031-2050	91.7%	100.0%	82.5%	71.2%	69.6%

Note: Change from Case 06B; Red-Better, Black-Minor (within +/- 1%), Worse-Blue
Source: Prepared by the JICA Study Team

Case 06B gives the projected water supply capacity from the Angat Reservoir at 35.9 m^3/s for M & I water supply in a 1/10 drought year and 20.2 m^3/s for agriculture in a 1/5 drought year.

The climate change impact on the dependability of supply for M & I water supply is regarded as better in three cases, minor in two cases, and worse in one case. The climate change impact on the ratio of annual demand to annual supply in a 1/10 drought year is found to be none in four cases, minor in one case, and worse in one case.

The climate change impact on the dependability of supply for agriculture is regarded as better in two cases, minor in three cases, and worse in one case. The climate change impact on the ratio of annual demand to annual supply in a 1/5 drought year is found to be none in two cases, minor in one case, and worse in three cases.



Source: Prepared by the JICA Study Team

Figure 10.4.1 Climate Change Impact on M & I Water Supply and Agriculture–Angat River Basin

(3) Results–Supply Capacity in 1/10 Drought Year

Case 06B indicates the water supply capacity of the Angat Reservoir as 53.8 m^3/s in a 1/10 drought year. Table 10.4.3 shows the change in the water supply capacity under the climate change conditions. In terms of the total water supply capacity, the climate change impact is regarded as better in three cases, minor in two cases and worse in one case. The water supply capacity under the climate change conditions ranges from 60.7 m^3/s (Case 31) to 48.3 m^3/s (Case 32).

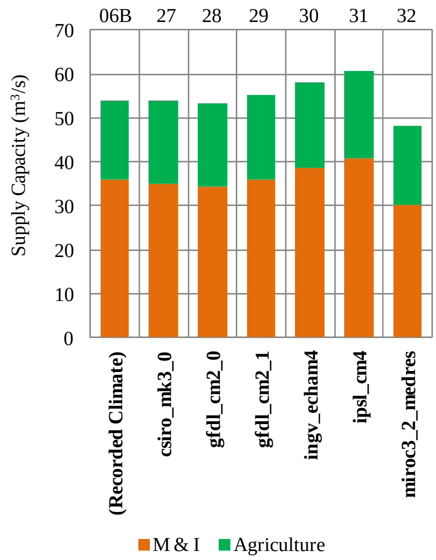
Table 10.4.3 Results of Water Balance Calculations: Supply Capacity in 1/10 Drought Year–Angat River Basin (under Climate Change Conditions)

Unit: m^3/sec

Case	GCM for Hydrological Data Set	M & I Water Supply	Agriculture	Total
06B	(Recorded Climate)	35.9	17.9	53.8
27	csiro_mk3_0	35.0	19.3	54.3
28	gfdl_cm2_0	34.4	19.2	53.6
29	gfdl_cm2_1	37.3	19.3	56.6
30	ingv_echam4	39.3	19.4	58.7
31	ipsl_cm4	41.4	19.3	60.7
32	miroc3_2_medres	30.3	18.0	48.3
Max		41.4	19.4	60.7
Ave		36.3	19.1	55.4
Min		30.3	18.0	48.3

Note: Change from Case 06B; Red-Better, Black-Minor (within +/-1%), Worse-Blue

Source: Prepared by the JICA Study Team



10.4.2 Agos River Basin–Laiban Reservoir and Associated Developments

(1) Calculation Cases

The water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change analysis and runoff simulation for the Agos River basin. Based on the results of Case 103 (Laiban Reservoir + Kaliwa Intake + Kanan No. 2 Reservoir), six cases under the climate change conditions are tested to assess the climate change impact as shown in Table 10.4.4.

Table 10.4.4 Water Balance Calculation Cases–Laiban Reservoir and Associated Developments (under Climate Change Conditions)

Case	Water Resources	Water Demand	Projected Water Allocation
110 111 112 113 114 115	With Project ● Laiban Reservoir ● Kaliwa Intake ● Kanan No. 2 Reservoir	Future (2040)	Preconditions: ● Drought safety level of 1/10 is ensured for the projected water allocation for M & I water supply within the Agos River basin. ● Drought safety level of 1/5 is ensured for the projected water allocation for agriculture within the Agos River basin. Water allocation to MWSS: 58.6 m^3/s (5060 MLD) Water conveyance from the Kanan No. 2 Reservoir to the Laiban Reservoir is 38.3 m^3/s (3310 MLD).

Source: Prepared by the JICA Study Team

(2) Results–Dependability

Table 10.4.5 and Figure 10.4.2 show the change in dependability of the projected supply capacity under the climate change conditions. Case 103 gives the projected water supply capacity of the Laiban Reservoir and associated developments at 58.6 m^3/s for MWSS in a 1/10 drought year.

The climate change impact on the dependability of supply for MWSS is regarded as better in three cases and worse in three cases. The climate change impact on the ratio of annual demand to annual supply in a 1/10 drought year is found to be none in three cases and worse in three cases.

Table 10.4.5 Results of Water Balance Calculations: Dependability–Laiban Reservoir and Associated Developments (under Climate Change Conditions)

M & I Water Supply - MWSS 58.6 m^3/s (5,060 MLD)

Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
103	(Recorded Climate)	1981-2010	97.5%	100.0%	100.0%	100.0%	86.8%
110	csiro_mk3_0	2031-2050	99.2%	100.0%	100.0%	100.0%	99.4%
111	gfdl_cm2_0	2031-2050	84.6%	100.0%	91.9%	77.4%	60.7%
112	gfdl_cm2_1	2031-2050	96.3%	100.0%	100.0%	97.4%	89.7%
113	ingv_echam4	2031-2050	99.2%	100.0%	100.0%	100.0%	97.6%
114	ipsl_cm4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
115	miroc3_2_medres	2031-2050	92.1%	100.0%	97.2%	92.5%	91.1%

M & I Water Supply - Local 2.0 m^3/s (170 MLD)

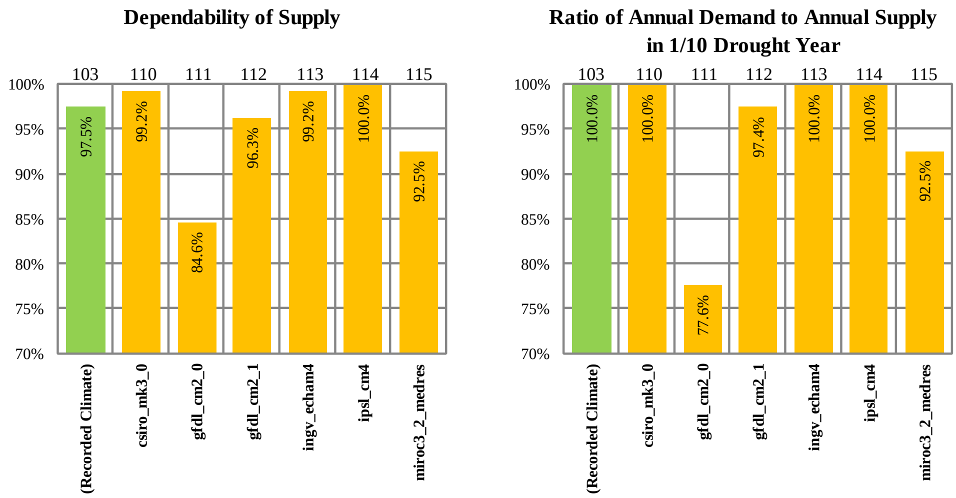
Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
103	(Recorded Climate)	1981-2010	99.7%	100.0%	100.0%	100.0%	100.0%
110	csiro_mk3_0	2031-2050	99.6%	100.0%	100.0%	100.0%	98.6%
111	gfdl_cm2_0	2031-2050	99.2%	100.0%	100.0%	100.0%	99.3%
112	gfdl_cm2_1	2031-2050	99.6%	100.0%	100.0%	100.0%	97.4%
113	ingv_echam4	2031-2050	99.6%	100.0%	100.0%	100.0%	99.2%
114	ipsl_cm4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
115	miroc3_2_medres	2031-2050	99.6%	100.0%	100.0%	100.0%	99.4%

Agriculture - NIS and Local 3.1 m^3/s (270 MLD)

Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
103	(Recorded Climate)	1981-2010	98.9%	100.0%	100.0%	99.6%	95.7%
110	csiro_mk3_0	2031-2050	99.2%	100.0%	100.0%	97.5%	94.9%
111	gfdl_cm2_0	2031-2050	96.3%	100.0%	96.0%	94.7%	91.6%
112	gfdl_cm2_1	2031-2050	99.2%	100.0%	100.0%	100.0%	99.2%
113	ingv_echam4	2031-2050	99.2%	100.0%	100.0%	99.6%	96.2%
114	ipsl_cm4	2031-2050	99.6%	100.0%	100.0%	100.0%	99.3%
115	miroc3_2_medres	2031-2050	98.8%	100.0%	100.0%	99.9%	99.9%

Note: Change from Case 06B; Red-Better, Black-Minor (within +/- 1%), Worse-Blue

Source: Prepared by the JICA Study Team



Source: Prepared by the JICA Study Team

Figure 10.4.2 Climate Change Impact on Water Supply for MWSS–Laiban Reservoir and Associated Developments

(3) Results–Supply Capacity in 1/10 Drought Year

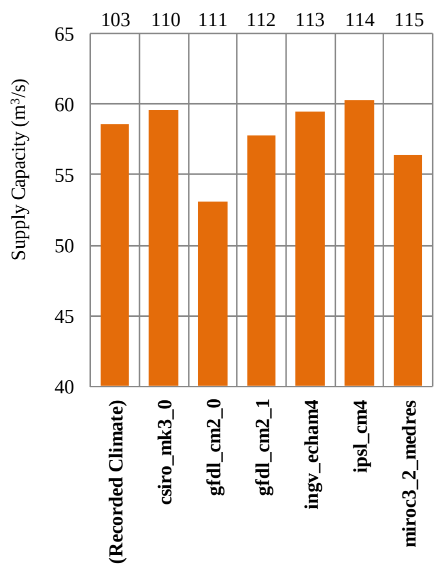
Table 10.4.6 shows the change in the water supply capacity under the climate change conditions. Case 103 indicates the water supply capacity for MWSS at 58.6 m^3/s in a 1/10 drought year.

In terms of the water supply capacity, the climate change impact is regarded as better in three cases and worse in three cases. The water supply capacity under the climate change conditions ranges from 60.3 m^3/s (Case 114) to 53.1 m^3/s (Case 111).

Table 10.4.6 Supply Capacity for MWSS in 1/10 Drought Year–Laiban Reservoir and Associated Developments (under Climate Change Conditions)

Unit: m^3/s

Case	GCM for Hydrological Data Set	Laiban + Kaliwa L + Kanan 2
103	(Recorded Climate)	58.6
110	csiro_mk3_0	59.6
111	gfdl_cm2_0	53.1
112	gfdl_cm2_1	57.8
113	ingv_echam4	59.5
114	ipsl_cm4	60.3
115	miroc3_2_medres	56.4
Max		60.3
Ave		57.8
Min		53.1



Note: Change from Case 103; Red-Better, Black-Minor (within +/-1%), Worse-Blue

Source: Prepared by the JICA Study Team

10.4.3 Agos River Basin–Agos Reservoir and Associated Developments

(1) Calculation Cases

The water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change analysis and runoff simulation for the Agos River basin. Based on the results of Case 106 (Kaliwa Low Dam + Agos Reservoir + Kanan No. 2 Reservoir), six cases under the climate change conditions are tested to assess the climate change impact as shown in Table 10.4.6.

Table 10.4.7 Water Balance Calculation Cases–Agos Reservoir and Associated Developments (under Climate Change Conditions)

Case	Water Resource	Water Demand	Projected Water Allocation
117 118 119 120 121 122	With Project ● Kaliwa Intake ● Agos Reservoir ● Kanan No. 2 Reservoir	Future (2040)	Preconditions: ● Drought safety level of 1/10 is ensured for the projected water allocation for M & I water supply within the Agos River basin. ● Drought safety level of 1/5 is ensured for the projected water allocation for agriculture within the Agos River basin. Water Allocation to MWSS: 55.8 m^3/sec (4820 MLD) The development of the Agos Reservoir consists of the water intake/conveyance for MWSS as well as the hydropower. Besides the water allocation for MWSS, 25.6 m^3/s (2210 MLD) is used for the hydropower with a dependability of 90%. As a future development, the Agos Reservoir receives firm-up water flows of 38.3 m^3/s (3310 MLD) released from the Kanan No. 2 Reservoir.

Source: Prepared by the JICA Study Team

(2) Results–Dependability

Table 10.4.8 and Figure 10.4.3 show the change in dependability of the projected supply capacity under the climate change conditions. Case 106 gives the projected water supply capacity of the Agos Reservoir and associated developments at 55.8 m^3/sec for MWSS in a 1/10 drought year.

The climate change impact on the dependability of supply for MWSS is regarded as better in four cases, minor in one case, and worse in one case. The climate change impact on ratio of annual demand to annual supply in a 1/10 drought year is found to be none in four cases, minor in one case, and worse in one case.

Table 10.4.8 Results of Water Balance Calculations: Dependability–Agos Reservoir and Associated Developments (under Climate Change Conditions)

M & I Water Supply - MWSS 55.8 m^3/s (4,820 MLD)

Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
106	(Recorded Climate)	1981-2010	98.1%	100.0%	100.0%	100.0%	90.4%
117	csiro_mk3_0	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
118	gfdl_cm2_0	2031-2050	97.1%	100.0%	100.0%	99.5%	63.3%
119	gfdl_cm2_1	2031-2050	98.3%	100.0%	100.0%	97.7%	88.1%
120	ingv_echam4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
121	ipsl_cm4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
122	miroc3_2_medres	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%

M & I Water Supply - Local 2.0 m^3/s (170 MLD)

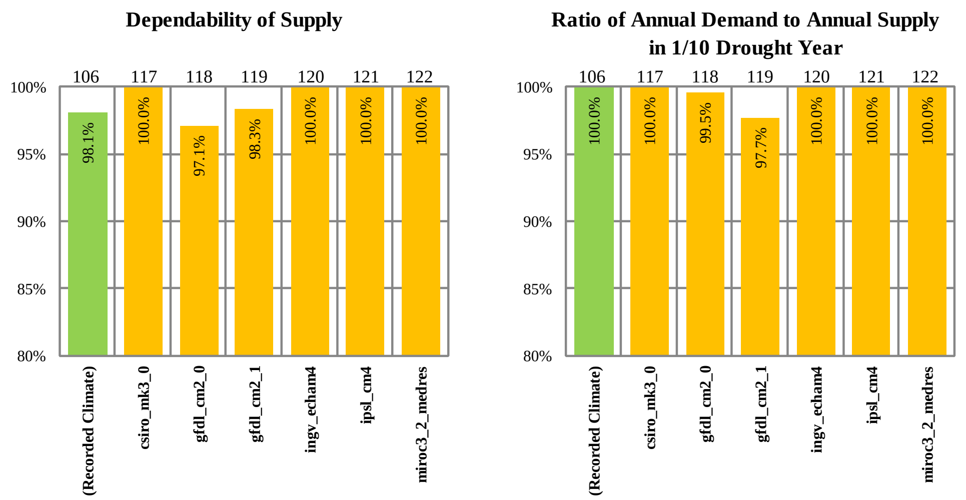
Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
106	(Recorded Climate)	1981-2010	99.7%	100.0%	100.0%	100.0%	100.0%
117	csiro_mk3_0	2031-2050	99.6%	100.0%	100.0%	100.0%	98.8%
118	gfdl_cm2_0	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
119	gfdl_cm2_1	2031-2050	99.6%	100.0%	100.0%	100.0%	96.3%
120	ingv_echam4	2031-2050	99.6%	100.0%	100.0%	100.0%	98.8%
121	ipsl_cm4	2031-2050	100.0%	100.0%	100.0%	100.0%	100.0%
122	miroc3_2_medres	2031-2050	99.6%	100.0%	100.0%	100.0%	99.7%

Agriculture 3.1 m^3/s (270 MLD)

Case	GCM for Hydrological Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
106	(Recorded Climate)	1981-2010	98.1%	100.0%	100.0%	97.8%	96.4%
117	csiro_mk3_0	2031-2050	98.8%	100.0%	100.0%	99.6%	97.6%
118	gfdl_cm2_0	2031-2050	95.4%	100.0%	99.9%	98.6%	91.9%
119	gfdl_cm2_1	2031-2050	99.6%	100.0%	100.0%	100.0%	100.0%
120	ingv_echam4	2031-2050	99.2%	100.0%	100.0%	99.5%	97.6%
121	ipsl_cm4	2031-2050	99.6%	100.0%	100.0%	100.0%	99.7%
122	miroc3_2_medres	2031-2050	97.5%	100.0%	99.6%	99.3%	99.3%

Note: Change from Case 106; Red-Better, Black-Minor (within +/- 1%), Worse-Blue

Source: Prepared by the JICA Study Team



Source: Prepared by the JICA Study Team

Figure 10.4.3 Climate Change Impact on Water Supply for MWSS–Agos Reservoir and Associated Developments

(3) Results–Supply Capacity in 1/10 Drought Year

Table 10.4.9 shows the change in the water supply capacity under the climate change conditions. Case 106 indicates the water supply capacity for MWSS at 55.8 m^3/sec in a 1/10 drought year.

In terms of the water supply capacity, the climate change impact is regarded as better in three cases, minor in one case, and worse in two cases. The water supply capacity under the climate change conditions ranges from 61.7 m^3/s (Case 114) to 53.8 m^3/s (Case 118).

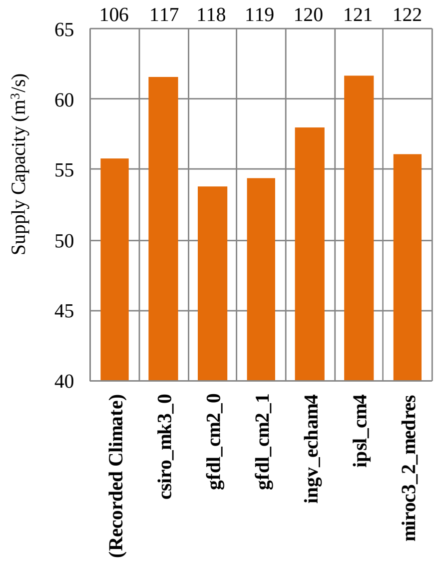
Table 10.4.9 Supply Capacity for MWSS in 1/10 Drought Year–Agos Reservoir and Associated Developments (under Climate Change Conditions)

Unit: m^3/s

Case	GCM for Hydrological Data Set	Kaliwa L + Agos + Kanan 2
106	(Recorded Climate)	55.8
117	csiro_mk3_0	61.6
118	gfdl_cm2_0	53.8
119	gfdl_cm2_1	54.4
120	ingv_echam4	58.0
121	ipsl_cm4	61.7
122	miroc3_2_medres	56.1
Max		61.7
Ave		57.6
Min		53.8

Note: Change from Case 106; Red-Better, Black-Minor (within +/- 1%), Worse-Blue

Source: Prepared by the JICA Study Team



10.4.4 Metro Manila Water Supply–Impact Assessment under Climate Change Condition

(1) Water Supply Capacity by Source

The supply capacity by source for the water supply in Metro Manila under the recorded climate condition and climate change conditions is listed in Table 10.4.10. It is assumed that all these would be the supply capacity in year 2040.

The supply capacity of the existing Angat Reservoir with the Umiray-Angat transbasin diversion is equivalent to the water allocation for MWSS in a 1/10 drought year after the deduction of the water allocation for M & I water supply and agriculture within the Angat River basin.

For the Tayabasan River and Kaliwa Low Dam, 90% dependable flow is adopted as the supply capacity since these are run-of-river scheme that does not have a storage capacity enough for regulating the seasonal variation of the river flow.

The supply capacity of the Laiban Reservoir or Agos Reservoir in combination with the Kanan No. 2 Reservoir is equivalent to the water allocation for MWSS in a 1/10 drought year.

The climate change impact on the supply capacity is assumed to be minor for the Laguna Lake and other sources.

Table 10.4.10 Water Supply Capacity by Source (under Climate Change Conditions)

Unit: m^3/s

GCM for Hydrological Data Set	Existing			Development by 2021		
	Angat Umiray	Laguna Lake & Other		Sumag River	Tayabasan River	Laguna Lake
(Recorded Climate)	24.9	1.5		2.2	1.2	2.3
csiro_mk3_0	24.2	1.5		2.0	1.8	2.3
gfdl_cm2_0	23.2	1.5		2.4	1.1	2.3
gfdl_cm2_1	25.7	1.5		2.8	1.5	2.3
ingv_echam4	28.4	1.5		2.1	1.5	2.3
ipsl_cm4	30.0	1.5		2.6	1.8	2.3
miroc3_2_medres	20.0	1.5		1.5	1.3	2.3

Unit: m^3/s

GCM for Hydrological Data Set	Laiban Reservoir and Associated Developments			Laiban Reservoir and Associated Developments		
	Laiban	Laiban + Kaliwa L	Laiban + Kaliwa L + Kanan 2	Kaliwa L	Kaliwa L + Agos	Kaliwa L + Agos + Kanan 2
(Recorded Climate)	20.1	20.4	58.6	4.7	34.1	55.8
csiro_mk3_0	21.3	21.3	59.6	5.7	43.6	61.6
gfdl_cm2_0	15.5	15.7	53.1	6.3	32.4	53.8
gfdl_cm2_1	19.4	19.8	57.8	4.7	30.7	54.4
ingv_echam4	21.1	21.4	59.5	5.1	34.6	58.0
ipsl_cm4	22.0	22.1	60.3	5.9	43.6	61.7
miroc3_2_medres	18.8	19.0	56.4	5.9	38.8	56.1

Source: Prepared by the JICA Study Team

(2) Water Supply Capacity by Scenario

Two scenarios of the water demand and supply balance towards 2037 are presented earlier in Section 10.3. The water supply capacity under the recorded climate condition and climate change conditions is summarized in Table 10.4.11 and Figure 10.4.4.

The Laiban Reservoir and associated developments will increase the total supply capacity up to 90.6 m^3/s (7824 MLD) under the recorded climate condition. The total supply capacity under the climate change condition ranges from 98.5 m^3/s (8334 MLD) to 83.0 m^3/s (7627 MLD).

The Agos Reservoir and associated developments will increase the total supply capacity up to 88.0 m^3/s (7600 MLD) under the recorded climate condition. The total supply capacity under the climate change condition ranges from 99.9 m^3/s (8452 MLD) to 82.8 m^3/s (7612 MLD).

Table 10.4.11 Combined Water Supply Capacity for Metro Manila (under Climate Change Conditions)

Laiban Reservoir and Associated Developments

Unit: m^3/s

GCM for Hydrological Data Set	Angat Umiray Sumag	Tayabasan Laguna Other	Laiban Kaliwa L Kanan 2	Total
(Recorded Climate)	27.1	5.1	58.6	90.8
csiro_mk3_0	26.2	5.7	59.6	91.5
gfdl_cm2_0	25.6	4.9	53.1	83.6
gfdl_cm2_1	28.5	5.3	57.8	91.6
ingv_echam4	30.5	5.3	59.5	95.3
ipsl_cm4	32.6	5.6	60.3	98.5
miroc3_2_medres	21.5	5.2	56.4	83.0
			Max	98.5
			Ave	90.6
			Min	83.0

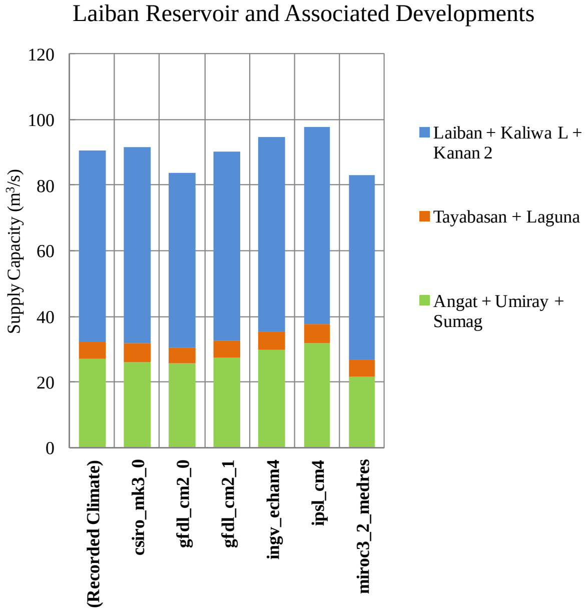
Agos Reservoir and Associated Developments

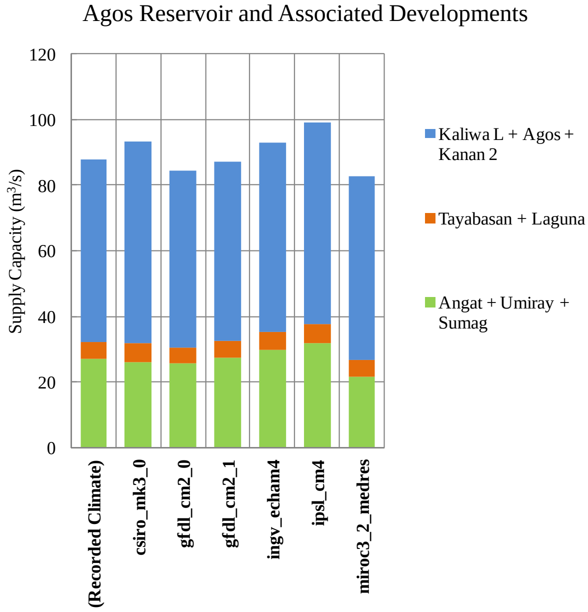
Unit: m^3/s

GCM for Hydrological Data Set	Angat Umiray Sumag	Tayabasan Laguna Other	Kaliwa L Agos Kanan 2	Total
(Recorded Climate)	27.1	5.1	55.8	88.0
csiro_mk3_0	26.2	5.7	61.6	93.4
gfdl_cm2_0	25.6	4.9	53.8	84.3
gfdl_cm2_1	28.5	5.3	54.4	88.2
ingv_echam4	30.5	5.3	58.0	93.8
ipsl_cm4	32.6	5.6	61.7	99.9
miroc3_2_medres	21.5	5.2	56.1	82.8
			Max	99.9
			Ave	90.4
			Min	82.8

Note: Change in Supply Capacity; Red-Better, Black-Minor (within +/- 1%), Worse-Blue

Source: Prepared by the JICA Study Team





Source: Prepared by the JICA Study Team

Figure 10.4.4 Combined Water Supply Capacity for Metro Manila (under Climate Change Conditions)

(3) Water Demand and Supply Balance towards 2037 under Climate Change Conditions

Figure 10.4.6 shows the water demand and supply balance towards 2037 under the climate change conditions. The timing of each water resource to be operational is the same as described earlier in Sub-section 10.3.2 (refer to Figure 10.3.1 and Figure 10.3.2).

The total supply capacity by year ranges between 'Climate Change Max' and 'Climate Change Min'. Table 10.4.12 shows a range of the climate change impact on the water supply capacity. It is recommended that the water supply capacity of the Laiban Reservoir and associated developments in 2037 would be variable with a range of +8.8% to -8.5% on the water supply capacity estimated under the recorded climate condition. A suggested range is +15.8% to -3.4% on the water supply capacity of the Agos Reservoir and associated developments.

Table 10.4.12 Water Supply Capacity for Metro Manila under Climate Change Condition

Laiban Reservoir and Associated Developments

Unit: MLD

Year	2021	2022	2026	2033	2037
Recorded Climate	3,152	4,892	5,916	6,881	6,802
Climate Change Max.	3,320 +5.4%	5,135 +5.0%	6,252 +5.7%	7,382 +7.3%	7,399 +8.8%
Climate Change Min.	3,000 -4.8%	4,682 -4.3%	5,607 -5.2%	6,397 -7.0%	6,226 -8.5%

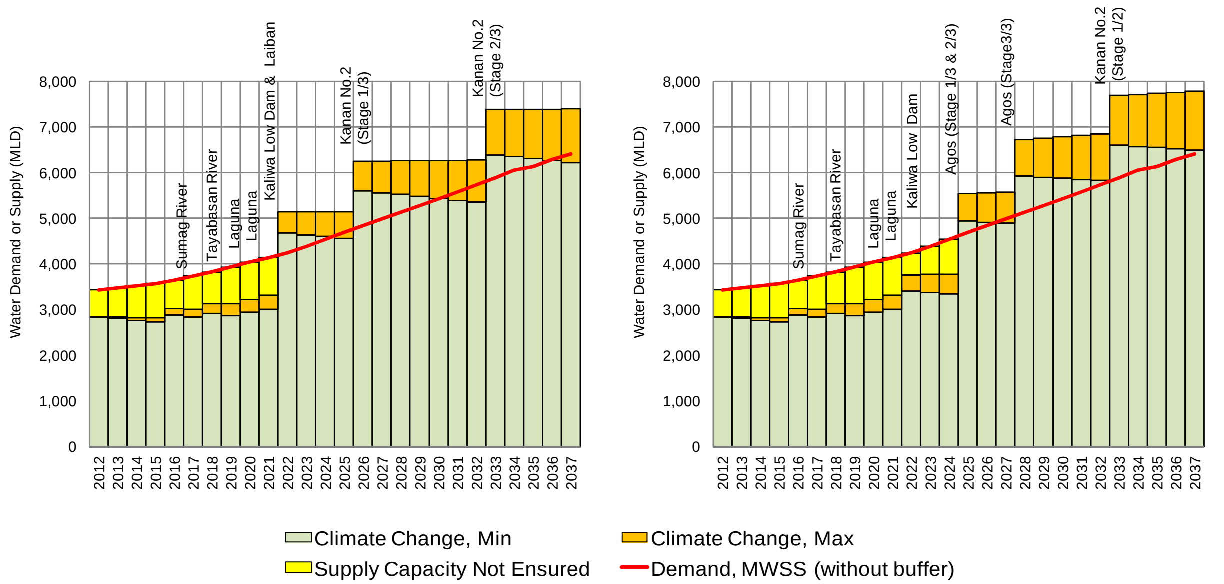
Agos Reservoir and Associated Developments

Unit: MLD

Year	2021	2025	2028	2033	2037
Recorded Climate	3,152	5,073	5,963	6,800	6,721
Climate Change Max.	3,320 +5.4%	5,537 +9.2%	6,732 +12.9%	7,692 +13.1%	7,783 +15.8%
Climate Change Min.	3,000 -4.8%	4,944 -2.5%	5,922 -0.7%	6,607 -2.8%	6,491 -3.4%

Source: Prepared by the JICA Study Team

Laiban Reservoir and Associated Developments | Agos Reservoir and Associated Developments



Source: Prepared by the JICA Study Team

Figure 10.4.5 Water Demand and Supply Balance–Metro Manila Water Supply (without buffer) under Climate Change Condition

(4) Water Demand and Supply Balance towards 2037 under Climate Change Condition–Worst Case

Under the climate change conditions, the dependable water allocation for MWSS is at the lowest in the hydrological data set for the period of 2031-2050 based on “miroc3_2_medres”.

Figure 10.4.6 shows the water demand and supply balance of MWSS towards 2037 under the climate change condition (“miroc3_2_medres”).

Compared with Figure 10.3.1 and Figure 10.3.2 shown before, both scenarios indicate the need of full development of the succeeding Kanan No. 2 Reservoir until 2037 under the climate change condition.

Table 10.4.13 Water Supply Capacity for Metro Manila under Climate Change Condition ("miroc3_2_medres")

Laiban Reservoir and Associated Developments

Project	Year	Capacity (MLD)
Angat & Umiray	(Existing)	(1,833)
Laguna & Other	(Existing)	(132)
(1) Sumag River	2016	136
(2) Tayabasan River	2018	114
(3) Laguna Lake	2020	100
(4) Laguna Lake	2021	100
(5) Laiban Reservoir + Kaliwa Low Dam	2022	1,653
(6) Kanan No.2 Reservoir, 1/3	2025	1,079
(7) Kanan No.2 Reservoir, 2/3	2031	1,079
(8) Kanan No.2 Reservoir, 3/3	2036	1,079
Total (1) to (8)		5,339

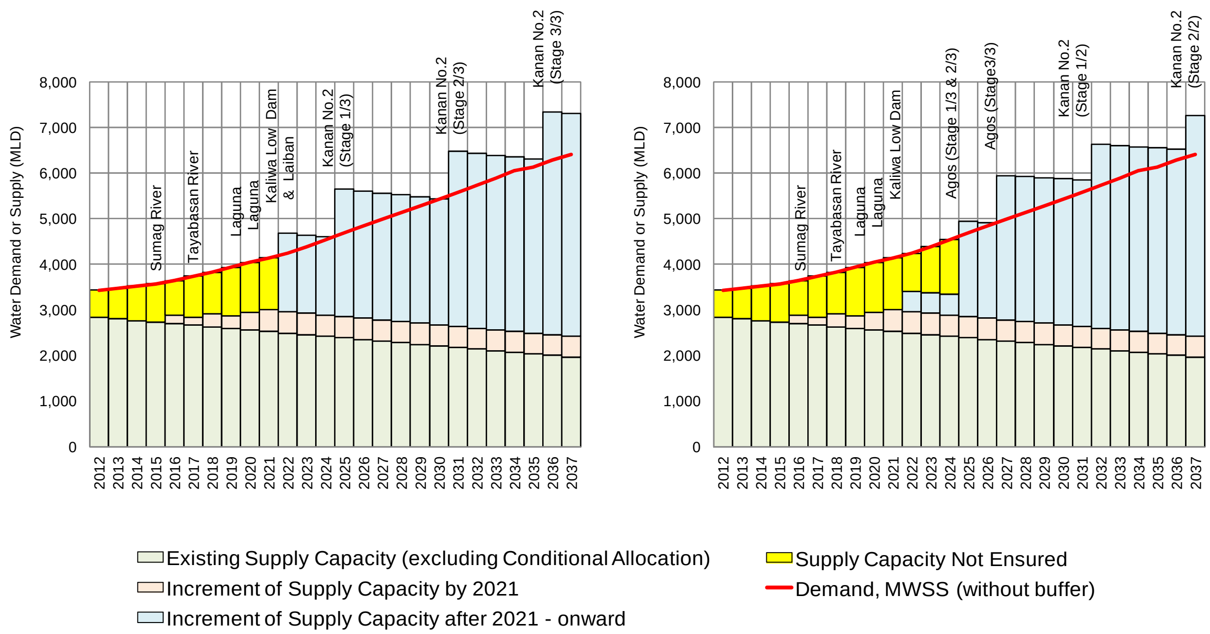
Agos Reservoir and Associated Developments

Project	Year	Capacity (MLD)
Angat & Umiray	(Existing)	(1,833)
Laguna & Other	(Existing)	(132)
(1) Sumag River	2016	136
(2) Tayabasan River	2018	114
(3) Laguna Lake	2020	100
(4) Laguna Lake	2021	100
(5) Kaliwa Low Dam	2022	2,205
(6) Agos Reservoir, Stage 1/3 and 2/3	2025	
(7) Agos Reservoir, Stage 3/3	2027	1,102
(8) Kanan No.2 Reservoir, Stage 1/2	2031	770
(9) Kanan No.2 Reservoir, Stage 2/2	2037	770
Total (1) to (8)		5,297

Source: Prepared by the JICA Study Team

Laiban Reservoir and Associated Developments

Agos Reservoir and Associated Developments



Source: Prepared by the JICA Study Team

Figure 10.4.6 Water Demand and Supply Balance–Metro Manila Water Supply (without Buffer) under Climate Change Condition ("miroc3_2_medres")

10.5 Pasig-Marikina River Basin

10.5.1 Water Resources

(1) Surface Water

Table 10.5.1 shows the availability of water resources in the Pasig-Marikina River basin under the 'Existing' condition based on the hydrological data set for the period of 1981-2010 (30 years).

Table 10.5.1 Water Resources Availability in the Pasig-Marikina River Basin

Existing Unit: m^3/s

Water Resources	Basin Area (km^2)	Average	Dependable Flow		
			80%	90%	95%
Location of Tayabasan Intake	75	4.13	0.38	0.25	0.22
Wawa	281	15.75	1.47	0.97	0.83
Sto Nino	512	25.44	1.81	1.11	0.96

Source: Prepared by the JICA Study Team

The Metro Manila Water Security Study carried out by the World Bank selected the following five project plans to be analyzed and the Tayabasan River Water Supply Project was finally listed up in the roadmap.

- Wawa Dam Project (50 MLD)
- Tayabasan River Water Supply Project (175 MLD)
- Wawa Water Supply Project (proposed by San Lorenzo Ruiz Builders, 300 MLD)
- Manila Northeast Water Supply Project (260 MLD)
- Marikina Multipurpose Dam Project (700 MLD)

According to the Metro Manila Water Security Study, the study on the Tayabasan River Water Supply Project was conducted by the Manila Water Company, Inc. (MWCI) to supply water to cope with the increasing demand in the Antipolo service area (Figure 10.5.1).

The project consists of a 53 m high concrete-buttress dam with a gross storage volume of 9.3 MCM for water intake, water treatment plant of 175 MCM (2.03 m^3/s), and treated water transmission facilities.

Source: Prepared by the JICA Study Team

Figure 10.5.1
Location of the Tayabasan Water Supply Project

(2) Groundwater

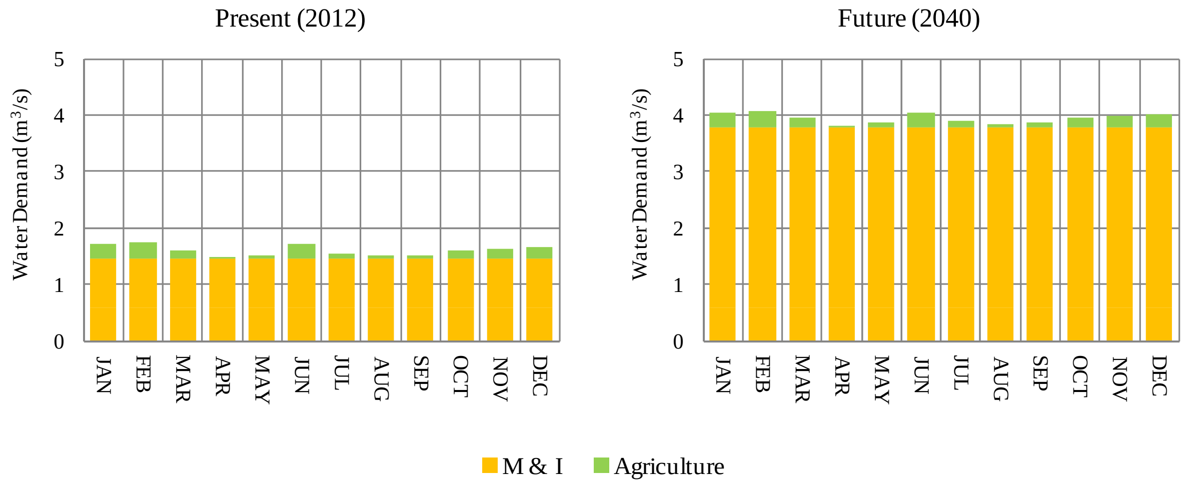
An exploitable groundwater yield refers to 0.60 m^3/s (52 MLD) as estimated in Sub-section 7.2.3.

10.5.2 Water Demands

Municipal and industrial (M & I) water demand within the Pasig-Marikina River basin is estimated at 1.45 m^3/s (125 MLD) at present (year 2012) and 3.79 m^3/s (327 MLD) in the future (year 2040) as described in Chapter 5 of this report.

The Pasig-Marikina River basin is entirely covered by the service area of MWSS (refer to Figure 7.3.1). Therefore, it is assumed that the surface water resources available and/or to be developed would be utilized to meet the M & I demands of both MWSS and other local uses within the river basin.

Averaged agriculture water demand in the Pasig-Marikina River basin in estimated at 0.15 m^3/s (13 MLD) at present (year 2012) and 0.16 m^3/s (14 MLD) in the future (year 2040) as described in Chapter 6 of this report.



Source: Prepared by the JICA Study Team

Figure 10.5.2 Water Demands within the Pasig-Marikina River Basin

10.5.3 Minimum Stream Flow Requirements

The minimum stream flow is defined as 10% of the dependable flow that is regarded as a discharge rate at 80% of a flow duration curve. The minimum flow requirements in the Pasig-Marikina River basin are listed in Table 10.5.3 below.

Table 10.5.2 Minimum Stream Flow Requirement in the Pasig-Marikina River Basin

Location	Basin Area (km^2)	Minimum Stream Flow Requirement (m^3/s)
Tayabasan Intake	75	0.038
Wawa	281	0.147
Sto Nino	512	0.181

Source: Prepared by the JICA Study Team

10.5.4 Drought Safety Level

Drought safety level of 1/10 should be ensured for M & I water supply. Water allocation for M & I water supply should be adequate during a drought year that would probably occur once in ten years (1/10 drought year). During a 1/10 drought year, there should be no deficit in allocating water to M & I water supply.

Drought safety level of 1/5 should be ensured for agriculture. Water allocation for agriculture should be adequate during a drought year that would probably occur once in five years (1/5 drought year). During a 1/5 drought year, there should be no deficit in allocating water to agriculture.

10.5.5 Water Balance Calculations

(1) Calculation Cases

Based on the hydrological data set for the period of 1981-2010 (30 years), the water balance calculations for the Pasig-Marikina River basin are performed in Cases 301, 302, and 303 as shown in Table 10.4.4 below.

Table 10.5.3 Water Balance Calculation Cases–Pasig-Marikina River Basin

Case	Water Resource	Water Demand	Projected Water Allocation
301	Existing	Present (2012)	M & I Water Supply: 0.85 m^3/s Agriculture: 0.15 m^3/s
302	Existing	Future (2040)	M & I Water Supply: 3.79 m^3/s Agriculture: 0.16 m^3/s
303	With Project ● Tayabasan Intake	Future (2040)	M & I Water Supply: 3.79 m^3/s Agriculture: 0.16 m^3/s

Source: Prepared by the JICA Study Team

(2) Results

Case 301 represents the present conditions of the Pasig-Marikina River basin. The projected water allocation for M & I water supply is satisfied for 303 months out of 360 months and dependability of supply is regarded as 84.2% (303/360). The ratio of annual supply to annual demand is 91.2% in a 1/10 drought year. The projected water allocation for agriculture is satisfied for 294 months out of 360 months and dependability of supply is regarded as 81.7% (294/360). The ratio of annual supply to annual demand is 76.0% in a 1/5 drought year.

Table 10.5.4 Results of Water Balance Calculations–Pasig-Marikina River Basin

No.	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis					
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply	Ratio of Annual Supply to Annual Demand: Drought Year				
								1/2	1/5	1/10	1/20	1/30
301	Existing	Present (2012)	M & I Water Supply	MWSS & Local	1.45	Not Specified	84.2% (303 / 360)	95.1%	92.3%	91.2%	88.1%	85.8%
			Agriculture	Local	0.15	Not Specified	81.7% (294 / 360)	90.4%	76.0%	71.6%	64.7%	61.3%
302	Existing	Future (2040)	M & I Water Supply	MWSS & Local	3.79	Not Specified	65.8% (237 / 360)	82.3%	78.8%	75.7%	73.6%	72.6%
			Agriculture	Local	0.16	Not Specified	65.6% (236 / 360)	71.9%	57.3%	57.0%	57.0%	31.6%
303	With Project	Future (2040)	M & I Water Supply	MWSS & Local	3.79	Not Specified	73.3% (264 / 360)	83.8%	80.3%	74.9%	74.8%	72.3%
			Agriculture	Local	0.16	Not Specified	72.5% (261 / 360)	71.9%	64.1%	58.1%	57.0%	57.0%

Source: Prepared by the JICA Study Team

Case 302 indicates that dependability of supply drops to 65.8% for M & I water supply and 65.6% for agriculture when the water demands increase towards the future (2040) without any water resources development.

Case 303 presents some improvements in dependability of supply with the Tayabasan Water Supply Project. But such improvements are limited with 73.3% for M & I water supply and 72.5% for agriculture.

An average flow at the intake of the Tayabasan is estimated at 4.13 m^3/s but varies from 0.32 m^3/s (March) to 10.92 m^3/s (August) in a year. A planned reservoir storage of 9.3 MCM is not large enough to supply 175 MLD (2.03 m^3/s) throughout the year. The dependability of the supply capacity of 2.03 m^3/s (175 MLD) is 70.6%. A flow rate with 90% dependability is estimated at 1.22 m^3/s (105 MLD).

10.5.6 Water Balance Calculations under Climate Change Conditions

(1) Calculation Cases

The water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change analysis and runoff simulation for the Pasig-Marikina River basin.

Based on the results of Case 303, six cases under the climate change conditions are tested to assess the climate change impact as shown in Table 10.5.5.

Table 10.5.5 Water Balance Calculation Cases–Pasig-Marikina River Basin (under Climate Change Conditions)

Case	Water Resource	Water Demand	Projected Water Allocation
303A 303B 303C 303D 303E 303F	With Project ● Tayabasan Intake	Future (2040)	M & I Water Supply: 3.79 m^3/s Agriculture: 0.16 m^3/s

Source: Prepared by the JICA Study Team

(2) Results

Case 303 gives the projected water supply capacity of 3.79 m^3/s for M & I water supply with a dependability of 73.3% under the recorded climate condition. Table 10.5.6 and Figure 10.5.3 show the change in the dependability of the projected supply capacity under the climate change conditions.

In terms of the dependability of M & I water supply, the climate change impact is regarded as better in four cases and worse in the other two cases. A ratio of annual demand to annual supply becomes better in three cases and worse in the other three cases.

Table 10.5.6 Results of Water Balance Calculations–Pasig-Marikina River Basin (under Climate Change Conditions)

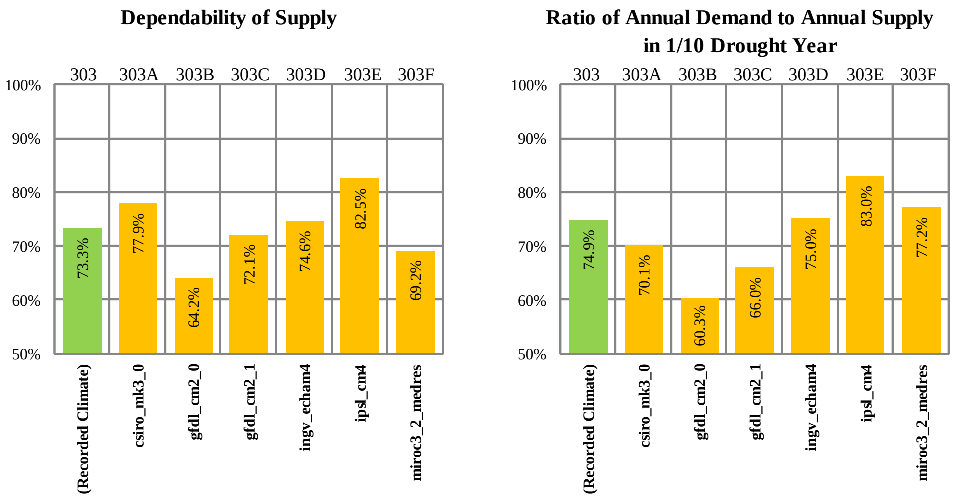
M & I Water Supply - MWSS & Local 3.79 m^3/s (327 MLD)

Case	Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
303	(Recorded Climate)	1981-2010	73.3%	83.8%	80.3%	74.9%	74.8%
303A	csiro_mk3_0	2031-2050	77.9%	90.8%	80.7%	70.1%	68.6%
303B	gfdl_cm2_0	2031-2050	64.2%	77.5%	63.5%	60.3%	50.0%
303C	gfdl_cm2_1	2031-2050	72.1%	88.2%	77.3%	66.0%	62.4%
303D	ingv_echam4	2031-2050	74.6%	86.7%	76.1%	75.0%	73.3%
303E	ipsl_cm4	2031-2050	82.5%	90.5%	86.4%	83.0%	82.5%
303F	miroc3_2_medres	2031-2050	69.2%	85.7%	79.9%	77.2%	74.3%

Agriculture - Local 0.16 m^3/s (13 MLD)

Case	Data Set	Period	Dependability of Supply	Ratio of Annual Supply to Annual Demand			
				Drought Year			
				1/2	1/5	1/10	1/20
303	(Recorded Climate)	1981-2010	72.5%	71.9%	64.1%	58.1%	57.0%
303A	csiro_mk3_0	2031-2050	76.7%	78.3%	57.3%	53.7%	43.5%
303B	gfdl_cm2_0	2031-2050	62.1%	57.3%	43.5%	43.3%	13.0%
303C	gfdl_cm2_1	2031-2050	70.8%	75.3%	49.6%	38.2%	33.8%
303D	ingv_echam4	2031-2050	72.5%	71.9%	51.2%	45.2%	43.5%
303E	ipsl_cm4	2031-2050	82.1%	90.2%	76.0%	71.9%	71.9%
303F	miroc3_2_medres	2031-2050	68.3%	71.9%	58.1%	57.8%	43.5%

Note: Change from Case 303; Red-Better, Black-Minor (within +/- 1%), Worse-Blue
Source: Prepared by the JICA Study Team



Source: Prepared by the JICA Study Team

Figure 10.5.3 Climate Change Impact on M & I Water Supply–Pasig-Marikina River Basin

10.5.7 Water Balance Calculations–Marikina Reservoir

(1) Water Balance Calculation–Based on Previous Reservoir Data

According to a preliminary analysis done by the Metro Manila Water Security Study, a possible development of the Marikina Multipurpose Reservoir for M & I water supply would be 700 MLD (8.1 m^3/s). This is enough to meet the M & I water demand of 327 MLD (3.79 m^3/s) within the Pasig-Marikina River basin as well as an augmentation of water supply capacity of MWSS to utilize a surplus of 373 MLD (4.31 m^3/s).

This Study reviews water resources to be available with the Marikina Multipurpose Reservoir through the water balance calculations described hereunder.

Source: Prepared by the JICA Study Team

Figure 10.5.4
Location of Marikina Reservoir

The following basic technical features are given in the final report of the Metro Manila Water Security Study (World Bank, July 2012).

- Location: Rodriguez, Rizal, immediate upstream of Montalban Gorge
- Catchment Area: 280 km^2
- Dam Height: 70 m from EL 30 m to EL 100 m
- Gross Storage: 160 MCM at EL 90 m
- Effective Storage: 130 MCM from EL 55 m to EL 90 m

The Metro Manila Water Security Study does not clearly provide flood control storage for the Marikina Multipurpose Reservoir. As suggested from the description of the water supply capacity of 8.1 m^3/s to be assured with reservoir storage of 100 MCM, the flood control storage should be 30 MCM. In the water balance calculations, it is assumed that the usable reservoir storage for M & I water supply would be 130 MCM from December to April and 100 MCM from May to November.

The results of the water balance calculations are summarized in Table 10.5.7 below. The water allocation of 3.79 m^3/s (327 MLD) to M & I water supply within the Pasig-Marikina River basin (MWSS and Local) is ensured as the annual supply accounts for 100% of the annual demand in a 1/10 drought year. The water allocation of 0.16 m^3/s (14 MLD) to agriculture within the Pasig-Marikina River basin (Local) is also ensured as the annual supply accounts for 100% of the annual demand in a 1/5 drought year.

The surplus of 3.73 m^3/s (323 MLD) to be supplied to the other service areas in Metro Manila seems fair in terms of dependability. The ratio of annual supply to annual demand is 86.6% in a 1/10 drought year.

Table 10.5.7 Results of Water Balance Calculation–Marikina Reservoir (Based on the Previous Reservoir Data)

No.	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis					
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply	Ratio of Annual Supply to Annual Demand				
								Drought Year				
								1/2	1/5	1/10	1/20	1/30
304	Marikina Reservoir	Future (2040)	M & I Water Supply	MWSS & Local	3.79	Not Specified	99.4% (358 / 360)	100.0%	100.0%	100.0%	98.4%	94.9%
				Surplus	3.73	Not Specified	96.9% (349 / 360)	100.0%	98.7%	86.6%	85.7%	84.7%
			Agriculture	Local	0.16	Not Specified	97.8% (352 / 360)	100.0%	100.0%	90.7%	90.1%	85.1%

Source: Prepared by the JICA Study Team

(2) Water Balance Calculation–Based on the Updated Reservoir Data

Besides the previous data of the Marikina Multipurpose Reservoir to develop 700 MLD, the final report of the Metro Manila Water Security Study also describes the updated reservoir data, which have been given by another study carried out by the World Bank entitled Master Plan for Flood Management in Metro Manila and Surrounding Areas as follows:

- The updated data indicate an effective storage of 75.3 MCM including flood control storage of 67.4 MCM.
- Based on the above, a possible water supply of 1.0 m^3/s to 1.5 m^3/s (86 MLD to 130 MLD) is due to the small storage available for M & I water supply.

Although any further detail of the updated reservoir data is not described in the final report of the Metro Manila Water Security Study, this Study reviews the water resources to be available with the updated reservoir data. In the water balance calculations, it is assumed that the usable reservoir storage for M & I water supply would be 75.3 MCM from December to April and 7.9 MCM (75.3-67.4) from May to November.

The results of water balance calculations are summarized in Table 10.5.8 below. For each of the cases, the projected water allocation for M & I water supply (MWSS & Local + MWSS Surplus) is given as follows:

- Case 305: 7.52 m^3/s (327 MLD for MWSS & Local + 323 MLD for Surplus)
- Case 306: 5.79 m^3/s (327 MLD for MWSS & Local + 173 MLD for Surplus)
- Case 307: 3.79 m^3/s (327 MLD for MWSS & Local + 0 MLD for Surplus)
- Case 308: 1.50 m^3/s (130 MLD for MWSS & Local + 0 MLD for Surplus)

Due to a limited storage available for M & I water supply during the flood season, dependability of supply becomes much lower than the result from the previous data. Case 307 envisages supplying only 3.79 m^3/s (328 MLD) equivalent to the demand for M & I water supply within the Pasig-Marikina River basin. But dependability of M & I water supply drops to 78.3% and the ratio of annual supply to annual demand is 77.0% in a 1/10 drought year.

The dependable water allocation for M & I water supply with a drought safety level of 1/10 is 1.50 m^3/s (130 MLD).

Table 10.5.8 Results of Water Balance Calculations–Marikina Reservoir (Based on the Updated Reservoir Data)

No.	Water Resource	Water Demand	Projected Water Allocation: Supply (m^3/s)			Projected Water Allocation: Drought Safety Level	Results of Water Balance Analysis: Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year: 1/2	1/5	1/10	1/20	1/30
305	Marikina Reservoir	Future (2040)	M & I Water Supply	MWSS & Local	3.79	Not Specified	71.9% (259 / 360)	82.9%	76.5%	74.3%	71.2%	68.9%
				Surplus	3.73	Not Specified	59.4% (214 / 360)	61.4%	52.6%	47.7%	43.6%	41.9%
			Agriculture	Local	0.16	Not Specified	71.7% (258 / 360)	71.9%	57.3%	57.0%	57.0%	31.6%
306	Marikina Reservoir	Future (2040)	M & I Water Supply	MWSS & Local	3.79	Not Specified	73.9% (266 / 360)	83.8%	76.9%	74.3%	71.2%	70.0%
				Surplus	2.00	Not Specified	64.2% (231 / 360)	64.6%	58.5%	54.7%	51.9%	50.4%
			Agriculture	Local	0.16	Not Specified	73.3% (264 / 360)	76.0%	57.3%	57.0%	57.0%	43.5%
307	Marikina Reservoir	Future (2040)	M & I Water Supply	MWSS & Local	3.79	Not Specified	78.3% (282 / 360)	86.3%	78.8%	77.0%	74.6%	74.6%
				Surplus								
			Agriculture	Local	0.16	Not Specified	77.2% (278 / 360)	81.4%	71.5%	58.1%	57.3%	57.0%
308	Marikina Reservoir	Future (2040)	M & I Water Supply	MWSS & Local	1.50	Not Specified	99.4% (358 / 360)	100.0%	100.0%	100.0%	96.5%	95.9%
				Surplus								
			Agriculture	Local	0.16	Not Specified	98.1% (353 / 360)	100.0%	100.0%	97.6%	95.9%	84.8%

Source: Prepared by the JICA Study Team

10.6 Pampanga River Basin

10.6.1 Water Resources

(1) Surface Water

The water balance calculations described in this section cover the sub-basins of the Pampanga River basin as shown in Table 10.6.1 and Figure 10.6.1. The sub-basins are given in the final report of the Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin (JICA/NWRB, 2011).

Table 10.6.1 Sub-basins of the Pampanga River Basin

Sub-basin	River	Basin Area (km^2)
PAN	Pampanga	849
PAM5	Pampanga	437
COR	Coronell	712
PAM4	Pampanga	799
PEN	Penaranda	570
PAM3	Pampanga	39
RCH104	Talavera	301
RCH103	Talavera	408
RCH102	Baliwag	696
RCH101	Chico	1,490
PAM2	Pampanga	1,518

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

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

Figure 10.6.1
Subdivisions of the Pampanga River Basin

Table 10.6.2 shows the availability of the water resources in the Pampanga River basin, resulting from the water balance calculations (Case 501) under the 'Existing' condition, based on the hydrological data set for the period of 1981-2010 (30 years).

'Existing' condition represents the river flows under the water resources developments and water utilizations listed below.

Major Water Resources Developments:

- Pantabangan Reservoir
- Aurora Transbasin Diversion
- Casecnan Transbasin Diversion

Municipal and Industrial Water Supply:

- Local water supplies using surface water

Major Irrigation Works (NIS)

- UPRIIS Ia served with water diversion from the Talavera Dam
- UPRIIS Ib, II, and V served with water diversion from the Rizal Dam

- UPRIIS III served with water diversion from the Bongabon Dam
- UPRIIS IV served with water diversion from the Penaranda Dam
- Aulo SRIP served with water diverted from a tributary in the sub-basin PAM4
- Pampanga Delta River Irrigation System (PDRIS) served with water diverted from the Cong Dadong Dam

Other Agriculture Water Uses

- CIS, SSI, livestock, and fishery using surface water

Table 10.6.2 Water Resources Availability in the Pampanga River Basin

Existing

Water Resources	Basin Area (km^2)	Average Flow (m^3/s)	Dependable Flow (m^3/s)		
			80%	90%	95%
Pantabangan Reservoir, Outflow	849	61.6	21.0	10.5	8.8
Rizal Dam	901				
Inflow from Upstream Basin		63.1	23.3	12.6	9.1
Diversion to UPRIIS Ib+II+V		36.6	9.5	8.0	2.0
Outflow to Pampanga River		26.5	7.1	5.3	4.1
Coronell River at downstream end of COR	712	32.0	8.5	6.1	4.8
Bongabon Dam	2,026				
Inflow from Upstream Basin		78.2	38.3	24.0	20.6
Diversion to UPRIIS III		16.0	4.7	4.5	4.0
Diversion to Penaranda Dam (UPRIIS IV)		12.3	4.2	3.7	0.0
Outflow to Pampanga River		49.9	4.3	3.4	3.4
Penaranda Dam	519				
Inflow from Upstream Basin		41.7	5.4	4.3	3.7
Diversion from Bongabon Dam		12.3	4.2	3.7	0.0
Diversion to UPRIIS IV		12.0	3.8	3.4	0.0
Outflow to Pampanga River		29.4	4.7	3.5	0.5
Pampanga River at downstream end of PAM3	3,406	105.4	16.0	10.9	8.0
Talavera Dam	301				
Inflow from Upstream Basin		15.9	3.3	2.5	1.9
Diversion to UPRIIS Ia		1.3	0.6	0.1	0.0
Outflow to Talavera River		14.6	2.2	1.4	0.9
Talavera River at downstream end of RCH103	709	32.5	10.1	8.7	7.3
Baliwag River at downstream end of RCH102	696	35.1	13.8	10.5	9.3
Chico River at downstream end of RCH101	2,895	126.3	37.3	33.2	28.3
Cong Dadong Dam	6,308				
Inflow from Upstream Basin		234.4	63.3	57.1	49.1
Diversion to PDRIS		4.3	1.3	1.2	0.0
Outflow to Pampanga River		230.1	58.2	49.0	44.4
Pampanga River at downstream end of PAM2	7,819	280.7	73.1	63.8	54.1

Source: Prepared by the JICA Study Team

(2) Groundwater

An exploitable groundwater yield in the Pampanga River basin is estimated at 21,397 l/s (1849 MLD) as described in Chapter 7 of this report. Within the sub-basins covered by the water balance calculations, the sustainable groundwater yield is estimated at 14,741 l/s (1274 MLD).

10.6.2 Water Demands

(1) Surface Water Demand

Based on the water demand projections described in Chapter 5, the M & I water demands to be served with the surface water resources in each of the sub-basins are complied as shown in Table 10.6.3.

The water demands of the national irrigation system (NIS) and other agriculture refer to the water demand projections described in Chapter 6 as shown in Tables 10.6.4 and 10.6.5.

Table 10.6.3
M & I Surface Water Demands in the Pampanga River Basin

Sub-basin	Present (2012) (m^3/s)	Future (2040) (m^3/s)
PAN	0.39	1.26
PAM5	0.06	0.18
COR	0.11	0.20
PAM4	0.98	1.84
PEN	0.03	0.06
PAM3	0.75	1.94
RCH	2.54	5.44
PAM2	1.33	3.50
Total	6.19	14.43

Source: Prepared by the JICA Study Team

Table 10.6.4 Surface Water Demands of NIS in the Pampanga River Basin

Present — Unit: m^3/s

Diversion Dam	NIS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
Talavera	UPRIIS Ia	2.10	2.30	0.70	0.00	0.10	2.00	2.00	0.60	0.70	1.90	1.60	1.60	1.29
Rizal	UPRIIS Ib+II+V	68.39	78.94	66.42	21.01	1.97	38.00	29.50	7.96	9.48	21.01	38.00	60.97	36.57
Bongabon	UPRIIS III	30.30	34.40	25.00	4.50	5.90	22.50	8.50	4.00	4.70	8.90	18.00	26.10	15.96
Penaranda	UPRIIS IV	25.00	27.10	15.30	0.00	4.20	16.40	6.10	3.40	3.80	9.90	17.00	20.30	12.29
	Aulo SRIP	1.10	1.20	0.60	0.00	0.20	0.70	0.30	0.10	0.20	0.40	0.70	0.90	0.53
Cong Dadong	PDRIS	8.70	9.40	5.30	0.00	1.50	5.70	2.10	1.20	1.30	3.40	5.90	7.00	4.26
Total		135.59	153.34	113.32	25.51	13.87	85.30	48.50	17.26	20.18	45.51	81.20	116.87	70.90

Future — Unit: m^3/s

Diversion Dam	NIS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
Talavera	UPRIIS Ia	2.10	2.30	0.70	0.00	0.10	2.00	2.00	0.60	0.70	1.90	1.60	1.60	1.29
Rizal	UPRIIS Ib+II+V	93.33	107.64	90.56	28.61	2.68	51.76	40.23	10.91	12.96	28.61	51.76	83.14	49.86
Bongabon	UPRIIS III	30.30	34.40	25.00	4.50	5.90	22.50	8.50	4.00	4.70	8.90	18.00	26.10	15.96
Penaranda	UPRIIS IV	25.00	27.10	15.30	0.00	4.20	16.40	6.10	3.40	3.80	9.90	17.00	20.30	12.29
	Aulo SRIP	1.10	1.20	0.60	0.00	0.20	0.70	0.30	0.10	0.20	0.40	0.70	0.90	0.53
Cong Dadong	PDRIS	15.66	16.92	9.54	0.00	2.70	10.26	3.78	2.16	2.34	6.12	10.62	12.60	7.67
	Balintingon	19.50	21.20	11.90	0.00	3.30	12.80	4.80	2.70	3.00	7.70	13.30	15.80	9.60
Total		186.99	210.76	153.60	33.11	19.08	116.42	65.71	23.87	27.70	63.53	112.98	160.44	97.20

Source: Prepared by the JICA Study Team

Table 10.6.5 Surface Water Demands of CIS, SSI, Fishery, and Livestock in the Pampanga River Basin

Present — Unit: m^3/s

Sub-basin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
PAN	0.80	0.87	0.49	0.01	0.21	0.79	0.30	0.17	0.19	0.48	0.55	0.65	0.46
PAM5	1.44	1.55	0.89	0.03	0.38	1.41	0.54	0.32	0.35	0.86	0.98	1.17	0.82
COR	2.99	3.24	1.83	0.00	0.75	2.93	1.09	0.61	0.68	1.77	2.03	2.42	1.69
PAM4	0.78	0.81	0.62	0.38	0.48	0.77	0.52	0.46	0.47	0.61	0.65	0.70	0.60
PEN	0.27	0.29	0.19	0.06	0.11	0.26	0.13	0.10	0.11	0.18	0.20	0.23	0.18
PAM3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
RCH	12.51	13.46	8.09	1.18	4.02	12.27	5.31	3.50	3.76	7.89	8.87	10.34	7.56
PAM2	10.20	10.89	7.00	1.98	4.04	10.03	4.98	3.66	3.85	6.85	7.56	8.63	6.61
Total	29.02	31.15	19.15	3.66	10.02	28.49	12.91	8.86	9.43	18.69	20.88	24.18	17.96

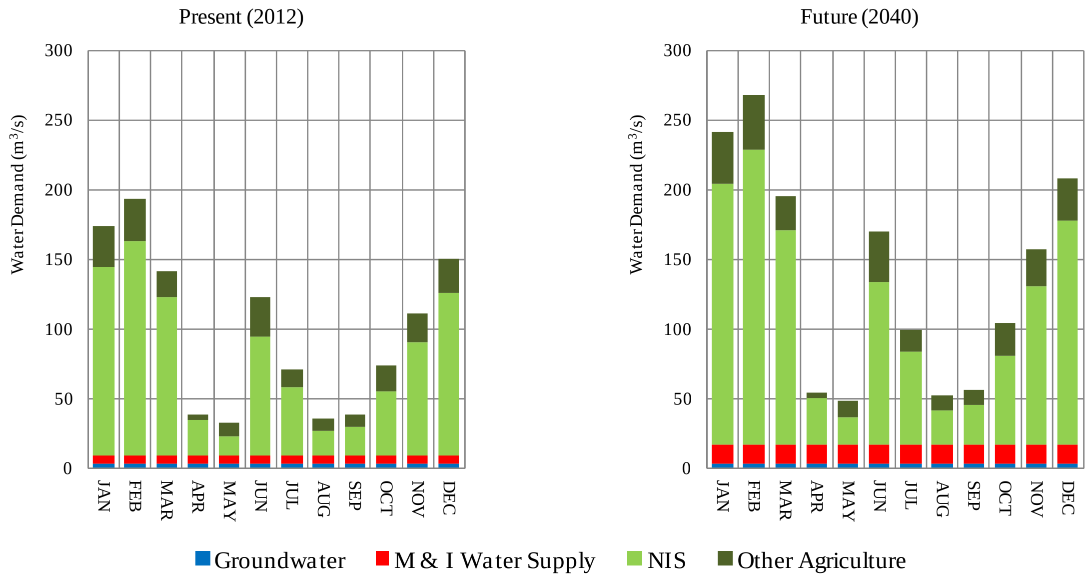
Future — Unit: m^3/s

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
PAN	0.85	0.92	0.52	0.01	0.22	0.83	0.32	0.18	0.20	0.51	0.58	0.69	0.48
PAM5	1.61	1.74	0.99	0.03	0.42	1.57	0.60	0.35	0.39	0.96	1.10	1.31	0.92
COR	3.97	4.31	2.43	0.00	1.00	3.89	1.45	0.81	0.90	2.35	2.70	3.21	2.24
PAM4	0.76	0.79	0.61	0.38	0.48	0.75	0.52	0.46	0.47	0.61	0.64	0.69	0.59
PEN	0.13	0.13	0.10	0.06	0.08	0.13	0.09	0.08	0.08	0.10	0.11	0.12	0.10
PAM3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
RCH	18.30	19.73	11.65	1.22	5.50	17.95	7.45	4.71	5.10	11.34	12.81	15.04	10.85
PAM2	11.30	12.08	7.69	2.02	4.35	11.11	5.41	3.92	4.14	7.52	8.32	9.53	7.25
Total	36.96	39.75	24.03	3.76	12.08	36.27	15.87	10.56	11.31	23.43	26.30	30.62	22.47

Source: Prepared by the JICA Study Team

(2) Groundwater Demand

The present groundwater exploitation in the Pampanga River basin is estimated at 3163 l/s (273 MLD) as described in Chapter 7 of this report. Within the sub-basins covered by the water balance calculations, the present groundwater exploitation is estimated at 2065 l/s (178 MLD). In the water balance calculations discussed in this chapter, it is assumed that the present groundwater exploitation would be maintained towards the future.



Source: Prepared by the JICA Study Team

Figure 10.6.2 Water Demands in the Pampanga River Basin

10.6.3 Minimum Stream Flow Requirements

The minimum stream flow is defined as 10% of the dependable flow that is regarded as a discharge rate at 80% of a flow duration curve in a quasi-natural flow condition. The minimum flow requirements in the Pampanga River basin are listed in Table 10.6.6 below.

Table 10.6.6 Minimum Stream Flow Requirement in the Pampanga River Basin

Location	Basin Area (km^2)	Minimum Stream Flow Requirement (m^3/s)
Pantabangan Reservoir	846	0.51
Rizal Dam	901	0.53
Bongabon Dam	2,026	1.73
Penaranda Dam	519	0.54
Talavera Dam	301	0.36
Cong Dadong Dam	6,308	3.80

Source: Prepared by the JICA Study Team

10.6.4 Drought Safety Level

Drought safety level of 1/10 should be ensured for M & I water supply. Water allocation for M & I water supply should be adequate during a drought year that would probably occur once in ten years (1/10 drought year). During a 1/10 drought year, there should be no deficit in allocating water to M & I water supply.

Drought safety level of 1/5 should be ensured for agriculture. Water allocation for agriculture should be adequate during a drought year that would probably occur once in five years (1/5 drought year). During a 1/5 drought year, there should be no deficit in allocating water to agriculture.

10.6.5 Water Balance Calculations

(1) Calculation Cases

The water balance calculations for the Pampanga River basin are performed in Cases 501 and 502 as shown in Table 10.6.7 below.

Table 10.6.7 Water Balance Calculation Cases–Pampanga River Basin

Case	Water Resource	Water Demand	Projected Water Allocation
501	Existing	Present (2012)	M & I Water Supply: 6.00 m^3/s NIS: 70.90 m^3/s Other Agriculture: 17.96 m^3/s
502	Existing and Balintingon Reservoir	Future (2040)	M & I Water Supply: 14.23 m^3/s NIS: 97.20 m^3/s Other Agriculture: 22.47 m^3/s

Source: Prepared by the JICA Study Team

(2) Results of Case 501

UPRIIS and PDRIS:

The water demand and supply balance is calculated at the diversion dams, namely, Rizal Dam, Bongabon Dam, Penaranda Dam, Talavera Dam, and Cong Dadong Dam, when comparing the usable river flows and irrigation diversion requirement.

The results indicated that a drought safety level of 1/5 is almost satisfied. The ratio of annual supply to annual demand in a 1/5 drought year is 96.7% in UPRIIS IV, 99.9% in UPRIIS V, and 100% in others.

M & I Water Supply and Other Agriculture:

The water demand and supply balance is calculated at the downstream end of the sub-basin when comparing usable river flow and the total of water demands within the sub-basin.

The results for M & I water supply indicated that the usable river flow in a 1/10 drought year is enough to meet the water demand. The results for other agriculture indicated that a ratio of annual supply to annual demand in a 1/5 drought year is lower than 100% in the sub-basins of PAM4, RCH102, RCH103, and RCH104.

Table 10.6.8 Results of Water Balance Calculations–Case 501

UPRIIS & PDRIS

NIS	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand				
				Drought Year				
				1/2	1/5	1/10	1/20	1/30
UPRIIS Ia	1.29	98.9%	(356 / 360)	100.0%	100.0%	97.9%	97.8%	97.1%
UPRIIS Ib	10.74	98.9%	(356 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
UPRIIS II	14.80	97.8%	(352 / 360)	100.0%	100.0%	99.9%	99.3%	98.7%
UPRIIS III	15.97	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.6%
UPRIIS IV	12.30	95.3%	(343 / 360)	100.0%	96.7%	92.4%	91.3%	74.7%
UPRIIS V	11.06	97.8%	(352 / 360)	100.0%	99.9%	99.7%	99.7%	99.6%
PDRIS	4.26	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

M & I Water Supply

Sub-basin	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand				
				Drought Year				
				1/2	1/5	1/10	1/20	1/30
PAN	0.38	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	91.5%
PAM5	0.06	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
COR	0.11	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM4	0.95	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PEN	0.03	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM3	0.73	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH103 & 104	0.60	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH102	0.59	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH101	1.27	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAN2	1.29	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

Other Agrigulture

Sub-basin	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand				
				Drought Year				
				1/2	1/5	1/10	1/20	1/30
PAN	0.46	98.9%	(356 / 360)	100.0%	100.0%	97.6%	90.8%	85.8%
PAM5	0.82	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
COR	1.69	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM4	1.13	93.3%	(336 / 360)	100.0%	95.5%	89.8%	87.8%	86.1%
PEN	0.18	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM3	0.04	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH103 & 104	1.03	78.3%	(282 / 360)	70.4%	65.2%	59.5%	58.0%	57.0%
RCH102	2.07	78.6%	(283 / 360)	79.3%	67.9%	65.0%	63.5%	60.1%
RCH101	4.46	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAN2	6.62	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

Note: PAM4 of other agriculture comprises the demands of Aulo SRIP and others within the sub-basin.
Source: Prepared by the JICA Study Team

(2) Results of Case 502

UPRIIS and PDRIS:

The water balance calculation involves the future expansion of UPRIIS V (16,879 ha to 37,200 ha), the new irrigation for 14,900 ha associated with the development of the Balintingon Reservoir, and the future expansion of PDRIS (6,604 ha to 11,920 ha). The results indicated that the ratio of annual supply to annual demand stays in a range of 94.9% (UPRIIS V) to 100% (PDRIS) in a 1/5 drought year.

M & I Water Supply and Other Agriculture:

The results for M & I water supply indicated that the usable river flow in a 1/10 drought year is still enough to meet the water demand. The results for other agriculture indicated that the ratio of annual supply to annual demand in a 1/5 drought year is lower than 100% in the sub-basins of PAN, PAM4, RCH102, RCH103, and RCH104.

Table 10.6.9 Results of Water Balance Calculations–Case 502

UPRIIS and PDRIS

NIS	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand Drought Year				
				1/2	1/5	1/10	1/20	1/30
UPRIIS Ia	1.29	96.7%	(348 / 360)	100.0%	98.8%	95.6%	95.4%	94.2%
UPRIIS Ib	10.74	88.9%	(320 / 360)	99.9%	99.1%	92.2%	90.5%	56.5%
UPRIIS II	14.80	85.3%	(307 / 360)	99.7%	95.2%	87.6%	86.9%	50.7%
UPRIIS III	15.97	94.2%	(339 / 360)	100.0%	96.1%	92.7%	72.8%	68.5%
UPRIIS IV	21.90	89.4%	(322 / 360)	99.3%	94.9%	88.4%	70.7%	69.1%
UPRIIS V	24.36	83.1%	(299 / 360)	99.3%	98.5%	91.4%	90.0%	57.3%
PDRIS	7.68	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

M & I Water Supply

Sub-basin	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand Drought Year				
				1/2	1/5	1/10	1/20	1/30
PAN	1.25	98.6%	(355 / 360)	100.0%	100.0%	95.3%	94.3%	91.5%
PAM5	0.18	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
COR	0.20	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM4	1.83	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PEN	0.06	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM3	1.93	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH103 & 104	1.31	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH102	1.30	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH101	2.79	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAN2	3.48	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

Other Agriculture

Sub-basin	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand Drought Year				
				1/2	1/5	1/10	1/20	1/30
PAN	0.48	97.2%	(350 / 360)	100.0%	99.6%	87.0%	80.5%	70.1%
PAM5	0.92	98.9%	(356 / 360)	100.0%	100.0%	96.5%	94.6%	94.3%
COR	2.24	99.4%	(358 / 360)	100.0%	100.0%	100.0%	98.9%	96.7%
PAM4	1.12	91.1%	(328 / 360)	99.4%	92.3%	86.6%	81.6%	81.5%
PEN	0.10	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM3	0.04	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH103 & 104	1.48	58.6%	(211 / 360)	53.9%	43.6%	33.3%	31.0%	25.1%
RCH102	2.97	64.2%	(231 / 360)	63.1%	57.6%	49.7%	49.0%	33.8%
RCH101	6.40	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAN2	7.26	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

Note: PAM4 of other agriculture comprises the demands of Aulo SRIP and others within the sub-basin.
Source: Prepared by the JICA Study Team

10.6.6 Water Balance Calculations under Climate Change Conditions

(1) Calculation Cases

The water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change analysis and runoff simulation for the Pampanga River basin.

Based on the results of Case 502, six cases under the climate change conditions are tested to assess the climate change impact as shown in Table 10.6.10.

Table 10.6.10 Water Balance Calculation Cases–Pampanga River Basin (under Climate Change Conditions)

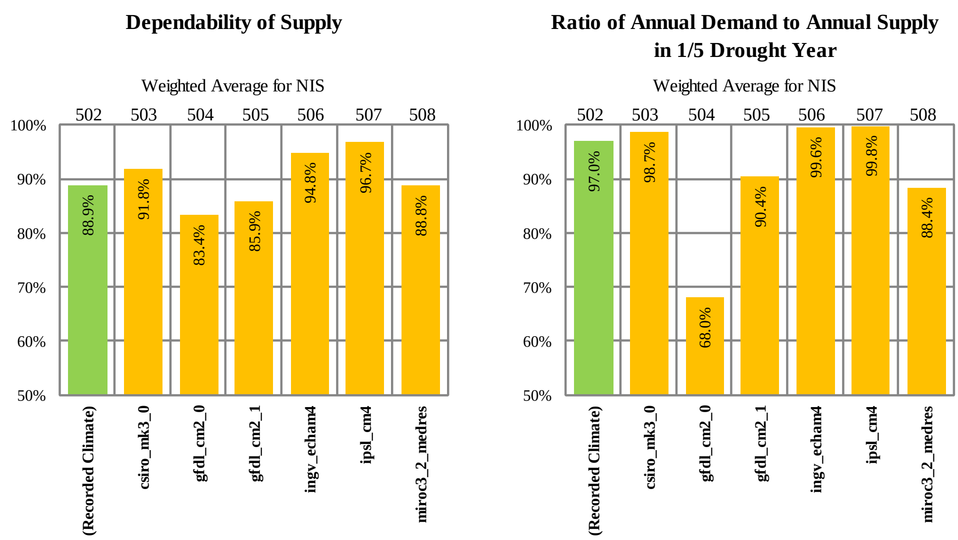
Case	Water Resource	Water Demand	Projected Water Allocation
503 504 505 506 507 508	Existing and Balintingon Reservoir	Future (2040)	M & I Water Supply: 14.23 m^3/s NIS: 97.20 m^3/s Other Agriculture: 22.47 m^3/s

Source: Prepared by the JICA Study Team

(2) Results

The results of water balance calculations in UPRIIS and PDRIS under the climate change conditions are shown in Table 10.6.11 and Figure 10.6.3.

In terms of dependability, the climate change impact tends to be better in four cases and worse in the other two cases. The ratio of annual demand to annual supply in a 1/5 drought year tends to be better in three cases and worse in the other three cases.



Source: Prepared by the JICA Study Team

Figure 10.6.3 Climate Change Impact on NIS–Pampanga River Basin

Table 10.6.11 Results of Water Balance Calculation under Climate Change Conditions–UPRIIS and PDRIS

Existing & Balintingon, Future Demand (2040)

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	96.7% (348 / 360)	100.0%	98.8%	95.6%	95.4%
UPRIIS Ib	10.74	88.9% (320 / 360)	99.9%	99.1%	92.2%	90.5%
UPRIIS II	14.80	85.3% (307 / 360)	99.7%	95.2%	87.6%	86.9%
UPRIIS III	15.97	94.2% (339 / 360)	100.0%	96.1%	92.7%	72.8%
UPRIIS IV	21.90	89.4% (322 / 360)	99.3%	94.9%	88.4%	70.7%
UPRIIS V	24.36	83.1% (299 / 360)	99.3%	98.5%	91.4%	90.0%
PDRIS	7.68	100.0% (360 / 360)	100.0%	100.0%	100.0%	100.0%

Case 503 csiro_mk3_0 2031-2050

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	92.1% (221 / 240)	100.0%	89.6%	88.0%	86.6%
UPRIIS Ib	10.74	87.5% (210 / 240)	99.9%	99.6%	98.8%	98.2%
UPRIIS II	14.80	95.0% (228 / 240)	100.0%	99.7%	97.7%	96.2%
UPRIIS III	15.97	98.8% (237 / 240)	100.0%	100.0%	95.8%	95.4%
UPRIIS IV	21.90	93.8% (225 / 240)	100.0%	96.9%	91.9%	90.2%
UPRIIS V	24.36	82.9% (199 / 240)	99.4%	98.4%	98.2%	96.9%
PDRIS	7.68	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%

Case 504 gfdl_cm2_0 2031-2050

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	88.3% (212 / 240)	90.9%	83.6%	82.8%	81.6%
UPRIIS Ib	10.74	80.0% (192 / 240)	99.8%	66.0%	55.2%	44.6%
UPRIIS II	14.80	77.9% (187 / 240)	100.0%	61.3%	50.5%	41.5%
UPRIIS III	15.97	87.5% (210 / 240)	100.0%	67.0%	62.4%	56.6%
UPRIIS IV	21.90	84.6% (203 / 240)	100.0%	67.4%	50.4%	43.1%
UPRIIS V	24.36	79.6% (191 / 240)	99.2%	65.5%	54.3%	44.1%
PDRIS	7.68	97.5% (234 / 240)	100.0%	93.3%	92.4%	86.0%

Case 505 gfdl_cm2_1 2031-2050

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	95.8% (230 / 240)	100.0%	99.2%	92.2%	91.3%
UPRIIS Ib	10.74	89.6% (215 / 240)	99.9%	91.2%	85.7%	82.8%
UPRIIS II	14.80	83.3% (200 / 240)	99.1%	89.7%	84.0%	80.9%
UPRIIS III	15.97	90.4% (217 / 240)	97.9%	90.1%	83.3%	77.4%
UPRIIS IV	21.90	85.0% (204 / 240)	95.6%	86.0%	81.6%	78.3%
UPRIIS V	24.36	78.8% (189 / 240)	99.3%	91.2%	85.1%	82.0%
PDRIS	7.68	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%

Case 506 ingv_echam4 2031-2050

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	87.9% (211 / 240)	92.8%	87.8%	81.0%	74.0%
UPRIIS Ib	10.74	87.5% (210 / 240)	99.8%	99.8%	99.6%	99.5%
UPRIIS II	14.80	99.6% (239 / 240)	100.0%	100.0%	100.0%	99.8%
UPRIIS III	15.97	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%
UPRIIS IV	21.90	99.2% (238 / 240)	100.0%	100.0%	98.6%	97.3%
UPRIIS V	24.36	86.7% (208 / 240)	99.3%	99.1%	98.2%	97.9%
PDRIS	7.68	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%

Case 507 ipsl_cm4 2031-2050

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	97.1% (233 / 240)	100.0%	98.3%	90.0%	87.3%
UPRIIS Ib	10.74	96.7% (232 / 240)	100.0%	100.0%	99.8%	99.8%
UPRIIS II	14.80	99.2% (238 / 240)	100.0%	100.0%	100.0%	99.6%
UPRIIS III	15.97	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%
UPRIIS IV	21.90	99.6% (239 / 240)	100.0%	100.0%	100.0%	99.8%
UPRIIS V	24.36	89.6% (215 / 240)	99.9%	99.3%	98.3%	98.2%
PDRIS	7.68	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%

Case 508 miroc3_2_medres 2031-2050

NIS	Demand (m^3/s)	Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year 1/2	1/5	1/10	1/20
UPRIIS Ia	1.29	94.6% (227 / 240)	97.9%	93.6%	91.6%	90.8%
UPRIIS Ib	10.74	84.6% (203 / 240)	99.9%	86.1%	80.8%	80.2%
UPRIIS II	14.80	86.3% (207 / 240)	100.0%	85.5%	76.8%	76.1%
UPRIIS III	15.97	95.0% (228 / 240)	100.0%	90.2%	87.3%	77.3%
UPRIIS IV	21.90	92.1% (221 / 240)	100.0%	88.5%	80.0%	78.4%
UPRIIS V	24.36	81.3% (195 / 240)	99.5%	85.8%	81.5%	80.9%
PDRIS	7.68	100.0% (240 / 240)	100.0%	100.0%	100.0%	100.0%

Note: Change from Case 502; Red-Better, Black-Minor (within +/- 1%), Worse-Blue

Source: Prepared by the JICA Study Team

10.7 Laguna Lake Basin

10.7.1 Water Resources

(1) Water Level, Surface Area, and Storage Volume

The final report on the Conceptual Study for the 1200 MLD Laguna Lake Bulk Water Supply Project (MWSS, 2001) describes the relationship of water level with the surface area water storage volume.

According to 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.

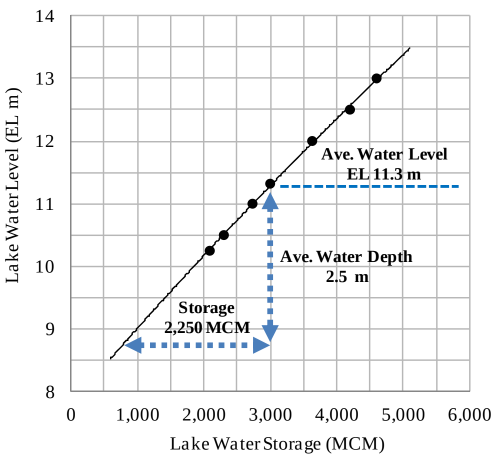
The environmental impact assessment of the 300 MLD Laguna Lake Bulk Water Supply Project (MWSS, 2002) shows the average water level of Laguna Lake is EL 11.3 m.

Suggested from the literatures mentioned above, the storage volume of 2250 MCM would correspond with a storage volume between EL 8.8 m to EL 11.3 m as shown in Figure 10.7.1

Table 10.7.1 Laguna Lake: Relationship of Water Level with Surface Area Water Storage

Water Level (EL m)	Surface Area (km^2)	Storage (MCM)
10.25	835	2,090
10.50	840	2,303
11.00	872	2,734
11.32	890	3,000
12.00	926	3,632
12.50	971	4,200
13.00	1,011	4,601

Source: Conceptual Study for the 1200 MLD Laguna Lake Bulk Water Supply Project, Final Report (MWSS, 2001)



(2) Preliminary Analysis of Lake Water Balance

Using the meteorological and hydrological data sets (period 1981-2010) resulting from the runoff simulation by this Study, the water balance of the Laguna Lake is estimated by the following equation:

$$dS = Q_{CA} + R - E - G - V_{USE} - Q_{OUT}$$

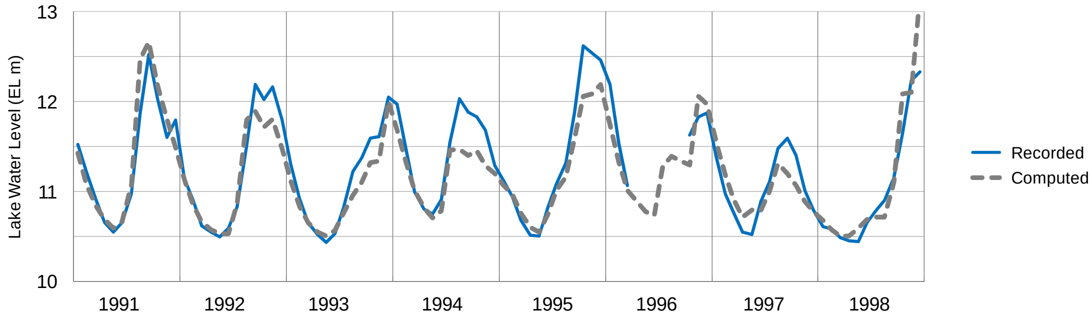
where,

dS: change of lake storage volume, Q_{CA}: runoff incoming from catchment areas, R: rainfall received on water surface, E: evaporation from water surface, G: seepage from bottom of lake, V_{USE}: water abstraction from lake, Q_{OUT}: outgoing flow from lake

The average low water level of the Laguna Lake is EL 10.5 m, which is almost the same as the mean sea level of the Manila Bay. The saltwater intrusion takes place during the high tide when the lake water level stays around the lowest during the dry season. For the purpose of the computation for the water balance, the water flows between Laguna Lake and Manila Bay are estimated with the following assumptions:

- Outflow from the lake takes place when the water level of the lake stays higher than EL 10.5 m.
- Reverse flow from the sea occurs when the water level of the lake becomes lower than EL 10.5 m.

The computations are performed to fit the computed water levels with the recorded water levels through trial and error as shown in Figure 10.7.1 to establish the approximate relationship between water level and outflow.

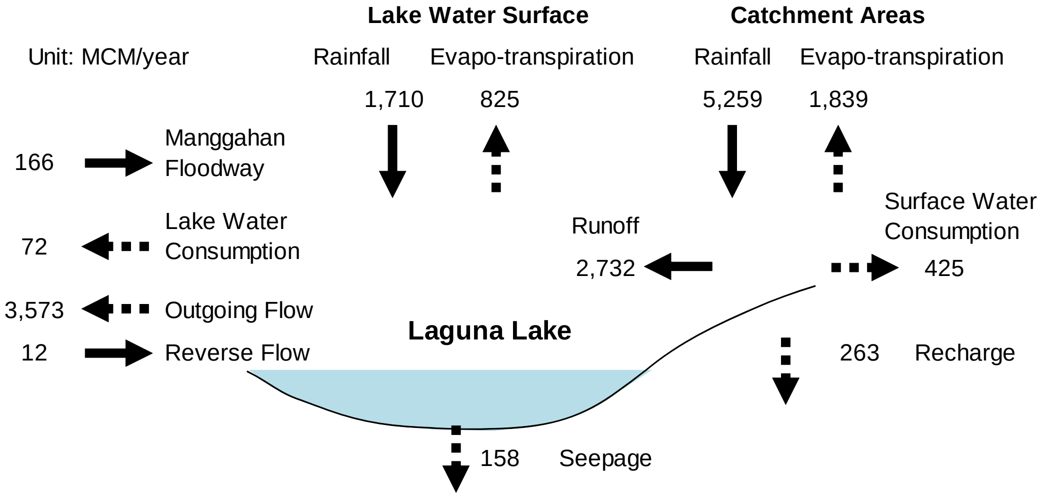


Source: Prepared by the JICA Study Team

Figure 10.7.1 Recorded and Computed Water Levels (1991-1998)

(3) Water Balance under Present Condition

In line with the preliminary analysis discussed above, the water balance of the Laguna Lake under the present condition is estimated as shown in Figure 10.7.1 which resulted from the water balance calculations (Case 701) based on the meteorological and hydrological data set for the period of 1981-2010 (30 years).



Source: Prepared by the JICA Study Team

Figure 10.7.2 Estimated Water Balance of Laguna Lake under Present Condition

10.7.2 Water Demands

(1) Surface Water

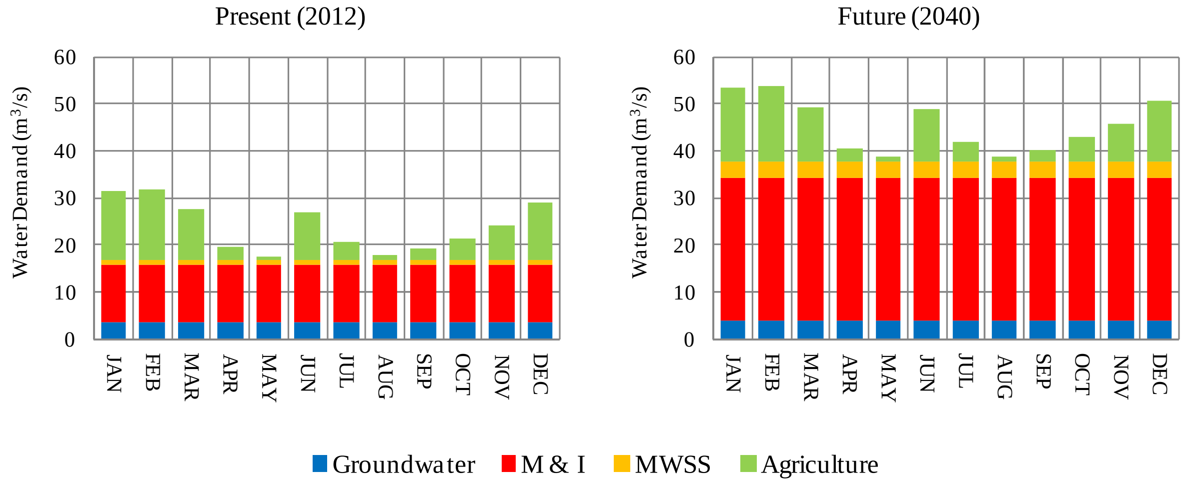
As described in Chapter 5 of this report, M & I water demand within the Laguna River basin is estimated at 12.05 m^3/s (1041 MLD) at present (year 2012) and 30.28 m^3/s (2616 MLD) in the future (year 2040).

As described in Chapter 6, the average agriculture water demand in the Laguna River basin is estimated at 7.00 m^3/s (604 MLD) at present (year 2012) and 7.68 m^3/s (663 MLD) in the future (year 2040).

Maynilad (MWSI) is taking the water from the Laguna Lake in order to operate the Putatan WTP with a capacity of 1.16 m^3/s (100 MLD). The Metro Manila Water Security Study carried out by the World Bank indicates that the capacity of the WTP is scheduled to be expanded up to 3.47 m^3/s (300 MLD) by year 2021 to utilize water from the Laguna Lake.

(2) Groundwater

It is assumed that the groundwater exploitation of 3709 liter/s (329 MLD) as described in Sub-section 7.2.2 would be utilized for the municipal and industrial water supplies and maintained towards the future. The groundwater demand for agriculture in 2040 is estimated to be 190 l/s (16 MLD) as described in Sub-section 6.7.2.



Source: Prepared by the JICA Study Team

Figure 10.7.3 Water Demands within Laguna Lake Basin

10.7.3 Minimum Stream Flow Requirement

The water balance calculations discussed in this subsection consider the macro-basis water demand and supply balance in the whole basin area of the Laguna Lake. Therefore, the minimum stream flow is defined as 10% of the dependable flow that is regarded as a discharge rate at 80% of the flow duration curve for the total runoff from the whole basin area of the Laguna Lake.

10.7.4 Drought Safety Level

In the water balance calculations discussed in this subsection, it is assumed that the drought safety level (e.g., 1/10 for M & I water supply, 1/5 for agriculture) could be ensured with the supplemental use of the water taken from the Laguna Lake when the runoff from the catchment areas would become insufficient to meet the water demands.

On the other hand, it is anticipated that the sea water intrusion due to the low lake water level during the dry season would be more frequent due to the excessive use of the water taken from the Laguna Lake.

With regards to the above, the drought safety level for the water demand and supply balance is assessed with an indicator of the percentage of supply volume depending on the lake water storage to the whole supply volume.

10.7.5 Water Balance Calculations

(1) Calculation Cases

The water balance calculations for the Laguna Lake basin are performed in Cases 701 and 702 as shown in Table 10.7.2 below. The conditions in the use of the water taken from the Laguna Lake are as follows:

- Water supply for the MWSS service area is fully dependent on the water taken from the Laguna Lake.
- M & I water supply and agriculture surrounding the Laguna Lake basin are served with the surface water resources available in the catchment areas of the Laguna Lake. Supplemental supply by the water taken from the Laguna Lake occurs when the water resources in the catchment areas would become insufficient to meet the water demands.

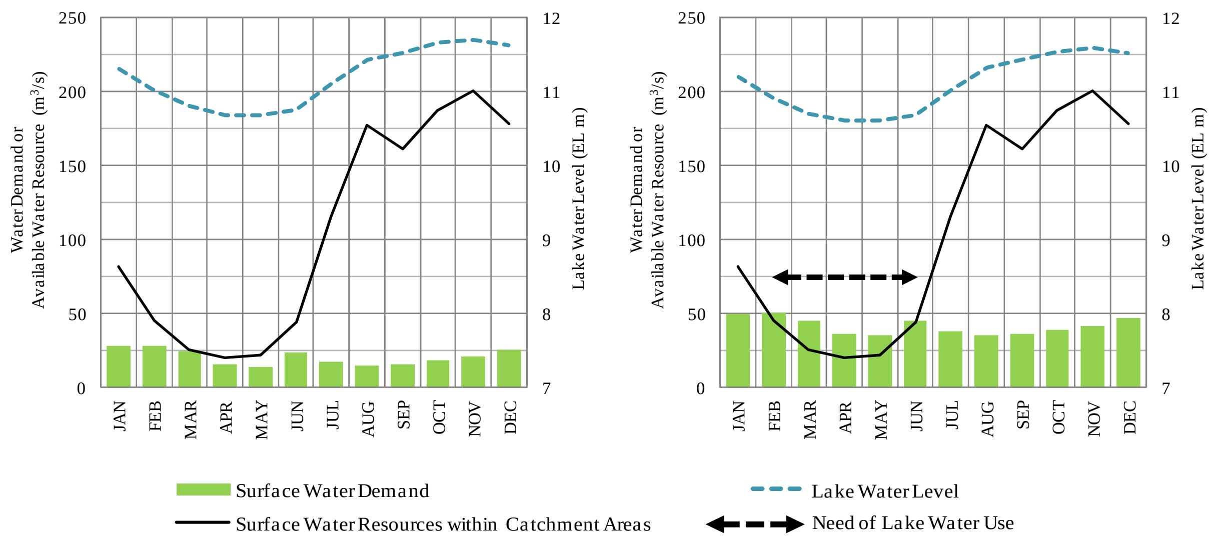
Table 10.7.2 Water Balance Calculation Cases–Laguna Lake Basin

Case	Water Resource	Water Demand	Projected Water Allocation
701	Rivers Laguna Lake	Present (2012)	MWSS: 1.16 m^3/s (from Laguna Lake) M & I Water Supply: 12.05 m^3/s Agriculture: 7.00 m^3/s
702	Rivers Laguna Lake	Future (2040)	MWSS: 3.47 m^3/s (from Laguna Lake) M & I Water Supply: 30.28 m^3/s Agriculture: 7.68 m^3/s

Source: Prepared by the JICA Study Team

(2) Results

The total of water demands is compared with the average runoff and water level for the computation period of 30 years as shown in Figure 10.7.4. The water use depending on the lake water storage stays in a limited amount at present (2012) but is anticipated to be larger in the future (2040).



Source: Prepared by the JICA Study Team

Figure 10.7.4 Comparison between Water Demand and Runoff from Catchment Areas

Water demand and corresponding water resources are summarized in Table 10.7.3. The supply depending on the lake water storage at present (2012) is estimated at 108 MCM/year accounting for 17% of the total supply of 637 MCM/year equivalent to the water demand. The supply depending on the lake water storage increases up to 371 MCM/year which accounts for 28% of the total supply of 1307 MCM/year.

Table 10.7.3 Water Demands and Corresponding Water Resources

Present (2012): Case 701

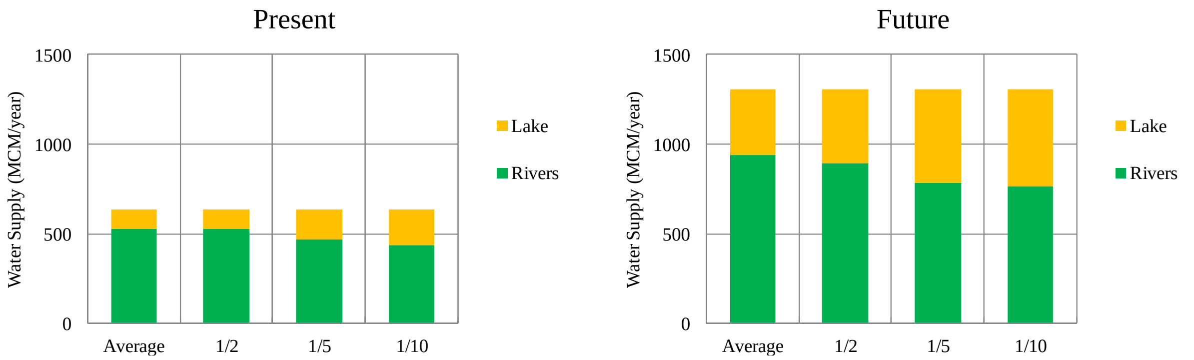
Water Use	Demand (MCM/year)	Supply (MCM/year)	
		Rivers	Lake
MWSS	37	0	37
M & I Water Supply (Local)	380	352	28
Agriculture (NIS and Local)	221	177	43
Total	637	529	108
	100%	83%	17%

Future (2040): Case 702

Water Use	Demand (MCM/year)	Supply (MCM/year)	
		Rivers	Lake
MWSS	110	0	110
M & I Water Supply (Local)	956	782	173
Agriculture (NIS and Local)	242	154	88
Total	1,307	936	371
	100%	72%	28%

Source: Prepared by the JICA Study Team

Figure 10.7.5 shows the water use depending on the lake water storage with a probable drought year. The water use depending on the lake water storage becomes higher together with the scale of drought. Under the future condition (2040), the percentage of water use depending on the lake water storage is estimated at 28% on average and 42% in a 1/10 drought year.



Source: Prepared by the JICA Study Team

Figure 10.7.5 Water Use Depending on Lake Water Storage–Laguna Lake Basin

10.7.6 Water Balance Calculations under Climate Change Conditions

(1) Calculation Cases

The water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change analysis and runoff simulation for the Laguna Lake River basin.

Based on the results of Case 702, six cases under the climate change conditions are tested to assess the climate change impact as shown in Table 10.7.4.

Table 10.7.4 Water Balance Calculation Cases–Laguna Lake Basin (under Climate Change Conditions)

Case	Water Resource	Water Demand	Projected Water Allocation		
702A 702B 702C 702D 702E 702F	Rivers Laguna Lake	Future (2040)	MWSS: M & I Water Supply: Agriculture:	3.47 m^3/s 30.28 m^3/s 7.68 m^3/s	(from Laguna Lake)

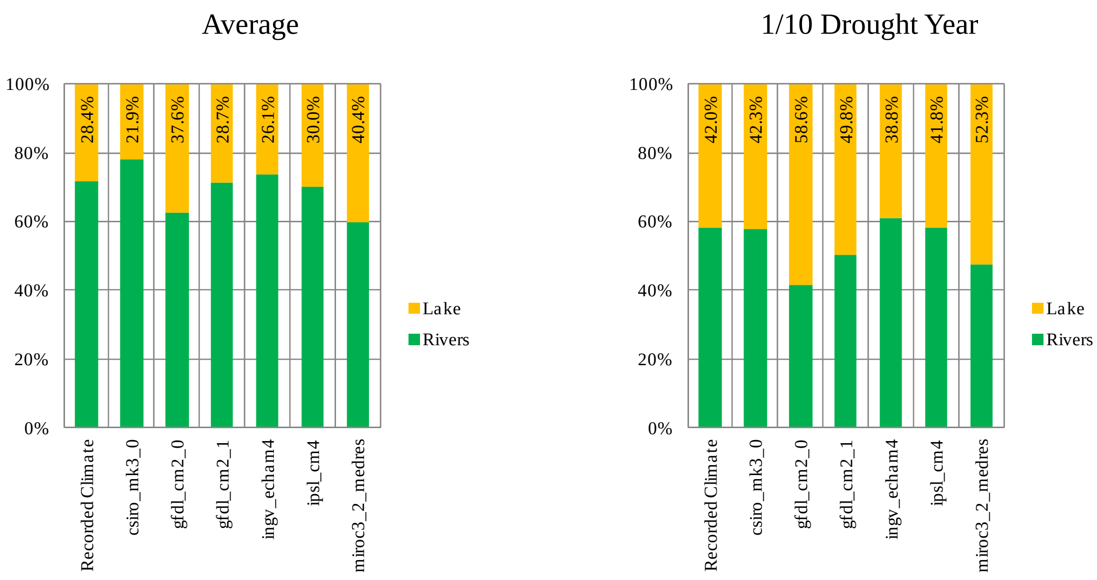
Source: Prepared by the JICA Study Team

(2) Results

The results of water use depending on the lake water storage are summarized in Figure 10.7.6. The percentage of water use depending on the lake water storage is estimated at 28% on average and 42% in a 1/10 drought year under the recorded climate condition.

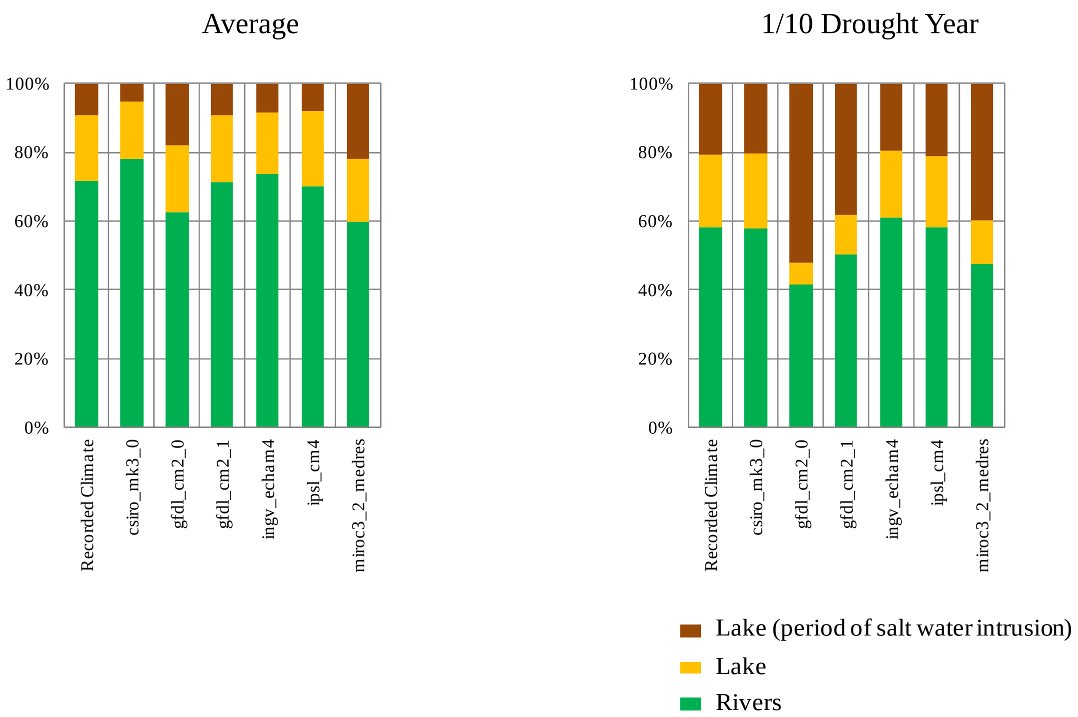
Compared with the percentage on average under the recorded climate condition, the climate change impact is regarded as better in two cases, minor (within +/- 1%) in one case, and worse in three cases. In terms of the percentage in a 1/10 drought year, the climate change impact is regarded as better in one case, minor (within +/- 1%) in two cases, and worse in three cases.

Figure 10.7.7 indicates the water supplied from the lake during the period of the salt water intrusion. Under the recorded climate condition, the percentage of the annual supply (from rivers and lakes) during the period of the salt water intrusion is estimated at 9% on average and 21% in a 1/10 drought year. The percentage ranges from 5% to 18% on average and from 20% to 51% in a 1/10 drought year under the climate change conditions.



Source: Prepared by the JICA Study Team

Figure 10.7.6 Climate Change Impact on Water Use Depending on Lake Water Storage



Source: Prepared by the JICA Study Team

Figure 10.7.7 Climate Change Impact on Salt Water Intrusion Affecting Supply from Lake Water Storage

10.7.7 Assessment of Water Supply from Laguna Lake to Metro Manila

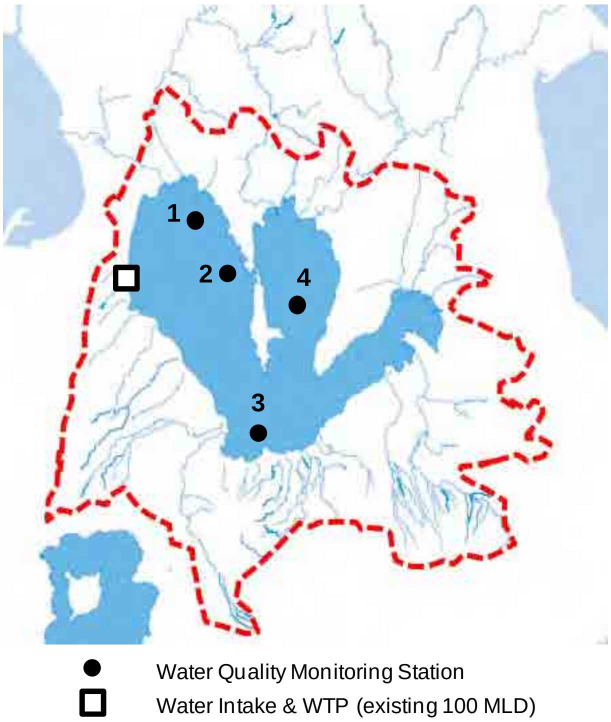
(1) Putatan Water Treatment Plant

The water supply from Laguna Lake to Metro Manila is planned with a capacity of 3.47 m^3/s (300 MLD) to be taken from the lake water storage. Of the planned 300 MLD, the Putatan

WTP is operated since 2010 with the water purification process including dissolved air flotation (DAF), micro filtration (MF), and reverse osmosis (RO).

According to 100 MLD MF-RO Putatan Water Treatment Plant issued by Maynilad, the RO of the Putatan WTP is designed to cope with the raw water quality of the Laguna Lake with TDS of 2800 mg/L and chloride of 1800 mm. The RO is operated when TDS exceeds 500 mg/L in conformity with the Philippine National Water Quality Standards for Drinking Water.

Based on the report entitled Laguna Lake as Water Supply Source issued by Maynilad describes the locations of water quality monitoring stations operated by LLDA, as shown in Figure 10.7.8. The water quality data at these stations are also described and outlined in Table 10.7.5. As suggested in the water quality data, the RO of the Putatan WTP would be designed on the basis of those observed at West Bay near Pasig and/or West Bay.



Source: Laguna Lake as Water Supply Source, Maynilad

Figure 10.7.8
Locations of the Water Quality Monitoring Stations

Table 10.7.5 Outlines of Water Quality Data (TDS and Chloride) for 2000-2006

Range of Mean Monthly TDS (ppm)

Monitoring Station	Low	High
1. West Bay near Pasig	600	3,700
2. West Bay	600	2,000
3. South Bay	600	1,000
4. Central Bay	600	1,600

Range of Mean Monthly Chloride (ppm)

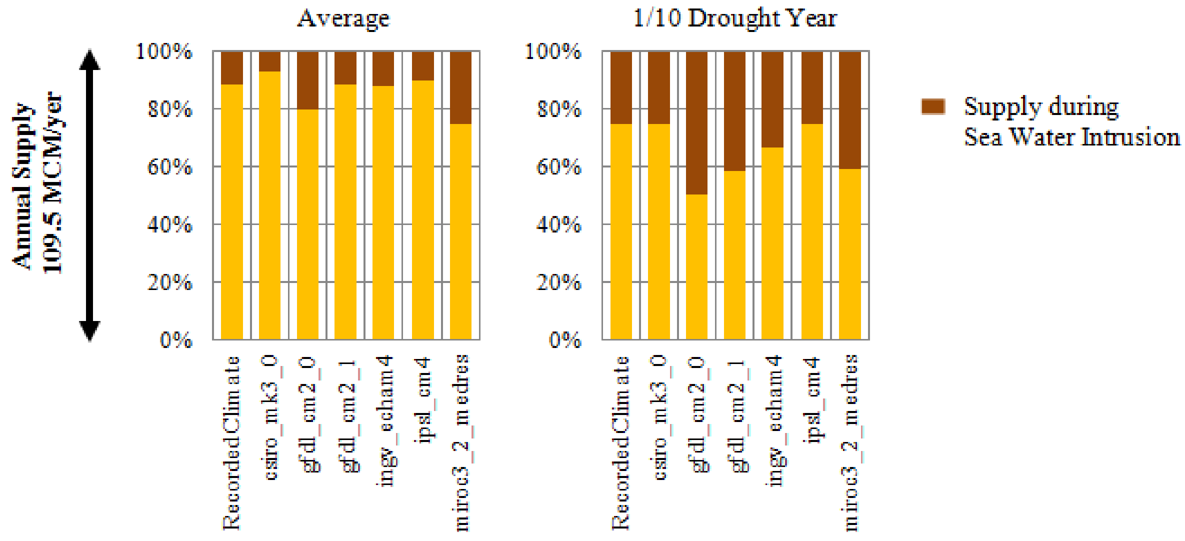
Monitoring Station	Low	High
1. West Bay near Pasig	300	2,800
2. West Bay	300	1,400
3. South Bay	300	600
4. Central Bay	300	800

Source: Laguna Lake as Water Supply Source, Maynilad

On the other hand, it is reported by Maynilad that the actual TDS at the raw water intake has been staying mostly below 500 mg/L and the RO has been rarely operated accordingly since the Putatan WTP initiated its operation. No analysis has been made so far to seek the outstanding difference of TDS between the designed and actual records.

(2) Dependability of Supply

Figure 10.7.9 shows the climate change impact on the future water supply of 300 MLD (109.5 MCM/year) in year 2040. Under the recorded climate condition, the percentage of the annual supply during the period of the salt water intrusion is estimated at 12% on average and 25% in a 1/10 drought year. Of the six cases under the climate change conditions, four cases indicate around 10% on average and two cases indicate 20% or higher. In a 1/10 drought year, it stays around 25% in two cases and indicates 30% or higher in four cases.



Source: Prepared by the JICA Study Team

Figure 10.7.9 Climate Change Impact on Sea Water Intrusion Affecting Water Supply from Laguna Lake to Metro Manila

Resulting from the water balance calculations described in this section, the water supply of 300 MLD from the Laguna Lake to Metro Manila is regarded as dependable in terms of the quantity of the available water resources. Meanwhile, it is anticipated that sea water intrusion would be more frequent due to the increase in the volume of water taken from the Laguna Lake in the future as well as drought accelerated by the climate change. The results of the water balance calculations suggested the need of measures to be taken to ensure the dependability of supply in terms of water quality.

It should be noted that the water balance calculations by this Study could focus on the macro basis analysis of the water resources availability under the present and future climate conditions in the Laguna Lake basin. Due to the limitations in the water balance calculations, this Study does not cover in-depth discussions between water balance and water quality of the Laguna Lake. The results of the water balance calculations otherwise provided the following suggestions for validating the dependability of supply from Laguna Lake to Metro Manila and the issues to be considered in the future.

1) Water Purification Process

For the planned expansion of the Putatan WTP up to 300 MLD, the design of the water purification process shall be reviewed and validated through further studies on the projections of water balance and water quality in the Laguna Lake. Based on such studies, the dependability of the water supply from Laguna Lake to Metro Manila shall be ensured with the application of the water purification process to cope with the potential risks on water quality.

2) Climate Change Adaptation

The following adaptation measures shall be undertaken when the forecasted risks on the water resources availability are found to be worse due to climate change.

- Water consumption shall be saved; e.g., water recycling in the industrial water uses accounting for the majority of the surface water demands in the Laguna Lake basin.
- The water conveyance from the Agos River basin shall be commenced and operated regionally to ensure water supply in Metro Manila and the neighboring areas in the Laguna Lake basin.

3) Water Quality Management

The Laguna Lake is threatened by the risks of water pollution attributed to the wastewater effluents from the catchment areas. Ecosystems and People, the Philippine Millennium Ecosystem Assessment (MA), and Sub-Global Assessment (DENR/LLDA, 2005) described the outlines of the water pollution in Laguna Lake on the basis of the water quality data in the 1990s as follows:

- The percentages of the major pollution sources; domestic, industry, and agriculture were estimated at 68.5%, 19.0%, and 11.5%, respectively.
- Many water quality parameters did not meet the criteria for Class C (intended for propagation and growth of fish and other aquatic resources, boating, and manufacturing processes after treatment: DENR Administrative Order 90-34) and indicated the worsening condition of the lake.
- The lake water was found to be contaminated with toxic and hazardous substances (e.g., heavy metals and persistent organic pollutants including pesticides) coming from industrial and agriculture sectors.

On the other hand, it is reported by Maynilad that so far there is no evidence suggesting the pollution by hazardous substances at the existing Putatan WTP. To maintain the Laguna Lake as water supply source in the future, water quality management is one of the essential issues on the water resources management in the Laguna Lake basin. The initiatives by LLDA for the water quality management are expected to be implemented as programmed in the Laguna de Bay Basin 2020–Framework for the New Laguna De Bay Master Plan consisting of the following:

- Land resources - integrated watershed management plan,
- Water resources development and management plan,
- Environment and water-related infrastructure plan,
- Socio-economic planning and development management structure,
- Institutions and institutional arrangement, and
- Information, education, and communication program.

10.8 Water Demand and Supply Balance Study for Alternative Water Demand Projection

10.8.1 Angat River Basin

(1) Alternative Water Demand Projections

The available surface water resources in the Angat River basin are allocated to MWSS and local water users. In this Study, it is assumed that the water allocation would initially be made to meet the local water demands of M & I water supply and agriculture and the remaining water could be allocated to MWSS. In order to evaluate the water allocation to MWSS, two alternatives of water demand projection within the Angat River basin are considered on the basis of the following assumptions:

M & I water supply (refer to Sub-section 5.5.7)

- Alternative 1: The groundwater exploitation for M & I water supply at present (year 2012) will be maintained towards the future.
- Alternative 2: The groundwater exploitation for M & I water supply increases towards the future and will be maximized as equivalent to the sustainable yield by year 2040.

Agriculture (refer to Sub-section 6.7.3)

- Alternative 1: As projected in Sub-section 6.7.2.
- Alternative 2: Promotion of water-saving irrigation will be effective for saving 10% of the water diversion requirement for NIS by year 2040.

The alternative water demand projections based on the above are shown in Table 10.8.1 below.

Table 10.8.1 Alternative Water Demand Projections–Angat River Basin

Water Use		Alternative 1 Water Demand (m^3/s)			Alternative 2 Water Demand (m^3/s)		
		Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
M & I Water Supply	Local	8.8	1.1	9.8	5.0	4.8	9.8
Agriculture	NIS	19.6	0.0	19.6	17.6	0.0	17.6
	Local	0.6	0.0	0.6	0.5	0.0	0.5
Total		28.9	1.1	29.9	23.1	4.8	27.9

Source: Prepared by the JICA Study Team

Section 10.1 of this report describes the calculations of the surface water demand and the supply balance on the basis of Alternative 1. The calculations with regards to Alternative 2 are described hereunder.

(2) Water Balance Calculation

The water balance calculation is performed with the precondition to ensure a drought safety level of 1/5 for the projected water allocation for agriculture as shown in Table 10.8.2 below.

Table 10.8.2 Water Balance Calculations Case–Angat River Basin

Case	Water Resources	Water Demand	Projected Water Allocation	
			M & I Water Supply	Agriculture
06C	With Project	Alternative 2 Future (2040)	Water allocation dependability with drought safety level of 1/10 for MWSS and Local	AMRIS 17.6 m^3/s Local 0.5 m^3/s Drought Safety Level: 1/5

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).

Source: Prepared by the JICA Study Team

Case 6C-Calculation Conditions:

- Water Resource: 'With Project' consisting of Angat Reservoir + Umiray transbasin diversion with Sumag River intake
- Water Demand: 'Future (2040)' based on Alternative 2
- Projected Water Allocation: Water allocation for agriculture is prioritized to ensure a drought safety level of 1/5. Within the water demand of M & I water supply, the demand in the Angat River basin (Local) is prioritized.

The results of the water balance calculations are summarized in Table 10.8.3 below. The calculated water allocation for M & I water supply (MWSS + Local) is 38.2 m^3/s (33.2 + 5.0).

Table 10.8.3 Results of Water Balance Calculation–Angat River Basin

Case	Water Resource	Water Demand	Projected Water Allocation				Results of Water Balance Analysis						
			Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Annual Supply to Annual Demand				
									Drought Year				
									1/2	1/5	1/10	1/20	1/43
06C	With Project (2040)	Future (2040)	M & I Water Supply	MWSS 33.2	Local 5.0	1/10	98.4%	(508 / 516)	100.0%	100.0%	100.0%	98.9%	82.1%
			Agriculture	AMRIS 17.6	Local 0.6	1/5	97.1%	(501 / 516)	100.0%	100.0%	89.2%	85.3%	31.7%

Note: Cells shown with [blue box] denote the priority water allocation (preconditioned).

Source: Prepared by the JICA Study Team

10.8.2 Agos River Basin

(1) Alternative Water Demand Projections

In this Study, the water balance calculations are performed to identify the scale of the water resources development in the Agos River basin in order to meet the water demand of MWSS in the future. In evaluating the water allocation for MWSS, the precondition is given to ensure the water allocation for M & I water supply and agriculture within the Agos River basin.

The alternatives of water demand projection within the Agos River basin are prepared as shown in Table 10.8.4, based on the assumptions given in Sub-sections 5.5.7 and 6.7.2.

Table 10.8.4 Alternative Water Demand Projections–Agos River Basin

Water Use		Alternative 1 Water Demand (m^3/s)			Alternative 2 Water Demand (m^3/s)		
		Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
M & I Water Supply	Local	2.0	0.0	2.0	0.0	2.0	2.0
Agriculture	NIS	2.9	0.0	2.9	2.6	0.0	2.6
	Local	0.3	0.0	0.3	0.3	0.0	0.3
Total		5.1	0.0	5.1	2.8	2.0	4.8

Source: Prepared by the JICA Study Team

Section 10.2 of this report describes the calculations of the surface water demand and supply balance on the basis of Alternative 1. The calculations with regards to Alternative 2 are described hereunder.

(2) Water Balance Calculations–Laiban Reservoir and Associated Developments

Water balance calculations for the Laiban Reservoir and associated developments are performed in Cases 201, 102, and 203 as shown in Table 10.8.5 below.

Table 10.8.5 Water Balance Calculation Cases–Laiban Reservoir and Associated Developments

Case	Water Resource	Water Demand	Projected Water Allocation
201	With Project ● Laiban Reservoir	Future (2040)	Preconditions: ● Drought safety level of 1/10 is ensured for the projected water allocation for M & I water supply within the Agos River basin. ● Drought safety level of 1/5 is ensured for the projected water allocation for agriculture within the Agos River basin. Water allocation dependability with drought safety level of 1/10 for MWSS is calculated under the preconditions above. Water conveyance from the Kanan No. 2 Reservoir to the Laiban Reservoir is 38.3 m^3/s (3310 MLD).
202	With Project ● Laiban Reservoir ● Kaliwa Low Dam		
203	With Project ● Laiban Reservoir ● Kaliwa Low Dam ● Kanan No.2 Reservoir		

Source: Prepared by the JICA Study Team

The results of water balance calculations are summarized in Table 10.8.6. The dependable water allocation for MWSS with a drought safety level of 1/10 is calculated for the Laiban Reservoir and associated developments as shown below.

Laiban Reservoir	21.2 m^3/s	(1830 MLD)
Laiban Reservoir + Kaliwa Low Dam	21.3 m^3/s	(1840 MLD)
Laiban Reservoir + Kaliwa Low Dam + Kanan No. 2 Reservoir	59.5 m^3/s	(5140 MLD)

Table 10.8.6 Results of Water Balance Calculations–Laiban Reservoir and Associated Developments

Case	Project (MLD)	Projected Water Allocation in 2040				Results of Water Balance Analysis					
		Supply (m^3/s)			Drought Safety Level	Dependability of Supply	Ratio of Supply to Envisaged Water Allocation				
							Drought Year				
							1/2	1/5	1/10	1/20	1/30
201	Laiban Reservoir	M & I Water Supply	MWSS	21.2	1/10	97.8% (352 / 360)	100.0%	100.0%	100.0%	87.9%	86.0%
			Local	0.0							
	1830	Agriculture	NIS Local	2.6 0.3	1/5	100.0% (360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
202	Laiban Reservoir Kaliwa Low Dam	M & I Water Supply	MWSS	21.3	1/10	98.1% (353 / 360)	100.0%	100.0%	100.0%	90.1%	89.2%
			Local	0.0							
	1840	Agriculture	NIS Local	2.6 0.3	1/5	100.0% (360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
203	Laiban Reservoir Kaliwa Low Dam Kanan 2 Reservoir	M & I Water Supply	MWSS	59.5	1/10	97.5% (351 / 360)	100.0%	100.0%	100.0%	90.4%	82.9%
			Local	0.0							
	5140	Agriculture	NIS Local	2.6 0.3	1/5	99.2% (357 / 360)	100.0%	100.0%	100.0%	96.0%	90.4%

Source: Prepared by the JICA Study Team

(3) Water Balance Calculations–Agos Reservoir and Associated Developments

Water balance calculations for the Agos Reservoir and associated developments are performed in Cases 204, 205, and 206 as shown in Table 10.8.7 below.

Table 10.8.7 Water Balance Calculation Cases–Agos Reservoir and Associated Developments

Case	Water Resource	Water Demand	Projected Water Allocation
204	With Project ● Kaliwa Low Dam	Future (2040)	Preconditions: ● Drought safety level of 1/10 is ensured for the projected water allocation for M & I water supply within the Agos River basin. ● Drought safety level of 1/5 is ensured for the projected water allocation for agriculture within the Agos River basin. The development of the Agos Reservoir consists of the water intake/conveyance for MWSS as well as the hydropower. Besides the water allocation to MWSS, 25.6 m^3/s (2210 MLD) is used for the hydropower with a dependability of 90%. As a future development, the Agos Reservoir receives firm-up water flows of 38.3 m^3/s (3310 MLD) released from the Kanan No. 2 Reservoir.
205	With Project ● Kaliwa Low Dam ● Agos Reservoir		
206	With Project ● Kaliwa Low Dam ● Agos Reservoir ● Kanan No.2 Reservoir		

Source: Prepared by the JICA Study Team

The results of water balance calculation for the Agos Reservoir and associated developments are summarized in Table 10.8.8. Case 204 represents solely the Kaliwa Low Dam that is regarded as a provisional development towards the development of the Agos Reservoir. Moreover, it does not ensure a drought safety level of 1/10 for the projected water allocation for MWSS. The remaining cases calculate the dependable water allocation for MWSS with a drought safety level of 1/10.

Kaliwa Low Dam (90% dependable capacity)	5.8 m^3/s	(500 MLD)
Kaliwa Low Dam + Agos Reservoir	36.0 m^3/s	(3110 MLD)
Kaliwa Low dam + Agos Reservoir + Kanan No. 2 Reservoir	57.1 m^3/s	(4930 MLD)

Table 10.8.8 Results of Water Balance Calculations–Agos Reservoir and Associated Developments

Case	Project (MLD)	Projected Water Allocation in 2040				Results of Water Balance Analysis						
		Supply (m^3/s)			Drought Safety Level	Dependability of Supply		Ratio of Supply to Envisaged Water Allocation – Drought Year				
								1/2	1/5	1/10	1/20	1/30
204	Kaliwa Low Dam	M & I Water Supply	MWSS	6.4	1/10	87.8%	(316 / 360)	97.2%	88.0%	85.7%	82.1%	81.8%
			Local	0.0								
	550	Agriculture	NIS Local	2.6 0.3	1/5	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
205	Kaliwa Low Dam Agos Reservoir	M & I Water Supply	MWSS	36.0	1/10	99.2%	(357 / 360)	100.0%	100.0%	100.0%	94.3%	93.9%
			Local	0.0								
	3110	Agriculture	NIS Local	2.6 0.3	1/5	98.1%	(353 / 360)	100.0%	100.0%	98.3%	96.4%	94.1%
206	Kaliwa Low Dam Agos Reservoir Kanan 2 Reservoir	M & I Water Supply	MWSS	57.1	1/10	98.1%	(353 / 360)	100.0%	100.0%	100.0%	92.5%	84.8%
			Local	0.0								
	4930	Agriculture	NIS Local	2.6 0.3	1/5	98.1%	(353 / 360)	100.0%	100.0%	98.3%	96.4%	94.1%

Source: Prepared by the JICA Study Team

10.8.3 Water Demand and Supply Balance–Metro Manila Water Supply

(1) Water Supply Capacity Resulting from Water Balance Calculations

The water supply in Metro Manila needs to be served with the water resources from the adjoining areas (river basins) at present and in the future as well. In this Study, it is assumed that the water resources available in the adjoining areas would initially be made to meet the local water demands of M & I water supply and agriculture and the remaining water could be allocated to MWSS.

Table 10.8.9 shows the water supply capacity from each of the river basins to MWSS with the application of the water demand projection of Alternative 2.

The surface water demand of Alternative 2 in each of the river basins becomes less as Alternative 2 envisages the increase of groundwater use for M & I water supply and 10% reduction of the water diversion requirement for NIS. Compared with Alternative 1, Alternative 2 indicates an increase in the water supply capacity available for MWSS accordingly.

Table 10.8.9 Water Supply Capacity–Water Resources for Metro Manila

Water Resources	JICA Study 2003 (MLD)	World Bank Study 2012 (MLD)	Present Study Demand Alt-1 (MLD)	Present Study Demand Alt-2 (MLD)	Remarks
Angat Reservoir with Umiray-Angat Transbasin Diversion		(4,000)	2,150 760 1,750	2,680 430 1,660	MWSS (2040) M & I Local (2040, preconditioned) Agriculture (2040, preconditioned)
Sumag River		188			
Angat Reservoir with Umiray-Angat Trans-basin Diversion + Sumag River		(4,188)	2,340 760 1,750	2,870 430 1,660	MWSS (2040) M & I Local (2040, preconditioned) Agriculture (2040, preconditioned)
Tayabasan River		175	105	105	Run-of-river Dependability 90%
Laguna Lake		300	300	300	Existing 100 MLD Planned 200 MLD
Laiban Reservoir	1,830	1,900	1,740	1,830	
Laiban Reservoir + Kaliwa Low Dam			1,760	1,840	
Kanan No.2 Reservoir	3,310	3,300			
Laiban Reservoir + Kaliwa Low Dam + Kanan No.2 Reservoir			5,060	5,140	
Kaliwa Low Dam	550	550	410	500	Run-of-river Dependability 90%
Kaliwa Low Dam + Agos Reservoir	3,000	3,000	2,950	3,110	
Kaliwa Low Dam + Agos Reservoir + Kanan No.2 Reservoir			4,820	4,930	

Source: Prepared by the JICA Study Team

(2) Water Resources Development and Water Demand and Supply Balance towards 2037

MWSS Water Demand Projection without Buffer:

With the application of the water demand projection of Alternative 2, the water resources development projects expected to be implemented towards the year 2037 are listed in Table 10.8.10. Water demand and supply balance towards 2037 is shown in Figure 10.8.1.

The required increment of water supply capacity is 41.7 m^3/s (3599 MLD) towards 2037. The roadmap proposed by the World Bank study includes the projects to be implemented by 2021 with the total supply capacity of 5.7 m^3/s (493 MLD). The remaining 35.9 m^3/s (3106 MLD) needs to be developed afterward in the Agos River basin.

Resulting from the water balance calculations, the Laiban Reservoir and associated developments increased the capacity to 52.5 m^3/s (4453 MLD) towards 2037. The Agos Reservoir and associated developments increased the capacity to 52.2 m^3/s (4153 MLD) towards 2037.

Table 10.8.10 Water Resources Development towards 2037 (without Buffer)

Laiban Reservoir and Associated Developments

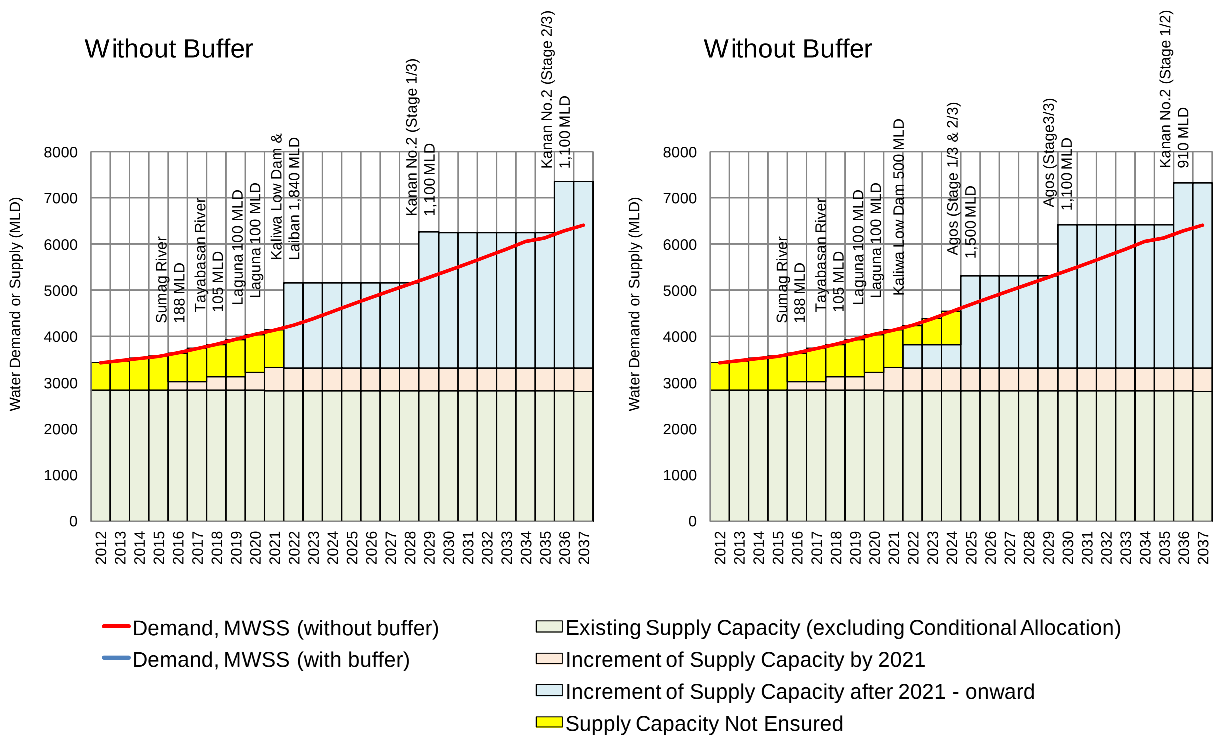
	Project	Year	Capacity (MLD)
	Angat & Umiray	(Existing)	(2,681)
	Laguna & Other	(Existing)	(132)
(1)	Sumag River	2016	188
(2)	Tayabasan River	2018	105
(3)	Laguna Lake	2020	100
(4)	Laguna Lake	2021	100
(5)	Laiban Reservoir + Kaliwa Low Dam	2022	1,840
(6)	Kanan No.2 Reservoir, 1/3	2029	1,100
(7)	Kanan No.2 Reservoir, 2/3	2036	1,100
	Total (1) to (7)		4,533

Agos Reservoir and Associated Developments

	Project	Year	Capacity (MLD)
	Angat & Umiray	(Existing)	(2,681)
	Laguna & Other	(Existing)	(132)
(1)	Sumag River	2016	188
(2)	Tayabasan River	2018	105
(3)	Laguna Lake	2020	100
(4)	Laguna Lake	2021	100
(5)	Kaliwa Low Dam	2022	500
(6)	Agos Reservoir, Stage 1/3 and 2/3	2025	1,500
(7)	Agos Reservoir, Stage 3/3	2030	1,110
(8)	Kanan No.2 Reservoir, Stage 1/2	2036	910
	Total (1) to (8)		4,513

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team

Laiban Reservoir and Associated Developments Agos Reservoir and Associated Developments



Source: Prepared by the JICA Study Team

Figure 10.8.1 Water Demand and Supply Balance–Metro Manila Water Supply (without Buffer)

MWSS Water Demand Projection with Buffer:

With the application of the water demand projection of Alternative 2, the water resources development projects expected to be implemented towards the year 2037 are listed in Table 10.8.11. Water demand and supply balance towards 2037 is shown in Figure 10.8.2.

The required increment of water supply capacity is 51.8 m^3/s (4479 MLD) towards 2037. The roadmap proposed by the World Bank study includes the projects to be implemented by 2021 with the total supply capacity of 5.7 m^3/s (493 MLD). The remaining 46.1 m^3/s (3986 MLD) needs to be developed afterward in the Agos River basin.

Resulting from the water balance calculations, the Laiban Reservoir and associated developments increased the capacity to 65.2 m^3/s (5633 MLD) towards 2037. The Agos Reservoir and associated developments increased the capacity to 62.8 m^3/s (5423 MLD) towards 2037.

Table 10.8.11 Water Resources Development towards 2037 (with Buffer)

Laiban Reservoir and Associated Developments

Project	Year	Capacity (MLD)
Angat & Umiray	(Existing)	(2,681)
Laguna & Other	(Existing)	(132)
(1) Sumag River	2016	188
(2) Tayabasan River	2018	105
(3) Laguna Lake	2020	100
(4) Laguna Lake	2021	100
(5) Laiban Reservoir + Kaliwa Low Dam	2022	1,840
(6) Kanan No.2 Reservoir, 1/3	2025	1,100
(7) Kanan No.2 Reservoir, 2/3	2030	1,100
(8) Kanan No.2 Reservoir, 3/3	2037	1,100
Total (1) to (8)		5,633

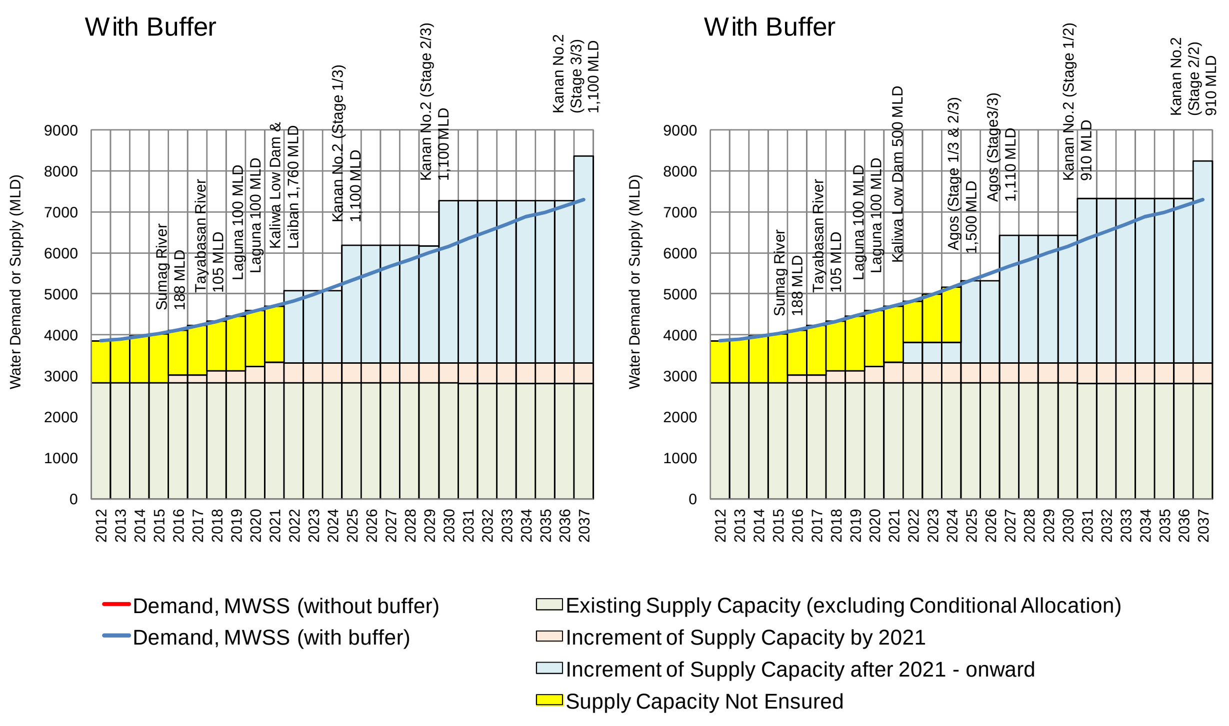
Agos Reservoir and Associated Developments

Project	Year	Capacity (MLD)
Angat & Umiray	(Existing)	(2,211)
Laguna & Other	(Existing)	(132)
(1) Sumag River	2016	188
(2) Tayabasan River	2018	105
(3) Laguna Lake	2020	100
(4) Laguna Lake	2021	100
(5) Kaliwa Low Dam	2022	500
(6) Agos Reservoir, Stage 1/3 and 2/3	2025	1,500
(7) Agos Reservoir, Stage 3/3	2027	1,110
(8) Kanan No.2 Reservoir, Stage 1/2	2031	910
(9) Kanan No.2 Reservoir, Stage 2/2	2037	910
Total (1) to (9)		5,423

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team

Laiban Reservoir and Associated Developments

Agos Reservoir and Associated Developments



Source: Prepared by the JICA Study Team

Figure 10.8.2 Water Demand and Supply Balance–Metro Manila Water Supply (with Buffer)

10.8.4 Metro Manila Water Supply-Impact Assessment under Climate Change Conditions

(1) Water Supply Capacity by Source

With the application of the water demand projection of Alternative 2, the water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change impact assessment and runoff simulation for each of the river basins.

Resulting from the water balance calculations, the water supply capacity by source for the water supply in Metro Manila is estimated as shown in Table 10.8.12 below.

Table 10.8.12 Water Supply Capacity by Source (under Climate Change Conditions)

Unit: m^3/s

GCM for Hydrological Data Set	Existing			Development by 2021		
	Angat Umiray	Laguna Lake & Other		Sumag River	Tayabasan River	Laguna Lake
(Recorded Climate)	31.0	1.5		2.2	1.2	2.3
csiro_mk3_0	30.6	1.5		1.8	1.8	2.3
gfdl_cm2_0	29.6	1.5		2.2	1.1	2.3
gfdl_cm2_1	31.8	1.5		2.4	1.5	2.3
ingv_echam4	34.4	1.5		2.2	1.5	2.3
ipsl_cm4	35.5	1.5		2.3	1.8	2.3
miroc3_2_medres	25.6	1.5		1.8	1.3	2.3

Unit: m^3/s

GCM for Hydrological Data Set	Laiban Reservoir and Associated Developments			Agos Reservoir and Associated Developments		
	Laiban	Laiban + Kaliwa L	Laiban + Kaliwa L + Kanan 2	Kaliwa L	Kaliwa L + Agos	Kaliwa L + Agos + Kanan 2
(Recorded Climate)	21.2	21.3	59.5	5.8	36.1	57.1
csiro_mk3_0	22.3	21.9	60.5	6.3	41.6	63.7
gfdl_cm2_0	16.6	16.6	54.3	7.1	39.1	56.8
gfdl_cm2_1	20.5	20.6	58.7	5.6	35.0	57.8
ingv_echam4	22.1	22.3	60.5	6.0	39.2	59.8
ipsl_cm4	22.9	22.9	61.2	6.6	45.6	64.1
miroc3_2_medres	18.8	19.8	58.1	6.7	42.9	59.4

Source: Prepared by the JICA Study Team

(2) Water Supply Capacity by Scenario

The Laiban Reservoir and associated developments increase the total supply capacity up to 97.7 m^3/s (8445 MLD) under the recorded climate condition. The total supply capacity under the climate change condition ranges from 104.6 m^3/s (8853 MLD) to 90.6 m^3/s (7669 MLD)

The Agos Reservoir and associated developments increase the total supply capacity up to 95.3 m^3/s (8235 MLD) under the recorded climate condition. The total supply capacity under the climate change condition ranges from 107.5 m^3/s (9097 MLD) to 91.9 m^3/s (7776 MLD)

Table 10.8.13 Combined Water Supply Capacity for Metro Manila (under Climate Change Conditions)

Laiban Reservoir and Associated Developments

Unit: m³/s

GCM for Hydrological Data Set	Angat Umiray Sumag	Tayabasan Laguna Other	Laiban Kaliwa L Kanan 2	Total
(Recorded Climate)	33.2	5.1	59.5	97.7
csiro_mk3_0	32.4	5.7	60.5	98.6
gfdl_cm2_0	31.8	4.9	54.3	91.0
gfdl_cm2_1	34.2	5.3	58.7	98.2
ingv_echam4	36.6	5.3	60.5	102.5
ipsl_cm4	37.8	5.6	61.2	104.6
miroc3_2_medres	27.4	5.2	58.1	90.6
			Max	104.6
			Ave	97.6
			Min	90.6

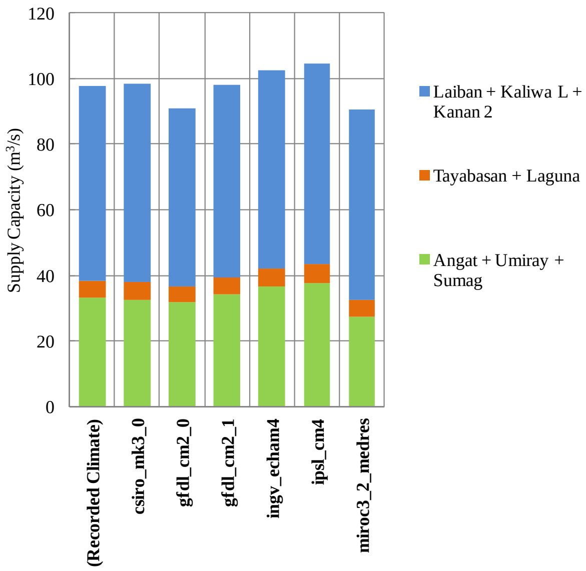
Agos Reservoir and Associated Developments

Unit: m³/s

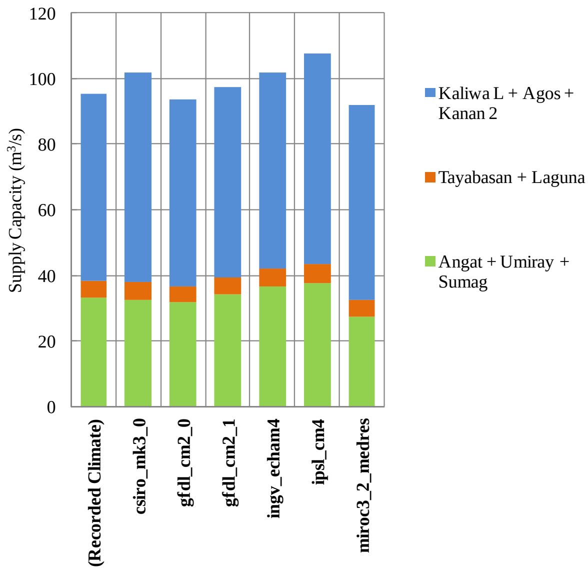
GCM for Hydrological Data Set	Angat Umiray Sumag	Tayabasan Laguna Other	Kaliwa L Agos Kanan 2	Total
(Recorded Climate)	33.2	5.1	57.1	95.3
csiro_mk3_0	32.4	5.7	63.7	101.7
gfdl_cm2_0	31.8	4.9	56.8	93.5
gfdl_cm2_1	34.2	5.3	57.8	97.3
ingv_echam4	36.6	5.3	59.8	101.8
ipsl_cm4	37.8	5.6	64.1	107.5
miroc3_2_medres	27.4	5.2	59.4	91.9
			Max	107.5
			Ave	99.0
			Min	91.9

Note: Change in Supply Capacity; Red-Better, Black-Minor (within +/- 1%), Worse-Blue
Source: Prepared by the JICA Study Team

Laiban Reservoir and Associated Developments



Agos Reservoir and Associated Developments



Source: Prepared by the JICA Study Team

Figure 10.8.3 Combined Water Supply Capacity for Metro Manila (under Climate Change Conditions)

(3) Water Demand and Supply Balance towards 2037 under Climate Change Conditions

Figure 10.8.4 shows the water demand and supply balance towards 2037 under the climate change conditions respectively. The timing of each water resource to be operational is the same as previously described in Sub-section 10.8.3 (refer to Figure 10.8.1).

The total supply capacity by year ranges between 'Climate Change Max' and 'Climate Change Min'. Table 10.8.14 shows a range of the climate change impact on the water supply capacity. It is suggested that the water supply capacity of the Laiban Reservoir and associated developments in 2037 would be variable with a range of +7.1% to -7.6% on the water supply capacity estimated under the recorded climate condition. The suggested range is +14.2% to -1.1% on the water supply capacity of the Agos Reservoir and associated developments.

Table 10.8.14 Water Supply Capacity for Metro Manila under Climate Change Condition

Laiban Reservoir and Associated Developments

Unit: MLD

Year	2021	2022	2029	2036	2037
Recorded Climate	3,321	5,160	6,257	7,354	7,353
Climate Change Max.	3,465 +4.3%	5,370 +4.1%	6,612 +5.7%	7,856 +6.8%	7,877 +7.1%
Climate Change Min.	3,163 -4.8%	4,938 -4.3%	5,878 -6.1%	6,820 -7.3%	6,797 -7.6%

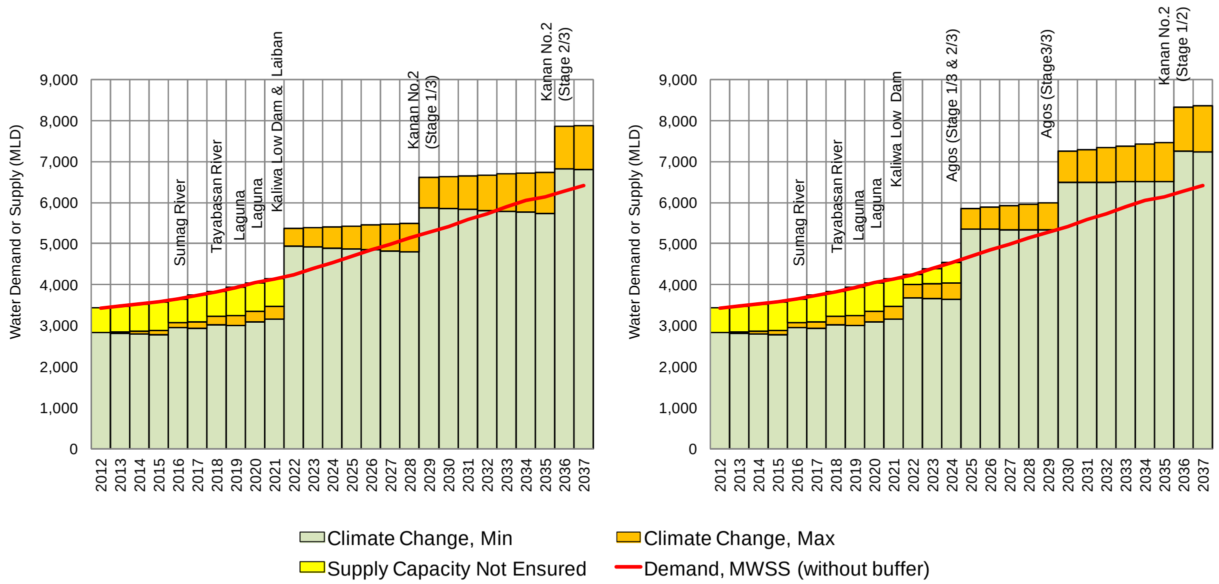
Agos Reservoir and Associated Developments

Unit: MLD

Year	2021	2025	2030	2036	2037
Recorded Climate	3,321	3,820	6,423	7,327	7,326
Climate Change Max.	3,465 +4.3%	4,005 +4.8%	7,247 +12.8%	8,329 +13.7%	8,369 +14.2%
Climate Change Min.	3,163 -4.8%	3,671 -3.9%	6,496 1.1%	7,249 -1.1%	7,245 -1.1%

Source: Prepared by the JICA Study Team

Laiban Reservoir and Associated Developments   Agos Reservoir and Associated Developments



Source: Prepared by the JICA Study Team

Figure 10.8.4 Water Demand and Supply Balance–Metro Manila Water Supply (without Buffer) under Climate Change Condition

(4) Water Demand and Supply Balance towards 2037 under Climate Change Condition–Worst Case

The dependable water allocation for MWSS is at the lowest in the hydrological data set for the period of 2031-2050 based on “miroc3_2_medres”. Figure 10.8.5 shows the water demand and supply balance of MWSS towards 2037 under the climate change condition (“miroc3_2_medres”).

Table 10.8.15 Water Supply Capacity for Metro Manila under Climate Change Condition ("miroc3_2_medres")

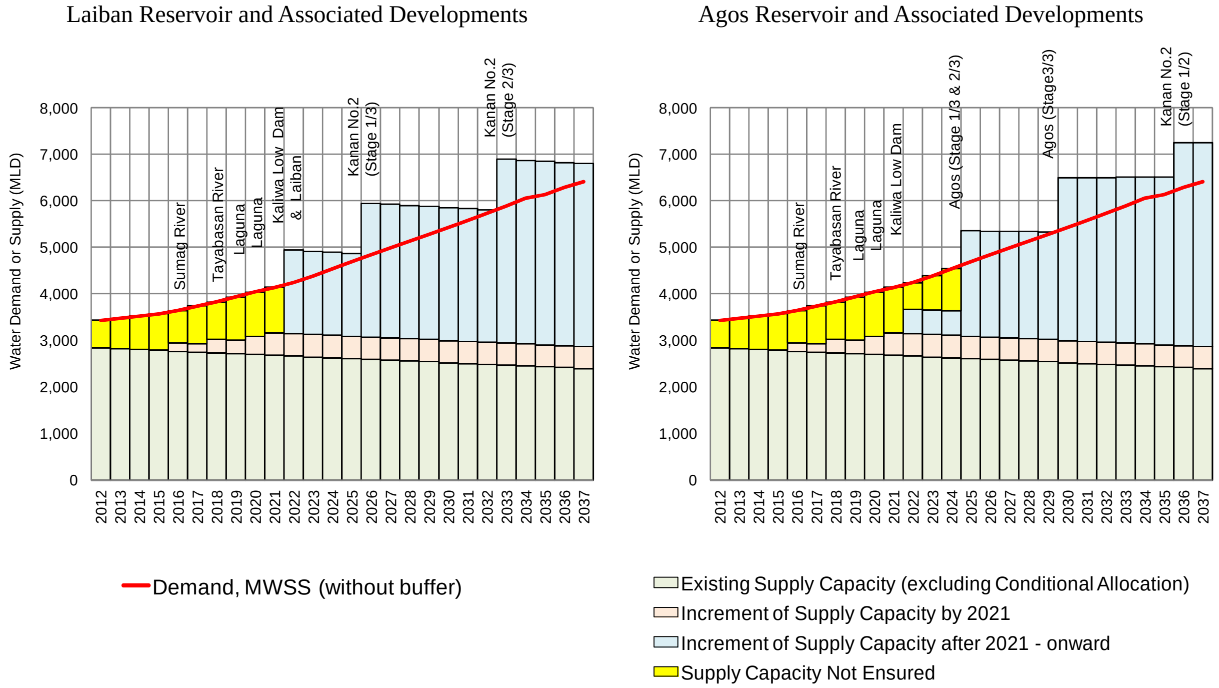
Laiban Reservoir and Associated Developments

Project		Year	Capacity (MLD)
	Angat & Umiray	(Existing)	(2,265)
	Laguna & Other	(Existing)	(132)
(1)	Sumag River	2016	157
(2)	Tayabasan River	2018	114
(3)	Laguna Lake	2020	100
(4)	Laguna Lake	2021	100
(5)	Laiban Reservoir + Kaliwa Low Dam	2022	1,724
(6)	Kanan No.2 Reservoir, 1/3	2026	1,100
(7)	Kanan No.2 Reservoir, 2/3	2033	1,100
Total (1) to (8)			4,395

Agos Reservoir and Associated Developments

Project		Year	Capacity (MLD)
	Angat & Umiray	(Existing)	(2,265)
	Laguna & Other	(Existing)	(132)
(1)	Sumag River	2016	157
(2)	Tayabasan River	2018	114
(3)	Laguna Lake	2020	100
(4)	Laguna Lake	2021	100
(5)	Kaliwa Low Dam	2022	2,431
(6)	Agos Reservoir, Stage 1/3 and 2/3	2025	
(7)	Agos Reservoir, Stage 3/3	2030	1,216
(8)	Kanan No.2 Reservoir, Stage 1/2	2036	731
Total (1) to (8)			4,848

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team



Source: Prepared by the JICA Study Team

Figure 10.8.5 Water Demand and Supply Balance–Metro Manila Water Supply (without Buffer) under Climate Change Condition ("miroc3_2_medres")

Compared with Figure 10.8.1 as previously shown, the Laiban Reservoir and associated developments indicate the need of full development of the succeeding Kanan No. 2 Reservoir until 2037 under the climate change condition. On the other hand, the Agos Reservoir and associated developments indicate no prominent changes in the development until 2037.

10.8.5 Pasig-Marikina River Basin

(1) Alternative Water Demand Projections

The alternatives of water demand projection within the Pasig-Marikina River basin are prepared as shown in Table 10.8.16 below, based on the assumptions given in Sub-sections 5.5.7 and 6.7.2. The water demand projection of Alternative 2 considers that a sustainable groundwater yield in the Pasig-Marikina River basin is 0.60 m^3/s (52 MLD) as described in

Sub-section 7.2.3 and will be fully utilized for the purpose of M & I water supply by the year 2040.

Table 10.8.16 Alternative Water Demand Projections–Pasig-Marikina River Basin

Water Use		Alternative 1 Water Demand (m^3/s)			Alternative 2 Water Demand (m^3/s)		
		Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
M & I Water Supply	Local	3.79	0.00	3.79	3.19	0.60	3.79
Agriculture	NIS	0.00	0.00	0.00	0.00	0.00	0.00
	Local	0.16	0.00	0.16	0.16	0.00	0.16
Total		3.95	0.00	3.95	3.35	0.60	3.95

Source: Prepared by the JICA Study Team

Section 10.5 of this report describes the calculations of the surface water demand and supply balance on the basis of Alternative 1. The calculations with regards to Alternative 2 are described hereunder.

(2) Water Balance Calculation

Based on the hydrological data set for the period of 1981-2010 (30 years), the water balance calculation for the Pasig-Marikina River basin is performed in Case 403 as shown in Table 10.8.17 below.

Table 10.8.17 Water Balance Calculation Case–Pasig-Marikina River Basin

Case	Water Resource	Water Demand	Projected Water Allocation
403	With Project ● Tayabasan Intake	Future (2040)	M & I Water Supply: 3.19 m^3/s Agriculture: 0.16 m^3/s

Source: Prepared by the JICA Study Team

The results indicated that dependability of supply is 76.7% for M & I water supply and 68.1% for agriculture with the Tayabasan Water Supply Project.

The average flow at the intake of the Tayabasan is estimated at 4.13 m^3/s but varies from 0.32 m^3/s (March) to 10.92 m^3/s (August) in a year. A planned reservoir storage of 9.3 MCM is not large enough to supply 175 MLD (2.03 m^3/s) throughout a year. The dependability of the supply capacity of 2.03 m^3/s (175 MLD) is found to be 70.6%. A flow rate with 90% dependability is estimated at 1.22 m^3/s (105 MLD).

Table 10.8.18 Results of Water Balance Calculation–Pasig-Marikina River Basin

No.	Water Resource	Water Demand	Projected Water Allocation: Supply (m^3/s)			Drought Safety Level	Results of Water Balance Analysis: Dependability of Supply	Ratio of Annual Supply to Annual Demand, Drought Year: 1/2	1/5	1/10	1/20	1/30
403	With Project	Future (2040)	M & I Water Supply	MWSS & Local	3.19	Not Specified	76.7% (276 / 360)	85.5%	82.7%	76.6%	76.3%	74.8%
			Agriculture	Local	0.16	Not Specified	75.6% (272 / 360)	82.5%	71.9%	61.5%	58.1%	57.0%

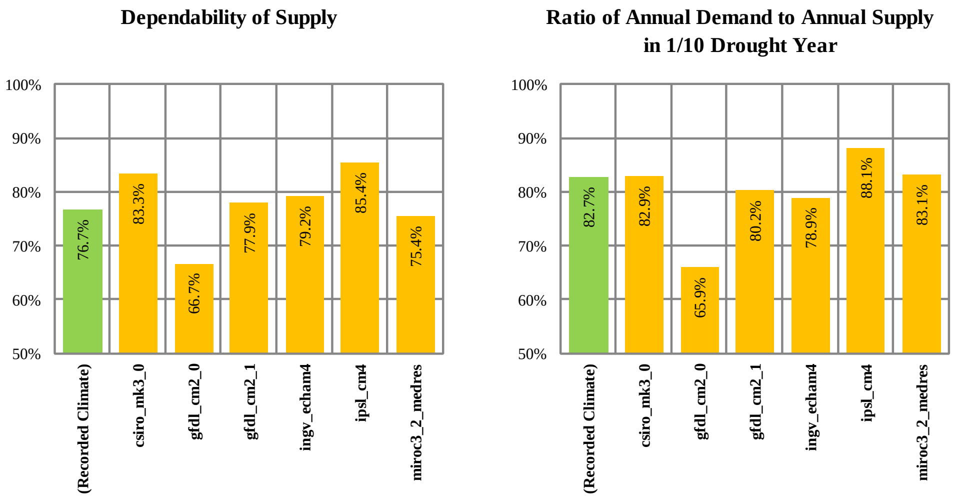
Source: Prepared by the JICA Study Team

(3) Water Balance Calculations under Climate Change Conditions

With the application of the water demand projection of Alternative 2, the water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change impact assessment and runoff simulation for each of the river basins.

Case 403 gives the projected water supply capacity of 3.19 m^3/s for M & I water supply with a dependability of 76.7% under the recorded climate condition. Figure 10.8.6 shows the change in dependability of the projected supply capacity under the climate change conditions

In terms of the dependability of M & I water supply, the climate change impact is regarded as better in four cases and worse in the other two cases. The ratio of annual demand to annual supply becomes better in three cases and worse in the other three cases.



Source: Prepared by the JICA Study Team

Figure 10.8.6 Climate Change Impact on M & I Water Supply–Pasig-Marikina River Basin

10.8.6 Pampanga River Basin

(1) Alternative Water Demand Projections

The alternatives of water demand projection within the Pampanga River basin are prepared as shown in Table 10.8.19 below, based on the assumptions given in Sub-sections 5.5.7 and 6.7.2.

A sustainable groundwater yield in the whole river basin of Pampanga is estimated at 21.40 m^3/s (1849 MLD) as described in Sub-section 7.2.3. Within the sub-basins covered by the water balance calculations, the sustainable groundwater yield is estimated at 14.74 m^3/s (1274 MLD).

The water demand projection of Alternative 2 considers that this sustainable ground water yield will be fully utilized for the purpose of M & I water supply by year 2040.

Table 10.8.19 Alternative Water Demand Projections–Pampanga River Basin

Water Use		Alternative 1 Water Demand (m^3/s)			Alternative 2 Water Demand (m^3/s)		
		Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
M & I Water Supply	Local	14.35	2.06	16.41	1.67	14.74	16.41
Agriculture	NIS	97.20	0.00	97.20	87.48	0.00	87.48
	Local	22.47	1.30	23.77	22.47	1.30	23.77
Total		134.02	3.36	137.38	111.62	16.04	127.66

Source: Prepared by the JICA Study Team

Section 10.7 of this report describes the calculations of the surface water demand and supply balance on the basis of Alternative 1. The calculations with regards to Alternative 2 are described hereunder.

(2) Water Balance Calculation

Based on the hydrological data set for the period of 1981-2010 (30 years), the water balance calculation for the Pampanga River basin is performed in Case 602 as shown in Table 10.8.20 below.

Table 10.8.20 Water Balance Calculation Case–Pampanga River Basin

Case	Water Resource	Water Demand	Projected Water Allocation
602	Existing and Balintingon Reservoir	Future (2040)	M & I Water Supply: 1.67 m^3/s NIS: 87.48 m^3/s Other Agriculture: 22.47 m^3/s

Source: Prepared by the JICA Study Team

The water balance calculation involves the future expansion of UPRIIS V (16,879 ha to 37,200 ha), the new irrigation for 14,900 ha associated with the development of the Balintingon Reservoir, and the future expansion of PDRIS (6,604 ha to 11,920 ha). The results indicated that the ratio of annual supply to annual demand stays at 99.7% in UPRIIS II and 100% in the other NIS divisions in a 1/5 drought year.

The results for M & I water supply indicated that the usable river flow in a 1/10 drought year is still enough to meet the water demand. The results for other agriculture indicated that the ratio of annual supply to annual demand in a 1/5 drought year is lower than 100% in the sub-basins of RCH102 and RCH103.

Table 10.8.21 Results of Water Balance Calculation–Pampanga River Basin

UPRIIS and PDRIS

NIS	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand Drought Year				
				1/2	1/5	1/10	1/20	1/30
UPRIIS Ia	1.17	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.4%
UPRIIS Ib	9.67	98.9%	(356 / 360)	100.0%	100.0%	100.0%	98.7%	84.0%
UPRIIS II	13.32	93.3%	(336 / 360)	100.0%	99.7%	96.4%	95.2%	78.4%
UPRIIS III	14.37	98.3%	(354 / 360)	100.0%	100.0%	97.5%	95.3%	83.8%
UPRIIS IV	19.71	97.2%	(350 / 360)	100.0%	100.0%	98.6%	78.4%	72.5%
UPRIIS V	21.93	98.9%	(356 / 360)	100.0%	100.0%	100.0%	99.9%	86.3%
PDRIS	6.91	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

M & I Water Supply

Sub-basin	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand Drought Year				
				1/2	1/5	1/10	1/20	1/30
PAN	0.15	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	91.5%
PAM5	0.02	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
COR	0.02	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM4	0.21	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PEN	0.01	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM3	0.22	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH103 & 104	0.15	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH102	0.15	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH101	0.32	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAN2	0.40	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

Other Agriculture

Sub-basin	Demand (m^3/s)	Dependability of Supply		Ratio of Annual Supply to Annual Demand Drought Year				
				1/2	1/5	1/10	1/20	1/30
PAN	0.48	99.4%	(358 / 360)	100.0%	100.0%	100.0%	91.4%	90.8%
PAM5	0.92	99.7%	(359 / 360)	100.0%	100.0%	100.0%	100.0%	99.6%
COR	2.24	99.4%	(358 / 360)	100.0%	100.0%	100.0%	99.6%	97.4%
PAM4	1.07	94.2%	(339 / 360)	100.0%	96.5%	92.2%	91.9%	87.7%
PEN	0.10	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAM3	0.04	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
RCH103 & 104	1.48	69.2%	(249 / 360)	61.3%	53.9%	51.9%	44.6%	42.2%
RCH102	2.97	80.3%	(289 / 360)	82.4%	74.2%	68.3%	67.7%	58.5%
RCH101	6.40	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%
PAN2	7.26	100.0%	(360 / 360)	100.0%	100.0%	100.0%	100.0%	100.0%

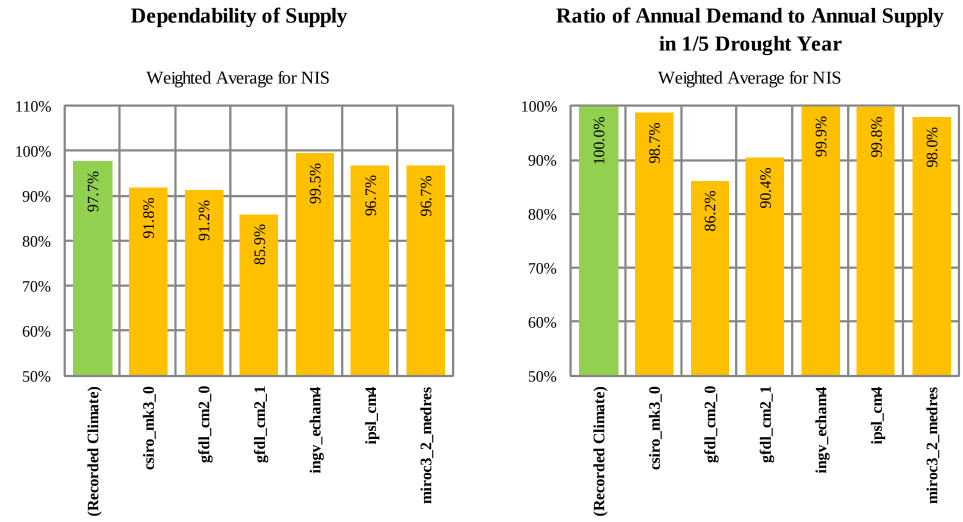
Source: Prepared by the JICA Study Team

(3) Water Balance Calculations under Climate Change Conditions

With the application of the water demand projection of Alternative 2, the water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change impact assessment and runoff simulation for each of the river basins.

The results of water balance calculations in UPRIIS and PDRIS under the climate change conditions are shown in Figure 10.8.7.

In terms of dependability, the climate change impact tends to be better in four cases and worse in the other two cases. The ratio of annual demand to annual supply in a 1/5 drought year tends to be better in three cases and worse in the other three cases.



Source: Prepared by the JICA Study Team

Figure 10.8.7 Climate Change Impact on NIS–Pampanga River Basin

10.8.7 Laguna Lake Basin

(1) Alternative Water Demand Projections

The alternatives of water demand projection within the Laguna Lake basin are prepared as shown in Table 10.8.22 below, based on the assumptions given in Subsections 5.5.7 and 6.7.2.

Table 10.8.22 Alternative Water Demand Projections–Laguna Lake Basin

Water Use		Alternative 1 Water Demand (m^3/s)			Alternative 2 Water Demand (m^3/s)		
		Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
M & I Water Supply	MWSS	3.47	0.00	3.47	3.47	0.00	3.47
	Local	30.28	3.70	33.98	29.06	4.92	33.98
Agriculture	NIS	5.30	0.00	5.30	4.77	0.00	4.77
	Local	2.38	0.00	2.38	2.38	0.19	2.57
Total		41.43	3.70	45.14	39.69	5.11	44.80

Source: Prepared by the JICA Study Team

Section 10.7 of this report describes the calculations of the surface water demand and supply balance on the basis of Alternative 1. The calculations with regards to Alternative 2 are described hereunder.

(2) Water Balance Calculations

Based on the hydrological data set for the period of 1981-2010 (30 years), the water balance calculation for the Laguna Lake basin is performed in Case 802 as shown in Table 10.8.23 below.

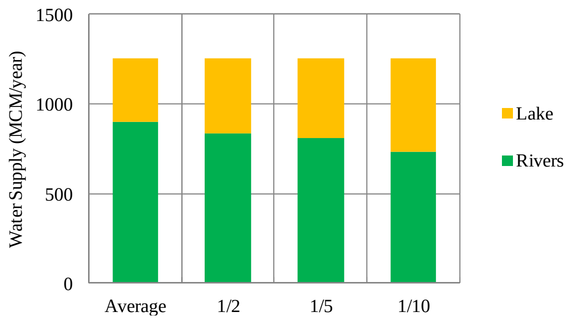
Table 10.8.23 Water Balance Calculation Case–Laguna Lake Basin

Case	Water Resource	Water Demand	Projected Water Allocation
802	Rivers Laguna Lake	Future (2040)	MWSS: 3.47 m^3/s (from Laguna Lake) M & I Water Supply: 29.06 m^3/s Agriculture: 7.14 m^3/s

Source: Prepared by the JICA Study Team

Water demand and corresponding water resources are summarized in Table 10.8.22. The supply depending on the lake water storage increases up to 350 MCM/year which accounts for 28% of the total supply of 1252 MCM/year.

Figure 10.8.8 shows the water use depending on the lake water storage by probable drought year. The water use depends on the lake. Under the future condition (2040), the percentage of water use depending on the lake water storage is estimated at 28% on average and 41% in a 1/10 drought year.



Source: Prepared by the JICA Study Team

Figure 10.8.8
Water Use Depending on Lake Water Storage–Laguna Lake Basin

Table 10.8.24 Water Demands and Corresponding Water Resources

Future (2040): Case 802

Water Use	Demand (MCM/year)	Supply (MCM/year)	
		Rivers	Lake
MWSS	110	0	110
M & I Water Supply (Local)	917	756	161
Agriculture (NIS and Local)	225	146	79
Total	1,252	902	350
	100%	72%	28%

Source: Prepared by the JICA Study Team

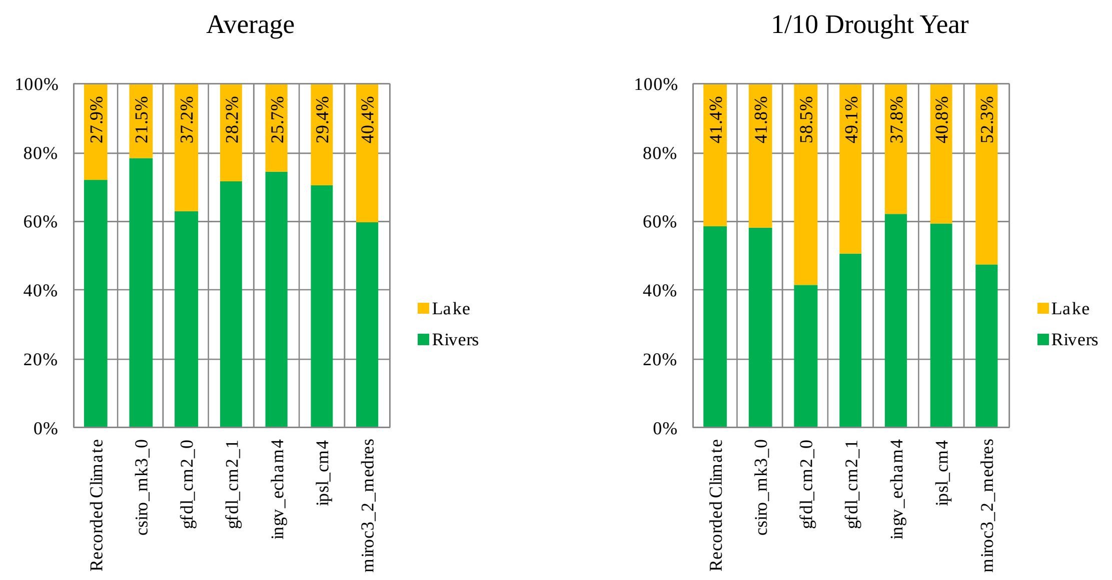
(3) Water Balance Calculations under Climate Change Conditions

With the application of the water demand projection of Alternative 2, the water balance calculations under the climate change conditions are performed using six hydrological data sets for the period of 2031-2050 resulting from the climate change impact assessment and runoff simulation for each of the river basins.

The results of water use depending on the lake water storage are summarized in Figure 10.8.9. The percentage of water use depending on the lake water storage is estimated at 28% on average and 41% in a 1/10 drought year under the recorded climate condition.

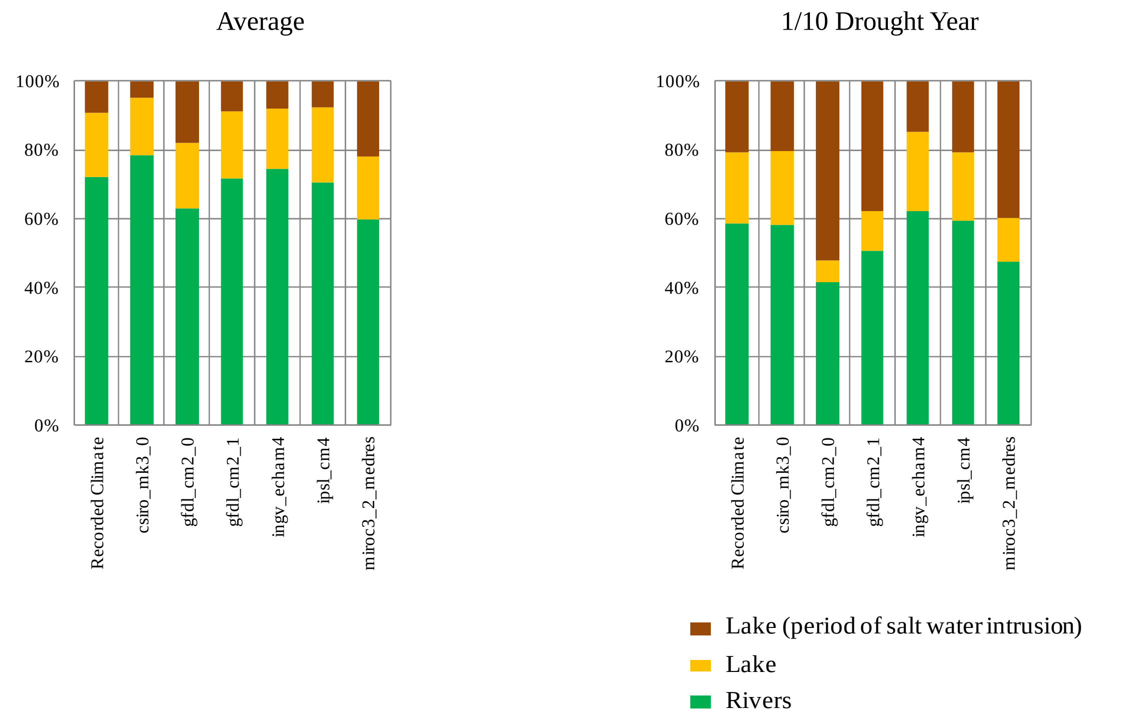
Compared with the percentage on average under the recorded climate condition, the climate change impact is regarded as better in two cases, minor (within +/- 1%) in one case and worse in three cases. In terms of the percentage in a 1/10 drought year, the climate change impact is regarded as better in one case, minor (within +/- 1%) in two cases and worse in three cases.

Figure 10.8.10 indicates the water supplied from the lake during the period of the salt water intrusion. Under the recorded climate condition, the percentage of the annual supply (from rivers and lakes) during the period of the salt water intrusion is estimated at 9% on average and 21% in a 1/10 drought year. The percentage ranges from 5% to 22% on average and from 20% to 52% in a 1/10 drought year under the climate change conditions.



Source: Prepared by the JICA Study Team

Figure 10.8.9 Climate Change Impact on Water Use Depending on Lake Water Storage–Laguna Lake River Basin



Source: Prepared by the JICA Study Team

Figure 10.8.10 Climate Change Impact on Salt Water Intrusion Affecting Supply from Lake Water Storage

10.9 Water Demand and Supply Balance of MWSS towards 2037 with Alternative Combination of Water Demand Projection and Climate Change Impact Assessment

Based on the results of water balance calculation in this chapter, this sub-section describes hereunder the water demand and supply balance of MWSS towards 2037 with the alternative combinations of water demand projection and climate change impact.

The alternative combinations of water demand projection and climate change impact are formulated with the following conditions:

- Water demand projections in Metro Manila: "Without Buffer" or "With" Buffer",
- Water demand projections in adjoining areas: "Alternative 1" or "Alternative 2", and
- Climate Change Impact: hydrological data sets based on climate change analysis of six GCMs

From the conditions above, at least 24 combinations can be formulated. Out of these, Table 10.9.1 shows the outlines of two cases; Case A: Minimized increment of water allocation for MWSS and Case B: Maximized increment of water allocation for MWSS.

Table 10.9.1 Alternative Combinations of Water Demand Projection and Climate Change Impact

	Case A: Minimized increment of water allocation for MWSS towards 2037	Case B: Maximized increment of water allocation for MWSS towards 2037
Water demand projections in Metro Manila	"Without Buffer"	"With Buffer" ● 15% on water demand projection without buffer
Water demand projections in adjoining areas	"Alternative 2" ● The groundwater exploitation for M & I water supply increases towards the future and will be maximized as equivalent to the sustainable yield by year 2040. ● Promotion of water-saving irrigation will be effective for saving 10% of the water diversion requirement for NIS by year 2040. Compared with Alternative 1, Alternative 2 indicates an increase in the water supply capacity available for MWSS.	"Alternative 1" ● The groundwater exploitation for M & I water supply at present (year 2012) will be maintained towards the future.
Climate change impact	ipsl_cm4 ● The climate change impact is mostly positive in the total of water allocation for MWSS.	miroc3_2_medres ● The climate change impact is mostly negative in the total of water allocation for MWSS.

Source: Prepared by the JICA Study Team

Under the water demand projection without buffer in Metro Manila, water demand projections of Alternative 1 in the adjoining areas and recorded climate condition, the required increment of water supply capacity is 47.1 m^3/s (4067 MLD) towards 2037 (refer to Sub-section 10.3). The required increment of the water allocation towards 2037 is estimated at 37.6 m^3/s (3252 MLD) in Case A and 61.7 m^3/s (5327 MLD) in Case B.

The water resources development towards 2037 with the Laiban Reservoir and associated developments is shown in Table 10.9.2 and the water demand and supply balance in Metro Manila is shown in Figure 10.9.1. In Case A, the water demand is satisfied until 2037 with

Laiban Reservoir coupled with the Kaliwa Low Dam to be operational in 2022 and the first stage of the Kanan No. 2 Reservoir to be operational in 2030. Case B requires the operation of Laiban Reservoir and the Kaliwa Low Dam in 2022 and full development of the Kanan No. 2 Reservoir until 2032.

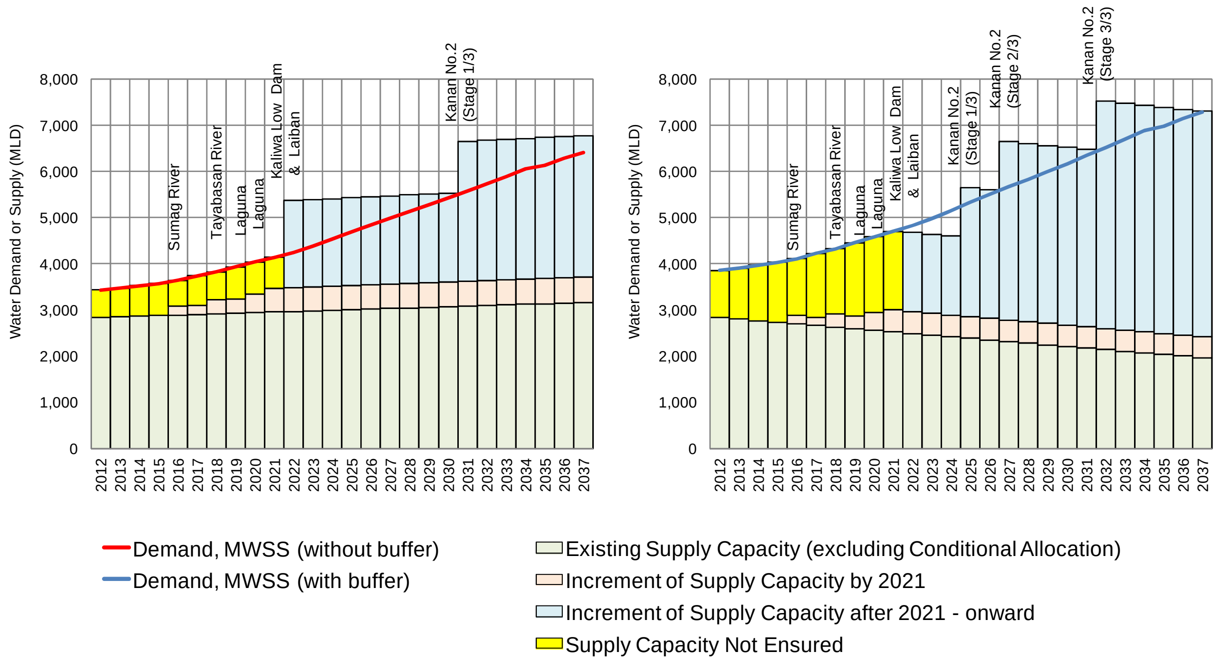
Table 10.9.2 Water Resources Development for Metro Manila Water Supply (Case A & B), Laiban Reservoir and Associated Developments

Project	Case A Capacity Increment Min.		Case B Capacity Increment Max.	
	Year	Capacity (MLD)	Year	Capacity (MLD)
Angat & Umiray	(Existing)	3,028	Existing	1,833
Laguna & Other	(Existing)	132	Existing	132
(1) Sumag River	2016	198	2016	136
(2) Tayabasan River	2018	148	2018	114
(3) Laguna Lake	2020	100	2020	100
(4) Laguna Lake	2021	100	2021	100
(5) Laiban Reservoir + Kaliwa Low Dam	2022	1,965	2022	1,653
(6) Kanan No.2 Reservoir, 1/3	2030	1,100	2025	1,079
(7) Kanan No.2 Reservoir, 2/3	(After 2037)		2027	1,079
(8) Kanan No.2 Reservoir, 3/3	(After 2037)		2032	1,079
Total (1) to (8)		3,610		5,339

Note: Capacity is estimated as of 2037.
Source: Prepared by the JICA Study Team

Case A: Minimized increment of water allocation for MWSS towards 2037

Case B: Maximized increment of water allocation for MWSS towards 2037



Source: Prepared by the JICA Study Team

Figure 10.9.1 Water Demand and Supply Balance–Metro Manila Water Supply (Case A and B), Laiban Reservoir and Associated Developments

The water resources development towards 2037 with the Agos Reservoir and associated developments is shown in Table 10.9.3 and the water demand and supply balance in Metro Manila is shown in Figure 10.9.2. Both Cases A and B are initiated with the Kaliwa Low Dam in 2022. In Case A, the water demand is satisfied until 2037 with the full development of the

Agos Reservoir; first and second stages in 2025 and third stage in 2035. Case B requires the full development of the Agos Reservoir by 2025 and afterward the development of the Kanan No. 2 Reservoir that needs to be fully completed by 2033.

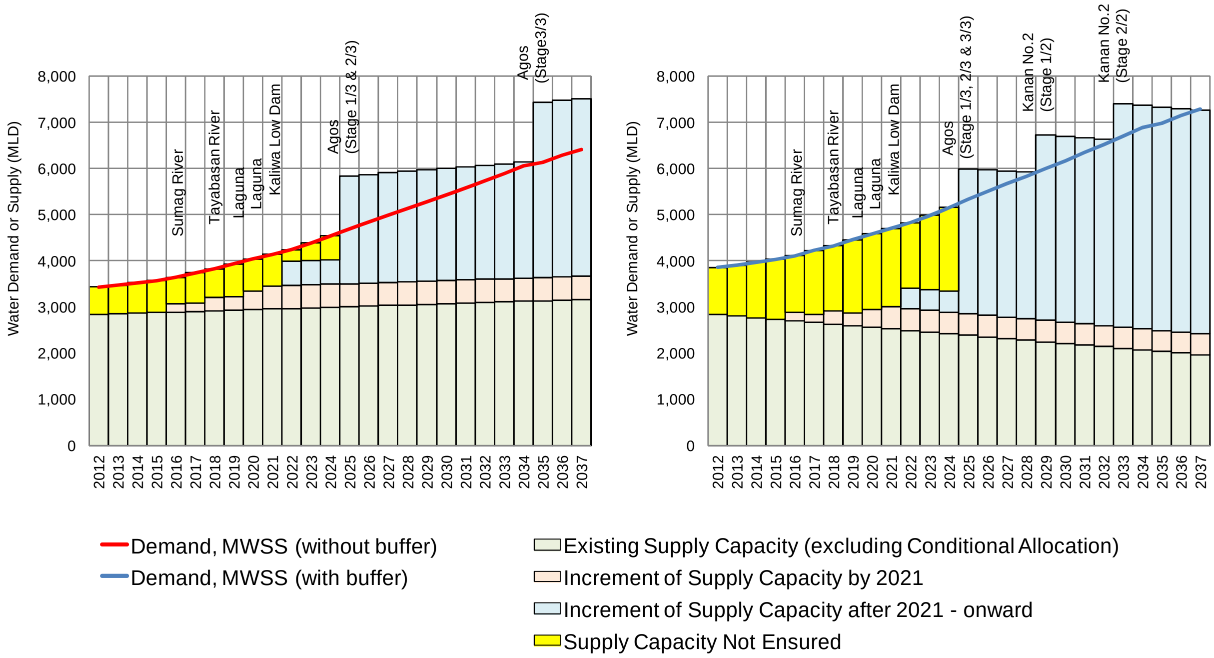
Table 10.9.3 Water Resources Development for Metro Manila Water Supply (Case A & B), Agos Reservoir and Associated Developments

Project	Case A Capacity Increment Min.		Case B Capacity Increment Max.	
	Year	Capacity (MLD)	Year	Capacity (MLD)
Angat & Umiray	(Existing)	3,028	(Existing)	1,833
Laguna & Other	(Existing)	132	(Existing)	132
(1) Sumag River	2016	198	2016	136
(2) Tayabasan River	2018	148	2018	114
(3) Laguna Lake	2020	100	2020	100
(4) Laguna Lake	2021	100	2021	100
(5) Kaliwa Low Dam	2022	2,568	2022	2,205
(6) Agos Reservoir, Stage 1/3 and 2/3	2025		2025	
(7) Agos Reservoir, Stage 3/3	2035	1,284	2025	1,102
(8) Kanan No.2 Reservoir, Stage 1/2	(After 2037)		2029	770
(9) Kanan No.2 Reservoir, Stage 2/2	(After 2037)		2033	770
Total (1) to (9)		4,398		5,297

Note: Capacity is estimated as of 2040.
Source: Prepared by the JICA Study Team

Case A: Minimized increment of water allocation for MWSS towards 2037

Case B: Maximized increment of water allocation for MWSS towards 2037



Source: Prepared by the JICA Study Team

Figure 10.9.2 Water Demand and Supply Balance–Metro Manila Water Supply (Case A and B), Agos Reservoir and Associated Developments

CHAPTER 11 DIAGNOSIS OF THE STUDY AREA

11.1 Water Resources Management

Water resources management includes the following activities; a) to diagnose the water resources in the area, b) to identify problems and causes of occurrence, and c) to draw up relevant appropriate interventions as countermeasures in the management of the problems. It finally introduces the optimum intervention to the site and operates it to enhance the management. Thus, water resources management presents the benefits accrued by the sustainability and safety of water resources without causing significant problems to various sectors. The substantial missions of water resources management are water utilization, disaster mitigation, and water conservation in general.

The studies described in the previous chapters diagnosed the water resources management in the Study Area from each specific sector or discipline focusing on water utilization. The diagnosis has identified problems in water resources management and the causes of the identified problems in the Study Area. The diagnosis identified the substantial required interventions including projects to make water resources management to be desirable through alleviating or solving problems as well. Along this line, the identified problems and causes indicate the key issues in the evaluation of a project proposed in the roadmap presented in the Metro Manila Water Security Study by WB. The required interventions identified by the diagnosis study are indicative for evaluation of the projects as well.

The Fault Tree Analysis (FTA) is a method developed by the Self Control Technology to diagnose the status of electronic equipment automatically. The method stores information of problems to occur frequently in a memory unit mounted on the equipment in the form of a tree structure together with automatic diagnosis system. The memory unit files the conceivable causes that would possibly bring about the problems and countermeasures that could remove or alleviate the causes as well. Once a problem occurs in the equipment, the automatic diagnosis system is activated and accesses the file to identify the problem, to detect causes of the problems, and to select the relevant countermeasure that could remove or alleviate the causes to solve the problem. The system exhibits a visual or voice message addressed to the operator of the equipment as an automatic diagnosis system.

Since the commencement of the works in February 2012, experts of the Study Team conducted the Study for various sectors, i.e., institution and organization, environment, socioeconomy and municipal water supply, irrigation, hydro-meteorology, hydrogeology, and water resources management. The results of the Study are useful to diagnose the water resources situations of MWSS service area and its adjoining river basins as mentioned in the previous paragraph. The First Technical Committee Meeting held on April 20, 2012 confirmed the results of the diagnoses in the form of a fault tree although it was at the intermediate stage of the Study.

Summing up the results of the diagnosis study from various disciplines discussed in the previous chapters, the Study has developed a fault tree on the water resources management for each of the MWSS service areas and adjoining river basins focusing on water utilization. A fault tree is some sort of “medical carte” which presents the summary of the diagnosis or examination results of the water resources management. A countermeasure on the end of a tree is a proposed treatment which is expected to be effective to remedy the problem. It is, in other words, an intervention which is required in the water resources management. A water resources development project is one of the physical interventions and the FTA enunciates the key issues for the assessment of a project proposed in the roadmap developed by the WB study through identification of problems and causes. A comparison of a project with relevant countermeasure in the fault tree furnishes the evaluation as well.

In view of water utilization, the multidisciplinary studies could not find any substantial problem in the water resources management in the Agos River basin and Umiray River basin. The river basins are sound in terms of quantity and quality. Further, water demand and supply balance study for the river basins confirmed that the potentials of both river basins provided to the projected water demands that will emerge in the relevant river basins even in the year 2040. In this consequence, Fault Tree Analysis is not prepared for both river basins.

The following section discusses the identified problems, causes, and conceivable countermeasures in details. The presented fault trees exhibit the summaries of the diagnoses and the key issues to assess the effects of the projects proposed in Metro Manila Water Security Study by the WB.

11.2 Diagnosis by River Basins

11.2.1 MWSS Service Area

One of the substantial problems in the MWSS service area is the limited water supply potential of Angat system of 4600 MLD according to the results of the water demand and supply balance study conducted. The Angat system is the one that mainly provides water supply to MWSS service area with a demand of 3400 MLD as well as to the Angat Maasim River Basin Irrigation System with a demand of 1700 MLD including the municipal water supply to Bulacan Province of 200 MLD. The alternative water sources of Metro Manila water supply are Laguna Lake and groundwater. The alternative systems could only share 200 MLD in total and the balance of 3200 MLD depends on the Angat system. Meanwhile, the AMRIS and Bulacan Province, both located in the Angat River basin, have no alternative water source. Eventually, the estimated potential is 2700 MLD which could be allocated to MWSS service area without causing harmful effects to others. The subsequent supply capacity of the MWSS service area is 2900 MLD including Laguna Lake and groundwater so far.

Rationalization of municipal water supply in the MWSS service area is quite seldom at present because highest priority is legally vested on municipal water supply and water of 3200 MLD is secured to be diverted to MWSS service area to meet the demand even in dry periods. On the contrary, shortfall of irrigation water supply is frequent in AMRIS especially during the dry season. Water supply to Bulacan Province is nil at present.

The countermeasure against the limited supply potential is to maximize the potential by providing new dams because the average annual water resources is more than enough in general and regulation of the high wet season river flow could solve the problem. Increasing the regulating capacity is the most effective countermeasure against the fluctuating monsoonal hydrology. Increasing the regulating capacity of Angat Dam by elevating the normal high water level is another option because the inflow to the reservoir in the wet season is far more than the present storage capacity of the reservoir.

The fluctuation of hydrology in the target area within a given year varies yearly based on the different effects of the monsoon. Further, average annual water resources potential fluctuates between years as well. Increasing the regulating capacity has the possibility to cope with the fluctuation between years depending on the extent of increase and fluctuation.

Actually, there are several plans being done to develop new alternative water sources to increase the regulating capacity and supply potential. The promising options are the realization of the proposed dams in the Agos River basins like Laiban Dam, Kaliwa Low Dam, Kanan Dam, and Agos Dam. At present, Sumug Dam is being implemented in the Umiray River basin. In this addition, Tayabasan Dam on the Pasig-Marikina River and the extension of water abstraction from Laguna Lake are other proposed options of countermeasures. The water demand and supply balance simulation study enumerated the possible increases in the supply capacity by each development option. The expected increases are summarized in Table 11.1;

Table 11.1 Capacity Development of the Proposed Option

Name of Option	River Basin	Enlargement (MLD)
Laiban Dam	Agos	1,900
Kaliwa Dam	Agos	1,000
Kaliwa Intake	Agos	500
Agos Dam	Agos	3,000 (5500)
Kanan No.2 Dam	Agos	3,300
Dam Heightening	Angat	
Sumug Dam	Umiray	188
Tayabasan Dam	Pasig-Marikina	175
Extention of Laguna Lake abstraction	Laguna Lake	200

Source : JICA Study Team

Among the proposed nine options only Sumug Dam Project is realized. There are several impediments that have hampered the implementation of the schemes. These are the large amount of investment, social problems like land acquisition and environmental issues. The complicated institutional procedures entail long processing time that impede the implementation of the proposed schemes.

The estimated annual escalation rate is almost 8.0% for the past ten years. Construction costs of a dam and other facilities have inflated accordingly. Optimum design is crucial to reduce construction cost through removal of ineffective expenditures. The design should take into consideration the multiple uses of dam to generate additional benefits other than water supply. Other purposes could share a part of the large amount of investment. Hydropower generation is one of these promising options.

Land acquisition and resettlement of the affected people are substantial social problems as usual. The people that will be affected tend to consider the offered resettlement and compensation plans even if these are not just and equitable and favor only the other party. One of the countermeasures against the issue is to bring the affected people into the implementation side of the water supply project. The affected people may become cooperative if they realize that successful implementation is beneficial to them. Their participation would be an effective countermeasure for the social issue.

A large scale intervention like provision of a dam has impact to the environment at the site. The design of the intervention should assess the impacts to be entailed and remedial options should be integrated in the project as its components.

Institutional procedures for the implementation of a scheme are quite complicated in the country because almost 30 agencies share the same mandate of water resources management. Institutional processing before the commencement of construction works takes a certain time after application. The cost incurred during the time inflates the implementation cost as well. Simplifications of the procedures and the decision making are required. The proposed establishment of the National Water Resources Council is supposed to be the most effective and realistic countermeasure.

Water resources management envisages demand side rationalization as an optional intervention to enhance water utilization as well. Rationalization of the demand is a different type of countermeasure against limited supply potential. The assumed per capita daily consumption of 150 lpcd is not extraordinary as compared with other urban areas. However, rationalization of demand by saving water should be considered because Metro Manila is dependent almost to all water sources on an inter-basin diversion scheme from adjoining areas. In this connection, introduction of water re-use system is proposed for both domestic and nondomestic uses as a countermeasure.

Water supply from Angat system in dry season is very limited. Demand rationalization through saving water in this period is effective to ease water supply conditions in MWSS service area. Incentive is effective to encourage saving of water. MWSS should provide incentives to those who would save water in the dry season. Although a careful institutional study is necessary, a seasonal water tariff system is effective to rationalize water demand in the dry season.

Another problem is the low reliability of water supply or water security in the MWSS service area. Angat system shares almost 95% of the total water supply in the area, in the nation's capital without additional supply. Any untoward incident to the system could dry up Metro Manila and will create a huge damage to the nation's socio-economy.

The proposed schemes for new source development as discussed above provide additional water sources and could be the countermeasure for low reliability of water supply as well.

The other substantial problem is lowered groundwater table due to over exploitation. Land subsidence is a significant problem today together with saline water intrusion. Present groundwater exploitation of 2782 l/s exceeds the preliminarily estimated potential of 680 l/s. A detailed research on the groundwater potential is necessary to identify safe yields from site to site. The water rights granted by NWRB should be reviewed taking account the well fields on the basis of the research conducted. Rules of groundwater exploitation should be established on the basis of the research conducted as well. Monitoring or recording equipment of groundwater exploitation should be installed in groundwater wells as much as possible. Institutional strengthening of NWRB is necessary to conduct the works mentioned above. The establishment of NWRC is effective for the strengthening of the system. Provision of rain water harvesting facilities like infiltration trench is effective in urbanized area to mitigate land subsidence.

11.2.2 Angat River Basin

The main problems in the Angat River basin are shortage in water supply and salinity of groundwater. The shortage is closely related with that of MWSS service area because substantial water of the river is diverted to the area through the Angat system. Shortfall in irrigation water supply is often experienced in AMRIS located in the downstream reach of Angat Dam. Bulacan Province is still waiting for the allocation of water for municipal uses. The over exploitation of groundwater has lowered groundwater table and has caused salinity problem due to connate salt.

The estimated municipal water demand depending on Angat system is 38.9 m^3/s summing up the demands of diversion to MWSS service area (37 m^3/s) and municipal water demand of Bulacan Province (1.9 m^3/s; 2006 Resolution of NWRB). The estimated annual mean irrigation water demand depending on Angat system is 19.2 m^3/s. Further, the Angat system is allowed to release its water to conserve the river environment. The allowable water to share is defined to be 1.9 m^3/s by the 2001 Resolution of NWRB. The total demand to Angat system is 60 m^3/s.

The estimated average supply capacity of Angat system is 53 m^3/s with the regulation made by Angat Reservoir that has a storage capacity of 894 million m^3. The deficit of 50% dependable supply capacity of 7 m^3/s is the root cause of the shortfall in water supply. The deficit becomes about 15 m^3/s in case where municipal water supply calls for 90% dependability and that of irrigation water supply is 80% according to the results of the demand and supply balance study.

The countermeasures for the shortfall in water supply are the development of new water sources and rationalization of irrigation water demand. In this respect, rationalization of municipal water demand in Manila is discussed in the previous section. Further, the former section discussed the provisions of new water sources like Laiban Dam as a countermeasure for the large municipal water demand in MWSS service area. Development of a substantial alternative water source for MWSS service area will provide Angat system a certain amount of slack in the capacity and is expected to solve water deficits in irrigation and water supply in Bulacan Province.

The development of alternative sources for AMRIS would be effective in alleviating shortfall in irrigation water supply. Maasim Dam and Bayabas Dam are the most promising options.

Rationalization of irrigation water demand is another effective countermeasure to alleviate irrigation water shortage. Alternate Wet and Dry Cultivation (AWDC) is a new paddy cultivation technology to control irrigation water demand. It adopts the intermittent water supply component of System of Rice Intensification (SRI) which is a more comprehensive and popular new technology for paddy cultivation being adopted all over the world. According to the practice of SRI, the new technology could save about 40% of irrigation water use under traditional cultivation. AWDC being promoted by the government is expected to save more or less water when it is adopted by irrigation system.

Real Time Operation System (RTOS) is another water saving technology for irrigation. An irrigation system guaranties 80% dependable water. An irrigation system is used to supplement the assumed effective rainfall against consumptive use through diverting water to paddy field. A system assumes the effective rainfall available in times of drought occuring once every five years (80% dependable) in its water supply. Accordingly, a part of the supplied water is wasted in four out of five years because the effective rainfall available in the four years are more than that of assumed. The RTOS measures rainfall depth actually received in the farm and decides the amount to supply adaptively under real time basis. Thus, wasting will be controlled remarkably. The controlled wasting keeps water in the reservoir otherwise it should be dispensed.

There are some irrigation facilities that are impeding effective water conveyance due to deterioration. Organizational strengthening is necessary to improve maintenance works.

The inflow to Bustos Dam which has no regulating capacity fluctuates widely due to the fluctuating release from Angat Dam. Frequently, inflows are far more than that to be tapped by the irrigation system. One of the main causes of fluctuation is the peak power generation without reregulation. Provision of a reregulating dam between the power station site and Bustos Dam is a countermeasure to alleviate the problem.

Inflow to Angat Reservoir fluctuates as well. The storage capacity of 894 MCM is insufficient to regulate the fluctuation. Heightening of NHWL increase the storage capacity and is proposed as a countermeasure as discussed in the previous section.

Sharing a water source with the municipal water demand of MWSS service area is the main cause of shortfall in irrigation water supply. Irrigation water supply has no chance once it conflicts with municipal water supply because of the vested priority stipulated in the Water Code. Alternative exclusive source development is proposed as a countermeasure against the problem as discussed in the above paragraph

Present estimated groundwater exploitation of 1.1 m^3/s is almost 1/4 of the estimated potential of 4.8 m^3/s. However, the substantial exploitations concentrated in narrow urbanized areas and have caused overexploitations of water resources in the local community. Lowered groundwater table approaches to the saline water due to the connate salt. Transfer water source from groundwater to surface water is a countermeasure to recover the elevation of groundwater table. Rationalization of groundwater exploitation in a narrow area is another countermeasure of the saline water problem. Institutional strengthening is necessary for the rationalization. The establishment of NWRC is the most realistic option for the problem.

11.2.3 Pampanga River Basin

The water demand and supply balance study revealed that the large water demand of 140 m^3/s in 2010 caused water supply shortfall in the Pampanga River basin especially in the dry season due to fluctuation of surface water resources within a year. Provisions of regulating facilities such as dams are the most effective supply side countermeasures to cope with the fluctuation of water resources. Various alternative plans have been proposed to provide additional dams. Balingtingon Dam Project is one of the most promising proposed plans. However, the implementation thereof was delayed due to various reasons. The reasons are almost similar to the Angat River basin discussed in the previous subsection. Therefore the possible countermeasures are similar to the case of the Angat River basin as well. These are; the optimization of design, encouraging affected people to participate in the water supply projects, provision of environmental protection works, and institutional enforcement.

About 130 m^3/s of water demand is attributed to irrigation water demand. Rationalization of the irrigation water demand is the other effective demand side countermeasure to improve the situation in view of water resources management. There are several causes that brought the high irrigation water demand which has similar causes as to the case of the Angat River basin. The proposed countermeasures are; real time operation system, research on less water consuming variety, and organizational reinforcement for better maintenance as discussed in the case of the Angat River basin.

Present estimated groundwater exploitation of 3.2 m^3/s is almost 1/3 of the estimated potential of 9.5 m^3/s. However, spatially concentrated exploitations have caused overexploitations of water resources in the local community similar to the condition that happened in the Angat River basin. Thus, salinity of groundwater is one of the main problems in the Pampanga River basin. Transfer of water source from groundwater to surface water is a countermeasure to recover the elevation of groundwater table. Rationalization of the concentrated groundwater exploitation in a narrow area is another countermeasure to the saline water. Institutional strengthening is necessary for the rationalization. The establishment of NWRC is one of the most realistic options to mitigate some problems in this river basin.

11.2.4 Pasig-Marikina River Basin

Present estimated groundwater exploitation of 0.5 m^3/s is more than 80% of the estimated potential of 0.6 m^3/s. Further, the spatially concentrated exploitations have caused overexploitation of water resources in the local community. Land subsidence is one of the main problems in the Passig-Marikina River basin. Groundwater recharge in the urbanized areas is effective to cope with the land subsidence. Rainwater harvesting and a provision of infiltration facility are conceivable countermeasures. Rationalization of the concentrated groundwater exploitation in a narrow area is another countermeasure to prevent groundwater depletion. Institutional strengthening is necessary for the rationalization. The establishment of NWRC is the most realistic option as a countermeasure in this river basin.

Transfer of water source from groundwater to surface water is another option to recover the elevation of groundwater table. The flood control plan in the river basin contemplates the development of Marikina Dam. The Metro Manila Water Security Study prepared by WB envisioned the utilization of a part of its storage for water utilization. The development of multipurpose Marikina Dam will provide surface water source to the river basin.

11.2.5 Laguna Lake Basin

The poor water quality is a problem for the water resources management in Laguna Lake basin. Treatment of the water requires expensive process to utilize water for municipal water supply. High costs to be incurred by the operation of treatment plants have hampered a large scale water resources development. Provisions of sewerage systems to treat domestic and industrial effluents are conceivable countermeasures in this respect. Aquaculture is another pollutant source in the lake. However, a comprehensive research is necessary to alleviate the problem caused by aquaculture. Gate operation is effective to control saline water intrusion to the lake although a comprehensive research is necessary because brackish water aquaculture is one of the substantial industries in the Laguna Lake basin.

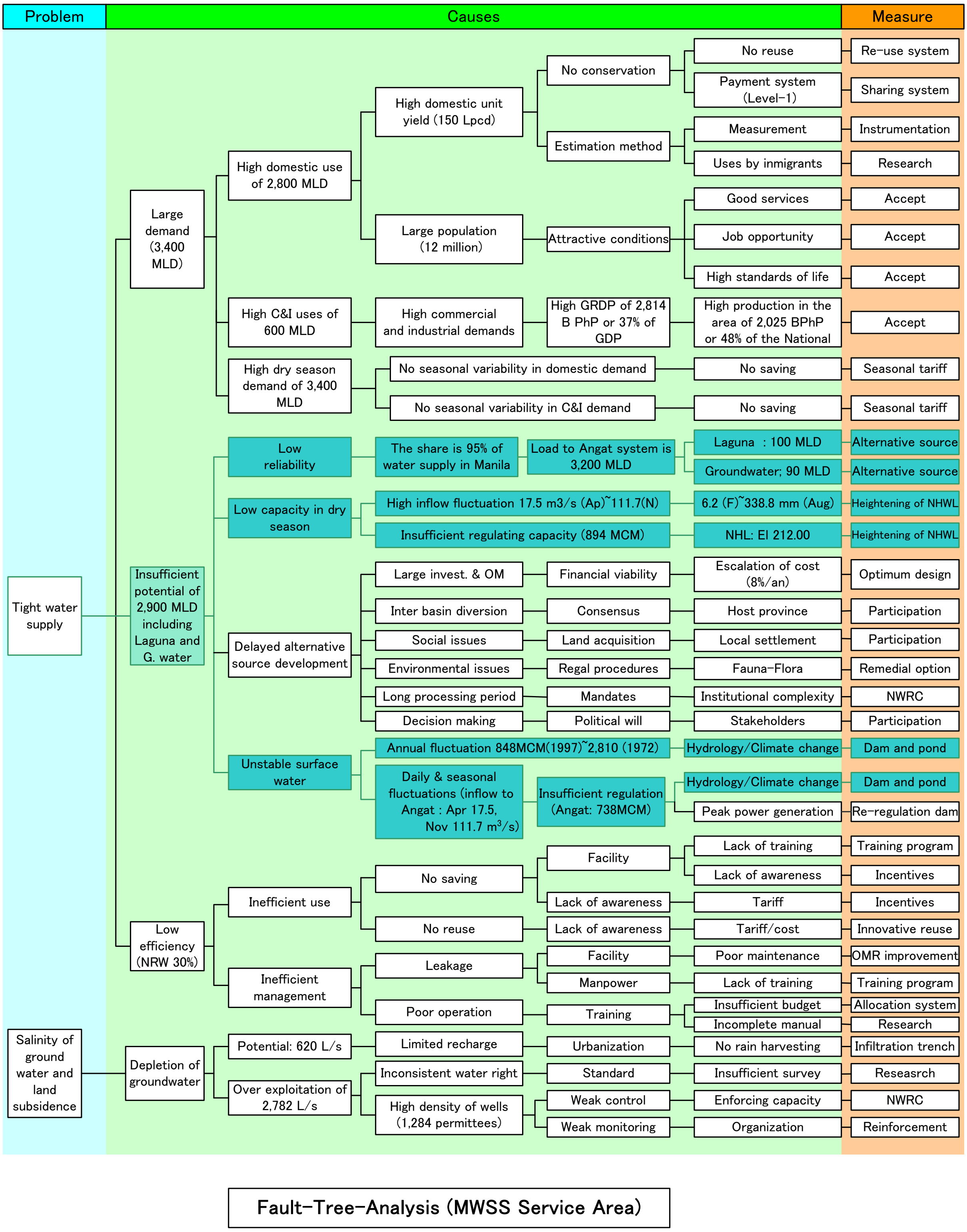
Present estimated groundwater exploitation of 3.7 m^3/s is almost 70% of the estimated potential of 5.5 m^3/s. However, spatially concentrated exploitations have caused overexploitations of water resources in the local community. Transfer of water source from groundwater to surface water is a countermeasure to recover the elevation of groundwater table. Capacity building of groundwater management is necessary to enhance water resources management in the basin. The establishment of NWRC is an effective countermeasure for this problem.

11.3 Effects of the Proposed Projects

Figures 8.1 to 8.4 show the Fault Tree analyses prepared.for relevant river basins.

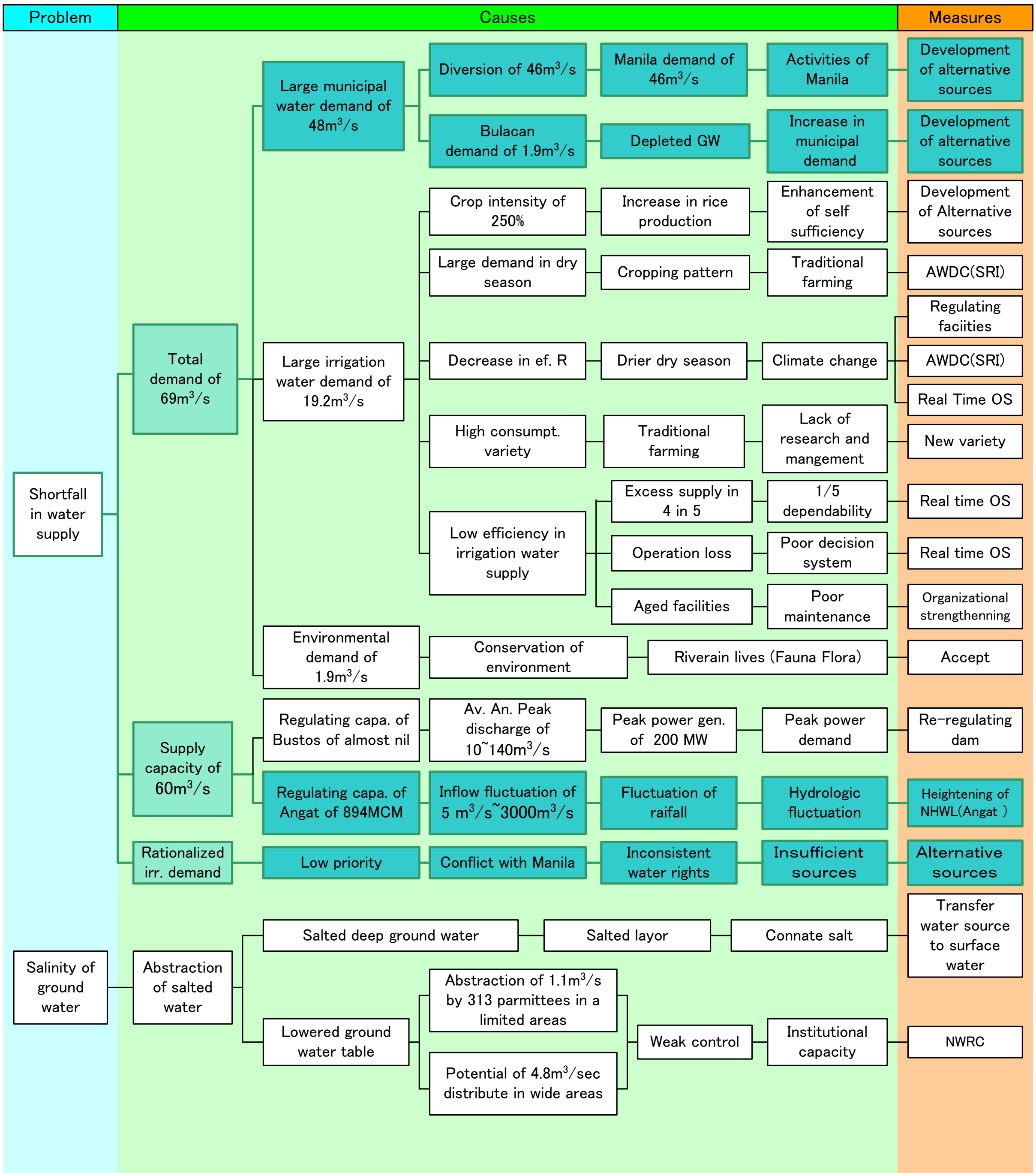
A Fault Tree analysis shows the problems on the left column shown with a blue background. The causes of the problem extend on the middle column shown with a green background from immediate causes to root causes. Possible countermeasures are listed on the right end column shown with a brown background.

The green box in the Fault Tree presents problem or cause to be alleviated by the projects proposed in the Metro Manila Water Security Study by the WB. The green box on the column for the proposed countermeasures is to be accomplished by relevant proposed projects. The effects of the proposed projects are to be assessed through examination of the impacts to the green box in the Fault Tree. Meanwhile, the boxes left uncolored (white) indicate that not any of the proposed projects can improve the problem or cause.



Source: Prepared by the JICA Study Team

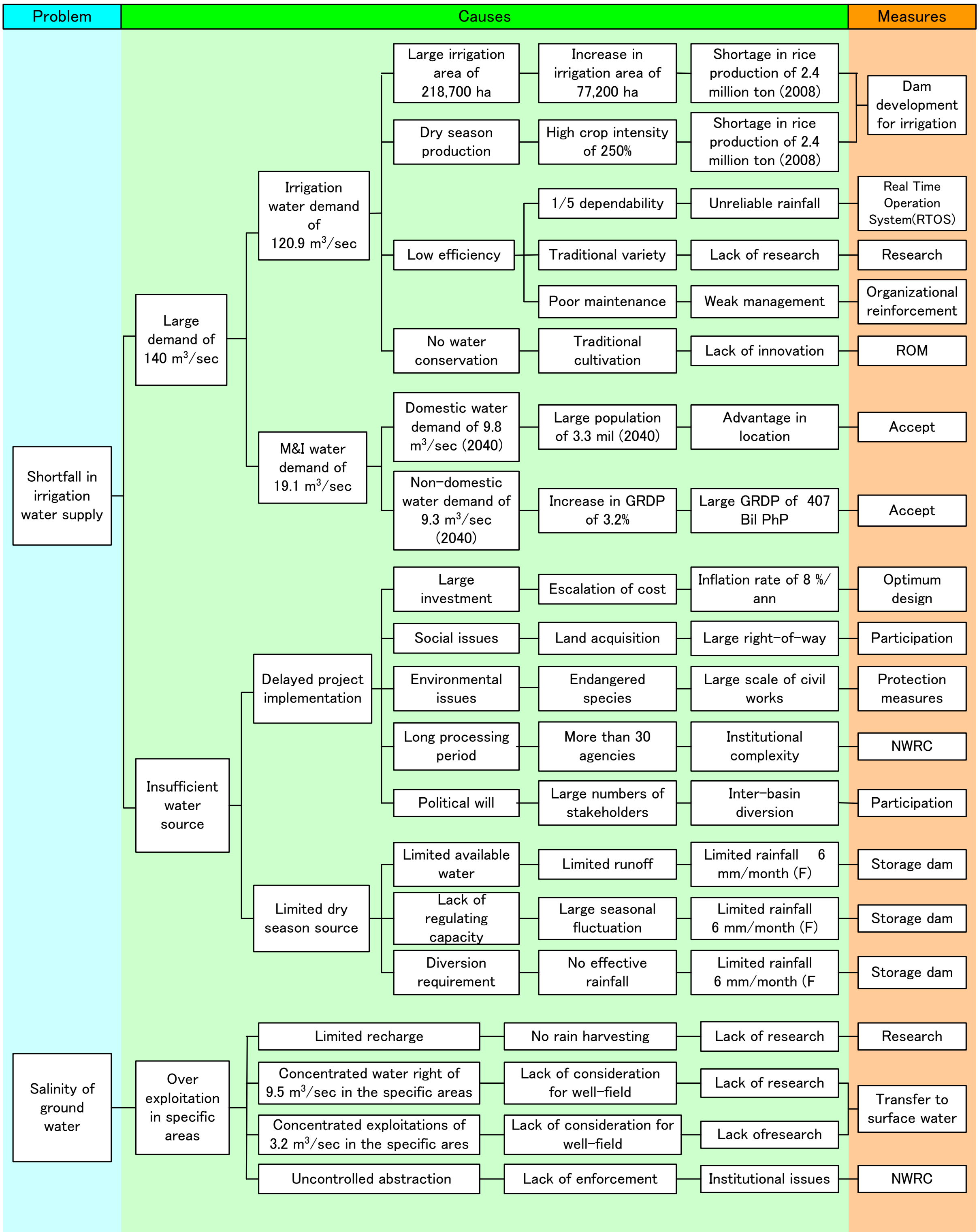
Figure 11.1 Fault Tree Analysis in the MWSS Service Area



Fault-Tree-Analysis (Angat River Basin)

Source: Prepared by the JICA Study Team

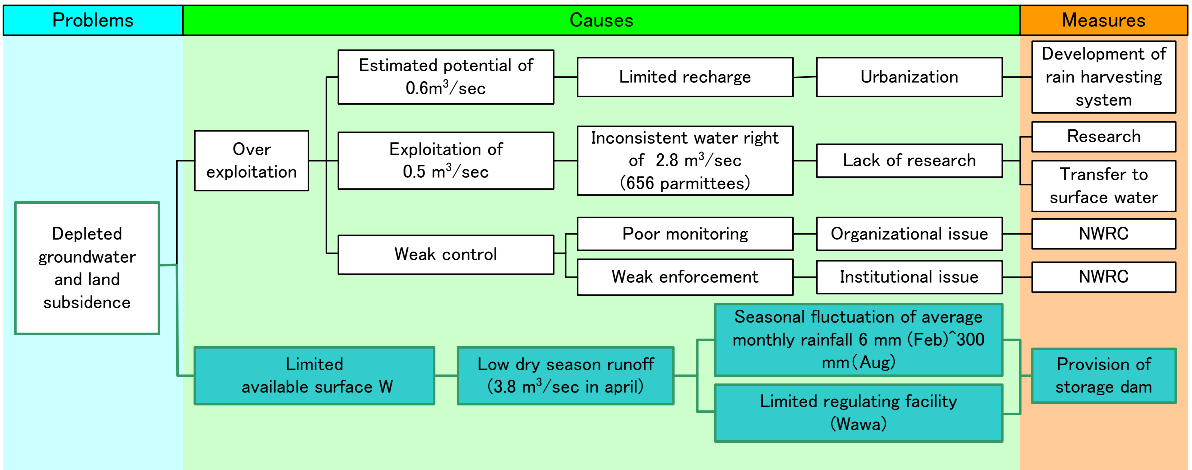
Figure 11.2 Fault Tree Analysis in the Angat River Basin



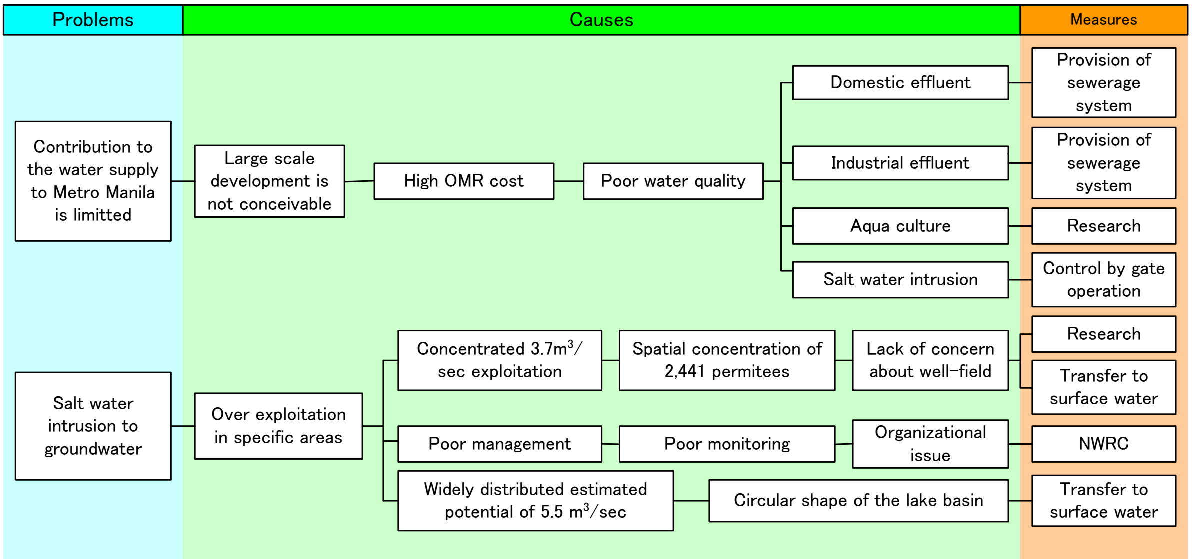
Fault-Tree-Analysis (Pampanga River Basin)

Source: Prepared by the JICA Study Team

Figure 11.3 Fault Tree Analysis in the Pampanga River Basin



Fault-Tree-Analysis (Pasig-Marikina River Basin)



Fault-Tree-Analysis (Laguna Lake Basin)

Source: Prepared by the JICA Study Team

Figure 11.4 Fault Tree Analysis in the Pasig-Marikina River Basin (Upper) and Laguna Lake Basin (Lower)

CHAPTER 12 ASSESSMENTS OF THE EFFECTS OF THE PROPOSED PROJECTS

12.1 Assessment of Water Resources Management Plan

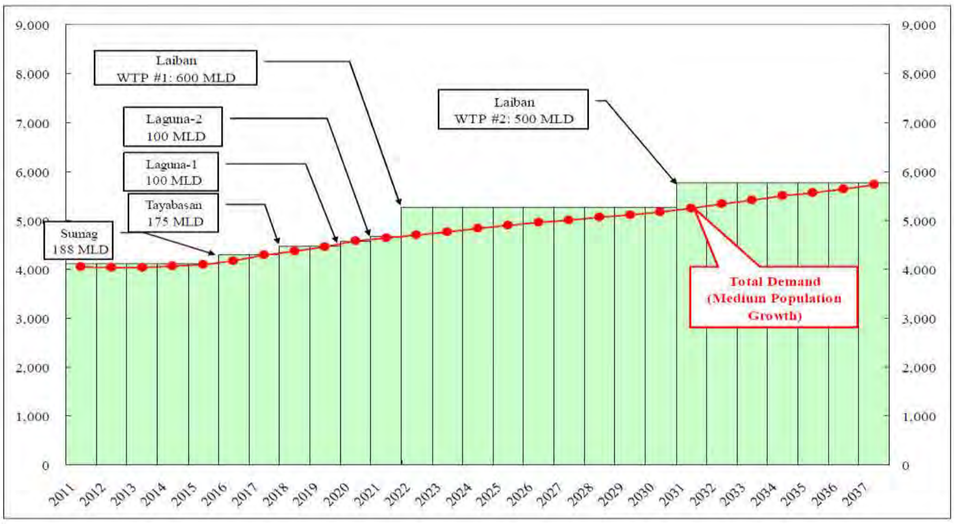
Water, a natural resource, is one of the basic needs of all living things including human beings. It has special features of spatial mobility and probabilistic uncertainty. There are considerable number of stakeholders in water resource spread in various areas and sectors. Subsequently, an intervention to manage water resources aiming to benefit certain stakeholder will create adverse impacts to wide areas and to other stakeholders from various sectors. Consequently, formulation of a water resources management plan requires a multidisciplinary approach to maximize the benefits or effects as well as to minimize adverse impacts so that the plan is acceptable and sustainable for all stakeholders. In this consequence, multidisciplinary evaluations of both effects and impacts are necessary to assess the proposed projects.

The diagnosis of water resources discussed in Chapter 11 has enumerated the needs in water resources management from a comprehensive viewpoint through the Fault Tree Analysis (FTA). The FTA further identified appropriate countermeasures that are effective to respond to the identified needs as well. In this manner, the FTA conducted has enunciated the issues that should be considered in the evaluation of a water resources management project.
The Multi-Objective-Analysis Method (MOA) evaluates the magnitude of benefits and impacts of an intervention to various disciplines or objectives. The method enumerates the magnitude of effects and impacts by the project to different disciplines applying unified figures. This study adopted the Multi-Objective Analysis for the assessment of the projects referring to the results of the diagnosis discussed in Chapter 11.

12.2 Selection of the Objectives for Impact Evaluation

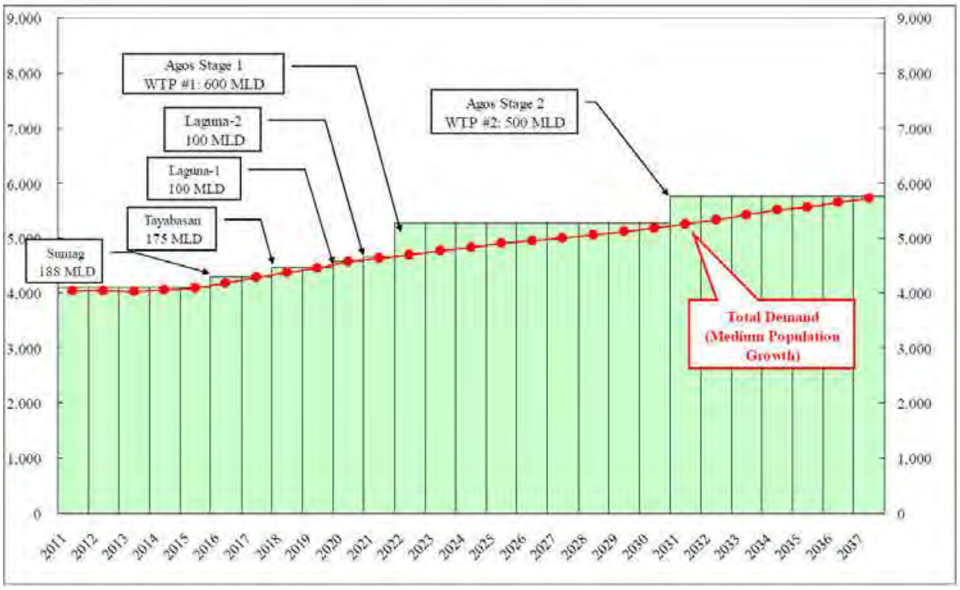
The Metro Manila Water Security Study (MMWSS) prepared by the World Bank presents two roadmaps (Scenario 1 and Scenario 2) to develop water sources for water supply in Metro Manila. Scenario 1 is shown in Figure 12.1 and Scenario 2 is presented in Figure 12.2.

The proposed projects in the roadmaps are the development of Smug River Diversion, Laguna Lake, Tayabasan Dam, Laiban Dam, Agos Dam, and Kanan No. 2 Dam. The task of this Study is to evaluate the effects and impacts of those development projects. The first stage development of Laiban Dam in Scenario 1 includes the development of Kaliwa Intake and the conveyance system. Meanwhile, it is the Agos Stage 1 Project that includes the development of Kaliwa Intake and the conveyance system in case of Scenario 2. Kanan No. 2 Dam does not appear in both scenarios. However, the study prepared by the WB proposed the development of the dam in case Laiban Dam alone could not provide the projected demand.



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

Figure 12.1 Proposed Roadmap (Scenario 1)



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

Figure 12.2 Proposed Roadmap (Scenario 2)

It should be noted that the roadmaps were prepared to meet the water demand projected by the study in the MWSS service area under the assumption that 4000 MLD could be shared to the diversion for the area. However, MWSS has projected a little higher water demands in its service area than the demands adopted for the development of the roadmaps. Further, a water source development plan should take into account other demands in the Angat River basin. Actually, the share of 4000 MLD for MWSS service area has affected the other water uses as mentioned before. Consequently, Laiban Dam could not provide all the demands and it is assessed that the development of Kanan No. 2 Dam is necessary before 2037.

The Multi-Objective-Analysis (MOA) is the adopted method to evaluate the effects and impacts of the proposed projects as mentioned in the previous section. The Technical Working Group formed by representatives of various stakeholder agencies held a meeting to discuss and define the selection of objectives, items, weights to be assigned to the items, and rating standards for the method.

The most significant problem in the target area is the security of municipal water supply in Metro Manila, the center of the national economy, as identified by the conducted diagnosis. Evaluation of effects and impacts to the economy is, therefore, necessary. Along this line, the economy is selected as an objective for the MOA in this Study.

The diagnosis done through the FTA identified that the delay in the development of alternative sources is one of the main causes that degraded the water security in the Study Areas. It further inquired into the cause and identified that low financial viability is one of the main causes that hampered the implementation of a proposed project that would served as alternative sources for Metro Manila water supply. As a consequence, MOA adopted the financial objective for evaluation.

Another cause of delays in the development of an alternative water source is the environmental issues according to the diagnosis. Some indigenous people reside in the proposed project area. Some special fauna and flora inhabit the proposed project areas. Such environmental issues have caused impediments to develop alternative sources. Environment forms an important objective in the MOA conducted.

Most of these lands are utilized by local people in the target areas and these are called affected people for some proposed projects. Meanwhile, low water security is one of the substantial social problems in the Study Areas. In view of this, social issue is adopted as an objective of the MOA in this Study.

The diagnosis identified some more problems. Demand side issues are such significant problems in water resources management in the Study Area. However, the scope of this Study is limited to the evaluation of the proposed projects. Interventions to alleviate the demand side problems are not included in the targets of evaluation. The Study evaluated the proposed projects for the adopted four objectives.

12.3 Selection of the Items for Impact Evaluation

The effects of the project are evaluated through assessing how the intervention alleviates the identified problems. The items were, therefore, selected referring to the results of diagnosis especially the listed causes in the Fault Tree analyses. The selection referred to regulations and procedures to assess the possibility to cause additional problems as well. The Technical Working Group Meeting finally defined the items.

The indices which represent the economic viability of a project were selected as items for the economic evaluation of the proposed projects. The selected indices are the economic internal rate of return (EIRR), benefit-cost (B/C) ratio, and net present value (NPV) of a project considering the differences in the scales of projects. The proposed project induces value added to water otherwise water will only be discharged to the sea. The Study evaluated the value added to be induced to water through the development projects in terms of annual water value.

Water to be developed supports the economic activities in Metro Manila as the utility. The supporting effect of a project is assumed to be proportional to the water volume to be developed. The proposed projects are mostly dam and reservoir. An area to be submerged by the proposed reservoir water is otherwise be utilized for economic activities. The opportunity cost to be incurred by a reservoir development is an impact of the project.

Financial internal rate of return (FIRR) is the index that represents the overall financial viability of a project. Meanwhile, annual benefit attracts investors to implement a project. Annual earning less annual expenditure is assumed to present simplified annual benefit. The diagnosis identified that the large investment required to implement a dam project is one of the substantial impediments that hampered the implementation of alternative source development. Operation, maintenance and repair cost (OMR) is another item which is identified to be an impediment together with investment. Overall system cost and the long run average cost are indices that demonstrate the profitability of a project and were adopted for the items of financial objective in the MOA.

Environmental issues have been the impediments for the implementation of a project according to the diagnosis. A dam project occupies a large area of land for the reservoir. Project implementation in a protected area requires complicated institutional procedures and adopted as an item for environmental objective. A special attention is necessary so as not to disturb the terrestrial ecology and the indigenous people during construction and operation of the facility in accordance with the regulation. An inter-basin diversion project taps water from a river. A project which could supply the planned water with 90% dependability or more could secure river maintenance flow. On the contrary, a project could supply less water than planned, which tends to get the water to be allocated to river maintenance flow. The dependability of maintenance flow is evaluated reflecting the dependability of a project. An intervention has impact to the watershed areas. In case the watershed area has been devastated, a water supply project will struggle to recover and enhance the condition. Thus, the project is beneficial for watershed management. In case the watershed area is well managed, the project will have an adverse impact to the watershed area. Construction works affect the environment. The significance of influence is assumed to be proportional to work volume. Multi-purpose dams are to be provided in the country. Hydropower generation contributes to control carbon dioxide emission.

A dam development affects the local community. The number of affected family is one of the most significant social impacts and was adopted as an item of social objective. A water supply project enhances sanitary conditions remarkably. The enhancement is assumed to be proportional to the water to be produced. Water security is one of the most important social securities. The ability to substitute the existing Angat system alleviates the risk of having a single source, therefore, is assumed to enhance social security. As presented in FTA, water supply to AMRIS is affected by the water diversion to Metro Manila. Alternative source development will contribute to secure water for AMRIS which provides livelihood to so called social weak. The diagnosis results pointed out that the institutional procedures are complicated and have been one of the impediments in the development of alternative water sources. The stages of project development and institutional procedures such as water right and environmental assessment are to be evaluated. Expenditures for OMR create job opportunities to the local people.

Table 12.1 summarizes the adopted items used in the evaluation;

Table 12.1 Items to be Evaluated Defined by the Technical Working Group

Economic Impacts

Item	Description	Unit
1) EIRR	Economic internal rate of return	%
2) Benefit/cost	Benefit-cost ratio	ratio
3) Net Present Value	Discounted total profit less total cost	M PhP
4) Worth of Water	Induced value added to water	M PhP/an
5) Utility	Supporting resource of economic activities	MLD
6) Land	Opportunity cost of land submerged	1,000 Ha

Financial Impacts

Item	Description	Unit
1) FIRR	Financial internal rate of return	%
2) Annual Benefit	Annual earning less annual expenditure	M PhP/an
3) Investment Cost	Required investment for project implementation	M PhP
4) OMR Cost	Annual running cost, for OMR per m^3	PhP/m^3
5) Overall System Cost	Development of source, conveyance and treatment	M PhP
6) LR Average Cost	Per m^3 adapting demand including depreciation	PhP/m^3

Environmental Impacts

Item	Description	Unit
1) Protected Area	Activities in protected areas	1,000 ha
2) Terrestrial Ecology	Disturbance to habitat	Number of species
3) Indigenous People	Population to be disturbed	Person
4) Environmental Flow	Rate of actually affordable flow	%
5) Watershed Mgmt	Preservation of watershed area	Deg. of devastation
6) Work Volume	Embankment volume	Mm^3
7) CO_2 Emission	Hydropower generation	MW

Social Impacts

Item	Description	Unit
1) Project Affected Family	Numbers of affected families	Nos.
2) Sanitary	Sufficiency of water supply	MLD
3) Social Security	Water supply security	MLD
4) Social Weak Issue	Water allocation to AMRIS	MLD
5) Institutional Issue	Water right, EIA and stage of implementation	Status
6) Job Opportunity	Expenditure for OMR	M PhP/an

Source: JICA Study Team

12.4 Project Performances on Each Item

The Metro Manila Water Security Study (MMWSS) prepared by WB has estimated substantial performances of each project concerning the selected item. The report thereof presents the EIRR, B/C, NPV, and the required land area. Value added of water to be induced does not appear in the report although it is an important issue to assess the economic effect of a project. Sierra Madre Water Corporation evaluated the unit value of water to be PhP 9.0 per cubic meter. This Study assumed that the product of this unit price and the annual production of a project provide the annual induced value added effect of the project. Water resource is a utility of an industry. The effect of a project as a utility is assumed to be proportional to the water to be produced by the project.

The report in the MMWSS provided performances of each project for financial indices.

The report provided substantial figures that indicate performances for environmental indices, such as protected area occupied by a project, numbers of vulnerable species in the project areas, number of IPs in the project area, embankment volume of a project, and electric power to be generated. The MMWSS assessed the present conditions of the watershed areas of the proposed projects. A project is environmentally beneficial if the intervention could secure an environmental flow. The actual rate of affordable water of a project with 90% dependability against the planned supply with same dependability was assumed to indicate the security of river maintenance flow of the project. Moroever, a project with a high rate would not take the water to be allocated to maintenance flow including environmental flow. Water demand and supply balance study estimated the actual affordable water for each project through simulation.

The PAF were surveyed by MMWSS and presented in the report. The assumed effects to sanitary condition, social security, and social weak are proportional to the water to be produced. The MMWSS presented the status of each project. The report present OMR cost to be incurred by each project. The jobs to be created by a project are assumed to be proportional to the OMR cost.

The performances of each project are enumerated and presented in Tables 12.2 to 12.5;

Table 12.2 Performance of the Project (Economic Impact)

Project	EIRR	B/C	NPV	Valuation of Water	Utility	Land Area	-
Unit	**%**	**-**	**BP**	**BP/a**	**MLD**	**1000 ha**	**-**
Weight	2	1	2	1	1	1	-
Sumag	37.0	2.7	4.2	0.6	188	0	-
Tayabasan Dam	23.2	1.6	1.3	0.6	175	0	-
Laguna Lake	-	-	-	0.7	200	0	-
Laiban Dam	15.7	1.1	1.3	6.2	1,900	2.3	-
Agos Dam	15.5	1.0	1.0	9.9	3,000	1.8	-
Kanan Dam No. 2	15.2	1.1	0.8	10.8	3,300	2.6	-

Source; JICA Study Team

Table 12.3 Performance of the Project (Financial Impact)

Project	FIRR	Ann. Benefit	Invest. Cost	OM Cost	System Cost	LRA Cost	-
Unit	**%**	**Bp/an**	**BP**	**P/m^3**	**Bp**	**P/m^3**	**-**
Weight	2	2	1	1	1	1	-
Sumag Dam	41.6	1.2	1.0	0.97	2.7	5.7	-
Tayabasan Dam	21.0	0.9	3.5	0.94	4.6	2.0	-
Laguna Lake	-	1.5	-	-	-	-	-
Laiban Dam	17.4	9.8	36.7	0.76	49.1	2.1	-
Agos Dam	18.5	16.1	43.3	0.90	63.8	2.7	-
Kanan Dam No. 2	18.6	16.6	55.9	1.24	80.7	1.8	-

Source; JICA Study Team

Table 12.4 Performance of the Project (Environmental Impact)

Project	Protd. Area	Eco-logy	IP	Env. Flow	Water-shed	Work Vol.	Co2
Unit	**1000 ha**	**Nos**	**Person**	**%**	**Deg.dvst**	**M m^3**	**MW**
Weight	0.5	0.5	1	1	2	1	2
Sumag Dam	16	0	0	75	mining	0	0
Tayabasan Dam	26	0	0	24	good	na	0.1
Laguna Lake	-	0	0	100	indstry	na	0
Laiban Dam	18	13	1,175	78	dvsttd	6.2	25
Agos Dam	88	12	118	92	dvsttd	6.7	51
Kanan Dam No. 2	70	22	118	86	ideal	9.1	54

Source; JICA Study Team
Note; Planned water abstraction of 200 MLD is supposed to be assured even in the driest condition.

Table 12.5 Performance of the Project (Social Impact)

Project	PAF	Sanit. Cond.	Social Sec.	Social Weak	Insti-tutional	Job Opp.	-
Unit	**Family**	**MLD**	**MLD**	**MLD**	**Status**	**Mp/an**	**-**
Weight	**2**	**1**	**1**	**2**	**1**	**1**	**-**
Sumag Dam	0	188	188	188	DD,ECC	67	-
Tayabasan Dam	300	175	175	175	PQ	60	-
Laguna Lake	0	200	200	200	IEE,FS	-	-
Laiban Dam	2,497	1,900	1,900	1,900	FS,ECC	527	-
Agos Dam	225	3,000	3,000	3,000	FS	985	-
Kanan Dam No. 2	100	3,300	3,300	3,300	FS	1,494	-

Source; JICA Study Team

12.5 Rating Table and the Results of Assessment

The Technical Working Group discussed the method during its Second Meeting held on September 5, 2012. It defined the rating standards and assigned points to a project as well in the conduct of the MOA. The point to be assigned is a figure between -3 and 3 in accordance with the performance of the project for the respective item. The point 3 or -3 is assigned to the range of performances including the maximum among projects for an item in general. The points of 2, 1, and 0 were assigned linearly to a range of performances in general. Accordingly, point zero is assigned to a project if the performance or impact is small. The developed rating standard is shown in Table 12.6.

Table 12.6 Rating Standard

Object	Item	Wei-ght	Unit	Point to be Assigned						
				-3	-2	-1	0	1	2	3
Fconomic Impact	1)EIRR	2	%	~6	6~8	8~10	10~12	12~14	14~16	16~
	2)B/C	1	-	~0.7	0.7~0.8	0.8~0.9	0.9~1.0	1.0~1.1	1.1~1.2	1.2~
	3)NPV	2	BP	~0.4	0.4~0.6	0.6~0.8	0.8~1.0	1.0~1.2	1.2~1.4	1.4~
	4)Valuation of water	1	BP/an	NA	NA	NA	0~1	1~4	4~8	8~
	5)Utility	1	Mld	NA	NA	NA	0~300	300~1000	1000~2000	2000~
	6)Land to be submerged	1	1000ha	~4	4~2	2~	0	NA	NA	NA
Financial Iimpact	1)FIRR	2	%	NA	NA	NA	~5	5~10	10~15	15~
	2)Annual benefit	2	BP/an	NA	NA	NA	~5	5~10	10~15	15~
	3)Investment cost	1	BP	~50	50~30	30~10	10~0	NA	NA	NA
	4)OM cost	1	P/m^3	~1.5	1.5~1	1~0.5	0.5~0	NA	NA	NA
	5)Overall system cost	1	BP	~80	80~40	40~5	5~0	NA	NA	NA
	6)Long run average benefit	1	P/m^3	NA	NA	NA	0~0.5	0.5~1.5	1.5~2.5	2.5~
Environ-mental Impact	1)Protected area	0.5	1000ha	~100	100~50	50~10	10～0	NA	NA	NA
	2)Terrestrial ecology	0.5	NOs	~50	50~20	20~	0	NA	NA	NA
	3)IP	1	Person	~1000	1000~500	500~	0	NA	NA	NA
	4)Environmental flow	1	%	~65	65~70	70~75	75~80	80~85	85~90	90~
	5)Watershed management	2	Dev.degree	Very G	Good	N Dev	VSlight Dev	Slightly D	Devastated	S D
	6)Work volume	1	Mm^3	~12	12~6	6~	0	NA	NA	NA
	7)CO2 emission	2	MW	NA	NA	NA	0	~25	25~50	50~
Social Impact	1)PAF	2	Family	~600	600~300	300~100	100~0	NA	NA	NA
	2)Sanitary condition	1	Mld	NA	NA	NA	0	~1500	1500~3000	3000~
	3)Social security	1	Mld	NA	NA	NA	0	~1500	1500~3000	3000~
	4)Social weak issue	2	Mld	NA	NA	NA	0~1500	1500~2000	2000~3000	3000~
	5)Institutional issue	1	Status	NA	NA	NA	No EC/WR	Water right	ECC	Both
	6)Job opportunity	1	MP/an	NA	NA	NA	0	~400	400~800	800~

Note; Unit: a: annual, B: Billion, Dev. degree: Devastated degree, ld: Litre per day, M: million, P: Philippine Peso

Rating D: Devastated, NA: Not available, N Dev.: Not devastated, SD: Significantly devastated

Some important data that show the performances regarding the economic and financial objectives of the Laguna Lake Development Project are not available. As a consequence, the Laguna Lake Development Project was excluded in the assessment of the MOA.

Tables 12.7 to 12.10 demonstrate the acquired point for each item applying the rating standard to the performance of each proposed project.

Table 12.7 Acquired Point (Economic Impact)

Project	EIRR	B/C	NPV	Valuation of water	Utility	Land area	-
Unit	**%**	**-**	**BP**	**BP/a**	**Mld**	**1000ha**	**-**
Weight	2	1	2	1	1	1	-
Sumag Dam	3	3	3	0	0	0	-
Tayabasan Dam	3	3	2	0	0	0	-
Laguna Lake	-	-	-	0	0	0	-
Laiban Dam	2	2	2	2	2	-2	-
Agos Dam	2	1	1	3	3	-1	-
Kanan Dam N02	2	2	2	3	3	-2	-

Source; JICA Study Team

Table 12.8 Acquired Point (Financial Impact)

Project	FIRR	Ann. benefit	Invest. cost	OM cost	System Cost	LRA Cost	-
Unit	**%**	**Bp/an**	**BP**	**P/m^3**	**Bp**	**P/ m^3**	**-**
Weight	2	2	1	1	1	1	-
Sumag Dam	3	0	0	-1	0	3	-
Tayabasan Dam	3	0	0	-1	0	2	-
Laguna Lake	-	0	-	-	-	-	-
Laiban Dam	3	1	-2	-1	-2	2	-
Agos Dam	3	3	-2	-1	-2	3	-
Kanan Dam N02	3	3	-3	-2	-3	2	-

Source; JICA Study Team

Table 12.9 Acquired Point (Environmental Impact)

Project	Protd. area	Eco-logy	IP	Env. flow	Water-shed	Work vol	Co2
Unit	**1000ha**	**Nos**	**person**	**%**	**Deg.dvst**	**M m^3**	**MW**
Weight	0.5	0.5	1	1	2	1	2
Sumag Dam	-1	0	0	0	1	0	0
Tayabasan Dam	-1	0	0	-3	-1	0	1
Laguna Lake	-	0	0	3	2	0	0
Laiban Dam	-1	-1	-3	0	2	-2	2
Agos Dam	-2	-1	-1	3	3	-2	3
Kanan Dam N02	-2	-2	-1	2	-1	-2	3

Source; JICA Study Team

Table 12.10 Acquired Point (Social Impact)

Project	PAF	Sanit. Cond.	Social Sec.	Social weak	Insti-tutional	Job Opp.	-
Unit	**Family**	**Mld**	**Mld**	**Mld**	**Status**	**Mp/an**	**-**
Weight	**2**	**1**	**1**	**2**	**1**	**1**	**-**
Sumag Dam	0	1	1	0	3	1	-
Tayabasan Dam	-1	1	1	0	3	1	-
Laguna Lake	0	1	1	0	3	-	-
Laiban Dam	-3	2	2	1	2	2	-
Agos Dam	-1	3	3	3	1	3	-
Kanan Dam N02	0	3	3	3	1	3	-

Source; JICA Study Team

The product of the acquired point and the assigned weight to each item indicate the effect of a project to respective item. Summation of points obtained gives the effect of a project to the objective. The effect of a project is assumed to be the total effects to the four objectives represented as the Gross Magnitude of Impact (GMI). The procedure of calculation is presented in Annex 12. The obtained GMIs are listed in Table 12.11 as follows;

Table 12.11 The Estimated Gross Magnitude of Impact

Project	Economic	Financial	Environmental	Social	Total(GMI)
Sumag	15	8	2.5	6	31.5
Tayabasan	13	7	1.5	4	25.5
Laiban	12	5	3	4	24
Agos	12	9	10.5	14	45.5
Kanan No. 2	14	6	2	16	38

Source; JICA Study Team

A GMI indicates the comprehensive effect of a project. A project with a high GMI has high positive effect from the comprehensive viewpoint and is desirable in general. Agos Dam Project in the second optional scenario proposed by the World Bank study as it presents the highest GMI of 45.5 among the proposed development projects. Kanan No. 2 Dam Project followed the Agos Dam Project with GMI of 38. Meanwhile, Laiban Dam Project, proposed in the first scenario as mentioned in the World Bank study (please see Figure 12.1) yielded the least GMI of 24 mainly due to a large scale development but insufficient water production capacity as compared with the projected water demand and the adverse impact to social objective.

As mentioned before, GMI of a project is the summation of the impacts to whole objectives selected. The impacts to the objectives vary from an objective to another. A large variation among the objectives has the possibility to take the society into an unstable development. Many industrial development projects with high economic viability but low environmental consideration have brought present environmental problems in many countries. Therefore, balance of impacts among the objectives is crucial in assessing a water resources development project which has multidisciplinary impacts. Further, a project with a well balanced impact is to be accepted by stakeholders from various sectors. The most modern MOA adopt the Degree of Unbalance (DUB) as the second index for project assessment in addition to GMI.

DUB is assessed as the generalized distance from the ideal condition where the estimated impact to each objective balances completely among whole objectives. In an ideal condition, all the impacts to relevant objectives have the same value. In case of the Sumag Diversion Project, the estimated GMI of 31.5 should be shared evenly by the four objectives to be ideal. The estimated ideal impact of complete balance to each objective is 7.875. The distance of the point assigned to an objective from the ideal point reflects the degree of unbalance. The generalized distance of the whole objectives demonstrates the overall deviation of a project from the case of complete balance.

Significance of a deviation or distance is inversely proportional to the magnitude of GMI. The influence of a generalized distance for a smaller GMI is more significant than the same distance for a larger GMI. Accordingly, to assess the significance of the distance normalization is necessary reflecting the magnitude of GMI[1]. The procedures of GMI and DUB estimations are presented in Annex 12.

The results of the Multi-Objective-Analysis are presented in Table 12.12 as follows;

Table 12.12 Results of the Assessment of the Project

Item	Sumag	Tayabasan	Laiban	Agos	Kanan No.2
GMI	31.5	25.5	24.0	45.5	38.0
Ideal point to a objective	7.9	6.4	6.0	11.4	9.5
Generalized distance	9.6	8.6	7.1	3.7	12,7
Normalization factor	15.8	12.8	12	22.8	19.0
Degree of imbalance	0.61	0.50	0.59	0.16	0.67

Source; JICA Study Team

Agos Dam Project obtained the highest GMI and the lowest DUB. Kanan No. 2 Dam Project yielded the second largest GMI followed by Sumag Project with the highest DUB but low environmental impact. The construction of a large dam in a natural forest area is the reason for the low environmental impact. However, the obtained DUBs are more or less the same level except for the Agos Dam Project.

[1] Takayanagi N, Mizutani Y, Loucks D.P.; Stakeholder Consensus Building in Multi-Objective Environment; Journal of Water Resources Planning and Management, ASCE

CHAPTER 13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

(1) Diagnosis revealed that there is no substantial problem in the Agos and Umiray River basins. The water demand and supply balance study which was conducted as a component of the diagnosis study confirmed that the water resources of the basins can provide and satisfy the water demands within the respective river basins. It further identified certain surplus water sources in each river basin. Diversion of the water to other river basin is harmless if the abstraction is appropriate in terms of place and time.

(2) Angat System has supplied water mainly to Metro Manila for the municipal water use and AMRIS for irrigation water use. The demand of Metro Manila is 46m^3/sec and that of AMRIS is 19.2 m^3/sec. The system is to supply municipal water of 1.9 m^3/s to Bulacan Province. The capacity of the system of 70 m^3/s does not afford to respond to the whole demands with the designed dependability of 90% for municipal water supply and 80% for irrigation water supply. Salinity of groundwater and land subsidence due to over exploitation are common problems in Metro Manila and the Angat River basin. Further, precise investigation is necessary for the effective use and management of groundwater to alleviate the shortage. Developments of alternative surface water sources, therefore, are the urgent issues in Metro Manila and the Angat River basin.

(3) MWSS projected future water demand in its service area including Metro Manila. The projected water demand in 2037 is 6412 MLD or 74.2 m^3/s which is 34m^3/s more than the existing demand. The increase in water demand will exacerbate the water supply condition unless a substantial water source development project is implemented.

(4) The share of water source for Metro Manila water supply from Angat system exceeds 95% at present. The security of Metro Manila water supply is critical due to the single source and developments of alternative surface sources are crucial to enhance the reliability.

(5) Diagnosis identified water deficit problem in the Pampanga River basin through water demand and supply balance study. Water in the wet season is more than enough but water shortage is rather often in the dry season due to a large total demand of 140 m^3/s in spite of the flow regulation by Pantabangan Reservoir and the inter-basin diversion by Casecnan system. Salinity of groundwater and land subsidence due to over exploitation are the identified problems in the Pampanga River basin. Development of groundwater is not conceivable measure to alleviate the shortage.

(6) NIA has planned to extend UPRIS in line with the governments policy to increase paddy production which is not sufficient today. NIA has planned to develop dam and reservoir to regulate the wet season flow for the uses in the dry season. Balintingon, Maasim and Bayabas Dams are promising measures to cope with the increase in demands. Water demand and supply balance study, however, concluded that these developments will not produce any surplus water to alleviate water shortages in Metro Manila and in the Angat River basin.

(7) The wet season flow of the Pasig-Marikina River is more than enough and has caused flooding from time to time in its downstream reaches. However, it decreases remarkably in the dry season. The water demand and supply balance study revealed that water regulation by

a dam is imperative to utilize water in a stable manner. The land use in the watershed area is intensive and appropriate dam site is quite difficult to find. The WB study proposed sharing a part of the storage space of the proposed Tayabasan Reservoir to Metro Manila water supply purpose although it is planned to control flood water. The WB study indicates the available water to Metro Manila is 0.1 m^3/s in dry season. Groundwater of the basin is depleted and land subsidence is a significant problem in the downstream reach areas.

(8) The water of Laguna Lake is polluted by domestic effluent, industrial effluent and fisheries. Seawater intrudes to the lake and the water is categorized to be brackish. Lake water utilization for municipal purposes requires treatment with complicated process.

(9) The WB study proposed large scale water resources developments in the Agos River basin in its roadmap. The proposal coincides and agreeswith the conclusions mentioned above. The proposed large scale projects therein are Laiban Dam, Agos Dam and Kanan No.2 Dam.

(10) The water demand and supply balance study revealed that the supply capacity of Laiban Dam is 1700 MLD. The dam could satisfy the demand until year 2026. An additional development project is necessary to meet the water demand after 2026 up to the target year of 2040. The WB study proposed Kanan No.2 Dam as the additional project in the future.

(11) The Multi-Objective-Analysis assessed the effects of each proposed project in view of the Integrated Water Resources Management concept. The results of the assessment are presented in the following table;

Item	Sumag	Tayabasan	Laiban	Agos	Kanan No2
GMI	31.5	25.5	24.0	45.5	38.0
Ideal point	7.9	6.4	6.0	11.4	9.5
Generalized distance	9.6	8.6	7.1	3.7	12,7
Normalization factor	15.8	12.8	12	22.8	19.0
Degree of imbalance	0.61	0.50	0.59	0.16	0.67

Source ; JICA Study Team

The estimated GMIs for all the projects are positive. Accordingly the viabilities of all the projects are attested as the solutions for the most serious problem in Metro Manila and the Angat River basin.

(12) The climate change analysis identified the influences to precipitation, air temperature and so on. The following table present the mean annual minimum and the maximum monthly rainfall depths at present (1981-2000) and in the future (2031-2050). The minimum month occurs in March in general and the maximum month occurs in July or August both at present and in the future as follows;

(Unit; mm)

Min/Max	Period	Laguna	Marikina	Angat	Pampanga	Umirai	Agos
Min.	Present	56.7	38.8	46.2	45.4	49.9	84.0
	Future	63.6	45.3	56.1	56.7	60.8	95.2
Max.	Present	395.3	503.4	516.2	384.4	518.3	414.5
	Future	416.0	492.9	486.7	404.2	489.5	431.5

Source; JICA Study Team

The results of the analysis indicate that the rainfall in the dry season increases in all river basins but there are river basins where wet season rainfall increase and where the wet season ainfall decrease.

(13) The climate change analysis revealed that the increase in air temperature is around 2.0 degree centigrade. The following table presents the recorded and projected annual minimum and maximum of mean monthly air temperature;

Min/Max	Period	Laguna	Marikina	Angat	Pampanga	Umirai	Agos
Minimum	Present	24,7	23.6	23.0	24.3	22.2	22.0
	Future	26.5	25.4	24.9	26.2	24.0	23.8
	Difference	1.8	1.8	1.9	1.9	1.8	1.8
Maximum	Present	28.1	27.5	26.9	27.8	26.1	25.9
	Future	30.3	29.6	29.1	29.8	28.3	28.1
	Difference	2.2	2.1	2.2	2.0	2.2	2.2

Source; JICA Study team

(14) The table in paragraph (12) indicates that rainfall will increase in the dry season in general. Meanwhile, the air temperature increases as presented in paragraph (13). The increase in air temperature amplifies the evapo-transpiration and eventually the potential of the water resources decrease. The following table presents the estimated monthly rainfall depth less the relevant projected potential evaporations. The figures in the row of Difference in the table enunciate the influence of the climate change to the water resources potential in the dry season;

Item	Period	Laguna	Marikina	Angat	Pampanga	Umirai	Agos
Potential in dry season	Present	-1.74	-2.15	-1.77	-1.82	-1.5	-0.36
	Future	-1,99	-2.3	-1.78	-1.97	-1.47	-0.42
	Difference	-0.25	-0.15	-0.01	-0.15	0.03	-0.06

Source; JICA Study Team

The table indicates that potentials of water resources decrease in the dry season except for the Umiray River basin. The projected decrease is more or less 10 % in the year 2040.

(15) The changes in climate affect the hydrological conditions in the river basins. The projected climate changes affect the capacities of the proposed projects. A dam and reservoir project attested efficiency to alleviate the impact of climate change although the effects vary depending on the locations (river basin), catchment areas and the storage capacities. The influences to the supply capacities in the case of a 10-year drought in MLD are presented in the following table;

Project	WB Study(2010)	JICA Study(2012)	JICA Study(2040)
Angat System	4,000	4,660	4,240
Sumag	188	188	188
Tayabasan	175	105	105
Laguna Lake	200	200	200
Laiban	1,900	1,740	1,640
Kaliwa Low Dam	550	550	500
Agos	3,000	2,950	2,950

Source; JICA Study team

The storage capacities of Angat Dam and the proposed Laiban Dam are 900 MCM and 650 MCM for the catchment areas of 546 $km^2$and 276 km^2 respectively. Meanwhile, the storage capacity of the proposed Agos Dam is 718 MCM for a catchment area of 860 km^2. The supply capacities of Angat Dam and the proposed Laiban Dam are supposed to be more susceptible to climate change than the proposed Agos Dam. Monitoring of climate change and watching the influence thereof to supply capacity is recommended to secure a stable water supply.

13.2 Recommendations

(1) JICA Study projected the influence of climate change to the water resources in the target area. It assessed the effects of the projects proposed by the World Bank Study as well. Both the projection and assessment are the outcomes of innovative and scientific methods. Meanwhile, the analysis on the future water demand and supply balances in the river basins adopted the official demand provided by MWSS. Further the analysis is in line with the Integrated Water Resources Management Concept because it takes the development plans in Metro Manila and Adjoining Areas into consideration. Accordingly the presented results of the Studyare recommended to be observed and referred to in the formulation of water sources development plans being conducted by MWSS. The results of a project assessment enunciate the hints how to improve the project because the assessment has enumerated the weaknesses of a project for improvement. A project which is environmentally weak, for an example, could be improved the weakness if the project be formulated through integrating an environment protective work as its component. It is recommended to avail the results of the assessment in such a way for effective plan formulation and smooth implementation of the project.

(2) Further it is recommended to adopt the assessment method (Multi-Objective- Analysis) to monitor the performances of works for project formulation through assessing to what extent the project has been improved by the project formulation. In case the monitoring judge the betterment be not sufficient, further improvement should be considered. The method could be a tool for the management of project formulation for water resources development.

(3) MWSS is carrying out the study on the water resources development which comprises Laiban Dam and Kaliwa Low Dam as its components under PDMF. The detailed design of Laiban Dam has been completed already. The Multi-Objective-Analysis conducted has assigned positive GMI and proved the viability of the project as well. The capacity of 1700MLD could meet the demands up to 2026 and an additional water source would be necessary thereafter. Demand control in Metro Manila and AMRIS could delay the year when an additional source is required. In this manner the demand control could enhance economic and financial efficiency of the Project. The estimated affected family of 2,500 is another problem of the project. Social efficiency of the Project could be enhanced if the Project will integrate a scheme to support the affected family (AF). A social program that encourages AF to participate in the water diversion works is one of those conceivable schemes. It is recommended to consider the betterments mentioned above in the project planning being conducted by MWSS. Said betterments are beneficial for project implementations because they will contribute to build up consensus among stakeholders in addition to the enhancement of economical and financial benefits.

(4) The results of the project evaluation indicate that the Agos Dam Project with Kaliwa Intake Facilities is a promising solution as well. However review of the feasibility study on Agos Dam conducted by JICA in 2003 is necessary in its first step of implementation reflecting updated new water demand and the conceivable influences of climate change. The review should cover social and environmental issues together with engineering matters. Special attention should be given to the following items in the review;

A) Institutional study to encourage public private partnership (PPP)
B) Institutional study to encourage local people in the proposed project site to participate in the river water diversion works to Metro Manila and
C) Water allocation to Metro Manila and hydropower generation
The estimated potential of the dam is 5,500 MLD. In Scenario 2 (please see Figure 12.2) it is planned to allocate 3000 MLD to Metro Manila and 2500 MLD to hydropower generation. However, the demand in the initial stage does not require 3000 MLD and more water than planned could be allocated to hydropower generation. On the contrary, the required water diversion from Agos Dam to Metro Manila will exceed 3000MLD after 2034. Accordingly the share of hydropower is forced to decrease from its 2500Mld planned allocation. There is a possibility to develop Kanan No2 Dam to solve the tradeoff of the water allocation in the future. The optimization of the installed capacity of the Agos Dam hydropower generation and the schedule to develop Kanan No.2 Dam are the key factors to review water allocation.

It is recommended that MWSS conduct the review of the Feasibility Study on the development of Agos Dam in parallel with the above PDMF Study. The Study should take account of Kaliwa Low Dam which is being studied by PDMF Study in addition to Kaliwa Intake.

(5) The project evaluation assigned the second highest total point of 38.0 to Kanan No.2 Dam Project. The Study being conducted by MWSS should examine the optimum measure to divert water to the proposed Laiban Dam. The substantial issue in this optimization is mode of hydropower generation because the generation may be controlled by the planned conveyance capacity of diversion structure and the diversion demand which is presumed to be diurnally constant. The reservoir water otherwise be able to generate peak power may generate firm energy in this option. The possible peak power generation should be accounted as opportunity cost in the optimization study. Concerning Kanan Dam Project, study on the optional dam function may be necessary as discussed in the above paragraph (4).

(6) Dams planned in the Pampanga River basin should be implemented as soon as possible because increase in paddy production is a substantial policy of the government.

(7) Drainage system and sewerage system should be improved in the Laguna Lake basin to improve the lake water quality.

(8) The diagnosis of the water resources management in the target areas identified that the large water demands are the main causes of the problems in water resources management. Therefore rationalization of the demands, which are not proposed in the roadmap by WB should be considered to alleviate the problems. The Fault-Tree-Analysis identified some measures to rationalize the demands. Actually it may take certain time before the effects of

the measures will emerge. However climate change is anticipated to decrease the water resources potential. In order to cope with the situation, it is recommended to commence the demand control measures in parallel with or as a component of the dam development projects. These are presented as follows;

(A) Introduction of water saving paddy variety,
(B) Extension of wet and dry cultivation or SRI cultivation,
(C) Introduction of Real Time Operation System in irrigation projects,
(D) Introduction of incentives to save water (Seasonal tariff) and
(E) NRW reduction

ANNEX

Chapter 3

Annex 3.1 Growth Rate of Population in MWSS Service Area

Municipality		NSO POPULATION			Past Growth Rate			NSO Provincial Medium Assumption						
		1-Sep-95	1-May-00	1-Aug-07	1995-2000	2000-2007	1995-2007	2010	2015	2020	2025	2030	2035	2040
West (MWSI)														
1	Caloocan City	1,023,159	1,177,604	1,381,610	3.06%	2.23%	2.55%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
2	Las Piñas City	413,086	472,780	532,330	2.93%	1.65%	2.15%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
3	Makati City *	79,889	77,778	90,582	-0.57%	2.12%	1.06%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
4	Malabon City	347,484	338,855	363,681	-0.54%	0.98%	0.38%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
6	Manila Ciy *	1,476,047	1,410,325	1,481,357	-0.97%	0.68%	0.03%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
8	Muntinlupa City	399,846	379,310	452,943	-1.12%	2.48%	1.05%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
9	Navotas City	229,039	230,403	245,344	0.13%	0.87%	0.58%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
10	Parañaque City	391,296	449,811	552,660	3.03%	2.88%	2.94%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
11	Pasay City	408,610	354,908	403,064	-2.97%	1.77%	-0.11%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
14	Quezon City *	1,227,472	1,341,254	1,653,221	1.92%	2.93%	2.53%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
17	Valenzuela City	437,165	485,433	568,928	2.27%	2.21%	2.24%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
1	Bacoor	250,821	305,699	441,197	4.33%	5.19%	4.85%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
3	Cavite City	92,641	99,367	104,581	1.51%	0.71%	1.02%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
6	Imus	177,408	195,482	253,158	2.10%	3.63%	3.03%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
7	Kawit	56,993	62,751	76,405	2.08%	2.75%	2.49%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
8	Noveleta	27,306	31,959	39,294	3.43%	2.89%	3.10%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
9	Rosario	54,086	73,665	94,228	6.84%	3.45%	4.77%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
	Total	**7,092,348**	**7,487,384**	**8,734,583**	1.17%	2.15%	1.76%							
East (MWCI)														
3	Makati City *	404,287	393,601	458,401	-0.57%	2.12%	1.06%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
5	Mandaluyong City	286,870	278,474	305,576	-0.63%	1.29%	0.53%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
6	Manila Ciy *	178,714	170,757	179,357	-0.97%	0.68%	0.03%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
7	Marikina City	357,231	391,170	424,610	1.96%	1.14%	1.46%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
12	Pasig City	471,075	505,058	627,445	1.50%	3.04%	2.43%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
13	Pateros	55,286	57,407	61,940	0.81%	1.05%	0.96%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
14	Quezon City *	761,947	832,577	1,026,229	1.92%	2.93%	2.53%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
15	San Juan City	124,187	117,680	125,338	-1.15%	0.87%	0.08%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
16	Taguig City	381,350	467,375	613,343	4.46%	3.82%	4.07%	1.38%	1.13%	0.89%	0.68%	0.49%	0.29%	0.07%
1	Angono	59,444	74,668	97,209	5.01%	3.71%	4.21%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
2	Antipolo City	345,512	470,866	633,971	6.86%	4.19%	5.23%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
3	Baras	20,060	24,514	31,524	4.39%	3.53%	3.87%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
4	Binangonan	140,700	187,691	238,931	6.37%	3.39%	4.54%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
5	Cainta	201,550	242,511	304,478	4.04%	3.19%	3.52%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
6	Cardona	35,501	39,003	44,942	2.04%	1.97%	2.00%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
7	Jala-jala	19,873	23,280	28,738	3.45%	2.95%	3.14%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
8	Rodriguez (Montalban)	79,668	115,167	223,594	8.22%	9.58%	9.05%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
9	Morong	36,048	42,489	50,538	3.59%	2.42%	2.88%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
10	Pililla	37,081	45,275	58,525	4.37%	3.60%	3.90%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
11	San Mateo	99,217	135,603	184,860	6.92%	4.37%	5.36%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
12	Tanay	69,181	78,223	94,460	2.67%	2.64%	2.65%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
13	Taytay	144,748	198,183	262,485	6.96%	3.95%	5.12%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
14	Teresa	23,906	29,745	44,436	4.79%	5.69%	5.34%	2.3%	1.9%	1.7%	1.5%	1.2%	1.0%	0.8%
	Total	**4,333,436**	**4,921,317**	**6,120,930**	2.76%	3.05%	2.94%							

Note: * Three municipalities are covered by two concession areas. The total population of the said municipalities is divided into each zone in proportion to the population number as used in UP-NEC study.

Annex 3.2
Population Projection in MWSS Service Area

	Municipality	Population based on NSO Medium Assumption								
		2010	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
1	Caloocan City	1,446,164	1,462,525	1,479,070	1,529,839	1,599,367	1,654,549	1,695,761	1,720,097	1,726,068
2	Las Piñas City	557,203	563,506	569,881	589,442	616,231	637,493	653,371	662,748	665,049
3	Makati City	94,814	95,887	96,972	100,300	104,859	108,477	111,179	112,774	113,166
4	Malabon City	380,674	384,980	389,335	402,699	421,001	435,527	446,375	452,781	454,353
6	Manila Ciy	1,550,572	1,568,113	1,585,854	1,640,287	1,714,835	1,774,001	1,818,188	1,844,281	1,850,684
8	Muntinlupa City	474,106	479,470	484,894	501,538	524,332	542,423	555,933	563,911	565,869
9	Navotas City	256,807	259,713	262,651	271,666	284,013	293,812	301,130	305,452	306,512
10	Parañaque City	578,482	585,027	591,645	611,953	639,765	661,839	678,324	688,059	690,447
11	Pasay City	421,897	426,670	431,497	446,307	466,591	482,690	494,713	501,812	503,554
14	Quezon City	1,730,466	1,750,043	1,769,841	1,830,590	1,913,787	1,979,817	2,029,130	2,058,251	2,065,396
17	Valenzuela City	595,511	602,248	609,061	629,967	658,597	681,321	698,291	708,312	710,771
1	Bacoor	488,569	501,620	515,020	557,407	628,491	701,168	772,102	839,916	902,801
3	Cavite City	115,810	118,904	122,080	132,127	148,977	166,204	183,018	199,093	213,999
6	Imus	280,340	287,829	295,518	319,839	360,627	402,329	443,031	481,942	518,025
7	Kawit	84,609	86,869	89,189	96,530	108,840	121,426	133,710	145,454	156,344
8	Noveleta	43,513	44,675	45,869	49,644	55,975	62,448	68,765	74,805	80,405
9	Rosario	104,345	107,133	109,995	119,047	134,229	149,751	164,901	179,384	192,814
	Total	**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**
3	Makati City	479,819	485,247	490,737	507,581	530,650	548,959	562,632	570,707	572,688
5	Mandaluyong City	319,854	323,472	327,132	338,360	353,738	365,943	375,058	380,440	381,761
6	Manila Ciy	187,737	189,861	192,009	198,600	207,626	214,789	220,139	223,298	224,074
7	Marikina City	444,449	449,477	454,562	470,165	491,533	508,492	521,158	528,637	530,472
12	Pasig City	656,762	664,192	671,706	694,762	726,337	751,398	770,113	781,166	783,877
13	Pateros	64,834	65,568	66,309	68,585	71,702	74,176	76,024	77,115	77,383
14	Quezon City	1,074,178	1,086,331	1,098,620	1,136,330	1,187,974	1,228,962	1,259,573	1,277,649	1,282,085
15	San Juan City	131,194	132,678	134,179	138,785	145,093	150,099	153,837	156,045	156,587
16	Taguig City	642,001	649,264	656,609	679,147	710,013	734,510	752,805	763,609	766,259
1	Angono	104,838	106,878	108,958	115,443	125,508	134,970	143,484	150,851	156,952
2	Antipolo City	683,725	697,029	710,592	752,886	818,532	880,236	935,767	983,810	1,023,601
3	Baras	33,998	34,660	35,334	37,437	40,701	43,769	46,531	48,920	50,898
4	Binangonan	257,682	262,696	267,808	283,748	308,488	331,743	352,672	370,778	385,775
5	Cainta	328,373	334,763	341,277	361,589	393,117	422,752	449,422	472,495	491,606
6	Cardona	48,469	49,412	50,374	53,372	58,025	62,400	66,336	69,742	72,563
7	Jala-jala	30,993	31,596	32,211	34,128	37,104	39,901	42,418	44,596	46,400
8	Rodriguez (Montalban)	241,142	245,834	250,617	265,534	288,687	310,449	330,034	346,978	361,012
9	Morong	54,504	55,565	56,646	60,017	65,251	70,169	74,596	78,426	81,598
10	Pililla	63,118	64,346	65,598	69,503	75,563	81,259	86,385	90,820	94,494
11	San Mateo	199,368	203,247	207,202	219,534	238,676	256,669	272,861	286,870	298,472
12	Tanay	101,873	103,856	105,876	112,178	121,959	131,153	139,427	146,585	152,514
13	Taytay	283,085	288,593	294,209	311,720	338,899	364,447	387,438	407,330	423,805
14	Teresa	47,923	48,856	49,807	52,771	57,372	61,697	65,589	68,957	71,746
	Total	**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**

Annex 3.3 Growth Rate of Population in Adjoining Areas (1/4)

STUDY AREA		NSO POPULATION			Past Growth Rate			NSO Provincial Medium Assumption						
		1-Sep-95	1-May-00	1-Aug-07	1995-2000	2000-2007	1995-2007	2010	2015	2020	2025	2030	2035	2040
1. AURORA	1 Dingalan	19,325	20,157	21,992	0.91%	1.21%	1.09%	2.3%	2.3%	2.1%	1.9%	1.6%	1.5%	1.3%
	2 Maria Aurora	30,796	33,551	35,289	1.85%	0.70%	1.15%	2.3%	2.3%	2.1%	1.9%	1.6%	1.5%	1.3%
	3 San Luis	20,947	21,256	23,766	0.31%	1.55%	1.07%	2.3%	2.3%	2.1%	1.9%	1.6%	1.5%	1.3%
	Total	**71,068**	**74,964**	**81,047**										
2. BATANGAS	1 Lipa City	177,894	218,447	260,568	4.50%	2.46%	3.25%	1.97%	1.85%	1.67%	1.48%	1.27%	1.08%	0.88%
	2 Malvar	27,771	32,691	41,730	3.56%	3.42%	3.48%	1.97%	1.85%	1.67%	1.48%	1.27%	1.08%	0.88%
	3 Santo Tomas	65,759	80,393	113,105	4.40%	4.82%	4.66%	1.97%	1.85%	1.67%	1.48%	1.27%	1.08%	0.88%
	4 Tanauan City	103,868	117,539	142,537	2.69%	2.70%	2.69%	1.97%	1.85%	1.67%	1.48%	1.27%	1.08%	0.88%
	Total	**375,292**	**449,070**	**557,940**										
3. BULACAN	1 Angat	39,037	46,033	53,117	3.60%	1.99%	2.62%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	2 Balagtas (Bigaa)	49,210	56,945	62,684	3.18%	1.33%	2.05%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	3 Baliuag	103,054	119,675	136,982	3.26%	1.88%	2.42%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	4 Bocaue	69,718	86,994	105,817	4.86%	2.74%	3.56%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	5 Bulacan	54,236	62,903	72,289	3.23%	1.94%	2.44%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	6 Bustos	41,372	47,091	60,681	2.81%	3.56%	3.27%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	7 Calumpit	70,839	81,113	98,017	2.94%	2.65%	2.76%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	8 Dona Remedios Trinidad	11,194	13,636	19,086	4.32%	4.75%	4.58%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	9 Guiguinto	52,575	67,571	89,225	5.52%	3.91%	4.54%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	10 Hagonoy	99,423	111,425	124,748	2.47%	1.57%	1.92%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	11 Malolos City	147,414	175,291	225,244	3.78%	3.52%	3.62%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	12 Marilao	68,761	101,017	160,452	8.59%	6.59%	7.37%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	13 Meycauayan City	137,081	163,037	196,569	3.79%	2.61%	3.07%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	14 Norzagaray	51,015	76,978	105,470	9.22%	4.44%	6.28%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	15 Obando	51,488	52,906	56,258	0.58%	0.85%	0.75%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	16 Pandi	40,520	48,088	60,637	3.74%	3.25%	3.44%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	17 Paombong	33,149	41,077	50,798	4.70%	2.97%	3.65%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	18 Plaridel	66,355	80,481	97,225	4.22%	2.64%	3.26%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	19 Pulilan	59,682	68,188	85,008	2.90%	3.09%	3.01%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	20 San Ildefonso	69,319	79,956	93,438	3.11%	2.17%	2.54%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	21 San Jose del Monte City	201,394	315,807	439,090	10.12%	4.65%	6.76%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	22 San Miguel	108,147	123,824	138,839	2.94%	1.59%	2.12%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	23 San Rafael	58,387	69,770	85,284	3.89%	2.81%	3.23%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	24 Santa Maria	101,071	144,282	205,258	7.93%	4.98%	6.13%	2.70%	2.41%	2.18%	1.94%	1.71%	1.48%	1.26%
	Total	**1,784,441**	**2,234,088**	**2,822,216**										
4. CAVITE	1 Carmona	35,686	47,856	68,135	6.49%	4.99%	5.58%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
	2 Dasmariñas	262,406	379,520	556,330	8.23%	5.42%	6.51%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
	3 Gen.Mariano Alvarez	86,824	112,446	136,613	5.70%	2.72%	3.88%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
	4 Silang	124,062	156,137	199,825	5.05%	3.46%	4.08%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
	5 Tagaytay City	29,419	45,287	61,623	9.68%	4.34%	6.40%	3.11%	2.67%	2.43%	2.21%	1.95%	1.70%	1.45%
	Total	**538,397**	**741,246**	**1,022,526**										

Annex 3.3 Growth Rate of Population in Adjoining Areas (2/4)

STUDY AREA		NSO POPULATION			Past Growth Rate			NSO Provincial Medium Assumption						
		1-Sep-95	1-May-00	1-Aug-07	1995-2000	2000-2007	1995-2007	2010	2015	2020	2025	2030	2035	2040
5. LAGUNA	1 Alaminos	31,442	36,120	40,380	3.02%	1.55%	2.12%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	2 Bay	37,563	43,762	50,756	3.33%	2.07%	2.56%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	3 Biñan	160,206	201,186	262,735	5.00%	3.75%	4.24%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	4 Cabuyao	77,302	106,630	205,376	7.14%	9.46%	8.55%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	5 Calamba City	218,951	281,146	360,281	5.50%	3.48%	4.27%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	6 Calauan	36,677	43,284	54,248	3.61%	3.16%	3.34%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	7 Cavinti	16,157	19,494	20,469	4.11%	0.68%	2.00%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	8 Famy	9,661	10,419	13,577	1.63%	3.72%	2.90%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	9 Kalayaan	16,955	19,580	21,203	3.13%	1.10%	1.89%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	10 Liliw	24,434	27,537	32,727	2.59%	2.41%	2.48%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	11 Los Baños	71,683	82,027	98,631	2.93%	2.58%	2.71%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	12 Luisiana	16,269	17,109	19,255	1.08%	1.64%	1.42%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	13 Lumban	21,996	25,936	28,443	3.59%	1.28%	2.18%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	14 Mabitac	13,309	15,097	17,608	2.74%	2.14%	2.38%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	15 Magdalena	15,927	18,976	20,204	3.82%	0.87%	2.02%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	16 Majayjay	18,989	22,159	23,681	3.36%	0.92%	1.87%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	17 Nagcarlan	43,679	48,727	57,070	2.37%	2.20%	2.27%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	18 Paete	21,809	23,011	24,696	1.16%	0.98%	1.05%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	19 Pgsanjan	28,999	32,622	35,944	2.55%	1.35%	1.82%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	20 Pakil	15,663	18,021	20,242	3.05%	1.62%	2.18%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	21 Pangil	17,664	20,698	23,421	3.45%	1.72%	2.40%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	22 Pila	31,251	37,427	44,227	3.94%	2.33%	2.96%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	23 Rizal	11,537	13,006	15,459	2.60%	2.41%	2.49%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	24 San Pablo City	183,757	207,927	237,259	2.68%	1.84%	2.17%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	25 San Pedro	189,333	231,403	281,808	4.39%	2.76%	3.39%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	26 Santa Cruz (Capital)	86,978	92,694	101,914	1.37%	1.32%	1.34%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	27 Santa Maria	22,296	24,574	26,267	2.11%	0.92%	1.38%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	28 Santa Rosa City	138,257	185,633	266,943	6.52%	5.14%	5.68%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	29 Siniloan	26,914	29,902	34,877	2.28%	2.15%	2.20%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	30 Victoria	25,424	29,765	33,829	3.44%	1.78%	2.43%	1.90%	1.67%	1.46%	1.25%	1.02%	0.81%	0.62%
	Total	**1,631,082**	**1,965,872**	**2,473,530**										

Annex 3.3 Growth Rate of Population in Adjoining Areas (3/4)

STUDY AREA		NSO POPULATION			Past Growth Rate			NSO Provincial Medium Assumption						
		1-Sep-95	1-May-00	1-Aug-07	1995-2000	2000-2007	1995-2007	2010	2015	2020	2025	2030	2035	2040
6. NUEVA ECIJA	1 Aliaga	45,815	50,004	61,270	1.89%	2.84%	2.47%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	2 Bongabon	44,856	49,255	63,639	2.02%	3.60%	2.98%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	3 Cabanatuan City	201,033	222,859	259,267	2.23%	2.11%	2.16%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	4 Cabiao	55,902	62,624	68,382	2.46%	1.22%	1.71%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	5 Carrangalan	29,950	31,720	33,233	1.24%	0.64%	0.88%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	6 Cuyapo	49,791	51,366	55,456	0.67%	1.06%	0.91%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	7 Gabaldon (Bitulok & Sabani)	25,750	28,324	29,619	2.06%	0.62%	1.18%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	8 Gapan City	77,735	89,199	98,795	2.99%	1.42%	2.03%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	9 General Mamerto Natividad	26,140	29,195	33,354	2.40%	1.85%	2.07%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	10 General Tinio													
	11 Guimba	77,935	87,295	96,116	2.46%	1.34%	1.78%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	12 Jaen	53,541	58,274	63,474	1.83%	1.19%	1.44%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	13 Laur	25,143	26,902	30,997	1.46%	1.97%	1.77%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	14 Licab	21,555	21,593	23,675	0.04%	1.28%	0.79%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	15 Llanera	28,127	30,361	33,493	1.65%	1.36%	1.48%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	16 Lupao	29,996	34,190	36,832	2.84%	1.03%	1.74%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	17 Science City of Muñoz	60,162	65,586	71,669	1.87%	1.23%	1.48%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	18 Nampicuan	10,708	11,033	11,786	0.64%	0.91%	0.81%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	19 Palayan City (Capital)	26,851	31,253	32,790	3.31%	0.66%	1.69%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	20 Pantabangan	22,183	23,868	25,520	1.58%	0.93%	1.18%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	21 Peñaranda	22,661	24,749	26,725	1.91%	1.07%	1.39%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	22 Quezon	29,172	31,720	33,988	1.81%	0.96%	1.29%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	23 Rizal	45,834	48,166	52,465	1.07%	1.19%	1.14%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	24 San Antonio	56,130	63,672	67,446	2.74%	0.80%	1.55%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	25 San Isidro	36,283	40,984	44,687	2.65%	1.20%	1.76%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	26 San Jose City	96,860	108,254	122,353	2.41%	1.70%	1.98%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	27 San Leonardo	46,545	50,478	54,596	1.75%	1.09%	1.35%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	28 Santa Rosa	47,522	51,804	58,762	1.87%	1.75%	1.80%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	29 Santo Domingo	40,992	45,934	47,960	2.47%	0.60%	1.33%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	30 Talavera	85,797	97,329	105,122	2.74%	1.07%	1.72%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	31 Talugtug	18,119	18,895	20,671	0.90%	1.25%	1.11%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	32 Zaragoza	33,826	37,645	40,355	2.32%	0.96%	1.49%	1.62%	1.50%	1.31%	1.10%	0.89%	0.70%	0.52%
	Total	**1,472,914**	**1,624,531**	**1,804,497**										
7. NUEVA VIZCAYA	1 Alfonso	4,447	4,808	6,655	1.69%	4.59%	3.44%	2.29%	1.95%	1.69%	1.46%	1.23%	1.01%	0.80%
	2 Aritao	29,151	31,705	34,206	1.82%	1.05%	1.35%	2.29%	1.95%	1.69%	1.46%	1.23%	1.01%	0.80%
	3 Dupax del Sur	13,900	16,371	17,354	3.57%	0.81%	1.88%	2.29%	1.95%	1.69%	1.46%	1.23%	1.01%	0.80%
	4 Dupax Del Norte	22,142	23,196	23,816	1.00%	0.36%	0.61%	2.29%	1.95%	1.69%	1.46%	1.23%	1.01%	0.80%
	5 Santa Fe	11,854	12,949	13,421	1.91%	0.50%	1.05%	2.29%	1.95%	1.69%	1.46%	1.23%	1.01%	0.80%
	Total	**81,494**	**89,029**	**95,452**										

Annex 3.3 Growth Rate of Population in Adjoining Areas (4/4)

STUDY AREA			NSO POPULATION			Past Growth Rate			NSO Provincial Medium Assumption						
			1-Sep-95	1-May-00	1-Aug-07	1995-2000	2000-2007	1995-2007	2010	2015	2020	2025	2030	2035	2040
8. PAMPANGA	1	Angeles City	234,011	263,971	317,398	2.62%	2.57%	2.59%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	2	Apalit	65,720	78,295	97,296	3.82%	3.04%	3.35%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	3	Arayat	85,940	101,792	118,312	3.69%	2.10%	2.72%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	4	Bacolor	13,097	16,147	25,238	4.59%	6.35%	5.66%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	5	Candaba	77,546	86,066	96,589	2.26%	1.60%	1.86%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	6	Floridablanca	76,683	85,394	103,388	2.33%	2.67%	2.54%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	7	Guagua	95,363	96,858	104,601	0.33%	1.07%	0.78%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	8	Lubao	109,667	125,699	143,058	2.97%	1.80%	2.26%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	9	Mabalacat	129,990	171,045	203,307	6.06%	2.41%	3.82%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	10	Macabebe	59,469	65,346	70,332	2.04%	1.02%	1.42%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	11	Magalang	52,607	77,530	98,595	8.67%	3.37%	5.41%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	12	Masantol	45,326	48,120	50,984	1.29%	0.80%	0.99%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	13	Mexico	91,696	109,481	141,298	3.87%	3.58%	3.70%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	14	Minalin	35,670	35,150	40,084	-0.31%	1.83%	0.98%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	15	Porac	75,408	80,757	102,962	1.48%	3.41%	2.65%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	16	San Fernando City (Capital)	193,025	221,857	269,365	3.03%	2.71%	2.84%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	17	San Luis	36,005	41,554	47,517	3.12%	1.87%	2.36%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	18	San Simon	35,474	41,253	48,050	3.29%	2.13%	2.58%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	19	Santa Ana	37,975	42,990	49,756	2.69%	2.04%	2.29%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	20	Santa Rita	32,321	32,780	36,723	0.30%	1.58%	1.08%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	21	Sto Tomas	29,628	32,695	37,866	2.13%	2.05%	2.08%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
	22	Sasmuan (Sexmoan)	23,146	23,359	26,630	0.20%	1.82%	1.18%	1.81%	1.62%	1.42%	1.23%	1.02%	0.81%	0.59%
		Total	**1,635,767**	**1,878,139**	**2,229,349**										
9. PANGASINAN	1	Umingan	51,693	58,603	62,497	2.72%	0.89%	1.61%	2.14%	1.99%	1.78%	1.59%	1.43%	1.27%	1.10%
10. QUEZON	1	Dolores	20,749	23,649	26,312	2.84%	1.48%	2.01%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	2	General Nakar	21,121	23,678	24,895	2.48%	0.69%	1.39%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	3	Infanta	39,772	50,992	60,346	5.47%	2.35%	3.56%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	4	Lucban	35,128	38,834	45,616	2.17%	2.24%	2.22%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	5	Real	27,641	30,684	33,073	2.26%	1.04%	1.52%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	6	Sampaloc	10,977	12,858	13,534	3.45%	0.71%	1.77%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	7	Sariaya	100,709	114,568	128,248	2.80%	1.57%	2.05%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
	8	Tayabas City	64,449	70,985	87,252	2.09%	2.89%	2.57%	1.70%	1.65%	1.50%	1.31%	1.10%	0.92%	0.78%
		Total	**320,546**	**366,248**	**419,276**										
11. TARLAC	1	Anao	9,240	10,045	10,806	1.81%	1.01%	1.32%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	2	Bamban	37,115	46,360	61,644	4.88%	4.01%	4.35%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	3	Capas	81,036	95,219	122,084	3.52%	3.49%	3.50%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	4	Concepcion	101,243	115,171	135,213	2.80%	2.24%	2.46%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	5	Gerona	63,740	72,618	82,022	2.83%	1.69%	2.14%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	6	La Paz	45,207	52,907	61,324	3.43%	2.06%	2.59%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	7	Pura	18,902	21,081	22,188	2.37%	0.71%	1.35%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	8	Ramos	15,476	16,889	19,646	1.89%	2.11%	2.02%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	9	Tarlac City (Capital)	230,459	262,481	314,155	2.83%	2.51%	2.63%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
	10	Victoria	47,546	50,930	57,085	1.48%	1.59%	1.55%	1.70%	1.55%	1.35%	1.16%	0.95%	0.74%	0.56%
		Total	**649,964**	**743,701**	**886,167**										
TOTAL			**8,612,658**	**10,225,491**	**12,454,497**										

Annex 3.4 Population Projection in Adjoining Areas (1/4)

STUDY AREA			Population based on NSO Medium Assumption								
Province		Municipatily	2010	2011	2012	2015	2020	2025	2030	2035	2040
1. AURORA	1	Dingalan	23,738	24,277	24,828	26,556	29,471	32,408	35,140	37,850	40,421
	2	Maria Aurora	38,091	38,955	39,839	42,613	47,290	52,002	56,386	60,735	64,860
	3	San Luis	25,653	26,235	26,830	28,699	31,849	35,022	37,974	40,903	43,681
		Total	**87,483**	**89,468**	**91,498**	**97,868**	**108,610**	**119,431**	**129,500**	**139,489**	**148,962**
2. BATANGAS	1	Lipa City	278,038	283,183	288,424	304,734	331,119	356,324	379,513	400,387	418,256
	2	Malvar	44,528	45,352	46,191	48,803	53,029	57,065	60,779	64,122	66,984
	3	Santo Tomas	120,688	122,922	125,196	132,276	143,729	154,670	164,735	173,796	181,553
	4	Tanauan City	152,094	154,908	157,775	166,697	181,130	194,918	207,603	219,022	228,796
		Total	**595,348**	**606,365**	**617,586**	**652,510**	**709,008**	**762,977**	**812,630**	**857,327**	**895,589**
3. BULACAN	1	Angat	58,052	59,454	60,890	65,409	72,841	80,199	87,273	93,906	99,960
	2	Balagtas (Bigaa)	68,508	70,163	71,857	77,189	85,960	94,643	102,992	110,820	117,964
	3	Baliuag	149,710	153,325	157,028	168,680	187,847	206,822	225,066	242,172	257,783
	4	Bocaue	115,649	118,442	121,302	130,304	145,109	159,768	173,861	187,075	199,135
	5	Bulacan	79,006	80,914	82,868	89,017	99,132	109,146	118,773	127,800	136,039
	6	Bustos	66,319	67,921	69,561	74,723	83,213	91,619	99,701	107,278	114,194
	7	Calumpit	107,124	109,711	112,361	120,699	134,413	147,991	161,045	173,285	184,456
	8	Dona Remedios Trinidad	20,859	21,363	21,879	23,503	26,173	28,817	31,359	33,742	35,918
	9	Guiguinto	97,515	99,870	102,282	109,872	122,356	134,716	146,600	157,742	167,910
	10	Hagonoy	136,339	139,631	143,003	153,615	171,070	188,351	204,965	220,543	234,760
	11	Malolos City	246,173	252,117	258,206	277,367	308,882	340,085	370,083	398,211	423,882
	12	Marilao	175,360	179,595	183,932	197,581	220,031	242,258	263,628	283,664	301,951
	13	Meycauayan City	214,833	220,021	225,334	242,056	269,560	296,790	322,969	347,516	369,919
	14	Norzagaray	115,270	118,053	120,904	129,876	144,633	159,244	173,291	186,461	198,482
	15	Obando	61,485	62,970	64,491	69,276	77,148	84,941	92,434	99,459	105,871
	16	Pandi	66,271	67,871	69,510	74,669	83,153	91,553	99,629	107,201	114,111
	17	Paombong	55,518	56,859	58,232	62,553	69,660	76,697	83,463	89,806	95,596
	18	Plaridel	106,259	108,825	111,453	119,723	133,327	146,795	159,744	171,885	182,965
	19	Pulilan	92,907	95,150	97,448	104,679	116,573	128,349	139,671	150,286	159,975
	20	San Ildefonso	102,120	104,586	107,111	115,060	128,134	141,077	153,522	165,190	175,839
	21	San Jose del Monte City	479,888	491,477	503,345	540,698	602,134	662,960	721,439	776,271	826,313
	22	San Miguel	151,739	155,404	159,156	170,967	190,393	209,626	228,117	245,455	261,278
	23	San Rafael	93,208	95,459	97,764	105,019	116,952	128,766	140,124	150,774	160,494
	24	Santa Maria	224,330	229,747	235,295	252,756	281,475	309,909	337,246	362,877	386,270
		Total	**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	1	Carmona	75,451	77,466	79,536	86,081	97,059	108,283	119,237	129,710	139,421
	2	Dasmariñas	616,064	632,521	649,418	702,865	792,499	884,143	973,587	1,059,098	1,138,392
	3	Gen.Mariano Alvarez	151,281	155,323	159,472	172,596	194,607	217,111	239,075	260,073	279,545
	4	Silang	221,281	227,192	233,261	252,458	284,653	317,570	349,697	380,411	408,893
	5	Tagaytay City	68,240	70,062	71,934	77,854	87,783	97,934	107,841	117,313	126,096
		Total	**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**

Annex 3.4 Population Projection in Adjoining Areas (2/4)

STUDY AREA		Population based on NSO Medium Assumption								
Province	**Municipatily**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
5. LAGUNA	1 Alaminos	43,001	43,720	44,452	46,721	50,243	53,455	56,244	58,558	60,389
	2 Bay	54,050	54,955	55,874	58,727	63,154	67,191	70,697	73,605	75,906
	3 Biñan	279,786	284,469	289,230	303,996	326,911	347,811	365,958	381,014	392,922
	4 Cabuyao	218,704	222,365	226,086	237,629	255,541	271,879	286,063	297,833	307,141
	5 Calamba City	383,662	390,084	396,612	416,861	448,283	476,944	501,827	522,473	538,803
	6 Calauan	57,769	58,735	59,718	62,767	67,499	71,814	75,561	78,670	81,128
	7 Cavinti	21,797	22,162	22,533	23,684	25,469	27,097	28,511	29,684	30,612
	8 Famy	14,458	14,700	14,946	15,709	16,893	17,973	18,911	19,689	20,305
	9 Kalayaan	22,579	22,957	23,341	24,533	26,382	28,069	29,533	30,748	31,709
	10 Liliw	34,851	35,434	36,027	37,867	40,721	43,324	45,585	47,460	48,943
	11 Los Baños	105,032	106,790	108,577	114,121	122,723	130,569	137,381	143,033	147,503
	12 Luisiana	20,505	20,848	21,197	22,279	23,958	25,490	26,820	27,923	28,796
	13 Lumban	30,289	30,796	31,311	32,910	35,390	37,653	39,618	41,248	42,537
	14 Mabitac	18,751	19,065	19,384	20,373	21,909	23,310	24,526	25,535	26,333
	15 Magdalena	21,515	21,875	22,241	23,377	25,139	26,746	28,142	29,299	30,215
	16 Majayjay	25,218	25,640	26,069	27,400	29,465	31,349	32,985	34,342	35,415
	17 Nagcarlan	60,774	61,791	62,825	66,033	71,010	75,550	79,491	82,762	85,349
	18 Paete	26,299	26,739	27,186	28,574	30,728	32,693	34,398	35,814	36,933
	19 Pgsanjan	38,277	38,917	39,569	41,589	44,724	47,583	50,066	52,125	53,755
	20 Pakil	21,556	21,916	22,283	23,421	25,186	26,797	28,195	29,355	30,272
	21 Pangil	24,941	25,358	25,783	27,099	29,142	31,005	32,623	33,965	35,026
	22 Pila	47,097	47,885	48,687	51,173	55,030	58,548	61,603	64,137	66,142
	23 Rizal	16,462	16,738	17,018	17,887	19,235	20,465	21,532	22,418	23,119
	24 San Pablo City	252,657	256,885	261,185	274,519	295,212	314,086	330,473	344,069	354,823
	25 San Pedro	300,097	305,119	310,226	326,065	350,642	373,060	392,524	408,673	421,446
	26 Santa Cruz (Capital)	108,528	110,344	112,191	117,919	126,808	134,915	141,954	147,794	152,413
	27 Santa Maria	27,972	28,440	28,916	30,392	32,683	34,773	36,587	38,092	39,283
	28 Santa Rosa City	284,267	289,025	293,862	308,865	332,146	353,382	371,819	387,116	399,215
	29 Siniloan	37,140	37,762	38,394	40,354	43,396	46,171	48,579	50,578	52,159
	30 Victoria	36,024	36,627	37,240	39,142	42,092	44,783	47,120	49,058	50,592
	Total	**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**

Annex 3.4 Population Projection in Adjoining Areas (3/4)

STUDY AREA		Population based on NSO Medium Assumption								
Province	Municipatily	2010	2011	2012	2015	2020	2025	2030	2035	2040
6. NUEVA ECIJA	1 Aliaga	64,636	65,607	66,593	69,639	74,329	78,524	82,086	85,017	87,269
	2 Bongabon	67,135	68,144	69,167	72,331	77,203	81,561	85,260	88,304	90,643
	3 Cabanatuan City	273,511	277,619	281,789	294,680	314,529	332,280	347,351	359,755	369,283
	4 Cabiao	72,139	73,222	74,322	77,722	82,957	87,639	91,614	94,886	97,399
	5 Carrangalan	35,059	35,585	36,120	37,772	40,316	42,592	44,524	46,114	47,335
	6 Cuyapo	58,503	59,381	60,273	63,031	67,276	71,073	74,297	76,950	78,988
	7 Gabaldon (Bitulok & Sabani)	31,246	31,716	32,192	33,665	35,932	37,960	39,682	41,099	42,187
	8 Gapan City	104,223	105,788	107,377	112,289	119,853	126,617	132,360	137,086	140,717
	9 General Mamerto Natividad	35,186	35,715	36,251	37,910	40,463	42,747	44,686	46,281	47,507
	10 General Tinio	0	0	0	0	0	0	0	0	0
	11 Guimba	101,397	102,920	104,466	109,244	116,603	123,184	128,771	133,369	136,902
	12 Jaen	66,961	67,967	68,988	72,144	77,003	81,349	85,039	88,076	90,408
	13 Laur	32,700	33,191	33,690	35,231	37,604	39,726	41,528	43,011	44,150
	14 Licab	24,976	25,351	25,732	26,909	28,721	30,342	31,718	32,851	33,721
	15 Llanera	35,333	35,864	36,403	38,068	40,632	42,925	44,872	46,474	47,705
	16 Lupao	38,856	39,439	40,032	41,863	44,683	47,204	49,345	51,108	52,461
	17 Science City of Muñoz	75,606	76,742	77,895	81,458	86,945	91,852	96,018	99,447	102,081
	18 Nampicuan	12,434	12,620	12,810	13,396	14,298	15,105	15,790	16,354	16,787
	19 Palayan City (Capital)	34,591	35,111	35,638	37,269	39,779	42,024	43,930	45,499	46,704
	20 Pantabangan	26,922	27,326	27,737	29,006	30,959	32,707	34,190	35,411	36,349
	21 Peñaranda	28,193	28,617	29,047	30,375	32,421	34,251	35,805	37,083	38,065
	22 Quezon	35,855	36,394	36,941	38,630	41,232	43,559	45,535	47,161	48,410
	23 Rizal	55,347	56,179	57,023	59,631	63,648	67,240	70,290	72,800	74,728
	24 San Antonio	71,151	72,220	73,305	76,658	81,822	86,440	90,360	93,587	96,066
	25 San Isidro	47,142	47,850	48,569	50,791	54,212	57,271	59,869	62,007	63,649
	26 San Jose City	129,075	131,014	132,982	139,065	148,432	156,809	163,921	169,775	174,272
	27 San Leonardo	57,595	58,461	59,339	62,053	66,233	69,971	73,145	75,757	77,763
	28 Santa Rosa	61,990	62,921	63,867	66,788	71,287	75,310	78,726	81,537	83,697
	29 Santo Domingo	50,595	51,355	52,126	54,511	58,182	61,466	64,254	66,549	68,311
	30 Talavera	110,897	112,563	114,254	119,480	127,528	134,726	140,836	145,866	149,729
	31 Talugtug	21,807	22,134	22,467	23,494	25,077	26,492	27,694	28,683	29,442
	32 Zaragoza	42,572	43,212	43,861	45,867	48,956	51,720	54,065	55,996	57,479
	Total	**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	1 Alfonso	7,177	7,317	7,459	7,903	8,592	9,240	9,823	10,327	10,745
	2 Aritao	36,890	37,608	38,340	40,622	44,164	47,493	50,489	53,082	55,229
	3 Dupax del Sur	18,716	19,080	19,451	20,609	22,406	24,095	25,615	26,930	28,020
	4 Dupax Del Norte	25,685	26,185	26,694	28,283	30,749	33,067	35,153	36,958	38,453
	5 Santa Fe	14,474	14,756	15,043	15,938	17,328	18,634	19,810	20,827	21,669
	Total	**102,943**	**104,946**	**106,988**	**113,356**	**123,240**	**132,530**	**140,891**	**148,124**	**154,115**

Annex 3.4 Population Projection in Adjoining Areas (4/4)

STUDY AREA			Population based on NSO Medium Assumption								
Province		Municipatily	2010	2011	2012	2015	2020	2025	2030	2035	2040
8. PAMPANGA	1	Angeles City	336,996	342,450	347,993	365,165	391,830	416,474	438,198	456,132	469,744
	2	Apalit	103,304	104,976	106,675	111,939	120,113	127,667	134,326	139,824	143,997
	3	Arayat	125,617	127,650	129,716	136,117	146,057	155,243	163,341	170,026	175,100
	4	Bacolor	26,796	27,230	27,671	29,036	31,156	33,116	34,843	36,269	37,352
	5	Candaba	102,553	104,213	105,900	111,125	119,240	126,739	133,350	138,808	142,950
	6	Floridablanca	109,772	111,548	113,354	118,947	127,633	135,661	142,737	148,579	153,013
	7	Guagua	111,060	112,857	114,684	120,343	129,131	137,252	144,412	150,322	154,808
	8	Lubao	151,891	154,350	156,848	164,588	176,606	187,714	197,505	205,588	211,724
	9	Mabalacat	215,860	219,354	222,904	233,904	250,984	266,769	280,685	292,172	300,891
	10	Macabebe	74,675	75,883	77,112	80,917	86,825	92,286	97,100	101,074	104,090
	11	Magalang	104,683	106,377	108,099	113,433	121,716	129,372	136,120	141,691	145,919
	12	Masantol	54,132	55,008	55,899	58,657	62,940	66,899	70,388	73,269	75,456
	13	Mexico	150,023	152,451	154,918	162,563	174,433	185,404	195,075	203,059	209,119
	14	Minalin	42,559	43,248	43,948	46,116	49,484	52,596	55,340	57,605	59,324
	15	Porac	109,319	111,089	112,887	118,457	127,107	135,102	142,149	147,966	152,382
	16	San Fernando City (Capital)	285,997	290,626	295,330	309,903	332,533	353,447	371,884	387,104	398,656
	17	San Luis	50,451	51,268	52,097	54,668	58,660	62,349	65,602	68,287	70,324
	18	San Simon	51,017	51,843	52,682	55,281	59,318	63,049	66,338	69,053	71,113
	19	Santa Ana	52,828	53,683	54,552	57,244	61,424	65,287	68,693	71,504	73,638
	20	Santa Rita	38,990	39,622	40,263	42,250	45,335	48,186	50,700	52,775	54,350
	21	Sto Tomas	40,204	40,855	41,516	43,565	46,746	49,686	52,278	54,417	56,041
	22	Sasmuan (Sexmoan)	28,274	28,732	29,197	30,638	32,875	34,943	36,765	38,270	39,412
		Total	**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	1	Umingan	67,068	68,400	69,758	73,995	80,820	87,446	93,880	99,970	105,571
10. QUEZON	1	Dolores	27,830	28,288	28,754	30,197	32,532	34,721	36,674	38,398	39,915
	2	General Nakar	26,331	26,765	27,205	28,571	30,780	32,851	34,699	36,330	37,766
	3	Infanta	63,828	64,878	65,946	69,256	74,611	79,631	84,111	88,065	91,544
	4	Lucban	48,248	49,042	49,849	52,351	56,399	60,194	63,580	66,569	69,199
	5	Real	34,981	35,557	36,142	37,956	40,891	43,642	46,097	48,264	50,171
	6	Sampaloc	14,315	14,551	14,790	15,532	16,733	17,859	18,864	19,751	20,531
	7	Sariaya	135,648	137,880	140,150	147,184	158,564	169,233	178,753	187,156	194,551
	8	Tayabas City	92,286	93,805	95,349	100,135	107,877	115,136	121,612	127,329	132,361
		Total	**443,468**	**450,767**	**458,185**	**481,182**	**518,386**	**553,268**	**584,390**	**611,862**	**636,038**
11. TARLAC	1	Anao	11,430	11,607	11,786	12,341	13,195	13,976	14,650	15,202	15,629
	2	Bamban	65,205	66,213	67,237	70,403	75,274	79,727	83,574	86,723	89,159
	3	Capas	129,137	131,133	133,160	139,430	149,078	157,897	165,516	171,753	176,576
	4	Concepcion	143,025	145,236	147,480	154,425	165,110	174,878	183,316	190,223	195,565
	5	Gerona	86,761	88,102	89,464	93,676	100,158	106,083	111,202	115,392	118,633
	6	La Paz	64,867	65,870	66,888	70,037	74,883	79,313	83,140	86,273	88,696
	7	Pura	23,470	23,833	24,201	25,341	27,094	28,697	30,082	31,215	32,092
	8	Ramos	20,781	21,102	21,428	22,437	23,990	25,409	26,635	27,639	28,415
	9	Tarlac City (Capital)	332,305	337,441	342,657	358,792	383,617	406,313	425,918	441,966	454,378
	10	Victoria	60,383	61,316	62,264	65,196	69,707	73,831	77,393	80,309	82,565
		Total	**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			**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**

Chapter 4

Annex 4.1

INDIGENOUS PEOPLE IN CALABARZON (REGION IV-A)

Province	CITY/MUNICIPALITY	BARANGAY	TRIBE	POLULATION
BATANGAS	ROSARIO	PUTINGKAHOY	AETA	
AETA	NONE			
LAGUNA	STA. MARIA			
QUEZON	GENERAL NAKAR	CANAWAY LUMUTAN MAGSIKAP MALIGAYA MINAHAN NORTE PAGSANGAHAN SABLANG SAN MARCELINO UMIRAY	DUMAGAT/REMONTADO	
	INFANTA	CATAMBUNGAN	DUMAGAT	
	REAL	LUBAYAT TANAUAN	DUMAGAT	
	TAYABAS	TONGKO	AETA	
	ALABAT*	BACONG	AETA	
	BURDEOS*	ANIBAWAN BONIFACIO BUKAL CARLAGAN MABINI RIZAL		
	CALAUAG*		AETA	
	CATANAUAN*	AGRO ANUSAN CANCULAJAO POBLACION BRGY 10 SAN ISIDRO SAN JOSE ANYAO SANTOL TAGBACAN IBABA TAGBACAN SILANGAN		
	LOPEZ*	VILLA ESPINA	AETA	
	LUCENA*	BARRA	BADJAO	
	MAUBAN*	CAGSIAY III	DUMAGAT	
	PANUKULAN*	BONBON	DUMAGAT	
	POLILIO*	TALUONG	DUMAGAT	
RIZAL	ANTIPOLO	CALAWIS SAN JOSE SAN YSIRO	DUMAGAT/REMONTADO	
	RODRIGUEZ (MONTALBAN)	PURAY SAN ISIDRO SAN RAFAEL	DUMAGAT/REMONTADO	
	TANAY	ALDEA CAYABU CUYAMABAY DARAITAN KAY BUTO LAIBAN MAMUYAO SAMPLALOC SAN ANDRES SANTO NIÑO STA. INEZ TANDANG KUTYO TINUCAN	DUMAGAT/REMONTADO	
			TOTAL	

NOTE: * OUTSIDE THE STUDY AREA

INDIGENOUS PEOPLE IN REGION III

Province	CITY/MUNICIPALITY	BARANGAY	TRIBE	POLULATION
AURORA				
BATAAN				
BULACAN				
PAMPANGA	FLORIDABLANCA	MAWACAT NABUCLOD		
	PORAC	CAMIAS DIAZ INARARO PLANAS SAPANG UWAK VILLA MARIA		
TARLAC ZAMBALES				

Annex 4.2

ENDANGERED SPECIES IN PROTECTED AREAS ADJACENT TO THE RIVER BASINS

RIVER BASIN	PROTECTED AREA	COMMON NAME	SCIENTIFIC NAME	STATUS
Angat	Angat Watershed Forest Reserve	Ashy thrush	Zoothera cinerea	Vulnerable
		Ashy-breasted flycatcher	Muscicapa randi	Vulnerable
		Celestial monarch	Hypothymis coelestis	Vulnerable
		Flame-breasted fruit dove	Ptilinopus marchei	Vulnerable
		Green racket-tail	Prioniturus luconensis	Vulnerable
		Green-faced parrotfinch	Erythrura viridifacies	Vulnerable
		Luzon fruit bat	Otopteropus cartilagonodus	Vulnerable
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine eagle	Pithecophaga jefferyi	Critically Endangered
		Philippine eagle-owl	Bubo philippensis	Vulnerable
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		Pygmy forest frog	Platymantis pygmaea	Vulnerable
		Spotted imperial pigeon	Ducula carola	Vulnerable
		Whiskered pitta	Pitta kochi	Vulnerable
Pampanga	Aurora Memorial National Park	Aurora mountain skink	Sphenomorphus tagapayo	Near threatened
		Banded Philippine burrowing snake	Oxyrhabdium leporinum	Least concern
		Black-sided forest skink	Sphenomorphus decipiens	Least concern
		Blue-legged tree frog	Rhacophorus bimaculatus	Vulnerable
		Cuming's eared skink	Mabuya cumingi	assessed
		Cuming's forest skink	Sphenomorphus cumingi	Least concern
		skink	Brachymeles bicolor	Near threatened
		Flame-breasted fruit dove	Ptilinopus marchei	Vulnerable
		Giant golden-crowned flying fox	Acerodon jubatus	Endangered
		Gray's monitor lizard	Varanus olivaceus	Vulnerable
		Green racket-tail	Prioniturus luconensis	Vulnerable
		Kabatangan frog	Rana tipanan	Vulnerable
		Kalinga narrowmouth toad	Kaloula kalingensis	Vulnerable
		Luzon blind snake	Typhlops luzonensis	Data Deficient
		Luzon dwarf snake	Calamaria bitorques	Least concern
		Luzon fruit bat	Otopteropus cartilagonodus	Vulnerable
		Luzon shrew	Crocidura grayi	Vulnerable
		Luzon water-redstart	Rhyacornis bicolor	Vulnerable
		Mottle-winged flying fox	Pteropus leucopterus	Endangered
		Narra	Pterocarpus indicus	Vulnerable
		Negros light-scaled snake	Pseudorabdion oxycephalum	Least concern
		Northern water snake	Rhabdophis spilogaster	Least concern
		Philippine bow-fingered gecko	Cyrtodactylus philippinicus	Least concern
		Philippine duck	Anas luzonica	Vulnerable
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine dwarf snake	Calamaria gervaisii	Least concern
		Philippine eagle	Pithecophaga jefferyi	Endangered
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		Philippine warty pig	Sus philippensis	Vulnerable
		Polillo forest frog	Platymantis polillensis	Endangered

ENDANGERED SPECIES IN PROTECTED AREAS ADJACENT TO THE RIVER BASINS

RIVER BASIN	PROTECTED AREA	COMMON NAME	SCIENTIFIC NAME	STATUS
Pampanga	Aurora Memorial National Park	Pygmy forest frog	Platymantis pygmaea	Vulnerable
		Pygmy fruit bat	Haplonycteris fischeri	Vulnerable
		Sierra Madre forest frog	Platymantis sierramadrensis	Vulnerable
		Species of skink	Sphenomorphus abdictus	Least concern
		Spotted imperial pigeon	Ducula carola	Vulnerable
		Steere's forest skink	Sphenomorphus steerei	Least concern
		Stub-limbed burrowing skink	Brachymeles bonitae	Least concern
		Tamaho	Gloeocarpus patentivalvis	Endangered
		Whiskered pitta	Pitta kochi	Vulnerable
		White-spotted forest skink	Sphenomorphus leucospilos	Least concern
		Yellow-striped slender tree skink	Lipinia pulchella	Least concern
	Candaba Swamp	Baer's pochard	Aythya baeri	Vulnerable
		Philippine duck	Anas luzonica	Vulnerable
		Spot-billed pelican	Pelecanus philippensis	Vulnerable
		Streaked reed-warbler	Acrocephalus sorghophilus	Vulnerable
	Casecnan Protected Landscape	Ashy thrush	Zoothera cinerea	Vulnerable
		Ashy-breasted flycatcher	Muscicapa randi	Vulnerable
		Flame-breasted fruit dove	Ptilinopus marchei	Vulnerable
		Green-faced parrotfinch	Erythrura viridifacies	Vulnerable
		Luzon fruit bat	Otopteropus cartilagonodus	Vulnerable
		Luzon water-redstart	Rhyacornis bicolor	Vulnerable
		Narra	Pterocarpus indicus	Vulnerable
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine eagle	Pithecophaga jefferyi	Critically Endangered
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		Philippine pygmy fruit bat	Haplonycteris fischeri	Vulnerable
		Philippine warty pig	Sus philippensis	Vulnerable
		Ulas	Guioa myriadenia	Endangered
	Manila Bay	Black-faced spoonbill	Platalea minor	Endangered
		Chinese crested tern	Sterna bernsteini	Critically Endangered
		Chinese egret	Egretta eulophotes	Vulnerable
		Philippine duck	Anas luzonica	Vulnerable
		Spotted greenshank	Tringa guttifer	Endangered
	Mt. Dingalan	Alamag	Aglaia aherniana	Vulnerable
		Green Racket-tail	Prioniturus luconensis	Vulnerable
		Green-faced parrotfinch	Erythrura viridifacies	Vulnerable
		Kabatangan frog	Hylarana tipanan	Vulnerable
		Kalinga narrowmouth toad	Kaloula kalingensis	Vulnerable
		Kanining-peneras	Aglaia pyriformis	Vulnerable
		Luzon fruit bat	Otopteropus cartilagonodus	Vulnerable
		Luzon water-redstart	Rhyacornis bicolor	Vulnerable
		Mottle-winged flying fox	Pteropus leucopterus	Endangered
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine eagle	Pithecophaga jefferyi	Critically Endangered

ENDANGERED SPECIES IN PROTECTED AREAS ADJACENT TO THE RIVER BASINS

RIVER BASIN	PROTECTED AREA	COMMON NAME	SCIENTIFIC NAME	STATUS
Pampanga	Mt. Dingalan	Philippine eagle-owl	Bubo philippensis	Vulnerable
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		Philippine warty pig	Sus philippensis	Vulnerable
		Pygmy forest frog	Platymantis pygmaea	Vulnerable
		Sierra Madre forest frog	Platymantis sierramadrensis	Vulnerable
		Spotted imperial pigeon	Ducula carola	Vulnerable
		Ulas	Guioa myriadenia	Endangered
		Whiskered pitta	Pitta kochi	Vulnerable
	Mt. Arayat			
	South Central Sierra Madre Mountains			
Pasig-Marikina	Pasig River			
Laguna Lake	Mt. Makiling Forest Reserve	Ashy thrush	Zoothera cinerea	Vulnerable
		Bagtikan/White lauan	Parashorea malaanonan	Critically Endangered
		Balobo	Diplodiscus paniculatus	Vulnerable
		Banded Philippine burrowing snake	Oxyrhabdium leporinum	Vulnerable
		Chinese egret	Egretta eulophotes	Vulnerable
		Elemi	Canarium luzonicum	Vulnerable
		Green-faced parrotfinch	Erythrura viridifacies	Vulnerable
		Kalinga narrowmouth toad	Kaloula kalingensis	Vulnerable
		Katmon-kalabao	Dillenia reifferscheidtia	Vulnerable
		Luzon short-nosed rat	Tryphomys adustus	Vulnerable
		Malapaho	Mangifera monandra	Endangered
		Malatapay	Alangium longiflorum	Vulnerable
		Manggachapui/Dalingdingan	Hopea acuminata	Critically Endangered
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine eagle-owl	Bubo philippensis	Vulnerable
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		White lauan	Shorea contorta	Critically Endangered
		Yakal-kailot	Hopea malibato	Critically Endangered
Laguna Lake	Mts. Banahaw-San Cristobal National Park	Ashy thrush	Zoothera cinerea	Vulnerable
		Bagtikan/White lauan	Parashorea malaanonan	Critically Endangered
		Banahao forest frog	Platymantis banahao	Vulnerable
		Beyer's sphenomorphus	Sphenomorphus beyeri	Near threatened
		Blue-legged tree frog	Rhacophorus bimaculatus	Vulnerable
		Bungang-ipot / Ipot palm	Areca ipot	Vulnerable
		Flame-breasted fruit dove	Ptilinopus marchei	Vulnerable
		Kalinga narrowmouth toad	Kaloula kalingensis	Vulnerable
		Luzon fruit bat	Otopteropus cartilagonodus	Vulnerable
		Luzon shrew	Crocidura grayi	Vulnerable
		Mountain forest frog	Platymantis montana	Vulnerable
		Naomi's forest frog	Platymantis naomiae	Vulnerable

ENDANGERED SPECIES IN PROTECTED AREAS ADJACENT TO THE RIVER BASINS

RIVER BASIN	PROTECTED AREA	COMMON NAME	SCIENTIFIC NAME	STATUS
Laguna Lake	Mts. Banahaw-San Cristobal National Park	Philippine eagle-owl	Bubo philippensis	Vulnerable
		Small rufous horseshoe bat	Rhinolophus subrufus	Vulnerable
		Southern Luzon giant cloud rat	Phloeomys cumingi	Vulnerable
		Species of frog	Platymantis indeprensus	Vulnerable
		Species of frog	Platymantis pseudodorsalis	Vulnerable
	Laguna de Bay			
	Tadlak Lake			
Agos	UP Land Grants (Pakil and Real)	Ashy-breasted flycatcher	Muscicapa randi	Vulnerable
		Celestial monarch	Hypothymis coelestis	Vulnerable
		Japanese night heron	Gorsachius goisagi	Vulnerable
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine eagle-owl	Bubo philippensis	Vulnerable
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		Streaked reed-warbler	Acrocephalus sorghophilus	Vulnerable
		Whiskered pitta	Pitta kochi	Vulnerable
Agos/Umiray	Mts. Irid-Angilo and Binuang	Ashy thrush	Zoothera cinerea	Vulnerable
		Ashy-breasted flycatcher	Muscicapa randi	Vulnerable
		Celestial monarch	Hypothymis coelestis	Vulnerable
		Flame-breasted fruit dove	Ptilinopus marchei	Vulnerable
		Giant golden-crowned flying fox	Acerodon jubatus	Endangered
		Green racket-tail	Prioniturus luconensis	Vulnerable
		Green-faced parrotfinch	Erythrura viridifacies	Vulnerable
		Luzon fruit bat	Otopteropus cartilagonodus	Vulnerable
		Luzon shrew	Crocidura grayi	Vulnerable
		Mottle-winged flying fox	Pteropus leucopterus	Endangered
		Narra	Pterocarpus indicus	Vulnerable
		Philippine dwarf kingfisher	Ceyx melanurus	Vulnerable
		Philippine eagle	Pithecophaga jefferyi	Critically Endangered
		Philippine eagle-owl	Bubo philippensis	Vulnerable
		Philippine hawk-eagle	Spizaetus philippensis	Vulnerable
		Philippine pygmy fruit bat	Haplonycteris fischeri	Vulnerable
		Philippine warty pig	Sus philippensis	Vulnerable
Agos/Umiray	Mts. Irid-Angilo and Binuang	Polillo forest frog	Platymantis polillensis	Endangered
		Sierra Madre forest frog	Platymantis sierramadrensis	Vulnerable
		Spotted imperial pigeon	Ducula carola	Vulnerable
		Ulas	Guioa myriadenia	Endangered
		Whiskered pitta	Pitta kochi	Vulnerable
		Yakal-kailot	Hopea malibato	Critically Endangered
Umiray	Umiray River			

Chapter 5

Annex 5.1 Projection of Service Coverage by Municipality (1/4)

Province		Municipality	Level III Coverage 2010	Level III Coverage 2020	Level III Coverage 2030	Level III Coverage 2040	Level II Coverage 2010	Level II Coverage 2020	Level II Coverage 2030	Level II Coverage 2040	Level I Coverage 2010	Level I Coverage 2020	Level I Coverage 2030	Level I Coverage 2040
1. AURORA	1	Dingalan	96.31%	97.54%	98.77%	100.00%	0.00%	0.00%	0.00%	0.00%	3.69%	2.46%	1.23%	0.00%
	2	Maria Aurora	96.12%	97.41%	98.71%	100.00%	0.00%	0.00%	0.00%	0.00%	3.88%	2.59%	1.29%	0.00%
	3	San Luis	51.65%	58.29%	64.94%	71.58%	0.00%	0.00%	0.00%	0.00%	48.35%	41.71%	35.06%	28.42%
		Average	**81.36%**	**84.42%**	**87.47%**	**90.53%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**18.64%**	**15.58%**	**12.53%**	**9.47%**
2. BATANGAS	1	Lipa City	53.71%	65.43%	77.14%	88.86%	7.76%	0.00%	0.00%	0.00%	38.53%	34.57%	22.86%	11.14%
	2	Malvar	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	Santo Tomas	98.39%	98.92%	99.46%	100.00%	0.00%	0.00%	0.00%	0.00%	1.61%	1.08%	0.54%	0.00%
	4	Tanauan City	53.71%	65.43%	77.14%	88.86%	7.76%	0.00%	0.00%	0.00%	38.53%	34.57%	22.86%	11.14%
		Average	**76.45%**	**82.44%**	**88.44%**	**94.43%**	**3.88%**	**0.00%**	**0.00%**	**0.00%**	**19.67%**	**17.56%**	**11.56%**	**5.57%**
3. BULACAN	1	Angat	51.39%	67.59%	83.80%	100.00%	0.00%	0.00%	0.00%	0.00%	48.61%	32.41%	16.20%	0.00%
	2	Balagtas (Bigaa)	79.75%	86.50%	93.25%	100.00%	0.00%	0.00%	0.00%	0.00%	20.25%	13.50%	6.75%	0.00%
	3	Baliuag	55.19%	70.13%	85.06%	100.00%	0.00%	0.00%	0.00%	0.00%	44.81%	29.87%	14.94%	0.00%
	4	Bocaue	73.31%	82.21%	91.10%	100.00%	0.00%	0.00%	0.00%	0.00%	26.69%	17.79%	8.90%	0.00%
	5	Bulacan	70.51%	80.34%	90.17%	100.00%	0.00%	0.00%	0.00%	0.00%	29.49%	19.66%	9.83%	0.00%
	6	Bustos	64.49%	76.33%	88.16%	100.00%	0.00%	0.00%	0.00%	0.00%	35.51%	23.67%	11.84%	0.00%
	7	Calumpit	97.03%	98.02%	99.01%	100.00%	0.00%	0.00%	0.00%	0.00%	2.97%	1.98%	0.99%	0.00%
	8	Dona Remedios Trinidad	93.43%	95.62%	97.81%	100.00%	0.00%	0.00%	0.00%	0.00%	6.57%	4.38%	2.19%	0.00%
	9	Guiguinto	37.27%	54.25%	71.23%	88.21%	0.00%	0.00%	0.00%	0.00%	62.73%	45.75%	28.77%	11.79%
	10	Hagonoy	89.17%	92.78%	96.39%	100.00%	0.00%	0.00%	0.00%	0.00%	10.83%	7.22%	3.61%	0.00%
	11	Malolos City	46.67%	63.65%	80.63%	97.61%	0.00%	0.00%	0.00%	0.00%	53.33%	36.35%	19.37%	2.39%
	12	Marilao	55.56%	70.37%	85.19%	100.00%	0.00%	0.00%	0.00%	0.00%	44.44%	29.63%	14.81%	0.00%
	13	Meycauayan City	72.03%	81.36%	90.68%	100.00%	0.00%	0.00%	0.00%	0.00%	27.97%	18.64%	9.32%	0.00%
	14	Norzagaray	68.73%	79.15%	89.58%	100.00%	0.00%	0.00%	0.00%	0.00%	31.27%	20.85%	10.42%	0.00%
	15	Obando	96.01%	97.34%	98.67%	100.00%	0.00%	0.00%	0.00%	0.00%	3.99%	2.66%	1.33%	0.00%
	16	Pandi	98.53%	99.02%	99.51%	100.00%	0.00%	0.00%	0.00%	0.00%	1.47%	0.98%	0.49%	0.00%
	17	Paombong	89.21%	92.80%	96.40%	100.00%	0.00%	0.00%	0.00%	0.00%	10.79%	7.20%	3.60%	0.00%
	18	Plaridel	70.59%	80.39%	90.20%	100.00%	0.00%	0.00%	0.00%	0.00%	29.41%	19.61%	9.80%	0.00%
	19	Pulilan	3.68%	20.66%	37.64%	54.63%	0.00%	0.00%	0.00%	0.00%	96.32%	79.34%	62.36%	45.37%
	20	San Ildefonso	30.80%	47.78%	64.77%	81.75%	0.00%	0.00%	0.00%	0.00%	69.20%	52.22%	35.23%	18.25%
	21	San Jose del Monte City	97.03%	98.02%	99.01%	100.00%	0.00%	0.00%	0.00%	0.00%	2.97%	1.98%	0.99%	0.00%
	22	San Miguel	46.53%	63.51%	80.49%	97.48%	0.00%	0.00%	0.00%	0.00%	53.47%	36.49%	19.51%	2.52%
	23	San Rafael	25.77%	42.75%	59.73%	76.71%	0.00%	0.00%	0.00%	0.00%	74.23%	57.25%	40.27%	23.29%
	24	Santa Maria	60.00%	73.33%	86.67%	100.00%	0.00%	0.00%	0.00%	0.00%	40.00%	26.67%	13.33%	0.00%
		Average	**65.53%**	**75.58%**	**85.63%**	**95.68%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**34.47%**	**24.42%**	**14.37%**	**4.32%**
4. CAVITE	1	Carmona	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	Dasmariñas	99.88%	99.92%	99.96%	100.00%	0.00%	0.00%	0.00%	0.00%	0.12%	0.08%	0.04%	0.00%
	3	Gen.Mariano Alvarez	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	Silang	91.56%	94.37%	97.19%	100.00%	8.14%	5.33%	2.51%	0.00%	0.30%	0.30%	0.30%	0.00%
	5	Tagaytay City	90.00%	93.34%	96.67%	100.00%	7.07%	3.73%	0.40%	0.00%	2.93%	2.93%	2.93%	0.00%
		Average	**96.29%**	**97.53%**	**98.76%**	**100.00%**	**3.04%**	**1.81%**	**0.58%**	**0.00%**	**0.67%**	**0.66%**	**0.65%**	**0.00%**

Annex 5.1 Projection of Service Coverage by Municipality (2/4)

Province	Municipality		Level III Coverage				Level II Coverage				Level I Coverage			
			2010	2020	2030	2040	2010	2020	2030	2040	2010	2020	2030	2040
5. LAGUNA	1	Alaminos	81.34%	87.56%	93.78%	100.00%	14.81%	8.59%	2.37%	0.00%	3.85%	3.85%	3.85%	0.00%
	2	Bay	68.19%	76.27%	84.35%	92.44%	8.70%	0.62%	0.00%	0.00%	23.11%	23.11%	15.65%	7.56%
	3	Biñan	23.08%	31.16%	39.24%	47.33%	30.77%	22.68%	14.60%	6.52%	46.16%	46.16%	46.16%	46.16%
	4	Cabuyao	34.33%	42.41%	50.50%	58.58%	0.00%	0.00%	0.00%	0.00%	65.67%	57.59%	49.50%	41.42%
	5	Calamba City	58.85%	66.94%	75.02%	83.10%	24.21%	16.12%	8.04%	0.00%	16.94%	16.94%	16.94%	16.90%
	6	Calauan	9.11%	17.19%	25.27%	33.36%	33.20%	25.12%	17.03%	8.95%	57.69%	57.69%	57.69%	57.69%
	7	Cavinti	0.00%	8.08%	16.17%	24.25%	68.57%	60.49%	52.41%	44.32%	31.43%	31.43%	31.43%	31.43%
	8	Famy	26.40%	34.48%	42.57%	50.65%	24.50%	16.42%	8.33%	0.25%	49.10%	49.10%	49.10%	49.10%
	9	Kalayaan	16.38%	24.47%	32.55%	40.63%	0.00%	0.00%	0.00%	0.00%	83.62%	75.53%	67.45%	59.37%
	10	Liliw	89.29%	92.86%	96.43%	100.00%	10.71%	7.14%	3.57%	0.00%	0.00%	0.00%	0.00%	0.00%
	11	Los Baños	86.92%	91.28%	95.64%	100.00%	0.00%	0.00%	0.00%	0.00%	13.08%	8.72%	4.36%	0.00%
	12	Luisiana	29.77%	37.86%	45.94%	54.03%	67.62%	59.54%	51.45%	43.37%	2.60%	2.60%	2.60%	2.60%
	13	Lumban	59.50%	67.58%	75.67%	83.75%	0.00%	0.00%	0.00%	0.00%	40.50%	32.42%	24.33%	16.25%
	14	Mabitac	30.98%	39.07%	47.15%	55.23%	24.71%	16.63%	8.54%	0.46%	44.31%	44.31%	44.31%	44.31%
	15	Magdalena	72.76%	80.84%	88.93%	97.01%	0.00%	0.00%	0.00%	0.00%	27.24%	19.16%	11.07%	2.99%
	16	Majayjay	88.13%	92.09%	96.04%	100.00%	11.87%	7.91%	3.96%	0.00%	0.00%	0.00%	0.00%	0.00%
	17	Nagcarlan	78.89%	85.93%	92.96%	100.00%	13.66%	6.62%	0.00%	0.00%	7.45%	7.45%	7.04%	0.00%
	18	Paete	81.34%	87.56%	93.78%	100.00%	0.00%	0.00%	0.00%	0.00%	18.66%	12.44%	6.22%	0.00%
	19	Pgsanjan	67.34%	75.42%	83.50%	91.59%	2.09%	0.00%	0.00%	0.00%	30.57%	24.58%	16.50%	8.41%
	20	Pakil	49.88%	57.96%	66.04%	74.13%	6.14%	0.00%	0.00%	0.00%	43.98%	42.04%	33.96%	25.87%
	21	Pangil	44.29%	52.37%	60.45%	68.54%	0.84%	0.00%	0.00%	0.00%	54.87%	47.63%	39.55%	31.46%
	22	Pila	0.00%	8.08%	16.17%	24.25%	2.00%	0.00%	0.00%	0.00%	98.00%	91.92%	83.83%	75.75%
	23	Rizal	94.50%	96.33%	98.17%	100.00%	0.86%	0.00%	0.00%	0.00%	4.64%	3.67%	1.83%	0.00%
	24	San Pablo City	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	25	San Pedro	71.67%	79.75%	87.84%	95.92%	7.67%	0.00%	0.00%	0.00%	20.67%	20.25%	12.16%	4.08%
	26	Santa Cruz (Capital)	37.02%	45.10%	53.19%	61.27%	0.00%	0.00%	0.00%	0.00%	62.98%	54.90%	46.81%	38.73%
	27	Santa Maria	42.00%	50.09%	58.17%	66.25%	36.50%	28.42%	20.34%	12.25%	21.49%	21.49%	21.49%	21.49%
	28	Santa Rosa City	33.74%	41.82%	49.91%	57.99%	0.00%	0.00%	0.00%	0.00%	66.26%	58.18%	50.09%	42.01%
	29	Siniloan	60.51%	68.60%	76.68%	84.76%	19.09%	11.01%	2.92%	0.00%	20.40%	20.40%	20.40%	15.24%
	30	Victoria	6.64%	14.73%	22.81%	30.90%	0.00%	0.00%	0.00%	0.00%	93.36%	85.27%	77.19%	69.10%
		Average	**51.43%**	**58.46%**	**65.50%**	**72.53%**	**13.62%**	**9.58%**	**6.45%**	**3.87%**	**34.95%**	**31.96%**	**28.05%**	**23.60%**

Annex 5.1 Projection of Service Coverage by Municipality (3/4)

Province	No.	Municipality	Level III Coverage				Level II Coverage				Level I Coverage			
			2010	2020	2030	2040	2010	2020	2030	2040	2010	2020	2030	2040
6. NUEVA ECIJA	1	Aliaga	23.00%	28.04%	33.09%	38.13%	0.00%	0.00%	0.00%	0.00%	77.00%	71.96%	66.91%	61.87%
	2	Bongabon	15.00%	20.04%	25.09%	30.13%	19.00%	13.96%	8.91%	3.87%	66.00%	66.00%	66.00%	66.00%
	3	Cabanatuan City	73.00%	78.04%	83.09%	88.13%	0.00%	0.00%	0.00%	0.00%	27.00%	21.96%	16.91%	11.87%
	4	Cabiao	18.00%	23.04%	28.09%	33.13%	4.00%	0.00%	0.00%	0.00%	78.00%	76.96%	71.91%	66.87%
	5	Carrangalan	0.00%	5.04%	10.09%	15.13%	0.00%	0.00%	0.00%	0.00%	100.00%	94.96%	89.91%	84.87%
	6	Cuyapo	14.00%	19.04%	24.09%	29.13%	0.00%	0.00%	0.00%	0.00%	86.00%	80.96%	75.91%	70.87%
	7	Gabaldon (Bitulok & Sabani)	0.00%	5.04%	10.09%	15.13%	65.00%	59.96%	54.91%	49.87%	35.00%	35.00%	35.00%	35.00%
	8	Gapan City	22.00%	27.04%	32.09%	37.13%	10.00%	4.96%	0.00%	0.00%	68.00%	68.00%	67.91%	62.87%
	9	General Mamerto Natividad	19.00%	24.04%	29.09%	34.13%	2.00%	0.00%	0.00%	0.00%	79.00%	75.96%	70.91%	65.87%
	10	General Tinio	33.00%	38.04%	43.09%	48.13%	7.00%	1.96%	0.00%	0.00%	60.00%	60.00%	56.91%	51.87%
	11	Guimba	19.00%	24.04%	29.09%	34.13%	0.00%	0.00%	0.00%	0.00%	81.00%	75.96%	70.91%	65.87%
	12	Jaen	20.00%	25.04%	30.09%	35.13%	2.00%	0.00%	0.00%	0.00%	78.00%	74.96%	69.91%	64.87%
	13	Laur	22.00%	27.04%	32.09%	37.13%	17.00%	11.96%	6.91%	1.87%	61.00%	61.00%	61.00%	61.00%
	14	Licab	31.00%	36.04%	41.09%	46.13%	0.00%	0.00%	0.00%	0.00%	69.00%	63.96%	58.91%	53.87%
	15	Llanera	4.00%	9.04%	14.09%	19.13%	4.00%	0.00%	0.00%	0.00%	92.00%	90.96%	85.91%	80.87%
	16	Lupao	0.00%	5.04%	10.09%	15.13%	0.00%	0.00%	0.00%	0.00%	100.00%	94.96%	89.91%	84.87%
	17	Science City of Muñoz	48.00%	53.04%	58.09%	63.13%	10.00%	4.96%	0.00%	0.00%	42.00%	42.00%	41.91%	36.87%
	18	Nampicuan	0.00%	5.04%	10.09%	15.13%	2.90%	0.00%	0.00%	0.00%	97.10%	94.96%	89.91%	84.87%
	19	Palayan City (Capital)	35.00%	40.04%	45.09%	50.13%	7.00%	1.96%	0.00%	0.00%	58.00%	58.00%	54.91%	49.87%
	20	Pantabangan	0.00%	5.04%	10.09%	15.13%	84.00%	78.96%	73.91%	68.87%	16.00%	16.00%	16.00%	16.00%
	21	Peñaranda	71.00%	76.04%	81.09%	86.13%	4.00%	0.00%	0.00%	0.00%	25.00%	23.96%	18.91%	13.87%
	22	Quezon	0.00%	5.04%	10.09%	15.13%	0.00%	0.00%	0.00%	0.00%	100.00%	94.96%	89.91%	84.87%
	23	Rizal	0.00%	5.04%	10.09%	15.13%	1.00%	0.00%	0.00%	0.00%	99.00%	94.96%	89.91%	84.87%
	24	San Antonio	20.00%	25.04%	30.09%	35.13%	5.00%	0.00%	0.00%	0.00%	75.00%	74.96%	69.91%	64.87%
	25	San Isidro	40.00%	45.04%	50.09%	55.13%	3.00%	0.00%	0.00%	0.00%	57.00%	54.96%	49.91%	44.87%
	26	San Jose City	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	27	San Leonardo	33.00%	38.04%	43.09%	48.13%	20.00%	14.96%	9.91%	4.87%	47.00%	47.00%	47.00%	47.00%
	28	Santa Rosa	44.00%	49.04%	54.09%	59.13%	5.00%	0.00%	0.00%	0.00%	51.00%	50.96%	45.91%	40.87%
	29	Santo Domingo	9.00%	14.04%	19.09%	24.13%	1.00%	0.00%	0.00%	0.00%	90.00%	85.96%	80.91%	75.87%
	30	Talavera	41.00%	46.04%	51.09%	56.13%	0.00%	0.00%	0.00%	0.00%	59.00%	53.96%	48.91%	43.87%
	31	Talugtug	17.00%	22.04%	27.09%	32.13%	0.00%	0.00%	0.00%	0.00%	83.00%	77.96%	72.91%	67.87%
	32	Zaragoza	10.00%	15.04%	20.09%	25.13%	11.00%	5.96%	0.91%	0.00%	79.00%	79.00%	79.00%	74.87%
		Average	24.41%	29.29%	34.18%	39.06%	8.87%	6.24%	4.86%	4.04%	66.72%	64.47%	60.96%	56.89%
7. NUEVA VIZCAYA	1	Alfonso	52.64%	59.37%	66.10%	72.83%	0.00%	0.00%	0.00%	0.00%	47.36%	40.63%	33.90%	27.17%
	2	Aritao	21.03%	27.76%	34.49%	41.22%	30.92%	24.19%	17.47%	10.74%	48.05%	48.05%	48.05%	48.05%
	3	Dupax del Sur	22.38%	29.11%	35.84%	42.57%	20.50%	13.77%	7.04%	0.31%	57.12%	57.12%	57.12%	57.12%
	4	Dupax Del Norte	5.92%	12.65%	19.38%	26.11%	49.23%	42.50%	35.78%	29.05%	44.85%	44.85%	44.85%	44.85%
	5	Santa Fe	4.24%	10.97%	17.70%	24.43%	79.40%	72.67%	65.94%	59.22%	16.36%	16.36%	16.36%	16.36%
		Average	21.25%	27.97%	34.70%	41.43%	36.01%	30.63%	25.24%	19.86%	42.75%	41.40%	40.05%	38.71%

Annex 5.1 Projection of Service Coverage by Municipality (4/4)

Province		Municipality	Level III Coverage				Level II Coverage				Level I Coverage			
			2010	2020	2030	2040	2010	2020	2030	2040	2010	2020	2030	2040
8. PAMPANGA	1	Angeles City	84.00%	87.92%	91.83%	95.75%	0.00%	0.00%	0.00%	0.00%	16.00%	12.08%	8.17%	4.25%
	2	Apalit	64.00%	67.92%	71.83%	75.75%	0.00%	0.00%	0.00%	0.00%	36.00%	32.08%	28.17%	24.25%
	3	Arayat	0.00%	3.92%	7.83%	11.75%	0.00%	0.00%	0.00%	0.00%	100.00%	96.08%	92.17%	88.25%
	4	Bacolor	26.00%	29.92%	33.83%	37.75%	9.00%	5.08%	1.17%	0.00%	65.00%	65.00%	65.00%	62.25%
	5	Candaba	18.00%	21.92%	25.83%	29.75%	1.00%	0.00%	0.00%	0.00%	81.00%	78.08%	74.17%	70.25%
	6	Floridablanca	77.00%	80.92%	84.83%	88.75%	0.00%	0.00%	0.00%	0.00%	23.00%	19.08%	15.17%	11.25%
	7	Guagua	58.00%	61.92%	65.83%	69.75%	1.00%	0.00%	0.00%	0.00%	41.00%	38.08%	34.17%	30.25%
	8	Lubao	22.00%	25.92%	29.83%	33.75%	0.00%	0.00%	0.00%	0.00%	78.00%	74.08%	70.17%	66.25%
	9	Mabalacat	80.00%	83.92%	87.83%	91.75%	0.00%	0.00%	0.00%	0.00%	20.00%	16.08%	12.17%	8.25%
	10	Macabebe	74.00%	77.92%	81.83%	85.75%	0.00%	0.00%	0.00%	0.00%	26.00%	22.08%	18.17%	14.25%
	11	Magalang	0.00%	3.92%	7.83%	11.75%	0.00%	0.00%	0.00%	0.00%	100.00%	96.08%	92.17%	88.25%
	12	Masantol	0.00%	3.92%	7.83%	11.75%	0.00%	0.00%	0.00%	0.00%	100.00%	96.08%	92.17%	88.25%
	13	Mexico	21.00%	24.92%	28.83%	32.75%	0.00%	0.00%	0.00%	0.00%	79.00%	75.08%	71.17%	67.25%
	14	Minalin	45.00%	48.92%	52.83%	56.75%	0.00%	0.00%	0.00%	0.00%	55.00%	51.08%	47.17%	43.25%
	15	Porac	17.00%	20.92%	24.83%	28.75%	11.00%	7.08%	3.17%	0.00%	72.00%	72.00%	72.00%	71.25%
	16	San Fernando City (Capital)	48.00%	51.92%	55.83%	59.75%	16.00%	12.08%	8.17%	4.25%	36.00%	36.00%	36.00%	36.00%
	17	San Luis	0.00%	3.92%	7.83%	11.75%	0.00%	0.00%	0.00%	0.00%	100.00%	96.08%	92.17%	88.25%
	18	San Simon	54.00%	57.92%	61.83%	65.75%	0.00%	0.00%	0.00%	0.00%	46.00%	42.08%	38.17%	34.25%
	19	Santa Ana	6.00%	9.92%	13.83%	17.75%	48.00%	44.08%	40.17%	36.25%	46.00%	46.00%	46.00%	46.00%
	20	Santa Rita	16.00%	19.92%	23.83%	27.75%	0.00%	0.00%	0.00%	0.00%	84.00%	80.08%	76.17%	72.25%
	21	Sto Tomas	67.00%	70.92%	74.83%	78.75%	0.00%	0.00%	0.00%	0.00%	33.00%	29.08%	25.17%	21.25%
	22	Sasmuan (Sexmoan)	0.00%	3.92%	7.83%	11.75%	0.00%	0.00%	0.00%	0.00%	100.00%	96.08%	92.17%	88.25%
		Average	35.32%	39.23%	43.15%	47.07%	3.91%	3.11%	2.39%	1.84%	60.77%	57.66%	54.46%	51.09%
9. PANGASINAN	1	Umingan	7.48%	8.70%	9.92%	11.13%	0.00%	0.00%	0.00%	0.00%	92.52%	91.30%	90.08%	88.87%
10. QUEZON	1	Dolores	86.23%	90.82%	95.41%	100.00%	0.00%	0.00%	0.00%	0.00%	13.77%	9.18%	4.59%	0.00%
	2	General Nakar	0.00%	6.22%	12.45%	18.67%	73.36%	67.13%	60.91%	54.68%	26.64%	26.64%	26.64%	26.64%
	3	Infanta	52.03%	58.26%	64.48%	70.71%	5.87%	0.00%	0.00%	0.00%	42.10%	41.74%	35.52%	29.29%
	4	Lucban	92.35%	94.90%	97.45%	100.00%	3.21%	0.66%	0.00%	0.00%	4.44%	4.44%	2.55%	0.00%
	5	Real	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	6	Sampaloc	59.62%	65.84%	72.07%	78.29%	40.38%	34.16%	27.93%	21.71%	0.00%	0.00%	0.00%	0.00%
	7	Sariaya	20.28%	26.50%	32.73%	38.95%	13.93%	7.71%	1.49%	0.00%	65.79%	65.79%	65.79%	61.05%
	8	Tayabas City	59.52%	65.74%	71.96%	78.19%	32.14%	25.91%	19.69%	13.47%	8.35%	8.35%	8.35%	8.35%
		Average	58.75%	63.54%	68.32%	73.10%	21.11%	16.95%	13.75%	11.23%	20.13%	19.52%	17.93%	15.67%
11. TARLAC	1	Anao	0.00%	5.04%	10.09%	15.13%	0.00%	0.00%	0.00%	0.00%	100.00%	94.96%	89.91%	84.87%
	2	Bamban	19.00%	24.04%	29.09%	34.13%	0.00%	0.00%	0.00%	0.00%	81.00%	75.96%	70.91%	65.87%
	3	Capas	38.00%	43.04%	48.09%	53.13%	0.00%	0.00%	0.00%	0.00%	62.00%	56.96%	51.91%	46.87%
	4	Concepcion	31.00%	36.04%	41.09%	46.13%	0.00%	0.00%	0.00%	0.00%	69.00%	63.96%	58.91%	53.87%
	5	Gerona	12.72%	17.77%	22.81%	27.85%	0.00%	0.00%	0.00%	0.00%	87.28%	82.23%	77.19%	72.15%
	6	La Paz	14.00%	19.04%	24.09%	29.13%	0.00%	0.00%	0.00%	0.00%	86.00%	80.96%	75.91%	70.87%
	7	Pura	0.00%	5.04%	10.09%	15.13%	0.00%	0.00%	0.00%	0.00%	100.00%	94.96%	89.91%	84.87%
	8	Ramos	22.37%	27.41%	32.46%	37.50%	0.00%	0.00%	0.00%	0.00%	77.63%	72.59%	67.54%	62.50%
	9	Tarlac City (Capital)	39.00%	44.04%	49.09%	54.13%	0.00%	0.00%	0.00%	0.00%	61.00%	55.96%	50.91%	45.87%
	10	Victoria	14.00%	19.04%	24.09%	29.13%	0.00%	0.00%	0.00%	0.00%	86.00%	80.96%	75.91%	70.87%
		Average	19.01%	24.05%	29.10%	34.14%	0.00%	0.00%	0.00%	0.00%	80.99%	75.95%	70.90%	65.86%

Annex 5.2
Projected Per Capita Consumption by Municipality (1/3)

Study Area		Projected lpcd								
		2010	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
1. AURORA	1 Dingalan	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	2 Maria Aurora	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	3 San Luis	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	Average	**120.0**	**120.6**	**121.2**	**123.0**	**126.1**	**129.3**	**132.6**	**135.9**	**139.4**
2. BATANGAS	1 Lipa City	155.8	156.6	157.4	159.7	163.8	167.9	172.1	176.5	180.9
	2 Malvar	125.4	126.0	126.6	128.6	131.8	135.1	138.5	142.0	145.6
	3 Santo Tomas	125.4	126.0	126.6	128.6	131.8	135.1	138.5	142.0	145.6
	4 Tanauan City	124.9	125.5	126.1	128.0	131.3	134.6	138.0	141.4	145.0
	Average	**132.9**	**133.5**	**134.2**	**136.2**	**139.7**	**143.2**	**146.8**	**150.5**	**154.3**
3. BULACAN	1 Angat	114.0	114.6	115.1	116.9	119.8	122.9	126.0	129.1	132.4
	2 Balagtas (Bigaa)	145.6	146.3	147.1	149.3	153.0	156.9	160.9	164.9	169.1
	3 Baliuag	135.7	136.4	137.1	139.2	142.7	146.3	150.0	153.8	157.6
	4 Bocaue	122.7	123.3	124.0	125.8	129.0	132.3	135.6	139.0	142.5
	5 Bulacan	113.9	114.5	115.1	116.8	119.8	122.8	125.9	129.1	132.3
	6 Bustos	148.2	148.9	149.7	151.9	155.8	159.7	163.7	167.9	172.1
	7 Calumpit	132.3	133.0	133.7	135.7	139.1	142.6	146.2	149.9	153.7
	8 Dona Remedios Trinidad	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	9 Guiguinto	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	10 Hagonoy	128.5	129.2	129.8	131.8	135.1	138.5	142.0	145.6	149.3
	11 Malolos City	120.1	120.7	121.3	123.2	126.3	129.5	132.7	136.1	139.5
	12 Marilao	155.8	156.6	157.4	159.7	163.8	167.9	172.1	176.5	180.9
	13 Meycauayan City	107.6	108.1	108.7	110.3	113.1	116.0	118.9	121.9	125.0
	14 Norzagaray	89.3	89.7	90.2	91.5	93.8	96.2	98.6	101.1	103.7
	15 Obando	92.7	93.1	93.6	95.0	97.4	99.9	102.4	105.0	107.6
	16 Pandi	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	17 Paombong	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	18 Plaridel	164.6	165.4	166.3	168.8	173.0	177.4	181.9	186.5	191.2
	19 Pulilan	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	20 San Ildefonso	125.9	126.5	127.1	129.0	132.3	135.6	139.1	142.6	146.2
	21 San Jose del Monte City	121.8	122.4	123.0	124.9	128.0	131.3	134.6	138.0	141.5
	22 San Miguel	144.2	144.9	145.6	147.8	151.6	155.4	159.3	163.3	167.5
	23 San Rafael	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	24 Santa Maria	130.7	131.4	132.0	134.0	137.4	140.9	144.4	148.1	151.8
	Average	**127.4**	**128.1**	**128.7**	**130.6**	**133.9**	**137.3**	**140.8**	**144.4**	**148.0**
4. CAVITE	1 Carmona	127.4	128.0	128.7	130.6	133.9	137.3	140.7	144.3	147.9
	2 Dasmariñas	116.1	116.6	117.2	119.0	122.0	125.1	128.2	131.5	134.8
	3 Gen.Mariano Alvarez	125.7	126.4	127.0	128.9	132.2	135.5	138.9	142.4	146.0
	4 Silang	127.9	128.5	129.1	131.1	134.4	137.8	141.3	144.8	148.5
	5 Tagaytay City	202.1	202.1	202.1	202.1	202.1	202.1	202.1	202.1	202.1
	Average	139.8	140.3	140.8	142.3	144.9	147.6	150.3	153.0	155.9

Annex 5.2
Projected Per Capita Consumption by Municipality (2/3)

Study Area			Projected lpcd								
			2010	2011	2012	2015	2020	2025	2030	2035	2040
5. LAGUNA	1	Alaminos	117.5	118.1	118.7	120.5	123.5	126.7	129.9	133.1	136.5
	2	Bay	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	3	Biñan	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	4	Cabuyao	139.3	140.0	140.7	142.9	146.5	150.2	153.9	157.8	161.8
	5	Calamba City	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	6	Calauan	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	7	Cavinti	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	8	Famy	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	9	Kalayaan	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	10	Liliw	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	11	Los Baños	139.1	139.8	140.5	142.6	146.2	149.9	153.7	157.5	161.5
	12	Luisiana	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	13	Lumban	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	14	Mabitac	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	15	Magdalena	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	16	Majayjay	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	17	Nagcarlan	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	18	Paete	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	19	Pgsanjan	114.7	115.3	115.9	117.6	120.6	123.6	126.8	130.0	133.3
	20	Pakil	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	21	Pangil	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	22	Pila	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	23	Rizal	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	24	San Pablo City	183.3	183.3	183.3	183.3	183.3	183.3	183.3	183.3	183.3
	25	San Pedro	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	26	Santa Cruz (Capital)	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	27	Santa Maria	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	28	Santa Rosa City	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
	29	Siniloan	104.7	105.3	105.8	107.4	110.1	112.9	115.7	118.6	121.6
	30	Victoria	133.1	133.8	134.5	136.5	139.9	143.5	147.1	150.8	154.6
		Average	**133.1**	**133.8**	**134.4**	**136.3**	**139.6**	**143.0**	**146.4**	**150.0**	**153.6**
6. NUEVA ECIJA	1	Aliaga	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	2	Bongabon	94.4	94.9	95.3	96.8	99.2	101.7	104.3	106.9	109.6
	3	Cabanatuan City	190.6	190.6	190.6	190.6	190.6	190.6	190.6	190.6	190.6
	4	Cabiao	123.1	123.7	124.4	126.2	129.4	132.7	136.0	139.5	143.0
	5	Carrangalan	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	6	Cuyapo	100.2	100.7	101.2	102.7	105.3	108.0	110.7	113.5	116.4
	7	Gabaldon (Bitulok & Sabani)	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	8	Gapan City	115.9	116.5	117.1	118.9	121.9	124.9	128.1	131.3	134.6
	9	General Mamerto Natividad	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	10	General Tinio	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	11	Guimba	116.1	116.7	117.3	119.1	122.1	125.2	128.3	131.6	134.9
	12	Jaen	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	13	Laur	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	14	Licab	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	15	Llanera	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	16	Lupao	151.9	152.6	153.4	155.7	159.6	163.7	167.8	172.0	176.4
	17	Science City of Muñoz	137.5	138.2	138.9	141.0	144.6	148.2	152.0	155.8	159.7
	18	Nampicuan	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	19	Palayan City (Capital)	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	20	Pantabangan	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	21	Peñaranda	109.1	109.7	110.2	111.9	114.7	117.6	120.6	123.6	126.7
	22	Quezon	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	23	Rizal	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	24	San Antonio	105.6	106.1	106.7	108.3	111.0	113.8	116.7	119.6	122.6
	25	San Isidro	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	26	San Jose City	117.0	117.6	118.2	120.0	123.0	126.1	129.3	132.5	135.9
	27	San Leonardo	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	28	Santa Rosa	135.8	136.5	137.2	139.2	142.7	146.3	150.0	153.8	157.7
	29	Santo Domingo	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
	30	Talavera	154.3	155.0	155.8	158.2	162.2	166.3	170.4	174.8	179.2
	31	Talugtug	85.2	85.6	86.1	87.4	89.6	91.8	94.1	96.5	99.0
	32	Zaragoza	118.9	119.5	120.1	121.9	125.0	128.2	131.4	134.7	138.1
		Average	**121.2**	**121.8**	**122.3**	**124.1**	**127.1**	**130.1**	**133.3**	**136.5**	**139.8**

Annex 5.2
Projected Per Capita Consumption by Municipality (3/3)

Study Area		Projected lpcd								
		2010	2011	2012	2015	2020	2025	2030	2035	2040
7. NUEVA VIZCAYA	1 Alfonso	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	2 Aritao	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	3 Dupax del Sur	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	4 Dupax Del Norte	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	5 Santa Fe	120.0	120.6	121.2	123.0	126.1	129.3	132.6	135.9	139.4
	Average	**120.0**	**120.6**	**121.2**	**123.0**	**126.1**	**129.3**	**132.6**	**135.9**	**139.4**
8. PAMPANGA	1 Angeles City	143.4	144.1	144.8	147.0	150.7	154.5	158.4	162.4	166.5
	2 Apalit	127.4	128.1	128.7	130.6	133.9	137.3	140.8	144.4	148.0
	3 Arayat	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	4 Bacolor	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	5 Candaba	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	6 Floridablanca	136.3	136.9	137.6	139.7	143.2	146.9	150.6	154.4	158.3
	7 Guagua	137.1	137.8	138.5	140.6	144.1	147.8	151.5	155.3	159.3
	8 Lubao	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	9 Mabalacat	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	10 Macabebe	131.3	131.9	132.6	134.6	138.0	141.5	145.0	148.7	152.5
	11 Magalang	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	12 Masantol	136.7	137.4	138.1	140.2	143.7	147.4	151.1	154.9	158.8
	13 Mexico	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	14 Minalin	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	15 Porac	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	16 San Fernando City (Capital)	148.8	149.5	150.3	152.6	156.4	160.4	164.4	168.6	172.8
	17 San Luis	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	18 San Simon	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	19 Santa Ana	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	20 Santa Rita	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	21 Sto Tomas	137.9	138.5	139.2	141.3	144.9	148.6	152.3	156.2	160.1
	22 Sasmuan (Sexmoan)	131.4	132.1	132.7	134.7	138.1	141.6	145.2	148.8	152.6
	Average	**137.4**	**138.1**	**138.8**	**140.9**	**144.4**	**148.1**	**151.8**	**155.6**	**159.6**
9. PANGASINAN	1 Umingan	112.7	113.2	113.8	115.5	118.4	121.4	124.5	127.6	130.9
10. QUEZON	1 Dolores	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	2 General Nakar	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	3 Infanta	102.5	103.0	103.5	105.1	107.7	110.4	113.2	116.1	119.0
	4 Lucban	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	5 Real	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	6 Sampaloc	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	7 Sariaya	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	8 Tayabas City	96.9	97.4	97.9	99.3	101.8	104.4	107.1	109.8	112.5
	Average	**97.6**	**98.1**	**98.6**	**100.1**	**102.6**	**105.2**	**107.8**	**110.5**	**113.3**
11. TARLAC	1 Anao	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	2 Bamban	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	3 Capas	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	4 Concepcion	136.3	137.0	137.7	139.8	143.3	146.9	150.6	154.4	158.3
	5 Gerona	117.2	117.8	118.4	120.2	123.2	126.3	129.5	132.8	136.1
	6 La Paz	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	7 Pura	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	8 Ramos	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	9 Tarlac City (Capital)	144.5	145.3	146.0	148.2	151.9	155.8	159.7	163.7	167.9
	10 Victoria	102.0	102.5	103.0	104.5	107.2	109.9	112.7	115.5	118.4
	Average	**111.2**	**111.7**	**112.3**	**114.0**	**116.9**	**119.8**	**122.8**	**125.9**	**129.1**

Annex 5.3 Domestic Demand Projection of Each Municipality (1/4)

Study Area			DOMESTIC WATER DEMAND (MLD)								
			2010	2011	2012	2015	2020	2025	2030	2035	2040
1. AURORA	1	Dingalan	4.25	4.35	4.45	4.77	5.33	5.89	6.43	6.98	7.51
	2	Maria Aurora	6.80	6.96	7.13	7.65	8.54	9.45	10.32	11.20	12.05
	3	San Luis	2.82	2.91	3.00	3.30	3.83	4.39	4.96	5.57	6.18
		Total	**13.87**	**14.22**	**14.58**	**15.72**	**17.69**	**19.74**	**21.71**	**23.74**	**25.75**
2. BATANGAS	1	Lipa City	41.00	42.23	43.50	47.54	55.35	64.00	72.92	82.02	91.06
	2	Malvar	8.59	8.75	8.91	9.41	10.23	11.02	11.75	12.42	13.01
	3	Santo Tomas	22.96	23.40	23.84	25.22	27.47	29.65	31.70	33.59	35.25
	4	Tanauan City	18.54	19.06	19.59	21.28	24.64	28.39	32.25	36.18	40.08
		Total	**91.10**	**93.44**	**95.84**	**103.45**	**117.69**	**133.06**	**148.63**	**164.21**	**179.40**
3. BULACAN	1	Angat	6.08	6.36	6.66	7.62	9.34	11.24	13.28	15.43	17.65
	2	Balagtas (Bigaa)	12.65	13.05	13.46	14.76	17.00	19.35	21.77	24.20	26.60
	3	Baliuag	19.27	20.14	21.04	23.95	29.19	34.93	41.07	47.53	54.18
	4	Bocaue	16.94	17.51	18.10	19.99	23.30	26.80	30.44	34.14	37.85
	5	Bulacan	10.46	10.83	11.21	12.42	14.54	16.80	19.16	21.58	24.00
	6	Bustos	10.46	10.87	11.29	12.65	15.07	17.68	20.44	23.30	26.21
	7	Calumpit	21.26	21.79	22.33	24.05	26.90	29.77	32.58	35.27	37.80
	8	Dona Remedios Trinidad	3.86	3.96	4.07	4.39	4.94	5.50	6.05	6.58	7.09
	9	Guiguinto	8.96	9.46	9.97	11.64	14.69	18.09	21.78	25.71	29.82
	10	Hagonoy	24.48	25.16	25.85	28.04	31.75	35.56	39.37	43.12	46.73
	11	Malolos City	25.17	26.44	27.75	32.00	39.70	48.22	57.42	67.16	77.28
	12	Marilao	25.69	26.87	28.08	32.00	39.06	46.81	55.11	63.84	72.85
	13	Meycauayan City	27.42	28.36	29.32	32.41	37.81	43.54	49.49	55.56	61.64
	14	Norzagaray	11.96	12.38	12.81	14.20	16.62	19.21	21.90	24.66	27.44
	15	Obando	8.49	8.70	8.92	9.61	10.77	11.93	13.07	14.16	15.19
	16	Pandi	12.83	13.14	13.47	14.48	16.16	17.85	19.49	21.06	22.52
	17	Paombong	9.89	10.16	10.44	11.32	12.82	14.36	15.90	17.41	18.86
	18	Plaridel	19.93	20.65	21.39	23.76	27.92	32.38	37.03	41.81	46.64
	19	Pulilan	3.36	3.70	4.07	5.26	7.50	10.07	12.94	16.08	19.42
	20	San Ildefonso	8.21	8.70	9.21	10.85	13.86	17.23	20.92	24.85	28.98
	21	San Jose del Monte City	87.68	89.86	92.10	99.17	110.94	122.76	134.34	145.44	155.85
	22	San Miguel	18.10	19.04	20.02	23.17	28.91	35.27	42.16	49.46	57.07
	23	San Rafael	6.78	7.22	7.67	9.12	11.81	14.83	18.14	21.68	25.42
	24	Santa Maria	29.76	31.00	32.29	36.41	43.76	51.76	60.26	69.12	78.20
		Total	**429.69**	**445.34**	**461.51**	**513.27**	**604.37**	**701.93**	**804.10**	**909.15**	**1015.26**
4. CAVITE	1	Carmona	14.79	15.18	15.58	16.86	19.02	21.24	23.42	25.52	27.50
	2	Dasmariñas	109.90	112.82	115.83	125.35	141.40	157.91	174.16	189.85	204.61
	3	Gen.Mariano Alvarez	29.26	30.04	30.84	33.37	37.64	42.03	46.34	50.51	54.43
	4	Silang	41.54	42.70	43.90	47.71	54.20	60.97	67.77	74.46	80.96
	5	Tagaytay City	19.60	20.08	20.56	22.09	24.60	27.13	29.53	31.86	33.98
		Total	**215.09**	**220.82**	**226.71**	**245.38**	**276.85**	**309.27**	**341.21**	**372.20**	**401.48**

Annex 5.3 Domestic Demand Projection of Each Municipality (2/4)

Study Area			DOMESTIC WATER DEMAND (MLD)								
			2010	2011	2012	2015	2020	2025	2030	2035	2040
5. LAGUNA	1	Alaminos	6.96	7.10	7.24	7.68	8.39	9.08	9.73	10.36	10.99
	2	Bay	8.36	8.54	8.74	9.34	10.34	11.46	12.57	13.64	14.64
	3	Biñan	25.04	25.68	26.33	28.40	31.90	35.47	39.02	42.48	45.82
	4	Cabuyao	20.40	21.07	21.76	23.93	27.65	31.46	35.28	39.02	42.64
	5	Calamba City	56.77	58.02	59.31	63.36	70.07	76.74	83.19	89.31	95.03
	6	Calauan	3.85	3.96	4.07	4.42	5.03	5.67	6.30	6.94	7.56
	7	Cavinti	1.59	1.62	1.67	1.79	2.01	2.24	2.47	2.69	2.90
	8	Famy	1.32	1.36	1.39	1.50	1.69	1.87	2.06	2.25	2.42
	9	Kalayaan	1.32	1.38	1.43	1.61	1.92	2.24	2.57	2.90	3.22
	10	Liliw	6.72	6.84	6.97	7.36	8.00	8.60	9.16	9.65	10.09
	11	Los Baños	19.94	20.36	20.79	22.12	24.28	26.38	28.35	30.15	31.76
	12	Luisiana	2.55	2.60	2.66	2.83	3.13	3.42	3.71	3.98	4.23
	13	Lumban	4.06	4.17	4.28	4.64	5.24	5.85	6.44	7.01	7.55
	14	Mabitac	1.87	1.91	1.96	2.11	2.36	2.62	2.87	3.12	3.36
	15	Magdalena	3.38	3.47	3.56	3.84	4.31	4.77	5.23	5.66	6.07
	16	Majayjay	4.83	4.92	5.01	5.30	5.76	6.20	6.61	6.98	7.30
	17	Nagcarlan	10.72	10.94	11.17	11.89	13.07	14.22	15.33	16.51	17.59
	18	Paete	4.53	4.63	4.74	5.07	5.62	6.17	6.68	7.17	7.61
	19	Pgsanjan	4.97	5.08	5.19	5.59	6.28	6.97	7.64	8.28	8.88
	20	Pakil	2.61	2.67	2.74	2.94	3.31	3.71	4.11	4.49	4.86
	21	Pangil	2.69	2.76	2.84	3.10	3.54	3.99	4.43	4.87	5.28
	22	Pila	1.47	1.54	1.61	1.90	2.43	3.00	3.59	4.20	4.81
	23	Rizal	3.22	3.28	3.34	3.52	3.82	4.10	4.35	4.57	4.77
	24	San Pablo City	71.26	72.09	72.92	75.49	79.20	82.26	84.54	86.02	86.73
	25	San Pedro	48.03	49.10	50.19	53.62	59.39	65.88	72.19	78.21	83.85
	26	Santa Cruz (Capital)	10.28	10.61	10.94	12.00	13.80	15.65	17.49	19.29	21.02
	27	Santa Maria	3.53	3.61	3.69	3.95	4.38	4.81	5.23	5.63	6.00
	28	Santa Rosa City	25.29	26.12	26.97	29.65	34.24	38.96	43.67	48.29	52.75
	29	Siniloan	4.50	4.60	4.69	4.99	5.48	5.97	6.43	6.90	7.41
	30	Victoria	1.50	1.58	1.65	1.91	2.35	2.81	3.30	3.79	4.27
		Total	**363.57**	**371.61**	**379.85**	**405.87**	**448.99**	**492.57**	**534.57**	**574.34**	**611.45**

Annex 5.3 Domestic Demand Projection of Each Municipality (3/4)

Study Area			DOMESTIC WATER DEMAND (MLD)								
			2010	2011	2012	2015	2020	2025	2030	2035	2040
6. NUEVA ECIJA	1	Aliaga	4.21	4.33	4.44	4.81	5.42	6.03	6.63	7.20	7.75
	2	Bongabon	3.97	4.04	4.11	4.34	4.72	5.09	5.44	5.77	6.07
	3	Cabanatuan City	60.76	61.74	62.73	65.79	70.54	74.83	78.52	81.60	84.02
	4	Cabiao	4.41	4.51	4.62	4.94	5.54	6.20	6.86	7.50	8.11
	5	Carrangalan	1.05	1.10	1.14	1.28	1.52	1.77	2.02	2.28	2.52
	6	Cuyapo	2.77	2.85	2.93	3.18	3.61	4.04	4.46	4.86	5.25
	7	Gabaldon (Bitulok & Sabani)	2.20	2.24	2.28	2.40	2.60	2.79	2.97	3.15	3.30
	8	Gapan City	7.18	7.33	7.48	7.96	8.75	9.53	10.29	11.19	12.03
	9	General Mamerto Natividad	2.12	2.17	2.22	2.38	2.70	3.02	3.33	3.64	3.93
	10	General Tinio	-	-	-	-	-	-	-	-	-
	11	Guimba	5.91	6.07	6.24	6.77	7.67	8.56	9.45	10.30	11.11
	12	Jaen	4.14	4.23	4.33	4.65	5.26	5.87	6.48	7.06	7.61
	13	Laur	2.43	2.48	2.53	2.68	2.94	3.20	3.44	3.68	3.89
	14	Licab	1.93	1.98	2.03	2.19	2.45	2.70	2.95	3.19	3.41
	15	Llanera	1.36	1.40	1.44	1.56	1.78	2.05	2.32	2.58	2.84
	16	Lupao	1.17	1.22	1.28	1.47	1.80	2.14	2.50	2.85	3.20
	17	Science City of Muñoz	9.33	9.51	9.70	10.28	11.23	12.16	13.03	13.98	14.85
	18	Nampicuan	0.40	0.41	0.42	0.46	0.54	0.63	0.72	0.81	0.90
	19	Palayan City (Capital)	3.04	3.10	3.16	3.36	3.67	4.00	4.36	4.69	5.01
	20	Pantabangan	2.22	2.25	2.29	2.40	2.58	2.75	2.91	3.06	3.19
	21	Peñaranda	3.68	3.74	3.81	4.02	4.37	4.74	5.09	5.41	5.70
	22	Quezon	1.08	1.12	1.17	1.31	1.56	1.81	2.07	2.33	2.58
	23	Rizal	1.69	1.75	1.80	2.02	2.40	2.80	3.20	3.60	3.99
	24	San Antonio	4.24	4.33	4.42	4.70	5.17	5.75	6.32	6.87	7.39
	25	San Isidro	4.39	4.47	4.56	4.84	5.36	5.89	6.40	6.88	7.32
	26	San Jose City	23.23	23.58	23.93	25.02	26.71	28.25	29.57	30.68	31.57
	27	San Leonardo	5.35	5.45	5.56	5.88	6.41	6.93	7.42	7.87	8.29
	28	Santa Rosa	6.93	7.07	7.21	7.66	8.39	9.21	10.00	10.74	11.43
	29	Santo Domingo	2.25	2.30	2.36	2.60	3.00	3.40	3.81	4.21	4.59
	30	Talavera	12.75	13.06	13.38	14.36	16.00	17.62	19.18	20.66	22.05
	31	Talugtug	1.03	1.06	1.08	1.17	1.31	1.45	1.59	1.72	1.85
	32	Zaragoza	2.22	2.27	2.32	2.49	2.76	3.04	3.31	3.63	3.95
		Total	**189.45**	**193.17**	**196.97**	**208.96**	**228.76**	**248.27**	**266.62**	**283.98**	**299.71**
7. NUEVA VIZCAYA	1	Alfonso	0.80	0.82	0.85	0.92	1.05	1.17	1.30	1.42	1.54
	2	Aritao	3.02	3.09	3.17	3.42	3.84	4.26	4.69	5.10	5.50
	3	Dupax del Sur	1.45	1.49	1.53	1.65	1.86	2.07	2.29	2.50	2.70
	4	Dupax Del Norte	1.79	1.84	1.89	2.03	2.28	2.53	2.79	3.04	3.28
	5	Santa Fe	1.25	1.27	1.30	1.39	1.54	1.69	1.84	1.98	2.12
		Total	**8.30**	**8.51**	**8.73**	**9.42**	**10.56**	**11.74**	**12.90**	**14.04**	**15.14**

Annex 5.3 Domestic Demand Projection of Each Municipality (4/4)

Study Area			DOMESTIC WATER DEMAND (MLD)								
			2010	2011	2012	2015	2020	2025	2030	2035	2040
8. PAMPANGA	1	Angeles City	64.07	65.35	66.66	70.76	77.41	83.90	90.04	95.61	100.48
	2	Apalit	14.08	14.37	14.67	15.61	17.15	18.65	20.09	21.41	22.57
	3	Arayat	3.77	3.92	4.08	4.57	5.42	6.32	7.24	8.15	9.03
	4	Bacolor	2.22	2.27	2.32	2.47	2.72	2.97	3.22	3.46	3.71
	5	Candaba	6.50	6.66	6.81	7.37	8.33	9.32	10.29	11.22	12.09
	6	Floridablanca	18.48	18.85	19.24	20.43	22.38	24.28	26.09	27.73	29.17
	7	Guagua	15.06	15.35	15.65	16.66	18.34	20.00	21.58	23.04	24.33
	8	Lubao	10.64	10.92	11.21	12.11	13.63	15.17	16.68	18.12	19.46
	9	Mabalacat	37.92	38.69	39.47	41.91	45.87	49.75	53.42	56.76	59.68
	10	Macabebe	11.74	11.98	12.23	12.99	14.24	15.45	16.61	17.66	18.59
	11	Magalang	3.14	3.27	3.40	3.81	4.52	5.27	6.03	6.79	7.52
	12	Masantol	1.62	1.69	1.76	1.97	2.33	2.72	3.11	3.50	3.87
	13	Mexico	10.24	10.51	10.79	11.67	13.15	14.64	16.12	17.53	18.84
	14	Minalin	4.76	4.87	4.98	5.32	5.89	6.45	7.00	7.50	7.96
	15	Porac	7.41	7.58	7.75	8.28	9.17	10.07	10.95	11.78	12.61
	16	San Fernando City (Capital)	38.74	39.50	40.27	42.69	46.64	50.51	54.19	57.57	60.55
	17	San Luis	1.51	1.57	1.64	1.83	2.18	2.54	2.91	3.27	3.63
	18	San Simon	6.55	6.69	6.83	7.29	8.03	8.77	9.48	10.13	10.71
	19	Santa Ana	3.74	3.82	3.89	4.13	4.52	4.90	5.28	5.63	5.94
	20	Santa Rita	2.31	2.37	2.44	2.65	3.00	3.37	3.73	4.07	4.40
	21	Sto Tomas	6.11	6.24	6.37	6.77	7.44	8.09	8.71	9.28	9.78
	22	Sasmuan (Sexmoan)	0.85	0.88	0.92	1.02	1.21	1.40	1.60	1.80	1.99
		Total	**271.46**	**277.35**	**283.36**	**302.33**	**333.57**	**364.54**	**394.34**	**422.02**	**446.89**
9. PANGASINAN	1	Umingan	2.73	2.80	2.87	3.08	3.43	3.79	4.15	4.51	4.87
10. QUEZON	1	Dolores	3.69	3.77	3.85	4.09	4.49	4.89	5.28	5.64	5.99
	2	General Nakar	1.99	2.03	2.06	2.17	2.35	2.52	2.69	2.85	3.01
	3	Infanta	6.39	6.52	6.65	7.06	7.79	8.63	9.46	10.28	11.08
	4	Lucban	6.85	6.97	7.09	7.46	8.08	8.70	9.30	9.86	10.38
	5	Real	5.21	5.30	5.39	5.66	6.09	6.51	6.89	7.22	7.53
	6	Sampaloc	1.81	1.84	1.87	1.97	2.14	2.31	2.47	2.62	2.77
	7	Sariaya	8.52	8.70	8.89	9.47	10.47	11.48	12.49	13.64	14.93
	8	Tayabas City	11.16	11.36	11.56	12.21	13.29	14.36	15.38	16.35	17.28
		Total	**45.62**	**46.48**	**47.35**	**50.09**	**54.71**	**59.42**	**63.97**	**68.48**	**72.97**
11. TARLAC	1	Anao	0.34	0.36	0.37	0.41	0.48	0.55	0.63	0.70	0.77
	2	Bamban	3.53	3.62	3.72	4.03	4.55	5.08	5.60	6.10	6.57
	3	Capas	10.10	10.34	10.58	11.35	12.61	13.87	15.09	16.23	17.29
	4	Concepcion	12.26	12.58	12.91	13.93	15.65	17.38	19.07	20.69	22.21
	5	Gerona	4.26	4.39	4.53	4.96	5.68	6.42	7.16	7.88	8.56
	6	La Paz	3.10	3.19	3.28	3.57	4.06	4.55	5.04	5.51	5.97
	7	Pura	0.70	0.73	0.76	0.84	0.99	1.14	1.29	1.44	1.58
	8	Ramos	1.21	1.25	1.28	1.38	1.55	1.73	1.90	2.06	2.22
	9	Tarlac City (Capital)	34.90	35.76	36.64	39.41	44.00	48.61	53.09	57.34	61.30
	10	Victoria	2.88	2.97	3.05	3.32	3.77	4.24	4.69	5.13	5.55
		Total	**73.29**	**75.19**	**77.12**	**83.20**	**93.35**	**103.57**	**113.56**	**123.09**	**132.02**
		Total	**1,704.17**	**1,748.92**	**1,794.89**	**1,940.77**	**2,189.98**	**2,447.88**	**2,705.76**	**2,959.76**	**3,204.93**

Chapter 6

Annex 6.5.1 Present and Future Irrigation Area of National Irrigation System

A. Angat River Basin

NIS	Sub-system	Intake Point	Irrigation Area (ha)		Remarks
			Present	Future	
Angat-Maasim RIS (AMRIS)	Angat, Maasim	Bustos weir	26,000	26,791	Right bank = 16,663 ha
	Total		26,000	26,791	Left bank = 10,128 ha

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA,

B. Pampanga River Basin

NIS	Sub-system	Intake Point	Irrigation Area (ha)		Remarks
			Present	Future	
Upper Pampanga River Integrated Irrigation System (UPRIIS)	District-Ia	Talavera weir	4,120	4,120	Irrigation area for District-V will be increased by UPRIIS Phase Expansion Plan.
	District-Ib	Rizal weir	16,400	16,400	
	District-II	Rizal weir	22,591	22,591	
	District-III	Bongabon weir	25,881	25,881	
	District-VI	Penaranda weir	19,924	19,924	
	District-V	Rizal weir	16,879	37,200	
	Total		105,795	126,116	
Pampanga Delta RIS (PDRIS)		Cong Dadong weir	6,604	11,920	Existing weir & main canal have full capacity.
	Total		6,604	11,920	
Aulo SRIP		Aulo weir	810	810	
	Total		810	810	
Nueva Ecija Pump RIS		Groundwater	1,313	1,313	
	Total		1,313	1,313	
Porlac-Gumain MP		Gumain weir	3,087	16,750	Irrigation area will be increased by new Gumain
	Total		3,087	16,750	
Balintingon MP		Penaranda dam	0	14,900	New dam irrigation plan
	Total		0	14,900	
Total			117,609	171,809	

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA,

C. Agos River Basin

NIS	Sub-system	Intake Point	Irrigation Area (ha)		Remarks
			Present	Future	
Agos	Agos	Intake	1,234	1,234	
	Dumacaa	Diversion dam (weir)	1,893	1,893	
	Hanagdong	Diversion dam (weir)	274	274	
	Lagnas	Diversion dam (weir)	639	639	
Total			4,040	4,040	

Source : NIA

D. Laguna Lake Basin

NIS	Sub-system	Intake Point	Irrigation Area (ha)		Remarks
			Present	Future	
Laguna	Cabuyao East	Diversion dam (weir)	348	348	
	San Cristobal	Diversion dam (weir)	413	413	
	Diezmo	Diversion dam (weir)	852	852	
	Macabling	Diversion dam (weir)	418	418	
	San Juan	Diversion dam (weir)	341	341	
	Sta. Maria	Diversion dam (weir)	974	974	
	Mayor	Diversion dam (weir)	375	375	
	Sta. Cruz	Diversion dam (weir)	2,185	2,185	
	Mabacan	Diversion dam (weir)	272	272	
	Balanac	Diversion dam (weir)	1,000	1,000	
	Lumban	Intake	57	57	
	Malaunod	Diversion dam (weir)	227	227	
Total			7,462	7,462	

Source : NIA

Annex 6.5.2 Present Communal Irrigation System and Small Scale Irrigation by River Basin

A. Angat River Basin

River	Sub-basin Code	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Angat	ANG01	3	77	0	0	77	
	ANG02	4	142	2	62	204	
	ANG03	0	0	0	0	0	
Total		7	219	2	62	281	

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin

River	Sub-basin Code	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Coronell	COR	18	3,408	0	0	3,408	
Pasac	PAS	36	4,697	13	386	5,083	
Penaranda	PEN	2	240	0	0	240	
Rio Chico	RCH	45	12,384	11	524	12,908	
Pampanga	PAM01	6	888	1	40	928	
	PAM02	38	8,840	13	529	9,369	
	PAM03	0	0	0	0	0	
	PAM04	7	457	0	0	457	
	PAM05	11	1,485	1	120	1,605	
	PAN	5	740	2	165	905	US of Rizal weir
Sub-total		67	12,410	17	854	13,264	
Total		168	33,139	41	1,764	34,903	

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

C. Umiray River Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Umiray	Quezon	0	0	0	0	0	
Total		0	0	0	0	0	

Source : NIA & BSWM

D. Agos River Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Agos	Quezon	1	224	0	0	224	
Total		1	224	0	0	224	

Source : NIA & BSWM

E. Pasig-Marikina River Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Pasig-Mari	Rizal	3	206	4	84	290	
Total		3	206	4	84	290	

Source : NIA & BSWM

F. Laguna Lake Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Laguna	Rizal	17	1,563	9	255	1,818	
	Laguna	22	2,171	14	524	2,695	
Total		39	3,734	23	779	4,513	

Source : NIA & BSWM

Annex 6.5.3 Future Communal Irrigation System and Small Scale Irrigation by River Basin

A. Angat River Basin

River	Sub-basin Code	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Angat	ANG01	4	202	0	0	202	
	ANG02	9	313	2	62	375	
	ANG03	0	0	2	55	55	
Total		13	515	4	117	632	

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin

River	Sub-basin Code	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Coronell	COR	20	4,308	5	220	4,528	
Pasac	PAS	45	5,397	16	561	5,958	
Penaranda	PEN	0	0	3	75	75	
Rio Chico	RCH	64	17,012	38	2,455	19,467	
Pampanga	PAM01	18	3,087	1	40	3,127	
	PAM02	39	9,640	26	931	10,571	
	PAM03	0	0	0	0	0	
	PAM04	5	379	2	50	429	
	PAM05	12	1,650	3	150	1,800	
	PAN	6	740	1	220	960	US of Rizal weir
Sub-total		80	15,496	33	1,391	16,887	
Total		209	42,213	95	4,702	46,915	

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

C. Umiray River Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Umiray	Quezon	0	0	0	0	0	
Total		0	0	0	0	0	

Source : NIA & BSWM

D. Agos River Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Agos	Quezon	6	523	0	0	523	
Total		6	523	0	0	523	

Source : NIA & BSWM

E. Pasig-Marikina River Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Pasig-Mari	Rizal	3	206	4	84	290	
Total		3	206	4	84	290	

Source : NIA & BSWM

F. Laguna Lake Basin

River	Province	Communal Irrigation System		Small Scale Irrigation		Total Area (ha)	Remarks
		Nos	Area (ha)	Nos	Area (ha)		
Laguna	Rizal	18	1,638	9	255	1,893	
	Laguna	24	2,341	14	524	2,865	
Total		42	3,979	23	779	4,758	

Source : NIA & BSWM

Annex 6.7.1 Estimation of Diversion Water Demands for Angat-Maasim RIS (AMRIS)

Present irrigation area for AMRIS = Dry Season 26,000 ha, Wet Season 20,335 ha

No.	Source of Estimate	Diver Water Demand for AMRIS (m3/s)													Remarks
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave	
1	Estimate by UPRIS Div.3	37.2	42.1	30.7	5.5	7.3	21.6	8.1	3.9	4.5	8.6	22.1	32.0	18.6	
2	Adjusted Umiray-Angat Transbasin F/S Study, 1992	33.0	30.9	25.7	13.3	4.9	13.2	15.5	11.8	16.0	13.0	23.6	32.8	19.5	Average historical diversion (1978-1987)
3	Adjusted Pre-F/S for additional water supply to AMRIS, 1994	34.0	38.7	19.2	0.6	0.0	0.0	0.9	0.6	1.4	0.0	21.6	29.3	12.2	Irrigation efficiency =45% for wet and dry season
4	Actual Diversion Records (Average for 28 years 1980-2008)	32.7	31.9	25.6	12.2	3.7	11.1	16.2	13.6	15.4	12.0	16.9	29.4	18.4	
5	NIA Estimate (for 2009/10 operation)	43.3	43.8	34.4	10.7	0.0	35.9	31.3	32.9	34.0	24.7	23.1	41.0	29.6	No effective rainfall considered
6	Estimate by the JICA Study Team (case-1) Effective Rainfall = Average year	41.0	41.4	31.8	9.5	0.0	23.2	4.9	0.0	0.5	5.8	17.7	32.6	17.4	Based on NIA's estimate, taking effective rainfall into consideration
7	Estimate by the JICA Study Team (case-2) Effective Rainfall = 80% dependability	**41.3**	**41.7**	**32.2**	**9.7**	**0.0**	**25.5**	**9.9**	**1.2**	**5.4**	**10.1**	**18.8**	**34.2**	**19.2**	Based on NIA's estimate, taking effective rainfall into consideration

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.2 Present Diversion Water Demands for UPRIIS

1. UPRIS Gross Demands (without consideration of Re-use in the Pampanga River System)

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Pampanga River Integrated Irrigation System (UPRIIS)	District-Ia	Talavera dam	Talavera	4,120	2.10	2.30	0.70	0.00	0.10	2.00	2.00	0.60	0.70	1.90	1.60	1.60
	District-Ib	Rizal weir	Pampanga	16,400	22.46	25.92	21.81	6.90	0.65	12.48	9.69	2.61	3.11	6.90	12.48	20.02
	District-II			22,591	30.93	35.70	30.04	9.50	0.89	17.18	13.34	3.60	4.29	9.50	17.18	27.58
	District-V			16,879	23.11	26.68	22.45	7.10	0.66	12.84	9.97	2.69	3.20	7.10	12.84	20.60
	Total at Rizal weir			55,870	76.50	88.30	74.30	23.50	2.20	42.50	33.00	8.90	10.60	23.50	42.50	68.20
	District-III	Bongabon weir	Pampanga	25,881	37.00	41.90	30.50	5.40	7.20	27.40	10.40	4.90	5.70	10.90	22.00	31.80
	District-IV															
	Total at Bongabon weir			25,881	37.00	41.90	30.50	5.40	7.20	27.40	10.40	4.90	5.70	10.90	22.00	31.80
	District-IV	Penaranda weir	Penaranda	19,924	26.10	28.30	15.90	0.00	4.40	17.10	6.40	3.60	4.00	10.40	17.70	21.10
	Total			105,795	141.70	160.80	121.40	28.90	13.90	89.00	51.80	18.00	21.00	46.70	83.80	122.70

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

2. UPRIS Net Water Demands (with consideration of Re-use in the Pampanga River System)

Reuse rate: Rizal weir point = 0.106, Bongabon weir point = 0.180, Penaranda weir point = 0.041

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Pampanga River Integrated Irrigation System (UPRIIS)	District-Ia	Talavera dam	Talavera	4,120	2.10	2.30	0.70	0.00	0.10	2.00	2.00	0.60	0.70	1.90	1.60	1.60
	District-Ib, II, V	Rizal weir	Pampanga	55,870	68.40	78.90	66.40	21.00	2.00	38.00	29.50	8.00	9.50	21.00	38.00	60.90
	District-III, IV	Bongabon weir	Pampanga	25,881	30.30	34.40	25.00	4.50	5.90	22.50	8.50	4.00	4.70	8.90	18.00	26.10
	District-IV	Penaranda weir	Penaranda	19,924	25.00	27.10	15.30	0.00	4.20	16.40	6.10	3.40	3.80	9.90	17.00	20.30
	Total			105,795	125.80	142.70	107.40	25.50	12.20	78.90	46.10	16.00	18.70	41.70	74.60	108.90

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.3 Future Diversion Water Demands for UPRIIS

1. UPRIS Gross Demands (without consideration of Re-use in the Pampanga River System)

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Pampanga River Integrated Irrigation System (UPRIIS)	District-Ia	Talavera dam	Talavera	4,120	2.10	2.30	0.70	0.00	0.10	2.00	2.00	0.60	0.70	1.90	1.60	1.60
	District-Ib	Rizal weir	Pampanga	16,400	22.47	25.92	21.80	6.89	0.65	12.46	9.69	2.63	3.12	6.89	12.46	20.02
	District-II			22,591	30.96	35.70	30.04	9.49	0.89	17.17	13.34	3.62	4.30	9.49	17.17	27.57
	District-V			37,200	50.97	58.78	49.46	15.62	1.46	28.27	21.97	5.96	7.08	15.62	28.27	45.41
	Total at Rizal weir			76,191	104.40	120.40	101.30	32.00	3.00	57.90	45.00	12.20	14.50	32.00	57.90	93.00
	District-III	Bongabon weir	Pampanga	25,881	37.00	41.90	30.50	5.40	7.20	27.40	10.40	4.90	5.70	10.90	22.00	31.80
	District-IV															
	Total at Bongabon weir			25,881	37.00	41.90	30.50	5.40	7.20	27.40	10.40	4.90	5.70	10.90	22.00	31.80
	District-IV	Penaranda weir	Penaranda	19,924	26.10	28.30	15.90	0.00	4.40	17.10	6.40	3.60	4.00	10.40	17.70	21.10
	Total			126,116	169.60	192.90	148.40	37.40	14.70	104.40	63.80	21.30	24.90	55.20	99.20	147.50

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

2. UPRIS Net Water Demands (with consideration of Re-use in the Pampanga River System)

Reuse rate: Rizal weir point = 0.106, Bongabon weir point = 0.180, Penaranda weir point = 0.041

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Pampanga River Integrated Irrigation System (UPRIIS)	District-Ia	Talavera dam	Talavera	4,120	2.10	2.30	0.70	0.00	0.10	2.00	2.00	0.60	0.70	1.90	1.60	1.60
	District-Ib, II, V	Rizal weir	Pampanga	76,191	93.33	107.64	90.56	28.61	2.68	51.76	40.23	10.91	12.96	28.61	51.76	83.14
	District-III, IV	Bongabon weir	Pampanga	25,881	30.30	34.40	25.00	4.50	5.90	22.50	8.50	4.00	4.70	8.90	18.00	26.10
	District-IV	Penaranda weir	Penaranda	19,924	25.00	27.10	15.30	0.00	4.20	16.40	6.10	3.40	3.80	9.90	17.00	20.30
	Total			126,116	150.73	171.44	131.56	33.11	12.88	92.66	56.83	18.91	22.16	49.31	88.36	131.14

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.4 Present Diversion Water Demands for National Irrigation System (1/2)

A. Angat River Basin (Annex 6.7.1)

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat-Massim RIS (AMRIS)	Left bank	Bustos weir	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
	Right bank	Bustos weir + 3 weirs	Angat+Massim													
	Total			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 : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin (Net water demands for UPRIS in Annex 6.7.2)

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Pampanga River Integrated Irrigation System (UPRIIS)	Dist - Ia	Talavera dam	Talavera	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
	Dist - Ib+II+V	Rizal weir	Pampanga	55,870	68.4	78.9	66.4	21.0	2.0	38.0	29.5	8.0	9.5	21.0	38.0	60.9
	Dist - III+IV	Bongabon weir	Pampanga	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
	Dist - IV	Penaranda weir	Penaranda	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
	Total			105,795	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		Aulo dam	Aulo	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
PDRIS		Cong-Dadong dam	Pampanga	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
Porlac-Gumain	Porlac-Solib	Porlac & Solib weirs	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 dam	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				4.1	4.8	4.0	1.3	0.1	2.7	1.6	0.5	0.5	1.3	2.1	3.7
Grand 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

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.4 Present Diversion Water Demands for National Irrigation System (2/2)

C. Agos River Basin

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agos				1,234	1.9	1.9	1.5	0.4	0.0	1.2	0.5	0.1	0.2	0.5	0.9	1.6
Dumacaa				1,893	2.9	2.9	2.3	0.7	0.0	1.8	0.7	0.1	0.4	0.7	1.3	2.4
Hanagdong				274	0.4	0.4	0.3	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.3
Lagnas				639	1.0	1.0	0.8	0.2	0.0	0.6	0.2	0.0	0.1	0.2	0.4	0.8
Total				4,040	6.2	6.3	4.9	1.5	0.0	3.8	1.5	0.2	0.8	1.5	2.8	5.2

Source : Prepared by Study Team

D. Laguna Lake Basin

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cabuyao East				348	0.5	0.5	0.4	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.4
San Cristobal				413	0.6	0.6	0.5	0.1	0.0	0.4	0.2	0.0	0.1	0.2	0.3	0.5
Diezmo				852	1.3	1.3	1.0	0.3	0.0	0.8	0.3	0.0	0.2	0.3	0.6	1.1
Macabling				418	0.6	0.7	0.5	0.2	0.0	0.4	0.2	0.0	0.1	0.2	0.3	0.5
San Juan				341	0.5	0.5	0.4	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.4
Sta. Maria				974	1.5	1.5	1.2	0.4	0.0	0.9	0.4	0.0	0.2	0.4	0.7	1.2
Mayor				375	0.6	0.6	0.5	0.1	0.0	0.4	0.1	0.0	0.1	0.1	0.3	0.5
Sta. Cruz				2,185	3.4	3.4	2.6	0.8	0.0	2.1	0.8	0.1	0.4	0.8	1.5	2.8
Mabacan				272	0.4	0.4	0.3	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.3
Balanac				1,000	1.5	1.6	1.2	0.4	0.0	1.0	0.4	0.0	0.2	0.4	0.7	1.3
Lumban				57	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Malaunod				227	0.3	0.4	0.3	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.2	0.3
Total				7,462	11.5	11.6	9.0	2.7	0.0	7.1	2.8	0.3	1.5	2.8	5.2	9.5

Source : Prepared by Study Team

Annex 6.7.5 Future Diversion Water Demands for National Irrigation System (1/2)

A. Angat River Basin (Annex 6.7.1)

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat-Massim RIS (AMRIS)	Left bank	Bustos weir	Angat	26,791	42.5	43.0	33.2	10.0	0.0	26.3	10.2	1.2	5.6	10.4	19.4	35.2
	Right bank	Bustos weir + 3 weirs	Angat+Massim													
	Total			26,791	42.5	42.3	33.2	10.0	0.0	26.3	10.2	1.2	5.6	10.4	19.4	35.2

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin (Net water demands for UPRIS in Annex 6.7.2)

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Pampanga River Integrated Irrigation System (UPRIIS)	Dist - Ia	Talavera dam	Talavera	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
	Dist - Ib+II+V	Rizal weir	Pampanga	76,191	93.3	107.6	90.6	28.6	2.7	51.8	40.2	10.9	13.0	28.6	51.8	83.1
	Dist - III+IV	Bongabon weir	Pampanga	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
	Dist - IV	Penaranda weir	Penaranda	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
	Total			126,116	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		Aulo dam	Aulo	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
Balintingon		Balintingon weir	Penaranda	14,900	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		Cong-Dadong dam	Pampanga	11,920	15.7	16.9	9.5	0.0	2.7	10.3	3.8	2.2	2.3	6.1	10.6	12.6
Porlac-Gumain	Polrac-Solib	Porlac & Solib weirs	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 dam	Gumain	15,292	11.0	10.6	5.7	5.7	6.7	4.9	3.5	5.8	5.1	2.2	7.8	10.8
	Total				12.9	12.9	7.6	6.3	6.7	6.2	4.3	6.0	5.3	2.8	8.8	12.5
Grand 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

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.5 Future Diversion Water Demands for National Irrigation System (2/2)

C. Agos River Basin

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agos				1,234	1.9	1.9	1.5	0.4	0.0	1.2	0.5	0.1	0.2	0.5	0.9	1.6
Dumacaa				1,893	2.9	2.9	2.3	0.7	0.0	1.8	0.7	0.1	0.4	0.7	1.3	2.4
Hanagdong				274	0.4	0.4	0.3	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.3
Lagnas				639	1.0	1.0	0.8	0.2	0.0	0.6	0.2	0.0	0.1	0.2	0.4	0.8
Total				4,040	6.2	6.3	4.9	1.5	0.0	3.8	1.5	0.2	0.8	1.5	2.8	5.2

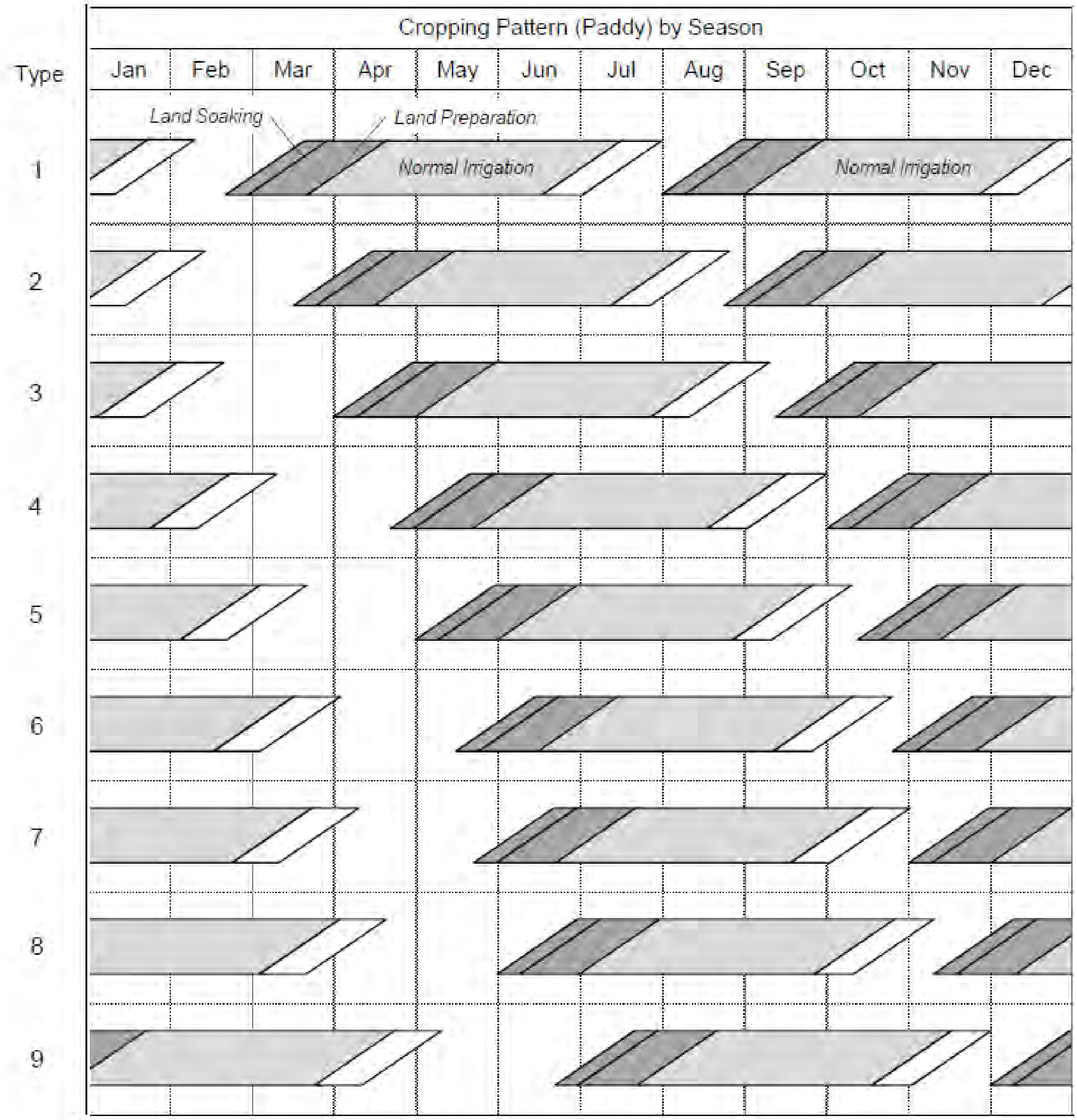
Source : Prepared by Study Team

D. Laguna Lake Basin

NIS	Sub-system	Intake Point	River	Irrigation Area (ha)	Diversion Water Demand (m^3/s)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cabuyao East				348	0.5	0.5	0.4	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.4
San Cristobal				413	0.6	0.6	0.5	0.1	0.0	0.4	0.2	0.0	0.1	0.2	0.3	0.5
Diezmo				852	1.3	1.3	1.0	0.3	0.0	0.8	0.3	0.0	0.2	0.3	0.6	1.1
Macabling				418	0.6	0.7	0.5	0.2	0.0	0.4	0.2	0.0	0.1	0.2	0.3	0.5
San Juan				341	0.5	0.5	0.4	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.4
Sta. Maria				974	1.5	1.5	1.2	0.4	0.0	0.9	0.4	0.0	0.2	0.4	0.7	1.2
Mayor				375	0.6	0.6	0.5	0.1	0.0	0.4	0.1	0.0	0.1	0.1	0.3	0.5
Sta. Cruz				2,185	3.4	3.4	2.6	0.8	0.0	2.1	0.8	0.1	0.4	0.8	1.5	2.8
Mabacan				272	0.4	0.4	0.3	0.1	0.0	0.3	0.1	0.0	0.1	0.1	0.2	0.3
Balanac				1,000	1.5	1.6	1.2	0.4	0.0	1.0	0.4	0.0	0.2	0.4	0.7	1.3
Lumban				57	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Malaunod				227	0.3	0.4	0.3	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.2	0.3
Total				7,462	11.5	11.6	9.0	2.7	0.0	7.1	2.8	0.3	1.5	2.8	5.2	9.5

Source : Prepared by Study Team

Annex 6.7.6 Proposed Cropping Pattern for Small Scale Irrigation Project



Remarks: *Irrigation Period:* *Land soaking & Land preparation* *Normal Irrigation*

No Irrigation Period: *Dry up period for harvesting*

Source: The Master Plan Study on the Small-Scale Irrigation Development Project, JICA, 1992

Annex 6.7.7 Present Diversion Water Demand for Communal Irrigation System

A. Angat River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	ANG01	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
	ANG02	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1
	ANG03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.2

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coronell	COR	3.0	3.2	1.8	0.0	0.7	2.9	1.1	0.6	0.7	1.8	2.0	2.4
Pasac	PAS	4.1	4.5	2.5	0.0	1.0	4.0	1.5	0.8	0.9	2.4	2.8	3.3
Penaranda	PEN	0.2	0.2	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.2
Rio Chico	RCH	10.9	11.8	6.6	0.0	2.7	10.6	4.0	2.2	2.5	6.4	7.4	8.8
Pampanga	PAM01	0.8	0.8	0.5	0.0	0.2	0.8	0.3	0.2	0.2	0.5	0.5	0.6
	PAM02	7.8	8.4	4.7	0.0	1.9	7.6	2.8	1.6	1.8	4.6	5.3	6.3
	PAM03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PAM04	0.4	0.4	0.2	0.0	0.1	0.4	0.1	0.1	0.1	0.2	0.3	0.3
	PAM05	1.3	1.4	0.8	0.0	0.3	1.3	0.5	0.3	0.3	0.8	0.9	1.1
	PAN	0.6	0.7	0.4	0.0	0.2	0.6	0.2	0.1	0.1	0.4	0.4	0.5
Sub-total		10.9	11.8	6.7	0.0	2.7	10.7	4.0	2.2	2.5	6.5	7.4	8.8
Total		29.1	31.5	17.8	0.0	7.3	28.5	10.6	6.0	6.6	17.2	19.7	23.5

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

C. Umiray River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Umiray	Quezon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source : Prepared by Study Team

D. Agos River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agos	Quezon	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.2
Total		0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.2

Source : Prepared by Study Team

E. Pasig-Marikina River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pasig-	Rizal	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1
Total		0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1

Source : Prepared by Study Team

F. Laguna Lake Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Laguna	Rizal	1.0	1.0	0.6	0.0	0.2	0.9	0.4	0.2	0.2	0.6	0.7	0.8
	Laguna	1.3	1.4	0.8	0.0	0.3	1.3	0.5	0.3	0.3	0.8	0.9	1.1
Total		2.3	2.5	1.4	0.0	0.6	2.2	0.8	0.5	0.5	1.4	1.6	1.9

Source : Prepared by Study Team

Annex 6.7.8 Future Diversion Water Demand for Communal Irrigation System

A. Angat River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	ANG01	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1
	ANG02	0.4	0.4	0.2	0.0	0.1	0.3	0.1	0.1	0.1	0.2	0.2	0.3
	ANG03	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total		0.6	0.6	0.3	0.0	0.1	0.6	0.2	0.1	0.1	0.3	0.4	0.5

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coronell	COR	3.8	4.1	2.3	0.0	0.9	3.7	1.4	0.8	0.9	2.2	2.6	3.1
Pasac	PAS	4.7	5.1	2.9	0.0	1.2	4.6	1.7	1.0	1.1	2.8	3.2	3.8
Penaranda	PEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rio Chico	RCH	14.9	16.2	9.1	0.0	3.7	14.6	5.4	3.1	3.4	8.8	10.1	12.1
Pampanga	PAM01	2.7	2.9	1.7	0.0	0.7	2.7	1.0	0.6	0.6	1.6	1.8	2.2
	PAM02	8.5	9.2	5.2	0.0	2.1	8.3	3.1	1.7	1.9	5.0	5.7	6.8
	PAM03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PAM04	0.3	0.4	0.2	0.0	0.1	0.3	0.1	0.1	0.1	0.2	0.2	0.3
	PAM05	1.4	1.6	0.9	0.0	0.4	1.4	0.5	0.3	0.3	0.9	1.0	1.2
	PAN	0.6	0.7	0.4	0.0	0.2	0.6	0.2	0.1	0.1	0.4	0.4	0.5
Sub-total		13.6	14.7	8.3	0.0	3.4	13.3	5.0	2.8	3.1	8.1	9.2	11.0
Total		37.1	40.2	22.6	0.0	9.3	36.3	13.5	7.6	8.4	22.0	25.1	30.0

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

C. Umiray River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Umiray	Quezon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source : Prepared by Study Team

D. Agos River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agos	Quezon	0.5	0.5	0.3	0.0	0.1	0.4	0.2	0.1	0.1	0.3	0.3	0.4
Total		0.5	0.5	0.3	0.0	0.1	0.4	0.2	0.1	0.1	0.3	0.3	0.4

Source : Prepared by Study Team

E. Pasig-Marikina River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pasig-	Rizal	0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1
Total		0.2	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.1

Source : Prepared by Study Team

F. Laguna Lake Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Laguna	Rizal	1.4	1.6	0.9	0.0	0.4	1.4	0.5	0.3	0.3	0.9	1.0	1.2
	Laguna	2.1	2.2	1.3	0.0	0.5	2.0	0.7	0.4	0.5	1.2	1.4	1.7
Total		3.5	3.8	2.1	0.0	0.9	3.4	1.3	0.7	0.8	2.1	2.4	2.8

Source : Prepared by Study Team

Annex 6.7.9 Present Diversion Water Demand for Small Scale Irrigation

A. Angat River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	ANG01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ANG02	0.05	0.06	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.04	0.04
	ANG03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		0.05	0.06	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.04	0.04

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coronell	COR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pasac	PAS	0.34	0.37	0.21	0.00	0.08	0.33	0.12	0.07	0.08	0.20	0.23	0.27
Penaranda	PEN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rio Chico	RCH	0.46	0.50	0.28	0.00	0.12	0.45	0.17	0.09	0.10	0.27	0.31	0.37
Pampanga	PAM01	0.04	0.04	0.02	0.00	0.01	0.03	0.01	0.01	0.01	0.02	0.02	0.03
	PAM02	0.46	0.50	0.28	0.00	0.12	0.45	0.17	0.10	0.11	0.28	0.32	0.38
	PAM03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PAM04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PAM05	0.11	0.11	0.06	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.07	0.09
	PAN	0.14	0.16	0.09	0.00	0.04	0.14	0.05	0.03	0.03	0.09	0.10	0.12
Sub-total		0.75	0.81	0.46	0.00	0.19	0.73	0.27	0.15	0.17	0.44	0.51	0.61
Total		1.55	1.68	0.95	0.00	0.39	1.52	0.56	0.32	0.35	0.92	1.05	1.25

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

C. Umiray River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Umiray	Quezon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source : Prepared by Study Team

D. Agos River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agos	Quezon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source : Prepared by Study Team

E. Pasig-Marikina River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pasig-	Rizal	0.07	0.08	0.05	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.05	0.06
Total		0.07	0.08	0.05	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.05	0.06

Source : Prepared by Study Team

F. Laguna Lake Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Laguna	Rizal	0.22	0.24	0.14	0.00	0.06	0.22	0.08	0.05	0.05	0.13	0.15	0.18
	Laguna	0.46	0.50	0.28	0.00	0.12	0.45	0.17	0.09	0.10	0.27	0.31	0.37
Total		0.68	0.74	0.42	0.00	0.17	0.67	0.25	0.14	0.16	0.41	0.46	0.55

Source : Prepared by Study Team

Annex 6.7.10 Future Diversion Water Demand for Small Scale Irrigation

A. Angat River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angat	ANG01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ANG02	0.05	0.06	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.04	0.04
	ANG03	0.05	0.05	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.03	0.04
Total		0.10	0.11	0.06	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.07	0.08

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

B. Pampanga River Basin

River	Sub-basin Code	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coronell	COR	0.19	0.21	0.12	0.00	0.05	0.19	0.07	0.04	0.04	0.11	0.13	0.16
Pasac	PAS	0.49	0.53	0.30	0.00	0.12	0.48	0.18	0.10	0.11	0.29	0.33	0.40
Penaranda	PEN	0.07	0.07	0.04	0.00	0.02	0.06	0.02	0.01	0.01	0.04	0.04	0.05
Rio Chico	RCH	2.15	2.34	1.32	0.00	0.54	2.11	0.79	0.44	0.49	1.28	1.46	1.74
Pampanga	PAM01	0.04	0.04	0.02	0.00	0.01	0.03	0.01	0.01	0.01	0.02	0.02	0.03
	PAM02	0.82	0.89	0.50	0.00	0.20	0.80	0.30	0.17	0.19	0.48	0.55	0.66
	PAM03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PAM04	0.04	0.05	0.03	0.00	0.01	0.04	0.02	0.01	0.01	0.03	0.03	0.04
	PAM05	0.13	0.14	0.08	0.00	0.03	0.13	0.05	0.03	0.03	0.08	0.09	0.11
	PAN	0.19	0.21	0.12	0.00	0.05	0.19	0.07	0.04	0.04	0.11	0.13	0.16
Sub-total		1.22	1.32	0.75	0.00	0.31	1.20	0.45	0.25	0.28	0.72	0.83	0.99
Total		4.13	4.47	2.52	0.00	1.03	4.04	1.51	0.84	0.94	2.45	2.80	3.34

Source : Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

C. Umiray River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Umiray	Quezon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source : Prepared by Study Team

D. Agos River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agos	Quezon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source : Prepared by Study Team

E. Pasig-Marikina River Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pasig-	Rizal	0.07	0.08	0.05	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.05	0.06
Total		0.07	0.08	0.05	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.05	0.06

Source : Prepared by Study Team

F. Laguna Lake Basin

River	Province	Diversion Water Demand (m^3/s)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Laguna	Rizal	0.22	0.24	0.14	0.00	0.06	0.22	0.08	0.05	0.05	0.13	0.15	0.18
	Laguna	0.46	0.50	0.28	0.00	0.12	0.45	0.17	0.09	0.10	0.27	0.31	0.37
Total		0.68	0.74	0.42	0.00	0.17	0.67	0.25	0.14	0.16	0.41	0.46	0.55

Source : Prepared by Study Team

Annex 6.7.11 Present and Future Water Demand for Groundwater Irrigation

Province	Present Groundwater Use			Future Groundwater Use			Remarks
	Demand NIA	Demand Others	Present	Future GW Irrigation Development		Future Demand	
	(m^3/s)	(m^3/s)	(m^3/s)	Area (ha)	Demand (m^3/s)	(m^3/s)	
Angat River Basin							
Total	0.00	0.00	0.00	0	0.00	0.00	
Pampanga River Basin							
PAM01	0.00	0.00	0.00	0	0.00	0.00	
PAM02	0.00	0.00	0.00	0	0.00	0.00	
PAM03	0.00	0.00	0.00	0	0.00	0.00	
PAM04	0.00	0.00	0.00	0	0.00	0.00	
PAM05	0.00	0.00	0.00	0	0.00	0.00	
PAN	0.00	0.00	0.00	0	0.00	0.00	
RCH	0.32	0.14	0.46	3,418	1.30	1.76	
PEN	0.00	0.00	0.00	0	0.00	0.00	
PAS	0.00	0.11	0.11	972	0.37	0.48	
Total	0.32	0.26	0.58	4,390	1.67	2.25	
Umiray River Basin							
Total	0.00	0.00	0.00	0	0.00	0.00	
Agos River Basin							
Total	0.00	0.00	0.00	0	0.00	0.00	
Pasig-Marikina River Basin							
Total	0.00	0.00	0.00	200	0.08	0.08	
Laguna Lake Basin							
Total	0.00	0.00	0.00	500	0.19	0.19	
Grand Total	0.32	0.26	0.58	5,090	1.94	2.52	

Source :
Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.12 Present and Future Water Demand for Fishery

Sub-basin	Net Fish Pond Area (km^2)		Fresh Water Use (%)	Present Fishery Water Demand				Future Fishery Water Demand			
				Total Water		Fresh Water		Total Water		Fresh Water	
	Present	Future		m^3/s	MCM/y	m^3/s	MCM/y	m^3/s	MCM/y	m^3/s	MCM/y
Angat River Basin											
ANG01	50.4	50.4	1.5	4.7	147.2	0.1	2.1	4.7	147.2	0.1	2.1
ANG02	1.0	1.0	100.0	0.1	2.6	0.1	2.6	0.1	2.6	0.1	2.6
ANG03	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	51.4	51.4		4.8	149.8	0.2	4.7	4.8	149.8	0.2	4.7
Pampanga River Basin											
PAM01	40.0	40.0	4.9	3.7	116.8	0.2	5.7	3.7	116.8	0.2	5.7
PAM02	58.4	58.4	100.0	5.4	170.5	1.9	59.3	5.4	170.5	1.9	59.3
PAM03	0.4	0.4	100.0	0.0	1.2	0.0	1.2	0.0	1.2	0.0	1.2
PAM04	3.9	3.9	100.0	0.4	11.4	0.4	11.4	0.4	11.4	0.4	11.4
PAM05	0.3	0.3	100.0	0.0	0.9	0.0	0.9	0.0	0.9	0.0	0.9
PAN	0.1	0.1	100.0	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3
RCH	11.8	11.8	100.0	1.1	34.5	1.1	34.5	1.1	34.5	1.1	34.5
PEN	0.5	0.5	100.0	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.5
PAS	134.8	134.8	100.0	12.5	393.9	2.7	85.8	12.5	393.9	2.7	85.8
Total	250.3	250.3		23.2	730.9	6.4	200.4	23.2	730.9	6.4	200.4
Umiray River Basin											
Total	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agos River Basin											
Total	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pasig-Marikina River Basin											
Total	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Laguna Lake Basin											
Total	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source :
Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Annex 6.7.13 Present and Future Water Demand for Livestock

Province	Present Number of Livestock (1000 heads)			Future Number of Livestock (1000 heads)			Present Water Demand		Future Water Demand	
	Cattle / Carabao	Others	Poultry	Cattle / Carabao	Others	Poultry	m^3/s	MCM/y	m^3/s	MCM/y
Angat River Basin										
Total	8	90	712	11	132	872	0.02	0.77	0.04	1.13
Pampanga River Basin										
PAM01	0	0	0	0	0	0	0.00	0.00	0.00	0.00
PAM02	30	360	2,848	45	530	3,489	0.10	3.09	0.14	4.51
PAM03	0	0	0	0	0	0	0.00	0.00	0.00	0.00
PAM04	15	37	1,571	22	54	1,924	0.01	0.46	0.02	0.67
PAM05	0	0	0	0	0	0	0.00	0.00	0.00	0.00
PAN	0	0	0	0	0	0	0.00	0.00	0.00	0.00
RCH	64	253	6,109	94	372	7,483	0.08	2.68	0.12	3.87
PEN	11	28	1,178	16	41	1,443	0.01	0.35	0.02	0.50
PAS	17	163	9,748	24	240	11,939	0.06	1.81	0.08	2.55
Total	137	841	21,455	202	1,237	26,278	0.27	8.39	0.38	12.10
Umiray River Basin										
Total	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Agos River Basin										
Total	1	9	100	2	14	122	0.00	0.09	0.00	0.13
Pasig-Marikina River Basin										
Total	4	28	333	6	41	407	0.01	0.27	0.01	0.40
Laguna Lake Basin										
Total	6	37	443	9	55	543	0.01	0.37	0.02	0.53
Grand Total	156	1,005	23,043	230	1,480	28,223	0.31	9.89	0.45	14.29

Source :
Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, JICA, 2011

Chapter 7

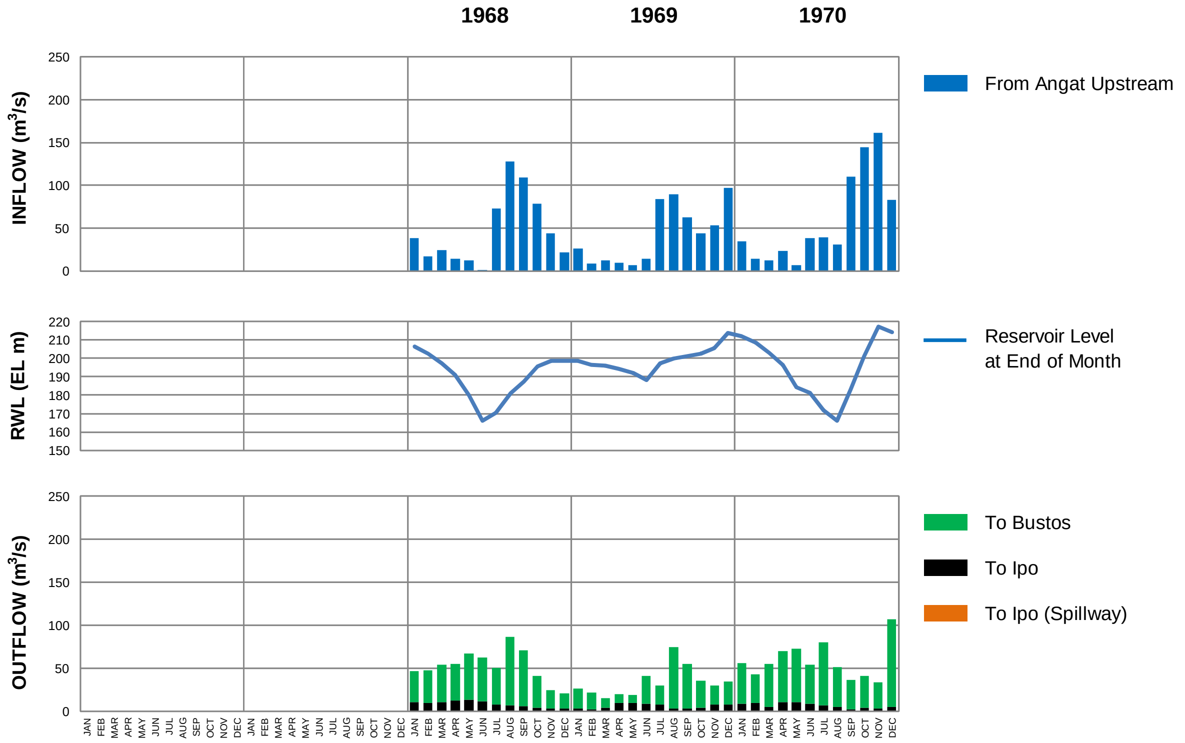
Annex 7.1.1
Technical Features of Angat Reservoir

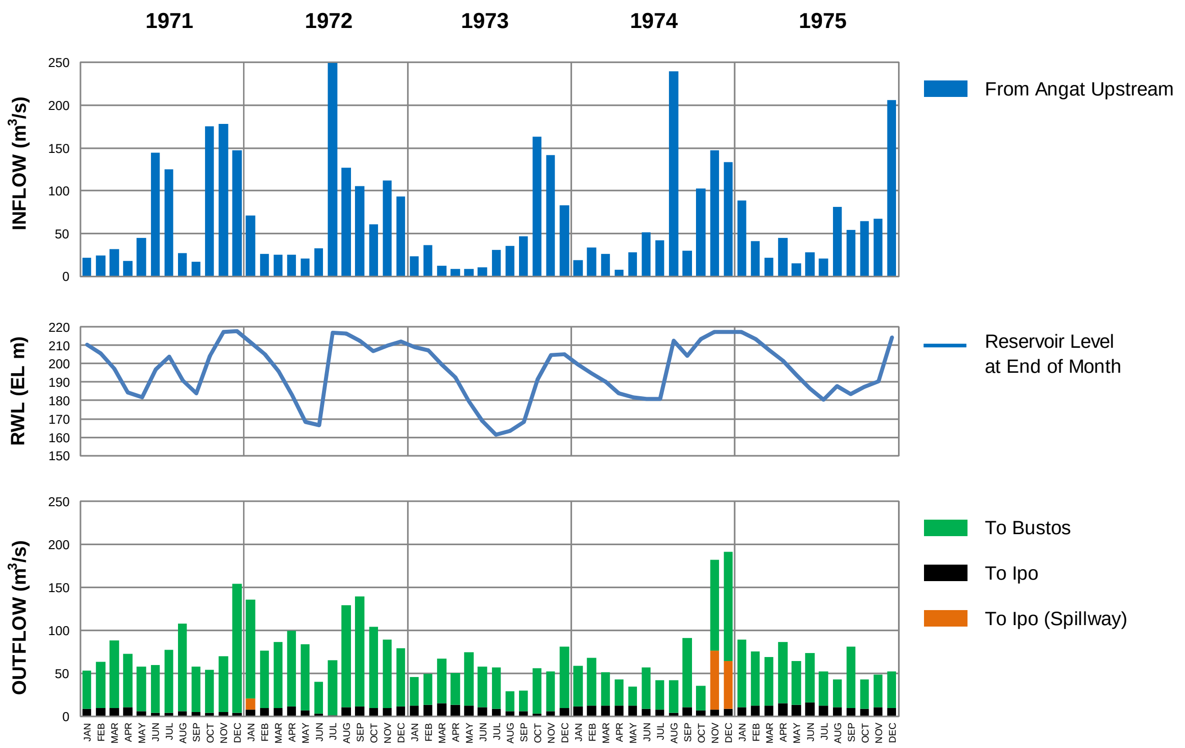
Completion	September 1967	
Purpose	Water Supply, Irrigation, Hydropower and Flood Control	
Type of Dam	Earth and Rockfill	
Height of Dam	131m	
Crest Length of Dam	568m	
Crest Level of Dam	EL 221.50m	
Crest Level of Overflow Section	EL 202.00m	
Spillway Gate	Radial Gates, 3 nos.	
Height of Spillway Gate	15.00m	
Width of Spillway Gate	12.50m	
Catchment Area	Angat River Basin	$546km^2$
	Umiray River Basin	$130km^2$
Reservoir Surface Area	$23.0\ km^2$	
Reservoir Inflow	Angat River	$59.3m^3/s$ (=1,869 MCM/yr)
	Umiray River:	$11.7m^3/s$ (= 370 MCM/yr)
Effective Storage	894 MCM (EL 160.00m to EL 219.00m)	
Flood Control Storage	198 MCM (EL 210.00m to EL 219.00m)	
Design Flood	$8,400\ m^3/s$	
Spillway Capacity	$5,600\ m^3/s$	
Design Flood Level	EL. 219.00 m	
Surcharge Water Level	EL. 213.00 m	
Full Supply Level	EL. 212.00 m	
Minimum Operation Level	EL. 160.00 m	
Intake	Invert Level of Inlet Work:	EL 149.00m
	Length 457m	
	Section: Circular	
	Pressure Tunnel (upstream side) D =8m	
	Penstock (downstream site) D = 7m	
Low Level Outlet	Length 607m	
	Section: Modified Horseshoe, D = 7.6m	
	Invert Level of Inlet:	EL 101.50m
	Invert Level of Outlet:	EL 95.74m
Hydropower Station, Main Unit		
Generators	No.1, 2, 3 and 4:	50MW × 4nos.
	Total 200MW	
Plant Discharge	$67.0m^3/s$ (Output 200MW, Reservoir Level at EL 216m)	
Main Tunnel	Length 1,800m, D = 8.5m	
Hydropower Station, Auxiliary Unit		
Plant Discharge	$49.5m^3/s$ (Output 46MW, Reservoir Level at EL 216m)	
Generators	No.1, 2 and 3:	6MW × 3 nos.
	No.4:	10MW × 1 no. (belonging to MWSS)
	No.5:	18MW × 1 no. (belonging to MWSS)
	Total 46MW	

Source:

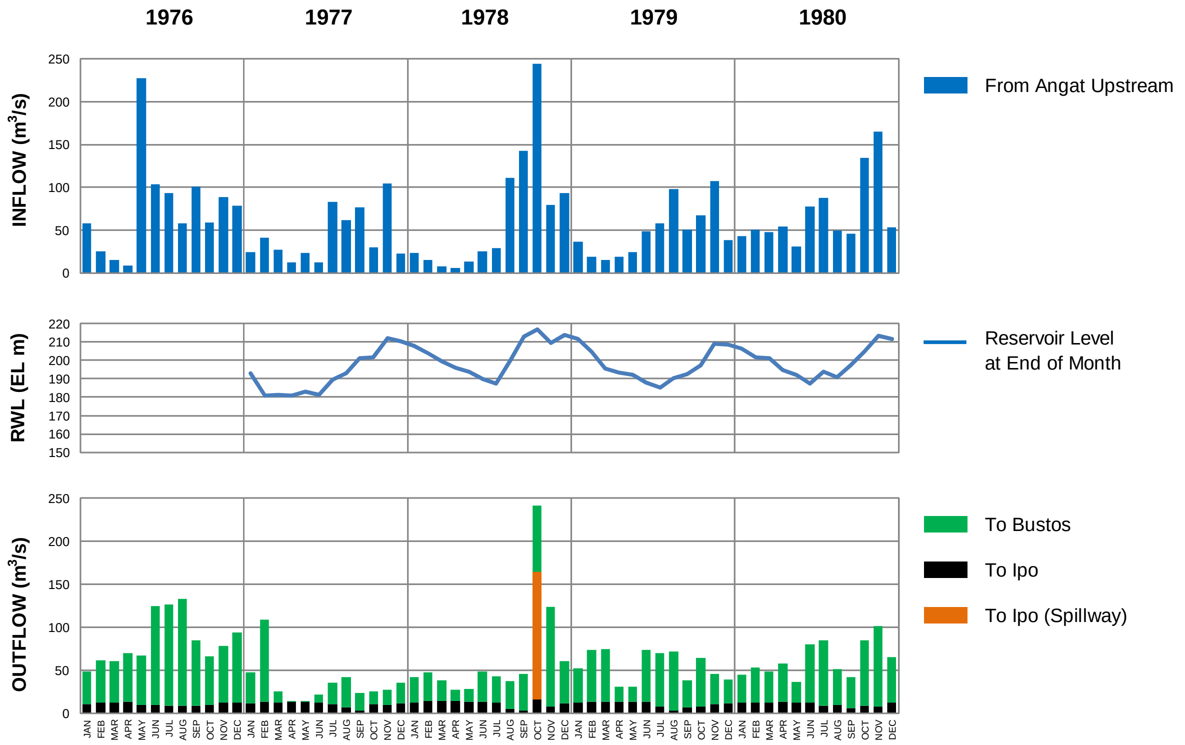
- The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, Final Report (JICA/NWRB, 2011)
- Technical Manual (Manila Water)
- Flood Operation Rule (Draft) for Angat Dam, Flood Forecasting and Warning System for Dam Operation Project, PAGASA / NIA / NPC, 1984

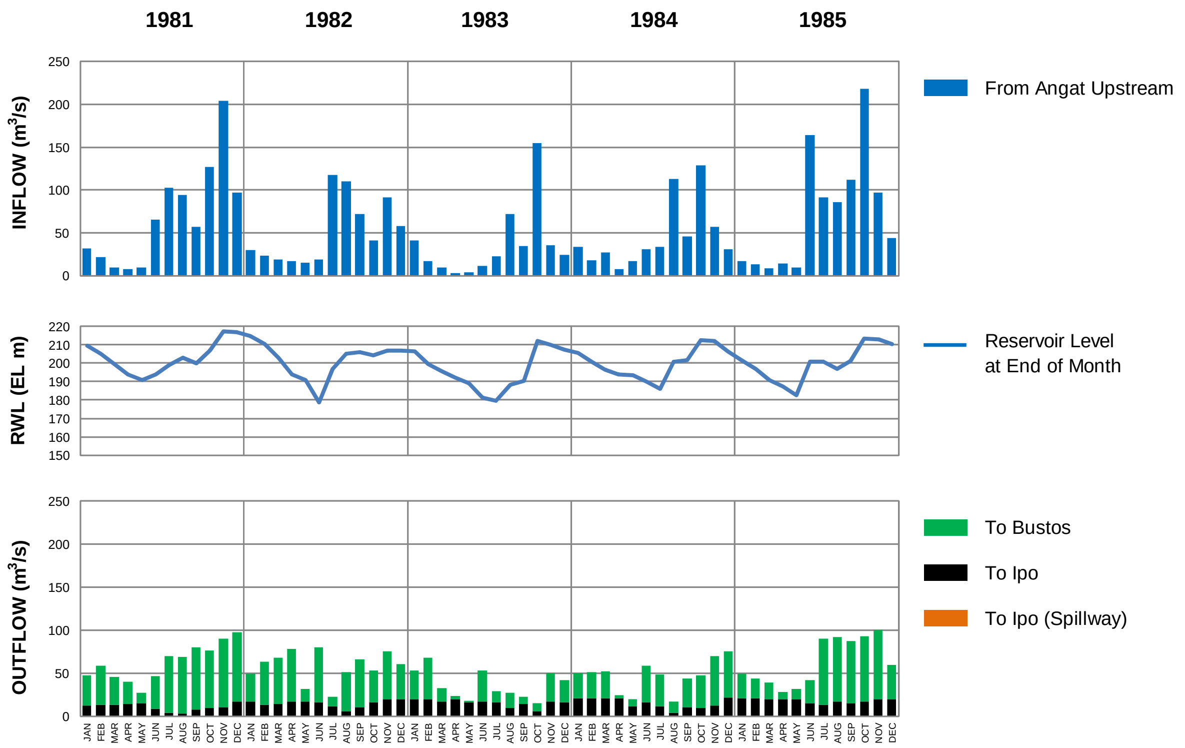
Annex 7.1.2 (1/5)
Monthly Inflows, Reservoir Levels and Outflows of Angat Reservoir



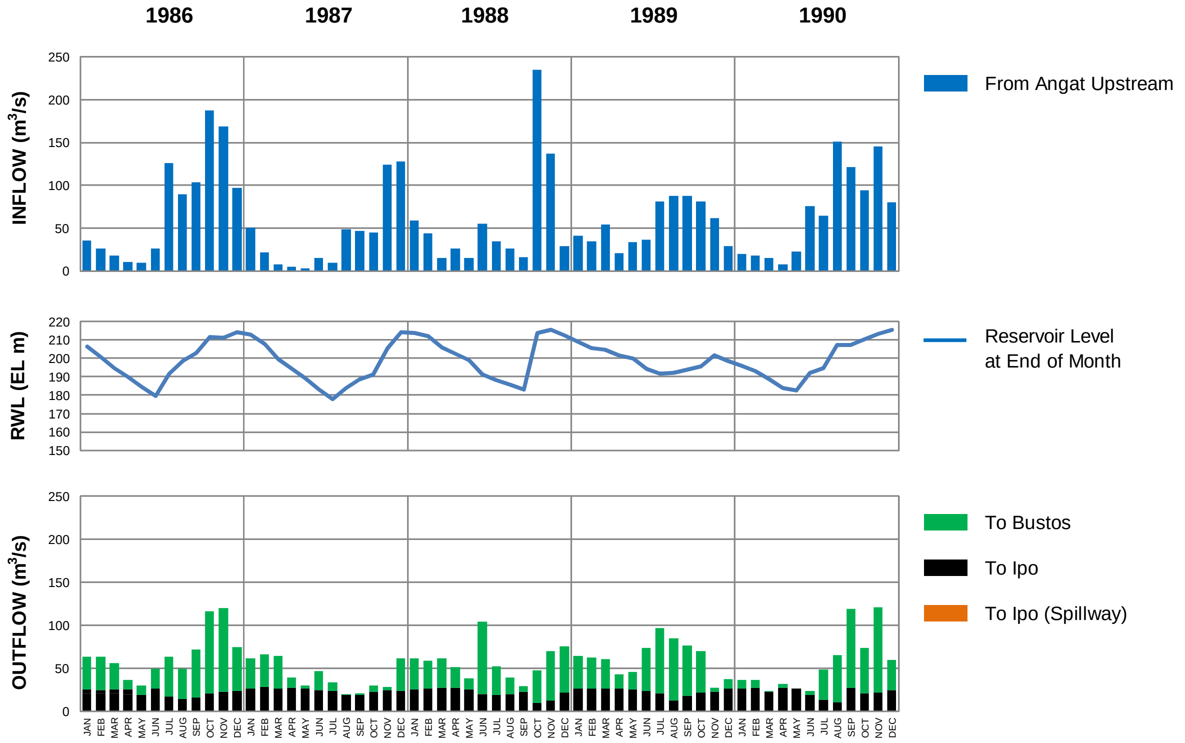


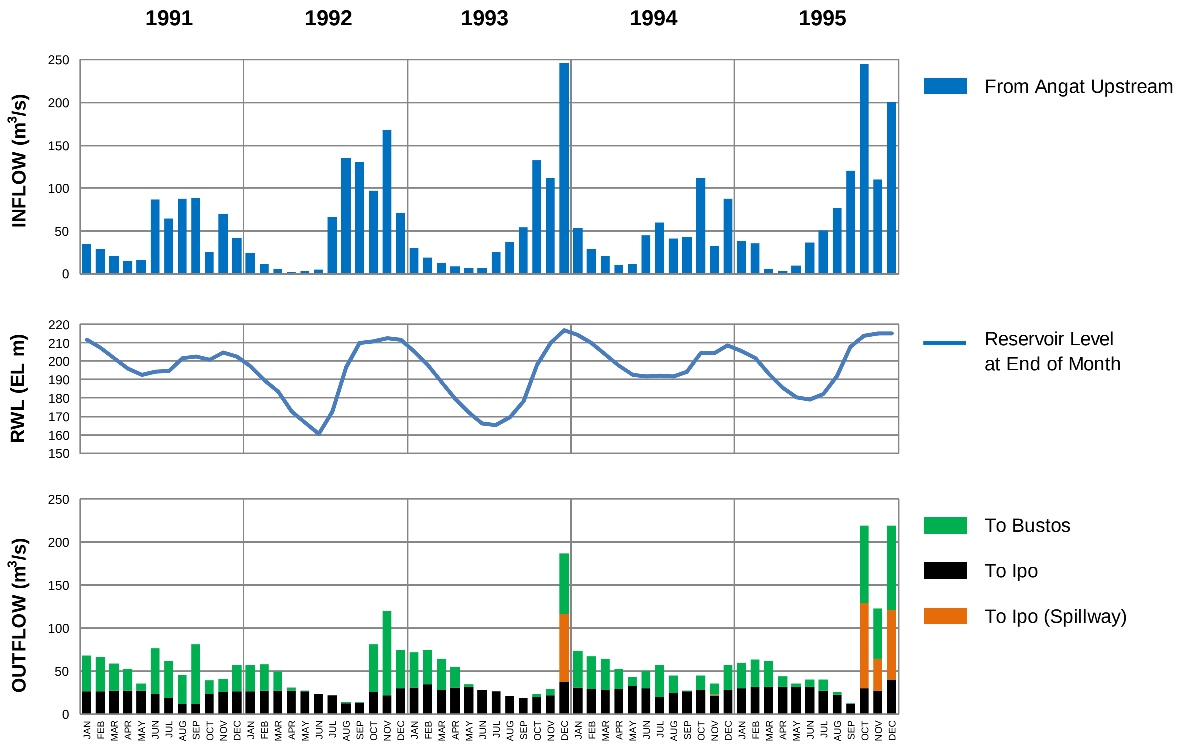
Annex 7.1.2 (2/5)
Monthly Inflows, Reservoir Levels and Outflows of Angat Reservoir



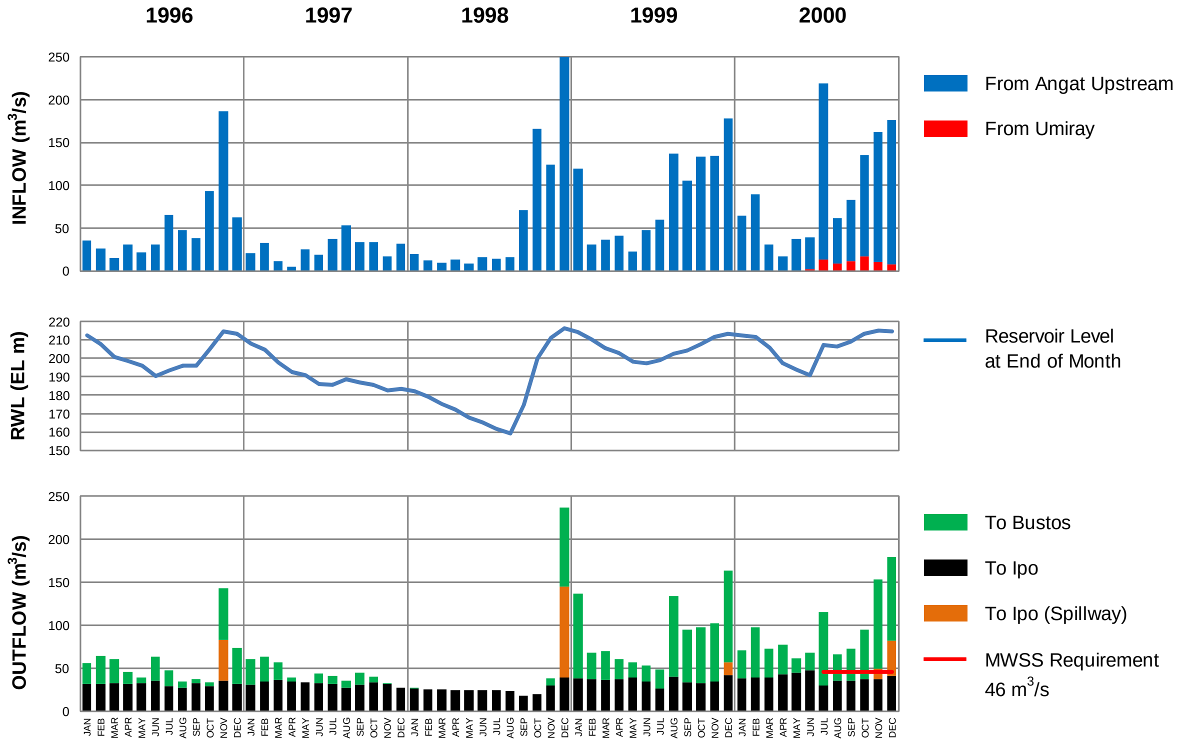


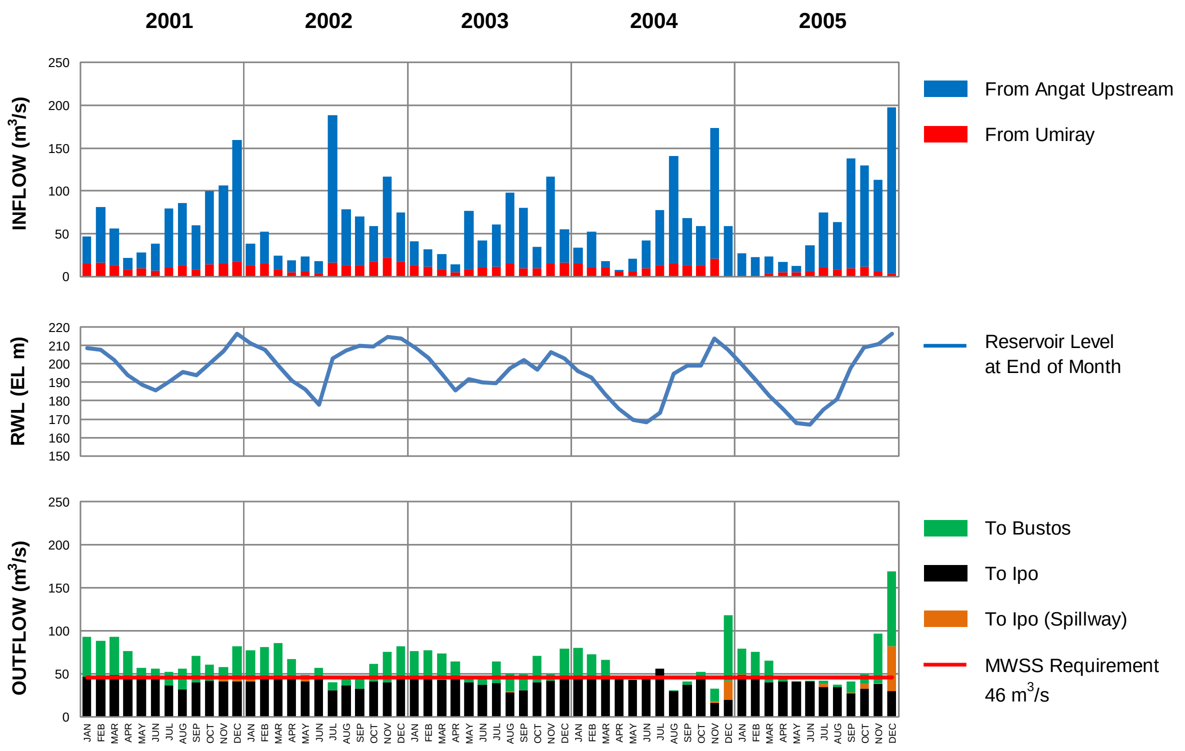
Annex 7.1.2 (3/5)
Monthly Inflows, Reservoir Levels and Outflows of Angat Reservoir



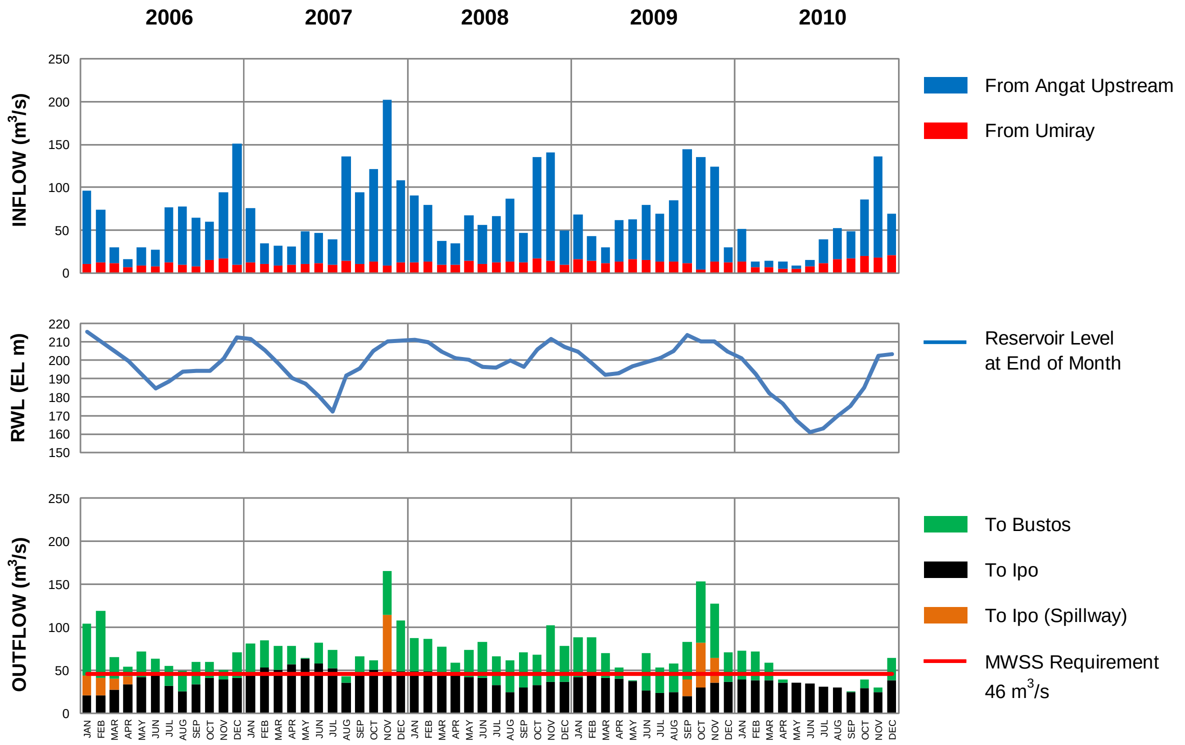


Annex 7.1.2 (4/5)
Monthly Inflows, Reservoir Levels and Outflows of Angat Reservoir





Annex 7.1.2 (5/5)
Monthly Inflows, Reservoir Levels and Outflows of Angat Reservoir



Annex 7.1.3
Technical Features of Ipo Dam and La Mesa Dam

Ipo Dam

Completion	1984
Purpose	Water Intake for Metro Manila Water Supply
Type of Dam	Concrete Gravity
Height of Dam	32m
Crest Length of Dam	202m
Crest Elevation of Dam	EL 103.50m
Crest Elevation of Overflow Section	EL 89.00m
Spillway	Radial Gates, 7 nos.
Height of Spillway Gate	12.00m
Width of Spillway Gate	10.00m × nos. and 14.00m × 5 nos.
Catchment Area	66km^2
Reservoir Surface Area	1.08 km^2
Reservoir Inflow	127.8 MCM/yr (from Upstream Catchment Area)
Gross Storage	7.5 MCM
Design Flood Level	EL 101.20 m
Minimum Operation Level	EL 93.00 m
Intake	Inlet Gates: 1.50m(B) × 2.50m(H) × 1 no. Invert Level EL 93.00m 1.50m(B) × 3.25m(H) × 3 nos. Invert Level EL 95.75m
Water Conveyance Tunnel	No.1: Horseshoe 2.04m × 2.19m, L = 6.4km, Q = 8.80m^3/s No.2: Horseshoe 2.20m × 3.00, L =6.4km, Q = 23.03m^3/s No.3: Circular 3.00m, L = 6.1km, Q = 23.15m^3/s
Low Level Outlet	D = 1.50m

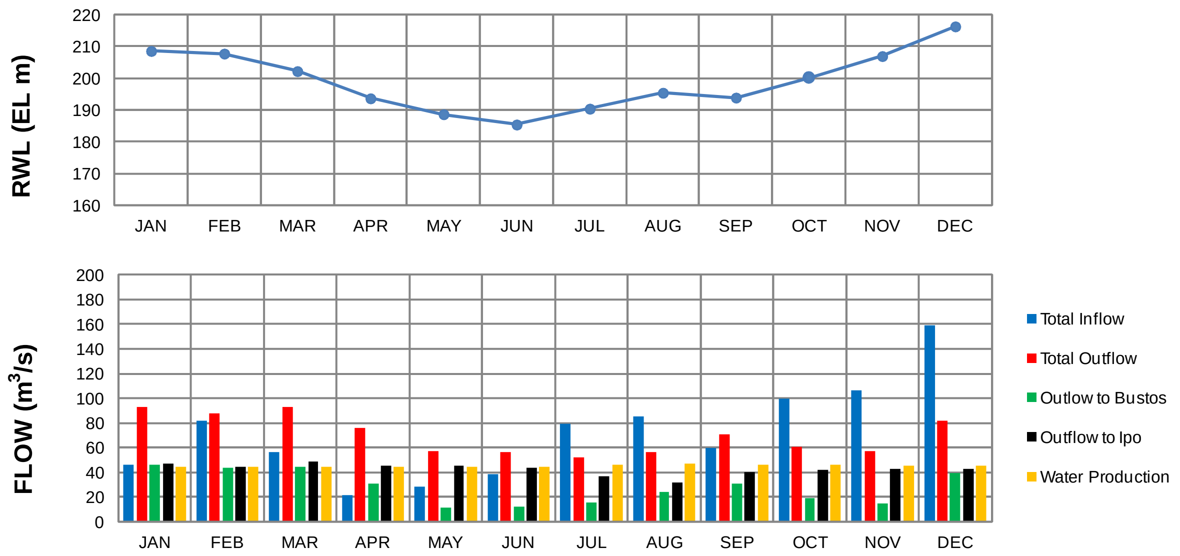
La Mesa Dam

Completion	1929
Purpose	Water Intake for Metro Manila Water Supply
Type of Dam	Earth
Height of Dam	24m
Crest Length of Dam	
Crest Elevation of Dam	EL 82.50m
Crest Elevation of Overflow Section	EL 80.15m
Catchment Area	2.7km^2
Reservoir Surface Area	7.0km^2
Reservoir Inflow	37 MCM/yr (from Upstream Catchment Area)
Gross Storage	50.5 MCM/yr
Design Flood Level	
Minimum Operation Level	EL 69.00m
Intake	3 nos.
Water Conveyance Pipeline	No.1: Horseshoe 1.70m×2.03m, L = 7.5km, Q = 6.6m^3/s No.2: Horseshoe 1.70m×2.03m, L = 7.5km, Q = 6.6m^3/s No.3: Horseshoe 2.70m×2.90m, L = 7.1km, Q = 13.2m^3/s

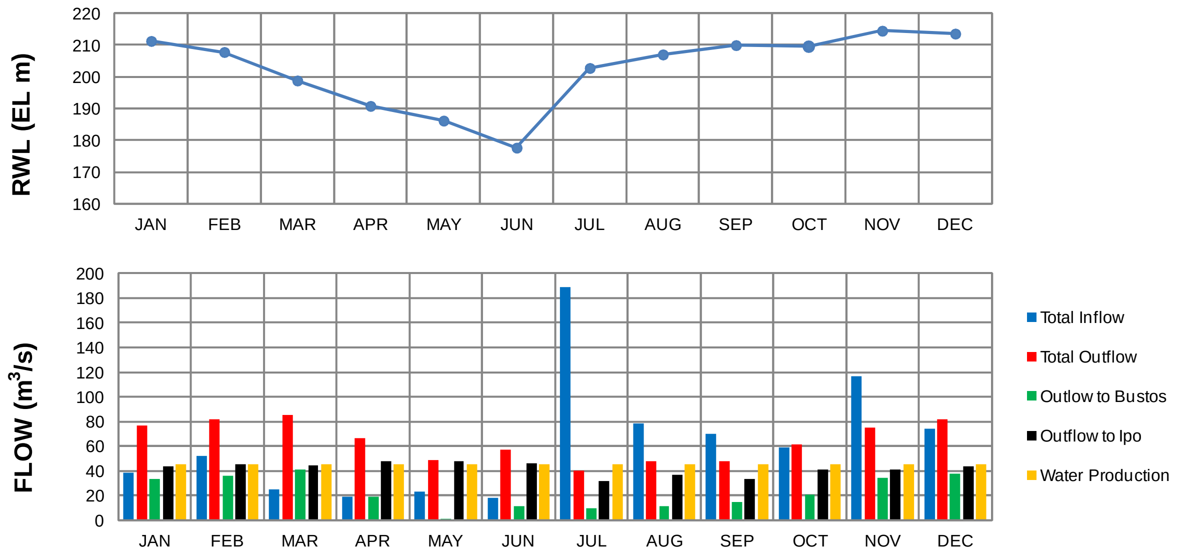
Source:
- Data provided by MWSS
- Technical Manual (Manila Water)

Annex 7.1.4 (1/5)
Angat Reservoir Level, Total Inflow, Total Outflow, Outflow to Bustos Dam, Outflow to Ipo Dam, and Total of Treated Water Production at WTPs for 2001-2010

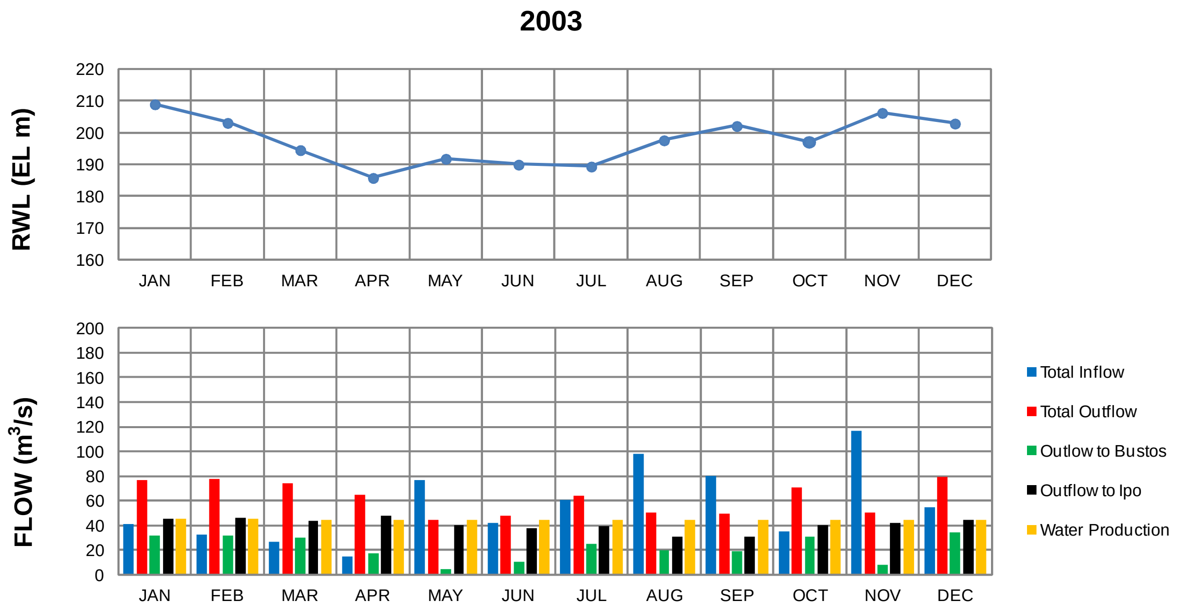
2001

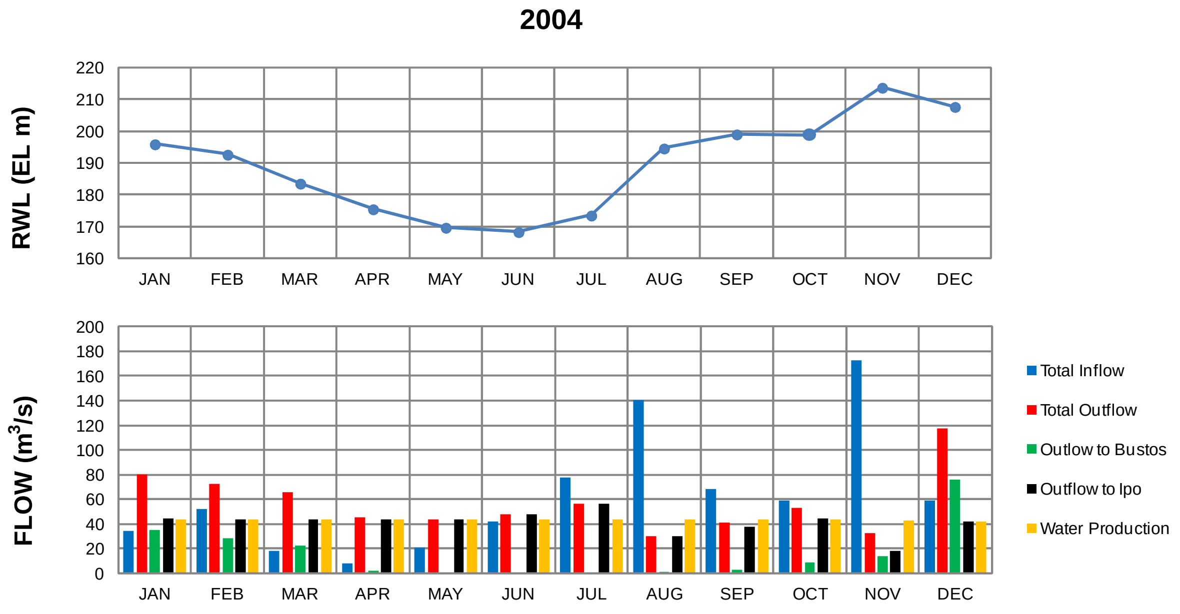


2002



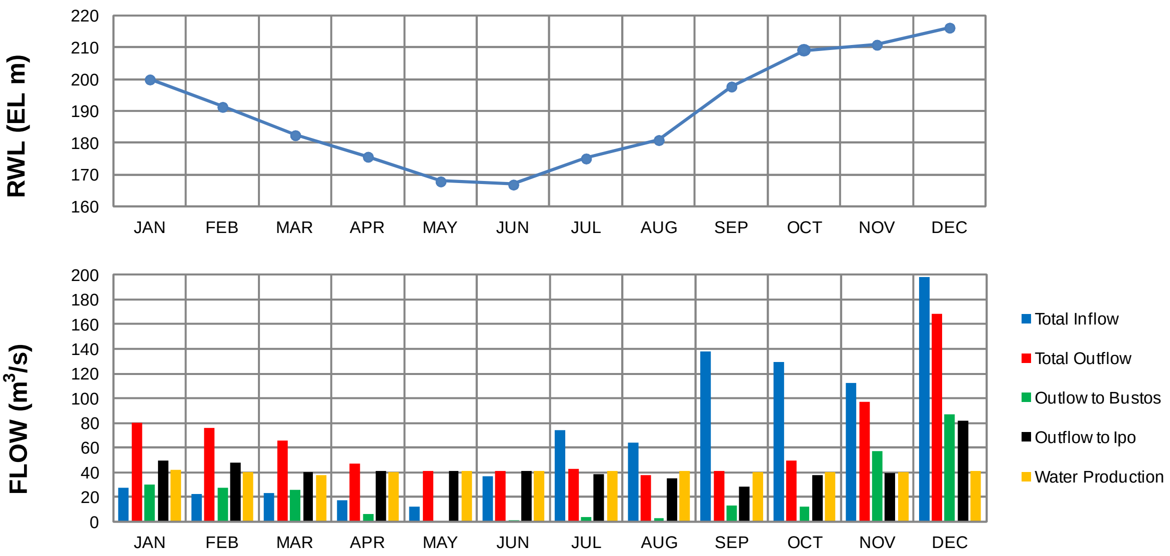
Annex 7.1.4 (2/5)
Angat Reservoir Level, Total Inflow, Total Outflow, Outflow to Bustos Dam, Outflow to Ipo Dam, and Total of Treated Water Production at WTPs for 2001-2010



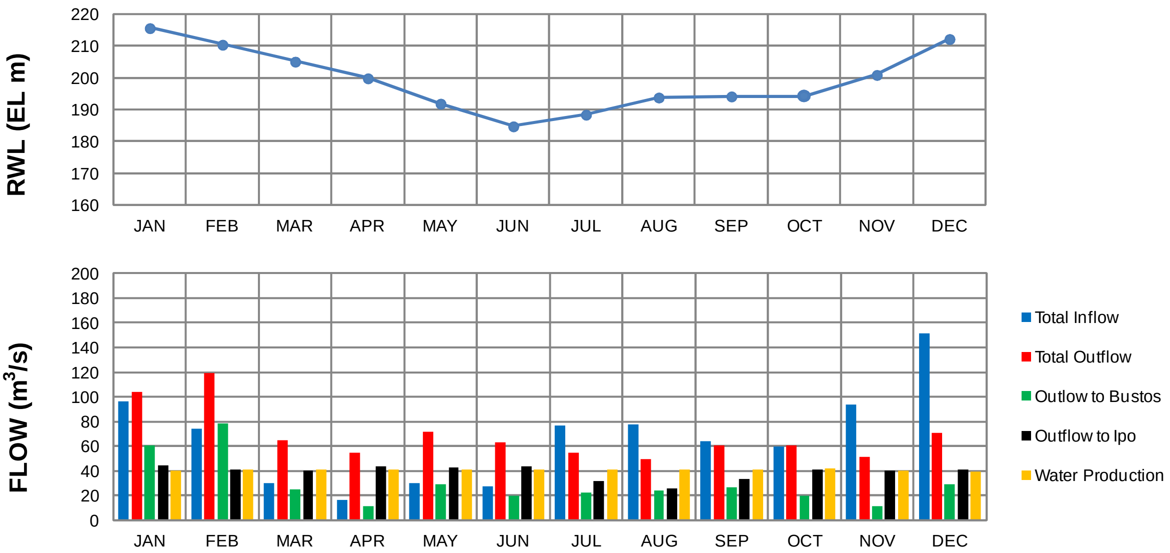


Annex 7.1.4 (3/5)
Angat Reservoir Level, Total Inflow, Total Outflow, Outflow to Bustos Dam, Outflow to Ipo Dam, and Total of Treated Water Production at WTPs for 2001-2010

2005

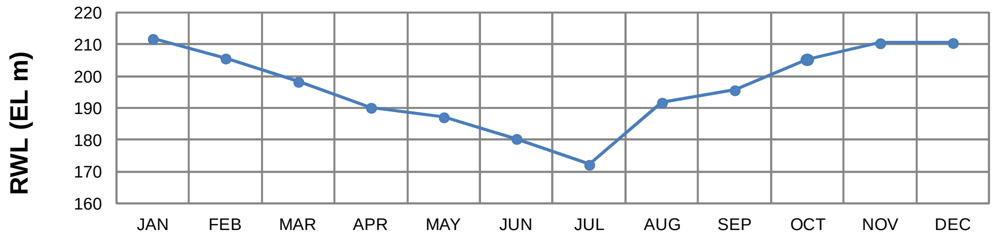


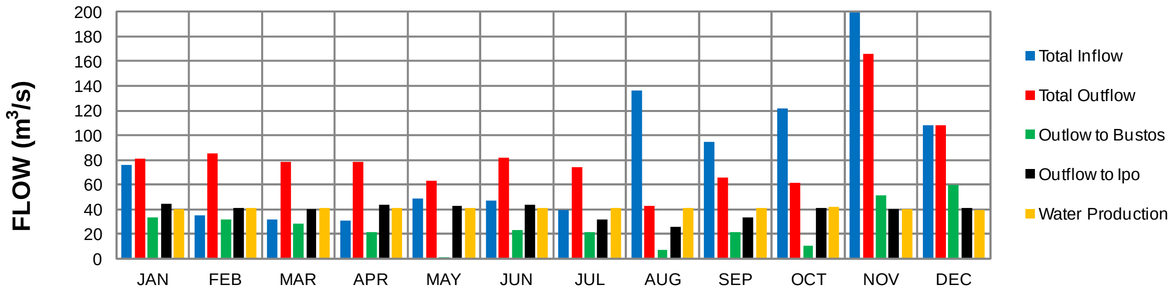
2006



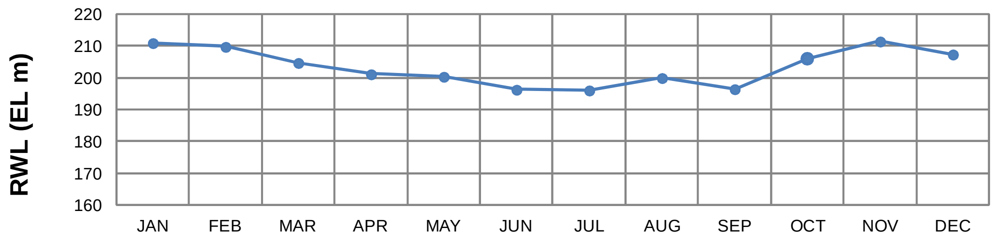
Annex 7.1.4 (4/5)
Angat Reservoir Level, Total Inflow, Total Outflow, Outflow to Bustos Dam, Outflow to Ipo Dam, and Total of Treated Water Production at WTPs for 2001-2010

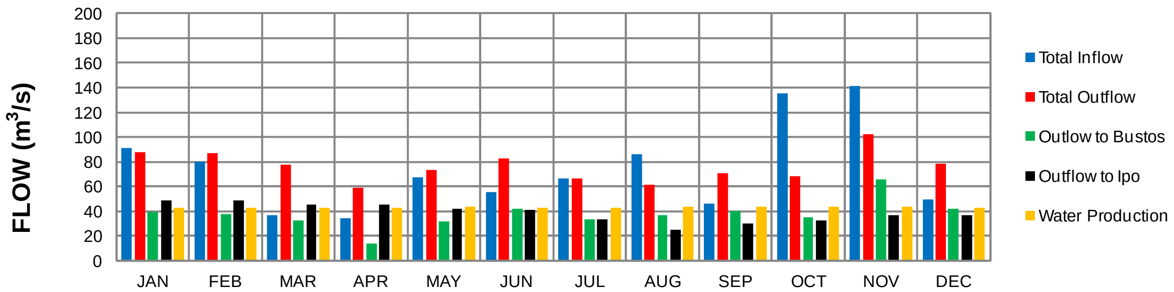
2007





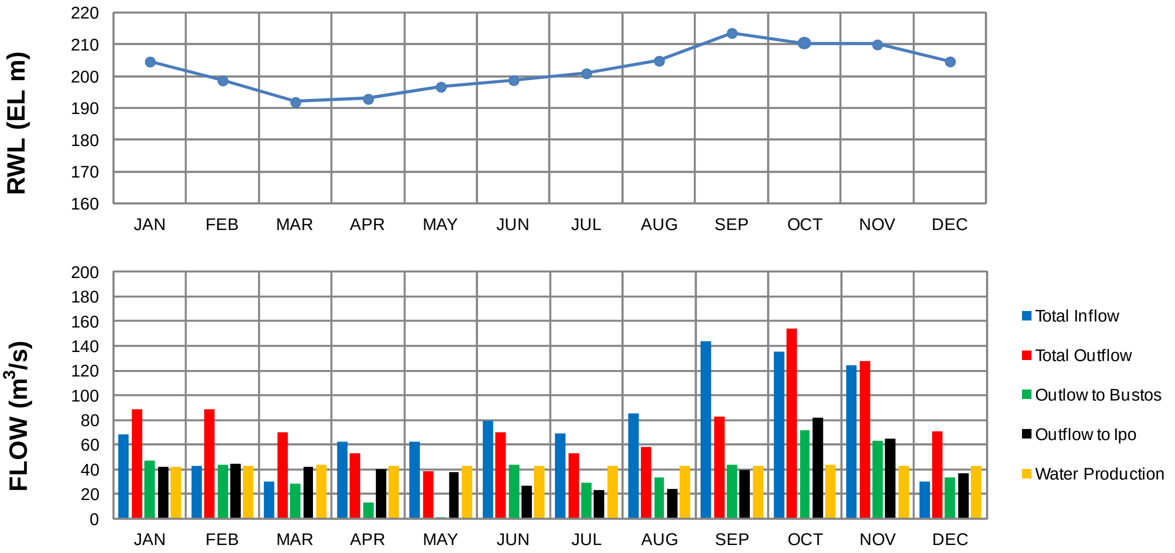
2008



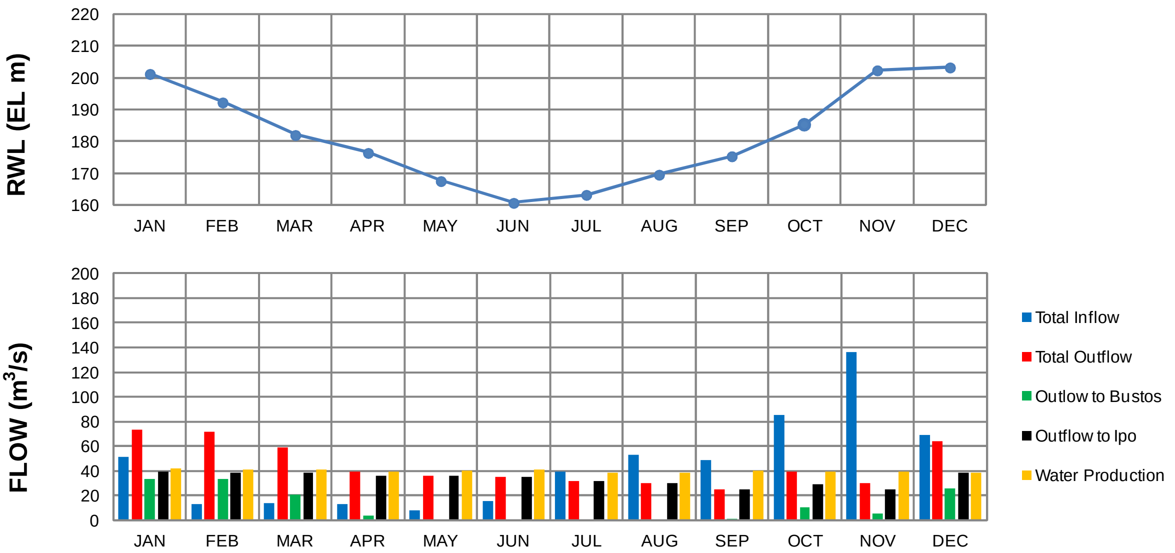


Annex 7.1.4 (5/5)
Angat Reservoir Level, Total Inflow, Total Outflow, Outflow to Bustos Dam, Outflow to Ipo Dam, and Total of Treated Water Production at WTPs for 2001-2010

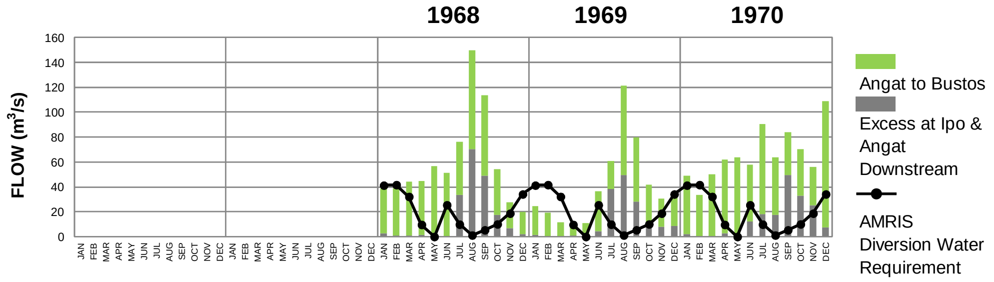
2009

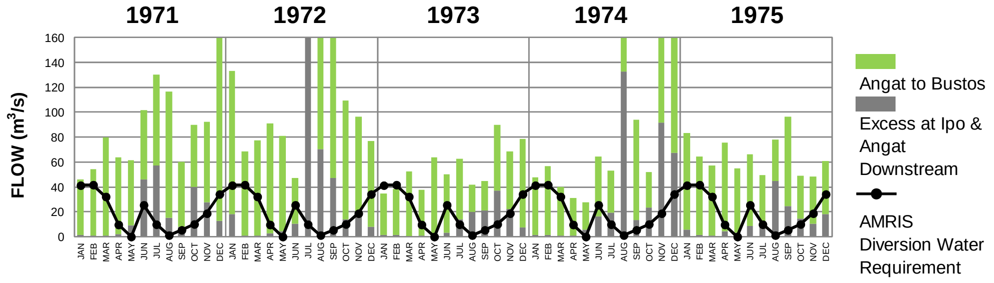


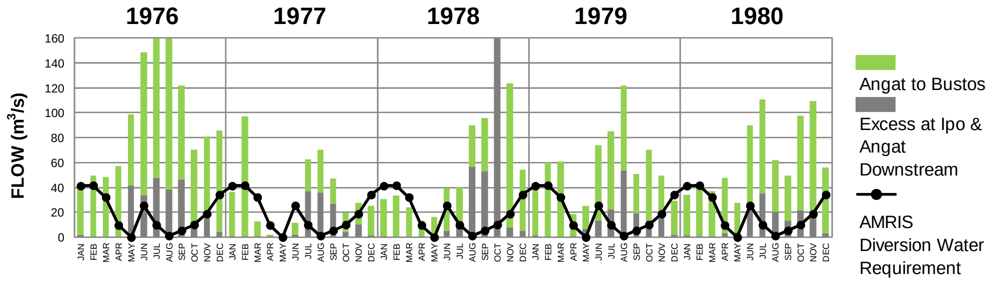
2010

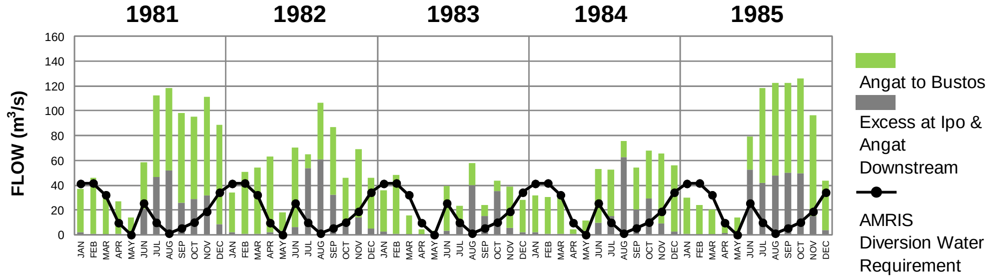


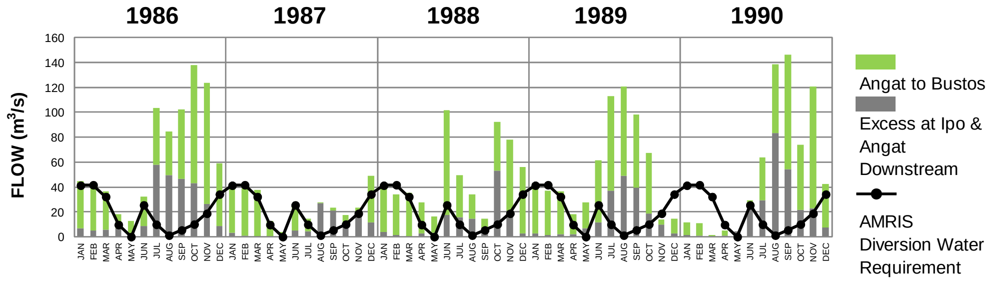
Annex 7.1.5 (1/2)
River Flow at Bustos Dam and Diversion Water Requirement of AMRIS



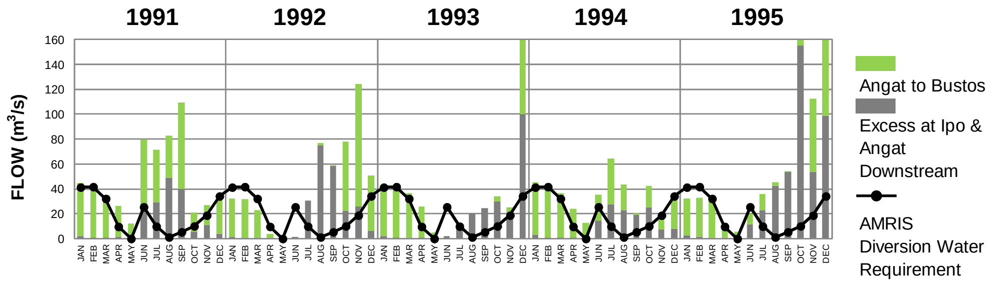


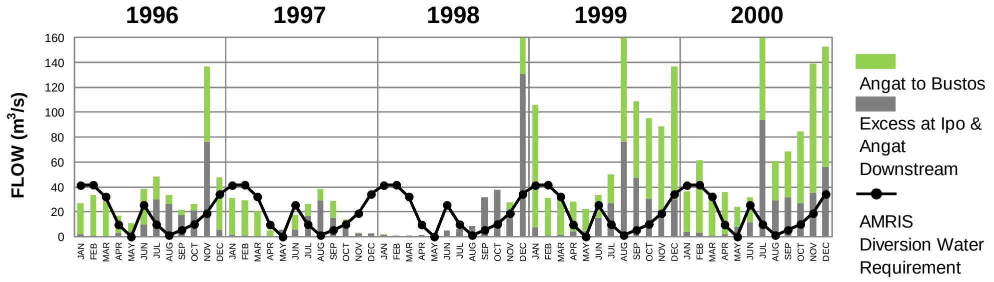


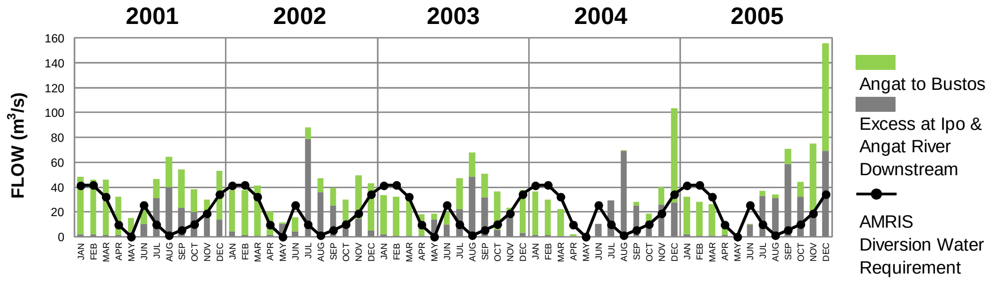


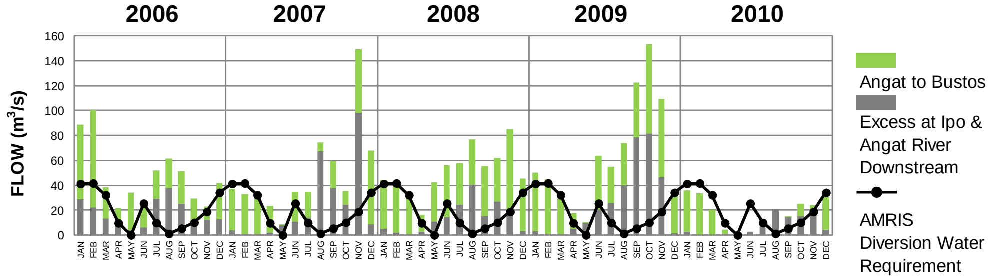


Annex 7.1.5 (2/2)
River Flow at Bustos Dam and Diversion Water Requirement of AMRIS

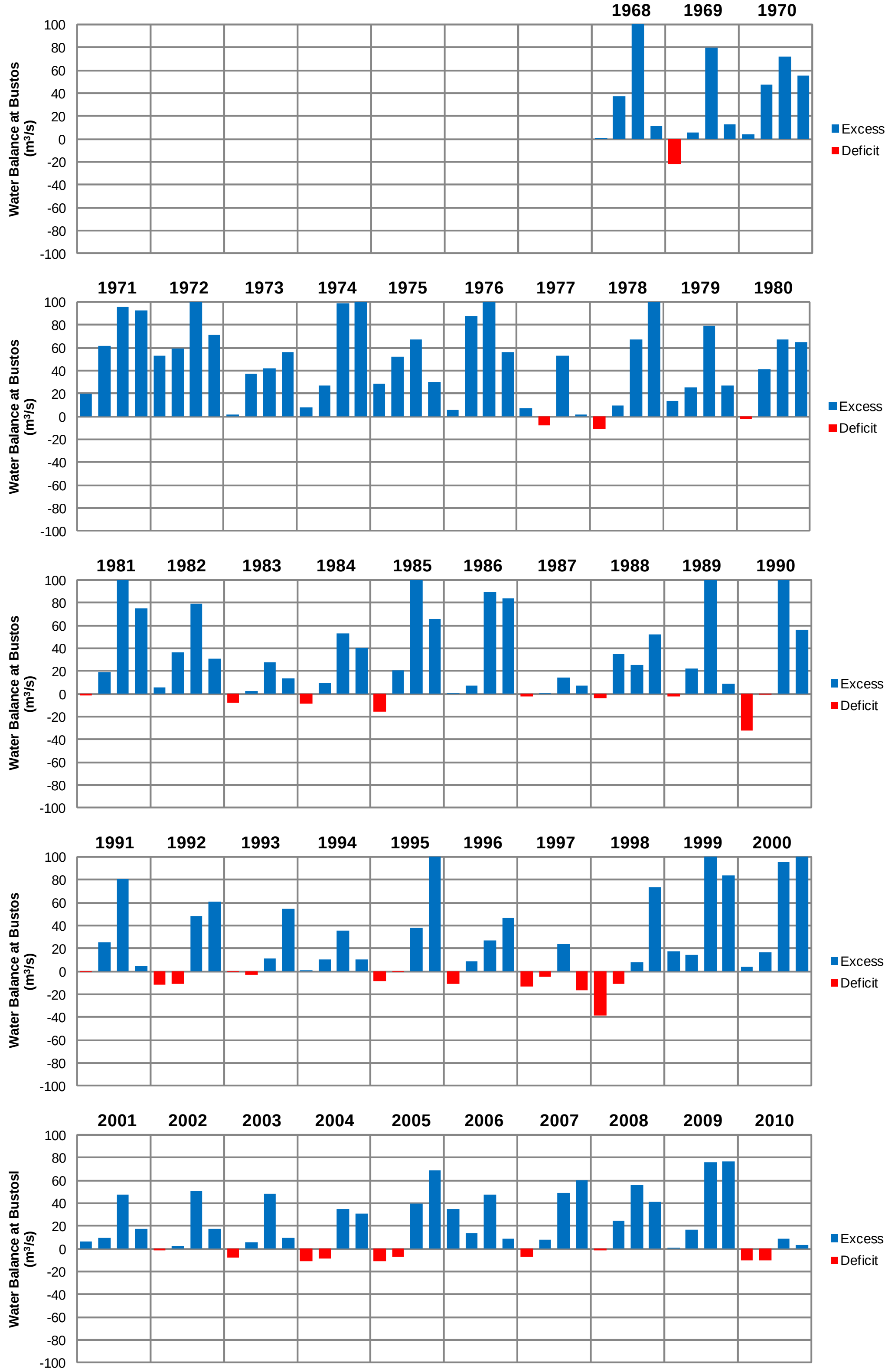








Annex 7.1.6
Computations of Water Balance at Bustos Dam

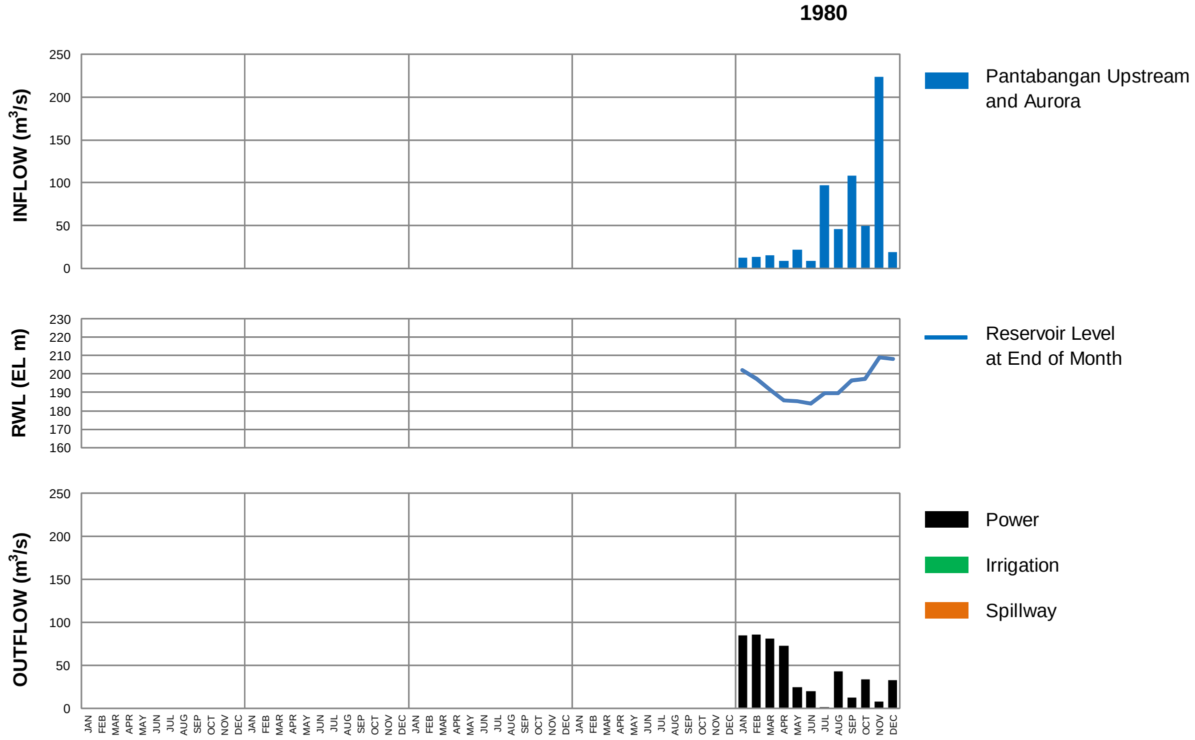


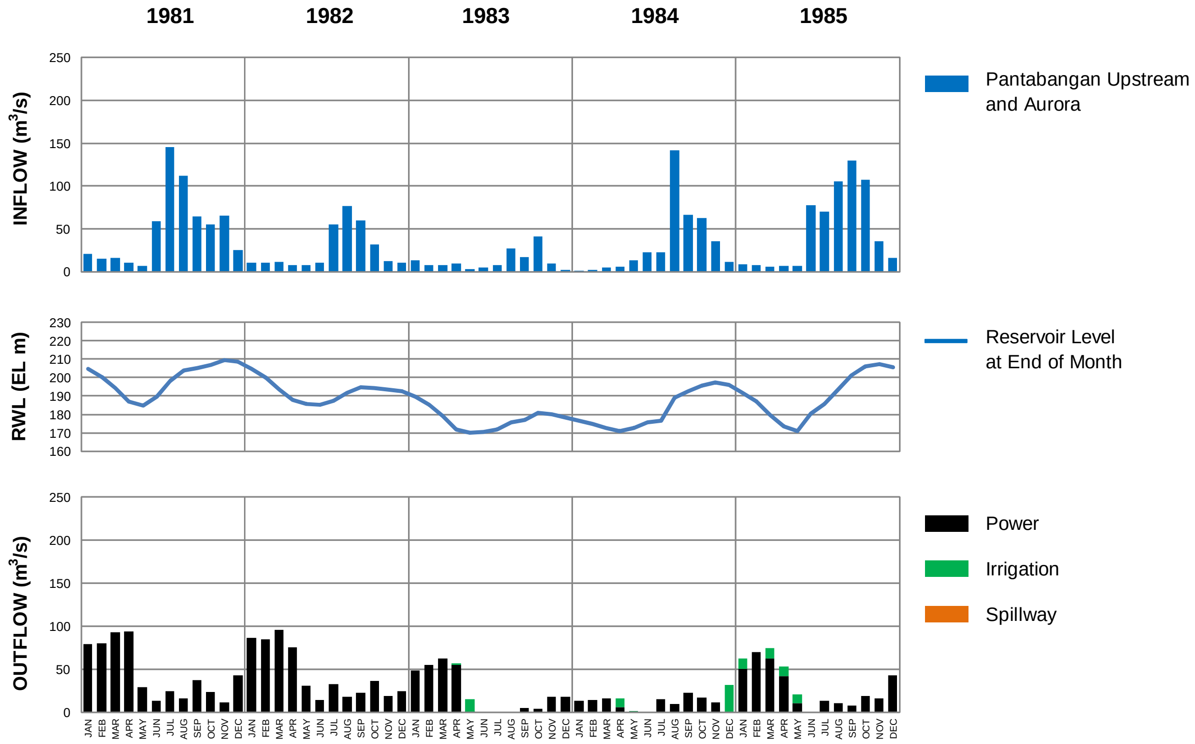
Annex 7.1.7
Technical Features of Pantabangan Reservoir

Completion	February 1974
Purpose	Hydropower, Irrigation and Flood Control
Type of Dam	Zoned Earth Fill
Height of Dam	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 (= 1,195 MCM/yr) Casecnan Transbasin Diversion: 23.8 m^3/s (= 751 MCM/yr)
Effective Storage	2,775MCM
Peak of Design Flood Inflow	13,000 m^3/s
Discharge Capacity of Spillway with Reservoir Water Level at Design Flood Water Level of EL. 230 m	4,200 m^3/s
Minimum of Flood Inflow	500 m^3/s
Dam Crest Elevation	EL 232.00 m
Crest Elevation of Non-gated Overflow Weir	EL 221.00 m
Crest Elevation of Gated Overflow Weir	EL 210.00 m
Number of Spillway Orifice Gates	3
Height of Spillway Orifice Gate	10.00 m
Width of Spillway Gate	8.00 m
Length of Non-gated Overflow Weir	15.00 m
Operation Speed of Spillway Gates	0.30 m/min.
Reservoir Surface Area at NHWL	63.1 km^2
Design Flood Water Level (DHWL)	EL 230.00 m
Surcharge Water Level (SWL)	EL 226.00 m
Normal High Water Level (NHWL)	EL 221.00 m
Flood Season High Water Level (FSHWL) from May to November	EL 216.00 m
Low Water Level (LWL)	EL 171.50 m

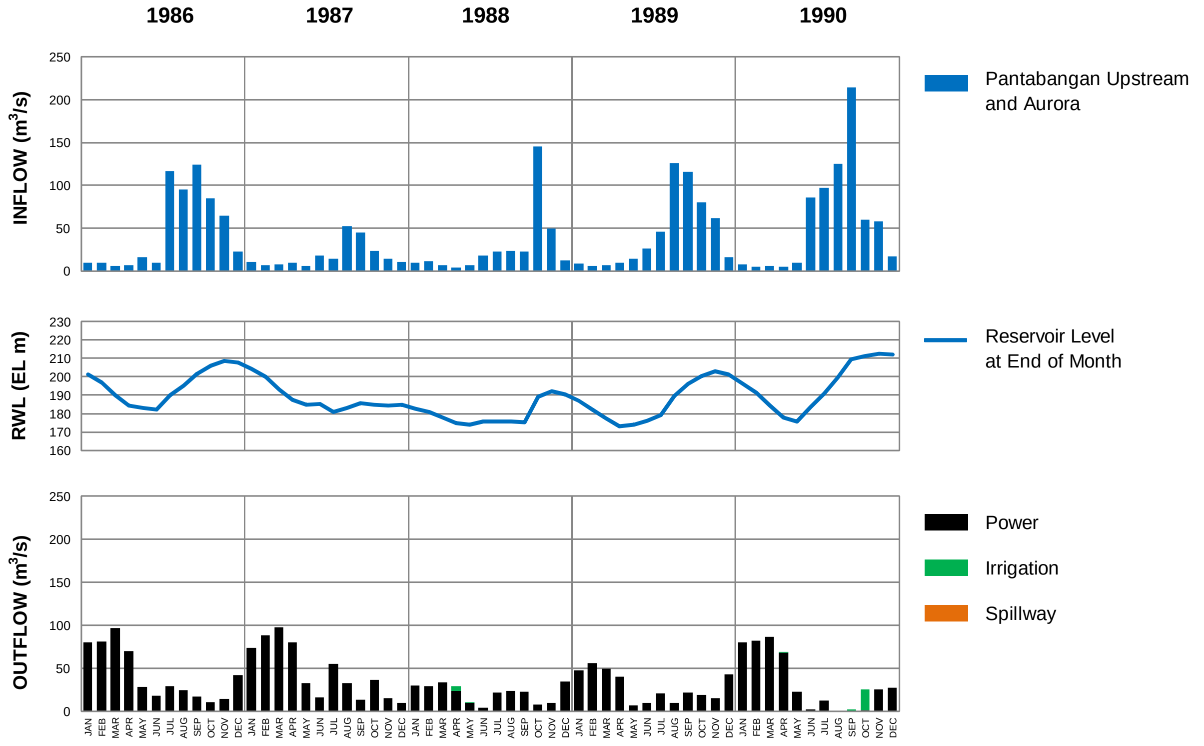
- The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in Pampanga River Basin, Final Report (JICA/NWRB, 2011)
- Flood Operation Rule (Draft) for Angat Dam, Flood Forecasting and Warning System for Dam Operation Project, PAGASA / NIA / NPC, 1984

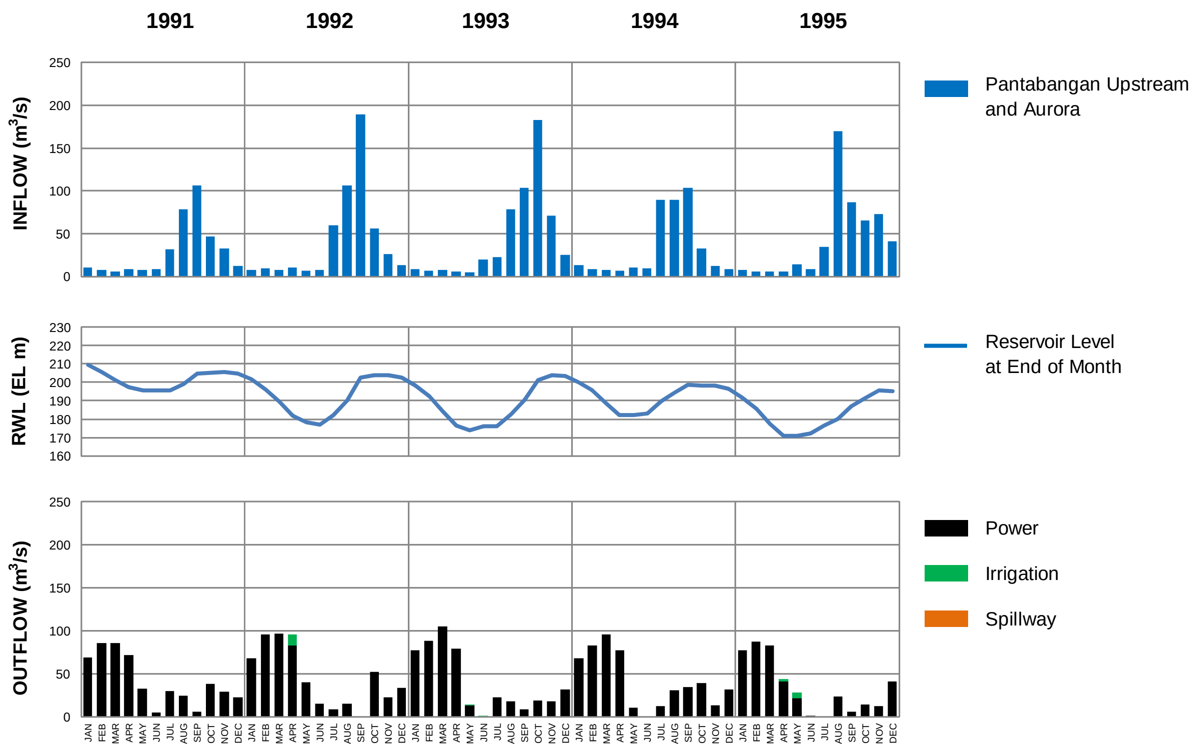
Annex 7.1.8 (1/4)
Monthly Inflows, Reservoir Levels and Outflows of Pantabangan Reservoir



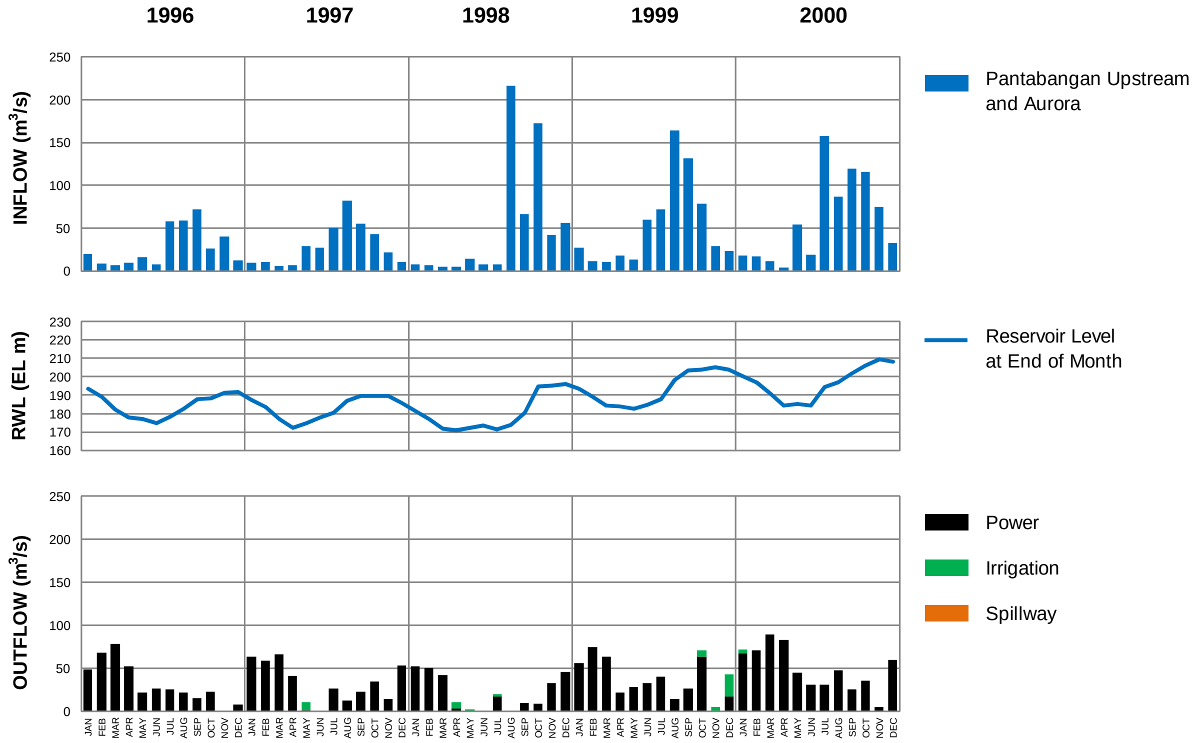


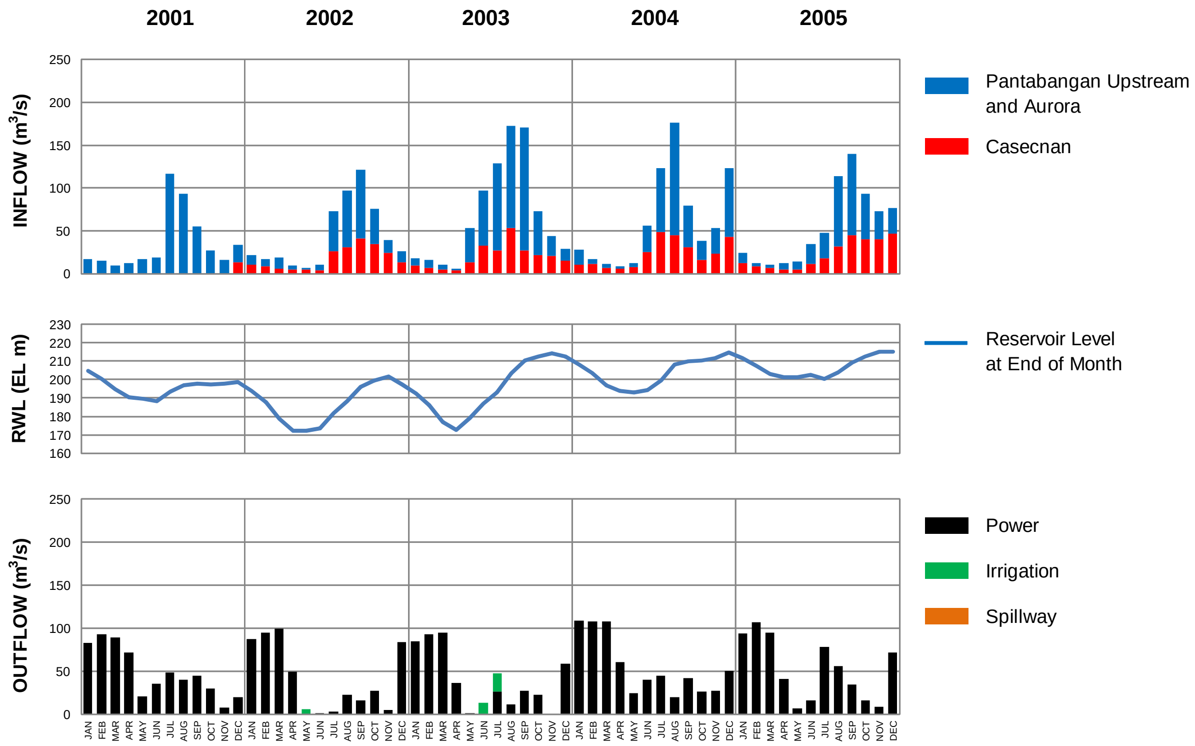
Annex 7.1.8 (2/4)
Monthly Inflows, Reservoir Levels and Outflows of Pantabangan Reservoir



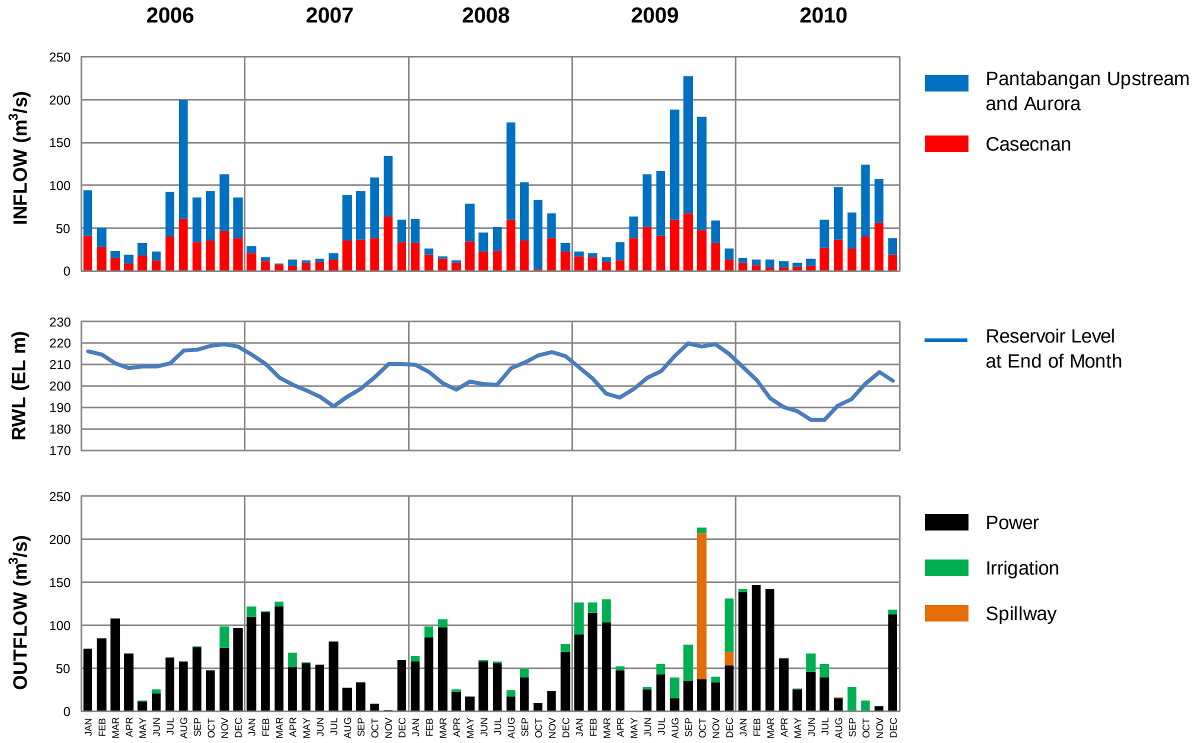


Annex 7.1.8 (3/4)
Monthly Inflows, Reservoir Levels and Outflows of Pantabangan Reservoir



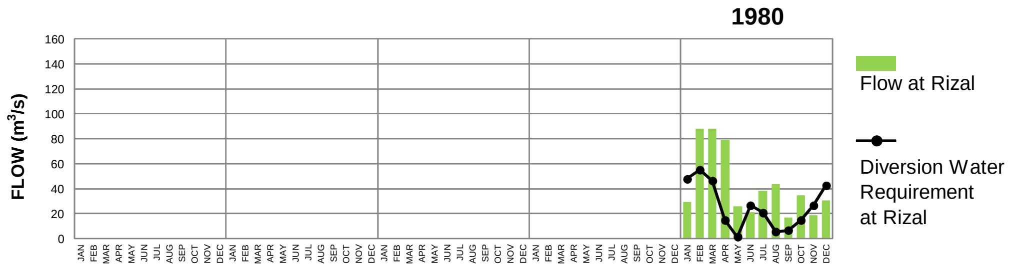


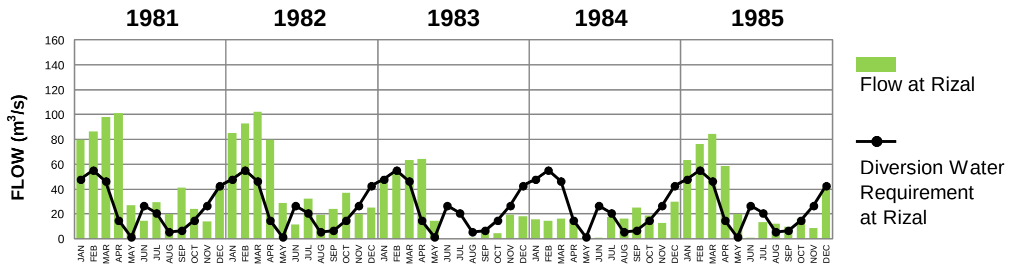
Annex 7.1.8 (4/4)
Monthly Inflows, Reservoir Levels and Outflows of Pantabangan Reservoir

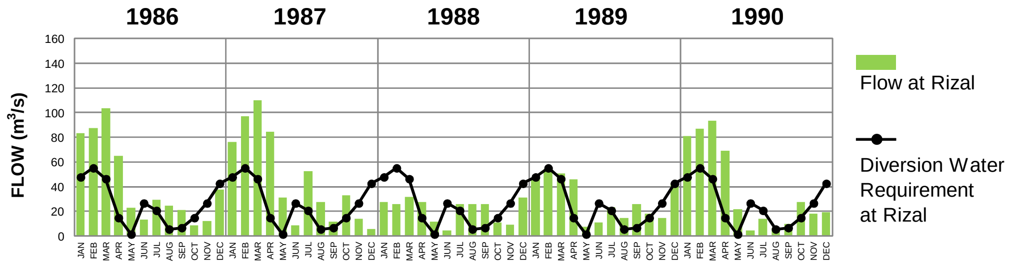


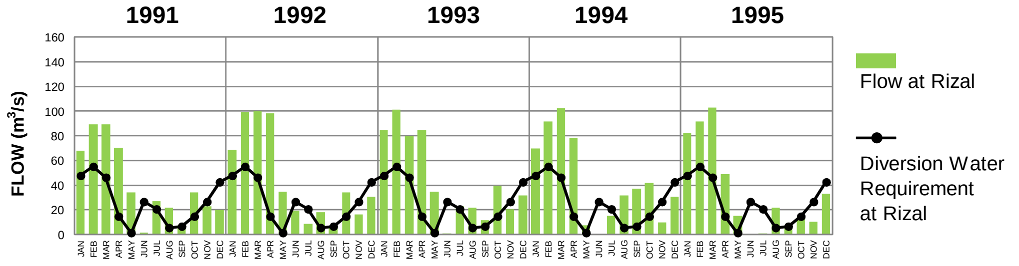
Note: The recorded out flows in Nov. 2007 and May 2009 are almost nil.

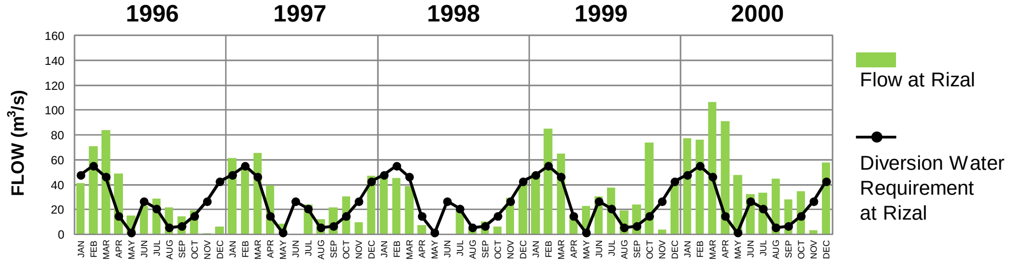
Annex 7.1.9 (1/2)
River Flow at Rizal Dam and Diversion Water Requirement of UPRIIS



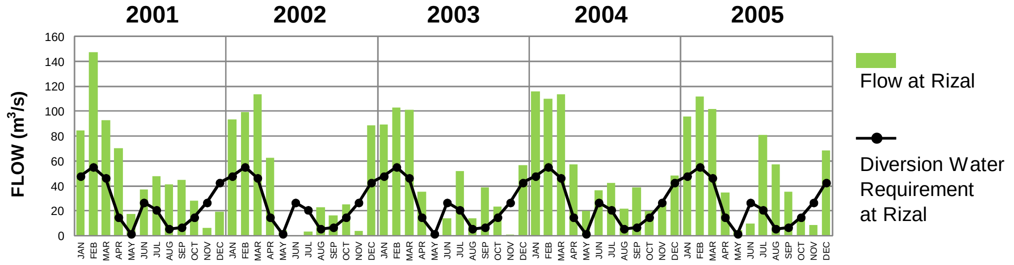


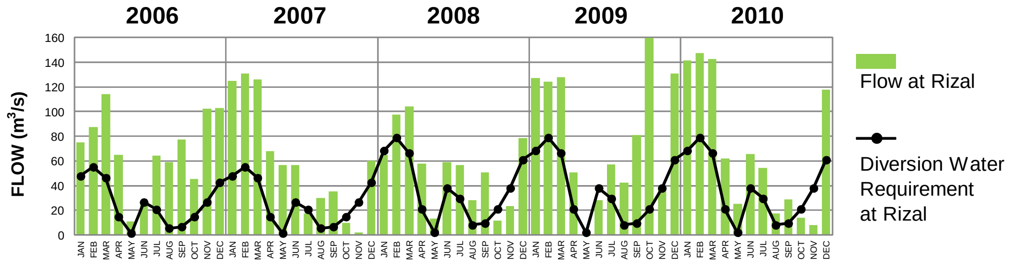




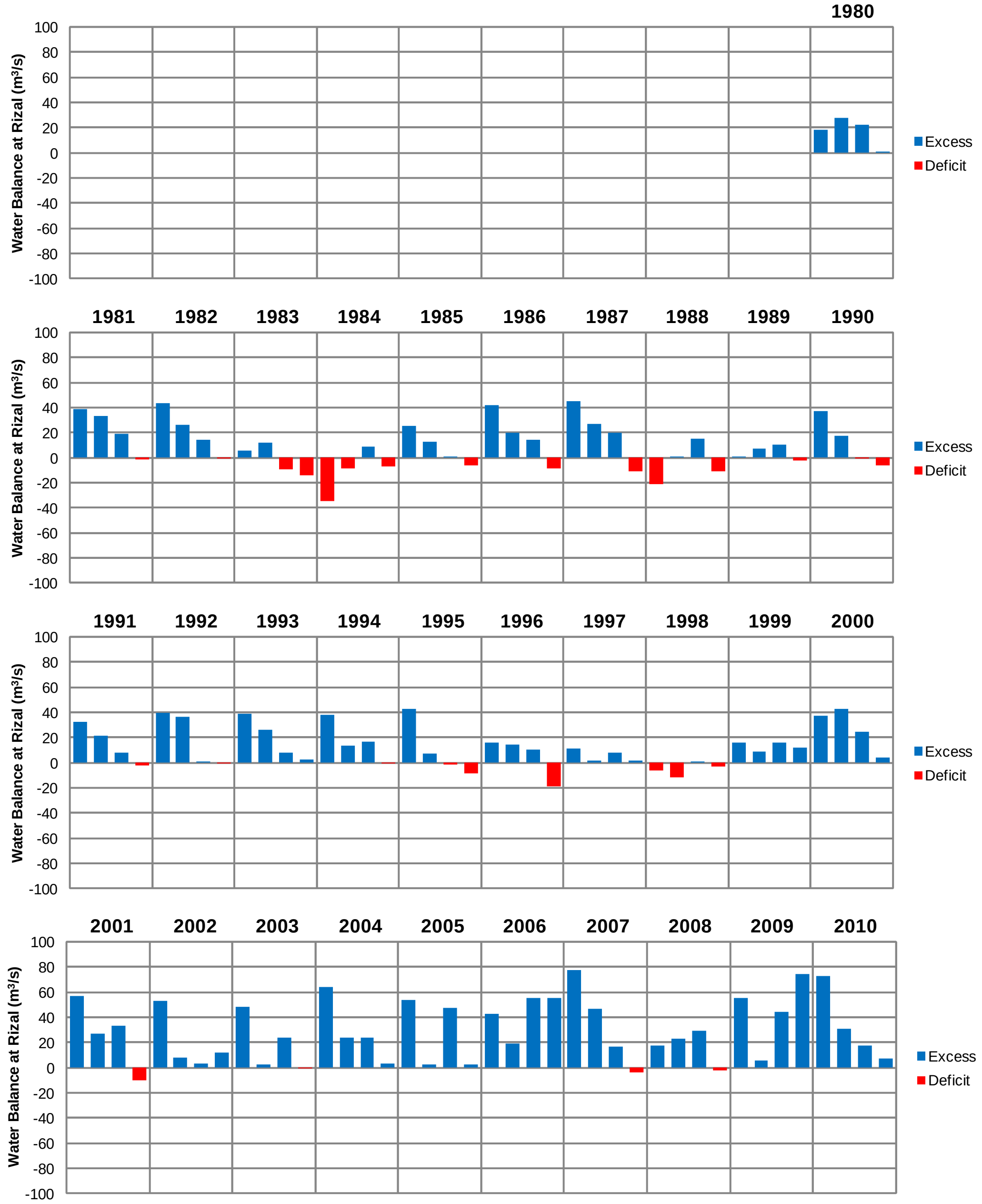


Annex 7.1.9 (2/2)
River Flow at Rizal Dam and Diversion Water Requirement of UPRIIS





Annex 7.1.10
Computations of Water Balance at Rizal Dam



Annex 7.3.1. Comparison of Service Indicators (Target and Actual Figures)

Indicators	Area		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
W1: Number of Total Service Connection (Thousand)	MWCI	Actual	311	324	333	339	353	370	426	463	503	562	639	684	736	813	-	-
		Bid Forecast	277	301	327	354	379	402	426	451	477	505	520	536	553	571	586	602
		Forecast at Rate Rebasing	-	-	-	-	-	-	381	396	413	430	447	685	754	780	812	826
	MWSI	Actual	458	469	518	571	602	598	612	629	649	703	729	762	815	912	-	-
		Bid Forecast	471	505	539	572	617	640	662	685	708	731	743	756	768	781	794	808
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	748	800	870	958	990
S1: Sewerage Connection (Thousand)	MWCI	Actual	21.8	22.2	22.8	25.3	27.2	28.2	29.3	29.4	29.5	29.6	29.8	30.0	34.0	68.9	-	-
		Bid Forecast	10.0	10.0	10.0	10.0	11.0	21.0	33.0	47.0	60.0	76.0	111.0	150.0	190.0	233.0	277.0	283.0
		Forecast at Rate Rebasing	-	-	-	-	-	-	25.9	26.1	26.4	26.6	26.8	49.0	58.0	68.0	106.0	106.0
	MWSI	Actual	56.0	56.0	61.0	63.0	61.0	58.0	56.0	55.0	53.0	51.0	38.0	38.0	42.0	44.0	-	-
		Bid Forecast	59.0	60.0	62.0	63.0	102.0	110.0	119.0	128.0	138.0	147.0	151.0	155.0	159.0	163.0	167.0	187.0
		Forecast at Rate Rebasing	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	40.0	41.0	42.0		
IN1: Billed Volume (MLD)	MWCI	Actual	495	517	637	683	733	748	756	797	852	919	1023	1059	1069	1121	-	-
		Bid Forecast	504	643	825	944	1,041	1,110	1,183	1,250	1,335	1,413	1,458	1,500	1,553	1,602	1,660	1,713
		Forecast at Rate Rebasing	-	-	-	-	-	-	782	814	881	913	945	1,074	1,107	1,133	1,171	1,199
	MWSI	Actual	642	546	676	749	797	741	718	706	690	713	780	870	978	1026		
		Bid Forecast	500	966	1,168	1,394	1,544	1,603	1,659	1,707	1,765	1,826	1,874	1,921	1,969	2,071	2,064	2,120
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	715	749	838	939	904	1,044	1,198	1,355	1,376
Production Volume (MLD)	MWCI	Actual	1,542	1,261	1,668	1,690	1,725	1,663	1,578	1,518	1,376	1,346	1,378	1,341	1,316	1,287	1,277	-
	MWSI	Actual	1,900	1,517	2,190	2,252	2,417	2,363	2,313	2,276	2,168	2,229	2,293	2,405	2,426	2,215	2,143	-
Average Tariff (Rs./m3)	MWCI	Actual	4.02	4.02	4.37	4.56	5.47	8.38	13.52	14.01	18.58	19.90	20.51	26.55	27.99	29.98	36.00	-
	MWSI	Actual	7.21	7.21	8.22	8.62	10.18	12.52	19.92	19.92	20.19	32.42	32.86	33.02	31.19	37.40	40.80	-
	Ave.	CPI Adjusted Average Tariff from 1996 Tariff Level (8.78Rs./m3)	9.27	10.13	10.73	11.16	11.92	12.28	12.71	13.47	14.49	15.39	15.82	17.29	17.84	18.52	19.33	-
NRW rate (%)	MWCI	Actual	45	39	40	43	48	52	51	43	35	30	24	20	16	13	-	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	25	25	25	25	25
	MWSI	Actual	66	62	69	67	69	69	69	68	66	64	66	64	57	51	-	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	62	57	51	46	40
W2: Continuity of Supply (24hours)	MWCI	Actual	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99%	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98%	-
	MWSI	Actual	-	-	-	-	-	-	-	-	-	-	-	58%	65%	71%	84%	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	56%	69%	83%	96%	100%
W3: Water Pressure (7 psi and avobe)	MWCI	Actual	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99%	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82%	-
	MWSI	Actual	-	-	-	-	-	-	-	-	-	-	-	67%	79%	86%	96%	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	57%	64%	85%	95%	100%
CA1: CAPEX (Million PHP)	MWCI	Actual	-	-	-	-	-	-	-	-	-	-	-	4,128	5,019	8,658	-	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	4,002	6,466	7,984	8,755	5,914
	MWSI	Actual	-	-	-	-	-	-	-	-	-	-	-	5,997	6,711	8,013	-	-
		Forecast at Rate Rebasing	-	-	-	-	-	-	-	-	-	-	-	7,655	6,487	7,900	7,423	7,346

Annex 7.3.2 Financial Data of MWCI and MWSI

	MWSI					MWCI				
	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Balance Sheet										
Assets	24,682	24,458	34,752	38,179	42,590	24,263	27,941	36,369	43,611	47,400
Current Assests	5,037	4,056	9,121	7,299	4,407	7,496	4,122	8,595	8,770	5,451
Noncurrent Assets	19,645	20,402	25,631	30,881	38,183	16,767	23,819	27,774	34,841	41,949
Service Concession Assets - net	12,774	17,145	22,237	29,063	36,189	16,186	21,914	23,914	29,662	36,230
Other Noncurrent Assets	6,871	3,257	3,394	1,818	1,994	581	1,905	3,860	5,179	5,719
Liabilities and Equity	24,682	24,458	34,752	38,179	42,590	24,263	27,941	36,369	43,611	47,400
Liabilities	21,427	27,700	33,814	34,418	34,646	12,389	15,463	21,911	26,764	27,585
Current Liabilities	6,933	14,610	8,398	8,634	10,216	4,399	4,427	4,231	5,203	5,373
Noncurrent Liabilities	14,494	13,090	25,416	25,784	24,430	7,990	11,036	17,680	21,561	22,212
Interest-bearing Loans	7,333		16,456	16,305	15,598	7,130	5,995	12,897	13,300	12,713
Service Concession Obligations	4,965	8,804	5,742	8,576	7,403		3,846	3,475	6,368	6,400
Other Noncurrent Liabilities	2,196	4,286	3,218	903	1,429	860	1,195	1,308	1,893	3,099
Equity	3,255	-3,242	937	3,762	7,944	11,874	12,478	14,458	16,847	19,815
Income Statement										
Operating Revenue	6,673	7,377	8,245	10,619	12,050	6,209	7,332	8,913	9,510	10,799
Water Service	5,115	5,790	6,420	8,576	9,904	5,250	6,241	7,540	8,045	8,857
Sewerage Service (sewerage and environment	1,277	1,298	1,387	1,624	1,739	840	986	1,275	1,377	1,713
Others	281	289	438	419	407	119	105	98	88	230
Costs and Expenses	4,303	3,988	4,532	4,974	4,932	3,711	3,864	4,375	4,648	4,835
Salaries, wages and benefits	1,725	1,310	1,234	1,351	1,284	927	917	933	997	1,050
Amortization of service concession assets	739	1,124	1,283	1,323	1,059	1,116	1,283	1,724	1,772	1,145
Utilities	323	328	373	417	565	396	447	448	478	597
Materials and supplies	190	195	174	247	367	20	25	27	26	26
Provision for doubtful accounts	178	171	102	226		394	130	116	14	379
Repairs and maintenance	84	147	175	221	321	87	136	139	139	172
Depreciation and amortization	484		112	120	135	0	123	167	181	275
Regulatory Cost			81	98	13	66	76	81	98	13
Others	580	713	998	971	1,188	686	727	740	943	1,178
Income before Other Income (Expenses)	2,370	3,389	3,713	5,644	7,118	2,498	3,468	4,538	4,862	5,964
Other Income (Expenses)	-1,591	-2,290	-1,737	-1,251	-2,553	-158	117	-262	-613	-756
Interest expense	-1,248	-1,917	-1,544	-2,370	-2,163	-588	-529	-689	-811	-1,155
Interest income	179	118	123	153	70	295	153	204	360	283
foreign exchange gains (losses)	-664	2,536	-878	-1,326	1,217	674	1,211	-1,452	270	27
Foreign currency differential adjustments	719	-2,530	549	1,243	-1,271	-544	-728	1,424	-362	-57
Others (net)	-577	-497	13	1,049	-406	5	10	251	-70	146
Income before Income Tax	779	1,099	1,976	4,393	4,565	2,341	3,584	4,276	4,249	5,208
Provision for (benefit from) deferred income tax	-225	-568	-18	1,569	-215	-123	987	1,469	1,006	1,258
Net Income	1,004	1,667	1,994	2,824	4,780	2,464	2,597	2,807	3,243	3,950
Financial Indicators										
Current Ratio	73%	28%	109%	85%	43%	170%	93%	203%	169%	101%
Indebtedness	87%	113%	97%	90%	81%	51%	55%	60%	61%	58%
Net Profit Margin	15%	23%	24%	27%	40%	40%	35%	31%	34%	37%
ROA	4.1%	6.8%	5.7%	7.4%	11.2%	10.2%	9.3%	7.7%	7.4%	8.3%
ROE	30.8%	N.A.	212.8%	75.1%	60.2%	20.8%	20.8%	19.4%	19.2%	19.9%

Note: Figures in the year 2010 are before audit

Source: Financial Statements of MWSI and MWCI

Chapter 12

Annex 12.1 Indicative Index for Evaluation of Item

1. Economic Impacts

Item	Description	Index
1) EIRR	Economic internal rate of return	%
2) Benefit/cost	Benefit-cost ratio	ratio
3) Net Present Value	Discounted total profit less total cost	MPhP
4) Worth of Water	Evaluation of water otherwise be valueless	MPhP/an
5) Utility	Supporting resource of economic activities	MLD
6) Land	Opportunity cost of land submerged	1,000 Ha

2. Financial Impacts

Item	Description	Index
1) FIRR	Financial internal rate of return	%
2) Annual Benefit	Annual earning less annual expenditure	MPhP/an
3) Investment Cost	Required investment for project implementation	MPhP
4) OMR Cost	Annual running cost, for OMR per m^3	PhP/ m^3
5) Overall System Cost	Development of source, conveyance and treatment	MPhP
6) LR average cost	Per m^3 adapting demand including depreciation	PhP/ m^3

3. Environmental Impacts

Item	Description	Index
1) Protected Area	Activities in protected areas (0.5)	1,000Ha
2) Terrestrial Ecology	Disturbance to habitat (0.5)	Nos. of species
3) Indigenous People	Population to be disturbed life	Person
4) Environmental Flow	Occurrence frequency of deficit	%
5) Watershed Mangmnt	Preservation of watershed area	Deg. of devastation
6) Work volume	Embankment volume	Mm^3
7) CO_2 emission	Hydropower generation	MW

4. Social Impacts

Item	Description	Index
1) Project Affected Family	Numbers of affected families	Nos.
2) Sanitary	Reliable sufficient water supply	Mld
3) Social Security	Water supply security	Mld
4) Social Weak Issue	Surplus potential over MWSS demand	Mld
5) Institutional Issue	Water right, EIA & stage of implementation	Status
6) Job opportunity	Directly or indirectly generated job by OMR	MPhP/an

Annex 12.2 Evaluated Impacts

Performance of Project (Economic Impact)

Project	EIRR	B/C	NPV	Valuation of water	Utility	Land area	-
Unit	%	-	BP	BP/a	Mld	1000ha	-
Weight	2	1	2	1	1	1	-
Sumag	37.0	2.7	4.2	0.6	188	0	-
Tayabasan Dam	23.2	1.6	1.3	0.6	175	0	-
Laguna Lake	-	-	-	0.7	200	0	-
Laiban Dam	15.7	1.1	1.3	6.2	1,900	2.3	-
Agos Dam	15.5	1.0	1.0	9.9	3,000	1.8	-
Kanan Dam N02	15.2	1.1	0.8	10.8	3,300	2.6	-

Performance of Project (Financial Impact)

Project	FIRR	Ann. benefit	Invest. cost	OM cost	System Cost	LRA Cost	-
Unit	%	Bp/an	BP	P/m^3	Bp	P/ m^3	-
Weight	2	2	1	1	1	1	-
Sumag	41.6	1.2	1.0	0.97	2.7	5.7	-
Tayabasan Dam	21.0	0.9	3.5	0.94	4.6	2.0	-
Laguna Lake	-	1.5	-	-	-	-	-
Laiban Dam	17.4	9.8	36.7	0.76	49.1	2.1	-
Agos Dam	18.5	16.1	43.3	0.90	63.8	2.7	-
Kanan Dam N02	18.6	16.6	55.9	1.24	80.7	1.8	-

Performance of Project (Environmental Impact)

Project	Protd. area	Eco-logy	IP	Env. flow	Water-shed	Work vol	Co2
Unit	1000ha	Nos	person	%	Deg.dvst	$M\ m^3$	MW
Weight	0.5	0.5	1	1	2	1	2
Sumag	16	0	0	75	mining	0	0
Tayabasan Dam	26	0	0	24	good	na	0.1
Laguna Lake	-	0	0	100	indstry	na	0
Laiban Dam	18	13	1,175	78	dvsttd	6.2	25
Agos Dam	88	12	118	92	dvsttd	6.7	51
Kanan Dam N02	70	22	118	86	ideal	9.1	54

Performance of Project (Social Impact)

Project	PAF	Sanit. Cond.	Social Sec.	Social weak	Insti-tutional	Job opp.	-
Unit	Family	Mld	Mld	Mld	Status	Mp/an	-
Weight	2	1	1	2	1	1	-
Sumag	0	188	188	188	DD,ECC	67	-
Tayabasan Dam	300	175	175	175	PQ	60	-
Laguna Lake	0	200	200	200	IEE,FS	-	-
Laiban Dam	2,497	1,900	1,900	1,900	FS,ECC	527	-
Agos Dam	225	3,000	3,000	3,000	FS	985	-
Kanan Dam N02	100	3,300	3,300	3,300	FS	1,494	-

Annex 12.3 Rating Standard

Object	Item	Wei-ght	Unit	Point to be Assigned						
				-3	-2	-1	0	1	2	3
Fconomic Impact	1)EIRR	2	%	~6	6~8	8~10	10~12	12~14	14~16	16~
	2)B/C	1	-	~0.7	0.7~0.8	0.8~0.9	0.9~1.0	1.0~1.1	1.1~1.2	1.2~
	3)NPV	2	BP	~0.4	0.4~0.6	0.6~0.8	0.8~1.0	1.0~1.2	1.2~1.4	1.4~
	4)Valuation of water	1	BP/an	NA	NA	NA	0~1	1~4	4~8	8~
	5)Utility	1	Mld	NA	NA	NA	0~300	300~1000	1000~2000	2000~
	6)Land to be submerged	1	1000ha	~4	4~2	2~	0	NA	NA	NA
Financial Iimpact	1)FIRR	2	%	NA	NA	NA	~5	5~10	10~15	15~
	2)Annual benefit	2	BP/an	NA	NA	NA	~5	5~10	10~15	15~
	3)Investment cost	1	BP	~50	50~30	30~10	10~0	NA	NA	NA
	4)OM cost	1	P/m^3	~1.5	1.5~1	1~0.5	0.5~0	NA	NA	NA
	5)Overall system cost	1	BP	~80	80~40	40~5	5~0	NA	NA	NA
	6)Long run average benefit	1	P/m^3	NA	NA	NA	0~0.5	0.5~1.5	1.5~2.5	2.5~
Environ-mental Impact	1)Protected area	0.5	1000ha	~100	100~50	50~10	10～0	NA	NA	NA
	2)Terrestrial ecology	0.5	NOs	~50	50~20	20~	0	NA	NA	NA
	3)IP	1	Person	~1000	1000~500	500~	0	NA	NA	NA
	4)Environmental flow	1	%	~65	65~70	70~75	75~80	80~85	85~90	90~
	5)Watershed management	2	Dev.degree	Very G	Good	N Dev	VSlight Dev	Slightly D	Devastated	S D
	6)Work volume	1	Mm^3	~12	12~6	6~	0	NA	NA	NA
	7)CO2 emission	2	MW	NA	NA	NA	0	~25	25~50	50~
Social Impact	1)PAF	2	Family	~600	600~300	300~100	100~0	NA	NA	NA
	2)Sanitary condition	1	Mld	NA	NA	NA	0	~1500	1500~3000	3000~
	3)Social security	1	Mld	NA	NA	NA	0	~1500	1500~3000	3000~
	4)Social weak issue	2	Mld	NA	NA	NA	0~1500	1500~2000	2000~3000	3000~
	5)Institutional issue	1	Status	NA	NA	NA	No EC/WR	Water right	ECC	Both
	6)Job opportunity	1	MP/an	NA	NA	NA	0	~400	400~800	800~

Note; Unit: a: annual, B: Billion, Dev. degree: Devastated degree, ld: Litre per day, M: million, P: Philippine Peso

Rating D: Devastated, NA: Not available, N Dev.: Not devastated, SD: Significantly devastated

Annex 12.4 Calculation Table of GMI

Item	Weight	Smug		Tayabasan		Laiban		Agos		Kanan	
		point	weighted	point	weighted	point	weighted	point	weighted	point	weighted
EIRR	2	3	6	3	6	2	4	2	4	2	4
B/C	1	3	3	3	3	2	2	1	1	2	2
NPV	2	3	6	2	4	2	4	1	2	2	4
Water Val	1	0	0	0	0	2	2	3	3	3	3
Utility	1	0	0	0	0	2	2	3	3	3	3
Land	1	0	0	0	0	−2	−2	−1	−1	−2	−2
E Total			15		13		12		12		14

Item	Weight	Smug		Tayabasan		Laiban		Agos		Kanan	
		point	weighted	point	weighted	point	weighted	point	weighted	point	weighted
FIRR	2	3	6	3	6	3	6	3	6	3	6
A. Benefit	2	0	0	0	0	1	2	3	6	3	6
Inv.cost	1	0	0	0	0	−2	−2	−2	−2	−3	−3
OM cost	1	−1	−1	−1	−1	−1	−1	−1	−1	−2	−2
System c	1	0	0	0	0	−2	−2	−2	−2	−3	−3
LRA Bene	1	3	3	2	2	2	2	2	2	2	2
F total			8		7		5		9		6

Item	Weight	Smug		Tayabasan		Laiban		Agos		Kanan	
		point	weighted	point	weighted	point	weighted	point	weighted	point	weighted
Prtectd A	0.5	−1	−0.5	−1	−0.5	−1	−0.5	−2	−1	−2	−1
Ecology	0.5	0	0	0	0	−1	−0.5	−1	−0.5	−2	−1
IP	1	0	0	0	0	−3	−3	−1	−1	−1	−1
Env. Flow	1	1	1	2	2	1	1	3	3	3	3
Watershed	2	1	2	−1	−2	2	4	3	6	−1	−2
W. Volume	1	0	0	0	0	−2	−2	−2	−2	−2	−2
CO2	2	0	0	1	2	2	4	3	6	3	6
E. Total			2.5		1.5		3		10.5		2

Item	Weight	Smug		Tayabasan		Laiban		Agos		Kanan	
		point	weighted	point	weighted	point	weighted	point	weighted	point	weighted
PAF	2	0	0	−1	−2	−3	−6	−1	−2	0	0
sanitry	1	1	1	1	1	2	2	3	3	3	3
S. Security	1	1	1	1	1	2	2	3	3	3	3
S. Weak	2	0	0	0	0	1	2	3	6	3	6
Institutiona	1	3	3	3	3	2	2	1	1	1	1
Job Opp.	1	1	1	1	1	2	2	3	3	3	3
S. Total			6		4		4		14		16

Annex 12.5

The computation procedures (Formulae) to obtain GMI and DUB

1) Gross Magnitude of Impact（GMI）by Projects

$$GMI = \sum_{i=1}^{n} \left\{ WOB(i) \times \sum_{j=1}^{m(i)} \left(WIT(i,j) \times P(i,j) \right) \right\}$$

where,	*GMI*:	Gross magnitude of impacts of the subprojects
	WOB(i):	Relative importance of the i-th objective
	WIT(i,j):	Relative importance of the j-th item in the i-th objective
	P(i,j):	Point (= -3 ~ 3)
	n:	Number of objectives
	m(i):	Number of items in the i-th objective

The importance of each objective is the same in this study and fixed to be 1.0

The relative importance of EIRR was set 2.0 in the economic objective in this study. Meanwhile that of protected area is 0.5 in the environment objective.

n is four (economy, financial, environmental and social).

m for each objective is as follows;

Economy	6
Financial	6
Environment	7
Social	6

2) Balance of Impacts Among the Objectives

$$GD = [\Sigma \{IOB(i)-C\}^2]^{0.5}$$

$$DUB = \frac{GD}{O}$$

where,	*GD*:	Generalized distance of impacts of a project
	DUB:	Degree of imbalance of impacts of the project
	IOB(i):	Total impact on the i-th objective

$$= \sum_{j=1}^{m} \left(WIT(i,j) \times P(i,j) \right)$$

C Coordinates of the iso-magnitude of impacts

$$= \frac{\sum_{i=1}^{n} IOB(i)}{n}$$

O Normalization factor
$= (\Sigma C^2)^{0.5}$

IOBs of Agos Dam Project for each objective is as follows

Economy	12
Financial	9
Environment	10.5
Social	14
Total	45.5 (GMI for Agos Dam Project)

C of Agos Dam Project is 11.4 (=45.5/4)

GD of Agos Dam Project is 3.7

O of Agos Dam Project is 22.8 (= $\{4 \text{x} 11.4^2\}^{0.5}$

DUB of Agos Dam Project is 0.16 (=3.7/22.8)

Annex 12.6 Calculation Sheet of Gross Magnitude of Impact(GMI) and Degree of Unbalance(DUB)

Term	Sumag	Tayabasn	Laiban	Agos	Knan
Economic Impacts	15	13	12	12	14
Financial Impacts	8	7	5	9	6
Environmental Impacts	2.5	1.5	3	10.5	2
Sopcial Impacts	6	4	4	14	16
Gross Magnitude of Impact of Project	**31.5**	**25.5**	**24**	**45.5**	**38**
Assumed Completely Balanced Impact	**7.875**	**6.375**	**6**	**11.375**	**9.5**
Distance of economic objective(2P)	50.766	43.891	36	0.3906	20.25
Distance of financial objective(2P)	0.0156	0.3906	1	5.6406	42.25
Distance of evironmental objective(2P)	28.891	23.766	9	0.7656	56.25
Distance of environmental objective(2P)	12.25	5.6406	4	6.8906	42.25
Generalized distance(2P)	91.922	73.688	50	13.688	161
Generalized distance	**9.5876**	**8.5841**	**7.0711**	**3.6997**	**12.689**
Normalization factor	15.75	12.75	12	22.75	19
Degree of imbalance	0.6087	0.5049	0.5893	0.1626	0.6678