People's Republic of China

FY2016 Ex-Post Evaluation of Japanese ODA Loan

"Yunnan Province Kunming City Water Environment Improvement Project"

" Yunnan Province Kunming City Water Environment Improvement Project （II) "

External Evaluator: Shima Hayase, IC Net Limited

0. Summary

The objective of this project is to improve the sewage treatment capacity in the city center of Kunming City in Yunnan Province by upgrading sewage treatment plants, thereby contributing to the improvement of the living environment in the area through the reduction of water pollutant in Dianchi Lake.

This project was consistent with China's development policies and development needs at the national, provincial, and municipal levels; in accordance with Japan's policy for assistance to China at the time of the appraisal. Therefore, its relevance is high. Expected effects have arisen because indicators for the main effects, such as the sewage treatment rate and the quality of the treated water, have achieved the targets. In 2016, for the first time in 30 years the water quality of Dianchi Lake which had been inferior class V[1], the lowest water quality standard, improved to class V. Reinforcing the sewage treatment capacity resulted in improvement of the quality of water discharged. The effectiveness and impact of this project are significantly high, because this project widely contributed to a decrease in the major pollutants discharged from the urban district of Kunming City into Dianchi Lake. The renovation of the sewage treatment plants, the expansion, the new establishment and construction of the pump stations and pipe network were conducted as scheduled and the project cost was lower than planned. A considerable delay was caused in the project period so that the efficiency of the project is fair. Regarding the sustainability of the effects that arose from this project, there are no problem in the operation and maintenance structure of the managing agency, the technological, and financial aspects. Therefore, the sustainability of the project is high.

In light of the above, this project is evaluated to be highly satisfactory.

[1] The water quality for rivers, lakes, and other water environments is classified into Class I-V pursuant to the Environmental Quality Standard for Surface Water (GB3838-2002). Class I: Applies primarily to water from water sources and national nature reserves; Class II: Applies primarily to concentrated water sources of potable water for domestic use in Class I preserves, valuable fish protection areas, and fish and shrimp spawning grounds; Class III: Applies primarily to concentrated water sources of potable water for domestic use in Class II preserves, general fish protection areas, and swimming areas; Class IV: Applies primarily to general industrial water areas and water areas for entertainment purposes that do not come into direct contact with humans; Class V: Applies primarily to agricultural water and water areas needed for general scenery. Below V is classified as inferior V.

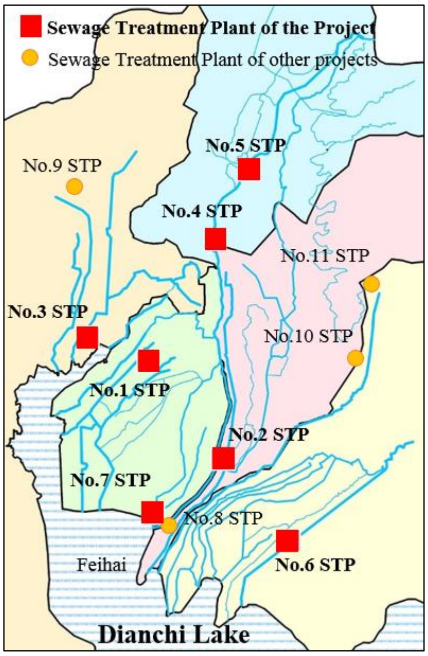
1. Project Description

Project location

Dianchi Lake Designated as a Natural Reserve

1.1 Background

Kunming City, the capital of Yunnan Province, has been one of the development hubs in Western China and an economic, transport, and trade center. Economic development of the city were accompanied by a rapid increase since the 1980s in the volume of untreated sewage flowing into Dianchi Lake, a fresh water lake on the Yangtze River. In the 1990s, the water quality of the lake worsened below the level unusable as agricultural water. Due to its geological formation with all the rivers in the city flowing into the lake, untreated sewage significantly affected the water quality of the lake. Thus, *the 10th Five Year Environmental Protection Plan (2001-2005)* regarded improvement in the water quality of the lake as a national key project and Kunming People's Government conducted the construction of sewage treatment plants and improving a network of sewage pipes in the city center. However, while the volume of discharged sewage was 688,000 m^3/day, sewage treatment capacity was only 464,000 m^3/day. As a result of that, untreated sewage continued to flow into Dianchi Lake. Moreover, due to an increase in population and so on, it was foreseen that the volume of discharged sewage would increase to 900,000 m^3/day in 2015. Thus, the improvement of sewage treatment capacity in the city and limitation of water pollutant substances flowing into the lake were urgent issues.



Source: Drawn from the material provided by Executing Agency

Figure 1: Dianchi Lake and sewage treatment plants in the city

1.2 Project Outline

The objective of this project is to improve the sewage treatment capacity in the city center of Kunming City in Yunnan Province by upgrading sewage treatment plants, thereby contributing to the improvement of the living environment in the region through the reduction of water pollutant in Dianchi Lake.

Loan Approved Amount/ Disbursed Amount	I: 12,700 million Japanese yen/12,647 million Japanese yen II: 10,400 million Japanese yen/6,647 million Japanese yen
Exchange of Notes Date/ Loan Agreement Signing Date	I: June 23, 2006/June 23, 2006 II: March 30, 2007/March 30, 2007
Terms and Conditions	Interest Rate: 0.75 % Repayment Period (Grace Period): 40 years (10 years) Conditions for Procurement: General Untied
Borrower / Executing Agencies	The People's Republic of China/ Kunming People's Government
Final Disbursement Date	May 2016
Main Contractor	I: Hunan Provincial Construction Engineering Corporation Group, Five Bureau of China Railway (Group) Company Limited II：China National Precision Machinery Import & Export Corp., Zhongtai Construction Group Share Co. Ltd.

	(all of them are in China)
Main Consultant	-
Feasibility Studies, etc.	F/S: Central and Southern China Municipal Engineering Design and Research Institute, State Power Corporation of China, Kunming Investigation, Design and Research Institute (June 2005)
Related Projects	【ODA Loan】 ・ Dalian Water Supply and Wastewater Treatment Project (2000) ・ Yichang Water Environmental Improvement Project (2002) ・ Nanning Environmental Improvement Project (2002) ・ Huhehaote City Water Environmental Improvement Project (2003) ・ Shaanxi Water Environmental Improvement Project (2004) ・ Water Supply and Quality Environmental Project in Changsha City (2004) ・ Guiyang Water Environmental Improvement Project (2004) 【Other International Organization】 ・ Yunnan Environmental Project (World Bank 1996)

2. Outline of the Evaluation Study

2.1 External Evaluator

Shima Hayase, IC Net Limited

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted according to the following schedule.

Duration of the Study: July, 2016 – October, 2017

Duration of the Field Study: November 9, 2016 – November 17, 2016, April 14, 2017 – April 17, 2017

2.3 Constraints during the Evaluation Study

Although it is stated that the effectiveness of the sewerage facilities upgraded under this project resulted in “a reduction in aquatic pollutant in Dianchi Lake,” it is difficult to directly assess to what level this project contributed to the reduction in water pollutant, as the water quality of the lake was influenced by many factors other than the sewerage facilities upgrade. Therefore, this ex-post evaluation regards a change in the water quality of Dianchi Lake as the impact. And so the contribution of this project will be analyzed by confirming the factors for the reduction in water pollutant and by comparing this to the reduction in the volume of aquatic pollutants as a result of sewage treatment and its ratio of the pollutants discharged into the water of Dianchi Lake.

3. Results of the Evaluation (Overall Rating: A[2])

3.1 Relevance (Rating:③[3])

3.1.1 Consistency with the Development Plan of China

(1) Consistency with the Development Plan at the Time of Appraisal

The 10th Five-year Plan of the People's Republic of China for Economic and Social Development (2001-2005), the national development plan at the time of appraisal, aimed at harmonious economic and social development and placed importance on the improvement of the environment, which had worsened during economic development. *The 10th Five-year Environmental Protection Plan (2001-2005)* specified the following objective concerning sewage treatment and the improvement of surface water quality: an increase in the sewage treatment rate to 45% in urban areas (60% if the population was 500,000 or more, 70% for prioritized cities). The plan regarded prevention of water pollution of "three rivers and three lakes[4]", including Dianchi Lake as a national key project. Moreover objectives from a previous plan were not achieved and *the 11th Five-year Environmental Protection Plan (2006-2010)*, added an objective of a 10% reduction in the total emission of the main pollutants, as compared to the 2015 levels to reduce environmental pollution.

The 10th Five-year Plan of for Economic and Social Development of Kunming City (2001 - 2005) and *the 11th Five-year Plan of for Economic and Social Development of Kunming City (2006 - 2010)* of Yunnan Province and Kunming People's Government specified the following objectives: improvement in the treatment capacity of sewage discharged into Dianchi Lake from the city center, the worst source of water pollution for Dianchi Lake; a reduction in pollutant in the area where further increase in the population is foreseen; limiting water quality worsening to a certain degree; and improvement of the living environment of the people in the city.

(2) Consistency with the Development Plan at the Time of Ex-post Evaluation

The 12th Five-year Plan of the People's Republic of China for Economic and Social Development (2011-2015), specified five propriety fields. Among them is the aim of "resource-saving and environmentally-friendly society". Regarding this aim the plan set the objective of improving the general level of infrastructure, including water supply and drainage and sewage treatment and refuse facilities by a unified urban public facility plan.

In *the 12th Five-year Environmental Protection Plan (2011-2015)*, aiming at preferential

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[2] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[3] ③ High, ② Fair, ① Low

[4] Refers to three rives (Haihe River, Liaohe River and Huaihe River) and three lakes (Tai Lake, Chao Lake and Dianchi Lake) in China. These were designated as national environmental protection reserves by "the Decision Concerning Certain Environmental Protection Issues by the State Council" in August, 1996.

implementation of eight environmental protection projects toward the harmonious development of the economic, social and environmental, three projects were concerned with the improvement of the water environment and the strengthening of construction of sewage treatment infrastructures. Among them, the objectives relevant to this project include: (a) an 8% reduction of chemical oxygen demand (COD) and 10% reduction of ammoniac nitrogen (NH3-N) by 2015, as compared to 2010 (b) strengthening of construction of sewage pipe networks, promoting remodeling of the division of the flow of rainwater and polluted water, an increase in the urban sewage treatment rate to 85%, detoxification of sludge, use of reclaimed water, reducing the level of phosphorus and nitrogen of sewage facilities especially located in basins of Dianchi Lake, Chao Lake and Lake Tai as well as those in other major cities (c) a comprehensive improvement in the water quality of Dianchi Lake, which was rated inferior class V, and rivers flowing into the lake by the following measures: designating the lake as a natural reserve; a restrictive use of the surrounding area of the lake; and conducting watershed protection and measure for water pollution. In response to this, the Yunnan Provincial Government drew up *the Plan for Water Pollution Measure for the Basin of Dianchi Lake (2011-2015)* in order to achieve a national objective of a comprehensive improvement in Dianchi Lake and surrounding areas.

In this way, the strengthening of construction of sewage treatment infrastructures and the improvement of the water quality of Dianchi Lake continued to be the main focuses for the development plan in the state and the city in the period between the appraisal and the ex-post evaluation. Thus, the relevance to this project is high.

3.1.2 Consistency with the Development Needs of China

In Kunming City where all the rivers flow into Dianchi Lake due to its landform, urban development and increase in the population were accompanied by an increase in the volume of sewage. Since 1986 the water quality of the lake has been inferior V, the worst level. Pollution has been in a critical state. According to the F/S, it was foreseen that water would be supplied to an increased population of 2,940,000 and the volume of water sewage would increase to 900,000 m^3/day in 2015. Further water pollutant was a concern.

According to the actual results at the time of the ex-post evaluation (2015), the volume of sewage is 1,504,000 m^3/day (forecast rate 167%) and water-supplied population is 3,940,000 (target rate 134%), which showed a higher growth rate compared with the forecast population of 2,940,000 at the time of the appraisal. As the volume of sewage increases at a pace which exceeds the forecast, further strengthening of the sewage treatment capacity is needed.

Plan for Water Pollution Measure for the Basin of Dianchi Lake (2011-2015) drew up an objective of reducing 6,000t of COD and 2,100t of NH3-N annually for the improvement of the water quality of Dianchi Lake. A contribution to reduction through strengthening of the sewage treatment capacity was demanded. In this way, the development needs for strengthening of the sewage treatment capacity are still high at the time of the ex-post evaluation, as at the time of the appraisal.

Table 1: Population in Kunming, Foresee and the Actual Results of the Sewage Volume

	F/S Baseline	F/S Prediction		Actual
	2002	2015	2030	2015
Total Population (10,000 persons)	274	320.7	360	402
Water-supplied Population (10,000 persons)	263.7	294	326	394
Sewage Volume (10,000 ㎥/day)	64	90	106	150.4

Source : Baseline and prediction in F/S, actual data submitted by Executing Agency
Note1 : The total population included fluid population
Note 2 : The forecast of sewage volume was calculated based on water supplied population

3.1.3 Consistency with Japan's ODA Policy

In *the Medium-Term Strategy for Overseas Economic Cooperation Operations (2005-2007)*, and *Country Assistance Policy for China FY2005* among the priority fields, JICA specified the need for improving sewage treatment facilities as a measure against water pollutant for avoiding or reducing the negative environmental impact of infrastructure development.

The above-mentioned 'Country Assistance Policy for China', which required a governmental role, regarded support for upgrading sewage treatment facilities and public projects as priorities. Regarding sewage sectors, it specified a policy to support the improvement of items the Chinese Government specified as policy challenges such as a comprehensive improvement of the water use efficiency through the improvement of the treatment rate and the upgrading of sewage facilities and water recycling facilities.

This project aimed at environmental conservation and was relevant to Japan's ODA policy that aimed at a comprehensive improvement of the water use efficiency through the construction of sewage facilities.

In light of the above, this project is fully relevant to the development policies, development needs of the Chinese Government, Yunnan Province and Kunming City and their needs at the time of the appraisal and the ex-post evaluation and to Japan's ODA policy at the time of the appraisal. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

(1) Planning and Results of Project Outputs

Although there were some changes, the project was carried out almost as planned as shown in Table 2. The changes were as follows:

(a) Upgrading of Sewage Network: The total length of extension was 102% of the designed length, approximately planned. A part of the sewage network was constructed with domestic funds prior to this project. Because of this previous construction, an adjustment was made to this project whereby, as part of this project, the construction length of a storm drain was reduced and instead a sewer culvert was constructed. For the same reason, the number of pump stations constructed was changed. A pump station exempted from this project was constructed with domestic funds. Surplus proceeds from these changes was used for the construction of the sewage network.

(b) Renovation, Expansion and Construction of the Sewage Treatment Plants: Because the 4th Sewage Treatment Plant was on a small site, an ozone-disinfection process which allowed for conducting advanced processes with a space-saved was applied. The ozone-disinfection facility was installed with domestic funds and the construction of a UV facility planned in this project was replaced with the construction of a deodorization facility.

(c) Training: Although 90 people from 8 groups were scheduled to participate in training in Japan, 81 people of 10 groups participated in training because China's policy on travel for government workers became stricter and tour groups were coordinated according to the purposes. The officers including administration and operation managers in charge of the operation and maintenance, and engineers took courses in each field, and training was almost carried out as planned.

Table 2: Comparison of Outputs of the Plan and the Actual Results

Plan		Actual
(a) Upgrading of Sewage Pipe Network		
Sewage Pipe Network: 336 km Installation of Sewage Pump Stations: 9 locations		Sewage pipe network: 342.7 km (+13.7km) Installation of sewage pump stations: 8 locations (-1)
(b) Sewage Treatment Plant		
Name	Content: Renovation, Expansion and New Construction	Results
1st STP A_2O Process[5] 120,000 m^3/day	Sludge Treatment Facility	As Planned
2nd STP A_2O Process 100,000 m^3/day	Coagulation Settling and Sludge Treatment Facility	As Planned
3rd STP ICEAS Process[6] 1500,000 m^3/day	Strengthening Treatment Capacity to 60,000 m^3/day Coagulation Settling and Sludge Treatment Facility	As Planned
4th STP ICEAS Process 60,000 m^3/day	Repairing UV Facility	Construction of Deodorization Facility
5th STP A_2O Process 75,000 m^3/day	Strengthening Treatment Capacity to 95,000 m^3/day Coagulation Settling, Sludge Treatment Facility and UV Facility	As Planned
6th STP A_2O Process 50,000 m^3/day	Strengthening Treatment Capability to 80,000 m^3/day Coagulation Settling and Sludge Treatment Facility	As Planned
7th STP A_2O Process	Construction 200,000 m^3/day	As Planned
Total of Existing Capacity 555,000 m^3/day Total of Additional Treatment Capacity 435,000 m^3/day		Total of Existing and Additional Treatment Capacity 990,000 m^3/day
(c) Overseas Training		
8 Groups Total of 90 People		10 Groups Total of 81 People

Source: materials submitted by Executing Agency
* The numbers in parentheses show a change in actual

Sludge Treatment Facility (the 1st STP)

Deodorization Facility (the 4th STP)

[5] Anaerobic Anoxic Oxic is a sewage treatment process, which removes more nitrogen and phosphorus, major causes for eutrophication in lakes, ponds and seas, more than the conventional activated sludge process, which is generally applied.
[6] Intermittent Cycle Extended Aeration is a sewage treatment process where biological treatment, sludge settling and discharging supernatant water are applied in the same tank.

3.2.2 Project Inputs

3.2.2.1 Project Cost

At the time of the appraisal, the project cost was estimated to be 52,981 million Japanese yen (25,222 million Japanese yen in foreign currency; 27,759 million Japanese yen in domestic currency). The actual cost was 43,820 million Japanese yen (19,114 million Japanese yen in foreign currency; 24,706 million Japanese yen in domestic currency), 83% of the planned cost at the time of the appraisal. The reasons why the actual cost was lower than the planned out was as follows: the cost for material and equipment were lower than the planned cost; the construction cost was lower than the planned cost as a result of competitive bidding; and an influence of fluctuations in exchange rates[7].

3.2.2.2 Project Period

At the time of the appraisal, the project implementation period was scheduled from June 2006 to December 2012 (79 months). The actual project was from June 2006 to May 2016 (120 months), 152% of the planned period, thus the project period was significantly longer than planned. Since the construction of a sewage pipes network was needed to coincide with road works in Kunming City, the project implementation period was significantly extended. The period of the road construction in the area where the network of sewage pipes were constructed was later than the assumption at the time of appraisal. Therefore it was delayed. However, because renovation, expansion and construction of the sewage treatment plants were conducted as planned, and sewage collection was possible with a network of sewage pipes and pump stations installed with domestic funds; the delay did not have negative effect on the project's effectiveness. The period of overseas training was also significantly extended because China's policy on travel for government workers became stricter.

3.2.3 Results of Calculations of Internal Rates of Return (Reference only)

The financial internal rate of return (FIRR) was recalculated with the actual costs and benefits which were submitted by Executing Agency. Although it was 5.5% at the time of the appraisal, the result was 7.4% (Table 3). This was because, compared with the plan at the time of the appraisal, the volume of sewage treatment was larger at the time of the ex-post evaluation, and the sewage treatment revenue[8] gained according to the volume which was higher than planned. In addition, it was because the project cost was below the planed cost.

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[7] At the time of appraisal (2004), calculation was made at a rate of 13.7 yen per Chinese yuan. However, as a period of time between 2006 and 2016 when expenses occurred the exchange rate shifted between 14.68 and 15.58 Japanese yen to Chinese yuan, the total projected cost in Japanese yen became smaller.

[8] The sewage treatment plants treat domestic wastewater as well as rainwater, which flow into sewages. As the cost for treating rainwater cannot be collected, subsidies from the municipal government are used. Thus the sewage treatment fee revenue consists of sewage treatment charge and subsidies.

Table 3: Comparison of FIRR at Appraisal and the Actual Results

Plan at Appraisal (2004)	Actual (2015)
5.5%	**7.4%**
Prerequisite Cost: Project Cost, Operation and Maintenance Benefit: Sewage Treatment Fee Revenue Project Life: 30 years	**Prerequisite** Cost: Project Cost, Operation and Maintenance Benefit: Sewage Treatment Fee Revenue Project Life: 30 years

Source: FIRR at the time of appraisal on materials submitted by JICA. The evaluator calculated the actual FIRR according to the data provided by Executing Agency.

In light of the above, although the project cost is lower than planned, the efficiency is fair because the project period is far longer than planned.

3.3 Effectiveness[9] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

The improvement in the capability of the sewage treatment in the city center of Kunming City was expected as the quantitative effects of the Project. The targets in three years after completion (2015) were set for the sewage treatment population, the volume of sewage treatment and the sewage treatment ratio in the whole city[10]. Although at the time of the appraisal the targets for sewage treatment capacity in each of the sewage treatment plants were not set, a comparison between the volume of sewage treatment and the designed capacity was used to confirm if each of the sewage treatment plants demonstrated their expected capacity.

3.3.1.1 Operation Indicators

(1) The Sewage Treatment Volume and the Rate in Kunming City

While the sewage treatment population in the center of Kunming City was the target ratio of 125%, the sewage treatment volume was the target ratio of 167%. Treatment capability was much higher than the target. The result of the sewage treatment rate tied with the target.[11] Therefore, it can be stated that all of the sewage treatment population, sewage treatment volume and the rate were higher than expected. (Table 4)

9 Sub-rating for Effectiveness is to be put with consideration of Impact.
10 The project completion year was 2016, however, because the completion of renovation, expansion and construction of the sewage treatment plants was October, 2010, the construction completion year was regarded as 2011. As planned at the time of the appraisal, the completion of this project was set on as one year after terms of warranty (2012). The degree of performance was checked by a comparison between the results in 2015, three years after completion, and the target data.
11 While the target of the sewage treatment ratio under this project was 99.8%, the result in 2015 was also 99.8%. In table 4, the data became 100%, being rounded off to one decimal place.

Table 4: Target and the Actual Results[12] of the Sewage Treatment Volume, the Rate, Sewage Treatment Population

	unit	Baseline	Target	Actual				
		2004	2015	2011	2012[13]	2013	2014	2015
		Appraisal Year	3 years After Project Completion	Completion of Sewage Treatment Plant Upgrade	Project Completion Year	1 year after Project Completion	2 years After Project Completion	3 years After Project Completion
Number of Sewage Treatment Plants	locations	6	7	7	7	9	9	12
Volume of Sewage Water	10,000m^3 /day	68.8	90.2	114.3	106.0	133.4	141.7	150.4
Volume of Sewage Treatment	10,000m^3 /day	46.4	90.0	97.8	94.3	123.3	136.0	150.1
Sewage Treatment Rate	%	67%	100%	86%	89%	92%	96%	100%
Volume under this Project	10,000m^3 /day	46.4	90.0	97.8	94.3	94.8	104.6	111.1
Ratio of this Project	%	100%	100%	100%	100%	77%	77%	74%
Population	10,000 persons	281	322	352	364	376	389	402
Sewage Treatment Population	10,000 persons	197	315.2	303	324	345	369	394

Source: Materials submitted by Executing Agency

The sewage treatment plants provided under this project treated 74% (111,100 m^3/day) of the total volume of sewage in the center of Kunming City as of 2015. Thus, it can be stated that these facilities fulfilled significant roles as the core of the sewage treatment system in Kunming City.

(2) The Treatment Volume of the Seven Plants[14] under the Project, the Sewage Treatment Rate, and the Plant Operation Rate[15]

The sewage volume flowing into each of the treatment plants improved by the project is higher than the volume estimated at the time of appraisal. In the target year, except for the 4th Sewage Treatment Plant, the volume treated at the rest of the six sewage treatment plants exceeded the designed capacity. As the actual treatment capacity was set up adding 10-20%

[12] The volume of sewage water and the volume of sewage treatment are the average volumes at the end of the year in the urban area of Kunming City. The volume of sewage water is calculated by multiplying annual consummation of tap water by certain coefficients. The inlet amount at the sewage treatment plants is consisted of discharged sewage water and others (rainwater and ground water). The sewage treatment rate is calculated by dividing the volume of sewage treatment by the volume of sewage water. The population represents the whole population of the urban area of Kunming City and the sewage treatment population represents the population, connected to sewage treatment service.

[13] As the rainfall amount in Kunming City in 2012 was less than a normal year, the collected sewage volume and the volume of sewage treatment were less than the previous year.

[14] The population covered by each of the sewage treatment plants and the sewage treatment population were not be used for the ex-post evaluation of this project for the following reasons: the sewage treatment areas were not in accordance with the local government's jurisdiction; and the numbers of meters were not in accordance with the number of households.

[15] Because the plant operation rate (how much each plant is used in comparison with its capacity) was not used as an operational effect indicator at the time of the appraisal, it was calculated as a reference for this ex-post evaluation.

extra, no problem occurred. Thus it can be said that the state of treatment was more than the expectation. In case when the inflow volume exceeded the actual treatment capacity due to unexpected heavy rains or other reasons, an adjustment was made by simplifying processes such as shortening settling time as an emergency measure, and then discharging the water into rivers. Permission was given for this measure by the Environmental Protection Bureau. As it was conducted observing water quality standards, it did not have any negative impact on the environment.

Table 5: Wastewater Treatment Volume, Facility Utilization Rate[16]of STPs

Baseline (Appraisal Year : 2005)							
Sewage Treatment Plants	1st STP	2nd STP	3rd STP	4th STP	5th STP	6th STP	7th STP
Design Capacity (10,000 m^3/day)	12.0	10.0	15.0	6.0	7.5	5.0	—
Wastewater Treatment Volume (10,000 m^3/day)	9.6	8.5	14.4	6.4	6.6	1.1	—
Rate (%)	100%	100%	100%	100%	100%	100%	—
Facility Utilization Rate (%) (Reference)	80%	85%	96%	107%	88%	18%	—
Actual (3 Years After Project Completion: 2015)							
Sewage Treatment Plants	1st STP	2nd STP	3rd STP	4th STP	5th STP	6th STP	7th STP
Design Capacity (10,000 m^3/day)	12.0	10.0	21.0	6.0	17.0	13.0	20.0
Wastewater Treatment Volume (10,000 m^3/day)	13.4	11.4	22.6	5.7	23.6	13.4	21.1
Sewage Treatment Rate (%)	100%	100%	100%	100%	100%	100%	100%
Facility Utilization Rate (%) (Reference)	112%	114%	108%	94%	128%	103%	105%

Source: Baseline data on material submitted by JICA. Actual data on materials submitted by Executing Agency.
Note : As the 7th Sewage Treatment Plant was newly constructed. There is no baseline data of 2005.

Reaction Tank in the 5th STP

Reaction Tank in the 6th STP

[16] Design capability is a daily maximum volume of treatment, wastewater treatment volume is a daily average of annual treatment volume, facility utilization rate of sewage treatment plants is calculated by daily average treatment volume by design capacity

(3) Use and Reuse of Discharged Water

At the time of the appraisal the target was not set for indicators regarding reclaimed water. In reality, the whole volume of the discharged water (annual volume of sewage water was approximately 400,000,000m^3 in the 2016 data) after treatment in the sewage treatment plants upgraded by this project, is conducted advanced processing. Then 98.6% is used as river scenic water for the purpose of river cleaning and odor control, and 1.4% is used as urban recycling water for greening in parks, sprinkling water for roads, car washing water, toilet water and industrial water. Among the urban recycling water, 95% has been transported by reclaimed water pipes and the rest of 5% has been transported to usage points by sprinkler trucks. As Kunming City where urbanization has been increased and facing water shortages, the expanded use of reclaimed water is promoted as an additional water source other than precipitation. The recycling of the discharged water from the sewage treatment plants is worthy of special mention.

3.3.1.2 Effect Indicators

The target value regarding water quality at the time of the appraisal was set only for the biochemical oxygen demand (BOD) concentration of discharged water. In Kunming City, discharged water from sewage treatment plants is required to meet the first-class A national standard[17]. Thus, other indicators of discharged water other than BOD are also compared with the national standard to confirm the achievement level of the effect regarding water quality.

Regarding a change in each indicator (outlet concentration) between 2011 and 2016[18] after the completion of sewage treatment plants upgrade, all the plants including the 1st to the 7th met the first-class A national standard regarding COD, suspended solids (SS), total nitrogen (T-N) concentration, total phosphorus (T-P) concentration, hydrogen ion concentration (pH) and coliform bacilli.[19] Thus it can be stated that expected effects have arisen.

Regarding a change in indicators, BOD concentration (inlet and outlet) and the reduction rate of each of the sewage treatment plants are shown as a sample. (Table 6) Although concentration at the inlet has increased since 2004 before project implementation, the reduction rate has become close to 100%. All the sewage treatment plants are able to fulfill

17 *Discharge Standard of Pollutants for Municipal Wastewater Treatment Plan (GB18918-2002)*

18 Since 2010, sewage treatment has been conducting with renovated treatment capacity. The actual data was calculated with the average values between January and December. This evaluation confirmed the target was attained if each indicator regarding outlet concentration from 2011 to 2016 (at the time of the ex-post evaluation) was below the baseline of the first class A national standard.

19 In 2012, in the 6th Sewage Treatment Plant, T-P outlet concentration was 0.53mg/L, 0.03 mg/L higher than the standard of 0.5mg/L. According to Executing Agency, it was because there was an abnormality of T-P in the sewage which flowed in. While the average T-P concentration was 10.4mg/L, it reached 66.7 mg/L at the highest at the time of abnormality.

the first-class national standard of outlet concentration of 10 mg/L.

Table 6: A Change in BOD Concentration in STP under the Project (unit: mg/L)

the First Class A Grade: Outlet Concentration below 10 mg/L		Baseline	Actual					
		2004	2011	2012	2013	2014	2015	2016
		Appraisal Year	Year of STP Upgrade Completion	Project Completion	1 year After Project Completion	2 years After Project Completion	3 years After Project Completion	4 years After Project Completion
1st STP	Inlet	115.0	230.4	170.5	333.6	265.1	209.6	261.3
	Outlet	9.1	4.1	1.5	1.3	1.0	1.1	0.8
	Reduction Rate	91%	98%	99%	100%	100%	99%	100%
2nd STP	Inlet	83.9	121.9	107.4	114.3	99.7	161.6	122.1
	Outlet	9.8	2.0	1.3	1.2	0.9	1.3	1.0
	Reduction Rate	88%	98%	99%	99%	99%	99%	99%
3rd STP	Inlet	137.3	299.2	425.2	238.3	163.3	162.3	115.4
	Outlet	14.0	4.5	1.9	1.5	1.5	1.4	1.0
	Reduction Rate	90%	99%	100%	99%	99%	99%	99%
4th STP	Inlet	135.9	93.5	85.1	130.8	130.1	193.0	180.9
	Outlet	4.7	1.5	1.5	1.5	1.4	1.7	1.0
	Reduction Rate	97%	98%	98%	99%	99%	99%	99%
5th STP	Inlet	125.1	192.3	181.0	198.0	203.9	162.9	196.5
	Outlet	7.9	1.6	1.3	1.6	1.2	1.0	0.8
	Reduction Rate	94%	99%	99%	99%	99%	99%	100%
6th STP	Inlet	114.5	441.9	251.9	193.2	177.0	150.4	161.1
	Outlet	7.5	1.7	2.0	1.2	1.1	1.1	1.0
	Reduction Rate	93%	100%	99%	99%	99%	99%	99%
7th STP	Inlet	—	236.0	222.0	197.9	147.2	156.6	188.6
	Outlet	—	1.7	1.2	1.0	1.0	1.2	0.9
	Reduction Rate	—	99%	99%	99%	99%	99%	100%

Source: Material submitted by Executing Agency
Note: At the time of the appraisal, target value for the quality of discharged water (BOD concentration) was set below 10mg/L (3 years after the project completion: 2015)
Note 2: Both inlet and outlet concentrations are annual average volumes, which are automatically measured daily by water quality monitoring devices set by third parties.

In light of the above, Kunming City has largely fulfilled the targets for the sewage treatment volume and the sewage treatment rate. Each of the sewage treatment plants treats wastewater at standards higher than expected. Although the facility utilization rate is above 100% at all treatment plants, except for the 4th Sewage Treatment Plant, adjustment of load is made within a range which does not have an impact on the environment. Discharged water after sewage treatment is 100% utilized. Additionally, due to the reason that the effect indicators have been fulfilled, it can be judged that quantitative effects have arisen in the project as a whole.

3.3.2 Qualitative Effects (Other Effects)

At the time of the appraisal, although it was stated that qualitative effects were "improvement of the living environment in Kunming City", it is regarded as the impact level of this project and integrated into "3.4 Impact".

3.3.2.1 Effect of Training[20]

According to the participants of the training in Japan, targetting the officers in charge of the operation and maintenance of the sewage treatment plants, the texts used in the training were incorporated into manuals of Kunming Dianchi Investment Liability Limited Company and its subsidiaries. The method of operating and maintaining treatment, odor control, and tidying-up in the plants they visited in Japan were added to the design and the operation. In addition, in recent years the operation and maintenance company gives technical guidance in other provinces and neighboring countries. Their experience from the training in Japan was also used for technical guidance.

In the sewage treatment plants they visited during their training in Japan, the acceptance of study tours and field trips was a service provided actively. Referring to the Japanese sewage treatment plants, study tour course was built in the 7th Sewage Treatment Plant. At the time of the ex-post evaluation, the plant was accepting approximately 6,000 visitors in a year. The experience of visiting the Japanese plants was used for accepting field trips of primary and junior high schools, cooperation for university students' research and study trips from other cities. According to the participants, after their training in Japan, they have placed higher importance on publicity and environmental education. They not only wait for requests from schools but also have been calling actively on schools to conduct field trips.

In light of the above, the targets for the followings were achieved: the sewage treatment rate in Kunming City; the sewage treatment population and the percentage of sewage treatment population; the operation indicators, such as the operation rate of each treatment plant; and the quality of discharged water as the effect indicator. Therefore, it can be stated that the effects of this project have arisen.

3.4 Impacts

3.4.1 Intended Impacts

"Reduction in water pollutant of Dianchi Lake" and "improvement of the living environment of the residents in the area" were the impacts expected by the project. Regarding them, changes

[20] Based on the training reports and interviews with the participants. Due to personal changes, the interview subjects were not available and only two were interviewed.

in the water quality of Dianchi Lake and the contribution of this project were analyzed. In addition, a beneficiary survey was conducted concerning changes in the lake environment and the living environment, and the state of emergence of project's impact was confirmed.

3.4.1.1 Reduction in Water Pollutant of Dianchi Lake and the Contribution of the Project

(1) Reduction in Water Pollutant at Dianchi Lake

Since 1986, the water quality of Dianchi Lake had been inferior class V. In 2016, for the first time in 30 years, it improved to class V[21]. According to staff of the Environmental Protection Bureau, eutrophication standard[22] of the lake improved from heavy, the worst in 6-grade evaluation to intermediate, and sometimes slight in 2016. Although bacterial growth took place in almost all areas of the lake 30 times annually, it improves to an occasional partial growth in a small area.

According to the officer at the environmental monitoring center, the following are factors for the improvement. Kunming City designated the periphery of Dianchi Lake as a protected area under *the Plan for Water Pollution Measure for the Basin of Dianchi Lake (2011-2015)*, and houses and pollution sources (agriculture, livestock, industry) were moved from the periphery of the lake to suburban areas; regulating sailing and fishing in the lake; and promoting protection of swamp and greening in the periphery. In addition, changing water of the lake took place more frequently from every 8 years to 5 year. Since December 2013, frequency has been increased from every 5 years to every 3 years. Improving water quality by introducing 500,000,000 to 600,000,000 m^3per year to the lake was also a contributing factor to the improvement in eutrophication (phosphorus, nitrogen). The officer explained that the pollution source of Dianchi Lake was mainly domestic wastewater from the urban area (70%) and agricultural diffused source (30%) , and that the largest factor was that the domestic waste water which occupied 70% of pollution source did not flow into the lake any more due to the spread of sewage treatment service.

(2) Change in Water Quality of Dianchi Lake

The major pollutant data of Dianchi Lake (Caohai[23], Waihai[24]) between 2006 and 2015 was submitted by the Environmental Protection Bureau Observation Station. The change of the pollutants flow into the Dianch Lake was analyzed with the water quality data after being

[21] Related articles were published in the People's Daily on Feb. 9, 2017.

[22] Standard set by China's Environmental Protection Bureau. Based on values of COD_{Mn}, T-P, T-N and chlorophyll, the state of lake is classified by 6 levels as follows: heavy eutrophication; intermediate eutrophication; slight eutrophication; eutrophication; middle nutrition and poor nutrition.

[23] The north side of Dianchi Lake, where water in the city center flows in, water pollution was serious because it was a small area and it was shallow.

[24] On the south side of Dianchi Lake the water depth is 5-6 meters. It occupies the majority of the lake.

adjusted by the coefficient of the precipitation[25]. The result of the analysis showed a reduction in T-N concentration, T-P concentration and NH3-N concentration both in Caohai and Waihai. Particularly, in Caohai where water flows into from the city center, a significant change has been observed since 2009.[26] In 2015, T-N concentration was reduced by 39% from the 2006 levels. T-P concentration was reduced by 14% from the 2006 levels. NH3-N concentration was reduced by 12% from the 2006 levels. However, BOD and COD, which are influenced by the climate, the growth of microbes and algae, did not show a significant change during the period as microbes could live in mud at the bottom of the lake for a long period of time.

In Kunming where the climate is stable, as natural impacts such as transpiration are small, the water quality data[27] after being adjusted with rainfall mainly reflected a change in a total lord of pollutant, which flows in. Comparing with adjusted value before the project and adjusted value after the project (2011 onwards), it is analyzed that this change is caused by an artificial factor, that is the influence of the improvement of sewage treatment rate. It is assumed that the project has contributed to the improvement in water quality in Dianchi Lake as 100% of sewage water discharged in the city center of Kunming City has started to be treated at the period of the plants construction completion in 2011. As a sample, the analysis of T-N concentration is shown in figure 2. (Refer to Attachment for a figure of other pollutant lords.)

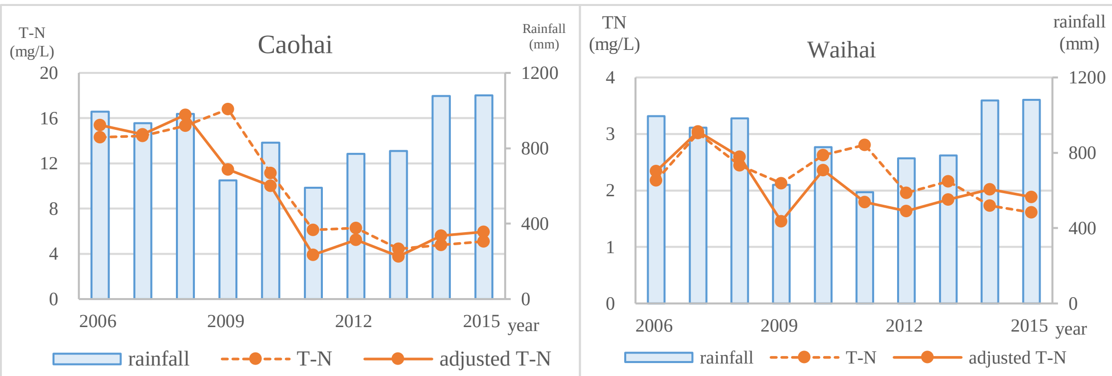


Figure 2: A change in T-N value in Dianchi Lake (Caohai: left) and Dianchi Lake (Waihai: right)

[25] Taking account of a change in rainfall of each year, actual value of water quality was adjusted with the following calculation. Adjustment factor=P_i/ P_{ave} , P_i/= rainfall in the first year, P_{ave} =annual average rainfall. Water quality value after adjustment = submitted data x adjustment factor.

[26] Waihai is 100 times larger than Caohai in size and water volume. As water may come in via Caohai, originally pollution was less than Caohai. Not much change was observed.

[27] Generally speaking, pollutant lord concentration is not only influenced by concentration flow in but also directly by water storage volume. Although water storage volume is influenced by evaporation and rainfall, temperature change rate has been approximately 0.1 and evaporation rate has been hardly changed through the year in Kunming City for the last 10 years. However, as a change in rainfall volume has been large, adjusting the water quality, which was submitted, made it possible to compare a change in water quality.

(3) Major Pollutants Load in Kunming City and Contribution by the Project

Regarding the major pollutants [28](COD, T-N, T-P), which were generated in the urban area of Kunming City and were discharged into Dianchi Lake, their reduction by the project (sewage treatment in the 1st to 7th sewage treatment plants) and reduction ratio, a survey on pollutant load generated in the urban area was conducted. The results of 2010 and 2012 are shown in Table 7.

Among the major pollutants in the urban area of Kunming City, the ratios of pollutants reduced by this project are as follows: in 2010, 81% in the case of COD and 61% in the case of T-N, 74% in the case of T-P, in 2012, 83% in the case of COD, 69% in the case of T-N, 78% in the case of T-P. Thus this project has significantly contributed to the reduction of water pollutants.

Table 7: Major Pollutants Generated in Kunming City and Contribution of the Project

Year	Item	COD	T-N	T-P
		t/year	t/year	t/year
Baseline				
2005	Pollutant Load Generated in Urban Area of Kunming City	41,986	9,810	927
Actual				
2010	Pollutant Load Generated in Urban Area of Kunming City	87,192	14,803	1,497
	Reduction Load by the Project	70,573	8,997	1,113
	Reduction Ratio by the Project	**81%**	**61%**	**74%**
2012	Pollutant Load Generated in Urban Area of Kunming City	97,461	16,444	1,662
	Reduction by the Project	81,011	11,322	1,302
	Reduction ratio by the Project	**83%**	**69%**	**78%**

Source: Material submitted by Executing Agency

Note：Separated actual data of Caohai and Waihai were not submitted.

3.4.1.2 Improvement of the Living Environment of Residents

Regarding "improvement in the living environment of residents", a beneficiary survey[29] (number of valid responses:100) was conducted to study the improvement in the water quality of Dianchi Lake, its having or not having an environmental improvement compared with before the project (2006), and at time of the ex-post evaluation and the degree of

[28] Since the urban area of Kunming City is adjacent to Dianchi Lake, all pollutant lord generated is flowed into Dianchi Lake through a network of discharged wastewater pipes and rives in the city. Thus the lord generated in the urban area is nearly the same amount of the lord flowing into the lake.

[29] A beneficiary survey was conducted and questionnaires covered local residents. The subjects of the survey were those who resided around the discharging points in the rivers where sewage water was discharged from 7 sewage treatment plants; and those who resided near Dianchi Lake. The subjects were a total of 100 residents: 56 residents who resided near discharging points in the six rivers; and 44 residents who resided near Dianchi Lake. Of the respondents, 37% were women and 63% were men and by age group, 25% were in their 20s, 30% were in their 30s, 22% were in their 40s, 14% were in their 50s, 7% were in their 60s, over 70 were 2%.

satisfaction with the sewage treatment service. [30]

According to the results of the beneficiary survey, regarding a change in the environment of Dianchi Lake and the rivers, where effluent water is discharged from the sewage treatment plants, compared with 10 years ago (approximately 2006) and at the time of the ex-post evaluation, more than 95% of the respondents answered that the followings improved respectively: the water quality; floating substances; odor; scenery; inhabitation of birds and fish; plants; the hygiene environment; and the drainage environment. It can be stated that many residents recognized improvement.[31]

More than a half of respondents pointed to the following factors for improvement: drainage; hygiene; and stricter regulations of factories which were sources of wastewater. Concerning the upgrading of the network of sewage pipes and the construction of sewage treatment plants, 43 respondents regarded these as factors for the environmental improvement.

Regarding the degree of satisfaction with the sewage treatment service at the time of the ex-post evaluation, 89% of the respondents answered that they were satisfied. 55 respondents gave "clogged sewage and backwater do not happen" as a reason. Regarding "measures for heavy rains and floods" while eight people gave this for a reason for their satisfaction, 14 people gave this for a reason for their dissatisfaction. Evaluation was diverse. According to the explanations given by Kunming Dianchi Investment Liability Limited Company, the reasons were as follows: a delay in division of sewage pipes and rain water pipes in the city center; and the collection of rainwater in case of heavy rains, which has been a challenge.

3.4.2 Other impacts

3.4.2.1 Impacts on the Natural Environment[32]

(1) Monitoring during Project Execution

At the time of the appraisal, significant negative impact on the natural environment was not assumed. During the renovation, expansion and construction of the sewage treatment plants and the construction of a networks of pipes under this project, as planned at the time of the appraisal, daily inspection was conducted on waste disposal, water pollution, noise and vibration. Also, the monitoring centers at municipal and ward levels conducted monthly

[30] A survey of companies near Dianchi Lake was planned. However, control over companies, which were pollutant sources, was strengthened due to staged amendments to the Dianchi Lake Protection Ordinance, established in 1998. Gradually factories were relocated and there is no factory in the areas. Thus, the beneficiary survey only covered local residents. In addition, because the periphery of Dianchi Lake was designated as an environmental protection reserve and living in the areas were restricted, residents near the sewage treatment plants were included as subjects of the beneficiary survey.

[31] Answers for respective items were as follows: water quality 98%; floating materials 97%; odor 97%; scenery 97%: inhabitation of birds and fish 95%: plants such as trees and flowers 98%; the hygienic state 95%; and the drainage environment 95%.

[32] The project's environmental impact research report was adopted by the State Environmental Protection Ministry in August, 2005.

inspection on the water quality of the sewage. According to Kunming Dianchi Investment Liability Limited Company, the construction was in accordance with the environmental protection standard and there were no issues during the construction.

(2) Monitoring after Project Completion and Environmental Consciousness on the Periphery

All the sewage treatment plants monitor the concentration of pollutants (COD, BOD, SS, T-N, T-P, pH, etc.) in the water for 24 hours by monitors installed at the sewage inlets and outlets. The monitors are managed by a third-party organization specialized in environmental monitoring. The monitoring data are directly sent online to the State Environmental Protection Ministry. In addition, in order to check the precision of the observation equipment, samples are taken and are carried in the laboratory in the 3rd Sewage Treatment Plant, and specialist staff examine the quality of water flowing into and out from the plants every day.

Previously, the peripheries of the sewage treatment plants were farms. However, at the time of the ex-post evaluation houses were built up to on the peripheries. Each sewage treatment plants have installed deodorant facilities and a system where pumps are operated underground so to reduce noise and vibration for consideration. In addition, for consideration of landscape and environment, on the treatment plant premises, trees were planted like in parks.

Sludge generated in the sewage treatment plants is dehydrated to a moisture content of about 80%[33], and is transported to be buried. It is not recycled. The construction of a sludge treatment center is likely to be completed by June, 2018.[34]

(3) Monitoring of Dianchi Lake

At 10 monitoring points for the water quality in Dianchi Lake where automatic inspection devices are installed by Dianchi Lake Monitoring Center monitoring of the water quality (eight criteria) is conducted annually. In addition to this, inspection of the water quality according to 24 criteria by artificial sample collection is conducted once a mouth. As algae grow in the summer time (April to October) in Dianchi Lake, water quality inspection is conducted once a week to inspect the generation of bacteria, which cause eutrophication. The results are sent to the State Environmental Protection Ministry as a weekly and monthly report.

[33] Before 2010, it was dehydrated to a moisture content of 83% and was transported. From 2010 onward, it is dehydrated to a moisture content of 80% to be transported.

[34] The following amounts are planned to be treated: 500t/day in the first stage (2018); 700t/day in the second stage (2020); 1,200 t/day in the third stage (December 2020).

3.4.2.2 Land Acquisition and Resettlement

At the time of the appraisal, it was planned that a total area of 35 ha would be acquired. In reality, a total area of 37.5 ha, 7% higher than the plan, were acquired. As the acquired sites were for agriculture, resettlement did not occur. Following Kunming City's standard, 174,450,000 Chinese yuan were paid as the compensation cost for lands and crop plants.

3.4.2.3 Other Impacts

After sewage treatment, the water from the sewage treatment plants is discharged into rivers in the city and finally flows into Dianchi Lake. The impact of the project is set on the improvement of Dianchi Lake. According to the result of an interview with the project executing agency and according to a beneficiary survey, answers state that odor and muddiness of the peripheries of the rivers have improved. It is assumed that the effects of the sewage treatment provided under this project have also contributed.

According to the Environmental Protection Bureau, the periphery of Dianchi Lake has become a subject for the protection of swamps and forests. In 2016, the swamp area in the lake has expanded 3,600 ha (54,000 mu) in comparison to 10 years ago and the plant coverage rate has increased from 20% in 2004 to 79% in 2015. Bird species have increased from 124 kinds to 138 kinds and fish to 23 kinds. According to the Agricultural Department of Kunming City, water and soil run off has decreased by 30% due to the protection of swamps and forests.

In light of the above, this project has achieved its objectives as planned. Therefore, the effectiveness and impact of this project are high.

3.5 Sustainability (Rating:③)

3.5.1 Institutional Aspects of Operation and Maintenance

To deal with a water quality issue of Dianchi Lake, Kunming City established "Dianchi Lake Protection Commission" in 1990. In 2004, the project's management office "Kunming Municipal Construction and Management Bureau for North Bank Water Environment Treatment Project of Dianchi Lake (KCMB)" was established in the commission and it has controlled the entirety of the project. At the time of the ex-post evaluation, domestic projects concerning the environmental protection of Dianchi Lake are being conducted and the system has not been changed.

Kunming Dianchi Lake Investment Company Limited, a state enterprise 100% owned by Kunming People's Government (hereinafter referred to as "DLICL"), has received a commission from Kunming City and has conducted the renovation, expansion and construction of the sewage treatment plants, covered by the project, under the direction of the

Construction Bureau. Receiving a commission from the city, DLICL has also conducted the operation and maintenance of the completed plants. At the time of the ex-post evaluation, there is no change in the system. However, the operation of the sewage operation plants is conducted by Kunming Dianchi Lake Wastewater Operation Company Limited, a subsidiary established in 2010, (hereinafter referred to as “Wastewater Co.”). The operation and maintenance of the network of pipes and pump stations are conducted by Kunming Dianchi Lake Drainage Facilities Company Limited (hereinafter referred to as Drainage Facilities Co.). There is an overlaying chain-of-command structure to the subsidiaries and the division of the roles are clarified. A consistent management system has been established.

Table 8 shows the number of staff in DLICL. Due to the expansion of its business, the number of engineers has increased significantly. Among them are environment engineers, engineers for water resources, architecture, water supply and drainage, ecology as well as legal experts of the water quality environment.

Table 8: Headcount of DLICL (unit : person)

Plan at the time of Appraisal (2006)					At the Time of the Ex-post Evaluation（2016）				
Total	Engineers	Operation	Administration	Accounting	**Total**	Engineers	Operation	Administration	Accounting
28	12	11	3	2	84	63	11	9	1

Source: DLICL

Table 9 shows the number of staff in each plant. According to DLICL, sufficient staff numbers necessary for the operation and maintenance of the plants is in place, including the engineers engaged in the operation and maintenance of the plants, the managers of the monitoring rooms, the patrol staff, and the engineers engaged in water quality inspection. The stuff members in the 2nd, 3rd, 4th, 5th, and 6th sewage treatment plants are fewer than at the time of the appraisal. This is because work that used to be conducted by manpower is now replaced by atomization. No issues have occurred with the operation and maintenance.

Table 9: Headcount of Each Sewage Treatment Plant's Production Department (unit: person)

	Plan at the Time of the Appraisal (2006)					At the Time of the Ex-post Evaluation (2016)				
	Total	Engineers	Operation	Admini-stration	Management	**Total**	Engineers	Operation	Admini-stration	Management
1st STP	30	4	2	2	22	31	4	2	2	23
2nd STP	32	4	2	2	24	30	4	2	2	22
3rd STP	42	6	2	2	32	38	5	2	2	29
4th STP	30	4	2	2	22	24	3	1	2	18
5th STP	32	4	2	2	24	26	4	2	2	18
6th STP	31	5	2	2	22	29	4	1	2	22
7th STP	—	—	—	—	—	24	4	2	1	17
Total	**197**	**27**	**12**	**12**	**146**	**202**	**28**	**12**	**13**	**149**

Source: Material submitted by Executing Agency

At the time of the ex-post evaluation, the number of engineers at Wastewater Co., who are in charge of maintenance of the facilities, is 255[35]. They maintain a network of pipes, 4,300km long in the city center of Kunming City, including the outputs of the project, 93 pump stations and 17 storm-water reservoirs for flood control. According to DLICL and Wastewater Co., sufficient staff numbers necessary for the operation and maintenance of the pipe network and pump stations, including mangers and engineers is in place.

To sum up, no issues have been observed in institutional systems of operation and maintenance.

3.5.2 Technical Aspects of Operation and Maintenance

In DLICL, there are engineers who have experience in designing sewage treatment plants, in operation and maintenance, and in repair and expansion since the 1980's. When its subsidiaries are established, these engineers are transferred to the subsidiaries and they also transfer their techniques to newly hired engineers. Every year, in-house technical training and training to respond to emergencies are held. The engineers who operate and manage sewage treatment plants, network pipes and pump stations are required to acquire qualifications as technicians[36]. Because there is a term of validity for the licenses and the renewal of the licenses requires undergoing training and examination, the technical level has been maintained.

[35] Of permanent staff members of Wastewater Co., the number of the engineers of the production department which is in charge of operation and maintenance are as follows: 120 (engineers: 42; senior engineers: 32; middle-class engineers: 9; and junior engineers: 37.) Besides the permanent staff, for a maintenance purposes, 200 employees are hired for cleaning the network of pipes in the city.

[36] Related technical qualifications include sewage treatment engineering, water quality chemical experimentation, electrical work, elevator and handling pumps.

Sewage treatment technology in Wastewater Co. is at a high level even in China[37]. The company's business expansion is underway as follows: acceptance of inspection; technical guidance in other provinces and neighboring country Lao People's Democratic Republic; joint research with the United States of America; and joint operation and management of sewage treatment plants in other provinces and overseas.

In light of the above, no issues have been observed in the technical aspects of operation and maintenance.

3.5.3 Financial Aspects of Operation and Maintenance

The operation of sewage treatment plants is under an outsourcing agreement (patent management rights) with the city. The revenue of the sewage treatment plant consists of a sewage treatment fee and subsidies from the city. The whole balance of all the seven sewage treatment plants after 2012 is shown in Table 10. Both the whole revue, consisting of sewage treatment fee and subsidies, from all the seven sewage treatment plants and a separate revenue from each plant exceed the operation and maintenance expenses.

Table 10: Revenues from all the seven sewage treatment plants

(Unit：10,000 Chinese yuan)

		2012	2013	2014	2015	2016
Expenses	Operation, Maintenance Cost	18,230	22,503	25,707	27,187	26,165
Revenue	Sewage Treatment Cost	20,727	21,315	22,871	22,911	22,000
	Subsidies from the City	38,680	39,035	43,295	47,185	46,730
	Balance	41,178	37,847	40,459	42,909	42,565

Source: Material submitted by Executing Agency
Note: Data in 2016 covers until Sept. 30.

At the time of the appraisal, the sewage treatment fee[38] in the city center of Kunming City was 0.8 Chinese yuan/m^3. In 2009, it was revised as follows: domestic wastewater was 1.00 Chinese yuan/ m^3, wastewater from government, commerce and industries was 1.25 Chinese yuan/m^3. The municipal government has entrusted its sewage treatment service business to DLICL for 30 years, from 2011 to 2041, and during this period, the sewage treatment cost[39] of 1.58 Chinese yuan/m^3 is guaranteed by the municipal government. This amount was calculated with the treatment cost set according to the size of each sewage treatment plant at the end of 2009, with an additional 10% for asset repair expenses. According to DLICL, it is sufficient as operation and maintenance costs.

[37] In 2013, the 3rd and 7th of the sewage treatment plants were selected as 10 of the best sewage treatment plants in the country for their energy-saving performance and reclaimed water use. The 1st sewage treatment plant was commended for its excellent standards, the 2nd, the 4th, 5th, and 6th sewage treatment plants were commended as pioneering plants.

[38] Since sewage treatment bills are charged by pay-as-you-go system along with water charges, the collection rate is nearly 100%.

[39] It is likely to be revised taking the inflation rate into consideration in 2017. Patent management rights will be renewed if there are no issues with operation and maintenance.

In light of the above, there are no issues in sustaining the financial aspect of the operation and maintenance.

3.5.4 Current Status of Operation and Maintenance

The status of the operation and maintenance of the sewage treatment plants provided under this project were studied by interviews with the operation and maintenance companies and the engineers during the field survey.

Both DLICL and its subsidiaries revise their mid-term operation and maintenance plans based on the urban development plans of the national government and Kunming City. Regarding each sewage treatment plant and pipe network, an operation plan was drawn up in accordance with the sewage treatment master plan of the city. Upgrading and repairing of the facilities are also being conducted. At the time of the ex-post evaluation, the capacity rate of each treatment plant exceeds 100%. However, problems do not occur for the following reasons: the actual treatment capacity is set up adding extra capacity; and in case of emergency such as heavy rains when the inflow volume exceeds the actual treatment capacity, the whole volume is treated without having a negative environmental impact. Moreover, the construction of two new treatment plants are planned for the city by 2020. The capacity rate is therefore likely to be eased.

The existing sewage treatment plants (the 1^{st} to the 6^{th} sewage plants), where renovation and expansion were conducted according to this project, and the newly established 7^{th} plant, all treat the volume according to the project plan and the national water quality standard as mentioned in the Effectiveness Section. Each facility has been put in order and complete manuals, patrol records and control room records are being kept.

According to the control rooms engineers, among operational issues, the major issue occurs when water exceeding the designed capacity flows into the plants in case of heavy rains. After getting permission from the Environmental Protection Bureau, a whole process is conducted with adjustment, including shortening treating time and simplifying the treatment process. Then water is discharged into rivers. So they can manage emergency situations while considering the environment.

The water quality of the sewage flowing into the sewage treatment plants and the discharged water are checked by a third organization with installed inspecting devices by every two hours. In addition, samples of water quality are collected by a car and they are inspected in a laboratory in the 3^{rd}Sewage Treatment Plant where a manual inspection is conducted. So the water quality is checked twice.

Water Quality Monitoring Device Operated by a Third-party

Control Room in the 7th STP

Regarding the facilities in the sewage treatment plants, periodical cleaning is conducted and the frequency of inspection is set. Cleaning and inspection are conducted as follows: pumps and reaction tanks are overhauled and cleaned once a year; sedimentation drain is cleaned monthly; and the MBR membrane of the 4th Sewerage Treatment Plant is cleaned every week. Dumped refuse across town flow into the network pipes. To avoid being clogged, 1,000 km, one fifth of the whole length, is cleaned every year.

Although some foreign parts have been introduced in the sewage treatment plants and pump stations, there are no problems in acquiring them because they can be secured through domestic agencies. In the sewage treatment plant and pump stations, electric power supply is secured. In case of power failure, the electric power supply is secured by switching the power source to an electric power transmission pathway of a different electric generating station.

The upgraded facilities in accordance with the project are kept in a condition whereby their expected capacity is demonstrated. Thus, it can be stated that the state of operation and maintenance is good.

In light of the above, no problems have been observed in the institutional, technical, and financial aspects of the operation and maintenance. Therefore, the sustainability of the project effects is high.

4. Conclusion, Lessons Learned, and Recommendations

4.1 Conclusion

The objective of this project is to improve the sewage treatment capacity in the city center of Kunming City in Yunnan Province by upgrading sewage treatment plants, thereby contributing to the improvement of the living environment in the area through the reduction of water pollutant in Dianchi Lake.

This project was consistent with China’s development policies and development needs at the national, provincial, and municipal levels; in accordance with Japan’s policy for assistance to

China at the time of the appraisal. Therefore, its relevance is high. Expected effects have arisen because indicators for the main effects, such as the sewage treatment rate and the quality of the treated water, have achieved the targets. In 2016, for the first time in 30 years the water quality of Dianchi Lake which had been inferior class V, the lowest water quality standard, improved to class V. Reinforcing the sewage treatment capacity resulted in improvement of the quality of water discharged. The effectiveness and impact of this project are significantly high, because this project widely contributed to a decrease in the major pollutants discharged from the urban district of Kunming City into Dianchi Lake. The renovation of the sewage treatment plants, the expansion, the new establishment and construction of the pump stations and pipe network were conducted as scheduled and the project cost was lower than planned. A considerable delay was caused in the project period so that the efficiency of the project is fair. Regarding the sustainability of the effects that arose from this project, there are no problem in the operation and maintenance structure of the managing agency, the technological, and financial aspects. Therefore, the sustainability of the project is high.

In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

None

4.3 Lessons Learned

<u>(1) Need for Cooperation with Related Departments on Environmental Improvement Projects</u>

The water quality of Dianchi Lake had been inferior class V, the lowest water quality standard, since 1986. For the first time in 30 years, it has improved to class V. Promoting the sewage treatment service has reduced the pollutant load flowing into Dianchi Lake. Collaboration with KCMB, the Environmental Protection Bureau and the municipal government on environmental regulations was effective as well. KCMB serves as a secretariat. The deputy mayor holds the post of the chief of KCMB as well and demonstrates strong leadership as bureau chief. KCMB gets the full cooperation of the Environmental Department, with which it is usually hard to build a cooperative relationship in China. The improvement in the water quality of the lake is regarded as a national key project. The following effective measures have been taken by Kunming City: regulating sailing and fishing in the lake; removing pollution sources (agriculture, livestock, industry) and houses from the periphery of the lake; protection of swamp; greening in the periphery; and changing the water of the lake. In projects, which require comprehensive measures such as environmental improvement, policies and measures to reduce environmental load are necessary along with the development of the physical progress of renewing the environment. In order to realize these in a comprehensive manner, a collaborative system with related departments such as the departments of environmental protection, finance, agriculture, fishing and housing is inevitable.

(2) Fine Example of Expanded Use of Reclaimed Water

Kunming City, where urbanization has increased, sometimes faces water shortages, so that expanded use of reclaimed water is promoted as an additional water source other than precipitation. The discharged water after treatment in the sewage treatment plants, upgraded by this project, is conducted advanced processing. Then 98.6% of the effluent water is used as river scenic water for river cleaning and odor control and 14% is used as urban recycling water for greening in parks, sprinkling water for roads, car washing water, toilet water and industrial water. Among the urban recycling water, 95% is transported by reclaimed water pipes. Some municipal governments are negative regarding the development of the reclaimed water network pipes because of a high cost. In a state when the reuse of reclaimed water has not advanced, the case of Kunming City can be described as a pioneering verification example.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
Sewage Pipe Network	Sewage Pipe Network: 336 km Sewage Pump Stations: 9 Locations	Sewage Pipe Network: 342.7 km Sewage Pump Stations: 8 Locations
Sewage Treatment Plant		
1st STP	Sludge Treatment Facility	As Planned
2nd STP	Coagulation Settling and Sludge Treatment Facility	As Planned
3rd STP	Strengthening Treatment Capacity to 60,000 m^3/day, Coagulation Settling and Sludge Treatment Facility	As Planned
4th STP	Repairing UV Facility	Replaced to Deodorization Facility Construction
5th STP	Strengthening Treatment Capacity to 95,000 m^3/day, Coagulation Settling, Sludge Treatment Facility and UV Facility	As Planned
6th STP	Strengthening Treatment Capability to 80,000 m^3/day, Coagulation Settling and Sludge Treatment Facility	As Planned
7th STP	Construction 200,000m^3/ day	As Planned
Training	8 groups total of 90 people	10 groups total of 81people
2. Project Period	June 2006 to December 2012 (79 months)	June 2006 to May 2016 (120 months)
3. Project Cost		
Foreign Currency Local Currency Total	25,222 million Japanese yen 27,759 million Japanese yen (2,026 million Chinese yuan) 52,981 million Japanese yen	19,114 million Japanese yen 24,706 million Japanese yen (1,654 million Chinese yuan) 43,820 million yen
ODA loan portion	I: 12,700 million Japanese yen II：10,400 million Japanese yen	I：12,647 million Japanese yen II：6,647million　Japanese yen
Exchange Rate	1 Chinese yuan＝13.7 Japanese yen (As of September 2005)	1 Chinese yuan=14.94 Japanese yen (Actual average between 2006 and 2016)
4. Final Disbursement Date　I：December 2013／II：July 2015		

Attachment 1: Impact Change in Water Quality of Dianchi Lake

Analysis Method

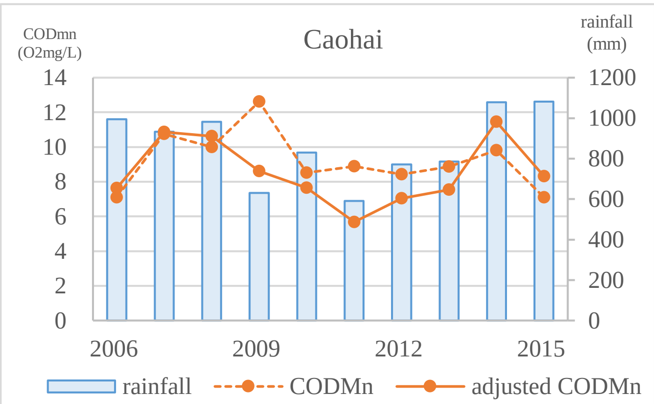
(1) Change in water quality of Dianchi Lake (Caohai, Waihai) between 2006 and 2015 was analyzed. The major pollutant (COD、BOD、T-N、T-P、NH3-N) concentration data was submitted by the Environmental Protection Bureau Observation Station as the average concentration (Caohai, Waihai) ,which was the integrated data of the observation points.

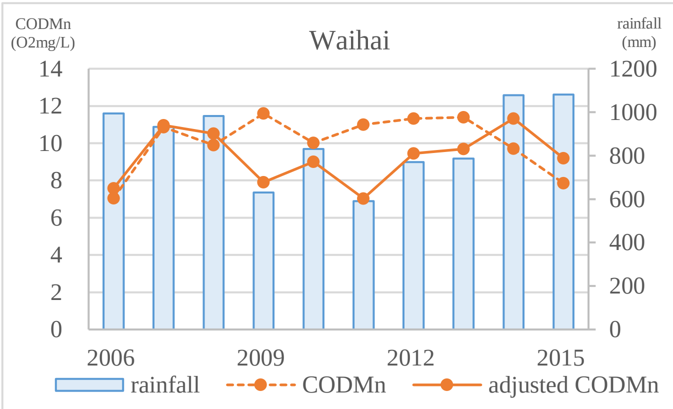
(2) Taking account of a change in rainfall of each year, actual value of water quality was adjusted with the following calculation.

Adjustment factor=P_i/ P_{ave} , P_i/= rainfall in the first year, P_{ave} =annual average rainfall.

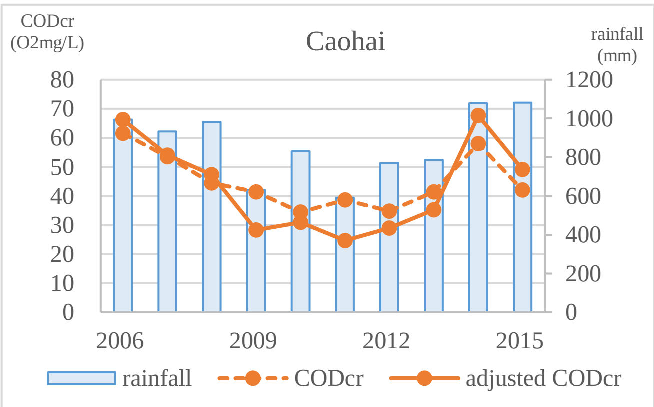
Water quality value after adjustment = submitted data x adjustment factor.

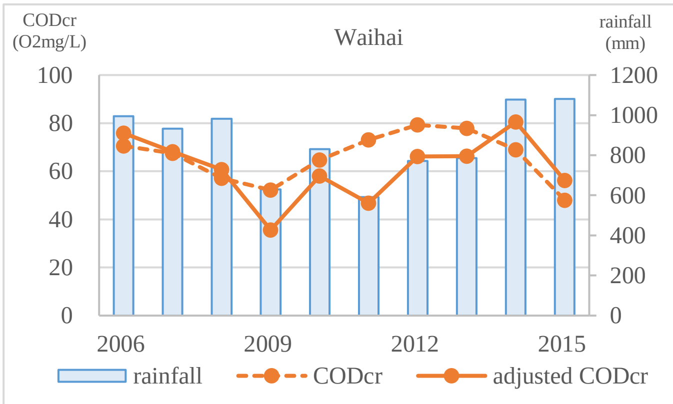
1. Chemical Oxygen Demand (COD_{Mn})



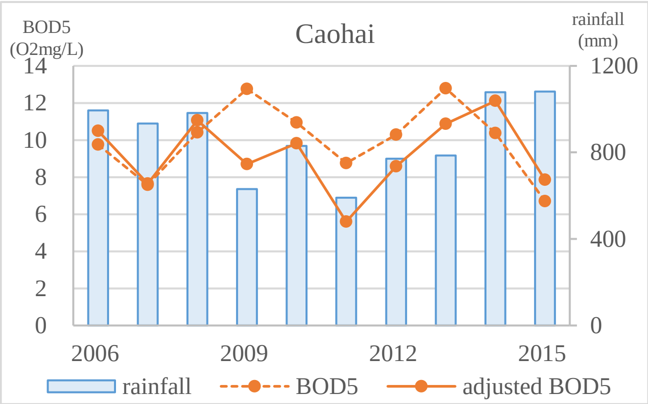


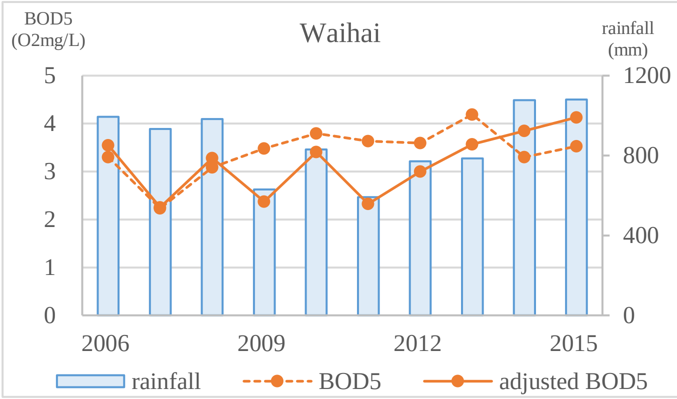
2. Chemical Oxygen Demand (CODcr)



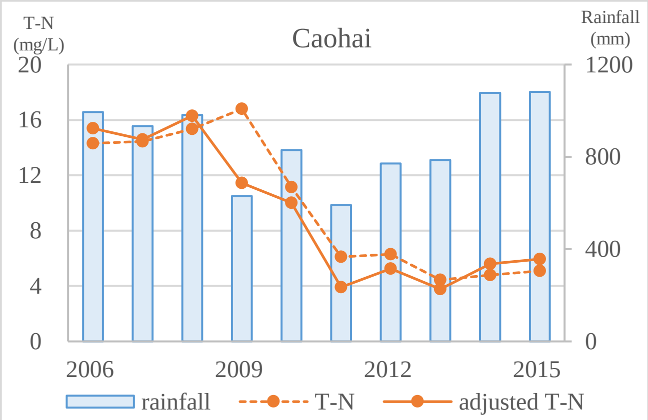


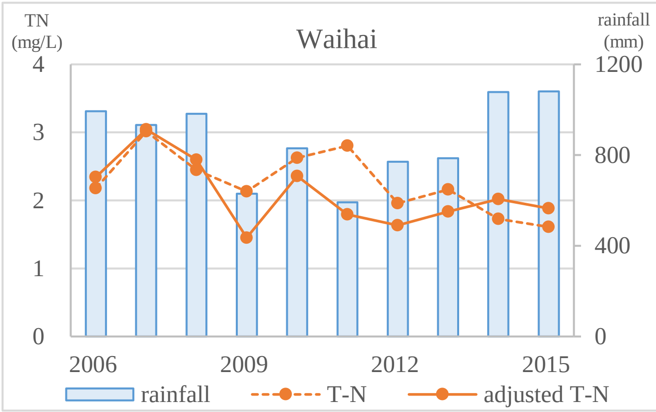
3. Biochemical Oxygen Demand (BOD5)



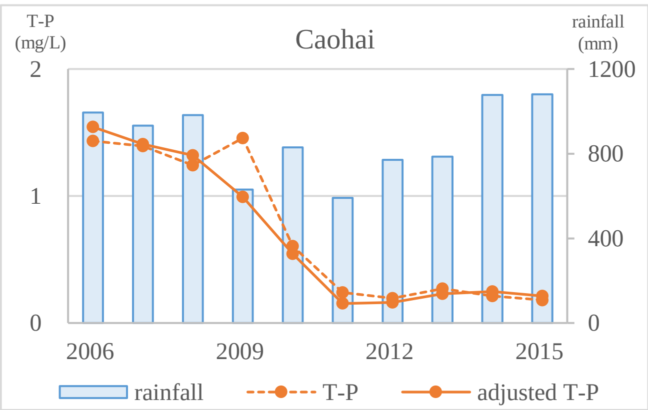


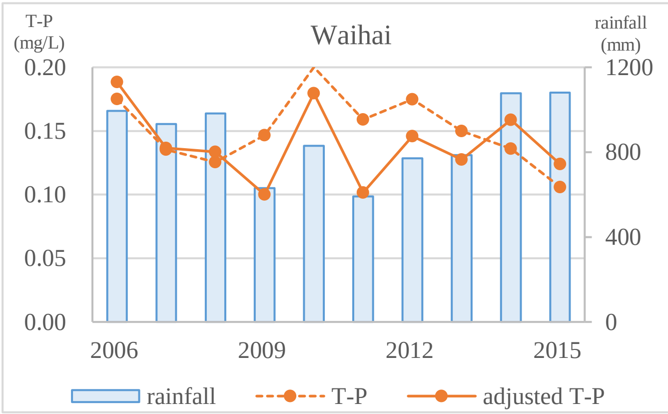
4. Total Nitrogen (T-N)





5. Total Phosphorus (T-P)





6. Ammoniac Nitrogen (NH3-N)