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Republic of Benin

FY2021 External Ex-post Evaluation Report of
Grant Aid Project
"Project for Access Improvement to Drinking Water in Two Communes,
Glazoue and Dassa-Zoume"

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0. Summary

The project aimed to increase water consumption in the target area by developing new water sources and constructing water supply facilities in Glazoue and Dassa-Zoume in the Republic of Benin. The project was consistent with Benin's urban water supply development policy and their development needs from the planning to the ex-post evaluation, of which the plans and approaches were appropriate. Considering the project is consistent with Japan's development policy and has been appropriately coordinated with other donors' projects with confirmed outcomes, the relevance and consistency have been highly assured. The efficiency is high because the output was almost as planned, the cost was within the plan, and the project period was kept slightly longer than planned. Regarding the effectiveness, neither city achieved the planned targets set by the project for "daily water withdrawal." This project indicator was not secured as planned due to a reduction in the groundwater level. Although the amount of water withdrawal in both cities increased compared to the plan, the amount of water supplied per capita decreased compared to the plan due to a significant increase in the number of individual hydrant subscribers and the population supplied with water. The project has been confirmed effective for reducing water fetching activities among children and women for households connected to individual hydrants after the project. Regarding the impact, the improvement of the sanitary conditions in the community and a decrease in the incidence of water-borne diseases have not been confirmed while the project's contribution to promoting women's participation in socio-economic activities through reducing the hours of water fetching activities was limited. Therefore, the empowerment of women was not confirmed. Project effects were confirmed for the improvement of children's school enrollment. Based on the above, the effectiveness and impacts of the project are moderately low.

Although slight issues have been observed in the financial aspects, including the status of the operation and maintenance system, there are good prospects for improvement/resolution.

Therefore, the sustainability of the project effects is high.

Based on the above, this project is evaluated to be satisfactory.

1. Project Description

Project Locations Map
City of Dassa-Zoume and Glazoue
(Source: Prepared by the evaluator)

Water Source Facility
at Dessa-Zoume (3-SE8)
(Photo taken by the evaluator)

1.1 Background

Benin is a country in West Africa facing the Gulf of Guinea. At the time of planning, the country's Gross National Income (GNI) per capita was $810 (World Bank, 2014), and its Human Development Index was 165th out of 187 countries (UNDP, 2013) under such harsh socioeconomic circumstances. Access to safe water was one of the country's major social issues in this socio-economic context. The country's national development plan was *Growth Strategy for Poverty Reduction (2011–2015)* (*Stratégie de Croissance pour la Réduction de la Pauvreté*), hereafter referred to as *SCRP.* The basic policy in the *SCRP* was to "improve the livelihoods of the people and achieve the Millennium Development Goals," and "improving access to safe water" was a priority issue. The national water supply rate in Benin was 57% in 1990 and 78% in 2015 (UNICEF). Although there was a significant improvement over five years, regional disparities remained an issue. *The National Action Plan for Integrated Water Resources Management* (2006–2015) (*Plan D'action National De Gestion Integree Des Ressources En Eau*), which was developed as an urban water supply policy, set a target of an urban water supply rate of 75% by 2015.

The water supply rates in the project's target areas, the cities of Glazoue and Dassa-Zoume, were 47% and 58%, respectively (Société Nationale des eaux du Bénin [SONEB], 2013). The water supply rates were lower than in other regions, which made accessing safe water difficult. In addition, there were concerns that the water supply situation in both cities would further deteriorate due to increased water demand caused by population growth and decreased water withdrawals from existing water source wells.

Under these circumstances, to improve access to safe water, the Government of Benin requested the Government of Japan to implement the grant aid project that aimed at increasing water supply by developing new water sources and improving water supply facilities.

1.2 Project Outline

To increase the water supply, the project would develop new water sources and construct water supply facilities, such as distribution pipes and elevated water tanks, in Glazoue and Dassa-Zoume in Benin. This would contribute to reducing water-borne diseases, improving the residents' living environment, and reducing water fetching activities.

Grant Limit/Actual Grant Amount	1,071 million/1,008 million
Exchange of Notes Date /Grant Agreement Date	March 2016/March 2016
Executing Agency	National Water Company of Benin
Project Completion	February 2019
Target Area	Dassa-Zoume and Glazoue
Main Contractor	Joint venture between Nissaku Co., Ltd. and Koken Boring Machine Co., Ltd.
Main Consultants	Joint venture between CTI Engineering International Co., Ltd. and Eight-Japan Engineering Consultants Inc.
Preparatory Survey	August 2014–May 2015
Related Projects	(Grant aid) "The Project for Reinforcement of Drinking Water Supply System in Couffo and Plateau Departments" (2021)

2. Outline of the Evaluation Study

2.1 External Evaluator

Ruiko Hino, Foundation for Advanced Studies for International Development

2.2 Duration of Evaluation Study

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

Duration of the Study: November 2021–November 2022

Duration of the Field Study: February 13–March 1, 2022 (first round of field survey)[1]

[1] The second field survey was conducted remotely.

3. Result of the Evaluation (Overall Rating: B[2])

3.1 Relevance/Coherence (Rating:③[3])

3.1.1 Relevance (Rating: ③)

3.1.1.1 Consistency with the Development Plan of the Republic of Benin

The *SCRP*, which was Benin's national development policy at the time of planning, identified "improving access to safe water" as one of the critical issues. In addition, the National Strategy for Urban Water Supply 2006–2015, a development strategy for the urban water supply sector, set a target of a 75% water supply rate in urban areas by 2015.

The succeeding national development policy of the *SCRP,* the *Programme d'Actions du Gouvernement (PAG) 2016–2021* (Government Action Plan 2016–2021), set one of the priority goals to ensure access to safe water for 2.5 million people in rural areas and 2.7 million people in urban areas by 2021, to achieve a water access rate of 100%. The *Programme d'Actions du Gouvernement (PAG) 2021–2026* (*Government Action Plan 2021-2026*) The latest national development strategy at the time of ex-post evaluation, allocates approximately 20% of the total budget to the sector of drinking water supply in urban areas. In addition, the latest national policy for urban water supply, the National Urban Water Supply Strategy 2016–2030 (*Stratégie Nationale de l'Alimentation en Eau Potable en Milieu Urbain et Périurbain 2016–2030*) sets the goal of 100% urban drinking water supply by 2030.

Thus, because ensuring access to safe water for urban residents has been a priority in Benin's national development policy and sectoral strategy from the time of planning to the time of ex-post evaluation, the project is consistent with the national and sectoral policies in Benin.

3.1.1.2 Consistency with the Development Needs of the Republic of Benin

At the time of planning, the water supply rates in the target areas, Dassa-Zoume and Glazoue, were 47% and 58%, respectively (SONEB, 2013), which were lower than the national average of 78% (WHO/UNICEF, 2015). Moreover, the average amount of daily water supply per capita from the urban water supply facilities was very low at10.4 L/person/day in both cities, while the national average was 39.40 L/person/day (SONEB, 2012-2013).[4]

At the ex-post evaluation, the urban water supply rates in Glazoue and Dassa-Zoume were 65.95% and 65.5%, respectively (SONEB questionnaire responses, 2020); however, the National Urban Water Supply Strategy 2016–2030 mentioned that a target of urban water supply rate would be 100%. This means that the need for urban water supply improvement remains high.

From the above, the need for urban water supply improvement in Glazoue and Dassa-

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

[3] ④： Very high, ③:High: ②: Moderately low, ①: Low.

[4] The World Health Organization (WHO) defines the guideline for access to safe water as "the availability of 20 liters of water per person per day within 1 km."

Zoume has been high from the time of planning to the time of ex-post evaluation.

3.1.1.3 Appropriateness of the Project Plan and Approach

Based on the lessons learned from the previous projects, it was decided at the time of planning that (1) seasonal and interannual fluctuations at the groundwater levels would be reflected on the preparatory survey design, (2) a soft component for the procedure of connecting to individual hydrants would be implemented, and (3) the executing agency would monitor the groundwater levels and the connection status of individual hydrants after construction. For (1), a pumping test was conducted again at the time of designing details, and based on the results, the pump to be procured was designed. As a response to (2), the technical assistance was provided to encourage residents to connect their own hydrants through the soft component “Public Awareness/Hygiene Education.” For (3), the technical assistance was provided to the executing agency through the soft component to enable monitoring of groundwater level after the installment of the facilities by the project. As a result, it was confirmed that the executing agency continuously monitored and recorded the groundwater levels at the ex-post evaluation.

From the above, the lessons learned from other projects, which were recognized at the time of planning, were appropriately reflected at the time of planning and implementation.

3.1.2 Coherence (Rating: ③)

3.1.2.1 Consistency with Japan's ODA Policy

At the time of planning, Japan's development cooperation policy for Benin, the Country Assistance Policy for the Republic of Benin (2012), set the basic policy of "supporting sustainable growth and poverty reduction that contributes to the improvement of citizen’s livelihood." The project is in line with this policy.

3.1.2.2 Internal Coherence

At the time of planning and implementing the project, there were no other JICA projects targeting the water supply sector in Benin and no JICA projects in the same target areas. This made it difficult to envision and implement specific linkages with other JICA projects.

However, through planning and implementing the project, which was the first Japanese grant aid for SONEB, the executing agency, knowledge and experience at the time of planning and implementing the Japanese grant aid were accumulated within SONEB. This led to easy facilitation of the planning process for the planned grant aid project, Project to Strengthen Drinking Water Supply Systems in the Kufo and Plateau Departments (Exchange Document Signed in 2021) (JICA Benin Office, interview with SONEB).

3.1.2.3 External Coherence

SONEB has placed the project and other donor projects (KfW,[5] Netherlands, etc.) in Benin's urban water supply development plan of Benin; therefore, urban water supply development is being promoted without duplication among the projects (SONEB questionnaire responses). In addition, JICA Benin Branch regularly participated in donor meetings to share information among donors, which avoided duplicate support, as mentioned above (JICA Benin Branch interview).

The project is consistent with Benin's development policies and development needs. Lessons learned from other projects were appropriately reflected at the time of planning and implementing the project, which shows that the project design and approach were appropriate. The project was also consistent with Japan's development policy. Although it was difficult to collaborate with other JICA projects directly, the project enhanced the executing agency's planning and implementation. It was adequately coordinated with other donors' projects, and promoted the development of Benin's urban water supply. Therefore, its relevance and coherence are high.

3.2 Efficiency (Rating: ③)

3.2.1 Project Outputs

As shown in Table 1, the output of the project was mainly in line with the plan. There were some minor changes, but these were reasonable and did not impair the effectiveness. Some items borne by the Benin side were delayed, such as installing fences at the construction facilities and securing power sources for well pumps and water supply pumps, but they were implemented almost as planned.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The project cost was 1,076 million yen (including 1,008 million yen for the Japanese side and 68 million yen for the Benin side[6]), which was within the plan (95% of the plan, see Table 2).

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[5] KfW has implemented a 7-year urban water supply development project starting in 2018, targeting the de facto capital of Cotonou, Abomey Calavi in Atlantique department, and Seme-Podji and Porto-Novo in Oueme department, with the goal of increasing the number of SONEB hydrants subscribers by 250,000. The main project activities are constructing the wells and expanding the water supply network. The Netherlands has implemented a 3-year urban water supply development project starting in 2020. The project includes constructing new wells in Adjara, renovating existing wells, constructing a water treatment plant, renovating water towers, constructing underground water tanks, and expanding and renewing the water supply network. The project aims to increase the water supply from less than 50 m3/h to 310 m3/h.

[6] 357 million CFA francs; calculated in yen using the average exchange rate for 2016–2019 (578.66 CFA francs/USD, 110.10 JPY/USD).

Table 1 Project Outputs (Planned and Actual)

	Plan		Actual (variance from the plan)	
	Facilities and equipment			
	Glazoue	Dassa Zoume	Glazoue	Dassa Zoume
Water source facilities	2 intake wells (exploratory wells)[7] 2 well pumps (1 × 0.34 m3/min, 1 × 0.1 m3/min)	2 intake wells (exploratory wells)[8] 2 well pumps (0.84 m3/min)	Change of well pump capacity [9] (0.1 m3 to 0.05 m3)	No difference
Raw water supply facilities	Raw water pipe Diameter 150mm × 2.07km Diameter 75mm × 1.01km 1 raw water storage tank (160 m3)	Raw water pipe Diameter 150mm × 0.37km 1 raw water storage tank (210 m3)	No difference	No difference
Disinfection facility	2 dissolution tanks (with agitator) 2 injection facilities	2 dissolution tanks (with agitator) 2 injection facilities	No difference	No difference
Water supply facilities	2 water pumps (0.29 m3/min × 2) Water supply pipe Diameter 150mm × 1.34km	4 water pumps (0.46 m3/min × 2, 0.24 m3/min × 2) Water supply pipe Diameter 200mm × 3.57km Diameter 150mm × 3.66km	No difference	No difference
Water distribution facilities	1 elevated water tank (new installation) (200 m3) Water distribution pipe Diameter 200mm × 0.96km Diameter 150mm × 3.29km	1 elevated water tank (new installation) (300 m3) Water distribution pond (existing) 1 pond (114 m3) Water distribution pipe Diameter 150mm × 1.06km Diameter 200mm × 2.39km	No difference	No difference
Building	1 administrative office 3 generator rooms 1 shade for disinfection equipment	1 administrative office 3 generator rooms 1 shade for disinfection equipment	No difference	No difference
Equipment	2 water quality analysis equipment (for measuring fluorine, pH, electrical conductivity, nitric acid, and residual chlorine) Complete set of water level gauges (2 fixed and 1 portable)	2 water quality analysis equipment (for measuring fluorine, pH, electrical conductivity, nitric acid, and residual chlorine) Complete set of water level gauges (2 fixed and 1 portable)	No difference	No difference
Consulting services (software components)				
	・Strengthen capacity for water intake and water quality control ・Raise awareness of sanitation among residents, etc.		No difference	

(Source: Prepared by evaluator based on materials JICA provided)

[7] The new wells in Glazoue are 7-SE8 (84.3 m depth) and 7-SE10 (52.0 m depth).
[8] The new wells in Dassa-Zoume are 3-SE4 (56.8 m depth) and 3-SE8 (86.0 m depth).
[9] Only one well changed pump capacity.

Table 2 Project Cost Plans and Actuals

(Unit: listed in table)

	Planned Cost (millions of yen)	Actual Cost (millions of yen)	Percentage of Actual Cost to Planned Cost (percentage)
Total Project Cost	1,137	1,076	95%
Japan's Project Cost	1,071	1,008	94%
Benin's Project Cost	66	68	103%

(Source: Prepared by the evaluator based on materials JICA provided and SONEB questionnaire responses)

3.2.2.2 Project Period

The project period was 36 months, from March 2016 to February 2019, which was slightly longer than the plan (116% of plan). Construction of the water supply facilities was completed in July 2018, while the soft component was completed in February 2019.

The project duration exceeded the plan because the supply of lumber for form and form timbering was drastically reduced in Benin. It was difficult to secure the necessary lumber for forming the main frame construction of the elevated water tank and the raw water storage tank, which affected the construction's progress (consultant questionnaire response).

The project's output was in line with the plan, and the project cost was within the plan; however, the project period slightly exceeded the plan.

Therefore, the efficiency of the project is high.

3.3 Effectiveness and Impacts[10] (Rating: ②)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operational and Effect Indicators)

The project's effectiveness indicator is the daily water withdrawal for each city. Table 3 shows the baseline, target, and actual values.

[10] When providing the sub-rating, Effectiveness and Impacts are to be considered together.

Table 3 Operational and Effect Indicators

(Unit: m^3/day)

	Baseline value 2014	Target value 2021	Actual value 2021		(Reference) Actual value (2019–2021 average)	
Glazoue Daily Water Intake	240	590	277	46%	318	53%
Water intake from wells newly constructed during the project	-	350	180	51%	181	51%
Existing well withdrawals	240	240	97	40%	137	57%
Dassa-Zoume Daily water withdrawal	352	1,352	738	54%	911	67%

Source: Ex-ante evaluation table p.3 and SONEB questionnaire responses)
Note: Target water withdrawal is the amount of water withdrawal adjusted to keep fluorine concentration below the water quality standard in Benin (1.5 mg/liter). It is an average value during the dry season (March to May). The measurement points are the water meters at each well.

As shown in Table 3, neither Glazoue nor Dassa-Zoume reached their target values. This is because the groundwater level had dropped, and the water could not be withdrawn at the capacity assumed at the time of planning (actual inspection, interview with SONEB).[11]

The groundwater in the wells that the project constructed is in the unconfined aquifer,[12] and rainfall easily affects the groundwater level. At the time of planning, it was pointed out that if drought occurred or annual rainfall decreased drastically in the areas, the amount of water withdrawal would be limited; thus, the planned water withdrawal might not be secured because of these factors (Preliminary Evaluation Report, p. 3). The executing agency measured the amount of water withdrawal and the groundwater level regularly, which was reflected on the operation plan, and it recovered the groundwater level properly as much as possible. This shows that they suitably dealt with operation for recovering the groundwater level. Therefore, it can be considered that this was caused largely due to external factors. Confirming the amount of rainfall around Dassa-Zoume, wells have not been recharged enough due to inadequate rainfall in 2020 and 2021.[13] In addition, the wells constructed in the project were equipped with wire-wound screens made of stainless steel; however, the screen clogging may have reduced the pumping rate[14] (consultant interviews).

[11] At the defect inspection, a drop in the groundwater level was noted. At well 7-SE10 in Glazoue, the pumping pump was temporarily stopped, and pumping was not possible due to the drop in the groundwater level. During the ex-post evaluation, a significant drop in the water level was confirmed at 3-SE4 in Dassa-Zoume, and pumping was stopped at 7-SE8 in Glazoue in 2020 due to the drop in the groundwater level.
[12] An unconfined aquifer is an aquifer sandwiched between geological features that allow water to pass through easily, and geological features called "impermeable layer" which do not allow water to pass through easily.
[13] On https://www.worldweatheronline.com/dessa-zoume-weather-averages/collines/bj.aspx Accessed March 5, 2022.
[14] In Japan, wells are renovated (e.g., cleaned) in every few years. The renovation restores the pumping capacity of the wells whose screens have become clogged due to long-term use and whose pumping capacity has decreased through cleaning and other means. The inside of the well is checked in advance with a well camera to determine what kind of repair is needed (specifically, the inside of the well can be visually confirmed by rotating and lowering an underwater camera into the well while taking pictures of the inside conditions). After the repair, the camera will be used again to confirm that the well is unclogged (consultant hearing).

The daily water withdrawals in both cities increased compared to the time before the project implementation (115% increase in Glazoue and 209% increase in Dassa-Zoume compared to the actual values in 2021 and 2014, respectively); however, they did not reach the target values. In addition, the increase in water withdrawals and the lower initial cost of connecting to individual hydrants had significantly impacted[15] the increase of the number of individual hydrants well beyond what was expected at the time of planning. As a result, the population having water supply significantly increased (see Table 4). This caused the water supply per capita to go below the planned amount in both cities. Moreover, the water from the most widely used water facilities, public wells with hand pumps, was sold at 10–25 CFA francs per 25 litters. The water charge of individual hydrants by SONEB was 5-11 CFA francs per 25 litters in ordinary households. Considering the water charge by SONEB hydrants was the same as or cheaper than the water cost from public wells with hand pumps, connecting to individual hydrants has probably become an incentive to residents.

However, the water supply per capita in both cities decreased compared to its amount at the time of planning. This might have been caused because the population with access to water supply significantly increased and also because the amount of the daily water withdrawals did not reach the target value the project was expected to achieve.

Regarding water quality, the chlorine concentration, fluorine concentration content, and nitrate-nitrogen concentration in the water supplied from the water supply facilities installed by the project were within the standards that Benin determined, which shows that water quality was effectively managed (data provided by the SONEB and SONEB questionnaire responses). A qualitative survey[16] was conducted with individual hydrant subscribers to investigate their satisfaction with the water quality. In Dassa-Zoume, 100% of respondents, and in Grazoue, 80% of respondents answered that they were satisfied with the water quality.[17]

In contrast, due to less amount of water withdrawals than planned and the significant increase in the population served, 24-hour water supply service has not been initiated. Water

[15] The initial fee, which was 10,000 CFA francs until 2017, was reduced to 5,000 CFA francs in 2018. This is a nationwide promotion (executing agency hearing).

[16] To ascertain the project's effectiveness after implementation, the survey targeted households that started using SONEB hydrants after 2018 (Glazoue: 20 people [8 men and 12 women; 5 in 30s, 3 in 40s, 3 in 50s, 6 in 60s, 2 in 70s, and 1 in 80s]; Dassa-Zoume: 21 people [9 men and 12 women, 1 in 20s, 5 in 30s, 5 in 40s, 5 in 50s, and 5 in 60s]). However, because the individual hydrant subscribers were widely scattered in both cities and it was extremely difficult to identify them, one user in Dassa-Zoume and two in Glazoue who subscribed in the second half of 2017, the year before the project was put into service, were included due to the limited survey period. In addition, a water sanitation awareness workshop was conducted as part of the project's soft component, aiming to promote a correct understanding of the SONEB water supply project among residents and ensure safe and hygienic water use. Considering a questionnaire was sent to the workshop participants, asking questions related to water-borne diseases, it was planned to include the workshop participants in the qualitative study to compare before and after the project implementation. However, most of the workshop participants could not be contacted, making it difficult to include them in the qualitative survey. Therefore, a comparison with the results of the questionnaire administered in the soft component was not conducted in this evaluation.

[17] Twenty valid respondents in Glazoue and 21 valid respondents in Dassa-Zoume.

supply hours vary from district to district. There are almost no water interruptions in some districts, while water is supplied for only 2 to 3 hours per day in others. Therefore, the satisfaction level with the amount and hours of water supply is not high among the individual hydrant subscribers. Sixty-five percent of the respondents in Glazoue and 36% in Dassa-Zoume were "dissatisfied" with the amount of water supply. In contrast, 35% in Glazoue and 59% in Dassa-Zoume were "dissatisfied" with the hours of the water supply (qualitative survey). However, despite being "dissatisfied" with the amount and hours of the water supply, no subscribers were willing to cancel the SONEB individual hydrant contract because of the availability of water fetching near their houses and the good water quality (qualitative survey).

Table 4 (Reference) Related Indicators

(Unit: listed in table)

Reference indicators	2014 at the time of planning	March 2018 (Note 4)	Estimated value at the time of planning (2020) (Note 5)	Actual results 2021	Changes since the time of planning
Glazoue City					
Number of hydrants at household (unit: number of hydrants)	772	1,342	875	1,885	224%
Population of water supply district (unit: person) (Note 1)	27,288	-	32,224	33,400	122%
Population served (unit: person) (Note 2)	9,264	-	10,496	22,620	244%
Water supply per capita (unit: liter/day)	25	-	40	12	48%
Dassa Zoume City					
Number of hydrants at household (unit: number of hydrants)	1,260	1,997	1,803	3,232	257%
Water District Population (unit: person)	29,571	-	32,487	33,673	114%
Population of water supply district (unit: person) (Note 3)	15,120	-	21,636	38,784	257%
Water supply per capita (liter/day)	23	-	40	19	82%

(Source) Cooperative Readiness Survey Report, Soft Component Completion Report, and SONEB questionnaire responses.

(Note 1) The population served is calculated by multiplying the number of hydrants × 2 (households) × 6 (persons). In Benin, one hydrant is considered to benefit two households (including adjacent households) multiplied by the average number of household members (6) (interview with SONEB).

(Note 2) The actual population served is estimated based on the population of the water districts as of 2014, using the population growth rate of each city from 2014 to 2021 (Glazoue: 2.93%, Dassa-Zoume: 1.87%).

(Note 3) Although the actual value of 2021 exceeds the population of the water supply district, this is used because some of the population may benefit beyond the water supply district. If the population of the water supply district (33,673) is used to calculate the water supply per capita in 2021, its volume would be 22 liters.

(Note 4) At the end of the software component.

(Note 5) Because these are projected values based on estimates at the time of planning and not the project's target values, comparisons with actual values (2021) are made with actual results at the planning (2014).

3.3.1.2 Qualitative Effects (Other effects)

The qualitative effect expected in the project, "the reduction in water fetching activities for women and children," has been examined in both target areas. The afield survey was conducted for those primarily responsible for the work to determine whether the time spent fetching water has been reduced compared to the time before connecting to the individual hydrants.

In Dassa-Zoume and Glazoue, as in other areas, the individual hydrants were located along the streets or on the premises adjacent to each residence. It was confirmed at the time of ex-post evaluation that residents fetched water from the hydrants located 2-10 meters apart from their houses and carried them to use. In this evaluation study, no one was using water pipes extended to their residence. Besides individual hydrants, both cities' water sources were public deep wells with hand pumps, improved shallow wells, traditional shallow wells, and water purchased from the SONEB hydrants of neighboring households. The public deep well with a hand pump was the most common source of water use. At the time of planning, the average distance residents needed to travel to fetch water ranged from 143 m to 275 m in Glazoue and 226 m to 309 m in Dassa-Zoume. The average distance residents need to travel to fetch water is estimated to have decreased significantly among households with individual hydrant connections.[18]

In Glazoue, wives and children fetched water before and after the connection of hydrants (see Table 5). Households where wives, wives and children, and children were the main collectors of water, accounted for 84% and 89% of the households before and after the connection, respectively. Households in which wives and children, including those under 12, were (or are) the primary collectors of water accounted for more than half of all households (57%) before and after connection. When asked about changes in hours spent fetching water before and after connection to individual hydrants, 16 of 18 valid responses (88%) indicated that it had decreased significantly.[19]

Similarly, in Dassa-Zoume, wives, and children fetched water before and after the connection of hydrants. Households where wives, wives and children, and children were the primary collectors of water accounted for 91% and 82% of the households, respectively, before and after the connection. Wives and children, including those under 12, led more than half of the households (68% before and 55% after the connection) in fetching water.

When asked about the change in time spent on fetching water before and after the

[18] Cooperative Readiness Survey Report, p.2-51; however, it was observed that hydrant subscribers also used other sources of water in combination, not only individual hydrants. The most common source of water used in combination was public deep wells. In Glazoue, many households used rainwater for washing clothes during the rainy season (qualitative study).

[19] The remaining two respondents reported no change. We asked questions using the largely decreased to slightly-increased method.

connection to the individual hydrants, 17 of the 18 valid responses (94%) indicated that it had decreased significantly, while one remaining respondent indicated that it had been reduced slightly.

The following estimates were made regarding the decrease in water fetching activities in both cities. According to the information obtained from the qualitative survey of individual hydrant subscribers, the average daily water consumption per capita in Glazoue and Dassa-Zoume was 31 and 22 liters, respectively. Since the amount of water supplied by SONEB hydrants in each city was 12 and 19 liters (see Table 4), it can be assumed that SONEB's individual hydrants supplied 38% and 86% of the water. Since the average household size in Benin is six, the average daily water consumption per household was 186 liters in Glazoue and 132 liters in Dassa-Zoume. If 25 liters of water were transported per fetch, the average household had to fetch water 7.5 times a day in Glazoue and 5.2 times a day in Dassa-Zoume before connecting to the individual hydrants. After connecting to individual hydrants, it is estimated that SONEB provides 38% of the water in Glazoue and 86% in Dassa-Zoume, which means users may fetch water up to 3.9 times per day in Glazoue and 0.7 times in Dassa-Zoume.

This shows that water fetching activities decreased dramatically among households connected to individual hydrants after the implementation of the project.

On the other hand, as water supply per capita decreased among households connected to individual hydrants before the project, water fetching activities might have increased.

Table 5 Primary water collectors by household

（Unit： Number of Households）

	Glazoue				Dassa Zoume			
	Before connection		After connection		Before connection		After connection	
	Number of Households	(%)	Number of Households	(%)	Number of Households	(%)	Number of Households	(%)
Wife	2	11%	2	11%	10	45%	4	18%
Wife and children	3	16%	3	16%	3	14%	7	32%
Households with children under 12 years old	3	16%	3	16%	2	9%	4	18%
Children	11	58%	11	58%	7	32%	7	32%
Households with children under 12 years old	6	32%	6	32%	3	14%	4	18%
Husband	1	5%	1	5%	1	5%	2	9%
Husband and Children	0	0	0	0	0	0	1	5%
Households with children under 12 years old	0	0	0	0	0	0	0	0
Other	2	11%	2	11%	1	5%	1	5%
	19	100%	19	100 %	22	100 %	22	100%

(Source: Prepared by the evaluator)

Thus, wives and children, including children under 12, are the primary water collectors in both cities. In most households, the time required to fetch water decreased significantly after connecting to individual hydrants. From the above, the implementation of the project has been effective in reducing the water fetching activities among women and children.

3.3.2 Impacts

3.3.2.1 Intended Impacts

The impacts expected to emerge through the project were "improvement of the sanitary conditions in the community and reduction of the incidence of water-borne diseases," "promotion and empowerment of women's participation in social activities through reduction of water fetching activities among women and children," and "improvement of children's school enrollment."

1) Improvement of the sanitary conditions in the community and reduction of the incidence of water-borne diseases

Individual hydrant and a polyethylene container for carrying water (Photo by the evaluator)

The qualitative survey of residents confirmed the situation of water handling related to hygiene and hand washing. Regarding the situation of water handling, it was confirmed whether covers were placed on containers when carrying water, whether covers were put on storage containers for drinking water, and whether storage containers for drinking water were clean.[20]

Metal washtub used to fetch water
(Photo by the evaluator)

Approximately 60% of valid respondents in both cities used containers with covers for carrying water.[21] The containers most used in the target areas were 25-liter capacity polyethylene and metal washtubs. Water was carried in metal washtubs without covers. Regarding storage containers for drinking water, 73% of valid respondents in Glazoue and 100% in Dassa-Zoume used covers.[22] While the most common storage containers for drinking water were polyethylene containers in Dassa-Zoume, more households used metal washtubs in Glazoue. Although there were differences between the two cities in storage containers for drinking water, in a survey of residents conducted in both cities in March 2018, 62% of respondents mentioned using covers to carry and store drinking water. The

[20] Some households did not transfer the drinking water from the carrying container to the storage container, but kept the drinking water in the carrying container. In this case, they answered that the carrying container was also used as the storage container.
[21] 19 valid respondents in Glazoue and 22 in Dassa-Zoume.
[22] 15 valid respondents in Glazoue and 20 in Dassa-Zoume.

survey did not distinguish between containers for carrying and storage. However, no improvement in the management of water regarding the situation with/without covers was observed in both cities, at least for transport containers.

Regarding the frequency of cleaning storage containers for drinking water, 53% of valid respondents in Glazoue and 74% in Dassa-Zoume washed containers at least once a week.[23] In the 2018 survey, 66% of respondents washed and kept their carrying and storage containers clean. Regarding the frequency of cleaning storage containers, there was a slight improvement in Dassa-Zoume, but no improvement was confirmed in Glazoue.

In conclusion, it is difficult to say that drinking water was carried hygienically in both cities and adequately managed, and confirmed that the sanitary conditions were not good enough.

The prevalence of water-borne diseases (diarrhea, cholera, dysentery, and typhoid fever) has been examined from 2017 to 2021 in a qualitative survey of residents. The results showed that there were few cases of water-borne diseases in households. There were no cholera cases in either city, and there were one to three cases of dysentery and typhoid fever each year in each city.[24] The number of cases of diarrhea was also low, with 87% of respondents in Glazoue and 80% in Dassa-Zoume reporting no cases in their households.[25] Two valid respondents in both cities reported the decrease in the number of cases of water-borne diseases in their households after connecting to the SONEB hydrant.[26] However, as the sample size was very small, the result does not serve as sufficient evidence that hydrant connection improved sanitation conditions and reduced water-borne diseases.

Table 6 shows the number of cases of water-borne diseases from the medical institutions in both cities (four institutions in Glazoue and one institution in Dassa-Zoume).[27] The number of cases of diarrhea, dysentery, and typhoid fever did not necessarily decrease over time; the number of SONEB hydrant subscribers has increased 1.6 times in Dassa-Zoume and 1.4 times in Glazoue since 2017. However, the following information does not indicate a negative correlation between the number of hydrant subscribers and the number of water-borne diseases.

[23] 13 valid respondents in Glazoue and 19 valid respondents in Dassa-Zoume
[24] 19 valid respondents in Glazoue and 19 valid respondents in Dassa-Zoume.
[25] Number of valid respondents in Glazoue: 16; Number of valid respondents in Dassa-Zoume: 15. Excluding respondents who chose “don't know”.
[26] The two respondents who started using SONEB hydrants in Dassa-Zoume in 2020 indicated that one each household member had diarrhea and typhoid fever in 2018, prior to the signing of each unit hydrant contract, but that there were no water-borne diseases in the household in other years.
[27] The names of the medical institutions are: Hospital de Zone de Dassa-Zoume, Centre de Sante communal de Glazoue, Centre de Sante d'arrondissement de Ouedeme (CSA), Centre de Sante d'arrondissement de Magoume, Missionaires Medicales de Marie de Zaffe.

Table 6 Number of Patients with Water-borne Diseases

(Unit: Number of patients)

	Glazoue					Dassa-Zoume				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Diarrhea	260	351	340	287	348	118	114	209	291	284
Dysentery	88	48	107	74	55	9	4	4	15	8
Typhoid fever	20	38	51	37	14	42	36	70	52	58
Number of subscribers to individual house hydrants	-	1,342	1,719	1,801	1,885	-	1,982	2,649	2,915	3,232

(Source: Prepared by evaluator based on information from medical institutions.[28])

From Table 6, the qualitative survey conducted in the evaluation and the statistical information obtained from medical institutions did not confirm the impact of the project in reducing the incidence of water-borne diseases among residents through the improvement of sanitary conditions.

2) Promotion and empowerment of women's participation in social activities through the reduction of water fetching activities among women and children

In Glazoue, households in which wives fetched water used the time generated by reducing water fetching activities after hydrant connection for other household chores (four respondents, 80%), income-generating work (two respondents, 40%), and sleeping or eating (one respondent, 20%).[29] When asked to identify changes in family and social relationships after hydrant connection, none indicated that wives became more confident or financially independent or had more time for family conversation.

In Dassa-Zoume, households in which wives fetched water used the time generated by reducing water fetching activities after the hydrant connection for other household chores (nine respondents, 75%), income generating work (four respondents, 33%), and sleeping and eating (four respondents, 33%).[30] When asked to identify changes in family and social relationships, one respondent (8%) indicated that his wife became more confident, but no one indicated that wives became more financially independent or had more time for family conversation.

Based on the above, as the results of this evaluation study show, the project limitedly contributes to the promotion of women's participation in socio-economic activities but not to women's empowerment.

[28] No cases of cholera were identified.
[29] Five valid respondents, based on multiple answers.
[30] Twelve valid respondents, based on multiple answers.

3) Improved school enrollment of children due to reduced hours of water fetching activities

In Glazoue, households in which children fetch water used the time generated by reducing water fetching activities after connecting to the hydrants for "study" (seven respondents, 58%), "other household chores" (five respondents, 42%), and "games, recreation, or rest" (three respondents, 25%) (12 valid responses, multiple answers). Regarding changes in school enrollment, five (45%) respondents answered that children who had enrolled in school without attending were now participating in schools, and one (9%) answered that their child enrolled in school after connecting to individual hydrants.[31]

In Dassa-Zoume, households in which children fetch water used the time generated by reducing water fetching activities after connecting to the hydrants for "study" (seven respondents, 46%), "other household chores" (four respondents, 26%) and "games, recreation, or rest" (three respondents, 20%).[32] Regarding changes in school enrollment, five (33%) respondents answered that children who had enrolled in school without attending were participating, and one (6%) answered that their children enrolled in school after connecting to individual hydrants.[33]

Based on the above, from the evaluation survey results, the project has contributed to a certain extent to the improvement of children's school enrollment.

3.3.2.2 Other Positive and Negative Impacts

1) Impacts on the Natural Environment

The project was considered to fall under Category B based on the *JICA Guidelines for Environmental and Social Considerations* (formulated in April 2010). At the time of planning, the project was not anticipated to significantly impact on the natural environment as target areas were not easily affected by national parks or near such areas. Negative impacts on the natural environment were not identified from the environmental monitoring sheet (June 2018)[34] and SONEB questionnaire responses. In addition, accidents during construction or after service were not identified.

2) Resettlement and Land Acquisition

At the time of planning, it was assumed that land acquisition involving involuntary resettlement would not occur.

The ex-post evaluation confirmed that land acquisition did occur in both cities, but all of it was on public land, and none involved involuntary resettlement (SONEB questionnaire responses).

[31] Twelve valid respondents, based on multiple answers.
[32] Fifteen valid respondents, based on multiple answers.
[33] Fifteen valid respondents, based on multiple answers.
[34] *Fiche de Suivi Environnemental daté de juin 2018*

3) Gender Equality

After connecting to individual hydrants, it confirmed the effect of reducing the hours of water fetching activities in households. In the target areas, women and girls are relatively engaged in water fetching activities more than men and boys, which appears that females benefited more than males by reducing the hours of water fetching activities. [35]

4) Marginalized People

Within the scope of the evaluation survey, there were no differences in beneficiary status by gender, age, ethnicity, or religion. However, some households may find it difficult to install individual hydrants by themselves due to the initial cost. Thus, the project depends on the income level of residents. For people without individual hydrants, some communities have public hydrants, and it may be possible to buy water from households with individual hydrants.[36] People who cannot afford to connect to individual hydrants can access safe or purified water.

5) Social Systems and Norms, Human well-being, and Human Rights

The qualitative survey has also examined if there were changes in life satisfaction between 2017 and 2021. In Glazoue, 13 respondents (62%) stated that their life satisfaction had increased, and eight (40%) cited improvement in public services (water supply) as the reason.[37] In Dassa-Zoume, ten respondents (48%) stated that their life satisfaction had increased, and five (23%) cited improvement in public services (water supply) as the reason.[38] Thus, among the households connecting to individual hydrants, approximately 40% of people in Glazoue and 20% in Dassa-Zoume perceived an increase in life satisfaction through the project. This indicates that the project has produced a partial yet certain level of impact on the residents' well-being.

"Daily water withdrawal," an indicator of the effectiveness of the project, did not achieve the target in either city. On the other hand, compared to the time of planning, the amount of water withdrawal in both cities increased, and the number of subscribers to individual hydrants and the population served also increased significantly; but the amount of water supply per capita decreased. We confirmed that the reduction of water fetching activities among children and women was effective in households connected to individual hydrants after the project implementation. Regarding the impact, improvement of the sanitary environment in the community and reduction of the incidence of water-borne diseases were not confirmed, and the limited contribution was confirmed to the promotion of women's participation in socio-economic

[35] In Glazoue, more girls than boys were engaged in water fetching (13 girls and eight boys). In Dassa-Zoume, slightly more girls than boys were engaged in water fetching (13 girls and 12 boys) (Based on qualitative research).
[36] In the target area, it is common for households with SONEB individual hydrants to sell water to those without (actual inspection).
[37] 20 valid respondents
[38] 21 valid respondents

activities by reducing the hours spent on fetching water, and women's empowerment was not confirmed. The effect on the improvement of children's school enrollment was confirmed.

From the above, the project has achieved its objectives only to a certain extent. Therefore, effectiveness and impacts of the project are moderately low.

3.4 Sustainability (Rating: ③)

3.4.1 Policy & System

As indicated in the relevance section, the direction of the expansion of water supply services in urban areas of Benin has not changed from the planning to the ex-post evaluation, and it is expected to continue in the future.

3.4.2 Institutional/Organizational Aspect

The operation and maintenance of water supply facilities constructed under the project are conducted by the Dassa-Zoume Branch office under the supervision of SONEB headquarters and the Direction Régionale Abomey-Bohicon ("DRAB"). Table 7 shows the division of roles within SONEB for the operation and maintenance of the project. It has not changed since the time of planning.

Table 7 Division of roles within SONEB for maintenance at the project

SONEB Headquarters	Repair of major facilities (well rehabilitation, pump replacement, etc.) Management of expenditures for staff salaries, electricity fees, and purchase of necessary materials and equipment (chemicals, etc.) (Including expenditures at local offices)
DRAB	Repair of medium facilities and issue of bills
Dassa-Zoume Branch Office	Operation and management of deep wells (operation of well pumps, operation records) Minor repairs (e.g., repair of leaks in water pipes, etc.) Reading water meters and collecting water charges Connecting to new hydrants Removal of water meters for non-payers and suspension of water supply

(Source: Prepared by the evaluator based on SONEB questionnaire responses)

Table 8 shows staff allocation at the Dassa-Zoume Branch Office, which is responsible for operating and managing the water supply facilities constructed by the project. It was identified that there was no shortage of personnel as required for the project operation and maintenance, based on SONEB questionnaire responses. Although the number of meter readers has decreased from the time of planning, the staff of the executing agency explained that it was possible to handle the current number of personnel (interview with SONEB).

Table 8 Staff Allocation at Dassa-Zoume Branch Office

(Unit: persons)

	2016	2019	2020	2021	2022
Director	1	1	1	1	1
Deputy Director	1	0	0	0	0
Secretary	1	1	1	1	1
Accountant	1	1	1	1	1
Facility Operations Leader	1	1	1	1	1
Facility Operator (Note 1)	1	1	4	4	4
Repair and maintenance Personnel (Note 2)	1	3	3	3	3
Glazoue Branch Manager	1	1	1	1	1
Dassa-Zoume Meter Reader	3	1	1	1	1
Glazoue meter reader	2	1	1	1	1
Total	13	11	13	14	14

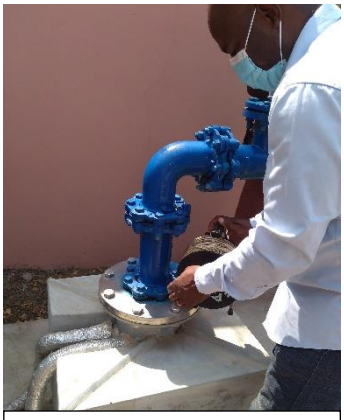
(Source: Prepared by the evaluator based on SONEB questionnaire responses)

Note 1: Three staff at Dassa-Zoume Branch Office and one staff member at Glazoue Branch Office.

Note 2: Two of them have been temporary employees since 2019.

3.4.3 Technical Aspect

At the ex-post evaluation, all facilities developed by the project were generally adequately managed and operated. It was also confirmed that several activities supported by technical assistance under the soft components (see Table 9) had been adequately implemented. As of February 2022, when the evaluator conducted the field survey, groundwater level monitoring was conducted almost daily in Dassa-Zoume and once a month in Glazoue (interview with SONEB). It was confirmed in the field survey that the Dassa-Zoume Branch staff would provide technical assistance to the Glazoue Branch staff. Subsequently, improvements were made according to the direction, and as of July 2022, groundwater levels were measured daily in Glazoue (interview with SONEB).



Measurement of groundwater level in Dassa-Zoume city well (Photo by evaluator)

Table 9 Technical Assistance with the Soft Component

1	Monitoring of water storage and distribution
2	Monitoring of groundwater level and data collection and feedback of data to operational management
3	Monitoring of water quality (fluorine concentration, residual chlorine, etc.) and feedback of data to operational management
4	Proper operation of individual equipment such as pumping equipment, disinfection equipment, emergency generators, etc.

The training was also provided to improve technical skills. Two staff members from the

Dassa-Zoume Branch participated in training for the maintenance of the metering pump.[39] Manuals for the maintenance and management of water supply facilities were also in place and were used by staff daily. Three staff members trained through the soft component (technical assistance) of the project continue to engage in the operation and maintenance of water supply facilities in Dassa-Zoume and Glazoue.

The above indicates that although there were some problems in the frequency of groundwater level monitoring in Glazoue, they have already improved. This means that the executing agency has sufficient technology for the operation and maintenance of the water supply facilities developed in the project.

3.4.4 Financial Aspect

Table 10 shows the overall financial status of the executing agency from 2016 to 2020. SONEB's overall operation status was good, with revenues exceeding expenditures[40]. Information on the financial status of the Dassa-Zoume Branch was not available. However, the SONEB headquarters has managed the revenues and expenditures of the Dassa-Zoume Branch. Thus, there was no problem with the financial status of the operation and maintenance of the water supply facilities constructed by the project. In addition, we identified no shortfalls in the maintenance costs of the water supply facilities constructed under the project (SONEB questionnaire responses).

Receivables in both cities increased significantly in 2021, the percentage of which was about 20% (see Table 11). It was attributed to the problem in SONEB's servers in December 2021, which resulted in canceling the SONEB-wide end-of-year campaign to collect unpaid water bills. Therefore, future improvement in collecting receivables is expected (interview with SONEB). If water gills are not paid for a certain period, the Dassa-Zoume Branch Office will press for payment and stop the water supply for those who have not paid. As shown in Table 7, those who have not paid fees will not be able to use the water while fees remain unpaid.

[39] A pump capable of repeatedly injecting a defined fixed amount of liquid with high accuracy.
[40] The "Others" category of revenue includes revenues from services rendered, transfers for the purchase of equipment and materials, depreciation, reversals of provisions and impairments, and changes in inventories.

Table 10 SONEB Financial Status

(Unit: thousands of CFA francs)

		2016	2017	2018	2019	2020
Annual Revenue	Collection of water charges	16,921,556	16,754,287	16,228,005	15,877,773	16,966,917
	Subsidiary aid	77,394	3,500	340,859	1,125,086	11,000
	Others	5,194,933	7,255,731	9,492,275	7,561,842	13,762,953
	Total	22,193,882	24,013,518	26,061,138	24,564,701	30,740,870
Annual Expenditure	Purchase of equipment and materials	4,239,827	4,249,981	6,207,258	4,407,243	4,969,236
	Personnel expenses	6,066,326	6,751,018	6,775,840	6,418,434	6,667,717
	Depreciation and amortization	6,745,358	7,057,435	8,077,395	9,304,887	10,557,113
	Others	4,950,415	3,770,614	4,708,643	3,566,673	4,796,948
	Total	22,001,925	21,829,049	25,769,137	23,697,238	26,991,015
Profit		191,957	2,184,469	292,001	867,463	3,749,855

(Source: Prepared by evaluator based on SONEB questionnaire responses)

Table 11 Water Charges Collected, Receivables, and Percentage Receivable in Glazoue and Dassa-Zoume

(Unit: CFA francs)

		2018	2019	2020	2021
Amount collected	Glazoue	26,482,882	37,146,990	39,038,325	33,658,690
	Dassa-Zoume	52,294,182	86,360,558	93,588,037	96,535,533
Accounts receivable	Glazoue	8,013,061	5,909,087	4,257,069	8,844,332
	Dassa-Zoume	4,289,098	8,895,606	5,451,671	26,430,832
Percentage of receivable	Glazoue	23%	14%	10%	21%
	Dassa-Zoume	8%	9%	6%	21%

(Source: Prepared by the evaluator based on information provided by SONEB[41])

3.4.5 Environmental and Social Aspect

At the time of planning, the project was supposed not to have negative impact on the natural environment. Even after the project was handed over, there were no negative environmental or social impacts (JICA-provided materials, SONEB questionnaire responses, and actual inspections).

[41] In July 2022, DRAB presented another set of data, but only on the amount collected and not on the amount receivable; thus, we used the data from the questionnaire responses here.

3.4.6 Preventative Measures to Risks

During the planning stage, the following five external conditions were assumed for achieving the overall project plan (Preparatory Survey Report, pp. 4-1, 4-2).

(1) Public security in Benin, including the target areas, will not affect the implementation of the project

(2) Financial status of SONEB will not deteriorate significantly

(3) SONEB staff trained in the project will continue their work

(4) No significant changes in Benin's water supply sector policy

(5) No extreme deterioration of water quality or reduction of pumping rate at intake wells

Regarding (1), no deterioration in public security was observed from the time of planning to the time of ex-post evaluation. Regarding (2), the financial status of SONEB is good, as mentioned above. Regarding (3), the three staff members who received technical training through the soft component of the project are still engaged in operation and maintenance at the time of ex-post evaluation. Regarding (4), as confirmed in section 3-4-1, "Policy and Institutions," there have been no significant changes in Benin's policies in the water supply sector.

Finally, regarding (5), as indicated in the effectiveness section, the groundwater levels in wells drilled in the project decreased, and the amount of water withdrawn was not adequate as planned at the time of ex-post evaluation. Under these circumstances, staff at the Dassa-Zoume Branch pumped water while measuring the groundwater level in the wells and checking the amount of groundwater daily. In addition, well pumps were changed to smaller capacities when necessary due to the decrease in the groundwater level (interview with SONEB). The problem of infrequent measuring of groundwater level in Glazoue has already improved, meaning that the risk was appropriately managed to a certain degree.

3.4.7 Status of Operation and Maintenance

At the time of ex-post evaluation, the facilities constructed under the project were generally adequately maintained, and there was no severe damage or loss.

As for the equipment provided, both water-quality analysis equipment and water-level gauges were used for daily operations and inspections. At the time of the defect inspection, the portable water level gauge was not functional at the Glazoue Branch, but at the time of ex-post evaluation, they were functional in both cities. However, the water level gauges of the elevated water tanks were not functioning in either city (actual inspection and interview with SONEB).

Part of the operation records, as well as the management ledger holding water levels and water quality data, was misplaced at the Glazoue Branch due to the retirement of a staff member (actual inspection, interview with SONEB). The executing agency was aware of the need to manage operation records, water levels, and water quality data and expressed the will to make

improvements. As a result, as of July 2022, operation records and water level and water quality data were recorded in the management ledgers in both cities (interview with SONEB).

From the above, while minor issues have been observed in the financial aspects, including the status of the operation and maintenance system, there are good prospects for improvement/resolution. Therefore, the sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project aimed to increase water consumption in the target area by developing new water sources and constructing water supply facilities in Glazoue and Dassa-Zoume in the Republic of Benin. The project was consistent with Benin's urban water supply development policy and their development needs from the planning to the ex-post evaluation, of which the plans and approaches were appropriate. Considering the project is consistent with Japan's development policy and has been appropriately coordinated with other donors' projects with confirmed outcomes, the relevance and consistency have been highly assured. The efficiency is high because the output was almost as planned, the cost was within the plan, and the project period was kept slightly longer than planned. Regarding the effectiveness, neither city achieved the planned targets set by the project for "daily water withdrawal." This project indicator was not secured as planned due to a reduction in the groundwater level. Although the amount of water withdrawal in both cities increased compared to the plan, the amount of water supplied per capita decreased compared to the plan due to a significant increase in the number of individual hydrant subscribers and the population supplied with water. The project has been confirmed effective for reducing water fetching activities among children and women for households connected to individual hydrants after the project. Regarding the impact, the improvement of the sanitary conditions in the community and a decrease in the incidence of water-borne diseases have not been confirmed while the project's contribution to promoting women's participation in socio-economic activities through reducing the hours of water fetching activities was limited. Therefore, the empowerment of women was not confirmed. Project effects were confirmed for the improvement of children's school enrollment. Based on the above, the effectiveness and impacts of the project are moderately low.

Although slight issues have been observed in the financial aspects, including the status of the operation and maintenance system, there are good prospects for improvement/resolution.

Therefore, the sustainability of the project effects is high.

Based on the above, this project is evaluated to be satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

The water-level gauge of the elevated water tank should be repaired as soon as possible, as it is a necessary piece of equipment for the proper operation and management of the pumps that supply water to the elevated water tank.

To secure the amount of pumped water, well diagnosis should be conducted by means of a pumping test, measurement of pumping capacity (or depth of burial), and in-well investigation by using well cameras; if there is a need to renovate the wells including casing and screen, renovation work through well cleaning should be conducted shortly.

Since the executing agency has a technical team that can operate well cameras, it would be helpful to have the participation of the technical team to investigate the well conditions using well cameras and make the necessary modifications.

4.2.2 Recommendations to JICA

JICA should provide appropriate technical assistance (e.g., dispatch of short-term experts) as necessary for the renovation of the wells, as mentioned in the recommendation to the executing agency.

4.3 Lessons Learned

Consideration of operation and maintenance plans from a medium- to long-term perspective

In general, there is no high awareness of renovating wells in developing countries, and the wells are commonly re-drilled when the water supply stops. At the time of planning of the project, there was no company in Benin that owned well cameras, and no engineers were available. Therefore, the renovation using well cameras was considered unrealistic, and the executing agency received no explanation. However, the situation has changed by the time of ex-post evaluation, and the executing agency now has a technical team that can use well cameras. As described above, there are maintenance methods that may not be realistic at the time of planning but could be handled within the executing agency over the medium to long term. Therefore, it is expected that JICA will discuss the maintenance and operation plan after the provision of the facility with the executing agency; thereby, the executing agency will proactively consider introducing new maintenance methods from a medium- to long-term perspective at the time of planning.

5. Non-Score Criteria

5.1 Performance

5.1.1 Objective Perspective

The project consultant reported progress monthly to the JICA Benin Office and the JICA Financial Cooperation Implementation Department in Japan during the project implementation period. This ensured appropriate communication among all the parties concerned.

By considering the lesson learned from the existing projects, which is "it is important to investigate and design based on seasonal and interannual variations of groundwater, and to monitor the water supply to residents after the project is completed," pumping tests were conducted again during the detailed design study of the project, and the pump design was changed. In addition, the soft component was implemented for the executing agency to be able to monitor groundwater fluctuations over time after the project. At the ex-post evaluation, the executing agency measures groundwater levels continuously. The project was implemented based on the lessons learned from the existing projects, and it has contributed to improving the project's sustainability.

5.2 Additionality

None.

Republic of Mali and Republic of Senegal

FY2021 Ex-Post Evaluation Report of
Japanese Grant Aid Project
"Projet de Construction des Ponts sur le Corridor du Sud
en République du Mali et en République du Sénégal" (Phase I, II, III)"

External Evaluator: Akemi Serizawa, Hiroshi Nishino, Juri Ishimoto
TAC International Inc.

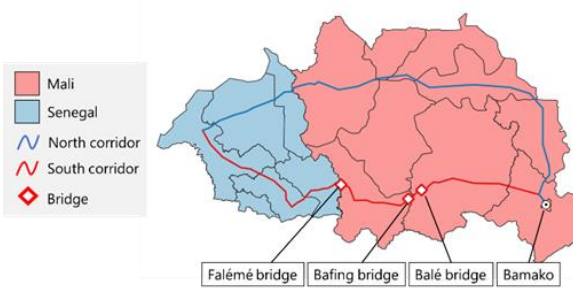
0. Summary

The objective of this project was to facilitate smooth traffic along the Southern Corridor connecting the capitals of Senegal and Mali by constructing three bridges on the corridor in Mali, thereby contributing to the economic development of roadside areas and the promotion of transport and trade between the two countries and with the neighbouring countries.

The relevance and consistency of this project are high as it was in line with the development plans and development needs of the two countries as well as with the Japan's assistance policy, and the bridges were integral parts of the Southern Corridor together with other road construction projects. The efficiency of the project is high as the project cost was within the plan while the project period was slightly longer than planned. The effectiveness and impact of the project are high because the objectives of the project, "to facilitate smooth traffic along the Southern Corridor" and "to contribute to the economic development of roadside areas and the promotion of transport and trade between the two countries and with the neighbouring countries," were generally achieved as planned. The sustainability of the project effects is moderately low as there are some financial problems in the operation and maintenance of the project due to the political instability in Mali.

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

1. Project Description



Project Locations
(Created by the ex-post evaluation team)

Bafing Bridge
(Photo taken by the local assistant)

1.1 Background

International roads are essential for foreign trade of Mali, a landlocked country. Due to the political crisis in Cote d'Ivoire, the port of Dakar in Senegal became Mali's main outer port replacing Abidjan, and the need of international roads connecting Mali and Senegal became even greater. The inland areas of the two countries lacked a well-developed road network. This hindered flow of people and commodities, and it was a major factor of socioeconomic underdevelopment and poverty. The government budget of the two countries was chronically in short due to external debt, and they were dependent on foreign assistance for the development of transport infrastructure including roads.

The construction of the Northern Corridor, starting from Dakar, the capital of Senegal, taking the northern route from Tambacounda to Bamako, the capital of Mali, was fully completed by 2007 with support of the European Union (EU) and other development organizations. The area along the Southern Corridor was blessed with fertile soil and water suitable for agriculture as well as industrial resources and tourist attractions, such as gold mines and national natural parks, but the road network was underdeveloped as this area was mountainous and many rivers did not have bridges. The construction of the Southern Corridor started with the support of international development partners, including Japan, in 2005. This grant aid project by JICA supported the construction of Falémé Bridge (Senegal-Mali border), Bafing Bridge, and Balé Bridge on the Southern Corridor.

1.2 Project Outline

The objective of this project was to facilitate smooth traffic along the Southern Corridor connecting the capitals of Senegal and Mali by constructing three bridges on the corridor in Mali, thereby contributing to the economic development of roadside areas and the promotion of transport and trade between the two countries and with the neighbouring countries.

Grant Limit / Actual Grant Amount	Phase I: 940 million yen / 914 million yen Phase II: 1,340 million yen / 1,321 million yen Phase III: 1,528 million yen / 1,390 million yen
Exchange of Notes Date / Grant Agreement Date	Phase I: N/A / Detailed design January 2008, Construction May 2008 Phase II: Detailed design (Mali) February 2009, Detailed design (Senegal) January 2009, Construction (Mali) May 2009, Construction (Senegal) May 2009 / Detailed design (Mali) February 2009, Detailed design (Senegal) January 2009, Construction (Mali) May 2009, Construction (Senegal) May 2009 Phase III: July 2009 / July 2009
Executing Agencies	Direction Nationale des Routes (DNR), Ministère de l'Equipement et des Transports,

	Mali Agence Autonome des Travaux Routiers (AATR), Senegal
Project Completion	Phase I: January 2010 Phase II: July 2011 Phase III: November 2011
Target Area	Kayes Region, Mali
Main Contractor	Dai Nippon Construction
Main Consultant	Katahira & Engineers International
Basic Design/Preparatory Survey	Basic design: May 2006‐February 2007‐ Feasibility study (1): September‐October 2007, Feasibility study (2): March 2008‐January 2009 Detailed design: Phase I February 2008‐January 2009, Phase II March‐September 2009, Phase III July 2009‐March 2010
Related Projects	[Southern Corridor development projects (Mali): loan] - EU and Kreditanstalt für Wiederaufbau (KfW Germany) (2005‐2007) - Islamic Development Bank (Banque Islamique de Développement: BID) (2006‐2008) - African Development Bank (AfDB) (Banque Africaine de Développement: BAD) and West African Development Bank (Banque Ouest Africaine de Développement: BOAD) (2006‐2009) [Southern Corridor development projects (Senegal): loan] - BID (2006‐2007) - BAD, BOAD and JBIC (2006‐2009). JBIC "Road Improvement and Transport Facilitation Program on the Southbound Bamako-Dakar Corridor" (2005‐2009) was a part of it. [JICA Project for Rehabilitation of the Third Wharf in Dakar Autonomous Port (2017): grant aid]

2. Outline of the Evaluation Study

2.1 External Evaluator

Akemi Serizawa, Hiroshi Nishino, Juri Ishimoto,[1] TAC International, Inc.

2.2 Duration of Evaluation Study

[1] Nishino and Ishimoto (in charge of satellite data analysis) belong to Metrics Work Consultants, Inc. and participated as reinforcements.

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

Duration of the Study: November 2021–November 2022

Duration of the Field Study by the local assistants: February–July 2022

2.3 Constraints during the Evaluation Study

The Japanese evaluators could not travel due to the political instability and security situations in Mali, and local assistants were employed for information collection and field visits.

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

3.1 Relevance/Coherence (Rating: ③[3])

3.1. 1. Relevance (Rating: ③)

3.1.1.1 Consistency with the Development Plans of Mali and Senegal

The *Poverty Reduction Strategy Paper (PRSP)*, formulated as Mali's medium-term development policy (2002–2006), identified "promotion of industrial development and improvement of economic infrastructure" as one of its basic strategies, aiming at balanced regional development and infrastructure improvement, strengthening of transport to stimulate the economy, and enhancement of access to social services and markets. Its Road Improvement Project (Projet d'Amélioration des Couloirs Routiers) (2004–2007) identified the improvement of international roads including the Southern Corridor as its key objective. Senegal's *PRSP* (2003–2005) focused on "the promotion of the productive sector and investment for the economic growth," "expansion of basic social services," and "improvement of the lives of the socially vulnerable people," and identified the formation of a transport system as one of the specific measures to take. Its Transport Sector Programme II (Programme Sectoriel des Transports II) (2001–2006) also focused on road development. As for regional policies, the West African Economic and Monetary Union (Union Économique et Monétaire Uuest-africaine: UEMOA) prioritized the development of infrastructure to facilitate international logistics for regional revitalization and poverty reduction, and the development of the Southern Corridor was its most important project. The New Partnership for Africa's Development (NEPAD) also gave top priority to the development of the Southern Corridor in its short-term infrastructure action plan (*Plan d'Action à Court Terme*) for regional integration.

At the time of the ex-post evaluation, Mali's *Strategic Framework for Economic Recovery and Sustainable Development (Cadre Stratégique pour la Relance Economique et le Développement Durable: CREDD[4])* (2018–2022) aims to reduce poverty and inequality by the promotion of inclusive and sustainable development. It identifies the improvement of transport infrastructure

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

[3] ④: Very High、③: High, ②: Moderately Low, ①: Low

[4] https://www.maliapd.org/wp-content/uploads/2019/07/Version-Finale-CREDD-2019-2023.pdf

including roads as one of its specific goals. This policy is maintained under the current transitional government since 2021. *Senegal Emerging Plan (Plan Sénégal Émergent*[5]) (2014–2035) aims to make Senegal one of the emerging countries by 2035, and its mid-term plan (2018–2023) is implemented in each sector in accordance with the three pillars: transformation and growth of the economic structure; human resources, social security and sustainable development; and governance, institution, peace and security. Roads are recognized as basic infrastructure vital for industrial development, regional development, improved access to social services, and trade development with the neighbouring countries. In addition, the UEMOA's Regional Economic Programme (Programme Economique Régional: PER[6]) (2006–) emphasizes the development of road infrastructure, and the Programme for Infrastructure Development in Africa (PIDA[7]) (2012–) of the African Union (AU) and other development organizations supports the development of infrastructure, including roads, with the aim of regional integration of Africa and regional economic development.

Based on the above, at the time of the ex-ante and ex-post evaluations, the project was consistent with the national development plans of Mali and Senegal as well as with the regional development policies in West Africa, all of which recognized roads as vital infrastructure for economic growth and poverty reduction.

3.1.1.2 Consistency with the Development Needs of Mali and Senegal

As described in the "Background " section, Mali, a landlocked country, has a great need of international roads leading to Dakar, Senegal as its outer port. The road network along the Southern Corridor was underdeveloped, but its Mali part was constructed between 2005 and 2009 with the support of the EU and other development organizations. This JICA project constructed three bridges on the Southern Corridor. Prior to the construction of the bridges, traffic was inconvenient as crossing of the river at the location of the new bridges was restricted to the dry season and only for four-wheel drive vehicles. People had to use boats to cross the river, which was time consuming and posed the risk of falling into the river.

At the time of the ex-post evaluation, the need for the Southern Corridor between Mali and Senegal was remained. According to the executing agencies of Mali and Senegal, use of the Southern Corridor increased from 2017 to 2019 because it is approximately 200 km shorter than the Northern Corridor and because the condition of the latter had deteriorated over time. For Senegal, Mali is its top export partner by value, and the volume of exports from Senegal to Mali was increasing since 2011. At the same time, for Mali, Senegal is its top import partner by value. Mali experienced two coups by the military regime in August 2020 and May 2021, and the

[5] https://www.economie.gouv.sn/en/dossiers-publications/publications/pse
[6] http://www.uemoa.int/fr/system/files/per_info_no1_janvier-juin2017.pdf
[7] https://au.int/en/ie/pida

Economic Community of West African States (ECOWAS) imposed sanctions on Mali from January to July 2022, including an embargo on all but basic necessities. As a result, the volume of trade and traffic to and from Mali is estimated to have decreased,[8] but the need for the Southern Corridor has not been impaired.

3.1.2 Coherence (Rating: ③)

3.1.2.1 Consistency with Japan's ODA Policy

At the time of the ex-ante evaluation, infrastructure development to contribute to the economic development of Mali and the neighbouring countries was a priority area of Japan's development assistance policy for Mali. The priority areas of Japan's cooperation for Senegal were "improving the livelihoods of the poor in rural villages" and "building a foundation for sustainable economic growth". Therefore, this project was in line with the development assistance policies for Mali and Senegal.

3.1.2.2 Internal Coherence

JBIC's "Road Improvement and Transport Facilitation Program on the Southbound Bamako-Dakar Corridor" (2005‐2009), co-financed by the African Development Bank (Banque Africaine de Développement: BAD) and the West African Development Bank (Banque Ouest Africaine de Développement: BOAD), constructed a part of the Southern Corridor between Kédougou and Saraya in Senegal. In addition, the third wharf, which was developed under the grant aid "Project for Rehabilitation of the Third Wharf in Dakar Autonomous Port" (2017), mainly handles cargo bound for Mali, and was expected to contribute to the expansion of logistics to Mali. Both projects, together with this Project, were expected to improve the logistics system between Senegal and Mali.

3.1.2.3 External Coherence

Each section of the Southern Corridor was constructed as planned and has been operating without problems since its opening, together with the three bridges constructed by this project. For the Sustainable Development Goals (SDGs), transport supports food security, health, energy, economic growth, infrastructure, as well as livelihood bases of people, and is recognized as a cross-cutting contributor to the achievement of development goals related to these issues.

Table 1 Construction of Southern Corridor in Mali

Section	LOT 1 Falémé Bridge at the border−Bafing Bridge	LOT 2 Bafing Bridge−Balé Bridge−Sekokoto	LOT 3 Sekokoto−Kita	LOT 4 Kita−Kati

[8] Trade and traffic data since 2022 was not available at the time of ex-post evaluation.

Length of the section	156.0 km	71.7 km Bafing−Balé 29.7 km Balé−Sekokoto 34.0 km	38.0 km (including construction of Bakoi Bridge)	162.0 km
Cost	25,663 million CFA francs (5,540 million yen)	15,124 million CFA francs (3,270 million yen)	6,760 million CFA francs (1,460 million yen)	19,235 million CFA francs (4,150 million yen)
Source of finance	(LOT 1 and LOT 2) BAD: 39,103 million CFA francs BOAD: 7,000 million CFA francs Government: 5,000 million CFA francs Total 51,103 million CFA francs		BID: 5,949 million CFA francs Government: 811million CFA francs	UE: 14,735 million CFA francs KFW: 4,000 million CFA francs Government: 500 million CFA francs
Construction	January 2008−June 2010	January 2008−December 2009	October 2006−June 2008	October 2005−May 2008

Source: documents provided by JICA

Table 2 Construction of Southern Corridor in Senegal

Section	LOT 1 Kédougou−Saraya	LOT 2 Saraya (PK.0 km)−PK.30 km	LOT 3 PK.30 km−Falémé
Length of the section	61.0 km	30.0 km	21.3 km
Cost	11,300 million CFA francs (2,430 million yen)	7,640 million CFA francs (1,640 million yen)	5,750 million CFA francs (1,240 million yen)
Source of finance	(LOT 1 and LOT 3) BAD: 5,650 million CFA francs BOAD: 5,000 million CFA francs JBIC: 4,690 million CFA francs Government: 1,710 million CFA francs Total 17,050 million CFA francs	BID: 4,750 million CFA francs Government: 2,890 million CFA francs	(Included in LOT 1)
Construction	January 2008−August 2009	April 2007−April 2008	January 2008−August 2009

Source: documents provided by JICA

The project was in line with the development plans and development needs of Mali and Senegal as well as with Japan's development assistance policies for the two countries. The bridges constructed by the project were an integral part to complete the Southern Corridor together with other road construction projects. Therefore, its relevance and coherence are high.

3.2 Efficiency (Rating: ③)

3.2.1 Project Outputs

The Bridges of Balé (110.15 m long), Falémé at the border (274.30 m long) and Bafing (273.80

m long) were constructed in Phase I, II, III of the project respectively. From the information provided by the executing agencies and the site visits in the ex-post evaluation, it was confirmed that all the outputs of the project were produced as planned.

Falémé Bridge
(Photo taken by the local assistant)

Falémé Bridge
(Photo taken by the local assistant)

Balé Bridge
(Photo taken by the local assistant)

Balé Bridge
(Photo taken by the local assistant)

3.2.2 Project Inputs

3.2.2.1 Project Cost

Only the planned and actual costs borne by Japan were compared, and the total actual cost of

Phase I, II and III was within the plan (95%). Since the project cost borne by Mali and Senegal was only bank charges and very small, it was ignored in the comparison. According to the project consultant, the cost was smaller than the plan because the same Japanese construction company carried out the work throughout the three phases of the project and the machinery and personnel were shared among the three phases as the construction periods overlapped.

Table 3 Comparison of planned and actual project costs

			Plan (million yen)	Actual (million yen)	Ratio actual/ plan
Phase I	Cost borne by Japan	Detailed Design	26	26	
		Construction	914	888	
		Total cost borne by Japan	940	914	97%
	Cost borne by Mali	(Bank charges: 9.44 million CFA francs= 2 million yen)[9]	2	No information	
	Total		942	No information	
Phase II	Cost borne by Japan	Detailed Design, Mali	15	36	
		Detailed Design, Senegal	15		
		Construction, Mali	655	1,285	
		Construction, Senegal	655		
		Total cost borne by Japan	1,340	1,321	86%
	Cost borne by Mali	(Bank charges: 4.85 million CFA francs= 1 million yen)[10]	1	No information	
	Cost borne by Senegal	(Bank charges: 4.85 million CFA francs= 1 million yen)	1	No information	
	Total		1,342	No information	
Phase III	Cost borne by Japan		1,528	1,390	91%
	Cost borne by Mali	(Bank charges: 11 million CFA francs= 3 million yen)	3	No information	
	Total		1,531	No information	
Total		Cost borne by Japan	3,808	3,625	95%

Source: documents provided by JICA

3.2.2.2 Project Period

The total actual project period from Phase I to Phase III was slightly longer than planned. According to the project consultant, this is because the planned project periods of Phase I and

[9] Phase I: CFA franc1 = JPY0.216
[10] Phase II and III: CFA franc 1= JPY0.244

Phase II were described in the feasibility study report without taking into account the period between the contract of consultant after the signing of the G/A (E/N) of the detailed design and the start of detailed design, which is usually one to two months.

Table 4 Comparison of planned and actual project period

		G/A（E/N）	Plan	Actual	Ratio (actual/ plan)
Phase I	Detailed Design (E/N)	January 2008	23 months including detailed design and tender	Completion of construction: January 2010. 25 months since the E/N of the detailed design	109%
	Construction (E/N)	May 2008			
Phase II	Detailed Design, Mali	February 2009	29 months including detailed design and tender	Completion of construction: July 2011. 31 months since the G/A of the detailed design	107%
	Detailed Design, Senegal	January 2009			
	Construction, Mali	May 2009			
	Construction, Senegal	May 2009			
Phase III		July 2009	From July 2009 to December 2011 (30 months including detailed design and tender)	Completion of construction: November 2011. 29 months	97%
Total			82 months	84 months	102%

Source: documents provided by JICA

While the project period slightly exceeded the plan, the outputs of the project were produced as planned and the project cost was within the plan. Therefore, efficiency of the project is high.

3.3 Effectiveness and Impacts[11] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

The operation indicators of the project have been achieved at all times immediately after the bridges were completed, without any change over time or difference between the rainy and dry seasons. According to the executing agencies and the communities around the bridges, the passage of the bridges has never been hindered since the openings. ECOWAS sanctions were imposed against Mali from January to July 2022, and Falémé bridge at the border was operated as follows, although it was physically passable as usual:

- Border crossing was by foot or moto taxi only. Vehicles were not allowed to pass through in principle.

[11] When providing the sub-rating, Effectiveness and Impacts are to be considered together.

- International bus service was suspended. Passengers had to get off the bus before the border, walk or take a moto taxi through the border, and board another bus at the other side.
- Embargo was in place against Mali except for basic necessities. Trucks carrying necessities entered Mali from Senegal once a day.

Table 5 Operation Indicators

Balé Bridge Indicators	Baseline value 2006	Target value 2010	Actual value 2010	Actual value 2022
		Completion year	Completion year	Ex-post evaluation
Period in which vehicles cannot cross the river	Approximately 4 months per year	None	None	None
Type of vehicles that can cross the river	Four-wheel drive vehicles only (crossings on the riverbed during dry season)	Large vehicles (trucks and buses) can cross the river year-round	Large vehicles (trucks and buses) can cross the river year-round	Large vehicles (trucks and buses) can cross the river year-round
River crossing time for pedestrians	Approximately 20 minutes (by canoe)	Approximately 2 minutes (on foot)	Approximately 2 minutes (on foot)	Approximately 2 minutes (on foot)

Falémé Bridge Indicators	Baseline value 2008	Target value 2011	Actual value 2011	Actual value 2022
		Completion year	Completion year	Ex-post evaluation
Period in which vehicles cannot cross the river	Approximately 7 months per year	None	None	None
Type of vehicles that can cross the river	Four-wheel drive vehicles only (crossings on the riverbed during dry season)	Large vehicles can cross the river year-round	Large vehicles can cross the river year-round	Large vehicles can cross the river year-round
River crossing time for pedestrians	Approximately 20 minutes (by canoe)	Approximately 3 minutes (on foot)	Approximately 3 minutes (on foot)	Approximately 3 minutes (on foot)

Bafing Bridge Indicators	Baseline value 2008	Target value 2011	Actual value 2011	Actual value 2022
		Completion year	Completion year	Ex-post evaluation
Period in which vehicles cannot cross the river	Throughout the year (at the location of the bridge)	None	None	None
Type of vehicles that can cross the river	Large vehicles could not cross the river	Large vehicles can cross the river year-round	Large vehicles can cross the river year-round	Large vehicles can cross the river year-round
River crossing time for pedestrians	Approximately 20 minutes (by canoe)	Approximately 3 minutes (on foot)	Approximately 3 minutes (on foot)	Approximately 3 minutes (on foot)

Source: documents provided by JICA, information from the executing agencies, site visits and interviews of the community

As the effect indicator of the project objective “to facilitate smooth traffic along the Southern Corridor”, the project documents listed "an increase in traffic volume in the area along the Southern Corridor". However, there were no baseline values set, and no traffic volume statistics or satellite data were available at the ex-post evaluation.[12] The communities around the bridges, however, recognized an increase in traffic after the construction of bridges and roads. It is assumed that the traffic volumes have reduced due to ECOWAS sanctions in 2022.

3.3.1.2 Qualitative Effects (Other Effects)

Those listed as qualitative effects in the ex-ante evaluation sheet were treated as impacts by reviewing the logic of the project. See the "Impact" section.

3.3.2 Impacts

3.3.2.1 Intended Impacts

The following effects were expected at the time of ex-ante evaluation:

- Economic revitalization of the roadside areas of the Southern Corridor
- Promotion of transport and trade between Senegal and Mali and those with the neighbouring countries
- Securing safe routes to school for children and increase in school enrolment and attendance rates
- Securing access to health facilities and increase in the number of emergency transportations
- Reduction of transport time to neighbouring markets

Based on the questionnaire responses from the executing agencies, interviews in the communities around the bridges[13] and site visits, it was confirmed that the construction of the

[12] Referring to a previous case study, we attempted to detect the operation of large vehicles using satellite data (Sentinel-2). However, we found it challenging to do so in this ex-post evaluation. The reasons are as follows. A published paper (Fisser, H., Khorsandi, E., Wegmann, M., & Baier, F. (2022). Detecting Moving Trucks on Roads Using Sentinel-2 Data. Remote Sensing, 14(7), 1595.) reported that the performance of the analysis varied widely among the countries and regions analyzed. An analytical article by Data Science Campus (August 2021), which attempted to replicate the method used in a previous case study in East Africa, also concluded that they did not obtain robust results. Thus, we concluded that the method is not reliable at this time and that it is not possible to verify the performance of the analysis using actual data.

[13] About five persons per bridge were interviewed and they were mainly influential personages in the villages as follows:
Near Balé Bridge: Balinda with a population of 500. Three men (two farmers and a member of village assembly) and two women (housewives) were interviewed.
Near Falémé Bridge: Mahina-Mine in Mali with a population of 3,000. Two men (village chief and a member of village assembly) and a woman (president of the women's association in the village) were interviewed.
Moussala in Senegal with a population of 2,000. Two men (Imam of the mosque and a member of village assembly) were interviewed.
Near Bafing Bridge: Badougouto Droite, also known as Sitahéto, with a population of 5,000. Two men (elders of the village) were interviewed.

bridges and roads had the anticipated impacts as follows. Numerical data, such as school attendance rate and the number of emergency transportation to the health facilities, were not available.

- Economic revitalization of roadside areas: It became easier to go to the other side of the river and other areas. This contributed to the increase in the transport volume of commodities and to the economic revitalization.
- The satellite data analysis confirms the manifestation of “economic revitalization of roadside areas” in the Southern Corridor on the Mali side. All complementary indicators (nighttime light, population, and urban area) have increased within a roughly 20 km distance from the Southern Corridor on the Mali side (see [column] below for details). In particular, the increase peaked in the area around 10 km from the Southern Corridor. On the other hand, we observed no increase in these indicators on the Senegalese side.
- Traffic and trade between the two countries and with the neighbouring countries: traffic volume had increased compared to the time of the ex-ante evaluation. According to the statistics of Senegal, the volume of trade between Senegal and Mali had been increasing since 2011 (see Table 6), but it is estimated that it has decreased due to the ECOWAS sanctions in 2022.
- Access to schools and change in school enrolment and attendance rates: Access to schools on the other side of the river has improved in terms of time required and safety compared to when canoes were used. The school attendance rate was quite high at around 90% according to the perception in the community, but it is not clear to what extent the new bridges had impact on the school attendance rate.
- Access to health facilities and markets: Many residents usually use health facilities and markets on the other side of the river. Access was improved by the new bridges. Data on transport times was not available.
- Income sources and annual income of the community: Income sources of the residents are commerce, agriculture, animal husbandry, gold mining, and fishing, and remain the same as before the project. Annual income increased slightly from about 1 million CFA francs before the project to about 1‐3 million CFA francs at the time of the ex-post evaluation, but considering inflation, the annual income remains the same level as at the time of the ex-post evaluation. The residents' income is supported by strong cotton shipments and an increase in small-scale commercial activities by women, among others.

Badougouto Gauche with a population of 400. A man (village chief) was interviewed.
Sitandinkoto with a population of 3,000. Three men (farmer, tailor and merchant) and a woman (housewife) were interviewed.

Table 6　Trade volumes between Senegal and Mali

(Unit: ton)

Year	Export from Senegal to Mali	Import from Mali to Senegal
2010	1,906,025	2,501
2011	1,779,140	11,588
2012	1,868,491	5,797
2013	1,540,222	5,480
2014	1,607,147	7,214
2015	2,501,219	8,515
2016	2,653,844	8,112
2017	2,857,135	9,962
2018	2,721,598	4,040
2019	2,984,417	2,381
2020	2,946,232	1,452

Source: Agence Nationale de Statistique et de la Démographie, Senegal. *Note d'Analyse du Commerce Extérieur* (versions from 2014 to 2020)[14]

3.3.2.2 Other Positive and Negative Impacts

1) Impacts on the Natural Environment

Phase III of this project was classified as Category C based on the *Guidelines for the Environmental and Social Consideration* (April 2004). There were no ex-ante evaluation sheets for Phase I and II, and categories of them were not specified. An environmental impact assessment for the Southern Corridor construction projects was conducted in 2002 with the support of the Islamic Development Bank (BID), and UEMOA conducted a supplementary study in 2005. According to the executing agencies, no negative environmental impacts were observed during the construction of the project, as environmental and social protection measures were taken based on the results of these studies, such as watering to reduce dust, controlled working hours of construction to reduce the impact of noise and vibration, and slope improvement along the riverbank to prevent soil erosion. In the interviews during the ex-post evaluation, the communities pointed out dust, noise, and air pollution due to increased traffic after the construction of the bridges.

2)　Resettlement and Land Acquisition

At the time of the feasibility study in 2007, one resettlement was planned within the scope of Phase III of the project, and the Government of Mali had already paid compensation for the resettlement and had assured that the removal of the residence would be completed by the end of March 2009. At the time of the ex-post evaluation, DNR Mali confirmed that one well was subject to relocation, the compensation of 350,000 CFA francs was paid by February 2008, and the relocation was completed by the end of 2008. No resettlement occurred on the Senegalese side according to the executing agency.

3) Gender Equality, Marginalized People, Social Systems and Norms, Human Well-being and

[14] http://www.ansd.sn/index.php?option=com_ansd&view=titrepublication&id=15&Itemid=289

Human Rights

According to interviews in the community, the increased traffic and more active human flow have resulted in a deterioration of public safety, including an increase in traffic accidents and incidents of theft, robbery, and violence. While small-scale commercial activities by women have increased, prostitution and sexual crimes have been reported to be on the rise.

The outcome of this project, "smooth transport along the Southern Corridor" and the expected impact, "contribution to regional economic development and promotion of transport and trade between the two countries and neighbouring countries" were generally achieved as planned. Although it is estimated that the volume of traffic and trade has decreased due to economic sanctions against Mali in 2022, this is an external factor of the project. On the other hand, an increase in traffic accidents, environmental pollution, and deterioration of public security have been reported around the bridges. Based on the above, this project has generally achieved its objectives. Therefore, effectiveness and impacts of the project are high.

[Column] Utilization of Satellite Data

Although multiple quantitative and qualitative sources are required to verify the manifestation of project effects, there are some situations, especially in terms of impacts, where quantitative indicators have not been established, and statistical data disaggregated at the target area level have not been available. Even in such cases, quantitative data necessary for evaluation can be collected by utilizing satellite data. In this ex-post evaluation, similarly, by utilizing free satellite data, more objective verification was possible by supplementing the information obtained through conventional methods (e.g., interviews with project officials and residents).

Below is a description of the specific areas analyzed, the data used, the analytical methodology, and the results. The analysis area was western Mali and eastern Senegal, including the Southern Corridor and surrounding areas (see Figure 1). The figure also shows the locations of the three bridges developed by the project.

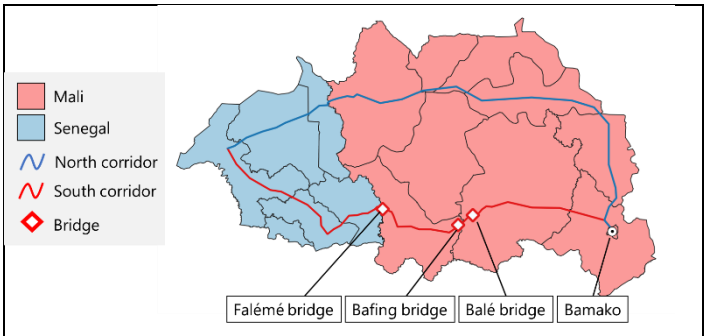


Figure 1 Project location

The data used were

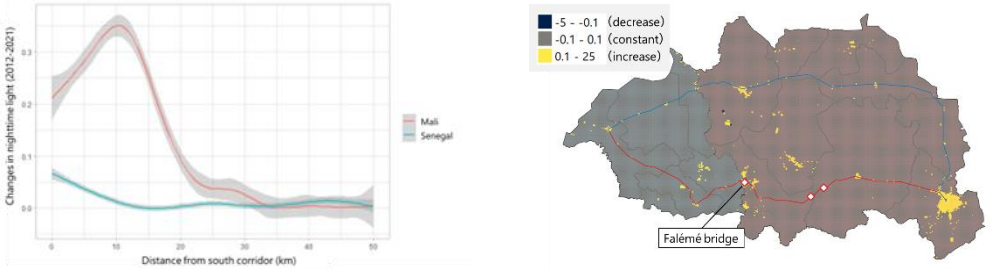
nighttime light,[15] population,[16] and urban area.[17] Nighttime light has been found to be correlated with local economic activity.[18] However, nighttime light does not readily reflect economic activity, especially in developing countries where the primary industry is agriculture. Therefore, other data (population and urban area) that also correlate with economic revitalization were collected to verify the impact of this project (economic revitalization of roadside areas) from multiple information sources.

The method of analysis was to spatially examine the extent to which the above three complementary indicators changed within a certain distance from the Southern Corridor. Specifically, we analyzed the relationship between the change in each indicator and its distance from the Southern Corridor within an area up to 50 km from the Southern Corridor from 2008 (2012 for nighttime light due to data limitations), when the first project started, to the latest year for which data were available (see Figure 2).

According to Figure 2, all indicators generally increase within 20 km from the Southern Corridor on the Mali side. In particular, the peak of the increase is around 10 km along the Southern Corridor (Figure 2 left). Nighttime light and population also increased near the Falémé bridge at the border (Figure 2 right). On the other hand, there is no increase in these indicators on the Senegalese side, with only a slight increase in nighttime light within 10 km from the Southern Corridor.[19]

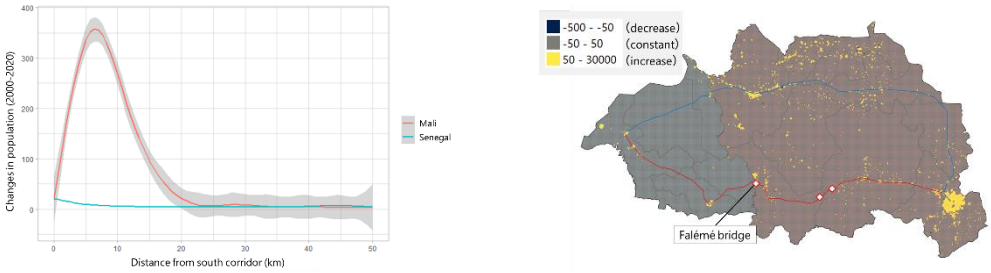
Based on the above results, we can say that on the Mali side, "economic revitalization of roadside areas" was confirmed. However, no similar impact was observed on the Senegalese side, suggesting that the cross-border spillover effect of the project to the west of the Falémé bridge was minor.

Nighttime light analysis results[20]



[15] Annual VNL V2 (annual data of VIIRS) median masked data (2012-2021) (resolution: about 500 m).
[16] WorldPop: Unconstrained individual countries UN adjusted (2000-2020) (resolution: 1 km).
[17] MODIS Land Cover Type Yearly Global 500 m (2001-2019) (resolution: 500 m).
[18] See, for example, the following paper.
Henderson, J. V., Storeygard, A., & Weil, D. N. (2012). Measuring economic growth from outer space. *The American Economic Review*, 102(2), 994-1028.
[19] In addition to the above analysis, we conducted a focused analysis within 20 km of the three bridges rather than the entire corridor. We found that the change was particularly significant around the Falémé Bridge, while we observed little change around the Bafing and Balé bridges.
[20] The vertical axis of the graph shows the brightness of the light source (radiance), taking a minimum value of -1.5 and a maximum value of 340,573 (units are "nanoWatts/cm2/sr").

Population analysis results[21]



Urbanization analysis results[22]

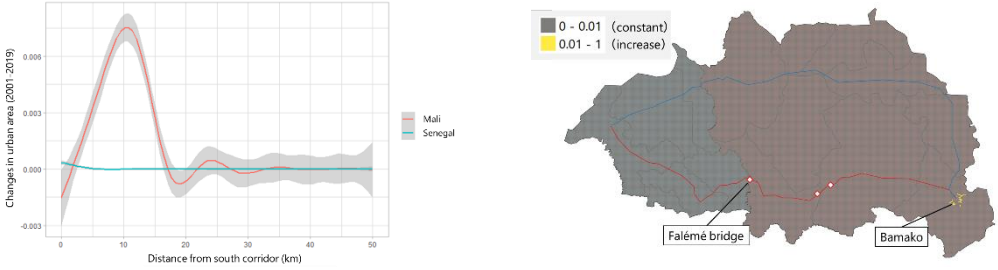


Figure 2 Change in each indicator and distance from the Southern Corridor (left), the spatial distribution of indicator change (right)

3.4 Sustainability (Rating: ②)

3.4.1 Policy and System

As noted in the section on Relevance, the road and transport sector is important in the development policies of Mali and Senegal, and the need for the Southern Corridor would not change even under Mali's transitional government. Therefore, the sustainability in the aspects of policy and system is high.

3.4.2 Institutional/Organizational Aspect

The executing agencies of Mali and Senegal both changed after the completion of the project. The original executing agency of Mali was the National Department of Roads, Ministry of Equipment and Transport (*Direction Nationale des Routes, Ministère de l'Equipement et des Transports*). It was replaced by the National Department of Roads, Ministry of Transport and Infrastructure (*Direction Nationale des Routes (DNR), Ministère des Transports et des Infrastructures*) when the transitional government was established after the coup in May 2021. The three bridges constructed by this project were managed by its Kayes Regional Department of Roads. After Kita Region was separated from Kayes Region in December 2020, Bafing and Balé Bridges have been managed by the Construction Monitoring and Control Division of Kita

[21] The vertical axis of the graph shows the number of people.
[22] The vertical axis of the graph shows the value of urbanization (the percentage of the area of each 1 km mesh classified as urban). The minimum value is 0, and the maximum value is 1.

Regional Department of Roads. The original executing agency of Senegal was the Autonomous Agency for Road Works (*Agence Autonome des Travaux Routiers: AATR*), and it was replaced by Senegal Agency for Road Works and Management (*Agence des Travaux et de Gestion des Routes Sénégal: AGEROUTE Sénégal*) in April 2010. The plan at the time of project completion was that Falémé Bridge at the border would be managed by the management committee consisted of Keniéba Subdivision of Roads, Kayes Regional Department of Roads of Mali and Tambacounda Regional Office of AGEROUTE Senegal. However, the management committee is not functioning at the time of ex-post evaluation, and the responsible sections of the two countries manage their respective parts of Falémé Bridge. Both parties communicate when needs arise. From the above, the sustainability in the institutional and organizational aspects is high.

3.4.3 Technical Aspect

Construction Monitoring and Control Division of Kita Regional Department of Roads has one engineer and two technicians. For Falémé Bridge, the Mali side has two engineers including the chief of Keniéba Subdivision and one administrative staff. The Senegalese side has four staff including the director of the regional office and three engineers, who are all in this office more than nine years. Daily operation and maintenance works, such as inspection, repair and cleaning, are sufficiently implemented for the three bridges. While there are no specific training or manuals for the operation and maintenance of the three bridges, no problems have been observed in staffing and the technical levels. Therefore, the sustainability in the technical aspect is high.

3.4.4 Financial Aspect

As shown in Table 7, the budget of the agencies responsible for operation and maintenance of the bridges was increasing in the two countries at the time of the feasibility study of the project (2007-2008), corresponding to the increase in road-related projects including the construction of the Southern Corridor. However, as shown in Table 8, the budget of DNR Mali has decreased significantly since 2019, with actual expenditures being less than 20% of the budgeted amount needed for the maintenance of roads and bridges. According to DNR, its proper revenue is only from road user fees, which are insufficient for maintenance, and therefore DNR obtains its budget from the central government which includes support from development partners. However, the recent political situation in Mali has halted support from major development partners, and budget from the central government has been significantly reduced due to ECOWAS sanctions as well as by the impact of COVID-19. The actual maintenance status of the three bridges shows that the impact of the budget decrease is not particularly significant at the time of the ex-post evaluation. However, due to the political situation in Mali, the current maintenance budget is unlikely to be restored to the previous level. Therefore, financial sustainability is moderately low considering the large-scale repairs of roads and bridges in the future. As for AGEROUTE Sénégal, the budget

appears to be adequate at the time of the ex-post evaluation.

Table 7. Budget status of executing agencies at the time of feasibility study of the project

(Unit: Million CFA francs)

Year	2003	2004	2005	2006	2007
DNR: Budget for business implementation	6,112	8,334	8,414	55,171	86,461
DNR: Budget for operation and maintenance	5,880	8,000	8,000	11,044	12,243
AATR: Budget for business implementation	49,263	60,223	60,000	129,340	137,978
AATR: Budget for operation and maintenance	20,000	49,000	49,960	27,846	33,242

Source: documents provided by JICA

Table 8. Financial status of DNR Mali at the time of ex-post evaluation

(Unit: Million CFA francs)

Year	2018	2019	2020	2021
Budget of DNR	1,405,000	503,000	475,000	499,000
Requested amount of budget for the operation and maintenance of infrastructure including roads and bridges	90,000	81,432	92,263	120,436
Actual expenditure for the operation and maintenance of infrastructure including roads and bridges	32,265	14,813	18,400	22,000

Source: Information from DNR

Table 9. Financial status of AGEROUTE Sénégal at the time of ex-post evaluation

(Unit: Million CFA francs)

Year	2018	2019	2020
Budget of AGEROUTE	495,805	495,805	354,844
(Of which) Budget for the operation and maintenance of infrastructure including roads and bridges	64,361	53,381	20,374
Actual expenditure for the operation and maintenance of infrastructure including roads and bridges	41,556	26,061	28,679

Source: Information from AGEROUTE

3.4.5 Environmental and Social Aspect

Please refer to the section on Impact.

3.4.6 Preventative Measures to Risks

According to interviews in the communities around the bridges, human flow and traffic,

especially of large vehicles, had increased after the construction of roads and bridges, and it has led to an increase in traffic accidents and deterioration of security, including robberies, theft, violence, and sexual crimes. Mali experienced two coups by the military government in 2020 and 2021, and terrorism by Islamic extremist groups has been frequent, resulting in a deterioration of security throughout the country.

3.4.7 Status of Operation and Maintenance

The local assistant confirmed during the site visit that the condition of the bridges and their operation and maintenance were good without particular problems. DNR Mali wants to repair a crack due to erosion at the bottom of the pier of the Bafing Bridge, but the local assistant, an engineer, observed the crack and confirmed that it was s minor and would not require immediate attention.

Some minor issues have been observed in the financial aspects in the current status of operation and maintenance, and they are not expected to be resolved. Therefore, sustainability of the project effects is moderately low.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of this project was to facilitate smooth traffic along the Southern Corridor connecting the capitals of Senegal and Mali by constructing three bridges on the corridor in Mali, thereby contributing to the economic development of roadside areas and the promotion of transport and trade between the two countries and with the neighbouring countries.

The relevance and consistency of this project are high as it was in line with the development plans and development needs of the two countries as well as with the Japan’s assistance policy, and the bridges were integral parts of the Southern Corridor together with other road construction projects. The efficiency of the project is high as the project cost was within the plan while the project period was slightly longer than planned. The effectiveness and impact of the project are high because the objectives of the project, "to facilitate smooth traffic along the Southern Corridor" and “to contribute to the economic development of roadside areas and the promotion of transport and trade between the two countries and with the neighbouring countries," were generally achieved as planned. The sustainability of the project effects is moderately low as there are some financial problems in the operation and maintenance of the project due to the political instability in Mali.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

None.

5. Non-Score Criteria

5.1. Performance

5.1.1 Objective Perspective

None.

5.1.2 Subjective Perspectives (retrospective)

None.

Republic of Cameroon

FY2021 Ex-Post Evaluation Report of Technical Cooperation Project

"The Project on Magmatic Fluid Supply into Lakes Nyos and Monoun and Mitigation of Natural Disasters through Capacity Building in Cameroon"

External Evaluator: Maki Hamaoka

Foundation for Advanced Studies on International Development

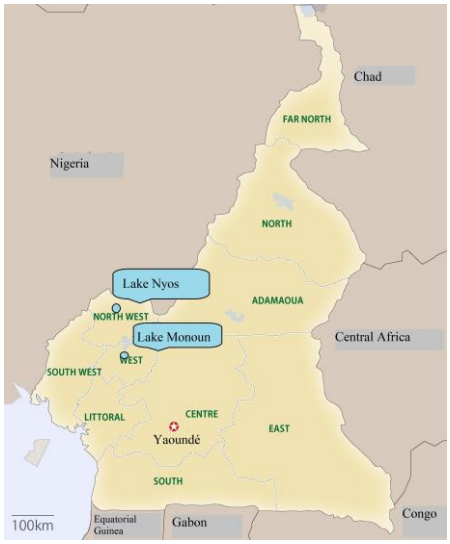
0. Summary

This project was implemented to establish a framework where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun through international joint research between Japan and Cameroon involving scientists from Institute of Geological and Mining Research (hereinafter referred to as "IRGM"), thereby disseminating information to local population on gas disasters and disaster prevention using IRGM's research results in collaboration with IRGM and Division of Civil Protection (hereinafter referred to as "DPC").

The objectives of this project were consistent with the policy priorities of the government of Cameroon; in light of the recognized need to monitor the amount of residual CO_2 continuously in the target lakes. Therefore, the relevance of the project is high. In addition, the objectives of this project aligned with Japan's ODA policy for Cameroon, with other JICA projects in disaster prevention management, and with other organizations that ensured the installation of degassing pipes and monitoring of the effects of degassing. Therefore, coherence is high. Although the project's international joint research produced a number of publications, the underutilization of IRGM's analytical equipment limited the achievement of the project's purpose, "independent research on limnic eruptions by Cameroonian researchers." In addition, the project's effectiveness and impact have been moderately low; this is reflected in the absence of significant results of the researchers' efforts to disseminate the project's gas disaster research results to the local population. Although delays in the disbursement of counterpart funds and equipment provision affected the achievement of some outputs, the project period and costs on the Japanese side were within the plan. Therefore, efficiency of the project is high. Although slight technical issues have emerged in the current operation and maintenance of the equipment, there are good prospects for improvement/resolution, the equipment which is currently out of service will be utilized and the monitoring of the lakes and sample analysis are expected to resume through the follow-up cooperation consisting of equipment procurement and dispatching engineers for the lake degassing system and lake water monitoring scheduled in FY2022. Therefore, sustainability of the project effects is high.

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

1. Project Description



Project Location(s)

Deep lake water discharged from a degassing pipe installed in Lake Nyos
(source: https://www.jica.go.jp/oda/project/1000710/index.html)

1.1 Background

In northwestern Cameroon, massive emissions of carbon dioxide (CO2) from Lake Monoun (in 1984) and Lake Nyos (in 1986) caused disasters that took the lives of many residents and livestock. The 1984 Lake Monoun explosion killed 37 people, and the 1986 Lake Nyos explosion killed 1,746 people and about 3,000 livestock. The area around Lake Nyos was closed to habitation, and the roads passing nearby were closed to traffic. Under these circumstances, by request of the government of Cameroon, technical cooperation project was implemented as Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as “SATREPS”) from April 2011 to March 2016 by IRGM as the counterpart research institution and Tokai University as the representative of the Japanese research institution.

1.2 Project Outline

Overall Goal[1]		In collaboration with IRGM and DPC's jurisdiction over disaster management, disseminate information to local residents about gas disasters and disaster prevention using IRGM's research results.
Project Purpose[2]		A framework is established where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun through science and technology cooperation between Japan and Cameroon.
Output(s)	Output 1	The mechanism of limnic eruption is understood.
	Output 2	The CO2 recharge system beneath Lakes Nyos and Monoun is understood.
	Output 3	The hydrogeological regime around Lakes Nyos and Monoun is understood.
	Output 4	The interaction between rock and in the CO2-rich fluid is understood.
	Output 5	Lakes Nyos and Monoun are monitored.
	Output 6	The experimental system for removing CO2-rich deep water to prevent gas rebuilding at Lake Monoun is set up.
	Output 7	Magmatism of Oku volcanic zone is understood.
	Output 8	Geochemical parameters of lakes along Cameroon Volcanic Lines (CVL) other than Nyos and Monoun are understood.
	Output 9	The results of scientific monitoring are systematically shared with DPC.
Total cost (Japanese Side)		420 million yen
Period of Cooperation		April 2011-March 2016
Target Area		Lakes Nyos and Monoun
Implementing Agency		IRGM
Other Relevant Agencies/ Organizations		Ministry of Economy, Planning and Regional Development (MINEPAT), Ministry of Territorial Administration (MINATD), Ministry of Scientific Research and Innovation (MINRESI), DPC
Organization in Japan		Tokai University (principal research institution), University of Tokyo, Osaka University, University of Toyama, Kumamoto University, Tokyo Institute of Technology
Related Projects		＜Projects of Other Donors> • *Security and Socio-Economic Reintegration of Lake Nyos Area* (UNDP, EU, 2008-2013) • *Natural Disaster Management and Civil Protection Projec*t (AFD) • *Lake Nyos Dam Reinforcement Project* (EU)

[1] Since no overall goal was set for this project, the evaluator analyzed the project information, proposed the above as the overall goal, and obtained the approval of the parties concerned.

[2] The project purpose, as stated in the Project Design Matrix (PDM), is "a framework is estab1ished where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun and utilize its outcomes for disaster management through scientific cooperation between Japan and Cameroon." After achieving the project purpose, the SATREPS project aims for the social implementation of research results as an overall goal. In the ex-post evaluation, the evaluator interpreted the project purpose of PDM "utilize [the project's] outcomes for disaster management" as equivalent to social implementation, evaluated this (rather than the stated project purpose) as the overall goal, proposed this interpretation to the parties concerned, and obtained their approval.

1.3 Outline of the Terminal Evaluation

1.3.1 Achievement Status of Project Purpose at the Terminal Evaluation

The project purpose was expected to be achieved to some extent. Out of the initial five indicators, two (communication, fundraising through acceptance of analytical request with charge) were achieved, and three (preparation of operational directions, appropriate use of observation and analysis equipment, and systematic storage of water and rock samples) were partially unachieved.

Regarding the operational directions, most of the simplified users' manuals were prepared, but Standard Operating Procedures (SOPs) for monitoring activities were not ready yet by the project's end. Some main analytical equipment such as an Atomic Absorption Spectrometer (AAS),[3] an isotope analyzer (Picarro),[4] a carbon isotope analyzer (13C Analyzer)[5] and multibeam sonar data processing were considered underutilized. It was expected that the unachieved indicators would be achieved by completing the instruction manual and conducting additional training on some analytical equipment in the remaining project period.

For the "systematic storage of water and rock samples," IRGM designed the storage, and Japanese experts provided advice on cataloging samples. Achievement of this indicator was expected only if the storage was renovated with funding from the World Bank.

1.3.2 Achievement Status of Overall Goal at the Terminal Evaluation

No overall goal was set for this project. If the project's findings on the mechanism of lake explosions were successfully shared with residents living near the lakes, the impact of the project's social implementation would be relatively high.

1.3.3 Recommendations from the Terminal Evaluation

(1) Measures to be taken by the termination of the project

- Disbursement of the remaining counterpart funds:

  MINEPAT and the Ministry of Finance were strongly requested to ensure the

[3] Equipment that analyzes minute amounts of metallic cations dissolved in water, used to analyze harmful heavy metals present in groundwater. The development of water resources is an important social issue in Cameroon, and many requests for sample analysis are expected if this equipment operates smoothly (source: documents provided by JICA).

[4] Equipment used to estimate the origin of water by analyzing the isotope ratio of hydrogen and oxygen. The isotope analyzer is indispensable for water quality surveys and for hydrological surveys aimed at water resource development. Once the equipment is operating smoothly, many requests for sample analysis are expected (source: documents provided by JICA).

[5] Equipment used to estimate the origin of CO2. It is possible to identify CO2 originating from magma, which is essential for monitoring volcanic activity (source: documents provided by JICA).

disbursement of the remaining amount of the counterpart funds, as expenditures only reached 60% of their planned amount.

- Follow-up for unachieved indicators:

Completion of monitoring activities' SOP was required. For the proper use and maintenance of the provided equipment, the number of analytical request orders would increase and IRGM technicians would obtain additional training in the use of the main equipment.

- Return of inputs to outputs:

Because only one of the five long-term trainees belonged to IRGM at the time of the terminal evaluation, it was desirable to act to ensure that the capacities of long-term trainees would be fully utilized for lake monitoring and disaster reduction activities.

- Improving sustainability:

In order to sustain the project's outcomes, it is indispensable to maintain and develop capacities built through the project and the network established by the project, including those connecting Japanese researchers and long-term trainees.

(2) Measures to be taken after project completion

- Utilization of the project outcomes:

Relevant stakeholders in Cameroon, including IRGM, were strongly recommended to secure the necessary funding to continue monitoring, take an additional measure for degassing, and utilize the outcomes generated by the project to ensure the safety of the lakes.

- Strengthening of organizational capacity:

So that they may effectively utilize the knowledge and technology gained throughout the project, IRGM was encouraged to further strengthen their organizational capacity. Specific recommendations included setting up mechanisms for sharing knowledge within the institute (e.g., holding regular seminars, preparing operational directions, and continuing regular meetings between IRGM headquarters and the laboratory) and ensuring the allocation of financial and human resources for lake monitoring and data analysis.

- Sharing of monitoring data among the project's research members:

The data generated from lake monitoring is valuable for the research members involved in the project. To generate additional scientific results from data utilization, the project's research members were encouraged to continue sharing the collected data with each other after the project ends.

- Strengthening disaster risk reduction framework:

Setting up an effective framework among stakeholders was recommended to strengthen disaster risk reduction after the project's completion.

2. Outline of the Evaluation Study

2.1 External Evaluator

Maki Hamaoka, Foundation for Advanced Studies on International Development

2.2 Duration of Evaluation Study

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

Duration of the Study: November 2021-December 2022

Duration of the Field Study by Local Consultant: March 2022-July 2022

2.3 Constraints during the Evaluation Study

(1) Since October 2017, numerous clashes have occurred between Anglophone separatist groups advocating independence and the security authorities in English-speaking regions, including the North-western regions in which Lake Nyos is located. The conflict has resulted in numerous casualties, including civilian casualties. There have also been incidents of kidnapping and murdering foreigners and, as of the ex-post evaluation, for the travel to this region, the travel cancellation advisory issued by the Ministry of Foreign Affairs of Japan is still in effect. Even for Cameroonians, travel to the above region remained dangerous. Therefore, the local consultant was unable to confirm the status of Lake Nyos on site. Moreover, the survey on information dissemination to the local people formerly living in the Lake Nyos neighborhood was conducted in Bamenda City, where many of the former residents now reside, but the difficulty of finding participants for workshops organized by the project during its implementation limited the scope of interviews.

(2) With regard to Lake Monoun, local people were dissatisfied with the project, believing that the government of Cameroon was prioritizing Lake Nyos in terms of disaster countermeasures. Residents took action to manifest their dissatisfaction by cutting the cables of the meteorological station that the project installed in Lake Monoun. During the ex-post evaluation, the local consultant visited Lake Monoun and interviewed local people with military escort, but encountered difficulty in obtaining information from them.

3. Results of the Evaluation (Overall Rating: B[6])

3.1 Relevance/Coherence (Rating: ③[7])

3.1.1 Relevance (Rating: ③)

3.1.1.1 Consistency with the Development Plan of Cameroon

At the time of the ex-ante evaluation, the government of Cameroon set forth its method of disaster prevention, “development of economic infrastructure and natural resources,” as

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

[7] ④: Very High, ③: High, ②: Moderately Low, ①: Low

the fourth of six axes described in the *Poverty Reduction Strategy Paper* (2003). In addition, in recognition of the gas disaster in Lake Nyos as an important issue, the government of Cameroon worked on degassing the lake water and assisting victims under the initiative "*National Program for the Rehabilitation and Security of the Nyos Zone*" (2008).

At the time of the project completion, it was not possible to confirm the position of disaster prevention and gas disasters in the Cameroonian government's development plan in the "*Growth and Employment Strategy Paper"* (2009), the successor policy of the Poverty Reduction Strategy Paper. However, given that the "*National Program for the Rehabilitation and Security of the Nyos Zone*" continued, it can be assumed that the government of Cameroon prioritized measures against gas disasters as part of its policy even at the time of project completion.

In light of the above, since efforts to prevent disasters through gas disaster research continued as a national program from the start to the completion of this project, this project was in line with the Cameroonian government's policy priorities.

3.1.1.2 Consistency with the Development Needs of Cameroon

As mentioned above, at the time of the ex-ante evaluation, the area around Lake Nyos and Lake Monoun had suffered many casualties and serious social and economic impacts; residents were living in evacuation shelters, and the main roads around Lake Nyos were closed. This project met Cameroon's social needs by mitigating human and social damage caused by magmatic fluid supply into lakes by providing scientific knowledge obtained from research and monitoring to disaster prevention efforts. In addition, only three lakes in the world have been found to cause gas disasters, making those described here unique. Although foreign researchers have conducted research on the circumstances of such disasters in the past, the mechanism has not been fully elucidated. In addition, foreign researchers took data out of the country, and the training of Cameroonian researchers who could independently continue research and monitoring was not progressing. Since the supply of CO_2 to the lakes continues, it was necessary to develop a system that allows Cameroonian researchers to conduct continuous and independent research and monitoring and human resource development through this project was consistent with Cameroon's needs.

The result of the measurement of the amount of CO_2 remaining in both lakes during the project implementation showed that after the installation of two additional degassing pipes in 2011, the amount of CO_2 in Lake Nyos started to decrease quickly with a rate of 1.44 Gmol/year, which was doubled after 2013 when 3 pipes started working. However after 2014, the amount decreased by a third (0.5 Gmol per year). At Lake Monoun, the amount of CO_2 remaining in the lake bottom increased from 2011 to 2014, and decreased in 2015. Since the change in the amount of CO_2 in both lakes was unpredictable, regular monitoring of the

lakes was necessary at the time of the project completion.

In light of the above, from the time of ex-ante evaluation to the time of project completion, it can be judged that this project was consistent with Cameroon's development needs.

3.1.1.3 Appropriateness of the Project Plan and Approach

Though guidelines for environmental and social considerations were not applied at the time the project was requested, it was formulated with consideration for the socially vulnerable. This consideration was intrinsic in its attention to the safety of the Lake Nyos and Lake Monoun areas, forced to evacuate due to gas disasters.

In this project's plan and approach, the following appropriateness issues emerged.

The outputs and project purpose in the narrative summary of the PDM used for the project implementation lacked logical organization. In addition, some of the indicators of the project purpose and outputs were not suitable as indicators for accurate evaluation of the objectives indicated in the project summary and it was difficult to evaluate the project according to the PDM. Therefore, the ex-post evaluation reviewed the indicators for the overall goal, the project purpose, and the outputs.

As described later in Section 3.2.2 Impacts, no results of the social implementation (i.e., the utilization of research results for disaster prevention) were confirmed at the time of the ex-post evaluation. Despite the lack of preparation for social implementation pointed out in the mid-term review, detailed components were not formulated at that time. Furthermore, at the time of the terminal evaluation, a framework for post-project social implementation did not yet exist. Accordingly, the fact that a system for social implementation was not established during the project explained the absence of results of such an initiative at the time of the ex-post evaluation.

Although the above-mentioned issues were found, the parties involved in this project could not have had a concrete image of social implementation because this project was an early SATREPS project. Ultimately, the project's expectations and execution did not differ considerably, as it generated many international joint research products, such as published papers and international conference presentations. Therefore, the appropriateness of the project plan and approach did not factor into the evaluation of the project's relevance.

3.1.2 Coherence (Rating: ③)

3.1.2.1 Consistency with Japan's ODA Policy

The priority areas of assistance to Cameroon in JICA's rolling plan (2009) were (1) human

resource development, (2) economic development, and (3) farming and fishing/rural development. This project was aligned with these priority areas as it aimed to contribute to the autonomy of Cameroon's researchers as well as to regional and economic development through improving disaster management around Lake Nyos and Lake Monoun.

In January 2005, the Japanese government announced the "*Initiative for Cooperation in Disaster Risk Reduction*" as a basic policy for assisting developing countries reduce their disaster risk through ODA. The policy mentioned using technology to observe and predict the danger of disasters, and supported human resource development related to technology for disaster risk assessment.

Furthermore, Japan has advocated the necessity and importance of strengthening diplomacy and utilizing ODA to facilitate science and technology cooperation. To strengthen cooperation in science and technology, the Cabinet Office's Council for Science and Technology Policy compiled "*Towards Strengthening Science and Technology Diplomacy*" (April 2007, May 2008), and "*Innovation 25*" (June 2007) which focused on developing countries.

In light of the above, the objectives of this project were well-aligned with Japan's ODA policy and the science and technology policies of the Japanese government.

3.1.2.2 Internal Coherence

One representative of IRGM and one representative of DPC participated in JICA's thematic training "Community Disaster Risk Reduction," held in Kobe from June 22 to August 1, 2015. In February 2016, the two representatives implemented the action plan prepared in the training by leading a workshop for the residents of the areas around Lakes Nyos and Monoun. At the workshop, the mechanism of limnic eruptions and the actions to be taken in the event of a limnic eruption as the research results of this project were explained. In this regard, the interconnection between this project and the training program was confirmed.

3.1.2.3 External Coherence

The government of Cameroon formulated the "*National Program for the Rehabilitation and Security of the Nyos Zone*" to ensure safety around Lake Nyos, return displaced persons to their hometowns, and revitalize the region. With this program, the government launched a five-year *Project for Security and Socio-economic Reintegration of Lake Nyos Area* with the support of the UNDP and the EU. The addition of two degassing pipes in this program was a pillar of the Lake Nyos disaster countermeasures. Degassing pipes were being procured at the time of the ex-ante evaluation. The plan of the program did not include observation and monitoring after the degassing pipes were set up, but the installation's

outcome was monitored in Output 5 of this project.

In addition, the French government (through the *Natural Disaster Management and Civil Protection Project*) and the EU (through the *Lake Nyos Dam Reinforcement Project*[8]) assisted in mapping risk zones, designing regulatory regimes, and formulating disaster prevention plans to improve disaster prevention and emergency response capabilities in the areas around Mount Cameroon and Lake Monoun. These projects had no particular collaboration with this project.

This project was consistent with the development plan and development needs of the government of Cameroon. In terms of coherence, the objectives of this project were well-aligned with Japan's ODA policy and assistance policies for Cameroon at the time of the ex-ante evaluation. Concrete evidence of the project's cooperation with JICA's other projects and with other aid agencies is apparent in the cooperation between this project and the JICA training scheme, in the installation of degassing pipes, and in the subsequent monitoring of the effect of degassing. Therefore, its relevance and coherence are high.

3.2 Effectiveness and Impacts[9] (Rating: ②)

3.2.1 Effectiveness

As mentioned in Section 2.3 Constraints during the Evaluation Study, the PDM used during the project implementation had some logical weaknesses in the project summary and indicators. Therefore, in the ex-post evaluation, the evaluator reviewed the indicators by organizing these into an Input-Outputs-Outcomes structure, as shown in the figure below.

[8] A project to construct a facility to properly drain the lake water when the water level rises in order to prevent the collapse of the natural dam that forms the rim of Lake Nyos (source: detailed planning survey report)
[9] When providing the sub-rating, Effectiveness and Impacts are to be considered together.

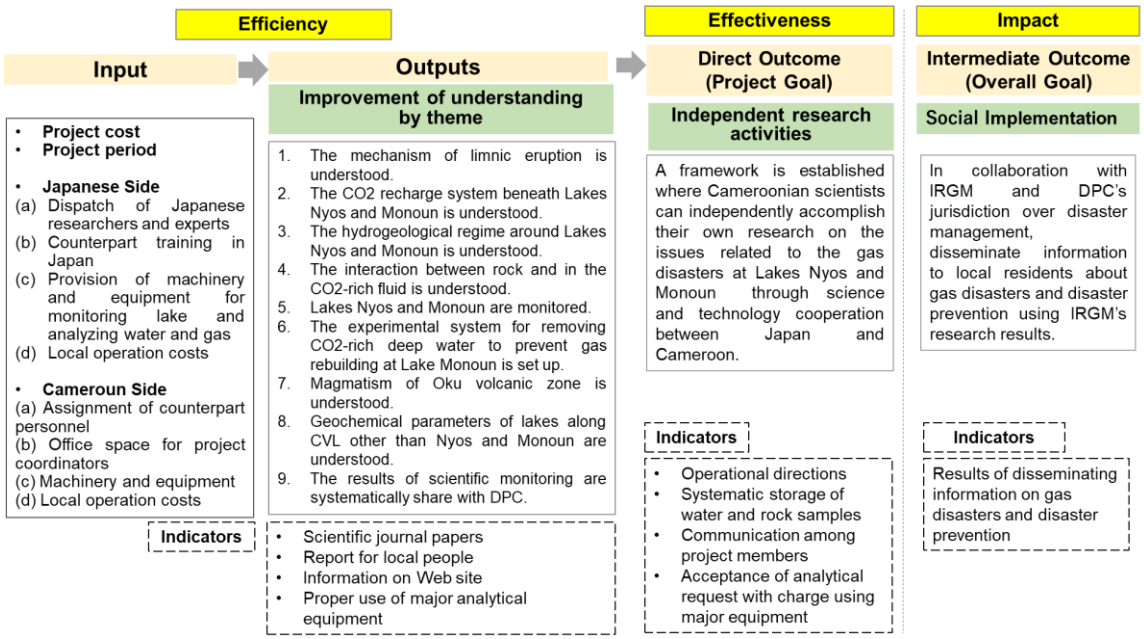


Figure 1 Logic of the Project as Organized in the Ex-Post Evaluation

Source: Prepared by the evaluator on the basis of the terminal evaluation report and answers to the questionnaire

3.2.1.1 Project Output

As shown in the project logic diagram above, one of the indicators of the initial project purpose, "appropriate use of equipment," is not an indicator of the revised project purpose, but rather an indicator of the conversion of input (provision of equipment) to output (proper use of the provided equipment). Evaluation focused on the appropriate use of four main items, used for acceptance of analytical request with charge and particularly important among the equipment provided by this project. The four items are (1) ion chromatograph (IC), (2) 13C Analyzer, (3) AAS, and (4) Picarro.

The achievement of each output is shown below (see Appendix 1 for the achievement status for each output).

- By the end of the project, Japanese experts and Cameroonian researchers had produced 31 scientific journal papers. One of these papers was published by *Scientific Report*, which belongs to Nature Publishing Group, thereby enhancing the reputation of Cameroonian scientists.
- These papers resulted from international joint research that strengthened the ability of IRGM researchers and technicians to observe lake water and analyze data and deepened their understanding of the mechanisms of lake explosions and the process of supplying carbon dioxide to lakes through the dispatch of Japanese experts, training in Japan, and provision of equipment.

- Due to the equipment's delayed provision and eventual malfunction, IRGM technicians were not able to use three of the four main pieces of analytical equipment independently and properly at the time the project was completed.

Table 1 Usage of Major Equipment at the Time of Project Completion

Equipment	Status
IC	・ Utilized without technical problems by IRGM staff
AAS	・ At the time of installation in December 2013, the manufacturer technician instructed the IRGM technicians on the operation. Installation of the equipment was delayed 2 years and 8 months after the start of the project. ・ From October to November 2014, a special researcher at Tokai University intensively instructed IRGM technicians on using the AAS. Furthermore, an IRGM researcher who had come to Japan as a long-term trainee at Tokai University learned how to operate the AAS at a manufacturer in Japan. ・ The AAS broke down in 2015 and was out of service for 6 months. At the time of terminal evaluation, the counterparts answered that they were not confident in their ability to use the equipment.
Picarro	・ When the project started, Picarro operated without any problems, but has been out of service for at least 2 years due to electrical and maintenance problems.
13C Analyzer	・ The equipment was provided in December 2014, 3 years and 8 months after the start of the project. In addition to this delay, it was not used outside training due to the lack of gas samples required for analysis.

Source: Prepared by the evaluator based on the terminal evaluation report

3.2.1.2 Achievement of Project Purpose

Table 2 shows the degree of achievement of project purpose at the time of the project completion.

Table 2 Achievement of Project Purpose

Project Purpose	Indicator	Actual	Achievement Level (Sub-Rating)[Note]
A framework is established where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun through science and technology cooperation between Japan and Cameroon.	Indicator 1: An operational direction in IRGM including the following contents • Lake observation • Lake, spring, well, rain water and river sampling • Water analysis • Gas analysis • Accreditation of analytical equipment	<Almost achieved> • At the time of the terminal evaluation, most of the simplified users' manuals for the major analytical equipment had been prepared, but SOPs on lake monitoring had not yet been prepared. At the time of the terminal evaluation, it was recommended that the IRGM prepare SOPs based on the monitoring that had been carried out, and revise them as necessary. • At the time of the follow-up survey conducted in January 2020, the SOP issue no longer existed at IRGM. The survey mission determined that follow-up on SOPs was unnecessary. • SOPs were not prepared, but this did not impede IRGM's monitoring activities. • Researchers accumulated the necessary knowledge during the project implementation and instructions for gaining further knowledge. However, no instructions have been prepared for the purpose of knowledge transfer.	③

	Indicator 2: Systematic storage of water and rock samples	<Achievement was limited> • The PDM indicates that this indicator can be verified by the presence of "shelves in the building of the laboratory for storing well-catalogued (GIS ref) water and rock samples." However, since it is not possible to check the achievement status only with the shelves, the evaluator verified IRGM staff's ability to store water and rock samples systematically. • The project prepared a design for sample storage in the basement of IRGM's laboratory. The storage was to be renovated within the "*Projet de Renforcement des Capacités dans le Secteur Minier (Project for Capacity Building in the Mining Sector)*", funded by the World Bank. However, the project was transferred from IRGM to the Ministry of Mines and Energy, and the sample storage was not refurbished. • During the project implementation, the Japanese experts made catalogs of collected water and rock samples, organized the samples, and stored them. However, IRGM counterparts were not aware of systematic storage at the time of the ex-post evaluation. Japanese researchers gave advice, but there were no specific activity records related to technology transfer on systematic storage, so the achievement of this indicator appears limited.	②
	Indicator 3: Communication among the project team members	<Achieved> • The PDM indicated this indicator to be verifiable by "use of a groupware through Internet." The ex-post evaluation confirmed achievement by interpreting the intention of the indicator as information sharing and exchange of opinions among project members or IRGM researchers, rather than simply the use of groupware.[10] • The mid-term review included recommendations for improved communication among project members. Since the mid-term review, monthly meetings have been held between IRGM headquarters, laboratory representatives, and the project coordinator to share information and discuss project matters among project members. • At the time of the terminal evaluation, communication among project members had greatly improved. Although groupware was not used, communication improved in various ways through mailing lists, websites, and seminars.	③

[10] The mid-term review conducted in 2013 pointed out that the lack of internal meetings in the project may have affected the smooth implementation of activities and, in turn, the outputs. Therefore, it was necessary to hold regular meetings with all project members, including project managers, researchers, engineers, and operational staff, to share information, discuss, make decisions, solve problems, and implement feedback. In addition to the above, the review recommended that communication and networking strengthen not only between representatives of the Japanese and Cameroonian sides, but also between researchers by effective use of means such as the internet and e-mail. Considering these recommendations, the evaluator in the ex-post evaluation interpreted the indicator to measure an improvement in communication among project members regardless of means.

	Indicator 4[11]: Acceptance of analytical request with charge using major equipment	< Achievement was limited > • IRGM staff was unable to use three of the four main analytical equipment independently by the project's completion. As a result, analytical request with charge was limited (see Table 3). In particular, Picarro and AAS were not used for analysis other than for practice purposes during project implementation and other research projects (see Table 4).	②

Source: Prepared by the evaluator based on the terminal evaluation report, answers to the questionnaire by the implementing agency, and answers to the questionnaire by the former experts.
Note: ④: Indicators were achieved more than planned, ③: achieved mostly as planned, ②:achieved to a limited extent, ①:not achieved

Table 3 Number of Acceptance of Analytical Requests with Charge

		←During the project implementation (April 2011–March 2016)→					←After the project completion (after March 2016) →					
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Universities	51	21	7	37	128	342	366	185	218	4	38	117
SATREPS	0	0	0	0	30	72	0	0	0	0	0	0
Others	131	147	131	149	280	236	152	451	174	122	137	209
Total	182	168	138	186	438	650	518	640	392	126	175	326

Source: Documents provided by the implementing agency

Table 4 Number of Samples Analyzed by Equipment

Item	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
IC	0	0	30	650	518	636	392	126	175	326
AAS	-	-	0	0	0	4	0	0	22	11
Picarro	(10)	0	0	(10)	0	0	0	0	0	0
^{13}C Analyzer	0	0	0	0	0	0	0	0	0	0

Source: Documents provided by the implementing agency

The project achieved its purpose only to a certain extent: two out of four indicators (preparation of operational directions, communication) were achieved or almost achieved, but two indicators (systematic storage of water and rock samples, acceptance of analytical request with charge using major equipment) were not achieved. Among them, the acceptance of analytical request with charge using major equipment, which is considered to be of relatively high importance for the project purpose of "independent research on the issues related to the gas disasters at Lakes Nyos and Monoun," had limited achievement due to delays in the procurement of equipment and preparation of laboratory facilities. This hindrance affected the expected proper use of the provided equipment, an output described in Section 3.2.1.1 Project Output.

[11] Initially, the indicator was "proper use of each analytical and observational instrument" but in the ex-post evaluation, it was reorganized as an indicator at the output level; accordingly, the project purpose to be achieved through the outputs changed to "analytical request with charge using major equipment".

3.2.2 Impacts

3.2.2.1 Achievement of Overall Goal

Achievement of the overall goal is limited, as shown in Table 5.

Table 5 Achievement of Overall Goal

Overall Goal	Indicator	Actual
In collaboration with IRGM and DPC's jurisdiction over disaster management, disseminate information to local residents about gas disasters and disaster prevention using IRGM's research results.	Results of disseminating information on gas disasters and disaster prevention	<Achievement is limited> ・ The Nyos and Monoun Community Enhancement for Disaster Risk Awareness workshop was held in February 2016 with the main objectives of raising awareness of the actual situation regarding gas disasters in the targeted lakes, increasing disaster prevention knowledge with 137 participants in Zoa City (Lake Nyos) and 145 participants in Kouoptamo City (Lake Monoun). The workshop was conducted as an action plan developed by two participants of the 2015 JICA thematic training "Community Disaster Management". Participants of the workshop were provided with a leaflet to raise local people's awareness, which the project had compiled into an easy-to-understand, illustrated guide to the mechanism of lake explosions and the actions to take in an emergency.[12] 7,000 leaflets were produced, and after the workshop, the remaining 6,500 leaflets were planned for use by the two participants of the above-mentioned thematic training to continue the action plan. However, the action plan was not continued due to the departure and resignation of the two participants. At the time of the ex-post evaluation, the remaining 6,500 leaflets were stored at DPC (400), JICA Cameroon Office (10), and IRGM (the remainder). ・ Since the change of DPC Director in 2016, little collaboration has occurred between IRGM and DPC. ・ In March 2022, the local consultant for this ex-post evaluation interviewed 15 residents, six in Bamenda, near Lake Nyos, and nine in Kouoptamo, near Lake Monoun. Four of the residents were confirmed to have participated in the above workshop and they explained the contents of the leaflet at village residents' meetings, women's meetings, and to their families after the workshop, but no information related to the lake explosion by the IRGM or DPC appeared to have been disseminated since the project was completed in March 2016.

Source: Prepared by evaluator based on answers to questionnaires from the implementing agency and field survey results by the local consultant

[12] The parties involved in the project were asked about the number of leaflets they distributed, but no information was obtained.

3.2.2.2 Status of Outputs and Project Purpose

As shown in Table 6, joint research between IRGM and several Japanese research institutes in various fields has continued since the completion of the project. The results of the joint research continue to emerge, with 30 papers published after the completion of the project.

Concerning observation of the lakes, security issues have made it difficult to monitor both Lake Nyos and Lake Monoun, and various activities, including monitoring, have not been carried out.[13]

The analytical request with charge increased in the latter half of the project implementation, and although it turned to decrease from 2018 to 2020, it has been increasing since 2021 (see Table 3).

Table 6 Status of Outputs after Project Completion

Outputs	Status after Project Completion to Ex-Post Evaluation
Output 1 The mechanism of limnic eruption is understood.	<The effect of the output continues> • In 2017, three papers were published jointly by Japanese and IRGM researchers.
Output 2 The CO2 recharge system beneath Lakes Nyos and Monoun is understood.	<The effect of the output continues> • Paper published in 2017 • Joint research continues with research funds from Osaka University. • CO2 monitoring method is utilized for disaster prevention purposes.
Output 3 The hydrogeological regime around Lakes Nyos and Monoun is understood.	<The effect of the output continues> • Submission to an international journal by the University of Tokyo • Presentation at an international conference by the University of Tokyo
Output 4 The interaction between rock and the CO2-rich fluid is understood.	<The effect of the output continues> • Information on CO2 gas emission simulation code is exchanged between University of Toyama and IRGM.
Output 5 Lakes Nyos and Monoun are monitored.	<Limited continuation of effects> As for Lake Monoun, the weather station has not been used since the cable was cut by a nearby resident during the project implementation. At Lake Nyos, the IRGM has not been able to confirm the status of the equipment due to the unrest in the North-western region.
Output 6 The experimental system for removing CO2-rich deep water to prevent gas rebuilding at Lake Monoun is set up.	<The effect of the output continues> • The experimental system for removing CO2-rich deep water installed at Lake Monoun broke down in 2017, but it was repaired by IRGM and it is still in use as of 2022. • One paper was published in 2017.

[13] Lake Monoun did not pose a security problem, but the local people were dissatisfied with the government because they perceived the safety of Lake Nyos as a priority, and they interfered with IRGM's monitoring activities on Lake Monoun. In fact, at the time of the ex-post evaluation, the local consultant was escorted by soldiers, and it was not possible to interview the local population calmly.

Output 7 Magmatism of Oku volcanic zone is understood.	<The effect of the output continues> • Joint research is continuing under the Grants-in-Aid for Scientific Research. • One paper was published in 2018 and one in 2019. • After the completion of the project, the IRGM researcher was employed as a postdoc for one year at the Earthquake Research Institute of the University of Tokyo. After returning to Cameroon, he led the research on continental mantle plumes and the training of young researchers at the Ministry of Mineral Resources, Industry and Technology Development. He has returned to Japan as a visiting researcher at the Earthquake Research Institute of the University of Tokyo for one year from October 2020, and continues joint research.
Output 8 Geochemical parameters of lakes along the CVLs other than Nyos and Monoun are understood.	<The effect of the output continues> • Joint research continues with research funds from Kumamoto University.[14] • Joint research is continuing under the Grants-in-Aid for Scientific Research. • Associate professors of Ibaraki University and IRGM researchers are continuing joint research under the visiting researcher/visiting professor system of the Earthquake Research Institute of the University of Tokyo.
Output 9 The results of scientific monitoring are systematically shared with DPC.	<The effect does not last> Refer to Section 3.2.2.1 Achievement of Overall Goal

Source: Prepared by the evaluator based on documents provided by JICA and answers to the questionnaire from the implementing agency

Based on the above, the scientific knowledge obtained through project implementation continues to be jointly researched with the research institutes in charge of each field, and results such as co-authored papers and conference presentations continue to occur. However, regarding the social implementation of returning research results to local residents, the effect was not expressed, because the implementation system and specific plans for implementing social implementation were not sufficiently considered during the project implementation, and after the project completion, the relationship between IRGM and DPC became weak. In light of the above, the achievement of the overall goal was only confirmed to a certain degree compared to the plan.

3.2.2.3 Other Positive and Negative Impacts

1) Impacts on the Natural Environment

At the time of the project request, the guidelines for environmental and social considerations were not applied to this project. No impact on the natural environment was reported at the time of the ex-post evaluation.

[14] Source: Documents provided by JICA

2) Resettlement and Land Acquisition

This project did not involve resettlement and land acquisition. In November 2013, explanatory meetings were held for residents in Wum City (Lake Nyos) and Kouoptamo City (Lake Monoun) to disseminate information to residents from the perspective of disaster prevention. In February 2016, workshops were held with the aim of raising awareness about the actual situation of gas disasters, disaster prevention knowledge, and emergency measures.

3) Gender Equality, Marginalized People, Social Systems and Norms, Human Well-being and Human Rights and Others

None

4) Unintended Positive/Negative Impacts

The eruption transition model of the maar volcano presented in the research by the Kumamoto University group (Elucidation of the history of eruptive activity around the volcanic lakes of the CVL) is being used in the ongoing comprehensive activity evaluation of volcanoes in Japan and the disaster prevention project. In addition, the model contributes to next-generation volcano research and the human resource development project of Ministry of Education, Culture, Sports, Science and Technology.

Since this project has achieved its purpose to some extent and overall goal only to a certain extent, effectiveness and impacts of the project are moderately low. For the project purpose, the level of achievement was limited because "acceptance of analytical request with charge" which is considered highly important among the indicators for the purpose of "independent research," was not sufficient, and specific results of “systematic storage of water and rock samples” was not confirmed. Regarding the achievement of the overall goal, it is judged that the expected effects have not been realized because IRGM and DPC have not established a system to disseminate information on the lake explosion in cooperation, and the research results have not been returned to the local population.

3.3 Efficiency (Rating: ③)

3.3.1 Inputs

Inputs	Plan	Actual
(1) Experts	• One long-term expert (project coordinator) • Approximately 12 short-term experts/year × 5 years (chief advisor, experts in geochemistry, volcanology, petrology, geology, geography, hydrology, etc. dispatched multiple times; MM is not specified)	• Long-term experts: three in total (project coordinator 56.79 MM) • Short-term experts: 15 short-term researchers in six fields, 29.93 MM
(2) Trainees received	Trainings for acquisition of a degree, acquisition of analysis equipment/operation/maintenance training, etc. (No information on the number of persons)	• Five persons for long-term training • 15 persons in total for short-term training
(3) Equipment	Equipment for monitoring lakes and analyzing water and gas samples	119 items for monitoring lakes and analyzing water and gas samples
(4) Local Operational Cost	Not specified	120 million CFA francs (Approx. 24.6 million yen)
Japanese Side Total Project Cost	Total 420 million yen	Total 420 million yen
Cameroon Side Total Project Cost	850 million XAF* (Approx. 175 million yen[15])	557 million XAF (Approx. 111.4 million yen)

* MM stands for man month.

* XAF is the ISO code of Central African CFA franc, which is the currency of six independent states in Central Africa, including Cameroon.

3.3.1.1 Elements of Inputs

Regarding the dispatch of experts, according to a questionnaire survey of counterparts at the time of the mid-term review, the period for which Japanese researchers were dispatched was not long enough for them to learn to operate the provided analytical equipment and the daily analysis work. About half of the respondents strongly requested long-term dispatch to receive training that is more detailed. Furthermore, in the questionnaire surveys and interview surveys conducted at the terminal evaluation, many counterparts answered that the number and duration of the dispatches of Japanese experts were limited. It is possible that the limited period of dispatch was a factor in the lack of sufficient mastery of some of the major equipment.

Regarding the trainees received, the researchers and technicians who participated in the short-term training program were able to acquire knowledge on the operation and maintenance of the same analytical instruments provided by the project through lectures and practical training, and they recognized the importance of sample management through visits

[15] The exchange rate was 1 Japanese yen = 4.7787 XAF (October 9, 2015) (source: terminal evaluation report, p.4)

to various laboratories in Japan. It was confirmed that the knowledge acquired through such practical training was utilized in the laboratory even after the training,[16] and it can be said that the short-term training was an input that led to outputs.

As for the long-term training, all five researchers, including one IRGM researcher, obtained a doctoral degree within three years of their dispatch and published several high-quality papers during their dispatch, contributing significantly to the achievement of Outputs 3, 7, and 8. One of the papers was published in a *Nature*-affiliated journal (*Scientific Report*). Of the five long-term trainees, one who was affiliated with IRGM at the time of dispatch continued to work at IRGM after returning to Cameroon. Of the remaining four, two were employed by IRGM and one is continuing his research at MINRESI, the parent organization of IRGM. Thus, all of the long-term trainees have demonstrated their achievements in researching lake explosions.

With regard to equipment, some of the equipment needed for lake observations and analysis of water and rock samples was not fully utilized. Although some of the reasons were unavoidable, such as falling into the lake or cables being cut by nearby residents, others were due to input from the Cameroonian side, such as problems with the laboratory's infrastructure (electrical system problems).

3.3.1.2 Project Cost

The total project cost borne by the Japanese side was 420 million yen representing 100% of the total amount budgeted.

The Cameroonian side was supposed to disburse 850 million CFA francs (about 175 million yen) as counterpart funds over a five-year period, but disbursements were made only twice, in 2011 and 2015, totaling 557 million francs, or 65.5% of the planned amount. According to the Cameroonian side, the difference between the planned and actual disbursement of counterpart funds was due to (1) late disbursement due to overload of work at the MINEPAT, which was in charge of counterpart funds, and (2) emergencies (Boko Haram measures and response to flooding in the northern region) that affected the distribution of treasury funds. Due to the delay in counterpart funding, one of the planned activities (geological mapping) and a field survey by IRGM were not carried out.[17]

3.3.1.3 Project Period

The actual project period was five years representing 100% of the total planned period.

Although delays in the disbursement of counterpart funds and the provision of equipment

[16] Source: Mid-term Review Report, vi
[17] Source: Terminal Evaluation Report, p.20

affected the achievement of some outputs, such as the utilization of equipment, the project period and the project costs on the Japanese side were within the plan. Therefore, efficiency of the project is high.

3.4 Sustainability (Rating: ③)

3.4.1 Policy and System

In 2022, the government of Cameroon launched a comprehensive research project, *the Lake Monoun Project*, targeting Lake Monoun.[18] IRGM is involved in the project on the scientific side as a member of the pilot committee that monitors and analyzes the data. With the launch of *the Lake Monoun Project*, it was confirmed that research on volcanic lake gas would continue institutionally. Therefore, it is judged that the sustainability of policies and systems is high.

3.4.2 Institutional/Organizational Aspect

At the time of the ex-post evaluation, IRGM has a staff of 284, of which 165 are researchers and 25 are technicians. The government of Cameroon has hired new young researchers in IRGM in recent years, and there is no quantitative shortage.[19] At the time of the ex-post evaluation, 14 of the 26 counterparts of the project are still with IRGM, seven had retired, and five had transferred to other related organizations, including MINRESI. Many of the counterparts continue to conduct research on volcanic lake gases and volcanoes as well as lead the training of young researchers. In addition, retired researchers are continuously mentoring IRGM researchers, thus knowledge and skills are being passed on from senior researchers to young researchers.

Regarding communication within the IRGM, no problems exist because meetings between IRGM executives and researchers are held monthly and internal meetings are held as needed. In addition, IRGM is making efforts to disseminate research results by holding an open day once a year for external audiences and holding seminars on an irregular basis.

Regarding the system for social implementation, as mentioned in Section 3.2.2.1 Achievement of Overall Goal, there is no collaboration between IRGM and DPC, and no mechanism or system has been established to disseminate research results on the mechanism of lake explosions and information on disaster prevention.

Because the main objective of this project is to conduct independent research on volcanic

[18] The contents of the project are as follows: “monitoring of the physico-chemical properties of Lake Monoun,” “installation of two photovoltaic pump systems,” “microbiological and ecological studies of Lake Monoun and other lakes in its vicinity,” “quantification of surface CO2 fluxes in and around Lake Monoun,” “Installation of meteorological stations and CO2 warning systems in and around Lake Monoun,” “construction of the Panke River weir and evaluation of water quality in the catchment area,” and “creation of 1:25,000 scale geological map around Lake Monoun” (source: documents provided by JICA).

[19] Source: Answers to the questionnaire from the implementing agency

lake gases, the ex-post evaluation focused on the system for this purpose. As a result, it is judged that IRGM has sufficient human resources to continue its research and observations in the future, no communication problems exist, and the sustainability of the institutional/organizational aspect is high.

3.4.3 Technical Aspect

As previously mentioned in Section 3.2.2.2 Status of Outputs and Project Purpose, IRGM has not conducted observation activities and monitoring in either Lake Nyos or Lake Monoun due to security issues, and it has not collected any observation data. In addition, even with regard to operational equipment, some equipment, such as the multibeam sonar, requires further technical training by IRGM, and other equipment, such as Picarro, is currently inoperable and needs to be investigated by the U.S. manufacturer (Picarro) to correct the problem and make it operational. Thus, for IRGM to resume monitoring and analyses that have been interrupted, or to put non-operational equipment back into operation and accept sample analyses from external parties, it is necessary to improve the operational and analytical capabilities of analytical equipment further.

A follow-up survey of the project was conducted from January to February 2020. The follow-up survey was conducted to examine follow-up cooperation to improve IRGM's ability to operate the equipment, strengthen the operation and maintenance system of the equipment, and ensure the sustainability of activities using the equipment, because there were variations in the level of understanding of operation of equipment and data analysis among IRGM technicians. As a result of the follow-up survey, JICA plans to procure equipment and dispatch engineers to restore the lake's gas venting system and lake water monitoring as follow-up cooperation in FY2022.

Based on the above, the IRGM's technical capacity to observe the lake independently and analyze samples is not sufficient at this time, but technical sustainability is expected to improve through follow-up cooperation scheduled for implementation in FY2022.

3.4.4 Financial Aspect

The sectoral budget allocation of the Cameroonian government was confirmed from the government's national budget data over time: From FY2011 to FY2015, 0.6-0.7% of the national budget was allocated to scientific research and innovation. Since the completion of the project, this percentage has decreased somewhat.[20] In addition, as shown in Table 7, the IRGM's overall budget has been declining since FY2015, and due to budget shortfalls, hazard maps, water resource maps, and soil maps have not been prepared. Regarding the budget, the government of Cameroon has prioritized the allocation of funds to the response

[20] Source: Documents collected by the local consultant

to the deteriorating security situation in the Northwest and Southwest regions due to clashes between the separatists who claim independence of English-speaking regions and security forces, and to the response to the new coronavirus, which has affected scientific research and budget allocation for the IRGM. This was considered an external factor in the ex-post evaluation.

If the number of analytical requests with charge using analytical equipment increases after the follow-up cooperation scheduled for FY2022, the financial aspect of the project is expected to improve.

Table 7 Budget of the IRGM

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Current budget (Total)		2,170,162,029	1,746,595,000	2,607,532,788	5,439,526,811	1,861,521,663	1,460,788,109	1,379,620,804	1,581,694,657	1,323,939,576	1,393,645,147	1,887,000,430	1,125,000,000
(1)	Running budget	689,876,626	686,697,000	670,000,000	555,284,378	587,408,512	600,804,484	622,047,235	688,714,701	503,695,716	552,773,513	619,909,196	500,000,000
	Structure												
01	Directorate	144,520,000	139,701,000	143,733,500	132,605,262	143,132,148	134,324,484	151,510,000	151,310,000	130,950,000	165,987,000	176,898,000	177,692,000
	Shared expenses	339,232,826	345,775,000	329,610,500	273,654,853	284,845,000	299,668,050	311,147,235	247,012,552	149,740,716	204,854,320	242,674,196	155,925,000
02	*CRGM*	50,050,000	53,420,000	57,020,000	50,230,000	50,945,000	50,090,000	53,750,000	68,400,000	46,930,000	26,735,000	48,000,000	30,420,000
03	CRH	60,500,000	62,620,000	64,190,000	48,616,090	51,760,000	50,110,000	47,110,000	46,337,149	36,660,000	36,310,000	30,570,000	28,660,000
05	LTM	50,476,000	45,540,000	48,140,000	32,683,483	37,055,000	40,310,000	38,960,000	38,820,000	31,220,000	29,070,000	27,700,000	25,300,000
04	LRE	39,869,000	40,271,000	42,386,000	31,635,490	34,468,364	30,502,000	28,360,000	28,160,000	22,460,000	18,335,000	14,915,000	18,267,000
06	LTI	35,278,800	35,790,000	36,640,000	27,089,200	31,610,000	27,210,000	23,810,000	24,310,000	19,010,000	16,777,193	15,662,000	17,816,000
07	*ARGV*	40,865,000	46,370,000	57,840,000	55,380,000	50,630,000	56,478,050	51,400,000	66,265,000	47,725,000	35,005,000	43,990,000	27,920,000
08	Tenders board	20,000,000	17,000,000	5,300,000	9,000,000	4,538,000	18,679,950	20,150,000	18,100,000	18,000,000	18,700,000	19,500,000	17,000,000
09	Management under the Program	0	0	0	0	0	0	1,000,000	0	1,000,000	1,000,000	0	1,000,000
(2)	Equipment and Investment	1,480,285,403	1,059,898,000	1,937,532,788	4,884,242,433	1,274,113,151	859,983,625	757,573,569	892,979,956	820,243,860	840,871,634	1,267,091,234	625,000,000

Source: Documents provided by the implementing agency

3.4.5 Environmental and Social Aspect

No environmental and social impacts were observed from the time of planning to the time of post-evaluation.[21]

3.4.6 Preventative Measures to Risks

The deterioration of security in the North-western and South-western regions since 2017, which affects the continuation of observations and monitoring of Lake Nyos, is a risk that was not foreseen at the time of planning, and is not a risk that the IRGM can address. As mentioned above, the sustainability of the project's outcome of independent study of lake explosions will be ensured by the resumption of at least the lake degassing system and lake monitoring in Lake Monoun through follow-up cooperation in FY2022.

3.4.7 Status of Operation and Maintenance

[21] Source: Answers to the questionnaire from the implementing agency

As with the 2020 follow-up survey, the maintenance status of the equipment at the time of the ex-post evaluation was confirmed, focusing on expensive equipment (see Table 8). In the field survey at the time of the ex-post evaluation, in addition to the equipment listed in Table 8, unused reagents and test equipment were found in cardboard boxes.

Table 8 Status of the Operation and Maintenance of the Equipment

No*	Item	Status	Remarks
1	IC	In use	
3	MK sampler 1	In use	
4	MK sampler 2	Not being used	Due to insecurity in the Lake Nyos area, the IRGM is not able to determine the current state of the equipment.
8	CTD logger	In use	The one procured by the project fell into the lake. IRGM procured the same equipment with its own funds.
13	Picarro	Not being used	
14	Desktop pH meter	Not being used	Battery leakage
15	Pure water maker	n.a.	
18	Multibeam sonar system	In use	As in the follow-up survey, IRGM needs more training on how to use the equipment.
29	CO2 flux meter	In use	
34	Thermometer	Not being used	
43	Alumina magnetic mortar	Not being used	At the time of the follow-up survey and ex-post evaluation, the equipment was kept in a cardboard box in storage.
86	13C Analyzer	In use	At the time of the follow-up survey, the equipment was not in use because IRGM was not able to prepare its in-house reference material (calcium carbonate), which should be calibrated against international reference material. Calcium carbonate can be prepared at the time of the ex-post evaluation, but it is not used because there are not many requests for sample analysis.
87	Polarization microscope	In use	
91	AAS	In use	
93	Graphite nebulizer for AAS	In use	
94	Standard water for isotope analysis	Not being used	Not working because Picarro is not working
96	Digital camera for Microscope	In use	
98	Volumetric titrator	In use	

Source: Prepared by the evaluator based on answers to the questionnaire from the implementing agency
* The number of the equipment list at the time of equipment provision

When equipment breaks down, IRGM purchases spare parts and repairs. Because most of the equipment provided by this project is highly precise, some parts cannot be replaced or repaired immediately. If IRGM technicians are unable to repair a device, then IRGM takes appropriate measures such as contacting the manufacturer online or requesting an agency to dispatch engineers.

From the above, although there is no problem in that IRGM technicians are responding appropriately even if they are unable to repair equipment failures, the reagents and equipment necessary for analysis remain unused. It seems that issues with the status of

operation and maintenance exist.

Slight issues have been observed in the technical and the current status of operation and maintenance, however, there are good prospects for improvement/resolution, in that the main equipment will be utilized and the lake observation and sample analysis is expected to resume through the follow-up cooperation consisting of procurement of equipment and dispatch of engineers for degassing system of the lake and resumption of monitoring of the lakes scheduled in FY2022. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented to establish a framework where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun through international joint research between Japan and Cameroon involving scientists from IRGM, thereby disseminating information to local population on gas disasters and disaster prevention using IRGM's research results in collaboration with IRGM and DPC.

The objectives of this project were consistent with the policy priorities of the government of Cameroon; in light of the recognized need to monitor the amount of residual CO2 continuously in the target lakes. Therefore, the relevance of the project is high. In addition, the objectives of this project aligned with Japan's ODA policy for Cameroon, with other JICA projects in disaster prevention management, and with other organizations that ensured the installation of degassing pipes and monitoring of the effects of degassing. Therefore, coherence is high. Although the project's international joint research produced a number of publications, the underutilization of IRGM's analytical equipment limited the achievement of the project's purpose, "independent research on limnic eruptions by Cameroonian researchers." In addition, the project's effectiveness and impact have been moderately low; this is reflected in the absence of significant results of the researchers' efforts to disseminate the project's gas disaster research results to the local population. Although delays in the disbursement of counterpart funds and equipment provision affected the achievement of some outputs, the project period and costs on the Japanese side were within the plan. Therefore, efficiency of the project is high. Although slight technical issues have emerged in the current operation and maintenance of the equipment, there are good prospects for improvement/resolution, the equipment which is currently out of service will be utilized and the monitoring of the lakes and sample analysis are expected to resume through the follow-up cooperation consisting of equipment procurement and dispatching engineers for the lake degassing system and lake water monitoring scheduled in FY2022. Therefore, sustainability

of the project effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Implementing Agency

(1) Formulation of Specific Plan for Social Implementation and its Implementation

IRGM is responsible for surveying, researching, and providing information from a scientific point of view regarding disaster management under the jurisdiction of DPC. Since the personnel change at DPC, no major cooperation has been observed, and information based on scientific evidence on the mechanism of volcanic lake gas emission and measures to take in case of gas disasters, which is one of the outcomes of the project, has not been disseminated. IRGM should have an opportunity to communicate with DPC at an early stage, and when the lake degassing system and lake water monitoring are restored in Lake Monoun through the follow-up cooperation scheduled in FY2022, it should regularly inform DPC of the status of the lake and distribute the remaining copies of the leaflet through DPC, etc.

(2) Strengthening Systematic Storage of Water and Rock Samples

Although water and rock samples collected during the project were catalogued during the implementation and the samples were stored in the underground store of the laboratory, IRGM was not yet able to manage systematic storage independently.

When the follow-up cooperation is implemented in FY2022, IRGM, together with Japanese researchers, should organize the water and rock samples that are currently left unorganized in the underground storage of the laboratory and it should fully learn the methods of classifying and managing samples. Then, it is desirable to document the person in charge, records, and management methods and to utilize the water and rock samples collected after thorough classification and management for future research.

4.2.2 Recommendations to JICA

(1) Follow-Up on Unachieved Matters

In the follow-up cooperation scheduled for FY2022, or as a separate scheme, it is desirable to follow up on the “systematic storage of water and rock samples” and “social implementation” that were confirmed to be insufficiently achieved in this ex-post evaluation. Specifically, with regard to “systematic storage of water and rock samples,” one idea is for Japanese experts to prepare a manual on systematic storage of samples together with IRGM researchers and technicians when the follow-up cooperation is implemented in FY2022, as well as to classify samples that have been left unclassified.

For social implementation, a feasible action plan could be formulated with IRGM and

DPC with Japanese experts at the time of implementing the follow-up cooperation, and then periodically monitored by JICA.

It would also be possible for the JICA Cameroon Office to monitor the progress of water and rock sample classification and management by visiting the laboratory. As for social implementation, the Cameroon Office can directly confirm the progress of social implementation to IRGM officials and exchange opinions with them, so that IRGM officials will be aware of external interest and progress in social implementation can be expected.

4.3 Lessons Learned

(1) Effective Efforts in the Implementation Phase to Achieve the Overall Goal in Technical Cooperation

This project, formed in 2010, was implemented in the initial stage of SATREPS, which began in 2008. Therefore, the concept of social implementation (i.e., ways to return the research results to society after the international joint research project was completed) may not have been well established among JICA officials, and Japanese researchers who focused on the research results did not seem to have made concrete plans for social implementation. There was no detailed implementation plan for social implementation at the beginning of the project. In addition, although social implementation efforts were included in the recommendations at the mid-term review, at the time of the terminal evaluation, there was no plan for social implementation other than the distribution of leaflets prepared by the project in the form of action plans for the two participants in the thematic training in Japan. Although plans to achieve the overall goal often materialize as a project progresses, it is important that the project team (implementing agency and experts) at least agree on the expected results and implementation methods as social implementation and the roles of related organizations by the middle of the project period. If possible, they should try the planned method once, before completing the project. This approach would enable social implementation, which is the overall goal of the SATREPS project, by relevant organizations in the partner country after the project is completed. For example, JICA and the project team should take advantage of various project opportunities, such as study meetings before the start of the project, kick-off meetings after the start of the project, and regularly held Joint Coordinating Committees, to discuss fully and have a common understanding of the achievement of the overall goal.

(2) Formulation of a Flexible Technical Training Plan for Equipment to Be Procured

If advanced equipment is included in the equipment to be procured, the period of technical training should be set longer from the beginning, and if the expected operation of the

equipment is not sufficiently established, then additional inputs should be made during the project period. It is desirable to review the inputs and activities flexibly while ascertaining the proficiency of the target persons.

5. Non-Score Criteria

5.1. Performance

5.1.1 Objective Perspective

None

Attachment 1: Achievement Status of Outputs

Output	Indicator	Status as of the Project Completion (March 2016)
Output 1 The mechanism of limnic eruption is understood.	Indicator 1-1: A scientific journal paper Indicator 1-2: Report for local people. Indicator 1-3: Information on Web site Complementary indicator 1-1: Appropriate records for proper use of observation and analytical equipment Complementary indicator 1-2: Appropriate use of IC	<Achieved> ・ Indicator 1-1: One scientific journal paper was published in 2015 and 1 paper was published in 2017.[22] ・ Indicator 1-2: In November 2013, workshops for local people were conducted at Wum and Kouoptamo. ・ Indicator 1-3: Information was published on two websites. ・ Complementary indicator 1-1: As per the goal that the date of equipment use, analyst, sample ID, and analysis fee were recorded in the notebook at the laboratory, these were recorded in the laboratory notebook. ・ Complementary indicator 1-2: IRGM researchers were able to use the IC without any problems, and there were no technical challenges.
Output 2 Deepen understanding of the CO2 supply process to Lake Nyos and Lake Monoun.	Indicator 2-1: A scientific journal paper Indicator 2-2: Report for local people Indicator 2-3: Information on Web site Complementary indicator 2-1: Appropriate use of 13C Analyzer	<Partially unachieved> ・ Indicator 2-1: One scientific journal paper is published in 2015 (same as Output 1)[23], two papers was published in 2017.[24] ・ Indicator 2-2: Same as Output 1. ・ Indicator 2-3: Same as Output 1 ・ Complementary indicator 2: Not used (except for training) due to delay in provision of equipment and lack of gas samples.
Output 3 Deepen understanding of hydrogeological characteristics around Lake Nyos and Lake Monoun.	Indicator 3-1: A scientific journal paper Indicator 3-2: Report for local people	<Achieved> ・ Indicator 3-1: Three scientific journal papers were published, one of which was published by *Scientific Report,* which belongs to Nature Publishing Group.[25] ・ Indicator 3-2: Same as indicator 1-2 under Output 1.
Output 4 Better understanding of water-rock interactions in the CO2 supply system.	Indicator 4-1: A scientific journal paper Complementary indicator 4-1: Appropriate use of AAS and Picarro	<Indicator 4-1 was achieved, complementary indicator 4-1 achieved limitedly> ・ Indicator 4-1: One scientific journal paper was published in 2015. ・ Complementary indicator 4-1: AAS was installed in December 2013, two and a half years after the project started. At that time, operation training from manufacturer technicians was provided. From October 19 to November 16, 2014, a special researcher at Tokai University gave intensive training to IRGM technicians on how to use it. Furthermore, an IRGM researcher staying in

[22] Source: Terminal evaluation report p.7 and documents provided by JICA
[23] Source: Terminal evaluation report, p.8
[24] Source: Documents provided by JICA
[25] Source: Terminal evaluation report p.9 and documents provided by JICA

		Japan as a long-term trainee at Tokai University learned how to handle AAS at a Japanese manufacturer. ・ In 2015, the voltage fluctuated due to a lightning strike and it broke down, making it unusable for six months. At the terminal evaluation in November 2015, the counterparts answered that they were somewhat concerned about using the system. ・ Picarro was operated without any problems from the start of the project, but there was a period of at least two years when it was out of service due to problems with the electrical system and maintenance.
Output 5 Lakes Nyos and Monoun are monitored.	Indicator 5-1: A scientific journal paper	<Achievement is limited> ・ One scientific journal paper was published in 2015 (same as the paper for Output 1). ・ Although the indicator was achieved, no meteorological observation data has been collected since May 2014 when the cables of the meteorological observation station were cut by local people. The achievement of "establishment of a monitoring system" is limited.
Output 6 The experimental system for removing CO2-rich deep water to prevent gas rebuilding at Lake Monoun is set up.	Indicator 6-1: A technical paper on the CO2 removal system	<Achieved> ・ A solar powered deep water removal system was installed in Lake Monoun, and the possibility of forced CO2 degassing was investigated. ・ Indicator 6-1: One technical paper was published in 2010.[26]
Output 7 Magmatism of Oku volcanic zone is understood.	Indicator 7-1: Ph.D. thesis Indicator 7-2: A scientific journal paper	<Nearly achieved> ・ Geochemistry of maar-bearing volcanoes has been investigated in the Oku Volcanic Group along the Cameroon Volcanic Line (CVL). The activity "Geological maps of the Nyos and Monoun areas are produced" was changed to "Eruptive history of Nyos volcano is understood" due to lack of disbursement of the counterpart fund. ・ Indicator 7-1: One Ph.D. thesis was published in 2014[27] and one in 2015[28]. ・ Indicator 7-2: Two scientific journal papers were published; one in 2014[29] and one in 2015[30]. Two more to be submitted by the end of the project.

[26] Source: Terminal evaluation report, p.11
[27] Source: Terminal evaluation report, p.12
[28] Source: Terminal evaluation report, p.12
[29] Source: Terminal evaluation report, p.12
[30] Source: Terminal evaluation report, p.12

Output 8 Geochemical parameters of lakes along CVL other than Nyos and Monoun are understood.	Indicator 8-1: A scientific journal paper	<Achieved> ・ Indicator 8-1: Two scientific journal papers were published in 2014.[31]
Output 9 The results of scientific monitoring are systematically share with DPC.	Indicator 9-1: Seminar with DPC Indicator 9-2: Special session in the 9th workshop of the Commission on Volcanic Lakes (CVL-9)	<Achieved> • Indicator 9-1: Staff of IRGM and DPC participated in the "community based disaster risk management" thematic training organized by JICA in Kobe, Japan in July 2015. They jointly prepared an action plan which included a workshop for local people. As part of the implementation of this action plan, a workshop was held for local people in February 2016. • Indicator 9-2: IRGM hosted the CVL-9 in Yaoundé, Cameroon in March 2016. The conference provided an opportunity to disseminate the results of the project to the world.

[31] Source: Terminal evaluation report, A5-1