Ex-Post Project Evaluation 2016 :

Package IV-2 (Peru, Nicaragua, Paraguay, Honduras)

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JAPAN INTERNATIONAL COOPERATION AGENCY

GLOBAL GROUP 21 JAPAN, INC.

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Republic of Peru

FY 2016 Ex-Post Evaluation of Japanese ODA Loan Project

"Provincial Cities Water Supply and Sewerage System Improvement and Expansion Project"

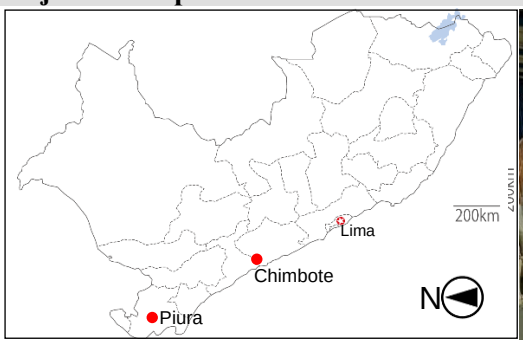
External Evaluator: Hajime Sonoda, Global Group 21 Japan, Inc.

0. Summary

The Provincial Cities Water Supply and Sewerage System Improvement and Expansion Project (hereinafter referred to as "the Project") was implemented in order to improve the water supply and sewerage services in the Northern Peruvian local cities of Piura (Piura Region) and Chimbote (Ancash Region) by means of rehabilitating and expanding water supply and sewerage facilities, thereby contributing to improvement of environmental sanitation in the target areas. Water supply and sewerage sector has consistently remained an important issue for the Government of Peru. At the time of appraisal of the Project, needs for water supply and sewerage development in the two target cities were high, and the Project facilities are still playing an important role at the time of the ex-post evaluation. Moreover, the Project is consistent with Japan's aid policies at the time of appraisal. Therefore, the relevance of the Project is high. Due to changes in government twice and worsening of the financial conditions of Sanitation Service Companies (hereinafter referred to as "SSCs") in the target cities after the signing of the loan agreement, commencement of the construction was delayed. In the case of the San Martin Sewage Treatment Plant (hereinafter referred to as "STP") in Piura, a change of the original plan to respond to the demand increase took a long time to finalize and this plant is not yet completed by the time of the ex-post evaluation. As a result, the project period more than quadrupled compared to the planned period. The total project cost exceeds the planned cost because of price inflation, an increase of the construction cost in this extended period and other reasons. Therefore, the efficiency of the Project is low. The Project has increased the water production volume and improved the water supply hours and water pressure in both cities and has also improved the water quality in Piura. Untreated sewage is no longer discharged to the river or the sea in Piura city and southern part of Chimbote. Improvement of the environmental and sanitation conditions are reported by residents in both cities. However, the water production volume by the water treatment plants (hereinafter referred to as "WTPs") has not reached the relevant planned level. In addition, the treated sewage does not meet the quality standards for treated waste water, partly because the volume of sewage received by the STPs far exceeds the planned volume. Therefore, the effectiveness and impact of the Project are fair. In regard to the operation and maintenance of the Project, the organizational aspects show minor problems in both cities, the financial aspects are problems in both cities and the technical aspects show problems in Chimbote. Based on the overall judgement of the above, the sustainability of the Project is fair.

In conclusion, the Project is evaluated as unsatisfactory.

1. Project Description



Project locations

Water Treatment Plant in Piura

1.1 Background

In Peru, when the economy collapsed in the late 1980s, hardly any investment was carried out in the water supply and sewerage sector, and deterioration of the facilities continued unchecked. Against the background of constant population inflow to urban areas, the water supply coverage rate decreased, the water supply capacity was unable to keep up with demand, and restrictions were placed on water supply hours in many local cities. The sewerage coverage rate was even lower than the water supply coverage rate with almost half of all local cities having no STPs and untreated sewage being discharged into rivers.

The administration of President Fujimori (1990 - 2000) considered water supply and sewerage improvement to be an important policy issue and conducted reform of the sanitation sector in 1992. As a result of this reform, a new system was established whereby regional governments provide water supply and sewerage services through SSCs with technical support under the National Program for Potable Water and Sewerage and supervision by the National Superintendence of Sanitation Services.[1]

In 1992, the National Program for Potable Water and Sewerage formulated the National Water and Sewage Program and the work began to improve water supply and sewerage services with the assistance of JICA and other donors.[2] For local cities, a series of feasibility studies on water supply and sewerage improvement projects were completed by 1995 with the assistance of the Inter-American Development Bank targeting multiple regional cities, including the two target cities of the Project.

Against the background described above, water supply and sewerage improvement work was

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[1] The National Program for Potable Water and Sewerage (PRONAP: Programa Nacional de Agua Potable y Alcantarillado), the National Superintendence of Sanitation Services (SUNASS: Superintendencia Nacional de Servicios de Saneamiento). Following the restructuring of government organizations, the work of PRONAP was inherited by the National Program for Urban Sanitation (PNSU/MVCS: Programa Nacional de Saneamiento Urbano/Ministerio de Vivienda, Construcción y Saneamiento).

[2] JICA provided loans for the "Lima-Callao Metropolitan Area Water Supply and Sewerage Improvement Project" (1996), "Southern Lima Metropolitan Sewerage Improvement Project" (1996) and "Pomacocha-Rio Blanco Water Resource Transfer Project (MARCA II)" (1997). The Inter-American Development Bank implemented feasibility studies in 36 out of 67 regional cities in Peru and offered funding for the improvement of infrastructure in some of these cities.

implemented under the Project in two cities, i.e. Piura (Piura District and Castilla District) in the Piura Region and Chimbote (Chimbote District and Nuevo Chimbote District) in the Ancash Region among the cities targeted by the said feasibility studies.[3]

1.2 Project Outline

To improve water supply and sewerage services in the Northern Peruvian local cities of Piura of Piura Region and Chimbote of Ancash Region by means of rehabilitating and expanding water supply and sewerage facilities, thereby contributing to improvement of environmental sanitation in the target area.

Loan Approved Amount / Disbursed Amount	13,901 million yen / 12,742 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	April 1999
Terms and Conditions	Interest Rate: Main work: 1.7%, 0.75% Consulting service: 0.75% Repayment Period (Grace Period): Main work: 25 years (7 years) Consulting service: 40 years (10 years) Conditions for Procurement: Main work: general untied Consulting service: bilateral tied
Borrower / Executing Agencies	Republic of Peru / Ministry of Housing, Construction and Sanitation (*Ministerio de Vivienda, Construcción y Saneamiento*: MVCS), National Urban Sanitation Program (*Programa Nacional de Saneamiento Urbano*: PNSU)
Final Disbursement Date	December 2011
Main Contractor	Construtora Norberto Odebrecht (Brazil)/ CBPO Engenharia Ltda. (Brazil), GYM S.A. (Peru), Ingeniería Andina Ina Bromco Cia. Ltda. (Columbia)/ Hidalgo & Hidalgo S.A.(Ecuador), Hidalgo & Hidalgo S.A. (Ecuador)/ Ingeniería Andina (Ecuador), Hidalgo & Hidalgo S.A. (Ecuador|)/ Construcción y Administración S.A. (Peru), Abengoa S.A. (Peru)/ Teyma Uruguay S.A. (Uruguay)
Main Consultant (Over 100 million yen)	NJS Co., Ltd.(Japan)/ Cardenas & Bautista S.C.R.L. (Peru), Nippon Koei Co., Ltd. (Japan)/ OIST (Peru)
Related Projects	Provincial Cities Water Supply and Sewerage System Improvement and Expansion Project (II) (ODA Loan, 2000)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hajime Sonoda (Global Group 21 Japan, Inc.)

[3] The City of Piura consists of Piura District and Castilla District and the City of Chimbote consists of Chimbote District and Nuevo Chimbote District. The administrative unit of these cities is "district" and there is no formal administrative unit equivalent to "city". In this report, however, both Piura and Chimbote are described as cities for convenience.

2.2 Duration of Evaluation Study

The ex-post evaluation study was conducted with the following schedule.

Duration of the Study: October 2016 - February 2018

Duration of the Field Survey: January 17 - February 9 and June 3 - 11, 2017

2.3 Constraints during the Evaluation Study

The feasibility study for the Project was conducted in 1995 and the project appraisal was conducted during in 1999. As nearly 20 years passed till the ex-post evaluation, collection of information on various examinations made at the time of appraisal was restricted. Accordingly, although the actual amount of sewage produced is substantially larger than the forecast in both cities, detailed analysis of the reasons for this could not be conducted during this ex-post evaluation because the feasibility study report by the executing agency could not be obtained in which the said forecast was made.

3. Results of the Evaluation (Overall Rating: D[4])

3.1 Relevance (Rating: ③[5])

3.1.1 Consistency with the Development Plan of Peru

As already described in 1.1 Background, the water supply and sewerage sector was an important policy issue at the time of appraisal (1999) and the Government of Peru was making efforts to improve the water supply and sewerage services in local cities. In subsequent years, the second presidency of Alan Garcia (2006 - 2011) greatly increased the amount of public investment in the water supply and sewerage sector under the slogan of "Water for All".[6] The government administration of Pedro Kuczynski (2016 -) who succeeded President Garcia considers the water and sanitation sector to be one of the highest priority sectors and has adopted the targets of a water supply coverage rate of 100%, 24 hour water supply and sewerage coverage rate of 100% in urban areas by 2021. To achieve these targets, the integration of SSCs is being promoted along with strengthening of the technical assistance by the Technical Organization for Sanitation Service Administration.[7]

The medium-term strategy (planning period: 2016 - 2021) for the water supply and sewerage sector prepared by MVCS in 2015 lists "increased access to high quality and sustainable water supply and sanitation services in urban and rural areas" as a strategic target, introducing plans for strengthening of the operational capacity of SSCs, participation of the private sector and measures to secure the sustainability of the services.

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4 A: Highly satisfactory; B: Satisfactory; C: Partially satisfactory; D: Unsatisfactory

5 ③: High, ②: Fair, ①: Low

6 According to data of MVCS, the ratio of public investment in the water supply and sewerage sector to the GNP was 0.1% or less until 2005, however, since 2009 it has been 0.6-0.8%.

7 Organismo Técnico de la Administración de los Servicios de Saneamiento (OTASS)

As such, the Project is highly relevant to the development policies of Peru at the time of both the ex-ante evaluation and ex-post evaluation.

3.1.2 Consistency with the Development Needs of Peru

As already described in "1.1 Background", many regional cities were in need of improvement of the water supply and sewerage systems at the time of appraisal (1999). In Piura (population of some 290,000 in 1999), one of the two target cities of the Project, groundwater from wells was the only source of water supply with such problems as a high level of salinity and high cost of water production, making the construction of water supply facilities which would use surface water as the supply source instead of groundwater necessary. Moreover, sewerage facilities were in need of improvement as they were not functioning properly. In Chimbote (population of some 280,000 in 1999), there was an urgent need for the development of the water supply and sewerage systems for its urban areas expanding southwards.[8] At the time of the ex-post evaluation, as described in "3.3 Effectiveness", the facilities improved or constructed under the Project in these cities are playing an important role in the provision of water supply and sewerage services, meaning that the importance of the Project has been sustained at the time of the ex-post evaluation.

However, the installed capacity (water production capacity and sewage treatment capacity) of the WTPs and STPs which were rehabilitated or constructed under the Project is smaller than the actual demand, except for the San Martin STP in Piura which is planned to be constructed with a larger scale than originally planned.[9] In regard to the WTPs, water demand exceeded the estimate made at the time of appraisal in both cities because of a higher population increase than the original forecast and lesser improvement of the non-revenue water rate than anticipated due to the delay of meter installation and chronic water theft.[10] Moreover, the scale of the WTPs was reduced as part of the change of the project scope which took place in 2003 against the background of fiscal austerity imposed by the Government of Peru.[11]

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[8] In southern Chimbote, the existing WTP uses an irrigation channel as the water source, while wells are used for water production in northern Chimbote. The 1999 population for each city is an estimate based on information obtained from the SSC for each city.

[9] Various reference materials collected for the ex-post evaluation suggest that the target year used to determine the plant scale was 2025 for the WTP in Piura and 2010 for the STP in Piura and the WTP and STPs in Chimbote from the beginning. However, no information was obtained to concretely verify the actual planning process. The situation of the plant capacities being below the actual demands appears to have already existed in 2010 for the WTP and STPs in Piura and the STPs in Chimbote based on data relating to the water demand forecast, water production volume, sewage treatment capacity, sewage reception volume, water quality after treatment, etc.

[10] As of 2016, the actual population increase is some 20% higher than the forecast made at the time of appraisal for the same year in both cities. Meanwhile, the meter coverage rate is slightly higher than 70% of the planned level and the non-revenue water rate is almost double than predicted. According to MVCS, water theft (illegal connection without payment) accounts for a fair proportion of the non-revenue water in both cities. Such a high level of water theft was not fully known at the time of project planning. As described in "3.3 Effectiveness", it can also be pointed out that the renewal of old distribution pipes by the Project might not have led to a sufficient reduction of water leakage. No information was found on how the Project was planned to contribute to the reduction of the non-revenue water rate.

[11] The review of the water demand forecast during the process of examining a possible change of the project scope re-examined such matters as the population, water supply coverage rate, meter installation rate, water consumption per capita and non-revenue water rate. In each city, the water consumption per capita was reduced from the original

In regard to the STPs, according to MVCS and the SSCs in Piura and Chimbote,[12] population increase beyond the forecast made at the time of appraisal led to an increase of the sewage arriving at each plant. In Piura, the volume of sewage has also increased as a result of the private exploitation of groundwater due to new residential development which was not assumed at the time of appraisal.

In summary, as the capacity of the WTPs and STPs rehabilitated or constructed under the Project is smaller than the actual demand, the development needs have not been fully met. However, the necessity for the Project is clear and the lower capacity than the demand does not mean that the Project is not relevant to the overall development needs.

3.1.3 Consistency with Japan's ODA Policy

In February 1998, prior to the ex-ante evaluation, the Japanese High-Level Mission on Economic Cooperation and the Government of Peru agreed that poverty reduction, assistance for the social sector, development of economic infrastructure and environmental conservation were priority agendas for future economic cooperation from the medium to long-term viewpoint. *The Country Assistance Program for Peru* (2000) formulated on the basis of this agreement says that "cooperation in basic human needs will continue to be promoted centering on the development of water supply and sewerage systems" under the agenda of poverty countermeasures. Therefore, the Project is relevant to Japan's ODA policies for Peru.

Based on the above, the Project is highly relevant to Peru's development plans and development needs as well as Japan's ODA policies. Therefore, its relevance is high.

3.2 Efficiency (Rating: ①)

3.2.1 Project Outputs

Water supply and sewerage facilities were improved in Piura and Chimbote under the Project. The planned and actual outputs of the Project are shown in Table 1. Many of the facilities constructed under the Project have either improved or expanded the existing water supply and sewerage facilities in each city. However, they are scattered in these cities and do not necessarily function in an integral manner. The implementation process and the changes made to the scope of the Project for each city are discussed next.[13]

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level, resulting in a lower water demand forecast. The concrete basis for this modification was not confirmed by the ex-post evaluation.

[12] The SSCs for Piura and Chimbote are EPS GRAU S.A. for the former and EPS SEDACHIMBOTE S.A. for the latter.

[13] All of the changes made to the original plan, which are described in the following sections, were agreed between MVCS, the executing agency and JICA prior to their implementation.

Table 1 Comparison of Planned and Actual Outputs

Planned (at the Time of Appraisal)		Actual
＜Piura water supply＞		
・ Intake	1,500 liters/sec	1,320 liters/sec
・ Construction of Curumuy WTP	880 liters/sec	600 liters/sec
・ Construction of transmission pipeline*	51.6 km	55.9 km
・ Construction/rehabilitation of distribution network**	59.4 km	40.9 km
・ Construction of distribution reservoirs	(5 sites) 10,350 m^3	(6 sites) 16,000 m^3
・ Rehabilitation of distribution reservoirs	0	(5 sites) 88,000 m^3
・ Rehabilitation of well pumps	10 sites	11 sites
・ Construction/rehabilitation of house connections**	11,760 households	6,000 households
・ Installation of water meters	22,500 units	21,636 units (+ 864 in reserve)
・ SCADA (treatment plant, distribution reservoirs and wells)		As planned
＜Piura sewerage＞		
・ El Indio STP*** (Oxidation pond system)	Rehabilitation: 6.0 ha Construction: 12.7 ha Total: 239 liters/sec	Rehabilitation: 6.0 ha Construction: 20.0 ha Total: 200 liters/sec
・ San Martin STP (Oxidation pond system)	Rehabilitation: 9.6 ha Construction: 11.9 ha Total: 241 liters/sec	New plant is constructed on premises of existing plant: 32.3 ha (planned) Total: 690 liters/sec (planned)
・ Construction of pressurized sewer pipeline	10 km	8.1 km
・ Construction of pumping stations	1 site	1 site
・ Rehabilitation of pumping stations	4 sites	12 sites
・ Rehabilitation of sewer network	26.7 km	36.1 km
＜ Chimbote water supply＞		
・ Construction of raw water reservoirs	70,000 m^3 x 2	None
・ Rehabilitation/expansion of WTP	500 liters/sec	550 liters/sec
・ Construction of transmission pipeline*	19.9 km	14.8 km
・ Construction/rehabilitation of distribution network**	77.6 km	69.3 km
・ Construction of distribution reservoirs	(5 sites) 14,850 m^3	(5 sites) 15,000 m^3
・ Construction/rehabilitation of house connections**	7,300 households	9,243 households
・ Installation of water meters	50,000 units	28,100 unites (+ 3,400 in reserve)
・ Rehabilitation of wells	(3 sites) 135 liters/sec	(3 sites) 135 liters/sec
・ Rehabilitation of raw water reservoirs	(3 sites) 70,000 m^3	None
・ Rehabilitation of distribution reservoirs	(8 sites) 20,800 m^3	(5 sites)
・ Pumping stations	2 for rehabilitation; 2 for construction	2 rehabilitated and 1 constructed
＜Chimbote sewerage＞		
・ Construction of pressurized sewer pipeline	3.9 km	1.4 km
・ Construction/rehabilitation of sewer network**	50.8 km	49.2 km
・ Rehabilitation of pumping station	1 site	1 site
・ Las Gaviotas STP (Oxidation pond system)	Expansion: 7.5 ha Rehabilitation: 12.0 ha Total: 155.3 liters/sec	Expansion: 8.6 ha Rehabilitation: 12.0 ha Total: 157 liters/sec
・ Centro Sur STP (Oxidation pond system)	Construction: 2.5 ha 22.8 liters/sec	Construction: 2.4 ha 17 liters/sec
・ House connection	New: 150 households Rehabilitation: 3,000 households	New: 3,569 households Rehabilitation: 2,856 households
< Consulting Service >		
Project supervision (detailed design/work management)		As planned
Additional study on the Chimbote sewerage system		As planned

Source: Materials provided by JICA, MVCS and SSC in each city

Notes:

* Pipeline from the WTP to distribution reservoir.

** While the original plan distinguishes construction from rehabilitation, the planned construction work appears to have included the replacement of existing pipelines. As such, the distinction between the planned construction work and planned rehabilitation work is unclear. There is no clear way to exactly distinguish the actual construction output and actual rehabilitation output.

*** El Indio STP of the Project consists of two separate STPs, namely “El Indio STP” which was rehabilitated and “Cuevín STP” which was newly constructed. They are located at the same premise but have different service areas. For convenience, in this report, these two STPs are referred together as “El Indio STP”.

(1) Piura

In regard to the water supply in Piura, fiscal constraints faced by the Government of Peru led to re-examination of the project scope and the water production capacity of the WTP to be newly constructed was reduced by some 30% and corresponding changes of the planned pipeline network were made (2003). At the same time, rehabilitation of those distribution reservoirs which had deteriorated with age was added to the scope. At the actual construction stage, changes were made to locations of the pipelines as well as work volume to reflect the newly discovered site conditions, including the non-existence of those pipelines subject to rehabilitation at the assumed locations and different geological conditions from those assumed. According to the Piura SSC, the renewal of the distribution network was conducted while disconnecting the house connections from the old pipelines which were not removed. As old and new pipelines became connected through the pipes for illegal connections installed by residents without permissions, water continued to flow to some parts of the old pipelines. Furthermore, since wood plugs were used to shut off the house connections to the old pipes, there is concern on leakages of water flowing from the new pipeline at those locations where sealing was not sufficient.[14]

In regard to the sewerage in Piura, during the process of reducing the project scope mentioned above, the scale as well as the planned treatment level of STPs (planned water quality of treated sewage) was reduced while not changing the planned volume of sewage to be received. This change was judged not to cause any major problems as the range of crops benefitting from the treated sewage used for irrigation was limited. Of the two planned new STPs, the work to construct the San Martin STP was delayed because of failure to acquire part of the planned land after signing for the work. The subsequent discovery that the actual volume of sewage to be treated was much larger than the original forecast made it necessary to plan a larger facility. Because the revised plan could not be completed by the final disbursement date (December 2011) of the ODA loan at the time, it was decided in May 2011 that this plant would be constructed using MVCS's own funds (within the scope of the Project). As of June 2017, the procurement process is in progress for this plant. At the El Indio STP, the treated sewage is used for irrigation. The outlet channel from this completed plant was connected to an existing small irrigation channel which was actually too small to handle the volume of treated sewage from the plant, causing standing water around the plant. To rectify the situation, the Regional Government of Piura constructed a temporary irrigation channel (outside the project scope) in 2014.

(2) Chimbote

In regard to the water supply in Chimbote, scope of the Project was reduced against the

[14] According to the Piura SSC, having learned a lesson from this, the pipeline renewal project in recent years involves the removal of old pipelines in its scope although it results in an increase of the project cost. The same applies to Chimbote.

background of fiscal constraints faced by the Government of Peru as in the case of Piura. The actual changes included reduction of the plant size and cancellation of the construction/rehabilitation of raw water reservoirs. Because of further deterioration of existing pipelines, expansion of residential areas and fresh paving of roads in the period from the time of appraisal to the commencement of construction in 2005, and new findings during the construction on existing water supply network and geological conditions the work volumes for various facilities were modified to accommodate these changes. The original plan envisaged the construction of new water treatment facilities along with the rehabilitation of existing facilities on the same premises. Following the proposal by the contractor that the construction of a new mechanical flocculation basin while utilizing some of the existing facilities, such as the sedimentation basin and filtration basin, would reduce both the construction cost and operation and maintenance cost and also increase the water production capacity, the original plan was modified as proposed by MVCS with the consent of JICA. Although the Chimbote SSC had no previous experience of operating a mechanical flocculation basin, no technology transfer by means of either advance training or trial operation after completion was conducted. (Refer "3.5.2 Technical Aspects of Operation and Maintenance" for more details.) According to the Chimbote SSC, the position of the drain pipe of the treated water storage tank is too high to conduct complete water drainage for cleaning, etc., forcing the SSC to use a separate pump to drain the water. As in the case of Piura, the distribution network was renewed without removal of the old pipelines, leaving a possibility of water leakage from the points where sealing was not sufficient.

In regard to the sewerage in Chimbote, groundwater level was higher than assumed at the two STPs and the work to introduce impervious protection was added in order to prevent penetration of underground water to the treatment ponds. Number of new house connections was greatly increased due to added connections to new houses. While the original assumption was that treated sewage from the two plants would be used for irrigation, as in the case of Piura, the length of the outlet channel was some 30 m. At the Las Gaviotas STP where the existing plant was expanded, the outlet channel was connected to the irrigation channel constructed by farmers who had been already engaged in irrigated farming using the treated sewage. At the newly constructed Centro Sur STP, farmers constructed the connecting irrigation channel but the drainage from this channel was poor, causing spillage. To rectify the situation, the Chimbote SSC raised the outlet channel by approximately 50 cm in order that the treated water could be released farther away.

3.2.2 Project Inputs

3.2.2.1 Project Cost

Table 2 shows the planned and actual project cost. Compared to the planned total project cost of 18,535 million yen (ODA loan of 13,901 million yen), the actual cost at the time of the ex-post evaluation is 17,905 million yen (97% of the planned cost) with 12,743 million yen of the ODA

loan being used (92% of the planned amount). With the addition of 134 million nuevos soles (around 4,650 million yen, planned amount as of June 2017) funded by the Peruvian side for the planned construction of the San Martin STP, the final total project cost is 22,555 million yen (122% of the planned cost).

Table 2 Planned and Actual Project Cost

(Unit: million yen)

	Planned			Actual (As of June 2016)		
	Total	ODA Loan	Peruvian side	Total	ODA Loan	Peruvian side
Piura water supply	7,269	6,397	872	5,636	4,721	915
Piura sewerage	1,519	1,337	182	*2,690	2,345	*345
Chimbote water supply	2,327	2,048	279	3,259	2,322	937
Chimbote sewerage	1,019	896	123	1,478	1,219	259
Price escalation	922	735	187	0	0	0
Physical contingency	1,306	1,142	164	0	0	0
Consulting services	1,346	1,346	0	2,135	2,135	0
Tax	2,827	0	2,827	2,707	0	2,707
Total	18,535	13,901	4,634	*17,905	12,743	*5,162

Source: Materials provided by JICA and MVCS

Note: *These figures do not include the cost of San Martin STP (approx..4.3 billion yen) to be constructed by the Peruvian funding.

Exchange rate (Planned) US$1 = 113.5 yen, 1 nuevo sol = 34.0 yen

(Actual) US$1 = 101.0 yen (actually applied rate)

1 nuevo sol = 32.7 - 38.4 yen (average rate during each contract term)

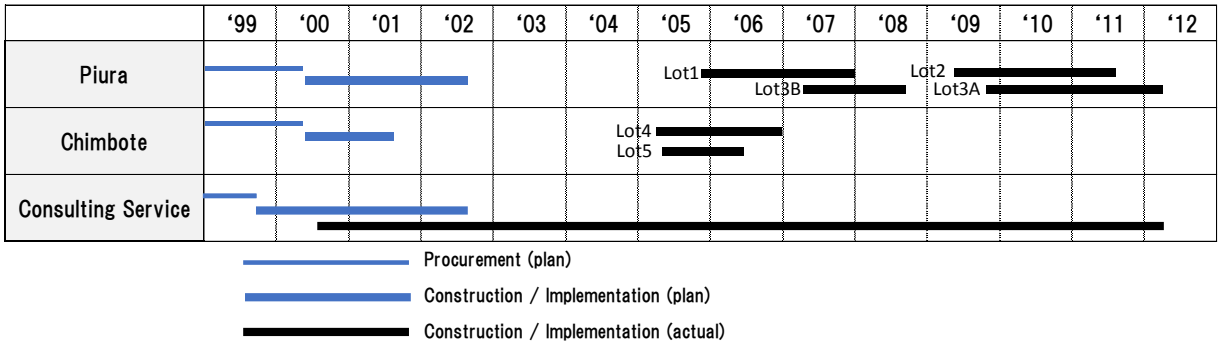
The reduction of the project scope with the fiscal constraints faced by the Government of Peru as its background was made in order to reduce the project cost. However, the US dollar-based total amount of the six contracts for the civil works for the water supply and sewerage components of the Project in the two cities (when the contracts were signed) already exceeded the relevant amounts planned at the time of appraisal by slightly more than 30%, because of the increased unit prices of materials, etc. as a result of price inflation since 1998. After the signing of these contracts, as explained in 3.2.1 Project Output, the amount of each contract was either increased or decreased because of the removal of the San Martin STP in Piura from the scope of the contract as well as ODA loan, increased construction volumes in both cities and other reasons. The actual cost of the consulting service substantially increased following the extension of the project period. Meanwhile, the average exchange rate during the period of the civil works from 2005 to 2011 was US$1 to 101 yen, signifying a massive appreciation of the yen from the planned US$1 to 140 yen at the time of appraisal. Because of the fact that the construction contracts were based on the US dollar or Peruvian nuevo sol, the strong yen reduced the yen-based project cost.

3.2.2.2 Project Period

The loan agreement for the Project was signed in April 1999 and the Project was scheduled

for completion in March 2003. The final loan disbursement date for the Project was extended twice[15], and six contracts subject for the ODA loan were completed by March 2012 (Fig. 1). These six contracts subject for the ODA loan under the Project are shown in Table 3. As of June 2017, the San Martin STP which was subsequently excluded from the scope of the ODA loan is undergoing the procurement process[16], meaning that the Project is not yet fully completed. The actual project period is 219 months as of June 2017 (April 1999 to June 2017), rising to 456% of the planned period of 48 months (April 1999 to March 2003). As nearly two more years are expected to be required until the completion of the San Martin STP, the actual project period will be considerably longer than planned.

Figure 1 Planned and Actual Project Period in Each City (ODA Loan Portion)



Source: Materials provided by JICA and MVCS

Major reasons for this considerable increase of the project period are listed below.

- After the signing of the loan agreement, reorganization of government ministries and downsizing of the executing agency occurred following the two changes of the administration. During the project period, financial situation of the SSCs in the two cities worsened because of political and economic confusions at the time, the austerity of government finance, decentralization policy implemented from 2002, and others.
- It took two years from 2002 to 2003 to narrow down the project scope reflecting the austere fiscal policy of the Government of Peru.
- After the commencement of the consulting services, it was discovered that the executing agency could not provide sufficient information to review and prepare the detailed design, resulting in the temporary suspension of the consulting service, based on the discussion between the executing agency and JICA, from 2001 to 2004 while maintaining the contract.

[15] The original final disbursement date was August 2004 but was extended to February 2009 which was further extended to November 2011.

[16] This plant is expected to require one and a half years to construct after signing of the construction contract. According to MVCS, the construction is in progress as of December 2017.

- In 2003, the failing business situation of the Piura SSC led to a proposal to introduce the concession method for part of the Project.[17] It took four years until 2006 to examine this proposal, delaying the commencement of the work for Lot 2 and Lot 3A.
- Some of the tenders had to be repeated because of such reasons as the absence of bidders within a predetermined price and the absence of bidders passing pre-qualification. The contract process for Lot 1, Lot 2 and Lot 3B took 2 - 5 years to conclude.
- Construction period for each contract was extended for up to six months because of the change of the scope of work, additional work due to unforeseen site conditions and delayed pump procurement (re-procurement / re-importation).
- The San Martin STP in Piura was originally included in Lot 3A as a subject for the ODA loan. However, it was put outside the scope of the ODA loan (within the project scope but to be funded by the Peruvian side) due to the necessity for the re-planning of this plant to make it bigger (2011). Following the subsequent re-planning and domestic appraisal procedures, construction of the plant is at the procurement stage as of June 2017.

Table 3 Construction Contracts for the Project (Those Covered by the ODA Loan)

Contract Lot	Description	Contract Date	Completion Date
Lot 1	WTP in Piura	November, 2005	December, 2007
Lot 2	Water Supply Network in Piura	May, 2009	July, 2011
Lot 3A	Water Supply and Sewer Networks in Piura	November, 2009	March, 2012
Lot 3B	STPs and Sewer Network in Piura	April, 2007	August, 2008
Lot 4	WTP and Water Supply Network in Chimbote	March, 2005	December, 2006
Lot 5	STPs and Sewer Network in Chimbote	April, 2005	June, 2006

Source: MVCS
Note: The San Martin STP in Piura is outside the scope of the ODA loan.

3.2.3 Results of Calculations for Internal Rates of Return (Reference Only)

Internal rate of return was not calculated at the time of appraisal. Trial re-calculation of the financial internal rate of return (FIRR) is conducted for reference in this ex-post evaluation in connection with the construction of the intake, WTP, transmission pipelines and distribution reservoirs of the water supply component of the Project for Piura. This re-calculation uses a project life of 25 years, construction, operation and maintenance costs as costs, and revenue from the water supply service and saving of the water production cost from wells (electricity cost) as

[17] The agreed policy was for a private company with a concession to be responsible for the construction/rehabilitation of the water supply and sewer networks and also for the operation and maintenance of these networks along with the WTP and STPs after their construction. This concession method was later abandoned after further examination.

benefits, and the resulting FIRR is 10.3%.[18] No re-calculation is conducted for other components of the Project due to the lack of enough data.

As is described above, the project cost exceeded the planned cost while the project period significantly exceeded the planned period. Therefore, the efficiency of the Project is low.

3.3 Effectiveness [19] (Rating: ②)

3.3.1 Quantitative Effects (Operational and Effect Indicators)

While the purpose of the Project was to improve the water supply and sewerage services in Piura and Chimbote, indicators to measure the level of achievement of this purpose in each city were not clearly given at the time of appraisal. For the ex-post evaluation, therefore, the level of achievement of the purpose was determined mainly based on those indicators directly linked to the specific purposes of the Project in each city as primary indicators, which were identified among various indicators related to urban water supply and sewerage services, taking into consideration the development/improvement needs for the water supply and sewerage systems in each city confirmed at the time of appraisal.[20] Those indicators related to expected substantial contributions of the Project were also used as secondary indicators. Target values for individual indicators were decided based on the forecast water supply and demand and other data for each city which were referred to at the time of appraisal.

(1) Water Supply in Piura

Prior to the implementation of the Project, water supply in Piura relied entirely on groundwater from wells. Of the 25 wells, groundwater supplied by 23 wells contains salinity exceeding 250 mg/liter which was the standard value for drinking water set by the government. In some areas, water supply by direct pumping from a well was unstable due to the lack of distribution reservoirs. The Project planned target to make surface water account for 70% of the water production in 2015 by means of constructing a WTP (installed capacity: 880 liters/sec) using surface water from an irrigation channel as the water source and construction of distribution reservoirs in order to lower the salinity level to below the standard by means of appropriately mixing surface water and groundwater at the distribution reservoirs. Table 4 shows the relevant planned and actual achievement of the selected indicators.

Water production volume in Piura for the period from 2013 to 2016 was 1,225 liters/sec which

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[18] EIRR was not calculated because it was difficult to convert such benefits as savings on the water acquisition cost on the part of water users and improvement of public sanitation into monetary value.

[19] The effectiveness is rated in consideration of not only the effects but also the impacts.

[20] Level of achievement was judged according to the indications of JICA's Ex-post Evaluation Reference. As for those indicators with which comparison between planned and actual achievement is possible, if achievement of an indicator is "80% or higher" compared to the planned level, level of achievement is judged "high". If it is between "50 - 79%" or "49% or lower", it is judged "medium" and "low" respectively.

was equivalent to 136% of the planned figure at the time of appraisal. However, the WTP constructed under the Project produced water at a rate of 458 liters/sec in this period and this was only 73% of the planned level (630 liters/sec). The reason for this was the reduction of the production capacity from the planned 880 liters/sec to 600 liters/sec due to the budgetary austerity of the government coupled with production restrictions posed by insufficient transmission facilities and the water source.[21] To supplement the insufficient water production, water production from wells at a rate of 767 liters/sec from 2013 to 2016 was approximately 2.6 times the planned level of 300 liters/sec. It must be noted that the Project also contributed to water production from wells.[22]

Table 4 State of Achievement of the Water Supply Indicators in Piura

Indicators	Before the Project	Planned figures at the time of Appraisal (1998)	Actual Results	Level of Achievement
Water production volume	Unknown	900 liters/sec (2013 - 2016)	1,225 liters/sec (2013 - 2016)	High (principal indicator)
Ratio of surface water	0% Groundwater alone	70% WTP: 630 liters/sec Wells: 270 liters/sec (2013 - 2016)	37% WTP: 458 liters/sec Wells; 767 liters/sec (2013 - 2016)	Medium (principal indicator)
Ratio of households with lower level of salinity than the standard	Unknown	100% of households to which surface water is supplied	61% of households to which surface water is supplied (24% of total households) (2016)	Medium (principal indicator)
Water supply hours per day	Unknown	Unknown	17 hours/day (2016)	Medium* (secondary indicator)
Water pressure	Unknown	Unknown	11 mwc** (2016)	Medium (secondary indicator)
Meter coverage rate	9% (1995)	86% (2010)	59% (2016)	Medium (secondary indicator
Non-revenue water rate	55% (2002)	22% (2015)	51% (2015)	Low (secondary indicator

Source: Materials provided by JICA and Piura SSC.
Notes: * Achievement level compared to 24 hour/day supply which is the target of the Government at urban areas.
** The unit (mwc) for the average water pressure is "water meter column" the pressure capable of supporting one meter water column.

[21] According to the Piura SSC, there is no design leeway for the capacity of the transmission pipeline from the WTP to each distribution reservoir and of the water conveying pump at the plant. In addition to that, the volume of water transmission has been restricted by the changed hydraulic balance of the pipeline, which was caused by the relocation of one distribution reservoir to a far site because of the inappropriate geological conditions of the planned site and also because of the change of the production volume of groundwater to be mixed at each distribution reservoir. Although the Piura SSC has tried to adjust the operation, the maximum transmission volume is restricted to some 540 liters/sec. Moreover, the plant has to be shut down for approximately one week, three or four times a year, for maintenance of the irrigation channel.

[22] Eleven wells were either rehabilitated or expanded under the Project. Data for December 2016 shows that these wells account for some 20% of the total water production volume in Piura.

Water production of the WTP using surface water is 37% (2013 - 2016) of the total water production and is just above half of the planned rate of 70%. Water from the WTP is supplied to 39% of the total households in Piura. 34% of the households receive water from the plant which is mixed with groundwater at the seven distribution reservoirs constructed under the Project.[23] Because the salinity level is not sufficiently lowered after mixing at some of the reservoirs due to the low ratio of water from the plant, the salinity is lower than the standard at only 61% (24% of the total number of households) of those households receiving water supply from surface water (39% of the total number of households).[24]

The average water supply hours in Piura in 2016 were 17 hours/day with an average water pressure of 11 mwc (the standard pressure at the time of the ex-post evaluation is 15 - 50 mwc). According to the Piura SSC, the average water supply hours in the city prior to the Project were 8 - 10 hours/day and the Project made an important contribution to improvement of the water supply hours. The construction of six distribution reservoirs under the Project is considered to have contributed to steady water distribution in some areas.[25] However, some 43% of the water production volume in Piura is accounted for by directly supplied groundwater from wells without passing distribution reservoirs, meaning that water supply is unstable in nearly half of Piura. According to the result of the beneficiary survey, 51% and 37% of the households surveyed are not satisfied with the water pressure and water supply hours respectively.[26] In contrast, many positive opinions were expressed regarding the water quality and frequency of disruptions of water supply. In general, 64% of the households surveyed replied that the water supply service had improved after the Project.

Renewal of the distribution network and installation of water meters under the Project are believed to have contributed to reducing the non-revenue water. The Project renewed 7% of the entire distribution network (pipelines) and installed some 21,600 water meters which are equivalent to 22% of the total number of house connections. However, the possibility of the non-removal of old pipelines at the time of renewal leading to water leakage as described earlier can

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23 The remaining 6% of these households receive water from the plant without the mixing of groundwater.

24 Based on the assumption that some 10% of households receive low salinity groundwater among those solely receiving groundwater supply (61% of the total number of households), the ratio of households receiving the supply of water of which the salinity is below the standard in Piura is inferred to be 30%.

25 Number of new house connections in the service areas of the six distribution reservoirs constructed under the Project is equivalent to 23% of the total number of connections. Group interviews (the beneficiary survey) conducted in these areas found that the unstable water pressure under the previous direct conveyance from a well substantially improved after the completion of a distribution reservoir.

26 The beneficiary survey (questionnaire survey) was conducted with 102 households in Piura and 105 households in Chimbote. A total of nine group interviews with residents were held in the two cities. The questionnaire survey targeted those households connected to the water distribution network of the SSC even before the implementation of the Project in each city and used the two-step sampling method based on the distribution area and random area sampling within the distribution area. By gender, 29% of the respondents were male and 71% were female, and by age group, 18% were in their 20's, 20% in their 30's, 25% in their 40's and 36% in their 50's or older. The main results of this questionnaire survey are included at the end of this report. Group interviews were held four times in Piura and five times in Chimbote with particular care paid to avoiding any geographical bias. The participants of these interviews were those who had responded to an appeal by those cooperating with the Project at the selected sites (a total of 48 people at nine sites).

be pointed out (see 3.2.1- (1)). The meter installation rate increased to 82% in 2013 but then declined to 59% in 2016 because of the slow progress of the work to replace meters which service life (5 years) had elapsed. The non-revenue water rate (51% in 2015) did not reach the target (22% in 2015). According to the water leakage control section of the Piura SSC, rampant water theft is the cause of much non-revenue water.[27]

Based on the above, using the water production volume, ratio of surface water and the ratio of households with a lower salinity level than the standard as the principal indicators and other indicators as secondary indicators, the degree of target achievement of the Project in regard to the water supply in Piura is fair.

(2) Sewerage in Piura

At the time of appraisal, the limited sewage treatment capacity of 217 liters/sec (49% of the generated sewage volume) in Piura against the generated sewage volume of 444 liters/sec meant that half of the sewage generated in the city was discharged to the Piura River without being treated. The Project planned the reduction of the environmental load by the discharge of untreated sewage by means of increasing the sewage treatment capacity to 95% (484 liters/sec) of the generated sewage volume (508 liters/sec: year unknown) through the rehabilitation and expansion of two STPs. The planned treatment standard was assumed to be the quality level enabling the recycled use of the treated sewage for irrigation. Table 5 shows the state of achievement of the relevant indicators.

The effective treatment capacity (capacity of the operable sewage treatment facilities) of the two plants at the time of the ex-post evaluation is rather low at some 284 liters/sec (72% of the planned capacity), because the rehabilitation and expansion works (within the scope of the Project but outside the scope of the ODA loan) for the San Martin STP with a treatment capacity of 144 liters/sec has not yet started (see the section on efficiency) and a part (60 liters/sec) of the El Indio STP of which the treatment capacity was increased to 200 liters/sec under the Project is not yet in operation (see the section on sustainability).

[27] The Piura SSC adopts stringent water theft control measures with the assistance of the police as part of its non-revenue-water reduction program.

Table 5 State of Achievement of Sewerage Service Indicators in Piura

Indicator	Before the Project	Planned figures at Time of Appraisal (1998)	Actual Results (2014 - 2016)	Level of Achievement
Discharge of untreated sewage to the environment	Yes	Reduction	None	High (secondary indicator)
STP utilization rate (volume of sewage inflow / treatment capacity)	Unknown	Unknown	San Martin: 297% El Indio: 257% Total: 274%	Medium* (secondary indicator)
Quality of treated sewage	BOD: 20.0 mg/l SS: 50.0 mg/l Coliform: unknown	Wastewater standards (at the time of the ex-post evaluation) * BOD: 100 mg/l SS: 150 mg/l Coliform: 10,000 MPN/100ml	San Martin: BOD: 97mg/l SS:73mg/l Coliform: 2.4×10^6 MPN/100ml El Indio: BOD: 100 mg/l SS:96 mg/l Coliform: 1.8×10^5 MPN/100ml	Low (principal indicator)
BOD load removal volume (tons/day)	Unknown	San Martin: 5.1 El Indio: 5.1 Total: 10.2	San Martin: 6.8 (2016) El Indio: 8.3 (2016) Total: 15.1 (2016)	High (principal indicator)

Source: Materials provided by JICA and Piura SSC.

Notes: * As a STP operating rate substantially exceeding 100% is undesirable due to its problematic implication on treated sewage quality, the level of achievement is judged to be medium. For judgement of the quality of treated sewage, the relevant standard in Peru (maximum permitted level) at the time of the ex-post evaluation is used.

These two plants receive a combined total of 941 liters/sec of sewage (2014 - 2016) and have a combined utilization rate (volume of sewage inflow÷treatment capacity) of 274%, significantly exceeding the adequate level. The real utilization rate is even higher when the non-operating part mentioned above is taken into consideration. Such an excessive load is the direct reason why the quality of the treated sewage does not meet the national water quality standard for treated water to discharge. According to the Piura SSC, it is thought that the sewage volume has greatly increased beyond the planned forecast due to the expansion of the sewerage collection area in response to the expansion of urban areas, the increase of sewage generation due to the high rise in the housing, and inflow of non-domestic wastewater which was not envisaged. In the case of the San Martin STP, the existing plan envisages an increase of its treatment capacity to 690 liters/sec in the future and that it will receive part of the sewage currently received by the El Indio STP.[28] It should be noted that, in Piura, untreated sewage has not been discharged to a river since 2015, and the increase of the city's sewage treatment capacity under the Project has indirectly contributed to this.

[28] Once the construction of the San Martin STP has been completed along with the full operation of the El Indio STP, the combined utilization rate will be slightly more than 100% and the quality of the treated sewage is expected to improve.

The treatment of sewage at the two plants is insufficient due to over-loading[29] and the quality of treated sewage does not meet some of the relevant national standard for treated water discharged from a STP. Although the average BOD concentration of the treated sewage from 2014 to 2016 of 97 - 100 mg/liter is within the standard value of 100 mg/liter,[30] half of the measured values during this period exceeded the standard. Meanwhile, the coliform count (measured in September 2016) is as high as 10 - 240 times the standard.

The actual BOD removal rate (BOD concentration after treatment ÷ BOD concentration before treatment) at both of the STPs of 65% is low against the planned 99% at the time of appraisal. However, the actual volume of BOD removal (15.1 tons/day in 2016) is as high as 148% of the planned volume (10.2 tons/day) partly because the BOD concentration of untreated sewage (282 - 288 mg/liter) exceeds the planned concentration (250 mg/liter) at the time of appraisal and partly because the actual volume of the treated sewage is more than three times the planned volume.

In summary, although the environmental load of sewage is reduced more than planned (principal indicator: volume of removal of the BOD load), treatment at the plant is not adequate due to overloading, resulting in the discharge of treated sewage which does not meet the wastewater standards (principal indicator: quality of treated sewage). As such, the degree of achievement of the target for the sewerage service in Piura is judged to be fair.

(3) Water Supply in Chimbote

In Chimbote, an increase of water production capacity by means of expanding the existing WTP was planned to (i) improve the existing service with a water supply coverage rate of 71% (1996) and water supply hours of 2 - 14 hours/day and (ii) deal with an increasing population and expansion of urban areas.[31] The plan for the Project also included the construction of two new raw water reservoirs to better accommodate the maintenance period of the irrigation channel which was the source of water supply and the construction of distribution reservoirs to make water distribution more stable. Table 6 shows the state of achievement of the relevant indicators.

[29] At a STP using the oxidation pond system, such pollutants as BOD and coliforms are treated by the natural biological process during the retention of sewage in the pond (lagoon). The treatment of the sewage progresses with the passing of time, but a larger inflow volume renders this treatment less adequate because of the shorter retention time.

[30] Because of an insufficient number of measurement, average values for the measurement results of three years is used.

[31] The planned production capacity after expansion was 500 liters/sec.

Table 6 State of Achievement of the Water Supply Indicators in Chimbote

Indicator	Prior to the Project	Planned at Time of Appraisal (1998)	Actual Results	Level of Achievement
Water production volume (liters/sec)	Unknown	1,240 Plant: 500/750 (note) Wells: 213/463 (2015)	886 Plant: 373 Wells: 513 (2014 - 2016)	Medium (principal indicator)
Water supply hours per day	2 - 14 hours/day	Unknown	17 hours/day (2016) *	Medium** (secondary indicator)
Water pressure	Unknown	Unknown	18 mwc*** (2016)	High (secondary indicator)
Water supply coverage rate	71% (1996)	96% (2016)	89% (2016)	Medium (secondary indicator)
Meter coverage rate	5% (year unknown)	90% (2016)	66% (2016)	Medium (secondary indicator)
Non-revenue water rate	48% (year unknown)	22% (2016)	42% (2016)	Medium (secondary indicator)

Source: Materials provided by JICA and Chimbote SSC.

Notes: The water production capacity of the plant was planned to increase to 750 liters/sec in 2011. Although the planned water production volume was not shown separately for the plant and wells, it is likely that the planned water production capacity of the plant under the Project (500 liters/sec) was thought to be fully utilized in 2015.

* Average water supply hours per day further improved to 19 hours/day for 2017.

** Achievement level compared to 24 hour/day supply which is the target of the Government at urban areas.

*** The unit (mwc) for the average water pressure is "meter water column" which is the pressure capable of supporting one meter water column.

The water production volume in Chimbote from 2014 to 2016 was 886 liters/sec which is equivalent to 71% of the planned capacity at the time of appraisal. The WTP expanded under the Project has an installed capacity of 550 liters/sec but the actual production for the said period was 373 liters/sec which is equivalent to 68% of the installed capacity. The main reason for this was that the newly introduced mechanical flocculation basin was not fully functioning.[32] The cancelation of the planned rehabilitation and expansion of raw water reservoirs due to the reduced scope of the Project restricted the securing of raw water during the maintenance periods of the irrigation channel which was the source of raw water supply. Moreover, although three wells (combined production capacity of 135 liters/sec) were rehabilitated under the Project, none of these are functioning at the time of the ex-post evaluation due to breakdown of the pump and/or lowering of the groundwater level. According to the latest water demand forecast of the Chimbote SSC, water demand in Chimbote in 2016 was 1,116 liters/sec, meaning that the actual water production volume is hugely insufficient.

[32] According to the Chimbote SSC, the new mechanical flocculation basin requires the injection of more flocculant when the turbidity of the raw water is high. In such a case, economical operation is only possible by substantially reducing the production volume (flow rate). For this reason, the WTP in Chimbote continues to use the existing deteriorated non-mechanical flocculation basin while minimizing the use of the mechanical flocculation basin. The mechanical flocculation pond was not used for several years after its completion but has been used since 2015 with hardly any mechanical agitation and a flow rate of one-fifth of the design capacity. Because of this, the maximum combined production capacity of the two ponds at this plant is some 450 liters/sec even in a period when the turbidity of the raw water is low. According to MVCS, after the second visit of the evaluator in June 2017, the Chimbote SSC gave relevant training to the operating staff and the mechanical flocculation basin is being operated periodically at around 40% of the capacity in order to complement water production.

The five distribution reservoirs constructed under the Project (combined capacity accounting for 40% of the total capacity of the distribution reservoirs in Chimbote) are believed to have contributed to the improvement of the water supply hours as well as water pressure and the stabilization of water distribution operation together with an increase of the water production volume due to expansion of the WTP. To be more precise, the daily water supply hours of 2 - 14 hours prior to the Project improved to an average of 17 hours in 2016. The current average water pressure of 18 mwc is within the standard (15 - 50 mwc). Although the ratio of unsatisfied households is 28% in the case of the water pressure and 31% in the case of the water supply hours in the beneficiary survey, many respondents mentioned the post-project improvement of the water pressure, water quality and water supply hours. In general, 64% of the households replied that the water supply service had improved compared to 6% which said that the service had worsened. Another point to note is that the Project improved the water supply coverage rate by three points through some 3,000 new connections to the existing distribution network.

Renewal of the distribution network and installation of water meters under the Project are believed to have contributed to the reduction of the non-revenue water rate. Under the Project, 9% of the total distribution network (pipelines) was renewed and some 31,500 water meters equivalent to 35% of the total number of house connections were newly installed. As mentioned earlier (see 3.2.1- (1)), while, renewal of the distribution network without the removal of the old pipelines created a possibility of causing part of the ongoing water leakage. Water meter coverage rate increased to 66% in 2016 but this is below the target 90% adopted at the time of appraisal. Non-revenue water rate is estimated to be 42% (2015), failing to achieve the planned rate. According to the Chimbote SSC, water leakage accounts for half of the non-revenue water, while water theft is another major factor for non-revenue water.

Based on the above, the degree of target achievement of the Project in regard to the water supply service in Chimbote is judged to be fair using the water production volume as the primary indicator and other indicators as secondary indicators.

(4) Sewerage in Chimbote

At the time of appraisal, the limited sewage treatment capacity of 52 liters/sec in Chimbote against the generated sewage volume of 723 liters/sec meant that most of the sewage generated in the city was discharged to the sea without being treated. The Project planned (i) treatment of the entire sewage generated in southern Chimbote (Nuevo Chimbote District) by means of rehabilitation and expansion of the Las Gaviotas STP and construction of the Centro Sur STP to achieve a treatment capacity of 166 liters/sec and (ii) renewal of the deteriorated sewer network in northern Chimbote (Chimbote District). For the treatment of sewage generated in northern Chimbote, it was planned to conduct a supplementary survey on the submarine pipeline as part of the consulting service (an engineering service) of the Project with a view to incorporating the

survey findings in the sewerage improvement plan for northern Chimbote. Table 7 shows the state of achievement of the relevant indicators.

Table 7 State of Achievement of Sewerage Service Indicators in Chimbote

Indicator	Prior to the Project	Planned at Time of Appraisal (1998)	Actual Results (2014 - 2016)	Level of Achievement
Discharge of untreated sewage to the environment	Yes	Reduced in the southern Chimbote	Southern Chimbote: No Northern Chimbote: Yes	High (secondary indicator)
STP utilization rate (volume of received sewage/ treatment capacity)	Unknown	Unknown	Las Gaviotas: 159% Centro Sur: 294% Total: 172%	Medium(note) (secondary indicator)
Quality of treated sewage	BOD: 86.0 mg/l SS: 155.0 mg/l Coliform: unknown	Wastewater standards (at the time of the ex-post evaluation) (note) BOD: 100 mg/l SS: 150mg/l Coliform: 10,000 MPN/100ml	Las Gaviotas: BOD: 122mg/l SS:73mg/l Coliform: 1.1×10^4 MPN/100ml Centro Sur: BOD: 132 mg/l SS:152 mg/l Coliform: 1.7×10^6 MPN/100ml	Low (principal indicator)
BOD load removal volume (tons/day)	Unknown	Las Gaviotas: 2.6 Centro Sur: 0.3 Total: 2.9	Las Gaviotas: 3.4 (2016) Centro Sur: 1.3 (2016) Total: 4.7 (2016)	High (principal indicator)

Source: Materials provided by JICA and Chimbote SSC.
Note: As a STP operating rate substantially exceeding 100% is undesirable, the level of achievement is judged to be medium. For judgement of the quality of treated sewage, the relevant standard in Peru (maximum permitted level) at the time of the ex-post evaluation is used.

The two STPs rehabilitated and expanded under the Project achieved a combined treatment capacity of 174 liters/sec which slightly exceeded the planned capacity. As these plants receive a combined total of 300 liters/sec of sewage (2014 - 2016), the combined utilization rate is 172% which is the direct reason for the low treatment level at these plants. According to the Chimbote SSC, main reasons for the substantial increase of sewage volume above the planned level are the population increase exceeding the forecast made at the time of appraisal, the expansion of sewerage service area in response to the expansion of urban areas and increase in water production.

Since the completion of the Project, there has been no discharge of untreated sewage into a river in southern Chimbote. Through the increase of the sewage treatment capacity, the Project has contributed to this result. Sewage treatment in northern Chimbote is outside the scope of the Project. As there is no STP in northern Chimbote at the time of the ex-post evaluation, sewage collected in this area is discharged untreated to the sea.[33]

As in the case of Piura, sewage treatment operation at the two plants cannot be described as adequate due to huge over-loading. The average BOD concentration from 2014 to 2016 of 122 -

[33] As part of the engineering service for the Project, the detailed design was conducted for the sewage collection and treatment facilities and submarine pipeline in northern Chimbote. This design was not implemented because of the huge construction cost involved. At the time of the ex-post evaluation, it is planned to expand the Las Gaviotas Sewage Plant to receive and treat the entire sewage generated in both northern and southern Chimbote.

132 mg/liter exceeded the standard value of 100 mg/liter.[34] The number of coliforms at the Centro Sur STP is 170 times higher than the standard value. The actual BOD removal rate at the two plants is 55 - 73% which is much lower than the planned 80% at the time of appraisal[35]. However, the actual volume of BOD removal (4.7 tons/day in 2016) is as high as 164% of the planned volume (2.9 tons/day), partly because the BOD concentration of untreated sewage (296 mg/liter) exceeds the planned concentration (250 mg/liter) at the time of appraisal and partly because the actual volume of sewage is 1.7 times the planned volume.

In summary, although the environmental load of sewage has been reduced more than planned (principal indicators: volume of removal of the BOD load), treatment at the plants is not adequate due to over-loading, resulting in the discharge of treated sewage which does not meet the wastewater standards (principal indicator: quality of treated sewage). As such, the degree of achievement of the target for the sewerage service in Chimbote is judged to be fair.

(5) Summary

The degree of achievement of the target based on the above analysis is fair for both the water supply service component and sewerage service component in both cities. Therefore, the effectiveness of the Project is fair.

The process for demand forecast and scope modification of the Project

The actual water demand exceeded the demand forecast estimated at the time of appraisal (1998). The new water demand forecast at the time of project scope modification to reduce the project cost was a downward revision from the forecast adjusted at the time of appraisal, resulting in further underestimation of the future demand and the reduced scale of the WTPs lowered the effectiveness of the water supply service component of the Project. At the STPs, the treatment level declined due to the inflow of a much higher volume of sewage than the treatment capacity. It can be said that at the time of appraisal, the forecast of the sewage inflow was too low, but at the time of scope modification for the STPs (2003), there was no increase of the treatment capacity based on the new forecast on sewage generation. Treatment capacities of the STP in Piura and STP and WTP in Chimbote were planned under the Project to meet the water demand up to 2010. At the time of the project scope modification in 2003, it could be predicted that these facilities would be operating at full capacity several years after their completion. Nevertheless, there was no examinations on new projects to expand these facilities after their completion. In the case of the San Martin STP of which the initial plan was changed

[34] Because of the insufficient amount of measured data, the mean value for the measurement results of three years is used.

[35] According to MVCS, a maintenance program for Las Gaviotas STP has been started in 2017, and judging from the color of the water, the quality of the treated sewage might have been improved as of December 2017.

to increase its treatment capacity in anticipation of a demand increase, the construction work has been delayed and it is now expected that this plant will be operating at full capacity immediately after its completion.

The forecasts referred at the time of appraisal were made in the feasibility studies initiated by the Peruvian side. As no records are available concerning the examination results of the appropriateness of the demand forecast method and preconditions, it is not clear whether JICA has conducted sufficient technical analysis on the demand forecast made at the time of appraisal. When the project scope was modified in 2002 - 2003 following the Peruvian proposal, technical analysis took place at JICA's head office. While it is not clear whether the studies by Peruvian side had been conducted properly, information gathering was conducted through JICA Peru Office and analysis of the proposal was made on the basis of a series of Peruvian replies to JICA's questions regarding the contents of the proposal document. This examination mainly focused on the water demand forecast. JICA did not examine the forecast volume of sewage arriving at the treatment plants as no change of the original plan was proposed. No confirmation of concrete plans for the period after 2010 were made either.

Sewerage pumping station (Piura)

El Indio STP (Piura)

Distribution Reservoir (Chimbote)

Centro Sur STP (Chimbote)

3.4 Impacts

3.4.1 Intended Impacts

The Project was expected to contribute to improvement of environmental and sanitation conditions of the target areas through the development and improvement of water supply and sewerage facilities. Development of the relevant impacts in the two cities is described next with reference to the findings of the beneficiary survey.

According to the beneficiary survey in Piura, many of the respondents mentioned that the sanitation at home had improved (improved: 63%; worsened: 0%). The main reasons for this are easier access to water, improved hygienic practices, adequate treatment of sewage and waste and improvement of the quality of drinking water.[36] Many mentioned that frequency of bouts of diarrhea had decreased (decreased: 43%; increased: 4%). A similar tendency is observed with the hygiene environment in the nearby area, while a few replied that the situation had worsened (improved: 57%; worsened: 17%). In Piura, rainwater drainage facilities are not sufficiently available. Local flooding occurs at the time of rain. Rainwater flowing into the sewer pipelines occasionally damage the sewers and gushes out through the manholes. These phenomena are believed to be the causes of the negative response.[37] Nearly half of the households mentioned such desirable changes from the viewpoint of daily life as improved sanitation and increased convenience of water use (less labor and cost to obtain high quality drinking water,[38] change of the water quality making it suitable for cooking and washing). Only a small number of households mentioned undesirable changes.

Many of the respondents of the beneficiary survey in Chimbote found that household sanitation had improved (improved: 69%; worsened: 9%). Main reasons for the improvement are easier access to water, improved hygienic practices and improved quality of drinking water. Many of the respondents also said that frequency of bouts of diarrhea had decreased (decreased: 32%; increased: 2%). A similar trend is found with the hygiene environment in the neighboring area (improved: 65%; worsened: 6%). The local health authority indicated that the frequency of bouts of diarrhea among children decreased compared to 10 years ago. One-third of the surveyed households mentioned such desirable changes of daily life as improved sanitation and increased convenience of water use (less labor to fetch water). Only a small number of households mentioned undesirable changes.

In summary, improved environmental and sanitation conditions were mentioned by residents in both Piura and Chimbote and the improved water supply and sewerage services under the Project are believed to have contributed to such improved conditions. It should be also noted that improvement of the rainwater drainage facilities in Piura is necessary although the required work

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[36] Among these reasons, better hygienic practices and waste treatment were not featured in the Project.

[37] Rainwater drainage is not covered by the scope of the Project.

[38] Some of the respondents mentioned that, as local groundwater had a high salinity level, they used to travel 15 minutes from Piura to fetch water from a well in another town.

is not part of the responsibility of the Piura SSC.

3.4.2 Other Positive and Negative Impacts

(1) Environmental Impacts

For the implementation of the Project, an environmental impact assessment (EIA) was conducted for each construction contract and an environmental permit was then issued by MVCS. According to the Directorate General of Environmental Affairs of the MVCS, this permit was not required according to the legal framework related to the environment for project approval,[39] so the EIA was conducted between 2005 and 2009 in parallel with the detailed design prior to the commencement of the actual works based on each contract.[40] At the time, scope of the EIA and criteria for environmental permit were unclear, and hardly any monitoring was conducted based on the environmental impact mitigation plan which was prepared together with the detailed design.

In regard to the two cities' three STPs which were rehabilitated and expanded using ODA loan under the Project, treated sewage is recycled for irrigation. Quality of the treated sewage, however, does not meet the government's standard for wastewater from a STP. The crops using this treated sewage are reeds, fodder crops, maize and others. Although the treated sewage does not come into contact with the edible parts of these crops, there is concern in regard to contamination of the crops as well as groundwater in the case of the El Indio and Centro Sur STPs where the number of coliforms far exceeds the standard.

The outlet channel from each of these three plants is as short as some 30 m and is then connected to an earthen channel constructed by farmers (Centro Sur and Las Gaviotas STPs) or a temporary earthen channel built by the local government (El Indio STP).[41]

At the El Indio STP in Piura, the regional government constructed an extended section of the discharge channel. However, this is an open channel constructed with sandy soil and it frequently collapses, causing the spillage of the treated sewage. In view of the costly maintenance and environmental considerations, the Piura SSC has conducted improvement work to make the most problematic sections to be closed conduits. The Piura SSC plans to consult with irrigating farmers who use the treated sewage on the improvement of the irrigation channels and appropriate management of the treated sewage to find a solution while proceeding with the improvement of

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[39] At the time of appraisal, it was stated that "environmental impacts of the project are extremely small, and the executing agency has completed its own EIA even though there is no legal requirement for the implementation of an EIA". The details of the EIA mentioned here cannot be confirmed in the ex-post evaluation. The EIA mentioned in the main text means the EIA which was conducted by the executing agency for each work lot based on the legal system established later.

[40] The EIA for the San Martin STP which was to be constructed with the own funds of the Peruvian side was conducted in 2015.

[41] The current requirement for the implementation of a STP construction project in relation to the recycling of treated sewage for irrigation is that the irrigation users and plant management body exchange a written agreement that the treated sewage is properly managed through adequate connection of the outlet channel to the irrigation channel. At the time of appraisal of the Project, there was no such requirement and it was understood that even if the discharge channel was short, extension would be made by the farmers themselves who wanted to use the treated sewage for irrigation purposes.

the El Indio STP by preparing an environmental adjustment and management program.[42]

Extension of outlet channel for El Indio STP (Piura)

Irrigation channel connected to Centro Sur STP (Chimbote)

There is a private airfield near the Centro Sur STP in Chimbote. After the implementation of the Project, marshes were formed at the side of this airfield and water birds visiting these marshes began to disrupt airfield operation. According to the Chimbote SSC, the marshes are believed to have emerged due to a rise of the groundwater level. However, it cannot be denied that the discharged treated sewage from the Centro Sur STP may have also been a remote cause. Although this STP is over-loaded, further expansion is difficult because of its limited land. In view of these, the Chimbote SSC plans to close this STP and expand the Las Gaviotas STP so that the sewage currently sent to the Centro Sur STP will be diverted to the Las Gaviotas STP via a new pumping facility for treatment. At the Las Gaviotas STP in Chimbote, an outlet channel to the sea has been constructed with the government's own funding and the recycling of treated sewage is restricted to reeds, etc. Because of this, the partial excess of the quality standard for treated sewage at this STP does not pose any major environmental problems. In contrast, the continued practice of discharging untreated sewage from northern Chimbote causes concern in regard to seawater contamination. In this regard, the Chimbote SSC plans to expand the Las Gaviotas STP in the future so that it can treat the entire sewage from both southern and northern Chimbote.

(2) Land Acquisition and Resettlement

At the San Martin STP in Piura, the existence of private land on part of the planned site was

[42] An environmental adjustment and management program is equivalent to an EIA and includes a facility improvement plan for a STP to conduct proper treatment. Approval of this plan by MVCS is one condition for public investment in the STP concerned and also for permission for discharge of the treated sewage by the National Water Authority (SUNASS). In Chimbote, the environmental control improvement plans targeting the two STPs have been approved by MVCS. None of the four STPs targeted by the Project have obtained a discharge permit from the SUNASS at the time of the ex-post evaluation. However, this permit system has only been recently introduced and many STPs in Peru do have such a permit.

discovered after the commencement of the work, and this STP was removed from the scope of the construction contract for the ODA loan. Its construction at a new site with Peruvian funding is planned and the new site has already been secured. There were no problems regarding land acquisition for the other three STPs and new WTP in Piura. Land acquisition for the expansion of the WTP in Chimbote was unnecessary as this expansion took place on the premises of the existing WTP. No resettlement was required for the implementation of the Project.

(3) Other Impacts

In both cities, water production using surface water as the supply source to replace part of groundwater became possible with the implementation of the Project and the production cost was reduced.[43] In particular, the WTP in Piura is now capable of conducting low cost and efficient water production and has become a model for the design and operation of WTPs in Peru. This WTP is used for training organized by the Piura SSC and MVCS and receives frequent visits from university researchers and students.

Based on the above, this project has somewhat achieved its objectives. Therefore, its effectiveness and impact are fair.

3.5 Sustainability (Rating: ②)

3.5.1 Institutional Aspects of Operation and Maintenance

As both SSCs in the two cities do not have sufficient manpower and equipment to properly conduct an emergency response or preventive maintenance, there are some problems relating to the institutional aspects as described below.

(1) Piura SSC

The Piura SSC provides water supply and sewerage services for 27 cities and towns in the Piura Region and has 786 employees. According to the SSC, its manpower size is generally adequate although it is insufficient to provide an emergency response in the rainy season, etc.

The WTP and transmission lines from the WTP to the distribution reservoirs are operated and maintained by 21 staff members, including five security guards. The WTP has a SCADA control room to coordinate water supply operation through telephone communication with the SSC's Piura Head Office and well or distribution reservoirs operators throughout the city. The El Indio STP has four operators and two security guards. No permanent operator is deployed at the San Martin STP due to insufficiency in personnel and bad security situations in the area. The water supply and sewer networks are repaired by 14 staff members and three outsourcing

[43] According to the SSC in each city, the unit water production cost at a WTP is one-fourth or one-fifth of the water production cost using a well.

contracts in response to claims made by residents. There is a preventive maintenance plan involving the use of a high-pressure cleaning vehicle and a bucket machine (pipe cleaning device) for the sewer system. According to the staff members in charge, however, cleaning operation is insufficient as limited personnel are busy dealing with emergency situations. Any repair of a large diameter sewer must be externally contracted when such work is necessary and takes time to complete. A total of 43 operators are deployed at wells and pumping stations. At the sewage pumping stations, removal of accumulated sludge and other work are outsourced. The SSC has a six-member maintenance team which is responsible for electrical and mechanical equipment in all of the 27 cities / towns where the SSC provides water and sewerage services. Repair work is conducted at a small workshop and is outsourced to a specialist company in Piura if necessary. According to the SSC, even though a preventive maintenance plan exists for electrical and mechanical equipment, it is hardly implemented because the team is too busy dealing with repair works.

(2) Chimbote SSC

The Chimbote SSC has 381 regular employees and 12 contract employees and operates water supply and sewerage services in southern Chimbote, northern Chimbote and two other cities.

The WTP is run by 13 operators on three shifts. During the first field survey, the position of the head of the WTP was vacant but a newly recruited young sanitation engineer has taken up the position since 2017. Of the two STPs, only the Centro Sur STP has one operator working during the daytime. Although no operator is deployed at the Las Gaviotas STP, the pumping stations which convey sewage to the Las Gaviotas STP have operators. The water supply network and sewer networks (pipelines) are directly maintained by 20 staff members in the case of the former and 10 staff members in the case of the latter. According to those in charge, the manpower level is inadequate to conduct a quick emergency response. The SSC possesses trucks, two high pressure cleaning vehicles, two bucket machines and other heavy machineries to deal with emergency situations requiring repair works for leakage or sewer blockage reported by residents. Although preventive maintenance of the sewer network is also conducted, the old bucket machines require renewal. Maintenance of electrical and mechanical equipment is conducted by one engineer and four workers. As the staff strength is insufficient, a request for assistance is frequently made to other sections. Minor repairs are conducted at the workshops on the premises of the SSC and major repairs are outsourced to a specialist company in the city.

3.5.2 Technical Aspects of Operation and Maintenance

(1) Piura SSC

The Piura SSC has 72 engineers. After the completion of the WTP by the Project, three engineers participated in JICA's training in Japan (JICA Group Training for Latin American

Countries).[44] All of them were appointed to senior positions on their return to Peru. According to these trainees, the training in Japan was a big incentive to improve the operation of the facilities of the SSC, especially the operation of the WTP, contributing to improvement of the technical level. Moreover, a system to inject an agent to contain the propagation of algae at the WTP was independently installed and the water treatment efficiency was increased through the adjustment of operation.[45] The new WTP is considered to be a model WTP and was the venue for technical training organized by the SUNASS in 2015 targeting 25 engineers of other SSCs in Peru. The Piura SSC built its own GIS in 2014 to accumulate customer as well as technical data. This system was built internally with the advice of engineers of other SSCs. At the time of the ex-post evaluation, training of two and a half years is in progress with German assistance for 23 staff members (operators) for them to obtain a qualification of technician relating to water production, water treatment and sewage collection. Based on the above, it is safe to assume that the technical standard of the Piura SSC is high.

(2) Chimbote SSC

Although the Chimbote SSC has several engineers, there is only one junior sanitation engineer who was newly recruited in 2017, and operation of the mechanical flocculation basin at the WTP is not appropriate.[46] Despite the fact that the SSC lacked any previous experience of operating a mechanical flocculation basin, the construction contract, including that for the WTP, did not include training nor trial operation period by the contractor. As far as the operation and maintenance of the WTP are concerned, a manual with only general contents was handed over and no training of the SSC staff members took place.[47] The dosage of the flocculant is based on an empirical value in correspondence with the daily measured raw water turbidity and flow rate but there is no regular jar test.[48] As such, the operation of the WTP by the Chimbote SSC is

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44 The Piura SSC sent one engineer in 2008 and three engineers in 2009 to JICA's training scheme in Japan entitled "Supplementary assistance to develop Japanese ODA Loan project's sustainability in the sanitation sector for Latin American Countries".

45 After its completion, the new WTP required frequent backwashing because of the massive propagation of algae and the water leakage rate [1 - (water production volume÷ water intake volume)] reached as high as 25%. The Piura SSC solved this problem without external assistance. The current water leakage rate is 3.7% compared to 10% assumed at the design stage.

46 See Footnote 32.

47 For the new flocculation basin, it is necessary to establish such parameters as the flocculent injection volume and agitation speed in response to the turbidity, pH value and treatment volume of raw water through test operation. However, the manual handed over to the SSC is only a general manual and does not refer to these parameters. According to a staff member involved in operation since the beginning, the contractor conducted test operation outside the scope of the contract (meaning unofficial test operation) for approximately one week but the operation did not reach the sufficient level of water treatment operation capacity. As such, actual operation commenced by staff members without an appropriate knowledge of the operation and maintenance of the WTP. According to MVCS, the contractor was required to deliver the facilities in proper functional conditions as stated in the contract and there was a one-year warranty after delivery. Because no claim that "the facilities did not function properly" was made to MVCS by the Chimbote SSC, MVCS did not take any special action.

48 The jar test determines the required injection volume of flocculant by means of injecting different volumes of flocculant to actual raw water and comparing the degree of flocculation of each injection volume. It is desirable to conduct this test on a daily basis. While the WTP in Piura conducts the jar test twice a day, the WTP in Chimbote

inadequate and there appears to be room for improvement of the technical level of this SSC. According to the SUNASS, in the background, a qualified engineer is not attracted to the SSC because of low salary level. On the other hand, in regard to sewer, as there are not facilities which require high level technology, no technical problems in operation and maintenance are identified.

3.5.3 Financial Aspects of Operation and Maintenance

Table 8 shows the financial conditions of the SSCs in the two target cities in the Project. As explained below, both SSCs have financial problems.

Table 8 Financial Status of SSCs in the Two Target Cities

(Unit: 1,000 nuevos soles)

	Piura SSC			Chimbote SSC		
	2013	2014	2015	2013	2014	2015
Operating revenue						
Water supply and sewerage tariff revenue (Including connection charge, etc.)	101,604	103,633	111,722	24,876	24,159	24,593
Operating costs	100,001	102,144	119,866	33,712	40,104	42,808
Cost of operations [(a)]	*70,624*	*71,276*	*84,657*	*22,800*	*27,772*	*29,039*
Retail expenses	*23,992*	*24,141*	*25,902*	*4,959*	*4,207*	*4,434*
Administration cost, etc.	*5,385*	*6,727*	*9,307*	*5,953*	*8,125*	*9,335*
Operating profit	1,603	1,489	-8,144	-8,836	-15,945	-18,215
Non-operating revenue	235	70	91	10,403	15,569	16,582
Non-operating cost	165	141	166	46	193	112
Ordinary profit	1,672	1,418	-8,219	1,521	-569	-1,745
Operating profit ratio	1.6%	1.4%	-7.3%	-35.5%	-66.0%	-74.1%
Current ratio [(b)]	127%	170%	125%	75%	107%	90%
Debt ratio [(c)]	891%	971%	1041%	944%	963%	921%

Source: SSC of each city

Notes:

(a) This includes the operation and maintenance cost and depreciation cost.

(b) Current assets/current liabilities

(c) Liabilities/capital

(1) Piura SSC

Both the operating profit and ordinary profit of the Piura SSC had been in the black up to 2014 but went into the red in 2015, partly because of writing off of the historical depreciation cost following the change of accounting standards to international accounting standards and partly because of the increased cost of operation due to an increased electricity charge. The SSC believes that the operating account in 2016 will return to the black. The current ratio exceeds 100% but is not sufficiently high enough, restricting the cash flow of the SSC. In fact, the maintenance of the STPs and sewage pumping stations is inadequate because of limited funds and manpower. When

has hardly conducted the test at all due to its manpower shortage and other reasons. According to MVCS, the Chimbote SSC intends to conduct jar tests more frequently to increase operational efficiency of the mechanical flocculation basin.

the financial health deteriorated in the early 2000's, the SSC deferred welfare payments for its staff members. These deferred payments are being paid out over a period of 30 years as a debt owed by the SSC to its staff members. Because of this payment, the debt ratio of the SSC is extremely high. Since 2017, the MVCS occupies the majority of the Board of Directors, and efforts to improve financial situations including debt treatment are continuing. According to the SSC, it is necessary to increase its service charges by some 60% in five years based on the revenue and expenditure plan for the future. As of June 2017, the SSC is in discussions with the SUNASS regarding the planned increase of the service charges.

(2) Chimbote SSC

The operating profit and ordinary profit of the Chimbote SSC have been in the red for the last three years in the case of the former and two years in the case of the latter. The service revenue accounts for only 60 - 70% of the operating cost and the operating profit ratio has been substantially negative. The revenue shortfall has been met by a subsidy from the regional government. The current ratio is often below 100%, restricting the cash flow. This means financial restrictions on maintenance. Because of the remaining debt service of a loan from the National Housing Fund (FONAVI) in the late 1990's, the debt ratio is extremely high, causing a problem for the medium to long-term financial health. The tariff was increased by 11% between 2008 and 2013 but the newly set charge did not take the maintenance cost of the raw water reservoir at the WTP and of the STPs, the renewal cost of water meters, etc. into consideration. The Chimbote SSC subsequently lodged a proposal for a 42% increase of the tariff in a five-year period from 2017 with the SUNASS taking the above-mentioned costs into consideration. Following appraisal by the SUNASS and other necessary procedures, including public meetings, an increase of 37% in a five-year period from May 2017 was approved.

Left: Cleaning works around the treatment pots (El Indio STP, Piura)
Right: Las Gaviotas STP (Chimbote)

3.5.4 Current Status of Operation and Maintenance

(1) Piura SSC

According to explanations given by the Piura SSC and the evaluator's own field survey findings, all water supply facilities ranging from the WTP, transmission pipelines, distribution reservoirs to wells and the distribution network are believed to be adequately operated and maintained. In regard to the sewerage facilities, however, some problems are found with the pumping stations and STPs.

According to the Piura Zone Office of the SSC, most of the city's 28 pumping stations for sewerage have electrical and mechanical problems. The pumps are damaged fairly quickly because of their full operational status, including reserve pumps, to deal with a large volume of sewage and also because of the much inclusion of sand and rubbish in the sewage.[49] An automatic operating system (system to control pumping operation in correspondence with the water level of collected sewage) and control panel frequently break down due to the adverse impact of voltage fluctuations. Because there are too many problems, repair work falls behind and there is no leeway to implement preventive maintenance. The fact that pumping operation can hardly afford to stop because of the large volume of sewage makes the implementation of preventive maintenance and repair work difficult.

At the El Indio STP, sludge and weeds floating on the surface are cleaned but deposited sludge in the treatment basins is not removed due to financial constraints. One of the ponds constructed under the Project at this STP has been divided by a dike constructed under a regional government project and is not in operation. This dike was introduced by the regional government for the purpose of installing an aeration system to increase treatment efficiency of the STP which had failed the wastewater quality standard due to over-loading. However, this project was suspended following a change of the regional government.[50] The water channel connected to the outlet channel of this STP was constructed by the regional government under the same project, but its temporary nature makes it prone to collapse. According to MVCS, the Piura SSC is conducting such regular maintenance works on the channel based on an annual plan as sludge extraction, weeding and slope strengthening.

(2) Chimbote SSC

Existence of sand deposits and vegetation at the raw water reservoirs of the WTP in

[49] According to the Piura SSC, this situation occurs when residents throw their rubbish and other foreign substance into sewers because they do not know how to properly use the sewer system. Moreover, residents sweep standing rainwater, including sand, on the road into the sewer system to improve drainage.

[50] The new regional government questioned the fact that the previous government implemented the project as "a maintenance project" despite it being an investment project, thereby bypassing the proper approval procedure for a public investment project. It then suspended the project and triggered a lawsuit against the previous government. During this lawsuit, the Piura SSC and regional government held a series of discussions to determine whether or not the dike could be removed but no conclusions have yet been reached. JICA has been monitoring these discussions but there is no prospect at present of the dike's removal.

Chimbote suggests a lack of maintenance for a long period of time. The work to remove these sand deposits using heavy machinery started in November 2016. Other than the mechanical flocculation basin, all of the facilities of this WTP are generally adequately operated and maintained.[51] However, some electrical and mechanical equipment has deteriorated after more than 10 years of operation since the completion of the WTP in 2006. The distribution reservoirs are subject to preventive maintenance, including cleaning and sterilization, and are generally adequately maintained. Of the 18 wells, including the three rehabilitated wells under the Project, some are out of order due to breakdown of the pump as pump repair or renewal has been slow due to budgetary constraints and many others are experiencing a decline of the production volume.

Floating sludge and sludge close to the edge of the treatment basins have been removed several times at the two STPs but the complete removal of sludge by emptying the basins has never taken place. At the Las Gaviotas STP, as the treatment basins rehabilitated under the Project did not originally have an impervious layer, lowering of the sewage level leads to the incursion of groundwater, making it impossible to completely drain the basins. (The treatment basins constructed under the Project have an impervious layer.) For this reason, the Chimbote SSC has prepared for the removal of sludge by a floating sludge pump and aims at commencing operation by the end of 2017.

To summarize on the sustainability of the Project, the institutional aspects show some minor problems in both cities, the financial aspects face challenges in both cities and the technical aspects show a problem in Chimbote. Based on the overall judgement of the above situations, the sustainability of the project effects is fair.

4. Conclusions, Recommendations and Lessons Learned

4.1 Conclusions

The Project was implemented in order to improve the water supply and sewerage services in the Northern Peruvian local cities of Piura (Piura Region) and Chimbote (Ancash Region) by means of rehabilitating and expanding water supply and sewerage facilities, thereby contributing to improvement of environmental sanitation in the target areas. Water supply and sewerage sector has consistently remained an important issue for the Government of Peru. At the time of appraisal of the Project, needs for water supply and sewerage development in the two target cities were high, and the Project facilities are still playing an important role at the time of the ex-post evaluation. Moreover, the Project is consistent with Japan's aid policies at the time of appraisal. Therefore, the relevance of the Project is high. Due to changes in government twice and worsening

[51] See Footnote 32 for the mechanical flocculation pond.

of the financial conditions of SSCs in the target cities after the signing of the loan agreement, commencement of the construction was delayed. In the case of the San Martin STP in Piura, a change of the original plan to respond to the demand increase took a long time to finalize and this plant is not yet completed by the time of the ex-post evaluation. As a result, the project period more than quadrupled compared to the planned period. The total project cost exceeds the planned cost because of price inflation, an increase of the construction cost in this extended period and other reasons. Therefore, the efficiency of the Project is low. The Project has increased the water production volume and improved the water supply hours and water pressure in both cities and has also improved the water quality in Piura. Untreated sewage is no longer discharged to the river or the sea in Piura city and southern part of Chimbote. Improvement of the environmental and sanitation conditions are reported by residents in both cities. However, the water production volume by the WTPs has not reached the relevant planned level. In addition, the treated sewage does not meet the quality standards for treated waste water, partly because the volume of sewage received by the STPs far exceeds the planned volume. Therefore, the effectiveness and impact of the Project are fair. In regard to the operation and maintenance of the Project, the organizational aspects show minor problems in both cities, the financial aspects are problems in both cities and the technical aspects show problems in Chimbote. Based on the overall judgement of the above, the sustainability of the Project is fair.

In conclusion, the Project is evaluated as unsatisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agencies

Piura SSC

- To secure a sufficient maintenance budget by adequately increasing the tariff for water and sewerage services.
- To increase water production volume by fully utilizing the water production capacity of the WTP through strengthening of the water transmission capacity based on the increased pumping capacity, etc. of the WTP.
- To implement preventive maintenance through outsourcing or other means along with the renewal and reinforcement of the sewage pumping facilities which have been experiencing a continued state of over-loading.
- To implement following measures at the El Indio STP;
    - Continuous negotiation with the regional government for an early removal of the dike constructed by the regional government.
    - Realization of proper maintenance of the oxidation ponds (removal of accumulated sludge), improvement of the outlet channel constructed by the regional government and adequate management of treated sewage with an agreement on the cooperation of

irrigation users by means of formulating and implementing an environmental management and adjustment program.

Chimbote SSC

- In relation with the mechanical flocculation basin, carry out the following activities by entrusting to those engineers with rich experience on mechanical flocculation basins; ① investigation of the causes of failure to achieve the design performance, ② training on establishment of parameters for adequate operation and operation and maintenance, and ③ renewal and improvement of equipment as necessary.
- To remove sludge at Las Gaviotas STP in accordance with the approved environmental management and adjustment program.

MVCS

- To urgently complete the rehabilitation and expansion of the San Martin STP in Piura.
- To examine the necessary technical and financial assistance for the purpose of ensuring the implementation of the recommendations listed above for the Piura and Chimbote SSCs.

4.2.2 Recommendations to JICA

JICA should conduct follow-up activities in liaison with MVCS and SSCs for ensured implementation of the above recommendations. It should also examine the possibility of providing technical assistance for the purpose of supporting the adequate operation of the WTP in Chimbote.

4.3 Lessons Learned

Adequate management of recycled treated sewage

When the recycling of treated sewage is planned in a sewage treatment project, full coordination with users of the recycled treated sewage is necessary so that the facilities and management system to adequately handle the treated sewage are in place. As for the recycling of treated sewage for irrigation, an existence of a management institution on the part of the irrigation farmers' organization and adequate connection between the outlet channel of the STP and irrigation channels are important. Adequate management of the treated sewage is essential to ensure the efficient use of the treated sewage and to avoid any environmental problems after the discharge of treated sewage from the STP. In this connection, it should be considered to carry out capacity development for farmers' organizations and repair or construction of irrigation channels as a part of those projects for recycling treated sewage for irrigation.

At the Centro Sur STP and El Indio STP rehabilitated / constructed under the Project, no capacity development for the users of the recycled treated sewage (farmers) was conducted

and the recycling of the treated sewage was left to farmers along with the construction / connection and operation of the irrigation channels. Because of this, the outlet channel of the STP was not connected to a suitable irrigation channels. In addition, as the volume of sewage for treatment exceeded the planned volume, there have been incidents of the spilling over of the treated sewage in the area near the STP. Examinations at the time of appraisal should have included the commitment of local farmers to the construction and adequate operation of the irrigation channels, existence of an irrigation plan and capacity of farmers' organization, and it could have been considered to include, as necessary, capacity building of farmers' organization and rehabilitation / construction of irrigation channels in the scope of the Project.

Need for an accurate demand forecast

In order to properly plan the facility size of a WTP (water production capacity) or a STP (sewage treatment capacity), an accurate demand forecast is required, necessitating use of an appropriate forecast calculation method as well as proper preconditions. Whenever a demand forecast is reviewed, efforts to further improve the accuracy of the demand forecast are necessary through a concrete examination of the latest data on population, water usage per capita, water saving effect by introduction of meters, water leakage reduction effect of renewal of deteriorated distribution pipes and other relevant matters. Even if it is necessary to reduce the project cost due to funding constraints, it is desirable for demand forecasting to be properly conducted, and immediate reduction of the project cost should preferably be achieved by bringing forward the original target year of the project (phasing of the project). When the adoption of such an option is difficult because of the implementation schedule, necessitating a reduction of the facility size, a plan to expand the facilities after the completion of the project should be swiftly prepared for implementation at the suitable time. In the case of this Project, as described in the article "the process of demand forecast and scope modification of the Project", it is unknown whether technical examinations of the forecast water demand as well as receiving volume of sewage were conducted at the time of appraisal and also at the time of changing the project scope. The significant departure from the forecast adversely affected the effectiveness and impacts of the Project.

Technical examination for the demand forecast review and application of comprehensive mid-term project management practices

When the scope of a project is changed from the feasibility study after a long period, a considerable change in the demand by that time is possible. It is, therefore, important for JICA to perform a technical examination for demand forecast review very carefully. In the Project, JICA headquarter conducted a technical examination on the proposal by the Peruvian side for a change of the scope, but this examination might not have been sufficient, partly because the

gathering of detailed information was not conducted in Peru (instead, replies to JICA's questionnaire on the Peruvian proposal were obtained on two or three separate timings).

Moreover, when extension of the final disbursement date is necessary because of a substantial delay of the commencement of construction works, JICA should examine the possibility of conducting detailed technical examinations comparable to those conducted at the time of appraisal. To determine whether such examinations are necessary or not, it may be an idea for JICA to conduct a comprehensive mid-term evaluation with a view to organize and record all the information gathered from the time of appraisal up to that point of the time of the said mid-term evaluation. In any case, it is important to appropriately organize and record the materials reviewed at each stage after appraisal.

Comparison of the Original and Actual Scope of the Project

Item	Planned	Actual
① Project Output		
＜Piura water supply＞		
・ Intake	1,500 liters/sec	1,320 liters/sec
・ Construction of Curumuy WTP	880 liters/sec	600 liters/sec
・ Construction of transmission pipeline*	51.6 km	55.9 km
・ Construction/rehabilitation of distribution network**	59.4 km	40.9 km
・ Construction of distribution reservoirs	(5 sites) 10,350 m^3	(6 sites) 16,000 m^3
・ Rehabilitation of distribution reservoirs	0	(5 sites) 88,000 m^3
・ Rehabilitation of well pumps	10 sites	11 sites
・ Construction/rehabilitation of house connections**	11,760 households	6,000 households
・ Installation of water meters	22,500 units	21,636 units (+ 864 in reserve)
・ SCADA (treatment plant, distribution reservoirs and wells)		As planned
＜Piura sewerage＞		
・ El Indio STP (Oxidation pond system)	Rehabilitation: 6.0 ha Construction: 12.7 ha Total: 239 liters/sec	Rehabilitation: 6.0 ha Construction: 20.0 ha Total: 200 liters/sec
・ San Martin STP (Oxidation pond system)	Rehabilitation: 9.6 ha Construction: 11.9 ha Total: 241 liters/sec	New plant is constructed on premises of existing plant: 32.3 ha (planned) Total: 690 liters/sec (planned)
・ Construction of pressurized sewer pipeline	10 km	8.1 km
・ Construction of pumping stations	1 site	1 site
・ Rehabilitation of pumping stations	4 sites	12 sites
・ Rehabilitation of sewer network	26.7 km	36.1 km
＜ Chimbote water supply＞		
・ Construction of raw water reservoirs	70,000 m^3 x 2	None
・ Rehabilitation/expansion of WTP	500 liters/sec	550 liters/sec
・ Construction of transmission pipeline*	19.9 km	14.8 km
・ Construction/rehabilitation of distribution network**	77.6 km	69.3 km
・ Construction of distribution reservoirs	(5 sites) 14,850 m^3	(5 sites) 15,000 m^3
・ Construction/rehabilitation of house connections**	7,300 households	9,243 households
・ Installation of water meters	50,000 units	28,100 unites (+ 3,400 in reserve)
・ Rehabilitation of wells	(3 sites) 135 liters/sec	(3 sites) 135 liters/sec
・ Rehabilitation of raw water reservoirs	(3 sites) 70,000 m^3	None
・ Rehabilitation of distribution reservoirs	(8 sites) 20,800 m^3	(5 sites)
・ Pumping stations	2 for rehabilitation; 2 for construction	2 rehabilitated and 1 constructed
＜Chimbote sewerage＞		
・ Construction of pressurized sewer pipeline	3.9 km	1.4 km
・ Construction/rehabilitation of sewer network**	50.8 km	49.2 km
・ Rehabilitation of pumping station	1 site	1 site
・ Las Gaviotas STP (Oxidation pond system)	Expansion: 7.5 ha Rehabilitation: 12.0 ha Total: 155.3 liters/sec	Expansion: 8.6 ha Rehabilitation: 12.0 ha Total: 157 liters/sec
・ Centro Sur STP (Oxidation pond system)	Construction: 2.5 ha 22.8 liters/sec	Construction: 2.4 ha 17 liters/sec
・ House connection	New: 150 households Rehabilitation: 3,000 households	New: 3,569 households Rehabilitation: 2,856 households
② Project Period	April 1999 - March 2003 (48months)	April 1999 - June 2017 (219 months, not completed yet)
③ Project Cost		
ODA Loan	13,901 million yen	12,743 million yen
Peruvian funding	4,634 million yen	5,162 million yen*
Total	18,535 million yen	17,905 million yen*
Exchange Rates	USD 1 = 113.5 yen 1 nuevo sol = 34.0 yen	USD 1 = 101.0 yen 1 nuevo sol = 32.7 - 38.4 yen

*These figures do not include the cost of San Martin STP (approx..4.3 billion yen) to be constructed by the Peruvian funding.

<Appendix> Main Findings of the Beneficiary Survey (Questionnaire Survey)

	Piura (102 Households)	Chimbote (105 Households)
Problems with the water supply service		
Water pressure	51%	27%
Supply hours	37%	31%
Price	36%	17%
Water quality	31%	7%
Supply cut (over one day)	18%	12%
Maintenance	6%	2%
Customer service	4%	0%
No problem	10%	49%
Satisfaction level with the water supply service		
Very much satisfied	1%	9%
Satisfied	20%	47%
Slightly satisfied	33%	28%
Slightly dissatisfied	39%	12%
Very much dissatisfied	7%	5%
Change of the water supply service before and after the Project (Improved % minus Worsened %)		
Water pressure	9 points	29 points
Supply hours	5 points	9 points
Supply cut	32 points	2 points
Water quality	37 points	26 points
Tariff	-25 points	-9 points
Maintenance	12 points	6 points
Customer service	12 points	-18 points
Change of the water supply service before and after the Project		
Greatly improved	28%	21%
Slightly improved	36%	45%
No change	17%	22%
Slightly worsened	14%	6%
Greatly worsened	3%	2%
Change of household water supply before and after the Project (Improved % minus Worsened %)	53 points	61 points
Problems with the sewerage service		
Spillage	5%	10%
Bad odor	6%	2%
Maintenance problem	3%	2%
Other	1%	0%
No problem	87%	91%
Satisfaction level with the sewerage service		
Very much satisfied	2%	14%
Satisfied	83%	69%
Slightly satisfied	2%	12%
Slightly dissatisfied	11%	2%
Very much dissatisfied	1%	1%
Change of household sanitation before and after the Project (Improved % minus Worsened %)	63points	70points
Reasons for improvement of household sanitation (Ratio of households pointing out each reason among those households which agreed with improvement)		
Availability of safe water to use	56%	80%
Improvement of hygienic practices	66%	61%
Improvement of sewage and waste treatment	56%	12%
Improved quality of drinking water	53%	68%
Improvement of neighborhood sanitation before / after the Project (Improved % minus Worsened %)	40%	62%
Frequency of diarrhea before and after the Project		
Increased	4%	2%
Decreased	43%	31%

Republic of Nicaragua

FY 2016 External Ex-Post Evaluation of Japanese Grant Aid Project

"The Project for Reconstruction of Bridges on Managua-El Rama Road"

External Evaluator: Hiromi S. Suzuki, IC Net Limited

0. Summary

The Project for Reconstruction of Bridges on Managua-El Rama Road (hereinafter referred to as "the Project") was implemented for the purpose of securing safe and smooth traffic between Managua and El Rama on National Highway No. 7 which is an international trunk road passing through Nicaragua by means of rebuilding three bridges, thereby contributing to the vitalization of domestic and international logistics and also to the promotion of the local economy along the route. At the time of both planning and ex-post evaluation, the Project is fully consistent with the national development policies, the transport sector policies and development needs of Nicaragua and with Japan's ODA policies and, therefore, its relevance is high. The outputs are generally as planned, and both the total project cost and project period were within the plan, thus the efficiency of the Project is high. The assumed effects of the Project, namely, traffic congestion before the bridge, and time for cars to cross the bridge improved significantly. On the other hand, although considerable improvements can be recognized for the temporal stoppage before entering the bridge as well as the average travelling speed on the bridge, these have not been fully eliminated as originally planned, because speed reduction zones were introduced by the Nicaraguan government after the completion of the Project in order to ensure the safety of local residents crossing the road. In addition, the risk of bridge collapsing due to aging has been eliminated. The assumed impacts on the promotion of the local economy along the route and vitalization of domestic and international logistics are confirmed. As the implementation of the Project has generally produced the planned effects, the effectiveness and impacts of the Project are high. The institutional, technical and financial aspects of the entities that are in charge of the Project's operation and maintenance, that is the Ministry of Transportation and Infrastructure (Ministerio de Transporte e Infraestructura: MTI), Road Maintenance Fund (Fondo de Mantenimiento Vial (FOMAV) and the Corporation of Regional Construction Companies (Corporación de Empresas Regionales de la Construcción: CORECO), as well as the current status of operation and maintenance of the Project are generally good and the sustainability of the effects of the Project is high.

In line of the above, the Project is highly satisfactory.

1. Project Description

Project Location

Las Banderas Bridge:
Primary school children crossing the bridge to attend school

1.1 Background

Nicaragua completely abolished its railway network in the 1990's and 98% of passenger and freight transportation relied on roads at the time of project planning (2010). However, the transportation infrastructure, including trunk roads, bridges, farm roads, etc., was insufficient, partly because of the after-effects of the civil war in the 1980's. The level of road network development was the lowest among countries in Central America. Even though roads and bridges had been improved by a number of donors, there were still bridges damaged by flooding, vehicle collision, etc.

Meanwhile, the Mesoamerica Integration and Development Project (Mesoamerica Project: MP) was formulated in 2001, incorporating a scheme to construct an international trunk road connecting Puebla in Mexico all the way to Panama (see "3.1.1 Consistency with the Development Policies of Nicaragua" for further details). In accordance with this scheme, the countries involved have proceeded with road improvement work for the purpose of vitalizing logistics in Central and South America and it was necessary for Nicaragua to follow suit. The Project forms part of the Atlantic Corridor and East-West Corridor, both of which are international trunk roads perceived in the scheme.[1] While the roads in these corridors have been improved by many donors[2], the three bridges targeted by the Project were more than 60 years old and their deterioration was aggravated by damage caused by Hurricane Mitch in 1998 to the point of their use being dangerous. These bridges were narrow and trucks and other large vehicles could not pass each other on the bridge, hampering smooth traffic flow.

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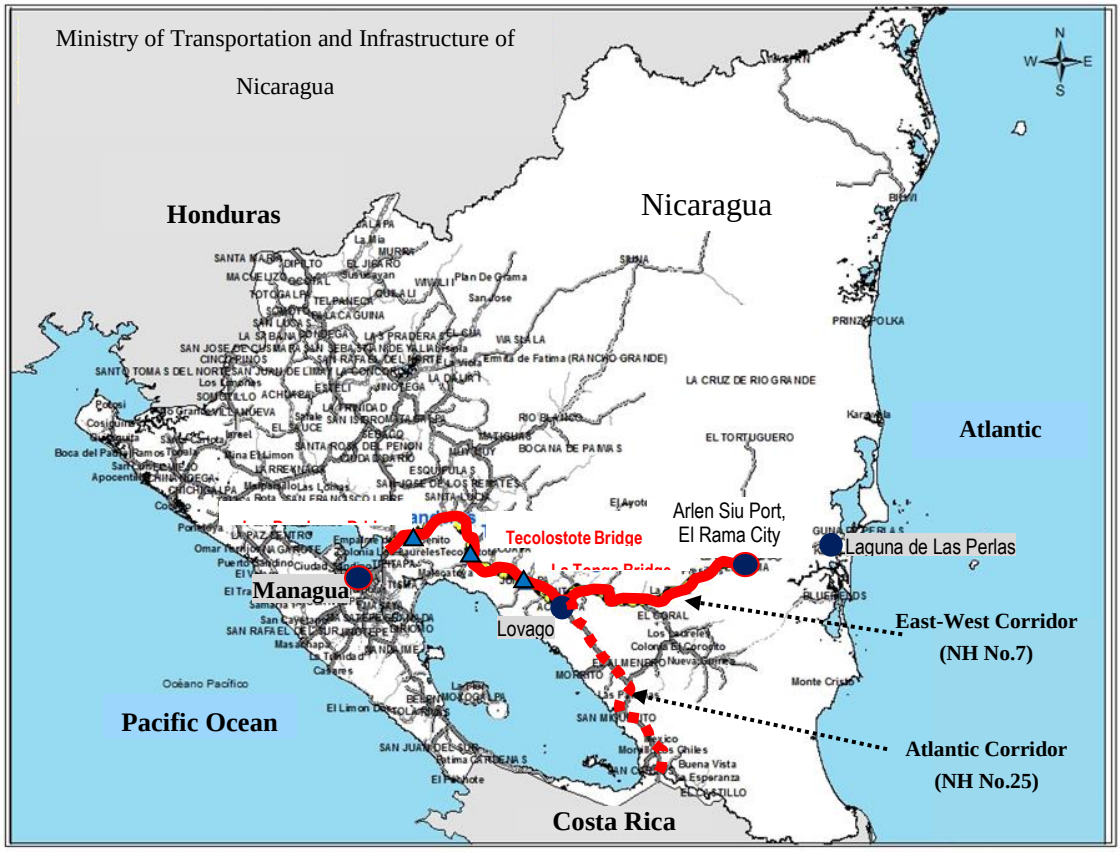
1 National Highway No. 7 where the bridges of the Project are located, are part of the East-West Corridor lining the Pacific Ocean side and Caribbean Seaside of Nicaragua. The section between Managua and Lovago also forms part of the Atlantic Corridor, an international trunk road in Central America. This Atlantic Corridor runs southwards from Lovago as National Highway No. 25 to link with Costa Rica. Meanwhile, the East-West Corridor continues from Lovago to El Rama to the east as National Highway No. 7.

2 See "Relevant Projects: Other donors" in the table in the Project Outline.

Against this background, the Government of Nicaragua made a request for a grant aid cooperation to the Government of Japan in July 2008 for the rebuilding of the three bridges in question. In response, the Japan International Cooperation Agency (JICA) conducted the Preparatory Study (Preliminary Investigation) in October 2009 and the Preparatory Study (Basic Design) in January 2010.

1.2 Project Outline

The purpose of the Project was to secure safe and smooth traffic between Managua and El Rama on the Atlantic and East-West Corridors by means of rebuilding three bridges, thereby contributing to the vitalization of domestic and international logistics and also to the promotion of the local economy along the route.



Source: Executing Agency

Fig. 1 Location of the Three Bridges on the National Highway No.7 (East-West Corridor)

Grant Limit/Actual Grant Amount	(Detailed Design) 62 million yen / 61 million yen (Construction) 1,878 million yen / 1,261 million yen
Exchange of Notes Date Grant Agreement Signing Date	(Detailed Design) December 2010 (Construction) June 2011
Executing Agency	Ministry of Transport and Infrastructure

Project Completion Date		July, 2013
Project Implementation Entities	Main Contractors	Fujita-Kawada Joint Venture
	Main Consultant	CTI Engineering International Co., Ltd.
Basic Design Study		January 2010-October 2010
Related Projects		[Technical Cooperation] Project for the Study of National Transport Plan in the Republic of Nicaragua (2012-2014) [Grant Aid] Project for Reconstruction of Bridges on Principal Trunk Roads (E/N: May 2000); Project for Reconstruction of Principal Bridges on National Highway No.7 (E/N: June 2007); Project for Construction of the Santa Fe Bridge in the Republic of Nicaragua (E/N: May 2010) [Other Organizations] Rehabilitation of the San Benito-San Lorenzo Road (Danish International Development Agency, 1999-2003); Rehabilitation of the Muhan-El Rama Road (World Bank, 2002-2003); Rehabilitation of the San Lorenzo-Muhan Road (Inter-American Development Bank(IDB), 2003-2005)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hiromi Suzuki S. (IC Net Limited)

2.2 Duration of the Evaluation Study

The ex-post evaluation study for the Project was conducted over the following period.

Duration of the Study: October 2016 to February 2018

Duration of the Field Survey: 19th February to 2nd March and 26th to 30th July 2017

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

3.1 Relevance (Rating: ③[4])

3.1.1 Consistency with the Development Policies of Nicaragua

The national development plan of Nicaragua at the time of the planning of the Project was the *National Human Resources Development Plan (2008-2012)* in which "the development of such economic infrastructure as roads, bridges, etc." was considered to be an important means of achieving the target for "productivity improvement". The "Mesoamerica Project" and the "*Program to Strengthen the Transportation Network of Trunk Roads*" were the two principal policies of the transportation sector at the time. The former was a wide area development

[3] A: Highly satisfactory; B: Satisfactory; C: Partially satisfactory; D: Unsatisfactory

[4] ①: Low; ②: Fair; ③: High

project[5] aimed at vitalizing logistics in Central America and the latter was an infrastructure policy for transportation formulated by the Ministry of Transport and Infrastructure (Ministerio de Transporte e Infraestructura: MTI). Both emphasized the development of the Pacific Corridor and Atlantic Corridor where the Project sites were located from the viewpoint of developing a transportation network of trunk roads, including international trunk roads.

The national development plan at the time of ex-post evaluation is the *National Human Resources Development Plan (2012-2016)* and the development of transport infrastructure is included in its 12 principal strategies and policies. In addition to the continuous improvement of semi-trunk roads and bridges and the development of basic road networks and transport infrastructure, one of the targets of this national plan is the continuous improvement of the East-West Corridor linking the Pacific side and Atlantic side of Nicaragua. The *Long-Term National Transport Plan*[6] *(2014-2033)* of the MTI considers roads and bridges to be essential infrastructure to ensure the sustainable growth of the national economy and to reduce disparities between the eastern and western areas of Nicaragua. It lists such strategies as the development of reliable road networks, strengthening of the trunk road network and international corridors, strengthening of road functions to improve the vulnerability to disasters and strengthening of the road maintenance system. Regarding the road improvement of the East-West Corridor, where the Project is located, the intended work includes repair of the road linking El Rama and Laguna de Perlas and the construction of new bridges. As these works proceed, the role as an international trunk road of the East-West Corridor, including the section where the Project is located, is expected strengthen and increase. In addition, as the high level of traffic accidents is considered to be a social problem in Nicaragua, an action plan for the safety of road transport is included in this transport plan.

As described above, the development policies of Nicaragua at the time of both ex-ante evaluation and ex-post evaluation consider the improvement of transport infrastructure, including roads and bridges, to be essential for economic development and productivity improvement. Therefore, the Project consistency is secured.

3.1.2 Consistency with the Development Needs of Nicaragua

The road section between Managua and El Rama where the subject bridges of the Project are located is a major trunk road connecting four departments (Managua, Boaco, Chontales and South Caribbean Coast Autonomous Region) which account for approximately one-third of the country's total population. Areas along the route are rich with agriculture and the livestock

[5] The *Mesoamerica Project* is a wide area development initiative succeeding the Plan Puebla Panama which was jointly announced by Central American countries and Mexico in June 2001. At the time of ex-post evaluation, the Pacific Corridor and Atlantic Corridor, both of which form part of the "Mesoamerica International Road Network" aimed at vitalizing logistics and tourism in Central America, have been developed with IDB loans.

[6] The *Long-Term National Transport Plan* was formulated based on the "Project for the Study on National Transport Plan in Nicaragua", a technical cooperation project (development study) of JICA implemented in 2014.

industry and the road is linked to Port of Arlen Siu, the principal port of El Rama on the Atlantic side.[7] However, as described in "1.1 Background", the target bridges of the Project were highly deteriorated to the point of the risk of collapse. Moreover, their narrow width forced vehicles to stop on both sides of the bridge, creating a bottleneck. The delayed improvement of the road and bridges in this section became an obstacle to not only the smooth domestic as well as international logistics but also to socioeconomic development. There was a strong need for bridge improvement from the viewpoint of safety and economic development.

At the time of ex-post evaluation, while the bottlenecks posed by these three bridges have been eliminated, this section maintains its high level of importance from the viewpoint of vitalizing domestic and international logistics and also of promoting the local economy.

Based on the above, the Project is highly consistent with the development needs of Nicaragua at the time of both planning and ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

Japan's Country Assistance Program for Nicaragua formulated in 2002 through discussions with the Government of Nicaragua adopted the basic policy of providing cooperation for a reduction of poverty and economic disparities, improvement of the socioeconomic infrastructure, support for democratization and strengthening of the disaster prevention capacity in view of the facts that the negative impacts of the long-fought civil war still remained and that the country suffered from many natural disasters. At the same time, the Program called for consistency with Japan's assistance for regional integration efforts led by the Central American Integration System. As the Program identified six priority areas, including improvement of the road and transport infrastructure, the Project as a road and transport infrastructure improvement project is highly consistent with Japan's ODA policies.

Based on the above, the Project is highly relevant to Nicaragua's development policies as well as Nicaragua's development needs and Japan's ODA policies. Therefore, its relevance is high.

3.2 Efficiency (Rating: ③)

3.2.1 Project Outputs

The outputs of the Japanese portion were generally achieved as planned (Table 1).[8]

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[7] The Port of Arlen Siu is a river port located some 100 km inland of the Caribbean Coast (Atlantic Coast) and plays an important role in the international logistics of goods between Nicaragua and the Caribbean Sea (Atlantic Ocean).

[8] The only major change was lengthening of three caisson piles for the abutment of La Tonga Bridge from 6.5 m to 8.5 m based on the findings of an additional boring survey which was conducted to verify the different geological features discovered during the construction work.

Table 1　Outputs of the Japanese Portion: Planned and Actual

Item		Planned			Actual
		Las Banderas Bridge Tipitapa, Managua	Tecolostote Bridge San Lorenzo, Boaco	La Tonga Bridge Juigalpa, Chontales	
General Contents		Change to a two-lane bridge	Construction of a new one-lane bridge parallel to the existing one-lane bridge	Change to a two-lane bridge	As planned for all three bridges
Road Standard		Trunk Road	Trunk Road	Trunk Road	
Design Speed		80 (km/h)	80 (km/h)	80 (km/h)	
Design Live Load		Equivalent to an increase by 25% of HS20-44 (Live Load B)	Equivalent to an increase by 25% of HS20-44 (Live Load B)	Equivalent to an increase by 25% of HS20-44 (Live Load B)	
Bridge Length		100.5 (m)	100.8 (m)	99.7 (m)	
Span Length		48.9+24.3+24.3 (m)	25.0+50.0+25.0 (m)	32.3+32.3+32.3 (m)	
Width		12.330 (m)	7.130 (m)	12.330 (m)	
Superstructure		Simple steel through truss bridge/PC2 span continuous girder I bridge	Steel 3 span continuous iron girder bridge	PC3 span continuous girder I bridge	
Substructure		Inverted T-type abutment Oval wall type pier	Inverted T-type abutment Oval wall type pier	Inverted T-type abutment Oval wall type pier	
Foundation Structure		Spread Foundation	Spread Foundation	Spread Foundation Caisson pile (diameter 2.5m, length 6.5m)	Only at La Tonga Bridge, the length of the three caisson piles was changed to 8.5m
Access Road	Extension at Starting Point	144.0 (m)	241.0 (m)	168.8 (m)	As planned for all of three bridges
	Extension at End Point	155.5 (m)	298.2 (m)	371.5 (m)	

* Source: document provided by JICA

The outputs of the Nicaraguan portion included the acquisition of land, resettlement, relocation of communication facilities, relocation of electricity poles and cables, relocation of water pipes (at Las Banderas Bridge and Tecolostote Bridge) and other (removal of existing bridges). According to the MTI, the planned outputs were generally achieved except for the following changes and additions.

- Because the number of commercial premises illegally occupying the planned construction sites had increased since the time of project planning, the scale of land acquisition and resettlement increased.

- For the relocation of electricity poles and cables, it was decided to lay the cables underground without using poles to increase the travelling safety of medium size and large trucks.

- Because of changes of the detour routes, the work to repair walls, fencing, etc. of buildings along the new detours was added.

- At the time of improving the access roads to Tecolostote Bridge, it was found that the site of the Tecolostote Secondary School located next to the bridge partly occupied the right of way for the national highway. In return for the transfer of this site by moving the boundary line of the school[9], the MTI agreed with the school to improve the perimeter fencing, multi-purpose ground and infrastructure (staircases, handrails, benches, etc.) near the entrance to the school and conducted the necessary work except for some items.

All of the above changes and additions to the output were necessary in order to secure safe and smooth traffic at the target bridges. Meanwhile, the changes and additions of the Nicaragua portion were necessary and appropriate in order to minimise any negative impacts of the Project on local residents and the environment.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The planned total project cost at the time of planning was 1,949 million yen (Japanese portion of 1,878 million yen and Nicaraguan portion of 71 million yen). The actual total project cost was 1,333 million yen (Japanese portion of 1,261 million yen and Nicaraguan portion of 72 million yen) which was 63% of the planned cost.

As far as the Japanese portion of the Project is concerned, although the construction cost increased because of the lengthening of three caisson piles for the abutment of La Tonga Bridge and increase quantity of superstructure for each bridge, the final amount of the Japanese portion was within the planned cost due mainly to the appreciation of the yen.[10]

The final Nicaraguan portion of the project cost exceeded the planned cost, partly because of underestimation of the removal cost of the existing bridges[11] at the time of planning, in turn

[9] As part of the premises of the Tecolostote Secondary School occupied the right of way for the national highway, no compensation would have been necessary in a normal situation. It was impossible to obtain more detailed and accurate information on the background for this agreement.

[10] The exchange rate of 91.36 yen to US$ 1 at the time of the Preparatory Study changed to 83.73 yen to US$ 1 at the time of the Detailed Design.

[11] This included the repair and reinforcement of the existing Tecolostote Bridge, demolition and removal of the existing La Tonga Bridge and repair and reinforcement of the existing Cuisalá Bridge. The rebuilding of Cuisalá Bridge was removed from the scope of the Project as the Preliminary Study conducted in 2009 found the work to be less urgent in reference to its structural safety and transport function. However, the implementation of the

due to the lack of a detailed survey, and partly because of the increased prices of some equipment and materials. The cost of land acquisition, resettlement and relocation of communication and utility poles and water pipes was within the planned cost despite some changes of the planned contents and additions.

Table 2 Project Cost: Planned and Actual

(Unit: million yen)

Item	Planned	Actual
【Japanese Portion】		
Construction Cost	1,878	1,190
Design and Supervision Cost		72
Sub-total	1,878	1, 261
【Nicaraguan Portion】		
Land Acquisition, Resettlement	16	12*
Relocation of communication, utility poles and water pipes	26	7
Other (Removal of the existing bridge, etc.)	29	56
Sub-total	71	72
Grand Total	1,949	1,333

Source: The planned cost for the Japanese portion is based on the E/N. The planned cost for the Nicaraguan portion is based on the report for the Preparatory Study. The actual cost for the Japanese portion is based on documents provided by JICA. The actual cost for the Nicaraguan side is based on documents provided by MTI.

Note: At the time of quantity survey: Foreign exchange rate as of March 2010: US$1=91.36 Yen
At the time of ex-post evaluation: 1 Cordoba=3.5181Yen (monthly average rate from January 2011 to July 2013; source: IMF data).

* The construction cost of fencing, multi-purpose ground and infrastructure (staircases, handrails, benches, etc.) for the Tecolostote Secondary School accounted for some14% (1.7 million yen) of the land acquisition and resettlement cost.

3.2.2.2 Project Period

The cooperation period, including the detailed design and tender periods, assumed at the time of planning was from October 2010 to June 2013 (two years and nine months or 33 months). The actual period was from December 2010 when the grant agreement was signed, to July 2013 (two years and eight months or 32 months) which was within the planned period (97% of the planned period).[12]

Based on the above, both the Project cost and the Project period were as planned. Therefore, the efficiency of the Project is high.

repair and reinforcement of five items was recommended and it was agreed that this work would be conducted at the expense of the Nicaraguan side.

[12] Because of the lack of information on the overall construction period and that on individual components of the Nicaraguan portion, project completion was defined as the completion and approval of the final inspection of the three bridges. Regarding the Project period by stage was, 91% of the planned period from the detail design to signing of contract for the main works; as for the construction period, it was 86% compared to the planned period for Las Banderas Bridge, 90% for Tecolostote Bridge, and 83% for La Tonga Bridge. As can be seen, all bridges were within the planned period.

3.3 Effectiveness[13] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

The principal objective of the Project was "to secure safe and smooth transport" and there were three main indicators for the project effect: "improvement of the average travelling speed", "elimination of the temporary stoppage of vehicles before the bridge" and "reduction of the river crossing time by vehicles". In this ex-post evaluation, four auxiliary indicators were added, taking the contents of the report for the Preparatory Study into consideration. These are "increase of the traffic volume", "elimination of traffic paralysis due to flooding, etc.", "reduction of traffic accidents" and "prevention of the loss of human life due to bridge collapse". Table 3 and Table 4 show the reference value, planned value and actual value for each of these indicators for the three bridges.

A) Main Effect Indicators

(1) Increase of the average travelling speed: At the time of planning, the target average travelling speed was set at between 60 km/hour and 80 km/hour which was the speed limit in Nicaragua. However, a traffic accident near Las Banderas Bridge[14] led to the introduction after project completion by the Nicaraguan side of speed reduction zones with a maximum speed limit of 30 km/hour on both side of the target bridges of the Project. While these speed reduction zones have contributed to securing safe transport, the average travelling speed has decreased, which kept the target achievement rate between 38% to 57%. However, it must be noted that the introduction of these speed reduction zones has not caused any traffic jams which were a regular occurrence prior to the Project and the average travelling speed has increased compared to the pre-project period at all three bridges.

Speed reduction zone at Las Banderas Bridge (towards El Rama)

[13] The effectiveness is rated in consideration of not only the effects but also the impacts.

[14] While the target bridges of the Project are on National Highway No. 7, they are located in the municipal areas of Tipitapa, San Lorenzo and Juigalpa and residential areas are spread on both sides of the river and road. There are also many schools, medical institutions and commercial premises on both sides of these bridges along the road. Because of this, residents cross the bridge and road on foot many times a day as National Highway No. 7 is part of their daily life. In August 2014, a primary school pupil was run over by a truck and died after crossing the highway near Las Banderas Bridge, triggering a protest by residents. In response to this protest, speed reduction zones were introduced on both sides of the three bridges rebuilt by the Project.

Table 3 Level of Achievement of Main Effect Indicators

Indicator	Reference value (2010)	Target/status to achieve three years after project completion (2016)	Actual 2016 three years after project completion (Target achievement rate; status of achievement)
(1) Improvement of average driving speed (km/h) (improvement of average driving speed entering to and departing from the bridge)			
Las Banderas	10-20 km/h	60-80 km/h	31 km/h (39%-52%)
Tecolostote	10-20 km/h	60-80 km/h	30km/h (38%-50%)
La Tonga	10-20 km/h	60-80 km/h	34 km/h (43%-57%)
(2) Elimination of the stoppage time before the bridge			
Las Banderas	Average stoppage time 2.5 minutes per bridge	None	20 seconds (87% improvement from the reference value)
Tecolostote	Average stoppage time 2.5 minutes per bridge	None	20 seconds (87% improvement from the reference value)
La Tonga	Average stoppage time 2.5 minutes per bridge	None	8 seconds (95% improvement from the reference value)
(3) Shortening of the average river crossing time per vehicle			
Las Banderas	2-5 minutes*	Shortened after the project completion	26 seconds (78%-91% improvement from the reference value)
Tecolostote	2-5 minutes *	Shortened after the project completion	24 seconds (80%-92% improvement from the reference value)
La Tonga	2-5 minutes *	Shortened after the project completion	16 seconds (87%-97% improvement from the reference value)

Source: The reference and target values are based on the ex-ante evaluation table and the report for the Preparatory Study. The actual values are based on the materials provided by MTI.

* The river crossing time by vehicle obtained from the results of the beneficiary survey was used as the reference value.

(2) Elimination of the temporary stoppage of vehicles before the bridge: Prior to the Project, the average stoppage time on both sides of the bridge was 2.5 minutes at each bridge. It was assumed that the Project would eliminate this stoppage time before the bridge as all the bridges would become two lane bridges instead of single lane bridges. At the time of ex-post evaluation, the introduction of speed reduction zones at these bridges as explained earlier means that vehicles stop for an average of some 20 seconds before Las Banderas Bridge and Tecolostote Bridge and an average of eight seconds at La Tonga Bridge. Although temporary stoppage has not been totally eliminated due to the installation of speed reduction zone that is an exogenous factor, a substantial improvement between 87% and 95% has been achieved against the reference value.

(3) Reduction of the river crossing time by vehicles (bridge crossing time): Because of the lack of a reference value in 2010 for this indicator, "an average river crossing time before the

Project" of 2 to 5 minutes which was information obtained by the beneficiary survey[15], was used as the reference value.[16] The actual value in 2016 was 26 seconds for Las Banderas Bridge, 24 seconds for Tecolostote Bridge and 16 seconds for La Tonga Bridge, showing a considerable improvement of 78% to 97% against the reference value. At the time of ex-post evaluation, even though the travelling speed has been reduced by the speed reduction zones, no traffic jams occur because of them. Therefore, the bridge crossing time has shortened and smooth traffic flow is observed at the moment of the ex-post evaluation.

B) Auxiliary Indicators

(1) Increase of the traffic volume (average annual daily traffic volume (AADT) vehicles/day): The traffic volume recorded by the executing agency differs from that of the Preparatory Study and the traffic volume survey conducted at each bridge at the time of the ex-post evaluation. The executing agency's traffic volume is data recorded at the monitoring points installed by the executing agency, and in addition to that, the location of such monitoring points is not located near the bridge. For example, although the monitoring points for Las Banderas Bridge and Tecolostote Bridge is inside the urban city, they are located slightly away from the bridges. On the other hand, the monitoring point of La Tonga Bridge is located in the rural area away from the urban area. Therefore, the traffic volume provided by the executing agency is not strictly comparable to the planned value data. However, as a request was made by the executing agency to use their data as official data for the purpose of ex-post evaluation, Table 4 lists both data provided by the executing agency and data obtained by the traffic volume survey[17] conducted during the field survey of the ex-post evaluation which used the same method employed at the time of planning. Based on MTI data, only small vehicles passing La Tonga Bridge failed to achieve the target because of the reason stated above. However, based on the traffic volume survey using the same method employed for planning, it is confirmed that the traffic volume in 2017 far exceeds the reference value at every bridge.

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[15] The details of the beneficiary survey (drivers) is as follows: (1) survey period: 8th to 12th March 2017; (2) sample size: 50 drivers at each bridge (total of 150 drivers); (3) gender ratio: 94% male and 6% female at Las Banderas Bridge, 90% male and 10% female at Tecolostote Bridge and 98% male and 2% female at La Tonga Bridge; (4) age: some 70% of the drivers were in their thirties and forties at all bridges; (5) bridges used: "all three bridges" were 74% of the respondents, and "Las Banderas Bridge and Tecolostote Bridge" was 26 % for all drivers surveyed at Las Banderas Bridge; at Tecolostote Bridge, "all three bridges" accounted for 33% of respondents, "Tecolostote Bridge only" for 36% and "Las Banderas Bridge and Tecolostote Bridge" for 26%; for La Tonga bridge "all three bridges" accounted for 66% of respondents, and "La Tonga Bridge only" for 33%.

[16] According to the findings of the beneficiary survey (drivers), although the average river crossing time used to be from 2 to 5 minutes before the Project, the problem was that all the old bridges had only one lane, which caused traffic congestions in order to cross the bridge, resulting in a traffic bottleneck. For example, during rainy season, traffic congestion uses to be even more severe, starting quite far before the bridge, and if the delay to reach the bridge due to congestion were included, the average river crossing time would even reach up to three hours.

[17] For the ex-post evaluation, the traffic volume for 12 continuous hours was surveyed for a total of five days. The daily traffic volume obtained was then converted to AADT data using MTI data from fixed point monitoring stations on National Highway No. 7.

Table 4 Level of Achievement of Auxiliary Indicators

			Reference value (2010)	Target/status to achieve three years after project completion (2016)	Actual 2016 three years after project completion (Target achievement rate; status of achievement)
(1) Increase of bridge crossing traffic volume (AADT: units/day) *					
Las Banderas	MTI Data	Small	2,186units 1,256units	Increased after the project completion	3,352 units (154% of the reference value)
		Large			1,583 units (126% of the reference value)
	Traffic Volume Survey for Ex-post Evaluation	Small			3,613units(165%of the reference value)
		Large			3,062 units (248% of the reference value)
Tecolostote	MTI Data	Small	1,858 units 699 units	Increased after the project completion	2,173 units (117% of the reference value)
		Large			983 units (141% of the reference value)
	Traffic Volume Survey for Ex-post Evaluation	Small			2,218 units (119% of the reference value)
		Large			1,101 units (157% of the reference value)
La Tonga	MTI Data	Small	4,369 units 784 units	Increased after the project completion	2,036 units (47% of the reference value)
		Large			786 units (100% of the reference value)
	Traffic Volume Survey for Ex-post Evaluation	Small			11,376 units (260% of the reference value)
		Large			2,753 units (351% of the reference value)
(2) Annual number of traffic paralyses (due to flooding)					
Las Banderas			One day in 5 years	None	None (100% achieved)
Tecolostote			One day in 5 years	None	None (100% achieved)
La Tonga			One day in 5 years	None	None (100% achieved)
(3) Absolute number of accidents					
Las Banderas			2 accidents (2011)	Decreased after the project completion	1 in 2013 7 in 2014 3 in 2015 (Decreased immediately after the Project but increased thereafter)
Tecolostote			3 accidents	Decreased after the project completion	2 in 2013 0 in 2014 1 in 2015 (Decreased after the Project)
La Tonga			9 accidents	Decreased after the project completion	7 in 2013 3 in 2014 9 in 2015 (Decreased after the Project but no clear improvement)
(4) Loss of human life due to bridge collapse					
Las Banderas			—	None	None (100% achieved)
Tecolostote			—	None	None (100% achieved)
La Tonga			—	None	None (100% achieved)

Source: The reference and target values are based on the ex-ante evaluation documents and the report for the Preparatory Study. The actual values are based on the materials provided by MTI. The bridge crossing volume is based on the MTI data plus the results of the traffic volume survey conducted for ex-post evaluation. The number of traffic accidents is based on the data by the Nicaragua police.

(2) Number of annual occurrences of traffic paralysis (due to flooding): No data on the annual occurrence of traffic paralysis due to flooding was available before the Project and the latest recorded incident was caused by flooding due to Hurricane Mitch. Not a single occurrence of traffic paralysis due to flooding occurred in the three-year period after the completion of the Project.

(3) Absolute number of traffic accidents: According to Nicaragua police statistics, the absolute number of traffic accidents in 2015 compared to that of the moment of plan, does not have a big change, and according to the annual data since the Project completion, there is no clear tendency. In addition, if the traffic volume of each bridge is taken into consideration, the occurrence rate of traffic accidents can be said to be low. The reasons for traffic accidents (contacts and collisions) cited by the Nicaragua police are failure to maintain an appropriate distance, inappropriate over-taking and road crossing by pedestrians and animals. In short, this means a lack of proper traffic education as well as traffic manners on the part of both drivers and pedestrians. After the completion of the Project, traffic congestion was eliminated, instead, traffic accidents occurred due to a faster travelling speed by vehicles, which highlighted the need for traffic education. It is likely that the number of traffic accidents would be higher if speed reduction zones had not been introduced.

(4) Loss of human life due to bridge collapse (number of deaths): Because all three bridges do not have any structural problems, and proper maintenance is conducted (for details see "3.5.4 Operation and Maintenance Status") there is hardly any risk of bridge collapse. It is, therefore, safe to say that the target has been achieved 100%.

In summary, as far as the main indicators are concerned, although the "average travelling speed" has improved, it is limited to certain level due to the introduction of speed reduction zones after Project completion by the government of Nicaragua. In regard to the "elimination of the temporary stoppage of vehicles before the bridge" and "reduction of the river crossing time", an improvement of more than 80% of the reference value has been achieved. In the case of auxiliary indicators, with the exception of "absolute number of accidents" for which a clear tendency could not be recognized, the other indicators have either achieved the target, or show an improving trend. In summary, the Project is recognized as having contributed to "securing safe and smooth traffic".

3.3.2 Qualitative Effects (Other Effects)

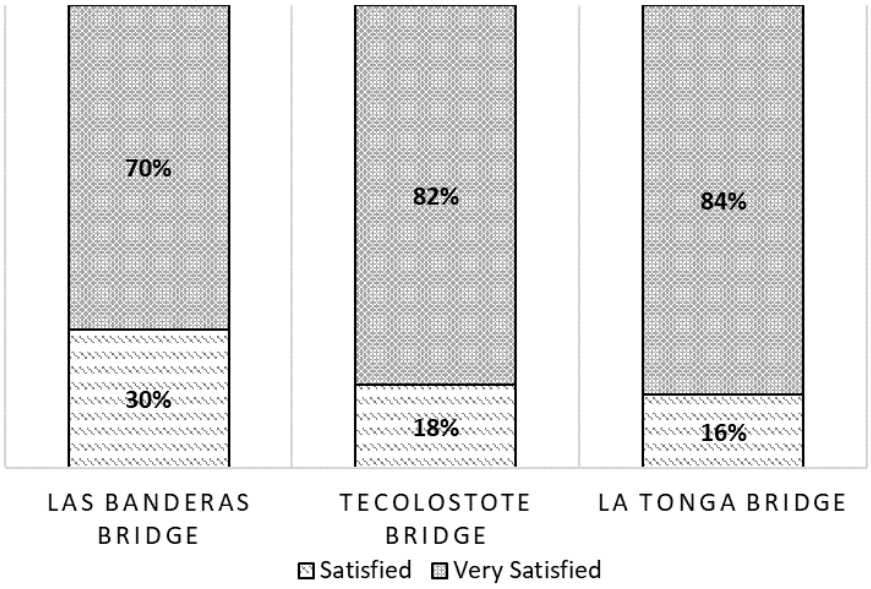
(1) Prevention of the collapse of structurally dangerous bridges due to degradation and aging (avoidance of the loss of human life): Although the target bridges had problems of deterioration due to degradation and aging before the Project, none of the bridges had experienced a collapse. In view of the fact that the total of AADT for the three bridges in 2010 was 7,252 vehicles coupled with their heavy use by pedestrians, the Project is believed to have made a major contribution to the avoidance of the loss of human life. In the group interviews with local residents[18], various opinions were expressed, including "the Project has considerably improved the safety of bridge users as there used to be a constant feeling of danger due to degradation and aging and also due to the narrow bridge width and severe wobbling before the Project" and "in the areas where the bridges are located, there are primary and secondary schools, hospitals, etc., and before the Project, it was difficult to go to school or to the hospital from the other bank of the river, but after the Project, safety of pedestrians has been secured". In sum, the Project is believed to have significantly contributed to improving the living environment of local residents.

(2) Level of satisfaction of the Project: Although the beneficiary survey (to drivers) found negative opinions such as the fact that the introduction of speed reduction zones has led to increased maintenance need regarding tyres, suspension, etc. and a shorter service life of vehicles, the level of satisfaction with the Project was extremely high based on the overall assessment of the quality, convenience, efficiency, safety, etc. of the bridges. As shown in Fig. 2, satisfaction level was evaluated in four levels, and in all the bridges the evaluation was as high as "satisfactory" or "highly satisfactory", while "not so satisfactory" or "not satisfactory at all" evaluations were none. Similarly, the interview survey with local residents and logistics service providers[19] found a very high level of satisfaction with the Project. Common requests made in these surveys were the following two: the reinstallation

[18] The details of the group interviews with local residents conducted as part of the ex-post evaluation are: (1) survey period: 21st to 27th February 2017; (2) sample size and gender ratio: 15 for Las Banderas Bridge (Tipitapa City) (7 males and 8 females), 29 for Tecolostote Bridge (San Lorenzo City) (8 males and 21 females) and 18 for La Tonga Bridge (Juigalpa City) (9 males and 9 females); (3) sampling method: a representative resident from the community designated by the municipal government informed local residents beforehand, and those residents who came to the assembly hall on the indicated day and time were interviewed. It is possible that by this sampling method, only those residents with a positive opinion of the Project would be gathered, resulting in a possible bias of the results. However, the objective of the survey was explained beforehand to the municipal government and the representative resident and requests were made to make an effort to conduct a random sampling as much as possible.

[19] Some of the large logistics service providers are members of the Nicaraguan Association of Transporters (NAT). The membership of this association includes 185 companies in possession of more than 50 large vehicles (trucks, buses, tank lorries, etc.), 80 companies in possession of more than 15 vehicles and 1,300 individual transporters in possession of 15 vehicles or less. Meanwhile, many users of the Project are companies (mostly self-employed) belonging to a small association in a local city. For this ex-post evaluation, a representative of the NAT was interviewed to obtain the opinions of large and medium-size companies. An additional interview survey was conducted with a total of 10 associations and self-employed operators based in cities where the target bridges of the Project are located.

of lighting facilities at Las Banderas Bridge and La Tonga Bridge which existed before the Project in order to improve security, and new design of future speed reduction zones to reduce the load on passing vehicles. To sum up, the level of satisfaction among all beneficiaries is high, and the effects of the Project can be recognized.



Source: Results of the Beneficiary Survey N=150

Fig. 2 Level of Satisfaction with the Project: Drivers

3.4 Impacts

3.4.1 Intended Impacts

The assumed impacts of the Project were (1) promotion of the local economy along the route and (2) vitalization of domestic and international logistics. For this ex-post evaluation, a beneficiary survey with drivers, group interviews with local residents and an interview survey with logistics service providers were conducted and the impacts of the Project were analysed based on the results of these surveys.

(1) Promotion of the local economy along the route: As shown in Table 5, it is clear that the Project has contributed to the vitalization of the economy and improvement of the living conditions for local residents along National Highway No. 7. In cities where the subject bridges are located, local industries have been vitalized due to fresh investment and expansion as a result of the Project. Local residents believe that their options have increased due to the availability of much more merchandise and that the increase of

commercial establishments has made life more convenient. In short, the Project is believed to have significantly contributed to “the promotion of the local economy along the route”.

Table 5 Impact: Promotion of Local Economy Along the Route

Survey Subjects	Results
Drivers (150)	• 90% of the respondents replied that "the Project has contributed to economic vitalization along National Highway No. 7 between Managua and El Rama". • 94% replied that "the Project has contributed to improvement of the living conditions of residents in cities located between Managua and El Rama.
Local residents/logistics service providers	• Common opinions concerning the three bridges: Many businesses have opened along National Highway No. 7 such as restaurants, petrol stations, large supermarkets, pharmacies and tourist shops. The price range of daily commodities has widened, providing more options for local residents. However, the prices of some goods have either increased or decreased due to an increased demand and it cannot be said that prices in general have stabilized. Although the effects on rectification of the poverty gap are not yet visible, further progress of the ongoing vitalization of the local economy might narrow the poverty gap in the medium to long-term. • Las Banderas Bridge: As far as quarrying, which is a local industry, is concerned, 8 medium-size domestic and foreign companies have commenced local operation since the completion of the Project, boosting local employment. Local residents employed by these companies now enjoy a stable income and health insurance. • Tecolostote Bridge: The leading industries in the city of San Lorenzo are agriculture (Altamira, the largest rice producer in Nicaragua is based in the city), animal husbandry and quarrying. The implementation of the Project has improved the efficiency of logistics for these industries. Along with a population increase, the local economy has certainly been vitalized. • La Tonga Bridge: In addition to the vitalization of local industries (agriculture and animal husbandry), the San Antonio District located on the El Rama side of the bridge has much developed with the opening of a large supermarket, bank, clinic, large hardware store, large warehouse of a multi-national beverage company, tourist shops, etc. compared to time before the Project when only a petrol station was located there. Following this development, the land price has increased to US$ 120 per 1 "bara" (0.70 ha) at the time of ex-post evaluation from US$ 80 per 1 "bara" for land along National Highway No. 7.

Source: Results of the beneficiary survey, group interviews and other interviews conducted by the evaluator.

(2) Vitalization of domestic and international logistics: The traffic survey conducted for this ex-post evaluation found that Managua is the main departure point for drivers using the Project-related bridges and the main destination is Juigalpa, followed by El Rama. At present, National Highway No. 7 is the only road linking Managua and El Rama and it is safe to assume that National Highway No. 7 on which the three bridges of the Project are located accounts for most of the logistics between Managua and El Rama. Drivers and logistics service providers have expressed their shared opinion that the Project has greatly contributed to the vitalization of domestic logistics (Table 6). Meanwhile, the cargo handling volume at the port of Arlen Siu, which plays a role in international logistics in Nicaragua in the city of El Rama, increased from 32,000 tons in 2010 to 48,000 tons in 2015. From the interviews to logistics service providers it was found that the improvement of National Highway No. 7 including the Project, has made international cargo logistics on the Atlantic side more efficient, stimulating up to some extent the corresponding operations.

A further contribution by the Project to the vitalization of international logistics can be expected with the progress of improvement of National Highway No. 7 and vitalization of the local economy along the route.[20]

Table 6 Impacts: Vitalization of Domestic and International Logistics

Survey Subjects	Results
Drivers (150)	• 84% replied that "the Project has contributed to the logistics of local industries". • 83% replied that "the Project has contributed to the logistics of the Eastern Region and international logistics".
Logistics service providers	• The Project has made the use of National Highway No. 7 safer and more efficient. As the current use of this road is mainly dominated by domestic logistics, the Project has made a considerable contribution to the vitalization of domestic logistics. To be more precise, the overall bridge crossing time has been reduced from 3-4 hours to a maximum of five minutes and, consequently, the travelling time between Managua and El Rama has been shortened from 8 hours before the Project to 6 hours. As a result, the occurrence of late deliveries has become less frequent, petrol consumption has been reduced, damage to animals and cargo has decreased significantly and the quality of merchandise has been secured. Logistics service providers have brought future access to Costa Rican markets with the opening of Santa Fe Bridge, etc. into their perspective and are hoping for the vitalization of such international logistics. • The introduction of speed reduction zones has increased the load on passing vehicles and the cost of replacing parts has increased by an average of some 30% compared to the pre-project period. However, the overall profit has increased due to an increased turnover and reduction of the fuel cost.[21]

Source: Results of the beneficiary survey, group interviews and other interviews conducted by the evaluator.

As described above, domestic logistics are the main logistical operation over the three bridges of the Project at the time of ex-post evaluation, but the vitalization of international logistics can be expected due to the utilization of the port of Arlen Siu and the further improvement of National Highway No. 7. As such, a sufficient impact is recognized in relation to "the vitalization of safe and smooth domestic and international logistics".

3.4.2 Other Positive and Negative Impacts

(1) Impact on the natural environment

For the Project, an "environmental management and monitoring plan" which is simpler than an environmental impact assessment was implemented based on the judgement made by

[20] The vitalization of international logistics by the Project is expected to be further enhanced with the commencement of international logistics between Nicaragua and Costa Rica through the Santa Fe Bridge located on the Atlantic Corridor (under JICA's grant aid "Project for Construction of Santa Fe Bridge in the Republic of Nicaragua" (2010) which has a complementary relationship with the Project, as well as with the further improvement of National Highway No. 7 planned by other donors.

[21] The interview with the Nicaraguan Association of Transporters found that the total volume of cargo transportation between Managua and El Rama increased from 2,000 tons/day before the Project to some 6,000 tons/day at the time of ex-post evaluation. The main cargoes from Managua to El Rama are sugar, iron, cement, processed food and grain while those from El Rama to Managua are vegetables, dairy products, domestic animals, construction materials and palm oil.

the Ministry of the Environment and Natural Resources (MARENA). The MARENA notified the MTI to obtain an environmental permit from those municipalities in which the bridges in question were located. This permit was obtained on June 25, 2010 for Las Banderas Bridge, June 29, 2010 for Tecolostote Bridge, and July 12, 2010 for La Tonga Bridge.[22] The excavation permit for the borrow pit and permit for the felling of trees were obtained for the Project in November 2010 from MARENA and the National Forestry Institute (INAFOR) respectively. For the implementation of environmental measures and environmental monitoring during the project implementation period, regular monitoring of the implementation status of the "environmental management and monitoring plan" was conducted with the attendance of representatives of the MARENA, municipal governments, MTI and contractor and instructions were issued when necessary.[23] In connection with the felling of trees, 200 seedlings were planted at Tecolostote Bridge as officially promised to the Tecolostote Secondary School. At La Tonga Bridge, 550 seedlings were planted as planned.[24] Prior to the completion of the Project, final inspection by MARENA took place in February 2013 and the completion of the environmental management and monitoring plan was confirmed and approved in August of the same year. Based on these results, it was possible to confirm that the impact of the Project on the natural environment was kept to a minimum.

(2) Resettlement and land acquisition

Relocation of businesses which illegally occupied the construction sites and also the acquisition of land resulted from the Project. These were completed in accordance with the relevant domestic procedures in Nicaragua in April 2011 prior to the commencement of the tender for the Project. The planned and actual performance are shown below.

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22 The initial environmental assessment was conducted in September 2009 and registration with the National Public Investment System (Sistema Nacional de Inversión Pública) was completed in January 2011.

23 During the construction work, several environmental measures were implemented: (i) as for dust and emissions, regular water spraying of the road and work site (especially the crusher) and periodic maintenance of vehicles was conducted thoroughly, (ii) as for noise and vibration, a low noise, low vibration construction method was adopted (use of a noise suppresser, etc.) to control noise and vibration in addition to the avoidance of school hours for the work in the case of Tecolostote Bridge located near a school and (iii) as for sewage (adverse impact on the river) portable toilets were installed to discharge treated sewage through a sewer. In order to prevent impact on rivers due to landslides etc., at the moment of construction works, necessary filling up of land and forestation were conducted in advance. In the beneficiary survey, 79% of the respondents said that "there was no socioeconomic or environmental impact during the construction work under the Project", while 15% said that "there were some impacts", and 6% did not answer. None of those who responded that "there were some impacts" placed any claims or demanded mitigation measures to the municipal government, as they considered that these impacts were within bearable limits. In the interviews to local residents, even though some also pointed out the occurrence of dust, they considered that they were within the allowable range, and most of them expressed a positive opinion of the safety measures, etc. introduced.

24 At the Las Banderas bridge site, 36 trees were felled. However, the survey conducted by the MARENA and INAFOR found that these trees were already in the process of dying and concluded that replacement planting was not required.

Table 7 Resettlement and Land Acquisition*: Planned and Actual

Bridge	Planned	Actual
Las Banderas Bridge	• Resettlement: A total of three general stores and cafes illegally occupying the site were required to relocate along with one shed and one rain gauge station. • Land acquisition: Not required	• Resettlement: Three commercial premises and one shed which illegally occupied the site were relocated to land provided by the municipal government. The rain gauge station was relocated in March 2011 by the National Land Agency. • Land acquisition: None
Tecolostote Bridge	• Resettlement: Not required • Land acquisition: Right bank downstream: 1,170 m^2, left bank downstream: 1,490 m^2	• Resettlement: 8 households which partially occupied the planned construction site illegally, withdrew from their illegally occupied areas for which compensation was paid based on the results of assessment by the assessor as indicated by the laws in Nicaragua. • Land acquisition: Conducted as planned. Compensation was paid to the landowner (one owner) after negotiations witnessed by the municipal government.
La Tonga Bridge	• Resettlement: Not required • Land acquisition: Right bank downstream: 900 m^2, left bank downstream: 2,715 m^2	• Resettlement: One household partially occupying the planned construction site illegally, withdrew from the illegally occupied area for which compensation was paid based on the assessment results of the assessor as indicated by the laws in Nicaragua. Seven commercial premises with occupied the planned construction site were relocated. • Land acquisition: Conducted as planned. Compensation was paid to the landowner (one owner) after negotiations witnessed by the municipal government.

Source: Preparatory Study Report for the planned, and documents provided by MTI for the actual.
*: Land under land acquisition, was land acquired from formal owners such as private persons or companies, and no illegally occupied land are included.

Regarding land acquisition, direct negotiations were conducted between the executing agency and the owners, however, regarding resettlement, meetings between the executing agency, the municipal governments where each of the bridges are located, and residents were held in 2011. Based on the contents agreed in the meetings, resettlement was completed without any delay. The resettlement of residents that were illegally occupying national or municipal land, a compensation to move was paid based on the evaluation results of an assessor in accordance with the laws of Nicaragua. As the sites for land acquisition were not used for any productive activity or for dwelling purposes, no socioeconomic or environmental impact occurred.

(3) Other impacts

There was one secondary impact which was not assumed at the time of project planning, which is the discontent indicated by the Tecolostote Secondary School to the fact that there are some items not yet conducted in spite of a formal agreement was signed between the executing agency and the school. As described in "3.2.1 Project Outputs", the construction of an access road to Tecolostote Bridge necessitated the moving of the boundary of Tecolostote Secondary School located at the side of the bridge. It subsequently became known that there was an agreement between the school and the MTI to conduct reforestation on the school premises, construction of perimeter fencing among other things. The site visit as part of the ex-post evaluation confirmed that most of the work was completed and that the intended reconstruction was properly carried out. However, classrooms (2 rooms) and the security station are yet to be constructed and the school has indicated their discontent to the fact that in spite of the agreement made in order to enable the construction of the bridge, the contents of the agreement have not been completely conducted as agreed. The MTI is currently arranging an assessment of the situation, and a meeting with the school as a first step with a view to including any necessary work in the FY 2018 budget.

From the above, the Project has largely achieved its objectives and, therefore, its effectiveness and impact are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

The supreme body responsible for the planning and monitoring of road infrastructure maintenance in Nicaragua is the General Direction of Terrestrial Transportation (GDTT) of the MTI. At the time of the ex-post evaluation, the MTI has 1,117 staff members of which 284 belong to the GDTT where two engineers supervise the maintenance of bridges. MTI does not conduct maintenance of road and bridges directly, as it is a supervisory entity.

The actual maintenance work is entrusted to the Road Maintenance Fund (Fondo de Mantenimiento Vial: FOMAV) which is an autonomous entity although it conducts these works in cooperation with MTI, and the Corporation of Regional Construction Companies (Corporatión de Empresas Regionales de la Construcción: CORECO). The daily and periodic preventive maintenance (initial repair of paving, cleaning of side ditches, repair of paved surfaces, installation of traffic signs and relocation/installation of bus stop signs etc.), of roads and bridges that are classified as relatively "good" or "normal" state based on the evaluation standards of MTI, are conducted by FOMAV, whereas the repair and maintenance of roads and bridges in bad shape and require large repairs are conducted by COERCO.

As an autonomous entity, FOMAV signs an annual agreement with the MTI and conducts the above mentioned routine maintenance and periodic maintenance. For the Project, FOMAV is in charge of the routine maintenance and periodic maintenance of bridges and access roads. FOMAV employs some 50 staff members (three engineers are directly involved in the maintenance of the bridges of the Project). FOMAV enters into a road maintenance contract with micro companies[25] formed by local residents for each road section and monitors their maintenance work on a monthly basis. In FY 2016, such a contract was signed with 54 micro companies (with a total of 846 employees). As each road section maintained by a micro company is located in the area where the staff members of the company live, the ownership level on the part of the company is relatively high. The good state of the bridges and access roads maintained by the micro companies was confirmed during by on-site visits conducted during the filed survey. The results of interviews with local residents and the beneficiary survey also show a high level of appreciation and satisfaction with the frequency and contents of the bridge and access road cleaning conducted by these micro companies. FOMAV's institutional organization, chain of command, contracts with micro companies, administration and monitoring procedures are also clear.


FOMAV workers conducting cleaning work near Tecolostote Bridge

Meanwhile, CORECO was established in 1988 under the jurisdiction of the MTI. It has four regional offices and the bridges of the Project are managed by COERCO-EICMEP Manuel Escobar Pereira Integral Construction Enterprise (COERCO-EICMEP) based in the south-eastern part of Managua Department. COERCO-EICMEP employs some 400 people (of which one engineer and nine workers are directly involved in the maintenance of the three bridges of the Project) and has some 105 units of maintenance equipment. It is in charge of relatively large-scale maintenance of the three bridges of the Project. The organizational structure and command system of COERCO are also clearly defined.

As described above, the existence of a comprehensive system to ensure the implementation of maintenance work without fail has been confirmed by this ex-post evaluation as all of the MTI, FOMAV and COERCO have a clear organizational system, command system and division of work regarding the maintenance of the Project.

[25] The method through which FOMAV employs micro companies as an entity in charge of the routine and period maintenance of roads was introduced in 1997 by a World Bank program. A micro company consists of at least 12 local residents, and it is contributing to the creation of employment of each region's poverty population and to gender equality (10% of the total 846 members are women). This method is highly acclaimed by the local residents, and the number of kilometres of road that where routine and periodic maintenance are conducted is increasing steadily, producing high results (Source: documents provided by FOMAV).

3.5.2 Technical Aspects of Operation and Maintenance

At the time of ex-post evaluation, none of the MTI, FOMAV or COERCO have an institutionalized human resources development system except for sporadic irregular training sponsored by a donor or using the MTI budget as listed below.

- Training by MTI: The only training related to bridges in FY 2017 by MTI, which was secured at the time of ex-post evaluation, features "Fundamentals of Bridge Structure" (total period: 8 months) and the participants include Project-related personnel of which 18 are from the MTI, two from the FOMAV and five from COERCO-EICMEP. Both the FOMAV and COERCO conduct irregular training on maintenance-related equipment as required. However, such training is not based on an officially established training schedule. All three organizations list "bridge inspection", "structural assessment of bridges" and "bridge maintenance methods using new technologies" as the most desirable areas for human resources development and consolidation in the coming years.

- Technical assistance and training by other donors: The training provided by donors ranges from that focusing on the strengthening of operation to that featuring maintenance techniques. At the time of ex-post evaluation, there are eight ongoing or planned training schemes on operation and maintenance systems and techniques sponsored by the World Bank, IDB, etc. The Nordic Development Fund (hereinafter referred to as "NDF") has implemented a long-term technical cooperation project entitled "Road Sector Support Program: Developing Adaptive Capacity for Climate Change" from 2012 to 2017. Other assistance are short-term training sessions, etc., all of which are contributing to the strengthening of the operation and maintenance system and technical capability of the MTI.

With respect to the maintenance manual, the Road Maintenance Manual of the Secretarial for Central American Economic Integration (hereinafter referred to as Secretaría de Integración Económica Centroamericana: SIECA) is used as a road maintenance manual for the checking of roads in Nicaragua. For bridge maintenance, the "General Specifications for the Construction of Roads and Bridges NIC-2000" is used. It must be noted that while the latter specifies the manpower strength and equipment required to be used for maintenance, it does not specify the work frequency. As such, the general understanding is that it is desirable to implement maintenance work as proposed in the Preparatory Study Report (2010) (Table 8). Daily maintenance and regular inspection are conducted by FOMAV and COERCO and workers visually inspect the bridge conditions, determine the priority ranking of the maintenance needs and conduct the actual work in accordance with the required frequency based on the ranking. There are no major problems in regard to the technical level of maintenance workers.

In summary, there are no major problems with the technical aspects of operation and maintenance of the Project because the maintenance work to be conducted by the FOMAV does not require high level techniques or expertise. However, none of the MTI, FOMAV or COERCO have an established training plan or human resources development system or qualification system. It is, therefore, desirable that they establish a human resources development system, secure an annual training budget and conduct these systematically.

3.5.3 Financial Aspects of Operation and Maintenance

A) MTI: At the time of ex-post evaluation, contrary to the overall increasing trend of the MTI budget, the budget for the large-scale maintenance of roads and bridges has shown a declining trend. The reason for this is the declining need for large-scale repair in line with the improvement of the national road network (including bridges). The defect inspection conducted in 2014 in relation to the Project pointed out that "The funding shortage to deal with emergencies and large-scale repair was dealt with by loans from the IDB and Central American Bank for Economic Integration (CABEI) and carrying-over to the following fiscal year occurs frequently. As there is not a proper fund procurement plan to meet the estimated essential maintenance cost, improvement of this situation is required." This situation had not improved by the time of the ex-post evaluation. But a procedure through which MTI can make a special budget application to the Ministry of Finance and Public Credit (MHCP) is clearly established as a system to deal with emergencies.

Table 8 Proportion of Road and Bridge Maintenance Budget in the MTI Budget

(Unit: million Cordoba)

	2010	2014	2015	2016
Budget	2,622	3,883	4,470	6,023
Road Maintenance Budget (Bridges Included)	303	338	206	168
Proportion to the Budget of the Ministry	11.6%	8.7%	4.6%	2.8%

Source: MTI

B) FOMAV: If proper routine and periodic maintenance is conducted, the Project's service life is 50 years, thus it is highly important for FOMAV to secure the necessary budget. The budget for FOMAV principally relies on the fuel tax imposed on petrol, gas oil, etc. and US$ 0.16/gallon (as of 2016) is allocated to FOMAV's budget. As shown below, FOMAV has operated in the black for the last three years, and in view of the fact that the annual maintenance cost for the bridges and access roads of the Project for which FOMAV is responsible is 710,000 Cordoba, which accounts for a mere 0.4% of the total profit in FY 2015, it can be said that FOMAV is in position to properly conduct routine and periodic maintenance.

Table 9 Income and Expenditure of the FOMAV

(Unit: million Cordoba)

		2014	2015	2016
Income	IEFOMAV*	1,028	1,207	1,211
	IDB, World Bank	18	26	25
	Other	221	170	213
	Sub-Total	1,267	1,403	1,449
Expenditure	Management and Personnel	18	12	13
	Administration and Finance Bureau	16	15	13
	Procurement Bureau	4	3	3
	Technical Bureau (Maintenance)	19	17	17
	Sub-Total	57	47	46
Operating Profit		1,210	1,356	1,403
Other Expenditures and Project Cost		962	1,189	773
Profit		246	167	630

Source: MTI and FOMAV. Up to November for 2016

* IEFOMAV: Income from fuel tax allocated to FOMAV

C) COERCO-EICMEP: The annual maintenance cost of the three bridges (bridge structure) of the Project for COERCO-EICMEP is 480,000 Cordoba which was equivalent to some 16% of the income in FY 2015. In principle, COERCO-EICMEP receives its annual budget from the MTI based on the annual road and bridge maintenance plan and no major financial problems are envisaged in the near future.

Table 10 Income and Expenditure of the COERCO

(Unit: million Cordoba)

		2014	2015
Income	Road Maintenance	288	297
	Other Services, etc.	8	9
	Sub-Total	296	306
Expenditure	Road Maintenance	221	237
	Other Equipment Maintenance	50	50
	Management Cost	16	16
	Sub-Total	287	303
Operating Profit		10	3
Other Expenditure		(2)	(1)
Profit		8	2

Source: COERCO

In summary, while further improvement is necessary for the MTI to secure the budget for emergency repair work, the financial state of FOMAV which conducts the routine and periodic maintenance as well as that of COERCO-EICMEP which is responsible for the maintenance of the bridge structure is enough to fully meet the necessary maintenance cost.

3.5.4 Current Status of Operation and Maintenance[26, 27]

The state of the maintenance of all three bridges is good, partly because they are still only three years old and partly because of the adequate routine and periodic maintenance by the FOMAV and COERCO-EICMEP. As shown in Table 11, the inspection frequency does not necessarily meet what is proposed in the Preparatory Study Report, but the current maintenance method has not caused any major problems by the time of the ex-post evaluation.

Table 11 Contents and Frequency of Maintenance Work Proposed in the Preparatory Study Report and Actual Performance by the Responsible Organizations

	Proposed Contents and Frequency of Maintenance Work	FOMAV Actual Performance	COERCO-EICMEP Actual Performance
Routine maintenance	Maintenance of side ditches, paving, expansion joints and shoulders and cleaning of the bridge: 4 times/year for 2 days each time	• Cleaning of traffic signs and access roads: twice/year • Cleaning of shoulders, side ditches and pavements and weeding: 4 times/year for 2 days each time • Painting of handrails of the pavement: once/year • Relocation/erection of road traffic signs and bus stop signs: as needed	Not responsible
Periodic inspection	Periodic inspection of the bridge and access roads (cracking, uneven surface, defects, etc.): 12 times/year for 1 day each	• Periodic inspection of the access roads: 12 times/year	The concrete maintenance conducted between project completion and ex-post evaluation includes pressure cleaning of the bridges, repainting and maintenance of the road markings and road signs at irregular intervals.
Repair	Repair of the paving, side ditches, body, bridge facilities, shoulders and slopes: once/year for 4 days	Not responsible	Because of the relatively short time since commencement of the usage of the bridges and because of the generally adequate routine and periodic maintenance, no need for repair has arisen up to the ex-post evaluation.

Source: The micro companies entrusted to conduct the routine maintenance of the bridges and inspection of the access roads are required to submit a monthly maintenance report to FOMAV. Similarly, COERCO-EICMEP prepares a monthly maintenance record and submits it to MTI. The contents of this table are based on the reports prepared by these micro companies (cooperatives) for 2013 to 2016 and reports submitted by COERCO-EICMEP.

[26] For evaluation of the maintenance conditions at the three bridges as part of the ex-poste valuation, the Central American Manual for Risk Management of Bridges 2010 (Manual Centroamericano de Gestión del Riesgo en Puentes, 2010) was used.

[27] In the Reports for the Basic Design Study, Preparatory Study and Defect Inspection, the Consultant made four recommendations/proposals ((1) repair and reinforcement of the existing Tecolostote Bridge, (2) demolition and removal of the existing La Tonga Bridge, (3) rehabilitation of a bus stop shelter at Las Banderas Bridge and Tecolostote Bridge and (4) repair and reinforcement of the existing Cuisalá Bridge) to the MTI. The completion of all of these recommendations/proposals by the time of the ex-post evaluation has been confirmed by the evaluator.

The field visit for the ex-post evaluation did not find either any blocked side ditches of the access roads with rubbish or any damage of the various facilities mentioned by the Report for Defect Inspection in 2014. Las Banderas Bridge and Tecolostote Bridge are steel truss bridges that use atmospheric corrosion resistant steel[28], and they were already painted with a special high-resistance paint at the time they were installed. However, at the moment of the ex-post evaluation, the said paint was out of stock and there was no information on where to buy it, and this fact was pointed out by the executing agency as a shortcoming. [29] As for other materials and its spare parts that are necessary for maintenance, no special problems were found through interviews to FOMAV and COERCO, as well as on-site visits.

The state of maintenance at the time of ex-post evaluation and points for desirable future improvement are listed below.

Table 12 State of Maintenance at the Time of Ex-Post Evaluation and Points for Future Improvement

State of Maintenance and Points for Future Improvement
【Las Banderas Bridge】  • Generally in good condition. • Rust is observed in the steel girders, mounting members, nuts and bolts of the superstructure. After analysing the rust, if it is rust caused by corrosion, it is necessary to clean any dirt, maintain a dry condition, and take necessary measures to prevent further corrosion by procuring the special paint from Guatemala*. Some of the hydraulic cylinders connecting the superstructure and substructure have bird droppings stuck to the neoprene cover. These droppings should be removed during periodic maintenance. • Surface cracks are observed with the paving near the joints between the bridge and access road. While urgent repair is not required, it is desirable for the work to be included in the scope of periodic maintenance. • The superstructure of the bridge when going from Managua to La Tonga has graffiti done with a sharp blade as well as with paint. Special paint should be procured from Guatemala to repair the area to prevent any corrosion from these graffiti.

[28] Atmospheric corrosion resistant steel is a steel that forms a layer of fine “protective rust” in its surface when exposed repetitively to an adequate humidity in the air (Source: Japan Iron and Steel Federation). Normally it is used without applying any paint, however, taking into consideration its appearance, in the Project a special paint was applied beforehand and then installed. The said special paint is a resin paint that is used to stabilize the rust of the atmospheric corrosion resistant steel. It has the effect of controlling rusting at its initial stage, preventing rust to expand to the surrounding area.

[29] However, after the first field visit, provision of information by the consultant speeded up, and MTI had received information that this special paint could be procured in Guatemala.

- It is necessary to install lighting which existed before the Project for night-time security.

【Tecolostote Bridge】

- Generally in good condition.
- Superstructure: rust is observed with the vertical and horizontal girders, diagonal and mounting members, nuts and bolts. After analysing the rust, if it is rust caused by corrosion, it is necessary to clean any dirt, maintain a dry condition, and take necessary measures to prevent further corrosion by procuring the special paint from Guatemala*.
- As many drivers appear to urinate towards the steel abutment, erosion in this area is advancing more rapidly compared to that of other areas. As there is also bad smell, it is necessary to adopt certain measures, including regular cleaning and the installation of a signs.
- Surface cracks of the paving near the joints between the bridge and access roads are observed. While urgent repair is not required, it is desirable for the work to be included in the scope of periodic maintenance as necessary.

【La Tonga Bridge】

- Generally in good condition.
- Because of the absence of a steel structure in both the superstructure and substructure, the problem of rust does not occur thus the condition of the bridge is good.
- Many drivers appear to urinate at the concrete pier. In addition to regular cleaning, some measures, including the installation of signs, should be taken.
- It is necessary to install lighting which existed before the Project for night-time security.

* For Las Banderas Bridge and Tecolostote Bridge, the Report for Defect Inspection in 2014 already pointed out that "Although the two newly constructed bridges are steel girder bridges using atmospheric corrosion resistant steel, the good quality of the members cannot be maintained if they are in a wet condition for a long period of time. Therefore, it is necessary to clean rubbish and dirt stuck to the steel members during periodic maintenance to keep them dry." (Report for Defect Inspection, 2014).

Based on the above, it was possible to confirm that the maintenance status of the bridges of the Project are generally good. In order to prevent further corrosion caused by graffiti in Las Banderas Bridge, it is desirable to procure the special paint from Guatemala and take necessary measures. As for the rust seen in Las Banderas Bridge and Tecolostote Bridge, once an analysis of the rust is conducted, it is desirable to consider and implement necessary measures.

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

4. Conclusion, Recommendations and Lessons Learned

4.1 Conclusion

The Project was implemented for the purpose of securing safe and smooth traffic between Managua and El Rama on National Highway No. 7 which is an international trunk road passing through Nicaragua by means of rebuilding three bridges, thereby contributing to the vitalization of domestic and international logistics and also to the promotion of the local economy along the route. At the time of both planning and ex-post evaluation, the Project is fully consistent with the national development policies, the transport sector policies and development needs of Nicaragua and with Japan's ODA policies and, therefore, its relevance is high. The outputs are generally as planned, and both the total project cost and project period were within the plan, thus the efficiency of the Project is high. The assumed effects of the Project, namely, traffic congestion before the bridge, and time for cars to cross the bridge improved significantly. On the other hand, although considerable improvements can be recognized for the temporal stoppage before entering the bridge as well as the average travelling speed on the bridge, these have not been fully eliminated as originally planned, because speed reduction zones were introduced by the Nicaraguan government after the completion of the Project in order to ensure the safety of local residents crossing the road. In addition, the risk of bridge collapsing due to aging has been eliminated. The assumed impacts on the promotion of the local economy along the route and vitalization of domestic and international logistics are confirmed. As the implementation of the Project has generally produced the planned effects, the effectiveness and impacts of the Project are high. The institutional, technical and financial aspects of the entities that are in charge of the Project's operation and maintenance, that is the MTI, FOMAV and COERCO, as well as the current status of operation and maintenance of the Project are generally good and the sustainability of the effects of the Project is high.

In line of the above, the Project is highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations for the Executing Agency

- It is desirable for MTI to supervise the proper implementation of maintenance-related issues to be carried out by FOMAV which are listed in Table 12 "State of Maintenance and Points for Future Improvement". Especially regarding the rust seen in Las Banderas Bridge and Tecolostote Bridge, once an analysis of the rust is conducted, it is desirable to consider and implement necessary measures. As for the prevention of corrosion due to graffiti in Las Banderas Bridge, since there is a risk of further corrosion from these parts, it is desirable to incorporate the budget for the procurement of this special paint from Guatemala in the FY 2018 budget at the latest.

- MTI and FOMAV should consider the introduction of lighting for Las Banderas Bridge and La Tonga Bridge to strengthen traffic as well as pedestrian safety. It is desirable for the necessary funding to be incorporated in the FY 2018 budget at the latest to urgently deal with this matter.

- As already recommended by the Report for Defect Inspection, there is no proper procurement plan in place to meet the estimated cost of dealing with emergencies and large-scale repair work. Even though an application procedure for a special budget exists, because Nicaragua is a country especially with a lot of natural disasters such as hurricanes, MTI is indicating its interest to proceed with the preparations so that in two years' time it can secure the relevant budget. As a first step, it is desirable to estimate the said cost in advance.

- According to the Nicaraguan police, traffic accidents are a leading cause of death in the country and constitute a serious social problem. In connection with the Project, speed reduction zones were introduced to reduce the travelling speed at the bridges following a fatal accident which occurred approximately one year after project completion. The MTI should strengthen traffic education so that the expected effects of the improved road infrastructure can be fully achieved, and the safe use of roads and bridges can be secured. To be more precise, the MTI should urgently invite the cooperation of the Ministry of Education, Police, municipal governments, NGOs, and research institutions to implement the 14 actions listed in the *"Five Year Action Plan for Road Traffic Safety"* proposed by the "*Road Traffic Safety Program*" of the "*National Transport Plan for Nicaragua*" which is referred to in "3.1.1 Relevance: Consistency with the National Development Policies" so that continuous transport education designed to improve and reform the traffic safety awareness of the Nicaraguan people can be enhanced and thoroughly implemented.

4.2.2 Recommendations for JICA

It is desirable for JICA to periodically monitor the implementation situation of the maintenance work recommended in Sustainability (Table 12: State of Maintenance and Points for Future Improvement), and to provide the necessary advice in order to secure the sustainability of the project effects.

4.3 Lessons Learned

Verification of the role of the bridge for the nearby community, and setting the target values for the effect indicators at the time of planning

In the Project, the target values for the effect indicators were set based on the standards for an international trunk road as the focus of the Project was to make the bridges perform their

functions as part of such a trunk road. However, due to the accident that occurred after Project completion, speed reduction zones were installed on both sides of each bridge. Because of this, one principal effect indicator could not achieve 80% of the target value. In Nicaragua, the legal speed limit for a national highway such as the one where the Project is located is 80 km/hour. However, when a bridge is located in a mid-size city such as Tipitapa, San Lorenzo or Juigalpa which expand to both sides of National Highway No. 7, as well as on both sides of the respective rivers, as in the case of the Project, the bridge is used not only by vehicles but also by pedestrians. Especially local residents routinely cross both the bridge and the national highway many times a day, which have become part of their lives. As the existence of a local community near each bridge and inadequate traffic manners were known at the time of planning, the planning of the Project in general and setting of indicators in particular should have taken them into consideration. For a similar project in the future, it is desirable to check (1) the existence of a community near the target bridge, and (2) the entrenchment of a culture among drivers and local residents to adhere to traffic manners. When a bridge and national highway on which a bridge is located form an integral part of the local life, advance consultation with the implementing agency should be held with a view to incorporating such items in the project plan as a pedestrian bridge, or speed reduction zones with a design which minimizes adverse impact on the vehicles. At the same time, it is desirable to discuss with the executing agency awareness-rising measures to be incorporated in the Project that point to the strengthening and thorough implementation of traffic safety and traffic manner education.

Assessment on possible procurement and selection of necessary paint, equipment and its spare parts for bridge maintenance in the domestic or regional market at the time of planning

The paint used in the Project was a highly durable paint designed to minimize the routine maintenance requirements and prevent corrosion. It was later found that this paint cannot be procured in the inside Nicaragua. At the time of ex-post evaluation, there was no stock of this paint, making maintenance work to prevent corrosion impossible especially at the Las Banderas Bridge that have graffiti by both paint and by a sharp object. During the ex-post evaluation, it was confirmed that the same special paint could be procured in Guatemala, however, for similar projects, it is essential to confirm the availability of any necessary paint and spare parts for equipment for bridge maintenance in the domestic market or regional market and to provide this information with the executing agency to secure the sustainability of the project effects.

END

Republic of Paraguay

FY 2016 External Ex-Post Evaluation of Japanese Grant Aid Project

"The Project for the Improvement of Water Supply System in Concepcion and Pilar Cities"

External Evaluator: Hiromi Suzuki S., IC Net Limited

0 Summary

The Project for the Improvement of Water Supply System in Concepcion and Pilar Cities (hereinafter referred to as "the Project") was implemented for the purpose of improving the quality of waterworks, increasing the water supply volume and improving access to safe water for residents of the cities of Concepcion and Pilar in Paraguay by means of rehabilitating the water intake facilities and constructing water treatment plants in these two cities, thereby contributing to improvement of the living environment and reduction of the morbidity of water-borne diseases. The Project is highly consistent with Paraguay's national development policies as well as Paraguay's development needs and Japan's ODA policies. Although the project period was within the planned period, the project cost exceeded the planned cost due to an increase of the Paraguay portion of the project cost. Therefore, the efficiency of the Project is fair. The construction of new intake and water treatment facilities in both cities led to an increased water production volume and water distribution volume, boosting the size of the population served by the water supply service together with an expanded service area of the Paraguay Sanitation Service Corporation (Empresa de Servicios Sanitarios del Paraguay S.A.: ESSAP) in both cities. In Pilar, however, the target water production volume could not be reached as water demand did not increase as expected. This was because some large consumers withdrew their investments, and new ones could not be attracted due to the delay in the urban development plan which existed already at the time of the Preparatory Study. Meanwhile, the water quality targets (turbidity and color) were achieved at both water treatment plants. In both cities, the immediate use of tap water for drinking became easier due to improvement of the water quality and establishment of a stable water supply without water cuts which has reduced the water-related cost, contributing to improvement of the living environment. Meanwhile, no significant change can be observed regarding the frequency of water-borne diseases because the project areas experienced only a relatively low morbidity of water-borne diseases to start with. The overall picture is that the Project did produce the planned effects and its effectiveness and impact are high. Regarding operation and maintenance, the decision-making process and authority are concentrated at the ESSAP Headquarters and the support system of the Headquarters to individual water treatment plants is not completely satisfactory. The facts that most of the people who received training under the technical assistance (hereinafter referred to as 'soft component') of this Project have now left ESSAP and that ESSAP does not have a firmly established human resources development program cause concern regarding the technical aspects of operation and maintenance. There are no issues regarding the

financial aspect of the operation and maintenance. Therefore, the sustainability of the effects that were brought about by the Project is fair.

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

1 Project Description

Project Locations

Concepcion Water Treatment Plant: Chemical Sedimentation Tank

1.1 Background[1]

The water supply coverage in Paraguay in 2007 was estimated to be 79.3% in urban areas and 38.2% in rural areas. Even though the situation had been gradually improving, the quality of the water supply service greatly differed from one city to another. In many cities, safe water for drinking was not supplied as less than 24% of the water supply utilities[2] were able to supply water which met the national water quality standards for drinking in Paraguay.

Of the two target cities of the Project, Concepcion, a central city of Concepcion Department, is located some 543 km north of Asunción, the capital, and has long developed as a strategic site for transport on the Paraguay River. Meanwhile, the city of Pilar is located some 385 km southwest of Asunción and is on the border with Argentina lying on the other side of the Paraguay River. It is an important site for logistics in southern Paraguay as it has a port capable of serving large ships. Although both cities played an important role as local cities along the Paraguay River, they suffered from the insufficient development of infrastructure, especially water supply and sewerage infrastructure. Both cities had a water treatment plant (hereinafter referred to as WTP) constructed in 1979. While these WTPs were still in operation at the time of the planning for the Project, the water treatment system in use was a simple system relying on direct filtration whereby the process of settling suspended solids in the water for removal was lacking. The existing system was incapable of adequately treating raw water from the Paraguay River which is characterized by a high level of turbidity and color. Moreover, the entire water supply facilities were highly deteriorated. With an increase of the water demand due to population growth, both WTPs had

[1] Based on the report for the Preparatory Study.
[2] With regard to water supply and sewerage services in Paraguay, the urban water supply service in cities with a population of 10,000 or more is under the jurisdiction of ESSAP.

been operating beyond their normal treatment capacity. As such, the water supply service in these cities was run at a risk in terms of stable supply as well as safety of the supplied water.

Under these circumstances, the Government of Paraguay made a request to the Government of Japan in 2007 for grant aid for the construction and rehabilitation of water treatment facilities and distribution pipelines in the cities of Concepcion and Pilar.

1.2 Project Outline

The purpose of the Project was to improve the quality of water, to increase the amount of water supply and to improve the access to safe water for residents of the cities of Concepcion and Pilar in Paraguay by means of rehabilitating the water intake facilities and constructing water treatment plants, thereby contributing to improvement of the living environment and reduction of the morbidity of water-borne diseases in these cities.

Concepcion Water Treatment Plant

Pilar Water Treatment Plant

E/N Grant Limit/Actual Grant Amount	1,489 million yen/1,489 million yen
Exchange of Notes Date/ Grant Agreement Date	August 2011/August 2011
Executing Agency	Ministry of Public Works and Communications (Ministerio de Obras Publicas y Comunicaciones: MOPC)
Project Completion	September 2013
Main Contractor	Hazama Ando Corporation
Main Consultant	Kyowa Engineering Consultants Co., Ltd.
Basic Design	February 2011-March 2012
Related Projects	[Technical Cooperation] The Project for Capacity Development of Distribution Network Management of ESSAP (March 2011-February 2014) [Grant Aid] The Project for Development of Groundwater for Drinking in Rural Areas (January 2009-February 2012); The Project for Improvement of the Drinking Water System for Coronel Oviedo City (September 2014-December 2018)

	[Other Projects] Strengthening the Management Technology of the Water Distribution Network (2010-2015); Water and Sanitation Sector Modernization Project (April 2009-September 2017)

2 Outline of the Evaluation Study

2.1 External Evaluator

Hiromi Suzuki S. (IC Net Limited)

2.2 Duration of Evaluation Study

The ex-post evaluation study was conducted with the following schedule.

Duration of the Study: October 2016 to February 2018

Duration of the Field Survey: 2nd to 23rd March and 30th July to 4th August 2017

3 Results of Evaluation (Overall Rating: B[3])

3.1 Relevance (Rating: ③[4])

3.1.1 Consistency with the Development Policies of Paraguay[5]

At the time of planning, *the Strategic Economic and Social Plan 2008-2013* which represented the national development policy of Paraguay at the time emphasized economic development and aimed at increasing competition with the participation of the civil society and private sector and at improving the living environment as well as the reducing poverty through the continuous creation of employment. *The Public Policy for Social Development: Paraguay for All the People 2010-2020* formulated to supplement the social aspect of the above Strategic Plan lists four goals to be achieved by 2020 and the Project was highly relevant to one of these goals, namely, "improvement of the quality of people's lives". Meanwhile, *the Poverty Gap Reduction Plan* (formulated by the Economic Planning Agency in 2004) adopted the target of increasing the water supply coverage from 60.8% in 2004 to 80.5% by 2015.

The national development policy of Paraguay at the time of ex-post evaluation is the *National Development Plan* 2014-2030. This Plan has three pillars. The first pillar which is "reduction of poverty and social development" includes the goal of increasing the water supply coverage of 64% and sewerage coverage of 11% in 2014 to 100% by 2030. As the improvement of infrastructure in the water supply and sanitation sector is a theme involving multiple ministries, there is no sectoral policy as was the case at the time of planning the Project and the relevant matters are included in the plans of the Ministry of Health and the Environment Agency. For example, the *National Poverty Reduction Program* formulated based on the national development

[3] A: Highly satisfactory; B: Satisfactory; C: Partially satisfactory; D: Unsatisfactory

[4] ①: Low; ②: Fair; ③: High

[5] Sources: Ex-ante evaluation sheet for the Project, *Japan's ODA Data for Paraguay* 2010 and 2011, Report on the Presidential Address in 2016 and Website for the National Poverty Reduction Program (NPRP).

policy includes the development of water supply as part of the improvement of the living and sanitation environments of the poor.[6]

Based on the above, the Project is highly consistent with the national development policies of Paraguay at the time of both planning and ex-post evaluation.

3.1.2 Consistency with the Development Needs of Paraguay[7]

At the time of planning, 23% of the people of Paraguay did not have access to safe water (2011). The water supply facilities in Concepcion and Pilar, the target cities of the Project, were constructed in 1979 and despite their advanced stage of deterioration, were operating above their nominal treatment capacity to meet an increasing water demand due to population growth. Based on the treatment capacity at the time, it was estimated that Concepcion and Pilar would face a water supply shortage of some 2,700 m^3/day and 1,500 m^3/day respectively by 2014. The water treatment facilities in other cities in Paraguay were using the rapid filtration system. Concepcion and Pilar were exceptions as they were using the upward and downward counter-flow filtration system[8] and this system was not fully capable of dealing with the high level of turbidity and color of the raw water from the Paraguay River. The daily average turbidity of the treated water in these two cities was 5.5 NTU[9] (maximum of 11.4 NTU) in Concepcion and 5.0 NTU (maximum of 10.0 NTU) in Pilar which was much higher than the quality standard for drinking water of a daily average value of 1.0 NTU in Paraguay. The color was also high at a maximum of 20, far exceeding the standard value of 5. Apart from a problem of the water supply volume, a problem of the water quality in these cities was highlighted by a number of people suffering from water-borne diseases. Moreover, the WTPs in both cities faced such technical problems as a lack of manuals for plant operation and failure to inject the correct amount of chemicals to match the fluctuations of the turbidity and color of the raw water.

According to data (for 2015) obtainable at the time of ex-post evaluation, the proportion of the population with no access to safe water was 15% which was an improvement from the time of planning. The ratio of population connected to the public water supply network increased from 64% to 73% as a result of progress of the development of water supply infrastructure in the period from 2014 to 2016.[10] The water supply coverage in Concepcion and Pilar, the target cities of the

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6 The contents of both *the Public Policy for Social Development 2010-2020: Paraguay for All the People* and *Poverty Gap Reduction Plan* at the time of planning have been integrated and rearranged in the *National Development Plan 2014-2030*.

7 The ex-ante evaluation sheet for the Project and *Japan's ODA Data for Paraguay 2010* are used to analyse this consistency related to the time of planning and the *National Development Policy* and materials provided by the MOPC are used to analyse this consistency related to the time of ex-post evaluation.

8 The upward and downward counter-flow filtration system feeds raw water at the middle of the filtration layer to facilitate filtration in two filtration channels (upward and downward). (Source: Japan Water Works Association).

9 NTU stands for Nephelometric Turbidity Unit which is used for the measurement of turbidity using the turbidity caused by formazin as the reference value. 1 NTU is defined as the turbidity caused by the dissolution of 1 mg of formazin in 1 litre of distilled water. (Source: Public Works Research Center).

10 Regulatory Body for Sanitation Services (Ente Regulador de Servicios Sanitarios: ERSSAN).

Project, increased to 72% and 79% respectively as a result of the implementation of the Project and the daily average turbidity value also improved to 0.2 NTU and 0.1 NTU respectively. The color improved to 3 in both cities, clearing Paraguay's water quality standard for drinking water. The construction of WTPs under the Project has contributed to such improvement, illustrating the important role played by the Project even after its completion. There is still a need for the continuous development of the water supply and sewerage infrastructure in other cities and rural areas. There is also a need for the further improvement of infrastructure and technologies as the state of maintenance, water quality, service quality, etc. widely vary from one city to another even in those local cities where water supply and sewerage infrastructure is in place.

Based on the above, the Project is highly consistent with the development needs of Paraguay in general and those of Concepcion and Pilar in particular at the time of both planning and ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy[11]

In regard to the Japanese ODA policy for Paraguay, the Economic Cooperation Policy Consultation for Paraguay in FY 2010 was held in July 2010 by the Field ODA Task Force taking the *National Development Plan* and development themes into consideration and it was agreed through such consultation that Japan would provide cooperation for three priority areas: (1) measures to combat poverty (consolidation of social services and livelihood improvement for the poor), (2) sustainable economic development (promotion of industries, consolidation of economic and social infrastructure and introduction of environmental measures) and (3) strengthening of governance. The Project was considered to particularly contribute to "sustainable economic development". As such, the Project is highly consistent with Japan's ODA policies.

Based on the above, this Project is highly relevant to Paraguay's development plan as well as Paraguay's development needs and Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

Under the Project, a new water treatment facility using the rapid sand filtration system was constructed on the premises of the existing WTP in addition to the construction/renewal of the intake facility in both cities at the expense of the Japanese side. Moreover, training on the operation and maintenance of WTPs was conducted as the soft component of the Project. Meanwhile, the Paraguay side paid for the auxiliary work for the two WTPs, construction of a distribution reservoir in Concepcion and renewal of the transmission pipeline in Pilar.

[11] Based on the ex-ante evaluation sheet for the Project and *Japan's ODA Data for Paraguay* 2010.

The planned contents and actual results of the infrastructure development, including WTPs, and soft component of the Project for which the Japanese side was responsible are shown in Table 1 and Table 2.

(1) Infrastructure development: Although minor changes, including those of the structure, shape, etc., of some facilities and the location of the staircase, were made for both WTPs, there was no impact on the project cost or project period. The two principal changes are described below.

- At the Concepcion WTP, following confirmation that the site boundary could be changed, the locations of the distribution reservoir, rapid filtration tank and pump room were moved southward by approximately 6 m.
- Because of the delayed loading of the reinforcing bars dispatched from Japan to a smaller vessel in Argentina at the stage of the foundation works for the WTPs, some of the reinforcing bars for the main structural bodies of the WTPs (flocculator, sedimentation tank, rapid filtration tank, distribution reservoir and pump room) were replaced by those which could be locally procured. This meant the mixed use of reinforcing bars made in Japan and those locally procured with different diameters and it was necessary to change the bar arrangement (narrowing of the interval to secure the required quantity of reinforcing bars or alternate use of two different reinforcing bars).

(2) Soft component: Guidance on water treatment technologies was provided through lectures and practice, targeting the managers of local ESSAP branches, head of each WTP and operators of the WTPs (Table 2). The actual results were similar to those planned. Evaluation of the degree of achievement of the technical assistance concluded that the intended results were achieved almost as planned (see 3.5.2 Technical Aspects of Operation and Maintenance for further details).

Table 1 Japanese Outputs: Planned Facilities and Actual Results

Item	Original Plan		Actual
	Concepcion	Pilar	
I. Intake Facilities			
1. Design Water Intake Volume	10,760 m^3/day (125L/sec.)	8,200 m^3 /day (95L/sec.)	As planned at both WTPs
2. Rehabilitation of the slab for the pump	Concrete base for pumps (existing water intake facilities will be used)		
3. Renovation of pump	3 vertical shaft type mixed flow pumps (one unit as a spare)		
	Q=3.70m^3/min. H=16m	Q=2.85m^3/min. H=16m	
4. Renovation of control and electrical panel	New (with interlock)		
5. Renovation of conduction pipes and internal pipes	Pipes around the pump (existing footbridges will be used)		
	Conduction pipe of Φ300, L=Approx. 150m	-	
II. Water Treatment Facilities			
1. Receiving well	Dwelling time 1.5 min.		As planned at both WTPs
2. Stirrer for rapid mixing of chemical products	Parshall Flume Injection and hydraulic jump parts		
3. Flocculator	3 phases ,2 horizontal flow flocculation tanks		
4. Horizontal Flow Sedimentation tank	L38m×W6.7m×2 tanks	L34m×W6.0m×2 tanks	
	Installation of channel for overflow, effective depth of 4m		
5. Rapid filtration tank	L6.3m×W3.8m×4 tanks	L5.5m×W3.4m×4 tanks	
	Sand layer thickness 70cm		
6. Back wash pump	2 volute type mixed flow pumps (one unit as a spare)		
	Q=19.12m^3/min. H=8m	Q=14.72m^3/min. H=8m	
7. Surface wash pump	2 centrifugal pumps of horizontal axis single suction (one unit as a spare)		
	Q=4.07m^3/min. H=15m	Q=2.76m^3/min. H=15m	
8. Clean water management tank	L7.4m×W0.9m 1 tank Used also as dosage tank		
9. Reservoir	W5.0m×L27.8m×2 tanks	W9.0m×L20.0m×2 tanks	Only at Concepcion WTP, the reservoir was moved approx. 6 m to the south
	Used also for clean water cannel Effective depth 3.6m		
10. Conveying pump	3 centrifugal pumps with horizontal axis single suction (one as reserve)		As planned at both WTPs
	Q=3.4m^3/min. H=67m	Q=2.15m^3/min. H=45m	
11. Pump for works inside the plant	Lifting pump of standard pressure with direct connection (independent alternative/automatic operation) Q=0.3m^3/min. H=20m		
12. Aluminium sulphate injector	Control room, dosing pump equipment		
13. Coal injector	Control room, dosing pump equipment		
14. Chlorine injector	Control room, dosing pump equipment, alarm system for detection of chlorine gas		
15. Measuring equipment	Raw water volume meter Parshall Flume		
	Filtered water volume meter Channel with rectangular plate of total width dam		
	Dispatched water volume meter Electromagnetic flow meter		
	Back wash water volume meter Flow meter by pressure difference with orifice plate		
	Water level meter inside the tanks with pump interlock function. Installed in the reservoir		
16. Sewer pipes inside the plant	Φ700mm L=Approx.235m	Φ600mm L=Approx. 64m	
	Concrete sewer pipes		

Source: Documents provided by JICA.

Table 2 Japanese Side Outputs:

Planned and Actual Outputs of Technical Guidance as Soft Component

Item	Planned	Actual
Target Persons	Managers of local ESSAP branches; heads of WTPs; WTP operators	• Concepcion WTP: 30 (including 3 from the MOPC) • Pilar WTP: 28 (including 2 from the MOPC) • Total: 58
Lecture Contents	• Theories: Characteristics of the quality of water from the Paraguay River; simplified hydrology at a WTP; theory of coagulation and flocculation and the jar test; mastering of proper knowledge concerning water treatment processes (sedimentation and filtration) and operation of a WTP (efficiency); understanding of an operation and maintenance manual; safety management (especially handling of chlorine gas and electrical equipment); method to adjust the quality of treated water; reduction of the operating cost and maintenance cost; understanding of a manual for routine maintenance. • Field activities: Accidents and safety at a WTP; operation and maintenance of a WTP	As planned
Results	WTP operation and maintenance manual; lecture and practice materials; completion report	As planned

Source: JICA for the planned contents. The actual number of participants is based on the attendance records kept by the MOPC.

The planned outputs for which the Paraguay side was responsible involved seven types of work, i.e. (1) WTP ground levelling, (2) construction of an access road at the Pilar WTP site, (3) power supply extension work to the WTP site, (4) fencing and other exterior work, (5) construction of a distribution reservoir in Concepcion, (6) renewal of the transmission pipeline in Pilar and (7) other (opening of a bank account and payment of the administrative cost, taxes and customs and import duties on equipment and materials and commissions). These outputs were achieved as planned.

In addition, ESSAP conducted the following work at its own expense after the completion of the Project to secure the stable operation of the two WTPs.

- Construction of a revetment on both sides of the intake tower in Pilar: Work to protect the river banks using gabions was conducted to ensure the safety of the conduction pipes from the intake tower to maintain stable water intake operation in the face of more than anticipated bank erosion.
- Installation of a private power generator at each WTP: A private power generator was installed at each WTP (300 KVA at the Concepcion WTP and 200 KVA at the Pilar

Private power generator at Pilar Water Treatment Plant

WTP) in 2015 as the unstable power supply in Paraguay meant a series of power cuts which caused cutting off of the water supply in the early days of the operation of the new WTPs.

As described above, the planned outputs of both countries were generally achieved without any major changes.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The planned total project cost at the time of planning was 1,546 million yen (Japanese portion of 1,489 million yen and Paraguay portion of 57 million yen). The actual total project cost was 1,571 million yen (Japanese portion of 1,487 million yen and Paraguay portion of 83 million yen), exceeding the planned total project cost by 2%.

Table 3 Planned and Actual Project Cost*

(Unit: thousand yen)

Item	Planned (Ex-Ante Evaluation)	Actual
【Japanese Portion】		
I. Construction Cost	**1,353,600**	**1,350,000**
1. Direct cost	-	935,800
2. Costs of common temporal facilities, supervision, general and administration	-	414,200
II. Design and Supervision Cost	**136,000**	**137,612**
1. Detailed design and work supervision cost	130,000	130,860
2. Soft component	6,000	6,752
Sub-total	**1,489,000****	**1,487,612**
【Paraguay Portion】		
1. WTP ground levelling	1,123	485
2. Construction of an access road at Pilar WTP site	2,724	8,671
3. Power supply extension work to the WTP site	470	330
4. Fencing and other exterior work	800	5,003
5. Construction of a distribution reservoir in Concepcion	20,429	38,310
6. Renewal of the transmission pipeline in Pilar	30,000	29,079
7. Other (Commissions, etc.)	1,520	1,532
Sub-total	**57,066**	**83,410**
Total	**1,546,066**	**1,571,002**

Source: JICA for the Japanese portion. JICA for the planned Paraguay portion and the MOPC and ESSAP for the actual results for the Paraguay portion.

*Estimating conditions at the time of planning (November 2011): Exchange rates: US$1=79.04 yen, Gs1=0.02 yen, at the time of ex-post evaluation: The average rate from 2011 to 2013 (Exchange rate of OANDA is used due to the absence of the IMF data) Gs1=0.019391 yen

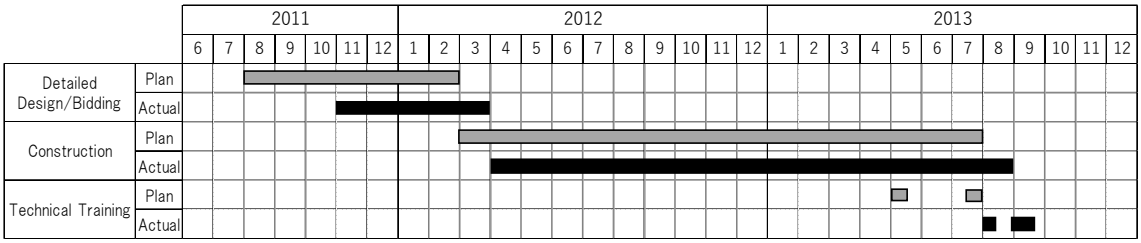
**The figures are based on JICA documents, but the figure for Sub-total is rounded up and does not coincide with the total of the above breakdown figures.

Although the Japanese portion of the project cost was within the planned cost, the Paraguay portion of the project cost ended at 146% of the planned cost. According to ESSAP, the reason for this cost over-run may have been under-estimation of the cost at the time of planning because

cost estimation at the time was not based on a detailed study.[12]

3.2.2.2 Project Period

The planned project period was from August 2011 to July 2013 (24 months). The actual project period was from November 2011 to September 2013 (23 months) which was 96% of the planned period.[13]



Source: JICA for the planned period; JICA and the MOPC for the actual period.

Fig. 1 Planned and Actual Project Periods

Because the detailed design and commencement of the tender were delayed by three months, project completion was delayed by two months. However, the actual project period was within the planned project period.

Although the project period was within the plan, the project cost was exceeded. Therefore, efficiency of the Project is fair.

3.3 Effectiveness[14] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

The Project aimed at "supplying safe water in Concepcion and Pilar". At the time of planning, four main indicators for the operation and effects were set: (1) population served, (2) production

[12] With respect to Paraguay's portion at the time of planning, a detailed analysis such as whether there was an underestimation or not, was not possible, as ESSAP has not kept the information on the quantities and unit costs of the items.

[13] On the ex-ante evaluation sheet, the project period was set at 24 months. Checking of the work schedule in the report for the Preparatory Study found that the above period did not include the time from the G/A to D/D. Because according to the "Evaluation Reference" it is necessary to compare the planned period to the actual period based on the same conditions, the planned project period here was from August 2011 when the detailed design commenced instead of the date of signing of the G/A to the completion of the Project. The completion of the Project is defined as the commissioning of the planned WTPs or completion of the soft component. Of the seven outputs to be achieved by the Paraguay side, the construction of a distribution reservoir in Concepcion was completed in December 2014 while the other outputs were completed by November 2014. Because this construction of a distribution reservoir was an extension to an existing facility, the delay did not hinder the opening of the WTP. Accordingly, the delay of the Paraguay outputs is not taken into consideration by this ex-post evaluation as far as the project period is concerned.

[14] The effectiveness is rated in consideration of not only the effects but also the impacts.

volume of the WTP, (3) average distribution volume and (4) quality of the treated water (color and turbidity) (Table 4). In this ex-post evaluation, four auxiliary indicators are added: (5) quality of the treated water (key items other than color and turbidity), (6) water supply time, (7) plant operation rate (production volume ÷ production capacity) and (8) unaccounted for water (Table 5).

(1) Main Operation/Effect Indicators

The target for (1) population served was achieved in both cities as the service area of ESSAP was expanded. Although expansion of the service area was the result of another project implemented by ESSAP, it is safe to say that the increased treatment capacity (supply capacity) as a result of the Project made such expansion possible. Both (2) production volume of the WTP and (3) average distribution volume increased in both cities. While both targets were achieved in Concepcion, the target achievement rate in Pilar was 79% for (2) production volume of the WTP and 84% for (3) average distribution volume. In order to find the reasons for the targets in Pilar not achieving 100%, the contents of the Preparatory Study were analysed in detail in collaboration with ESSAP and it was found that the urban development plan which was used in order to estimate the water demand, consisted of a plan to expand the residential area, and a plan to attract new large consumers. The former proceeded more or less as planned, thus the target of the population served could be achieved. However, the latter did not proceed as planned, and in addition to that, some large consumers withdrew their investment seeing that the urban development plan was experiencing a substantial delay in its implementation. The fact that the number of large consumers, whose water demand per consumer is big, and accounted for a considerable part of the water demand estimation did not grow, resulted in the overall amount of water demand not achieving the levels of that were originally estimated, which in turn led to the failure to achieve the target for the (2) production volume of the WTP. However, at the time of ex-post evaluation, the implementation of this urban development plan by the Pilar municipal government is making progress to the point that further growth in number of customers, an increase of the water production volume and increase of the water distribution volume can be expected to take place in 2018 and thereafter.[15]

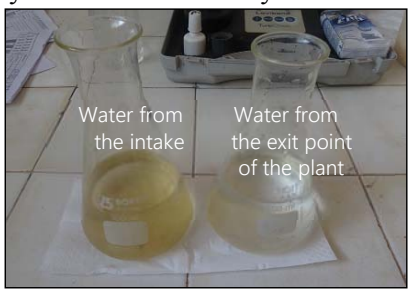
[15] At the time of ex-post evaluation, Phase I (2015-2025) of the Pilar Municipal Water Supply System Master Plan which is part of an urban development plan formulated by the Pilar municipal government is in progress. According to this Master Plan, the infrastructure development for water supply in Pilar will increase the average daily water demand to 13,337 m^3 by 2025. One immediate outcome of the Master Plan will be the construction of a new distribution network to enable water supply to some 600 households in the San Jose, San Vicente and San Juan Pablo Districts in Pilar by the end of FY 2017. These new connections will increase not only the water demand but also the water production and distribution volumes to enable achievement of the water production and distribution targets of the Project.

Table 4 Main Indicators for Project Effects: Degree of Target Achievement

Indicator		Reference Value Year of Project Planning 2010)	Target to be achieved three years after Project completion (2016)	Actual	
				Three years after Project completion (2016)	Degree of target achievement
(1) Population served (persons)*					
Concepcion		26,565	29,685	34,150	115%
Pilar		22,492	25,672	33,840	132%
(2) Production volume of the WTP**(m^3/day)					
Concepcion		6,346	8,906	9,080	102%
Pilar		4,404	6,434	5,067	79%
(3) Average volume distributed to ESSAP service area**(m^3/day)					
Concepcion		5,897	8,096	8,835	109%
Pilar		3,652	5,849	4,889	84%
(4) Quality of treated water (Recommended standard water quality in Paraguay)					
Concepcion	Color (grade)	35 (Maximum)	≤ 5 (constant)	3 (constant)	100%
	Turbidity (NTU)	11.3 (Maximum)	≤ 1 (constant)	0.1-0.4	100%
Pilar	Color (grade)	20 (Maximum)	≤ 5 (constant)	3 (constant)	100%
	Turbidity (NTU)	24(Maximum)	≤ 1 (constant)	0.1-0.4	100%

Source: JICA for the reference values and target values. ESSAP for the actual values.
* Coverage (population served÷population targeted) is 60% for Concepcion and 71% in Pilar in 2016.
** As the detailed check of the planned values in the ex-ante comparison table discovered that the values used were those for 2019 in the report for the Preparatory Study, they were corrected for 2016 values. The water production volume at a WTP is not the same as the water supply volume as 10% of the produced water is assumed to be used for the WTP operation, including the washing of the filtration tank.

The target for (4) quality of the treated water (color and turbidity) was achieved at both WTPs where the recommended standard water quality in Paraguay has been constantly met. Water quality data for the Paraguay River (source of raw water) for 2016 shows a maximum color value of 100 to 120 in the dry season (April to November) and 120 to 140 in the wet season (December to March) but the color of the treated water is constantly 3. Similarly, the turbidity of the raw water widely fluctuates between 9.6 NTU and 75 NTU irrespective of season while the turbidity of the treated water by the WTP is stable at 0.1 to 0.4 NTU.



Concepcion Water Treatment Plant: Water from the intake and the exit point of the plant

(2) Auxiliary Operation/Effect Indicators

At both WTPs, (5) quality of the treated water (total coliform count, residual chlorine[16],

[16] The concentration of residual chloride is checked every hour at the WTP while others are checked, tested and recorded once every two weeks using samples collected by the Quality Control Section of ESSAP Asunción Metropolitan Area Branch. Although inspection of the total coliform count, manganese and total iron does not follow the recommended frequency (once a day) of the quality standards for drinking water in Paraguay, the

manganese and total iron) meets the relevant national standard. The water quality standard for the concentration of residual chloride is that of the distribution network. In Pilar, water quality data from six monitoring points for the distribution network shows a concentration range of between 1.0 mg/L and 1.8 mg/L which meets the relevant standard. The concentration value of 2.5-2.7 mg/L at the outlet of the WTP is acceptable.

Table 5 Auxiliary Indicators for Project Effects: Degree of Target Achievement

Indicator		Reference Value (2010)	Target to be achieved three years after Project completion (2016)	Actual	
				Three years after Project completion (2016)	Degree of target achievement
(5) Quality of treated water (Recommended standard water quality in Paraguay) *					
Concepcion	Total coliform count (MPN)	0	0 (constant)	0 (constant)	100%
	Concentration of residual chloride (mg/L)	2.4	0.2-2.0 (constant within the distribution network)	1.0-1.5	100%
	Manganese (mg/L)	<0.05	≤30 (constant)	Not detected	100%
	Total iron (mg/L)	0.2	0.3 (constant)	0.075 (average)	100%
Pilar	Total coliform count (MPN)	0	0 (constant)	0 (constant)	100%
	Concentration of residual chloride (mg/L)	2.1	0.2-2.0 (constant within the distribution network)	2.5-2.7	100%
	Manganese (mg/L)	<0.05	≤30 (constant)	0 (constant)	100%
	Total iron (mg/L)	0.2	0.3 (constant)	0.092 (average)	100%
(6) Water supply time (hours/day) *					
Concepcion		About 24 hours	24 hours	Approx. 24 hours	Almost achieved
Pilar		About 24 hours	24 hours	Approx. 24 hours	Almost achieved
(7) Plant operation rate (%) (production volume ÷production capacity) *					
Concepcion		NA	—	84%	—
Pilar		NA	—	62%	—
(8) Unaccounted-for water (%)					
Concepcion		40%	—	39%	
Pilar		21%	—	21%	

Source: JICA for the reference values and target values. ESSAP for the actual values.
*: Because of the lack of accurate data to use as the reference values, findings of the social conditions survey conducted as part of the Preparatory Study were used. According to this study, 24 hour water supply operation was basically in place and there was no planned supply cut in either the rainy season or the dry season in principle. Irregular supply cut due to power cut, etc. did occur 2 to 4 times a month in both cities.
MPN: the most probable number in 100 ml of sampled water.

In the case of (6) water supply time, even though some water supply cut-off incidents occurred after the commissioning of the WTPs due to a power cut, 24-hour water supply has been maintained since 2015 when ESSAP installed a power generator for emergency use at both WTPs.[17] The plant operation rate is determined by the ratio of the production volume to the

ERSSAN which is the regulatory body for water supply and sewerage services in Paraguay and which supervises the water quality control and other operations of water supply service providers approves the present inspection regime.

[17] Efforts were made to obtain data to determine the plant utilization rate (annual operating hours ÷ 8,760 hours x

production capacity of the WTP and ESSAP considers a ratio of 80% or higher to be adequate. The actual figure for the Concepcion WTP is 84% but that for the Pilar WTP is as low as 62%. The reason for this is as described earlier. Due to the substantial delay of the implementation of the urban development plan of the Pilar municipal government, the water demand growth by large consumers could not be expected, resulting in the sluggish performance of the water production volume. In the case of (8) unaccounted for water, the figure for Concepcion slightly improved from the reference value of 40% to 39%. In Pilar, both the reference value in 2010 and the actual figure in 2016 were 21%, showing no specific change. It must be noted that this indicator is used for reference as the Project was not designed to improve unaccounted for water.

3.3.2 Qualitative Effects (Other Effects)

The qualitative effects of the Project assumed at the time of planning were (1) reduction of the morbidity of water-borne diseases, including diarrhoea, due to improvement of the water quality and (2) accumulation of accurate knowledge of the treated water and improved WTP operation and maintenance skills through technical guidance on WTP operation and maintenance technologies under the soft component of the Project. The actual performance regarding (1) is analysed in 3.4.1 Intended Impacts while that regarding (2) is analysed in 3.5.2 Technical Aspects of Operation and Maintenance.

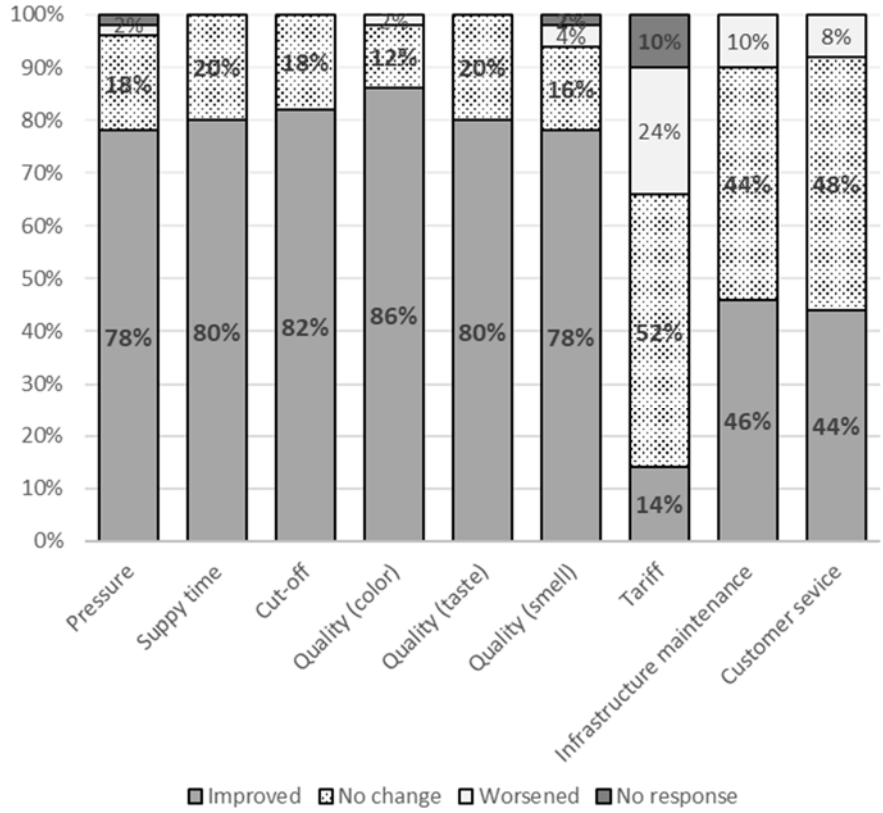
In summary, the Project led to the increased production of safe water in both cities while increasing the population served, distribution volume and water supply time. In Concepcion, all the indicators achieved their respective targets. In Pilar, the water production volume and water distribution volume achieved some 80% of their respective targets and this achievement rate is expected to increase in the near future. All the other indicators achieved their respective targets. Therefore, the effectiveness of the Project is judged to be high.

3.4 Impacts

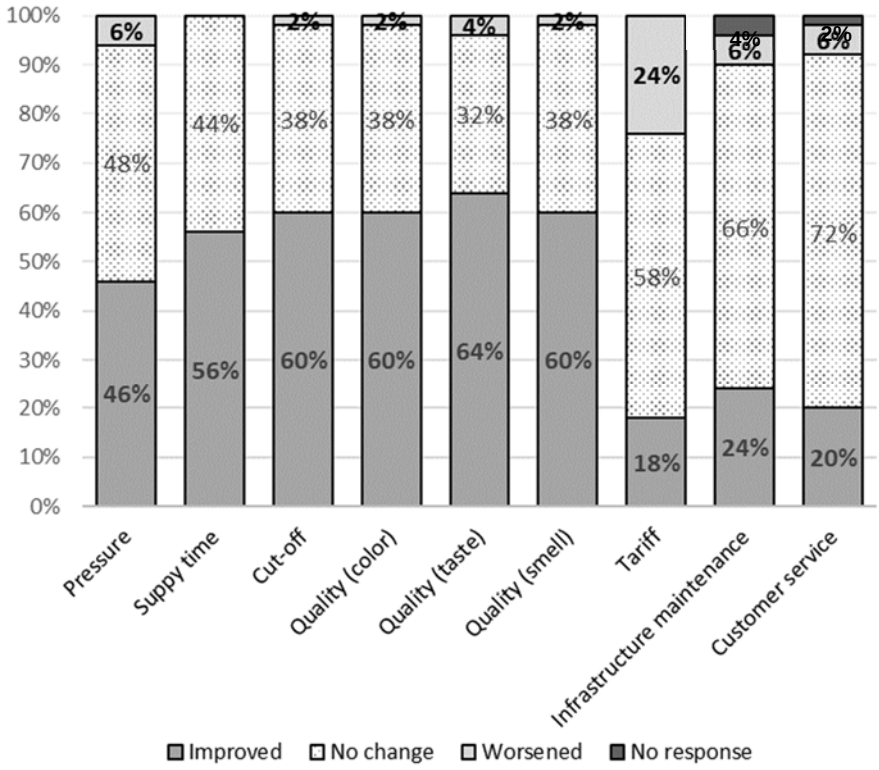
3.4.1 Intended Impacts

The expected impacts of the Project were “improvement of the living environment of residents in Concepcion and Pilar” and “reduction of the morbidity associated with diarrhoea and other water-borne diseases due to improvement of the water quality”.

100). However, it was impossible to obtain accurate data as much of ESSAP’s data is not digitalized and the added figures in the paper records are often inaccurate.



Concepcion



Pilar

Source: Beneficiary Survey

Fig. 2 Changes of Tap Water Before and After the Project

(1) Improvement of the living environment of residents in Concepcion and Pilar:

To ascertain improvement of the living environment, a beneficiary survey[18] was conducted to check any improvement (in terms of colour, taste and odour) of tap water felt by customers when using or consuming water, reduction of the frequency of water cuts, any change of water usage and reduction of the water cost. As shown in Fig. 2, most respondents to this survey selected the answer "improved" in both cities regarding the water supply time, frequency of water cuts and quality of tap water. The actual ratio of positive replies was higher in Concepcion than Pilar, indicating a difference in the perception between the water users in these cities. A conceivable reason for this difference is the different awareness of the operation of a new WTP since 2013 by the residents of these cities (80% of the respondents in Concepcion were aware of a new WTP in the city compared to 56% in Pilar).[19] It is inferred that such biased awareness led to a difference in the perception of any changes of tap water due to the Project among the residents of the two cities. The water treated by the new WTP constructed under the Project meets the quality standards for drinking water as evidenced by the actual performance of the various indicators listed in Table 4 and Table 5 and by the water quality inspection results of ESSAP for tap water in the two cities. It is, therefore, safe to judge that the Project has contributed to improvement of the living environment in both Concepcion and Pilar.

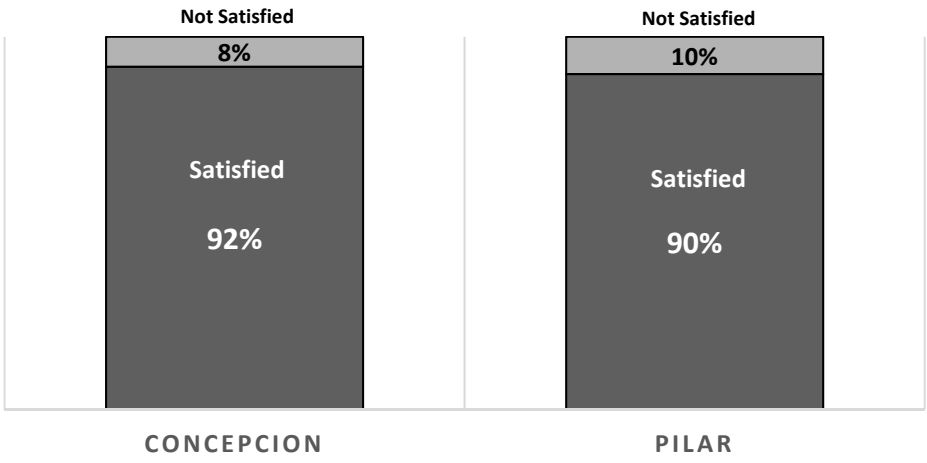
Meanwhile, the overall level of satisfaction with the Project was high at 92% in Concepcion and 90% in Pilar as shown in Fig. 3. The biggest reason cited for satisfaction is that "the water quality has improved". Even before the Project, tap water was the main drinking water for residents but there was now a change of how to treat potable water for drinking after the Project. Before the Project, the proportion of people "drinking potable water without any treatment" was 36% in Concepcion and 64% in Pilar. After the Project, this figure increased to 94% and 84% in the respective cities.[20] The second reason cited is "the substantial reduction of the frequency of water cuts". Before the Project, water cuts frequently occurred in the morning and during the dry season. Currently, there are virtually no water supply fluctuations in terms of the supply hours or season and water supply is basically provided 24 hours a day. Before the Project, it was not unusual for residents to use well water of questionable quality or to purchase water from a supplier other than ESSAP with an average monthly payment of Gs 10,000-50,000. Because there are

[18] The beneficiary survey was conducted on 18th and 19th March 2017 in Concepcion and 21st and 22nd March 2017 in Pilar. It featured any changes before and after the Project and one condition for the respondents was that each respondent had been a customer of ESSAP before and after the Project. The sample size was 50 households in each city, totalling 100 households. For the purpose of sampling, five blocks in Concepcion and nine blocks in Pilar were selected. The sampling rules were the random selection of the survey starting point on the map, followed by an actual visit to one out of every two randomly selected households. The gender ratio was 50% male and 50% female in Concepcion and 44% male and 56% female in Pilar.

[19] As the Concepcion WTP is located inside the city, the Project was part of the daily life of the local residents throughout its planning, construction and operation stages. In contrast, the Pilar WTP was constructed at a military site located with some distance from the urban area and it is possible that the level of its recognisability among the local residents could have been low from its construction stage.

[20] The treatment of potable water before the Project included the use of filters, bottling, settling or injection of chlorine.

currently no water cuts, people no longer worry about how to obtain water at the time of a water cut or how to pay the cost.



Source: Beneficiary Survey N = 100 (50/city)

Fig. 3 Overall Degree of Satisfaction with the Project

In summary, although there are some differences between the two cities, positive impacts of the Project on improvement of the living environment can be observed, including improvement of the quality of tap water, stable water supply without water cuts and elimination of the opportunity cost of obtaining water.

(2) Reduction of the morbidity associated with diarrhoea and other water-borne diseases due to improved water quality:

For this ex-post evaluation, efforts were made to obtain statistics on the morbidity associated with water-borne diseases from the Ministry of Health and local hospitals in each city following similar efforts at the time of planning. However, as local hospital covers not only residents of urban areas where ESSAP supplies water but also people in rural areas where suppliers other than ESSAP supply water and areas where people rely on well water because water supply infrastructure is not in place, neither the Ministry of Health nor local hospitals have detailed information on such water supply situation. Accordingly, it is difficult to quantify the "reduction of the morbidity associated with diarrhoea and other water-borne diseases due to improvement of the water quality by the Project" based on available statistics.[21]

In interviews with an epidemiologist at a local hospital in Concepcion and the head of a local

[21] According to statistics obtained for Pilar, the proportion of people suffering from mild diarrhoea among the total number of patients fell from 8% in 2008 and 2009 to 1% in 2016. At the same time, the proportion of patients suffering from diarrhoea and dehydration fell from 1% in 2008 and 2009 to much less than 1% at 0.05%-0.1% in 2014-2016. However, the proportion of ESSAP customers among patients is unknown.

hospital in Pilar, the substantial improvement of the quality of tap water in both cities after the implementation of the Project is highly appraised. However, one problem pointed out is the level of awareness of the importance of sanitation management on the part of residents as illustrated by inadequate hygiene control when cooking (lack of washing of raw material, thorough heating, etc.) and lack of routine hand-washing after visiting the toilet. According to the beneficiary survey, the proportion of residents replying that "the number of people suffering from water-borne diseases was not high to start with even before the Project and no specific change has taken place since the Project" is high at 86% in Concepcion and 92% in Pilar. No actual decrease of the morbidity associated with water-borne diseases is evident as an impact of the Project.

From the above, this indicator was considered only to a limited extent, because a clear causal relationship between the Project and the number of persons that contracted water-borne diseases could not be verified.

3.4.2 Other Positive and Negative Impacts

(1) Impacts on the natural environment:

An environmental management plan (EMA) was formulated based on the findings of the environmental impact assessment (EIA) and the Concepcion WTP and Pilar WTP were issued an environmental licence by the Environment Agency in September 2012 and 2013 respectively. In the Preparatory Study, the Project was determined to have "a minimum or hardly any impact" on 18 of the 23 check items suggested by the JICA Guidelines for Environmental and Social Considerations and "a positive impact" on the remaining five items in Concepcion. Similarly, it was considered that the Project would have "a minimum or hardly any impact" on 20 items while three items would experience "a positive impact" in Pilar. In short, it was believed that the Project would have very little negative impact on the environment in both cities. Several measures were adopted during the construction period to minimize any negative impact caused by noise or vibration, etc. on the social and natural environments. These included the transportation of construction waste and sludge to the municipal waste collection yard using dedicated vehicles and the spraying of water at the construction sites to suppress dust. As far as noise is concerned, the construction hours avoided the early morning and night-time. A vibration suppression method was employed to control vibration.[22] As for the environmental monitoring after the starting of WTP operations, both ESSAP and ERSSAN are monitoring the water quality and these satisfy the water quality standards of Paraguay. The Report on the Implementation Status of the EIA

[22] The beneficiary survey also investigated the possible impacts of the Project on the environment and the proportion of respondents who said that "there was no impact" was 88% in Concepcion and 100% in Pilar. The Pilar WTP site is located on a military site which is far away from any urban area. Therefore, such impacts as waste water, rubbish and vibration that might appear during the construction period were not felt by the residents in Pilar. Meanwhile, in the case of Concepcion, 12% of the respondents answered to have felt these impacts. In Concepcion where the WTP is located in an urban area, ESSAP held advance meetings to explain the Project to nearby residents, and since ESSAP had already gained their understanding, the actual construction work proceeded without any problems.

submitted by ESSAP to the Environment Agency was approved in 2015, confirming that the impacts of the Project on the natural environment have been kept to a minimum.

(2) Resettlement and land acquisition:

As the Project was intended to renew existing facilities and equipment, no resettlement or acquisition of new land was necessary.

(3) Other impacts:

In addition to the expected impacts described so far, it was anticipated that the Project would have positive impacts regarding (i) the facilitation of poverty reduction, (ii) gender consideration and (iii) cooperation with other schemes of other donors. Regarding (i), as ESSAP service areas are not the dwelling areas of poor people to start with, the proportion of ESSAP users among residents was high even before the Project. This impact cannot be achieved unless the water supply service is extended to reach the dwelling areas of poor people. In regard to (ii), while it was planned to balance the gender proportion of the possible participants of the explanatory meeting held prior to the commencement of the construction work, the majority of the participants of this meeting and other events tended to be male due to the cultural background. Nevertheless, no negative impact of this unbalanced gender presence was confirmed. Regarding (iii), there was an expectation of cooperation with the Project for Capacity Development of Distribution Network Management of ESSAP (2011-2014), a technical cooperation project of JICA. As this project includes the Concepcion and Pilar branch offices of ESSAP in its scope of cooperation, it was hoped that the infrastructure development under the Project would effectively drive the cooperation between the two projects (two schemes) forward. However, the change of the government in 2014 triggered a change of staff at these branches and neither the MOPC nor ESSAP has detailed information to corroborate this impact.

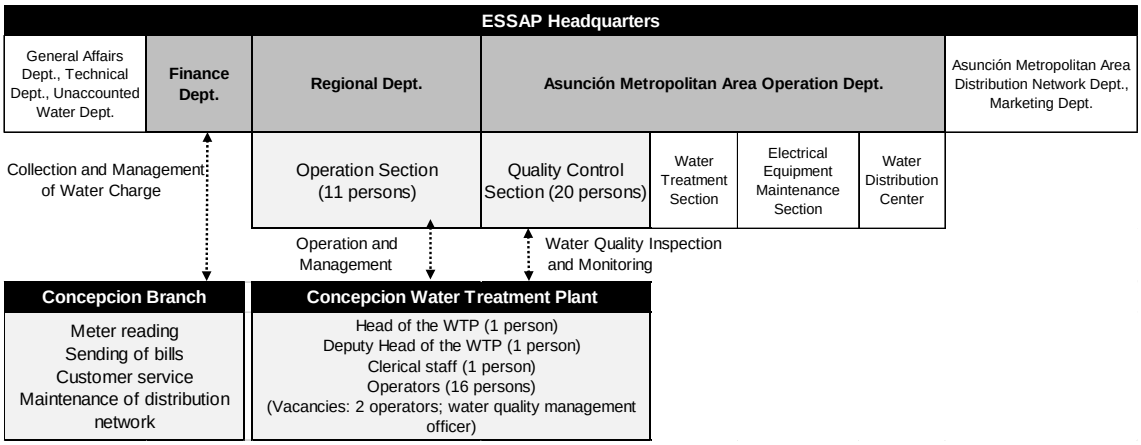
Based on the above, positive impacts are confirmed regarding “improvement of the living environment of the citizens of Concepcion and Pilar” among the envisaged impacts. These impacts include improvement of the tap water quality and a stable water supply without water cuts. In contrast, no clear difference is observed before and after the Project regarding a reduction of the morbidity of diarrhoea and other water-borne diseases due to improved water quality. Meanwhile, the impacts on the natural environment have been kept to a minimum and no land acquisition or resettlement has been necessary.

The Project has largely achieved its objectives and, therefore, its effectiveness and impact are high.

3.5 Sustainability (Rating: ②)

3.5.1 Institutional Aspects of Operation and Maintenance

The competent body responsible for supervision of the Project is the MOPC which is the executing agency of the Project and the actual operation and maintenance work is delegated to ESSAP. The authority for the operation and maintenance of water supply and sewerage services is almost entirely concentrated at the ESSAP Headquarters. Fig. 4 shows the operation and maintenance system for water supply service taking Concepcion as an example, but the system is the same in Pilar.



Source: ESSAP.

Fig. 4 Operation and Maintenance System: Example of the Concepcion WTP

As shown in Fig. 4, the section responsible for the operation and maintenance of the WPTs constructed under the Project is the Operation Section of the Regional Department of the ESSAP Headquarters. While routine operation and maintenance is conducted by each WTP, emergency maintenance and maintenance requiring a high level of professional skill are conducted by each WTP in cooperation with the Operation Section of the Regional Department. In the case of water quality inspection, eight items, including turbidity, color and pH, are checked by an operator at each WTP on a daily basis but more detailed checking is conducted by the Asunción Metropolitan Area Quality Control Section.[23] This section has 20 chemical engineers and is well equipped. These 20 engineers oversee water quality management for "Asunción Metropolitan Area" and "other areas" on a rotation basis. The WTPs constructed under the Project receive visits for sampling once every two weeks. After the water quality analysis of the sampled water, the section reports the analysis results and provides guidance on necessary measures to be implemented to each WTP. The Asunción Metropolitan Area Quality Control Section also conducts the water

[23] The Asunción Metropolitan Area consists of Asunción (the capital) and 12 neighbouring cities.

quality analysis of river water from the Paraguay River, which is the source of the raw water for the two WTPs, and shares the information with the two WTPs. Similarly, information on the eight water quality check items for each WTP is sent every day by next early morning to the Quality Control Section. Each city has a branch of ESSAP and these branches constantly share information with the relevant WTPs. Each branch acts as an independent body and is responsible for meter reading, sending of bills, customer service and maintenance of the distribution network. In short, the organizational structure and command chain are clearly defined at the headquarters, branches and WTPs.

Water quality exam at the Asunción Metropolitan Area Quality Control Section

At the time of ex-post evaluation, the most important issue was the manpower shortage of each organization. According to the Operation Section of the Regional Department of the ESSAP Headquarters, maintenance support for WTPs in 22 cities nationwide is provided by 11 engineers/technicians. This means that breakdown maintenance is all they can cope with even though they would like to implement a plan and monitoring with more emphasis on preventive maintenance. The reality is that they are too busy with corrective maintenance; thus, the maintenance priority is given to those WTPs with more urgent problems. The support system of the ESSAP Headquarters for WTPs in local cities is not totally satisfactory as only two vehicles are assigned to this support in addition to a shortage of manpower. The planned minimum manpower strength for the operation and maintenance of each WTP under the Project was 21, consisting of the plant head (1), deputy plant head (1), 18 operators (two shifts per day with 12 hours/shift; 6 teams with 3 operators each) and one for the water quality management office. At the time of ex-post evaluation, the Concepcion WTP has three vacancies (two operators and one for the water quality management office) while the Pilar WTP has four vacancies (three operators and one for the water quality management office). Because of the absence of an intra-net covering the entire ESSAP, communication between the Headquarters and branches basically relies on personal mobile phones or the internal delivery service for paper documents, etc.

3.5.2 Technical Aspects of Operation and Maintenance

At the time of ex-post evaluation, high school is the highest educational background for most workers at the Concepcion WTP (there is one operator who is a qualified electrician and one clerk who is a university graduate). Similarly, at the Pilar WTP, there is one university graduate which is the plant manager, one qualified electrician, one qualified electromechanical worker and one qualified electronics worker. While the ESSAP Headquarters has many engineers and technicians with much front line experience at various WTPs, their knowledge and know-how are not fully

utilized to serve the entire ESSAP operation. ESSAP lacks an established human resources development system and that OJT is the only practical means of training.[24] The insufficient professional knowledge and know-how of the younger generation of employees and lack of a human resources development system are cited as matters of the strongest concern on the part of the ESSAP Headquarters and WTP management alike.

As the soft component of the Project, training was provided for 58 operators and other staff members of ESSAP. However, the change of the government in 2014 led to a major replacement of personnel throughout ESSAP for political reasons and a total of 38 staff members were forced to leave their jobs. As most of the remaining staff members are due to retire in two to three years' time, it is clear that the experience and know-how accumulated up to the present is likely to be lost in the near future. Those people who received training under the Project and who are still working at a WTP (present heads and team leaders at WTPs) are making a conscious effort to train young staff members by means of OJT. Many of these former trainees have expressed the common opinion that "we learned through the training of the importance of conducting operation and maintenance work based on a scientific understanding of the water treatment process and, therefore, we can teach the operation and maintenance procedure through OJT. However, our lack of professional knowledge to teach fundamental theories (for example, why it is necessary to adjust the quantity of chemicals to be injected) means a need for continuous training by an expert." In the case of the WTPs constructed under the Project, in addition to the fact that it is only a few years since they started operations, the head of the Concepcion WTP and deputy head of the Pilar WTP are former trainees of the Project and have been supervising WTP operation and maintenance based on a manual which clearly explains the necessary operation and maintenance procedure for very easy understanding. Nevertheless, it cannot be said that "adequate operation and maintenance work is conducted in response to changes of the quality of raw water and quantity of intake based on a full understanding of the water treatment theory", causing concern in regard to the sustainability of the technical aspects of operation and maintenance.

Pilar Water Treatment Plant: Inspecting the water intake pump

In regard to the issue of water quality management, the position of water quality manager is currently vacant at both WTPs. However, the technical expertise of the Asunción Metropolitan Area Quality Control Section of ESSAP is sufficient and its staff members conduct equipment inspection and calibration and OJT for operators when they visit a WTP. It is said that the stock

[24] At the time of ex-post evaluation, a training session featuring "safety control: fire extinguishers", "safety control: urgent measures to be taken by staff at the time of an accident, etc." and "planning" is organized every two years and targets those working at the Headquarters and WTPs.

level of chemicals, equipment, etc. at this section is sufficient to conduct nationwide water quality management, including the WTPs in Concepcion and Pilar.

In summary, while the technical aspects concerning water quality management are satisfactory, improvement of some aspects of the operation and maintenance of the WTPs constructed under the Project is necessary because of (i) the departure of most of the operators trained under the soft component and (ii) lack of a comprehensive human resources development program for operation and maintenance on the part of ESSAP.

3.5.3 Financial Aspects of Operation and Maintenance

As was the case at the time of planning, the entire operation and maintenance cost is controlled by ESSAP Headquarters. Neither a local branch nor a WTP has its own budget implementation plan and is only given a small amount of cash. As such, these bodies conduct routine maintenance work using their budget, materials, etc. allocated each year. The Headquarters has total budgetary authority for the expansion or improvement of facilities. A local branch only conducts meter readings and checking of the reading records and the collection and management of the water charge are conducted by the Finance Department of the Headquarters. Accordingly, the financial situation of operation and maintenance in the two target cities of the Project relies on the financial situation of ESSAP as a whole. Since 2009,[25] ESSAP has maintained a relatively healthy financial situation. The profit and loss statements up to 2015 which were obtained by the evaluator show that the profit of the term after income tax deduction (Gs 1,587,632,950) for 2015 is Gs 55,835,491,170, illustrating stable business which is in the black.

The assumed maintenance cost (for 2019) at the time of planning was Gs 1,069 million/year for the Concepcion WTP and Gs 713 million/year for the Pilar WTP. While it was difficult to obtain data on the actual maintenance cost, the interview survey with the heads and operators of the WTPs found that there has been no shortage of the necessary oil, lime and liquid chemicals, etc. for routine maintenance because of advanced application for their supply. The revenue from the water supply service in both cities showed an increasing trend from 2013 to 2015. Even though the expenditure also increased, the overall balance was in the black.

[25] The responsibility for the improvement and operation of water supply facilities in Paraguay was transferred from the former Sanitation Enterprise Corporation (CORPOSANA) to ESSAP in 2003. ESSAP pays most of the revenue (some 80% in 2008) to the government as facility usage fees and its account has been in the red since the beginning. In 2008, the Ministry of Finance decided to waive these fees to reduce the financial burden on ESSAP. Following this decision, the business operation which had been in the red went into the black in 2009. The commissioning of the large-scale Asunción No. 3 WTP in 2012 quickly increased the water production volume, number of users and revenue from the water supply service, widening the account surplus. (Source: Preparatory Study for the Project for Improvement of the Water Supply System in Coronel Oviedo, 2014).

Table 6 Profit and Loss Statement of ESSAP (2013-2015)

(Unit: million Gs)

	2013	2014	2015
Revenue			
Water supply service	226,197	243,312	254,657
Sewerage service	49,527	53,876	56,058
Sub-total	275,724	297,188	310,715
Expenditure			
Administration cost	84,508	76,193	89,069
Water supply network maintenance	32,574	25,683	31,670
Operating cost	12,123	19,109	24,191
Water supply service	34,812	63,869	57,339
Sewerage service	42,550	46,246	51,023
Sub-total	206,567	231,100	253,292
Profit/loss before income tax	**69,160**	**65,087**	**57,423**

Source: ESSAP Annual Report (2015)

In summary, the ESSAP Headquarters has maintained its business in the black and no major problems can be foreseen regarding the financial aspects of operation and maintenance. Although the budget allocated to each WTP has been the minimum amount necessary, the budget allocation for a stable operation and maintenance has been sufficient, indicating no problems in the financial aspect in general.

Pilar Water Treatment Plant:

3.5.4 Current Status of Operation and Maintenance

The status of operation and maintenance and usage of the facilities at the time of ex-post evaluation are generally good as described in Table 7.

Table 7 Status of Operation and Maintenance at Each WTP

[Concepcion WTP]

- Status of operation and maintenance: Generally good
- Reinforcement of the control bridge of the intake facilities: The handrails and stage planks of the control bridge are not reinforced. An urgent response is required in view of an accident where an operator slipped on the bridge and broke a bone.
- Lack of safety control: The WTP can be freely accessed by anyone as no guards are posted at the entrance.

[Pilar WTP]

Intake Pump

- Status of operation and maintenance: Generally good
- Problem with the intake: Because the gate at the intake26 has worn out and it is not fulfilling its role anymore, small fish and sand are sucked into the intake pump. Despite the standard service life of 12-15 years with proper maintenance, the bearings have required replacement three times in four years, causing a much high maintenance work volume compared to that originally required.
- Repair of the flow meter at the rapid filtration tank: The flow meter of the rapid filtration tank is out of order due to a lightning strike and the coordination of its repair with the ESSAP Headquarters is necessary.
- Repair of access road to the WTP: Part of the road from the site entrance to the WTP property has been damaged by flooding of the river and has not been repaired, making it difficult to access the WTP in the rainy season.

The field survey at the WTPs found the following two minor issues requiring improvement.

(1) The spare parts provided under the Project are randomly stacked in the warehouse and inventory control is inaccurate. The lack of a proper warehouse management system results in inefficiency, including the loss of a key to the warehouse when required and time-consuming search for required parts. This situation requires improvement by proper sorting and setting in order along with digitalization of the inventory and data management. Safety precautions (use of helmets, etc.) are not properly implemented.

(2) One part (diaphragm) of the adjusting valve of the lime injection system is extremely worn. As a similar part which can be procured in the domestic market is of low quality, its quick procurement by either contacting the supplier or the consultant which supervised the work or considering the upgrading of the maintenance work, including the frequency of maintenance, is necessary. Lime produced in Paraguay is hard and frequently clogs the injection pipe, making it necessary to consider and implement pipe cleaning work more frequently than recommended in the manual. Because of the possibility that the current lime injection volume is more than necessary, consultation with the Quality Control Section may well be required.

At the time of defect inspection, two recommendations were made to the two WTPs: (1) staff members of both WTPs should exchange opinions and renew the maintenance manual in order to continue the good operation and maintenance situation and (2) each ESSAP branch should establish a stable operation system which does not rely on the Headquarters for the continual

[26] According to interviews to the consultant and ESSAP, regarding Pilar WTP's water intake gate, the problem had already been pointed out at the moment of the Preparatory Study. However, because it would surpass the budget, it was not included in the Project, and ESSAP would fix the problem separately when the budged could be secured.

adequate operation and maintenance of the WTP facilities. More detailed recommendations for the Concepcion WTP include an increase of the manpower, storage and control of spare parts at the WTP, control of the cleaning frequency of the flocculator and sedimentation tank, etc. on the authority of the head of the WTP rather than the ESSAP Headquarters and the appointment of a person responsible for quality control at the WTP. While those recommendations relating to infrastructure have been implemented, the positions of some operators and quality control officer are still vacant. No fundamental reforms, including the exchange of opinions between the personnel of the WTPs and improvement of the dependency of ESSAP branches and WTPs on the Headquarters, have been implemented by the time of the ex-post evaluation.

From the above, some minor problems are observed in terms of the institutional and technical aspects and, therefore, the sustainability of the project effects is fair.

4 Conclusion, Recommendations and Lessons Learned

4.1 Conclusion

The Project was implemented for the purpose of improving the quality of waterworks, increasing the water supply volume and improving access to safe water for residents of the cities of Concepcion and Pilar in Paraguay by means of rehabilitating the water intake facilities and constructing water treatment plants in these two cities, thereby contributing to improvement of the living environment and reduction of the morbidity of water-borne diseases. The Project is highly consistent with Paraguay's national development policies as well as Paraguay's development needs and Japan's ODA policies. Although the project period was within the planned period, the project cost exceeded the planned cost due to an increase of the Paraguay portion of the project cost. Therefore, the efficiency of the Project is fair. The construction of new intake and water treatment facilities in both cities led to an increased water production volume and water distribution volume, boosting the size of the population served by the water supply service together with an expanded service area of the ESSAP in both cities. In Pilar, however, the target water production volume could not be reached as water demand did not increase as expected. This was because some large consumers withdrew their investments, and new ones could not be attracted due to the delay in the urban development plan which existed already at the time of the Preparatory Study. Meanwhile, the water quality targets (turbidity and color) were achieved at both water treatment plants. In both cities, the immediate use of tap water for drinking became easier due to improvement of the water quality and establishment of a stable water supply without water cuts which has reduced the water-related cost, contributing to improvement of the living environment. Meanwhile, no significant change can be observed regarding the frequency of water-borne diseases because the project areas experienced only a relatively low morbidity of

water-borne diseases to start with. The overall picture is that the Project did produce the planned effects and its effectiveness and impact are high. Regarding operation and maintenance, the decision-making process and authority are concentrated at the ESSAP Headquarters and the support system of the Headquarters to individual water treatment plants is not completely satisfactory. The facts that most of the people who received training under the technical assistance (hereinafter referred to as 'soft component') of this Project have now left ESSAP and that ESSAP does not have a firmly established human resources development program cause concern regarding the technical aspects of operation and maintenance. There are no issues regarding the financial aspect of the operation and maintenance. Therefore, the sustainability of the effects that were brought about by the Project is fair.

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

4.2 Recommendations

4.2.1 Recommendations for the Executing Agency (MOPC)

- While the contents (theory and practice) of the training organized as the soft component of the Project were highly appraised, the number of staff members who participated in this training and who still work for ESSAP at the time of ex-post evaluation is quite limited. Although these staff members lead the OJT for newly recruited young employees, many of them are due to retire in two or three years' time, making the proper inheritance of their skills and know-how within ESSAP an urgent matter. Because ESSAP does not have an established human resources development program, it is essential for ESSAP to assess the training requirements, and to introduce a training program which targets WTP operators in local cities throughout Paraguay taking as a reference the contents of the training conducted under the soft component, while seeking external assistance. The training of in-house trainers is also necessary with a view to ensuring the sustainability of the new human resources development program.

- Even though the situation slightly differs from one WTP to another, the management of documents, reference materials and spare parts at WTPs are generally insufficient, meaning that it is difficult to quickly find what is required when it is required. Both the Concepcion and Pilar WTPs must establish the custom of cleaning and sorting out. The Concepcion WTP is making gradual progress in this regard by employing a clerk. It is essential that this work continue while thoroughly enforcing the custom of cleaning and sorting out in the routine work of all staff members. At the Pilar WTP, only the head of the WTP is in possession of a warehouse key and this practice is very inefficient. The warehouse even stores documents describing the maintenance schedule, composition of operation and maintenance teams, work schedule and responsible work of each staff member, all of which are required for daily work.

These documents which should be routinely consulted must be moved to the control room in which the operators work to ensure their proper use.

- At the Concepcion WTP, no guards are posted at the entrance of the WTP premises, allowing anyone free access to the WTP. The establishment of a controlled WTP access system is desirable to guarantee the proper operation of the WTP and supply of safe water for residents. In the case of the Pilar WTP, part of the access road from the entrance to the WTP proper becomes difficult to use, especially during the rainy season, as described in Table 7. The urgent repair of this section is desirable from the viewpoint of managing labour safety.

- Regarding the water intake gate for the Pilar WTP, as it is described in Table 7, it has worn out and it is not fulfilling its role anymore. This has resulted in heavy abrasion of the intake pump bearings, necessitating the replacement of the bearings more frequently than assumed. The urgent construction of this gate is desirable.

- Because the ex-post evaluation was conducted only a short time after the opening of the subject WTPs, both WTPs have not experienced any serious operation or maintenance issue. However, the concentration of the decision-making authority for many minor issues at the ESSAP Headquarters suggests a rather inefficient system in general. In the medium to long-term, the authority to determine the replacement frequency of spare parts, to procure spare parts, chemicals, etc. for water quality inspection and to arrange one's own budget should be given to the WTPs as a step towards more efficient operation and maintenance. At the same time, enhancement of the technical competence of the staff members of the WTPs and strengthening of the operation and maintenance system at the municipal level are desirable to secure the sustainability of the Project.

4.2.2 Recommendations to JICA

- It is hoped that JICA will examine the feasibility of introducing the dispatch of experts, third country training and other schemes so that ESSAP can establish and implement its own human resources development program.

4.3 Lessons Learned

Examination of a technology transfer method when the substantial replacement of personnel can be expected to take place at the time of a government change

A change of the government took place immediately after the completion of the Project, resulting in a sweeping change of the personnel of both the MOPC which is the executing agency for the Project and ESSAP which is responsible for the operation and maintenance of the project-related facilities. This meant that many of the people who underwent training to master essential

skills and know-how under the soft component of the Project were forced to leave their positions. The resulting lack of the inheritance of skills and know-how may well damage the sustainability of the Project in the medium to long-term. When a similar project is to be implemented in a country where a similar situation is likely to occur, it is desirable to consider the implementation of a separate training project targeting not only the staff members of the project-related WTP but also those of other WTPs as well as staff members of the sections in the headquarters who manage and provide technical assistance to WTPs nationwide, so that technical skills are accumulated as institutional capacity in the entity even if a major change of the personnel occurs.

END

Republic of Honduras

FY 2016 External Ex-Post Evaluation of Japanese Grant Aid Project

"The Project for Landslide Prevention in the Tegucigalpa Metropolitan Area"

External Evaluator[1]: Hajime Sonoda, Global Group 21 Japan, Inc.

0. Summary

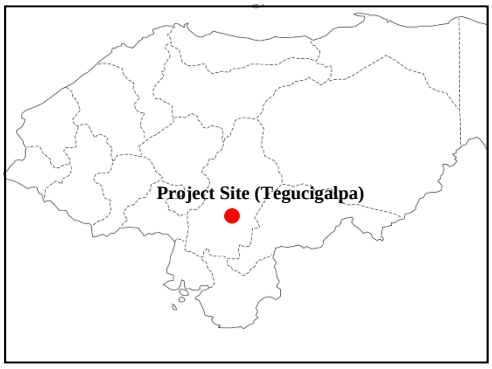
The Project for Landslide Prevention in the Tegucigalpa Metropolitan Area, a grant aid cooperation project, (hereinafter referred to as "the Project") was implemented to mitigate the risk of landslide disaster in El Berrinche and El Reparto of Tegucigalpa by means of constructing landslide prevention facilities and developing a landslide monitoring system and an early warning and evacuation system, thereby contributing to promotion of landslide prevention in the Tegucigalpa metropolitan area. The Government of Honduras has consistently made conscious efforts regarding disaster management and there is a strong necessity in Tegucigalpa for disaster prevention targeting landslides and floods. The Project was relevant to Japan's ODA policy at the time of its planning and, therefore, the relevance of the Project is high. As the project cost was within the planned amount but the project period exceeded the planned period, efficiency of the Project is fair. Landslide prevention facilities introduced by the Project have been functioning properly and the targeted landslide blocks have been stabilized. Although the information dissemination to nearby residents has not been sufficient, landslide monitoring continues and an early warning system operated by the Tegucigalpa Municipal Emergency Committee (*Comité de Emergencia Municipal*: hereinafter referred to as "CODEM") and community disaster management organizations is functioning in the two targeted sites. Technical capability of the Municipality of Tegucigalpa to handle landslide prevention measures is being strengthened but the application of these measures in the metropolitan area is limited. While the concrete achievement of the new facilities to mitigate disaster damages cannot be verified because there has been no heavy rain since the completion of the Project, the Project has provided many residents with peace of mind. To summarize, effectiveness and impact of the Project are high. There are no major issues in regard to the institutional, technical and financial aspects of the Project in terms of its sustainability. Taking the good operation and maintenance conditions of the landslide monitoring system and the landslide prevention facilities into consideration,

[1] In order to undertake detailed technical and professional analysis in addition to an evaluation analysis by the external evaluator, an expert analysis by Professor Hiroshi Fukuoka (Director of the Research Institute for Natural Hazards and Disaster Recovery, Niigata University) was conducted. Professor Fukuoka specializes in landslide studies and has participated extensively in international research and technology dissemination activities related to landslide, for example landslide survey in Machu Picchu, Peru, technical cooperation in Central America and Central Asia (as an expert dispatched by JICA), among others. Professor Fukuoka participated in the initial field survey of this ex-post evaluation and gathered information from field visit as well as from the executing agency, exchanged views with government organizations and academic research institutions related to disaster management in Honduras, and prepared an expert analysis paper. In this ex-post evaluation, evaluation results, recommendations and lessons learned were compiled with Professor Fukuoka's advices. Summaries of his expert analysis paper are shown as Box1 and 2. It should be noted that the external evaluators (Sonoda) took part in the analysis on "Relationship with JICA's other cooperation on landslides (Box 2)" of the expert's analysis.

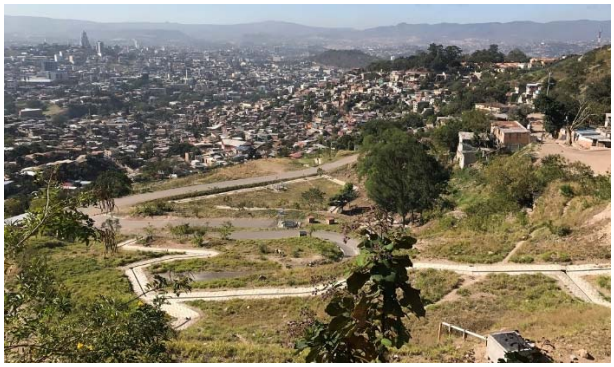
sustainability of the Project is high.

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

1. Project Description



Project Location



Complete view of El Reparto (After the implementation of countermeasures)

1.1 Background

Tegucigalpa, the capital of Honduras, is vulnerable to natural disasters because of the natural conditions which make it prone to flooding and landslides and its disorderly urbanization with a continuous inflow of poor people from rural areas. Total more than 13,000 people have been either killed or missing due to Hurricane Mitch in Honduras, which hit Central America in October, 1998. In Tegucigalpa alone, number of people killed or missing exceeded 1,000. A massive landslide which occurred in El Berrinche of Tegucigalpa not only destroyed residential areas but also blocked Choluteca River which was running through the centre of the city, causing flood damage over a wide area in the centre of the metropolitan area.

As part of the assistance for post-hurricane reconstruction in Honduras, Japan International Cooperation Agency (JICA) implemented the “Study on Flood Control and Landslide Prevention in the Metropolitan Area” from 2001 to 2002 with a view to formulating a disaster management master plan for flood and landslide prevention in Tegucigalpa. In this study, having identified high risk areas for flood and landslide, feasibility studies on urgent and priority projects were conducted. The Project was implemented in response to the request made by the Government of Honduras concerning landslide prevention measures of which feasibility was studied.

1.2 Project Outline

The Project is implemented to reduce the risk of landslide disaster in El Berrinche and El Reparto of Tegucigalpa by constructing landslide prevention facilities, conducting landslide monitoring and developing an early warning and evacuation system, thereby contributing to promote landslide prevention in the metropolitan area.

E/N Grant Limit / Actual Grant Amount	(Detailed Design) 45 million yen; (Main Work) 1,053 million yen (Detailed Design) 45 million yen; (Main Work) 994 million yen
Exchange of Notes Date / Grant Agreement Date	(Detailed Design) February 2011; (Main Work) June 2011 (Detailed Design) February 2011; (Main Work) June 2011
Executing Agency	The Joint Coordination Committee composed of the following members was responsible for project implementation and maintenance: Municipal Administration of Central District (AMDC, Chairman), Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment, Permanent Contingency Commission (COPECO)
Project Completion	October 2013
Main Contractors	Hazama Ando Corporation
Main Consultant	Joint Venture of Central Consultant Inc. and Earth System Science Co., Ltd.
Preparatory Study	July – December 2010
Related Projects	Study on Flood Control and Landslide Prevention in the Metropolitan Area (Development Study; 2001 – 2002); Project on Capacity Development for Disaster Risk Management in Central America "BOSAI"(Technical Cooperation; 2007 – 2012); Hazard Geology Focusing on the Landslides in Tegucigalpa (Dispatch of Science and Technology Experts: 2012-2014); Assistance for Strengthening and Capacity Building of Professional techniques for the Control and Mitigation of Landslide in Tegucigalpa Metropolitan Area (Dispatch of Individual Experts; 2015 – 2016); Project on Capacity Development for Disaster Risk Management in Central America, Phase 2 (Technical Cooperation; 2015 – 2020)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hajime Sonoda (Global Group 21 Japan, Inc.)

2.2 Duration of Evaluation Study

This ex-post evaluation study for the Project was conducted over the following period.

Duration of the Study: October 2016 to February 2018

Duration of the Field Survey: February 9 to 24, 2017 and May 29 to June 3, 2017

2.3 Constraints for Evaluation

As both of the sites targeted by the Project are areas with unstable public security, a police escort was required for the field visit by the evaluator. Because of the difficulty of staying for a long time, it was impossible to visually and closely check some of the facilities constructed under the Project. Moreover, as it was risky to enter neighboring

residential areas, interviews with community disaster management organizations were held in the conference room of CODEM. Direct interviews with schools and residents in and around the targeted sites were not possible. A beneficiary survey by a local consultant was conducted with the guidance of community disaster management organizations and being escorted by police,[2] and it was not possible to conduct random sampling of target households.

3. Results of the Evaluation (Overall Rating:A3)

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of Honduras

At the time of planning (2010), Honduras, as a country most severely hit by Hurricane Mitch, was keen to introduce measures to prevent natural disasters. *Natural Disaster Management System Act*[4] was enacted in 2009 and the *National Plan 2010 – 2022* formulated in 2010 lists natural disaster management as one of the seven priority targets. At the same time, the *National Climate Change Strategy* was formulated as a strategic plan for disaster management sector under the *National Plan*.

At the time of ex-post evaluation, Honduras maintains its National Climate Change Strategy. Active promotion of disaster management by Honduras based on the framework of the *Natural Disaster Management System Act* is illustrated by its adoption of the *National Policy for Integrated Risk Management*[5] in 2013 and the *National Plan for Integrated Risk Management (2014 – 2019)*[6] in 2014.

As described above, the Project was highly relevant to the development policy of Honduras at the time of both its planning and ex-post evaluation.

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[2] As part of the ex-post evaluation, a beneficiary survey using a questionnaire was conducted through personal interviews, targeting those residents under direct threat of landslide in the two targeted areas. The purpose of this survey was to establish whether or not the early warning and evacuation system at household and community levels had been properly established, and what changes had been made to local lives due to the mitigation of landslide risk. In the light of unstable public security of these areas, the interviewers visiting the districts were guided by a member of a community disaster management organization with a police escort. Interviewees were selected by judgement sampling. Number of households actually interviewed was 51 in El Berrinche and 54 in El Reparto. The ratio of men to women was 28% to 72%.

[3] ①: Low; ②: Fair; ③: High

[4] *National Disaster Management System Act* (*Ley del Sistema Nacional de Gestión de Riesgos*) covers disasters in general and aims at prevention, mitigation, response and rehabilitation of/to disasters.

[5] *National Policy for Integrated Risk Management* (*Política de Estado para la Gestión Integral del Riesgo en Honduras*) aims at strengthening the cooperation between various organizations as a general target. More concrete targets are ① enhanced understanding of the threat and risk of disasters, ② incorporation of the concept of comprehensive risk management in policies, ordinances, strategies, etc., ③ strengthening of disaster prevention budget management, ④ capacity building of organizations and ordinary citizens and ⑤ swift and appropriate response to emergencies and disasters.

[6] *National Plan for Integrated Risk Management* is a six-year plan formulated by the Permanent Contingency Commission (COPECO) in 2014 for the purpose of effectively implementing the *National Policy for Integrated Risk Management*. It provides more detailed descriptions of the implementation bodies, implementation timing, evaluation indicators and other relevant matters concerning concrete targets, strategic guidelines and policies stipulated by the said policy.

3.1.2 Consistency with the Development Needs of Honduras

Of the target areas of the Project, the landslide occurred at El Berrinche at the time of Hurricane Mitch (1998), in addition to the complete destruction of some 100 houses and seven people recorded missing, brought about extensive flood damage due to a landslide dam formed by the clogging of Choluteca River that is located to the south of El Berrinche. On the other hand, more than 100 houses were completely destroyed in El Reparto. Despite such damages in the past, no adequate landslide prevention measures had been in place in either sites at the time of planning, continuing the situation of a persistence risk of new landslides due to rainfall.

At the time of ex-post evaluation, however, the landslide risk is believed to have been greatly reduced by the Project in both sites (see the section on Effectiveness). Meanwhile, according to the Municipality of Tegucigalpa, there are incidents of landslides or cliff failures almost every year in Tegucigalpa, even from 2014 and onwards, causing damage to houses, etc. *The Action Plan* [7] formulated by the Municipality of Tegucigalpa in 2016 states that 11% of the municipal population lives in high landslide risk areas, and land areas with medium to high landslide risk account for 80% of the metropolitan area, creating a major obstruction to the development of the metropolitan area. Moreover, 85% of the population of these landslide risk areas are low income people living in newly developed residential areas. The Action Plan proposes four strategic targets: ① integrated water management, ② reduction of the vulnerability to natural disasters, ③ inclusive and orderly growth and ④ safe and prosperous communities. For the purpose of disaster management, the Action Plan proposes appropriate regulations for land use, recognition of the disaster risk (including a detailed study with landslide damage projection), introduction of a natural disaster insurance system, flood control measures targeting Choluteca River, resettlement of residents from landslide risk areas, landslide survey and monitoring, and introduction of an early warning system. The Action Plan also refers to the maintenance of landslide prevention facilities constructed under the Project.

Based on the above, the relevance of the Project to the development needs of Honduras is high at the time of both planning and ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

At the time of planning, according to the *Rolling Plan* (2010, Ministry of Foreign Affairs) for Honduras, four priority areas for assistance were "basic education", "health and water", "regional development" and "disaster management and measures against climate change". As "disaster management" is listed as one of the development themes under "disaster management and measures against climate change", the Project is classified as assistance for the said development theme.

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[7] *The Tegucigalpa and Comayagüela Action Plan* (*El Plan de Acción para Tegucigalpa y Comayagüela*) assisted by the Inter-American Development Bank.

Based on the above, the Project is highly relevant to Honduras's development plan and development needs as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

Under the Project, structural measures to prevent landslides[8] were implemented targeting El Berrinche and El Reparto along with the development of landslide monitoring facilities and technical assistance under the capacity building component (hereinafter referred to as "soft component") of the Project. The planned and actual outputs by the Japanese side are shown in Table 1.

Table 1 Comparison between the Planned and Actual Outputs

	El Berrinche		El Reparto	
Structural Measures for Landslide Prevention	(Planned) 8	(Actual) 8	(Planned) 2	(Actual) 2
Catchment well	6,500m	6, 500m	3,200m	2,910m
Water collecting boring works	250m	250m	none	none
Horizontal boring works	692m	751m	147m	139m
Drainage boring works	3,379m	2,454m	1,951m	1,443m
Open and closed canals	16,199m^3	17,100m^3	3,736m^3	4,710m^3
Soil removal works	16,699m^3	17,600m^3	4,209m^3	3,310m^3
Embankment works				
Monitoring System	(Planned)	(Actual)	(Planned)	(Actual)
Rain gauge	1	1	1	1
Extensometer	4	4	2	2
Borehole inclinometer	1	2	1	1
Automatic groundwater gauge	3	3	1	1
Soft Component Maintenance system of the facility Monitoring system Early warning and evacuation system	(Actual) In connection with the topics listed in the left column, lectures, field visits, analytical exercise of landslide stability, exercise of preparing a hazard map, etc. were conducted in three sessions along with the construction work, principally targeting those officials involved in disaster management activities in Tegucigalpa. No evacuation drills were conducted.			

Source: Materials provided by JICA and Tegucigalpa city

[8] According to the *Landslide Prevention Act* of Japan, a landslide is defined as "the phenomenon of sliding down of part of the ground caused by groundwater, etc. or the phenomenon of ground movement accompanying the sliding down of the ground". The type of landslide targeted by the Project is the recurrent sliding of soil mass (landslide block) along the sliding surface formed by a landslide in the past. When the groundwater level rises due to heavy rain, the soil mass above this level is subject to buoyant force, and the resistance force (friction force) of the sliding surface becomes smaller than the sliding force (force that the soil mass would slide down along the sliding surface), causing a landslide. Therefore, a landslide can be prevented by controlling a rise of the groundwater during rain through evacuating groundwater by catchment wells and horizontal boring works, and draining of surface water by channel works, etc. Removal of soil in the upper part of a landslide block reduces the sliding force while banking in the lower part of a landslide block increases the resistance force. Works designed to improve the balance between the resistance force and sliding force by removing such causative factors of a landslide are called "control works". In contrast, works designed to stop part or whole of the landslide movement by using the resistance force held by anchors, steel pipe piles, caisson piles, etc. are called "prevention works". Under the Project, landslide prevention was implemented through control works.

The Honduran side was responsible for the relocation of power poles and distribution lines, improvement of the sewer inlets to the target areas, provision of a temporary yard, disposal of waste, deployment of policemen and traffic policemen during the construction work and construction of a gabion revetment at the scouring site on the left bank of Choluteca River. These works were carried out as planned.

The plan for the Project was prepared during the "Preparatory Study for the Project for Landslide Prevention in the Tegucigalpa Metropolitan Area" (July-December, 2010, hereinafter referred to as "the Preparatory Study"). The planning policy of the Preparatory Study to primarily use "control works" in view of economy was appropriate (see Box 1). The findings of interviews with CODEM and the field survey indicate that the scope and construction quality of the structural measures implemented under the Project are appropriate.

During the Preparatory Study, a new movement of one landslide block not previously recognized was confirmed in a peripheral area of El Berrinche. Although this block was outside the planned scope of the control works under the Project, one bore hole to install an inclinometer was added for monitoring purposes at the time of the detailed design. No control works were implemented for this block. As for the structural measures for landslide prevention, changes were made to the locations and quantities of water collecting and drainage boring works, canals and catchment wells to be adjusted to topographical deformation occurred before the commencement of construction, and also to the location of the construction road to avoid unstable sites prone to landslides. These changes were judged to be necessary and appropriate.

As for the data transfer and warning transmission from monitoring equipment, wireless transmission using mobile phone lines was originally assumed. This was changed at the time of the detailed design to cable-based data transfer with the installation of observation stations at the premises of nearby cooperating households. While this change was made in consideration of mitigating the risk of theft and better economy, it became necessary for officials in charge to visit these stations to obtain data. The original plan for groundwater gauges was an automated measurement and transfer of continuous data to observation stations. All the three automatic groundwater gauges installed in El Berrinche broke down, however, due to a lightning strike during the construction. Then, all of them were changed to manual gauges in consideration of the difficulty of repairing such breakdowns in the future (the bore hole for measuring operation were left for the installation of the manual gauges which were procured separately). These changes meant that it would be necessary to visit these bore holes each time to measure the groundwater level in El Berrinche and that continuous data would not be available. In El Reparto, an automatic water gauge was installed as planned for observation of the groundwater level.

The above changes of the monitoring system, etc. were made based on judgements on the actual site conditions. The change of the data transfer method and installation of manual water gauges for observation of the groundwater in El Berrinche adversely affected the convenience of

data acquisition and data continuity. Moreover, even though the scope of monitoring and locations of the monitoring equipment are considered to be generally adequate, they are not necessarily sufficient because of its configuration featuring an equipment quantity and locations commonly employed for small-scale landslides (see Box 1).

Training organized as part of the soft component was attended by members of CODEM and other stakeholder organizations i.e. Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment, and Permanent Contingency Commission (hereinafter referred to as "COPECO"). CODEM members underwent training primarily focusing on landslide monitoring and maintenance of the facilities. According to CODEM, contents of the training were adequate. Although some of the theoretical topics requiring specialized knowledge of geology, etc. were difficult, the trainees acquired basic knowledge of landslide and basic skills for the operation and maintenance (including landslide monitoring) of the Project. As all of the training participants from other stakeholder organizations had moved to other organizations by the time of the ex-post evaluation, it was not possible to obtain their opinion on the training. Some senior officials of the community disaster management organization in the two areas also participated in the training, but no evacuation drill with the participation of residents was conducted because CODEM was too busy due to a mudslide caused by the rupture of a water main during the period planned for it.

Box 1

Summary of an Expert Analysis (1) : Appropriateness and effectiveness of the structural measures and landslide monitoring of the Project

Hiroshi Fukuoka (Director of the Research Institute for Natural Hazards & Recovery, Niigata University, Professor)

Landslide prevention facilities were constructed under the Project using such "control works" as catchment wells, open canals, drainage boring works, soil removal and embankment works. In Japan, such "prevention works" as anchors, steel pipe piles and caisson piles may be used to tackle potentially large landslides in socially important areas. However, these require large budget, their maintenance is complicated and the local production of replacement parts is very difficult. Because of this, the restriction of the scope of the Project to "control works" is considered to be a valid decision. The catchment wells installed are appropriate as using the standard design in Japan in terms of the diameter, depth, liner plate, protection net for the opening, maintenance steps and drainage boring. Design of all other facilities does not raise any special concerns.

However, it cannot be said that these new facilities have completely eliminated the possibility of reactivation of large-scale landslide in El Berrinche in future triggered by a direct hit of an earthquake or extremely heavy rain and formation of a landslide dam due to the clogging of Choluteca River and flooding of central Tegucigalpa on the opposite bank. To prepare for such an event, construction of underdrains along the river channel could be useful as well as stockpiling of drainage pump and fabric pipes. As these measures are cheaper than caisson

piles and other “prevention works”, feasibility of their adoption should be examined from now on.

As for landslide monitoring, extensometers and borehole inclinometers, both of which are typical and the most reliable instruments to observe any ground movement, were selected and installed under the Project. Having understood the scope of monitoring and the structure and mechanism of these instruments, CODEM has conducted their maintenance, collection and basic analysis of the data by itself. Therefore, types of monitoring facilities installed is generally appropriate and it appears that minimum necessary technical transfer has been successfully performed. However, the landslide monitoring system introduced under the Project comprises a quantity and deployment of equipment usually employed to monitor small-scale landslides, it gives an impression that the system was half-finished in both sites.

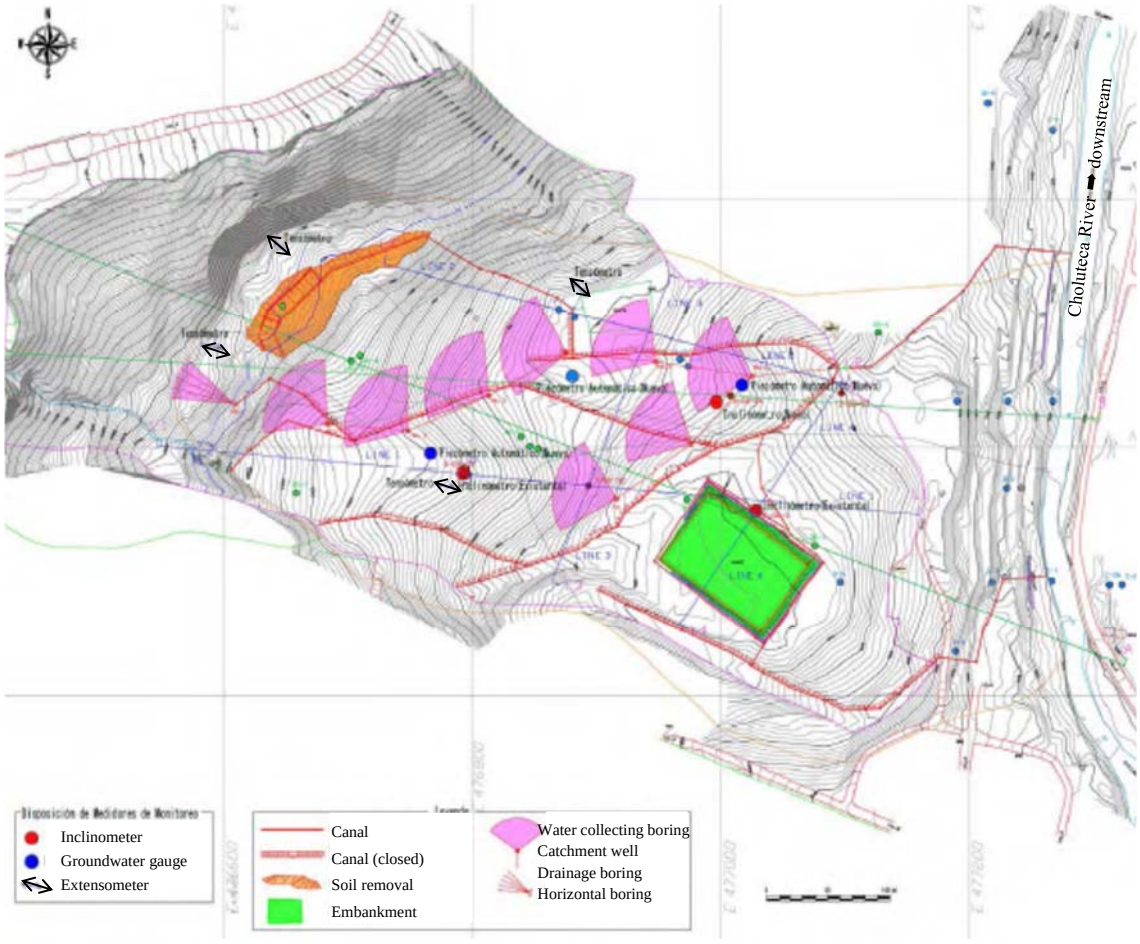
In El Berrinche, a socially important district, a monitoring system for the entire landslide area should be established with total coverage of the landslide blocks from top to bottom by extensometers and periodical monitoring using a total station.[9] In regard to data analysis, there is still some room for improvement in view of devising data analysis according to the quality of data, for example, removal of noises, extraction of minute displacements, etc.

As far as extensometers are concerned, a unit of short span extensometer of 10m - 20m is installed at several places near the top of the slope. Movement of the main scarp could have been detected with high accuracy if another unit of short-span extensometer had been installed branching out from the long span invar line (up to 100 m). In the case of borehole inclinometers, the most basic analysis method has been transferred. However, there were cases where sliding movement could not be quantified simply by repeating this method when the actual displacement was smaller than the margin of error. Monitoring frequency of the groundwater level is insufficient. Technical transfer was not made on quantitative assessment of the effects of catchment wells based on the groundwater level monitored since the construction of a catchment well in comparison with the monitoring results before construction, for which monitoring should had been started before construction. Observation stations are installed on the premises of individual households and have been properly maintained. However, there has been a lack of training for house dwellers on how to respond when an early warning siren is sounded. There has also been a lack of evacuation drills.

In general, CODEM has conducted maintenance of the facilities installed under the Project in a competent manner. Monitoring results of the two sites, especially the data recorded by the extensometers and borehole inclinometers, do not show any significant movement, indicating that the target landslide blocks have been stable. This means that the Project has generally achieved its objective of stabilizing the landslides. It is acknowledged that, by combining “control works” which are inexpensive and based on a simple structure, the Project has been achieving sufficient effects in terms of the stabilization of landslides. There is, however, no sufficient understanding of what level of heavy rainfall and subsequent rise of groundwater could lead to a reactivation of landslides because of the lack of sufficient data to properly analyse the relationship between the rainfall intensity and movement of landslide blocks. The landslide in El Berrinche has a complex structure where many landslide blocks thrust into one another. At the time of planning, stability analysis was conducted with only two sections and this cannot be described as sufficient. Further trial calculations using more suitable models are desirable in the future.

[9] A total station is a survey instrument which integrates an electro-optical distance meter, which measures distance by beaming light to the target point and electronically analysing the reflected light reaching the instrument, and an electronic theodolite which measures angles. Both angles (vertical as well as horizontal angles) and distance can be simultaneously measured by a single instrument. When this instrument is applied to a landslide, three-dimensional movement vectors of the survey point can be obtained.

At the time of constructing catchment wells, neither photographs of geological sections, soil samples from the sliding surface were preserved nor observation data on preconstruction groundwater level were preserved. In Japan, 360-degree photographs of a geological section are taken at 1 m intervals of the drilling depth at the time of the drilling and construction of a catchment well. As these photographs show the conditions of geological structure, inclination and conditions of sliding surface much better than drilling cores, they are extremely useful as reference materials for understanding mechanism of the landslide and also for visitors after the completion of the construction work. Soil samples from the sliding surface are essential to determine, through a soil test, the strength parameter which is the most important element of stability analysis and also important for future examination of countermeasures. Meanwhile, data related to the changes of groundwater level before and after the well construction is the most important data used for judging effects of the well after its completion. It is regrettable that the precious opportunity to obtain these materials and data was not seized.



Source: Preparatory Study

Fig. 1 Planned layout of landslide control works (example of El Berrinche)

Complete view of El Berrinche

Open canal (El Berrinche)

Catchment well and its interior in El Berrinche
(water collection boring works deployed in a fan-like fashion can be observed)

3.2.2 Project Inputs

At the time of planning, it was assumed that the Project would be implemented by a Joint Coordination Committee composed of Municipality of Tegucigalpa (Chairman), Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment and COPECO. At the beginning, the Joint Coordination Committee met every week and staff members of the participating organizations underwent the training held as part of the soft component. All of the organizations except Municipality of Tegucigalpa gradually lost interest, declining the level of the Joint Coordination Committee activities. This decline, however, did not particularly affect the implementation of the Project, as the principle organization for implementation was Municipality of Tegucigalpa and coordination with other organizations were made separately as necessary. No problems resulting in a major increase of project cost or project period occurred at the project implementation stage.

3.2.2.1 Project Cost

The planned total project cost was 1,101 million yen of which 1,096 million yen and 5 million yen were to be borne by the Japanese and Honduran sides respectively. The actual project cost for the Japanese side was 1,039 million yen (95% of the planned amount) for the detailed design and project implementation (construction of facilities, procurement of equipment, supervision and soft component) and was within the planned amount. No information was obtained regarding the actual project cost of the Honduran side.

3.2.2.2 Project Period

The planned project period was approximately 32 months from January 2011 when the grant agreement was to be signed to August 2013, including the detailed design and procurement periods. In reality, the grant agreement was signed in February 2011 and the construction work commenced in December 2011 after the detailed design and procurement periods. The work was completed in October 2013. The actual project period, therefore, was 33 months from February 2011 to October 2013 (103% of the planned period), exceeding the planned project period.

Although the project cost was within the plan, the project period exceeded the plan. Therefore, the efficiency of the Project is fair.

3.3 Effectiveness[10] (Rating: ③)

The purpose of the Project is to "reduce the risk of landslide disaster in the two target areas" which can be achieved by "reducing the probability of landslide occurrence (stabilization of landslide blocks)" and "reducing the risk of damage (when a landslide occurs)". As described in detail below, the landslide prevention facilities introduced under the Project have so far been functioning properly and it is fair to judge that the targeted landslide blocks have been stabilized. On the other hand, even though the information dissemination to the residents cannot be described as sufficient, landslide monitoring is continuing in the two target areas by the Project, suggesting that the early warning system run by CODEM and the community disaster management organization is duly functioning. Therefore, it can be judged that the purpose of the Project has been generally achieved.

3.3.1 Reduction of the Probability of Landslide Occurrence

In the Project, reduction of the probability of landslide occurrence will be achieved by (i) lowering groundwater level at the time of rain by evacuating groundwater, which is a causal factor

[10] The effectiveness is rated in consideration of not only the effects but also the impacts.

for instability of landslides, through construction of catchment wells and canals, and by (ii) changing the balance of sliding and friction forces of landslide blocks through soil removal and embankment works.

As for the 10 catchment wells, during the field survey, it was observed that they were properly functioning and collecting groundwater. Open canals also appeared to be functioning without any problems. According to the data of the groundwater level gauges installed at four locations in the two sites, the groundwater level in the two sites declined by an average of 3.8m compared to the preconstruction level and the actual decline exceeded the planned 5m at the two locations. Such declines of the groundwater level are believed to have contributed to stabilizing landslide blocks.[11] Both the soil removal works and embankment works in the two sites are found to be functioning well with proper maintenance and no topographical deformation affecting the landslide risk is observed.[12] In contrast, in El Reparto, there is a high possibility of inflow of household waste water from a large settlement at the top of the slope into the groundwater, not being caught by the open canals. The incursion of oil into the catchment wells has also been reported. It can be pointed out that there is a possibility that such inflow of household waste water affects the groundwater level, increasing the risk of landslide occurrence.

Monitoring data from the extensometers and borehole inclinometers installed at the two sites indicate that no specific movements have been detected since the completion of the Project at the landslide blocks targeted for landslide prevention by the Project. Therefore, it is safe to judge that the expected effects of the Project regarding reduction of the risk of landslide occurrence has largely been achieved, as the landslide prevention facilities introduced under the Project are adequately functioning in general and believed to have stabilized the targeted landslide blocks.[13]

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[11] Recalculation of the safety factor (ratio between the sliding force and friction force: a larger value indicates a higher level of the stability of a landslide block) was made in consideration of the actual decline of the groundwater level at El Reparto, for which information on the safety factor calculation process in the Preparatory Study was obtained. The recalculated safety factor was 1.18 which exceeded the planned safety factor of 1.15. No similar recalculation was possible for El Berrinche as the calculation process employed at the time of planning was unknown, while, as the decline of the groundwater level has not reached 5 m in this area, the actual safety factor is inferred to be below the planned level. In the Preparatory Study, safety factor was considered as a quantitative indicator for effectiveness of the Project. However, in this report, only the ground water level was referred in the main text, but not the safety factor, considering that (i) safety factor itself is not measurable on site, (ii) re-calculation based on declined ground water level was possible only for El Reparto, and (iii) decline in ground water level is directly related with an increase of the safety factor.

[12] Since Municipality of Tegucigalpa declared the two areas as non-habitable zone, no illegal settlement has taken place at the landslide sites in the two areas. In El Berrinche, those neighbouring residents who cooperate for maintenance of the landslide prevention facilities cultivate maize, pulses, etc. at the site with a consent of the Municipality. In El Reparto, such neighbouring residents also cultivate crops and graze livestock. No irrigation is conducted in either sites and there is no danger of reactivation of landslide due to cultivation or grazing.

[13] Scope of the Project was designed to prevent reactivation of landslide with the equivalent level of rainfall by Hurricane Mitch. However, no heavy rainfall comparable to that of Hurricane Mitch has been recorded since the completion of the Project to the time of the ex-post evaluation. Therefore, there is a possibility that landslide may be reactivated due to an earthquake or exceptional rainfall in the future, and it does not mean that the Project has completely nullified the risk of landslide. Moreover, according to CODEM, very slow movement in response to rainfall has been observed at the landslide block which has been newly discovered in El Berrinche and where only monitoring equipment was installed. As the movement observed does not affect the entire landslide, however, this movement is not considered dangerous.

3.3.2 Reduction of the Risk of Damages When a Landslide Occurs

Reduction of the risk of damage when a landslide occurs will be achieved by appropriate evacuation of residents based on early warnings issued according to the results of landslide monitoring.

(1) Landslide Monitoring

A range of monitoring devices (borehole inclinometers, groundwater level gauges, extensometers and rain gauges) installed in the two sites of the Project have been properly functioning and continuous monitoring is carried out.[14] After completion of the Project, during the period from 2015 to 2016, in accordance with the advice of a succeeding technical cooperation (dispatch of experts) entitled "Assistance for Strengthening and Capacity Building of Professional Techniques for the Control and Mitigation of Landslides in the Tegucigalpa Metropolitan Area" (hereinafter referred to as "the succeeding technical cooperation") based on the monitoring results up to that point and in view of more effective monitoring, location of two extensometers was changed and the span of one of them was extended from 10m to 20m. While extensometers and rain gauges in both sites and one water gauge for observation of groundwater in El Reparto gather continuous hourly data by automated recording, borehole inclinometers in both sites and underground water gauges in El Berrinche do not provide continuous data because of their manual measurement operation by the staff in charge on-site. Based on the guidelines prepared under the Project for landslide monitoring, the manual measurement of the groundwater level by visiting officials is planned twice a month as standard practice, and to be performed as required after each heavy rainfall. The guidelines also plan an acquisition of data at each observation station to take place twice a week. According to CODEM, however, frequency of manual measurement and visits to observation stations has been roughly half of the plan due to constraints imposed by the limited number of vehicles and personnel.[15]

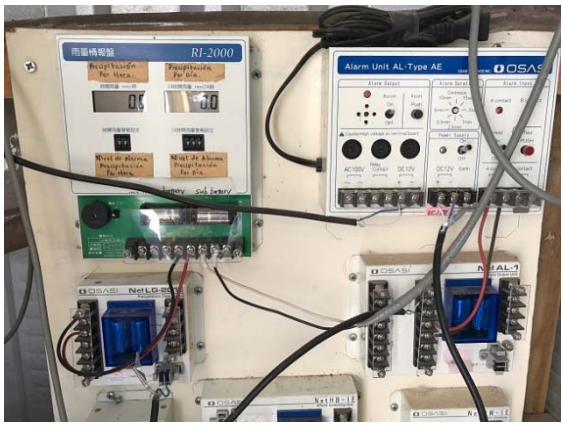
The monitoring results are made into graphs using a dedicated software. After a simple analysis, they are compiled into a monitoring report prepared every six months. This report also includes the results of and necessity for maintenance works.

As described above, although the frequency of data acquisition by manual measurement and from observation stations is not often, CODEM has been independently conducting the operation of monitoring equipment and data collection / analysis. It is, therefore, judged that the landslide monitoring envisaged by the Project has been implemented generally in an appropriate manner.

[14] Excludes an inclinometer in one borehole which was rendered unusable because a stone was dropped (see the section on sustainability). As a borehole inclinometer monitors movement inside a landslide block, its inoperability does affect the monitoring but not the risk of the targeted landslide block.

[15] Even if the acquisition of data from the observation stations is less frequent, the data itself is accumulated through the automated recording function and there should be no missing data.

Extensometer (El Reparto)



Inside of the observation station (El Reparto)

(2) Early Warning and Evacuation System

Each observation station established at a cooperating household in the two areas is accompanied by a warning system (siren) which issues warnings based on the observation results of rain gauges and extensometers. An alarm is sounded when the rainfall intensity reaches 10mm/hr or 100mm/day or more, or any extensometer records a movement of 2mm/hr or more. These reference values were suggested by the consultant in charge of the soft component of the Project.[16] So far, erroneous sounding has occurred when an extensometer has been touched by an animal or other but the alarm has not sounded due to rainfall or movement of landslide blocks. Whenever an alarm sounds regardless of there being a genuine or erroneous cause, the cooperating household immediately reports it to CODEM to trigger a visit by staff members to the site in question. As part of the soft component, proposals were made concerning appropriate procedures for (i) judgement of whether an alarm is erroneous or genuine, (ii) conducting on-site monitoring (identification of precursory phenomena) when a landslide risk is confirmed, and (iii) judgement on evacuation and cancellation of an alert. These procedures have been adhered to as proposed.

There is a total of five community disaster management organizations in the two areas, all of which were organized in 2010 after training assisted by GOAL (an international NGO established in 1977) and US Agency for International Development (USAID). Senior members of two of these organizations participated in the training for the soft component of the Project but neither the preparation of a hazard map / an emergency plan nor evacuation drill with resident participation took place within the scope of the Project.[17] There is regular telephone

[16] According to the expert who conducted the detailed analysis, these reference values are set based on international experience, including that of Japan, and the situation of past disaster cases in the two targeted districts, and they are considered to be appropriate as initial reference values. However, more precise and customized reference values for each landslide block is possible in the future by establishing the relationship between rainfall intensity and movement of landslide block for each site based on continuous monitoring. While, it must be noted that these sirens were not installed assuming to directly convey warning messages to nearby residents.

[17] According to the results of interviews with CODEM, after the completion of the Project, the GOAL / USAID conducted a landslide evacuation drill in El Berrinche in 2014 while the GOAL and COPECO jointly conducted an earthquake evacuation drill in El Reparto in the same year. In 2016, the COPECO organized a training session for all the community disaster management organizations in the city, including those in the two areas, and a football

communication regarding disaster prevention between CODEM and the five community disaster management organizations. Given the facts that staff members of CODEM periodically visit the cooperating households with the installed observation station for data gathering and that there is also cooperation between CODEM and resident groups entrusted with security and maintenance works, it is fair to say that there is a firmly established communication and coordination between CODEM and each community disaster management organization.

On the other hand, the beneficiary survey found that 95% of the respondents had no experience of participating in a disaster management seminar, training or drill. Only 16% responded that they would obtain information on disaster management from the community disaster management organization and half of the respondents said that they did not even know of the existence of such an organization. Moreover, only half of the respondents were judged to have adequate knowledge of disaster risk and evacuation.[18] It appears that many residents judge the level of risk and necessity for evacuation at the time of heavy rain based on their past experiences of disaster. 70% of the residents understand the purpose of the Project but only 56% understand its functions (stabilization of landslide through evacuation of groundwater, landslide monitoring, etc.).

Based on the above, while the alarm and evacuation system operated by CODEM and five community disaster management organizations based on the early warning system installed under the Project is judged to be functioning, dissemination of information to residents is not sufficient.

3.4 Impacts

3.4.1 Intended Impacts

Overall goal of the Project is "promotion of landslide prevention measures in the metropolitan area". The Project was expected to play a pioneering role as a model case for landslide prevention for other landslide risk areas of Tegucigalpa. In this context, the following impacts of the Project can be pointed out.

(1) Promotion of landslide prevention for other landslide risk areas in Tegucigalpa

The Municipality of Tegucigalpa has identified a total of 22 landslide risk areas that require landslide prevention measures. Other than El Berrinche and El Reparto where landslide prevention measures were introduced by the Project, introduction of structural measures has made little progress in other areas except for El Bambú and Ulloa where minor works have been conducted for landslide prevention as described below.

ground on the embankment works constructed by the Project in El Berrinche was used for some of the training activities.

[18] These judgements were made by the surveyors based on the responses to the questionnaire survey.

- El Bambú was originally included in the scope of the Project along with El Berrinche and El Reparto. However, an active movement of one landslide block observed during the Preparatory Study led to the judgement that it would be difficult to realize permanent control works. As a result, El Bambú was excluded from the scope of the Project, and a basic concept for emergency measures consisting of canals and embankment works was presented as part of the Preparatory Study. In subsequent years, the Municipality of Tegucigalpa constructed the canals and embankments ("Landslide Control Works in El Bambú", 2013) utilizing the assistance of JICA (counterpart fund for non-project grant aid cooperation). According to CODEM, landslide movement in this district has been relatively stable although movement has not completely stopped.

- In Ulloa, there are some 2,500 households in the landslide risk area. In this area, GOAL has installed a monitoring system with USAID funding to observe (manually) the groundwater level and to monitor any damage (cracks) to houses, along with construction of canals, resettlement of some residents and introduction of a warning and evacuation system based on rain gauges run by community disaster management organizations.

- In some other landslide risk areas, retaining walls and construction of evacuation roads were implemented with the assistance of the Central American Bank for Economic Integration (CABEI) and Germany. However, there has been no case in these areas of the construction of catchment wells or large-scale soil removal and embankment works or horizontal boring works like the Project.

Reasons for the slow progress of the implementation of structural measures include (i) the financial restriction which makes such implementation rely on external aid and the fact that (ii) it is difficult to find relocation sites for those households living on a landslide block as there are little well-located land appropriate for living in the metropolitan area. In the case of Ulloa, for example, only some 30 households out of 1,000 households which need relocation have been relocated so far because of the lack of suitable relocation sites. On the other hand, at present, detailed surveys of each area for planning structural measures are being carried out slowly with an assistance of JICA and others. According to the stakeholders in Honduras, the consultant for the Project and the experts worked for the succeeding technical cooperation, there is little prospect of implementing catchment wells, which was employed by the Project, being introduced in other landslide risk areas of Tegucigalpa because of their huge construction cost and high level of technical difficulty. Even if some structural measures are to be introduced in the coming years, it is likely that such measures will be limited to open canals, horizontal boring works, soil removal and embankment works as they are relatively low cost and easily constructed.

As far as non-structural measures (development of a landslide monitoring system and early

warning / evacuation system) are concerned, a monitoring system consisting of two extensometers and two rain gauges was established under the succeeding technical cooperation. In addition, Municipality of Tegucigalpa plans to install such monitoring equipment as rain gauges, inclinometers and others with an assistance of CABEI for the purpose of clarifying the relationship between rainfall and landslides, improving the warning and evacuation system and studying feasible control works, focusing on eight landslide risk areas other than the two areas of the Project and El Bambú. Furthermore, CODEM has distributed 32 simple rain gauges to community disaster management organizations in 16 landslide risk areas and has established a mechanism whereby CODEM maintains contact with these organizations as required at the time of rain with a view to issuing a warning when the rain intensity exceeds a set threshold.

As described above, landslide prevention in Tegucigalpa has been making gradual progress and the Project can be said to have constituted the starting point for the promotion of the implementation of landslide prevention in the city.

(2) Capacity building of organizations related to landslide prevention

Technical capacity to implement landslide prevention measures is being strengthened in Municipality of Tegucigalpa due to the consolidation of municipal units related to disaster management assisted by the succeeding technical cooperation (See Box 2). Apart from CODEM which is responsible for operation and maintenance of the Project, Municipality of Tegucigalpa also has a Risk Assessment Unit which prepares risk maps and conducts risk assessment with site visits, etc. in proceeding building permit applications in order to prevent inappropriate construction in disaster risk areas. In 2014 after the completion of the Project, Municipal Unit for Integrated Risk Management was established under the direct control of the Mayor as an organization to provide technical support for the municipality's disaster management efforts.[19]

The Project realized the first full-scale landslide prevention measures in Municipality of Tegucigalpa. Tegucigalpa acquired basic knowledge and practical experience to implement landslide prevention measures in a concrete manner through the Preparatory Study, construction of various structures, installation of a monitoring system and their operation and maintenance under the Project. After completion of the Project, JICA through the succeeding technical cooperation provided (i) advices on the organizational development of the Municipality for landslide prevention, (ii) technology transfer regarding compilation of a landslide ledger, (iii) technology transfer regarding operation and maintenance of the landslide prevention facilities and the monitoring equipment installed under the Project, and (iv) advices on collaboration with the National Autonomous University of Honduras. Even though there are some technical issues that

[19] This Unit has five civil engineers of which four completed the disaster prevention officer training program organized by COPECO. Weekly training took place for one and a half years. There is a total of 80 disaster prevention officers nationwide.

may require assistance by external experts, such as enhancement of technical capacity for analysing monitoring data, improvement and strengthening of monitoring system and improvement of early warning and evacuation system, Municipality of Tegucigalpa is believed to be strengthening its technical capability to deal with landslide prevention. The Project has made a major contribution in this context as it constituted the starting point for the capacity building of the Municipality for landslide prevention.

For the implementation of the Project, the Joint Coordination Committee chaired by Municipality of Tegucigalpa with the participation of other stakeholder organizations (Ministry of Public Works, Transportation and Housing, Ministry of External Planning and Cooperation, Ministry of Natural Resources and Environment and COPECO) was established and staff members of these organizations participated in the training held as a soft component of the Project. In this ex-post evaluation, interviews were conducted at the Ministry of Public Works, Transportation and Housing and the Ministry of Natural Resources and Environment, but it was not possible to verify the direct impact of the Project on capacity building due to the fact that those staff members participating in the Project have since changed positions. In the case of COPECO, the Project is believed to have achieved indirect capacity building as a person who was closely involved in the preparatory and implementation stages of the Project as a staff member of the CODEM subsequently became responsible for the metropolitan area at COPECO.

As the landslide control works introduced under the Project were unprecedented in Central and Latin America, they have been visited by researchers, engineers and students of Honduras and other countries. The football field in El Berrinche which was constructed as part of the project facilities was used as a venue for the training organized by COPECO etc. for community disaster management organizations. Interviews with organizations related to disaster prevention (COPECO and CODEM) and researchers of universities found that opportunities for people to visit concrete landslide control works has greatly contributed to education and enlightenment. As such, the Project has important demonstration as well as educational effects.

Box 2

Summary of an Expert Analysis (2): Relationship with JICA's Other Cooperation Regarding Landslides

Hiroshi Fukuoka (Director of the Research Institute for Natural Hazards & Disaster Recovery, Niigata University, Professor)

The Project was implemented as a priority project which was selected based on the master plan formulated by JICA's "Study to Plan Urgent Flood and Landslide Control Measures in the Tegucigalpa Metropolitan Area" (Development Study; 2001 – 2002). The landslide hazard map compiled under this Study visually presented an entire picture of landslide risk areas in Tegucigalpa for the first time, providing a momentum for institutionalization of land use restrictions. One reason for the selection of the two targeted sites of the Project and El Bambú as targets for the priority project was that the number of households to be resettled was rather

small in comparison with the expected scale of damage. This selection can be considered as valid in view of the fact that resettlement has not made much progress in other landslide risk areas. As for flood control measures and non-structural measures, it has been 15 years since the proposal was made. Such measures have been being gradually implemented or in preparation for implementation by Municipality of Tegucigalpa and COPECO, even though the original plan has not been exactly followed. In the light of the above, it is fair to say that the directions proposed by the master plan was generally appropriate.

JICA implemented the "Project on Capacity Development for Disaster Risk Management in Central America – BOSAI (Phase 1)" from 2007 to 2012 for the purpose of strengthening community disaster management led by local governments and community disaster management organizations, and is currently implementing the Phase 2 of this project for the planned period of 2015 to 2020. The areas targeted by these Phase 1 and 2 projects differ from those of the Project and the counterpart personnel of the Phase 1 have gradually left CODEM. As such, there is only limited collaboration between the BOSAI projects and the Project.

Since the commencement of the Project, JICA has conducted capacity development concerning landslide control measures, including strengthening of linkage between universities / research institutes and the government, through "Hazard geology focusing on the landslides in Tegucigalpa (Dispatch of Science and Technology Researchers; 2012 – 2014)" and "Assistance for Strengthening and Capacity Building of Professional Techniques for the Control and Mitigation of Landslides in Tegucigalpa Metropolitan Area (Dispatch of Experts: 2015 – 2016)". Even though collaboration between universities/research institutes and the municipal administration has unsolved issues, cooperation with academic community is essential for development and inheritance of landslide prevention technologies in Honduras. It is, therefore, imperative to seek more appropriate forms of cooperation in future.

3.4.2 Other Positive and Negative Impacts

(1) Impacts on natural environment

The Project aimed at stabilizing landslide blocks and reducing the impacts of landslides on natural environment. An environmental permission (building permission) for the Project was issued by the Tegucigalpa city. An environmental mitigation plan was prepared and carried out during construction. According to Municipality of Tegucigalpa, no major environmental impacts were confirmed neither during nor after the construction. In the two targeted areas, cherry trees were planted at the expense of the contractor for the greening along with the implementation of landslide control works. However, hardly any of these cherry trees now survive due to damage caused by the grazing of animals and the lack of watering and other care.

(2) Land acquisition and resettlement

Land for the Project was acquired in El Reparto from absentee landowners prior to the commencement of the construction. No problems were encountered with the acquisition of land. Nine households in El Reparto were resettled. According to CODEM official in charge of this resettlement at the time, it was not socially a simple process as many of the residents did not agree with resettlement. However, the actual resettlement took place without problems with the assistance of GOAL (NGO) which had been involved in the fostering of community disaster

management organizations in the two areas. Because of the change of municipal administration, it was not possible to obtain detailed information on the resettlement process and compensation.

(3) Socioeconomic impacts on the target area

The Project is expected to reduce landslide damages in the two areas but there has been no concrete case to verify the damage reduction effect of the control works, because, to date, there have been no heavy rainfall comparable to that caused damage (Hurricane Mitch, 1998).

According to the senior officials of the community disaster management organizations in the two areas, residents have undergone such psychological changes as "now we can sleep with peace of mind" and "no need to worry about resettlement or evacuation any more". Other impacts have also been reported, including increased investment in housing, increase of land and house prices and return of some residents who moved to other areas after the landslide caused by Hurricane Mitch. Moreover, it has been pointed out that the frequency of road cracks and spring water incidents at the time of rain in the surrounding area has declined since the implementation of the Project. These phenomena may suggest impacts of the Project but are difficult to verify in a concrete manner.

The beneficiary survey found such opinions as "elimination of the risk has led to peace of mind" (59% of the respondents) and "life is more convenient due to the access road constructed under the Project" (24%). However, it must be noted that the principal interests of daily life of local residents of the two areas are the development of sewerage, improvement of public security, improvement of roads and traffic and increase of income. The priority of disaster prevention generally ranks low.

(4) Regional impact concerning the dissemination of landslide prevention measures

With an assistance of JICA, the first and second Central America and Caribbean Landslide Conference was held in Tegucigalpa in March 2013 and July 2016 respectively. During these conferences, presentations on the Project and site visits were made.[20] Moreover, the Project was introduced at the Central American Regional Conference of the Centre of Coordination for the Prevention of Natural Disasters in Central America (CEPREDENAC) held in Tegucigalpa in March 2017. As described above, the Project has been introduced at international conferences held in Tegucigalpa to other Latin American countries, contributing to the dissemination of

[20] At the first conference, 20 research presentations were made by 12 countries. The conference which lasted for four days was attended by some 100 people. At the second conference, 43 presentations were made by universities, research institutes and such administrative organizations as the Central American Integration System (SICA: *Sistema de la Integración Centroamericana*) and Centre of Coordination for the Prevention of Natural Disasters in Central America (CEPREENAC: *Centro de Coordinación para la Prevención de los Desastres Naturales en América Central*) in 12 countries (Honduras, Germany, Argentina, Colombia, Mexico, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Cuba and Japan). This conference lasted for three days and was attended by some 220 people.

landslide prevention measures.

Through its implementation, the Project has largely achieved its objectives. Therefore, the effectiveness and impact of the Project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

Municipality of Tegucigalpa established Municipal Unit for Integrated Risk Management in 2014 to centralise disaster management and coordinate all of the relevant units. This unit is the final decision-making body concerning the disaster management making both technical and administrative judgements. Its staff strength has gradually increased to six (of which five are civil engineers) as of February 2017. It is in a position of providing technical advice for operation and maintenance of the Project. In addition to this unit, the Municipality has other organizations related to disaster management such as Risk Assessment Unit and CODEM.

The Risk Assessment Unit has two civil engineers and conducts risk assessment by means of risk maps and field visits for building permission applications in order to prevent inappropriate construction in disaster risk areas.

The main business of CODEM is to respond to disaster-related emergencies. It deals with forest fires in dry season and landslides and flooding in rainy season in accordance with the procedures stipulated in the emergency response manual. It issues early warnings and conducts emergency response through communication and coordination with such relevant public bodies as COPECO and other ministries concerned as well as community disaster management organizations. It also provides training and equipment for the community disaster management organizations. As it is also in charge of maintenance of disaster prevention works, it conducts regular monitoring and maintenance of the facilities introduced by the Project. As of February 2017, it has 49 staff members of which 11 have a bachelor's degree or higher. However, it does not have any civil engineers.

Of the staff members of CODEM, 10 belonging to the section responsible for early warning and risk management are in charge of operation and maintenance of the Project. As all of these 10 staff members have other assignments, however, the staff strength of this section is insufficient. CODEM has four vehicles, while all of them require renewal in view of their deterioration. In addition, the number of vehicles is insufficient at the time of an emergency. In the case where monitoring of other landslide sites begins in the future, the current organizational set-up will find it difficult to deal with new demands, most likely making it necessary to establish a dedicated monitoring section.

In the two sites targeted by the Project, while the security service for the new facilities was originally contracted to a private security company, the poor public security in these districts led

to incidents of assault against the security guards who were outsiders. Following the change of the mayor in subsequent years, this contract came to an end. The new mayor has concluded a security and cleaning contract with a small company established by several residents (including a member of the community disaster management organization). For major cleaning and repair works before and after the rainy season, paid-for cooperation of other residents is also obtained.

As described above, institutional arrangement for disaster prevention in Municipality Tegucigalpa has gradually improved and there are no major problems regarding institutional aspect of operation and maintenance of the Project. However, manpower and vehicles assigned by CODEM to Project-related works are not necessarily sufficient and establishment of a dedicated section with appropriate human resources and vehicles is believed to be necessary when monitoring of other landslide sites begins in the future.

3.5.2 Technical Aspects of Operation and Maintenance

Staff members of CODEM who are responsible for operation and maintenance have obtained sufficient knowledge, through the training organized as part of the soft component, on operation and maintenance of the landslide prevention facilities as well as monitoring equipment and gathering of monitoring data. They are also very familiar with the handling of data retrieval equipment (network controller) and analytical software. Even though some of them have left their positions since the completion of the Project, key members remain and conduct operation and maintenance of the said facilities without any problems as routine works based on manuals. *The Maintenance Guidelines for Landslide Prevention Facilities* and *Monitoring Guide of Landslide* produced under the soft component have been used. In the succeeding technical cooperation, a much more detailed operation and maintenance manual was prepared in addition to the above and practical training was conducted on monitoring data compilation and analysis.

Monitoring reports compiled by CODEM presents monitoring data and basic analysis. CODEM is capable of conducting inclinometer installation work without external help and also of providing guidance on this work.[21] However, CODEM still has room for improvement regarding the flexible use of analytical methods in response to the quality of data (for extensometers), analysis of small sliding quantity at the sliding face (for borehole inclinometers) and correlation analysis between the rainfall intensity and displacement of landslide blocks (based on rain gauges and extensometers). Also, there are restrictions on data and analysis software.[22] Deformations of open canals are recorded for the purpose of conducting repair work, but there is no mechanism to utilize such information, in combination with the records of slope deformation

[21] In the training organized by JICA on the prevention of road disasters for the Ministry of Public Works, Transportation and Housing, one CODEM staff member was invited to lecture at a session featuring landslide monitoring.

[22] Measurement by CODEM is not for continuous data as manual ground water gauges are used. In addition, it is not frequent due to its limited manpower / vehicles. While the acquired data from observation stations is analysed using a dedicated software, it is not convenient because the data recorded by other equipment cannot be incorporated.

(cracks and rock falls from a sliding cliff), to analyse movement of landslide in a systematic manner.

Municipal Unit for Integrated Risk Management of Tegucigalpa which provides technical assistance for CODEM has civil engineers. However, none of them is a landslide specialist.

Based on the above, Municipality of Tegucigalpa is judged to generally possess adequate technical capability concerning operation and maintenance of the Project. However, in order to further enhance landslide prevention, it would be necessary to acquire more advanced professional capability concerning analysis of monitoring data and landslide study, otherwise to establish cooperation with universities or other organizations that have a high level of expertise.

3.5.3 Financial Aspects of Operation and Maintenance

Budget scale of Municipality of Tegucigalpa in 2016 was some 5.1 billion lempira (approximately 2.4 billion yen), of which some 2.9 billion lempira (approximately 1.4 billion yen) was earmarked for investment in public works, recording an almost double increase of the municipal budget in four years. According to CODEM, new mayor is proactive in disaster prevention projects. As for the project to improve Choluteca River which caused massive damage at the time of Hurricane Mitch, detailed design has been completed and it is scheduled for gradual implementation in phases. In the past, construction of retaining walls to control cliff collapse used to be considered only after a relevant request had been submitted by residents. In contrast, present practice is for the Municipality to take initiative in disaster prevention projects even though no requests are received.

Table 2 Transition of Expenditure of the Tegucigalpa City

(Unit: million lempira)

	2013	2014	2015	2016
Operating Expenses	957	978	865	912
Personnel Cost	699	773	678	725
Goods and Services	244	185	167	162
Others	14	20	20	25
Others	1,603	1,493	2,136	4,216
Investment	680	633	1,169	2,894
Transfer	75	85	88	119
Public Bonds	843	774	879	1,203
Others	5	1	0	0
Total	2,560	2,471	3,001	5,128

Source: Municipality of Tegucigalpa
Note: 1 yen = 0.21 lempira (April, 2017)

According to CODEM, 400,000 lempira was allocated for operation and maintenance of the Project in 2016. This figure was more than the estimate (80,000 – 350,000 lempira/year) at the

time of the Preparatory Study. A range of equipment required for operation and maintenance has been procured and there are reserve batteries, extensometer wire (invar wire), etc. in stock. For 2017, it is expected to receive more funding than the amount for 2016.

Based on the above, there are no significant constraints regarding the financial aspects of operation and maintenance of the Project.

3.5.4 Current Status of Operation and Maintenance

CODEM conducts regular inspection of the facilities twice a year, i.e. before and after rainy season. Based on the results of these inspections, it conducts cleaning and repair works. Any damage visually detected on the canals and other facilities is repaired. Functional state of the catchment wells is judged based on groundwater level monitoring. It is assessed based on groundwater level and amount of groundwater collected, and if it is considered necessary, maintenance works such as cleaning of the collecting pipes using a high-pressure cleaning equipment are carried out in order to maintain their function. At the time of heavy rain, ad hoc cleaning may be conducted. During the field survey, some rubbish was observed in open canals, for which CODEM carry out cleaning, inspection and repair twice a year before and after the rainy season. The field survey confirmed that the landslide prevention facilities introduced under the Project were functioning properly without any major damages.

In general, all of the monitoring equipment are found to be steadily functioning.[23] Because of the poor public security in the two targeted areas, there have been several incidents of theft of the data cable between the monitoring devices to the observation station as well as the wire of extensometers. The extensometers, the groundwater gauges and the borehole pipes for groundwater gauges and inclinometers are protected by brick walls and an iron lid, being locked up for their protection from theft, malicious damage or interference with their functioning. The catchment wells are protected by a locked wire fence for the same purpose.

No major problems have been observed in regard to the institutional, technical and financial aspects of the operation and maintenance of the Project and, therefore, the sustainability of the project effects is high. However, further progress of landslide prevention measures would require the strengthening of personnel and vehicles and also more advanced professional capability of personnel for the future.

[23] Protection of the borehole pipe of one inclinometer was insufficient and the pipe was rendered unusable by a stone thrown in it. It is difficult for CODEM to repair or install a new pipe by itself as the material is to be imported.

4. Conclusions, Recommendations and Lessons Learned

4.1 Conclusion

The Project was implemented to mitigate the risk of landslide disaster in El Berrinche and El Reparto of Tegucigalpa by means of constructing landslide prevention facilities and developing a landslide monitoring system and an early warning and evacuation system, thereby contributing to promotion of landslide prevention in the Tegucigalpa metropolitan area. The Government of Honduras has consistently made conscious efforts regarding disaster management and there is a strong necessity in Tegucigalpa for disaster prevention targeting landslides and floods. The Project was relevant to Japan's ODA policy at the time of its planning and, therefore, the relevance of the Project is high. As the project cost was within the planned amount but the project period exceeded the planned period, efficiency of the Project is fair. Landslide prevention facilities introduced by the Project have been functioning properly and the targeted landslide blocks have been stabilized. Although the information dissemination to nearby residents has not been sufficient, landslide monitoring continues and an early warning system operated by CODEM and community disaster management organizations is functioning in the two targeted sites. Technical capability of the Municipality of Tegucigalpa to handle landslide prevention measures is being strengthened but the application of these measures in the metropolitan area is limited. While the concrete achievement of the new facilities to mitigate disaster damages cannot be verified because there has been no heavy rain since the completion of the Project, the Project has provided many residents with peace of mind. To summarize, effectiveness and impact of the Project are high. There are no major issues in regard to the institutional, technical and financial aspects of the Project in terms of its sustainability. Taking the good operation and maintenance conditions of the landslide monitoring system and the landslide prevention facilities into consideration, sustainability of the Project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

As part of this ex-post evaluation of the Project, considering also the expert's analysis shown in Box1 and 2, following recommendations are made to the Honduran side.

(1) Enhancement of landslide prevention at El Berrinche

Municipality of Tegucigalpa should tackle the following issues in cooperation with COPECO, universities, research institutes and others, in consideration of the facts that (i) scale of the landslide in El Berrinche is huge and there are more than one landslide blocks, (ii) potential damages due to re-activation of the landslide which may be triggered by an earthquake or exceptionally heavy rain will be very extensive, and (iii) the Project has not eliminated the

landslide risk to zero.

- In order to established a monitoring system that can accurately observe any displacement of the entire landslide site, such measures should be examined as installing a series of linked extensometers covering the entire landslide site from top to bottom and periodic and whole area monitoring using a total station.
- In order to establish the relationship between rainfall intensity, groundwater level and movement of landslide blocks and issue more appropriate warnings based on it, it is necessary to improve the data acquisition and transfer methods and perform further detailed analysis while receiving advice from experts.
- In preparation for an event in which Choluteca River is clogged by reactivated landslide, simulations on the desk should be conducted focusing on emergency responses, including early warning, evacuation and emergency measures to cope with the landslide dam. Results of such simulation should be considered when more effective counter measures are examined.

(2) Strengthening of CODEM's arrangement for operation and maintenance

In order to conduct operation and maintenance of the Project in a more appropriate manner, Municipality of Tegucigalpa should consider strengthening of manpower of the relevant section of CODEM, establishment of a new section dedicated to landslide prevention and renewal/enhancement of vehicles.

(3) Information dissemination to the residents near landslide risk areas

Retraining of the members of community disaster management organizations and information dissemination to residents are required in order to strengthen early warning and evacuation system by community disaster management organizations in the two targeted areas of the Project. Municipality of Tegucigalpa should examine and implement appropriate activities, including evacuation drills with the participation of residents, study visits to landslide prevention facilities and disaster management fairs.

(4) Containment of inflow of household waste water to the landslide

In El Reparto, groundwater collected by catchment wells contains much household waste water. It is inferred that household waste water not caught by the open canals flows into groundwater from a major settlement located at the upper part of the slope. In the neighbouring Nueva Santa Rosa, reactivation of landslide has been observed at a slope and this movement may well be caused by the infiltration of household waste water as a result of urban development. It is desirable to contain such infiltration of household waste water to landslides by means of

developing a sewerage system even though gradually.

(5) Fostering of landslide experts

Fostering of landslide experts to ensure the domestic existence of the professional skills required by the administration is an important long-term issue to be tackled by Honduras in view of promoting landslide prevention. The Government of Honduras (COPECO, Ministry of Public Works, Transportation and Housing and other ministries), university research institutes (National Autonomous University of Honduras and Engineering Polytechnic University of Honduras) and Municipality of Tegucigalpa should establish appropriate cooperation to foster and utilize landslide experts. As short to medium-term measures, exchanges with and technical assistance from the organizations specialized on landslides in Japan and other countries should be also examined.

4.2.2 Recommendations to JICA

JICA should examine possibility of providing relevant assistance through technical cooperation in order to facilitate implementation of the above recommendations.

4.3 Lessons Learned

Provision of reference materials obtainable at construction stage

If there is an opportunity to obtain important reference materials at the construction stage of a facility construction project which introduce new technologies, conscious efforts should be made to preserve such materials by means of clearly indicating it in the scope of works for the construction contract, so that the obtained reference materials can be provided to the recipient country for technology transfer. In the case of the Project, cross-sectional photographs to be taken during construction of catchment wells, soil samples of sliding faces and data on groundwater level were not preserved. Despite their importance, they could not be offered to the Honduran side.

END