Hashemite Kingdom of Jordan

FY2019 Ex-Post Evaluation of Japanese Grant Aid Project

"Project for Energy Conservation through Upgrading Water Supply Network in the Hashemite Kingdom of Jordan"

External Evaluator: Kenichi Inazawa, Octavia Japan, Co., Ltd.

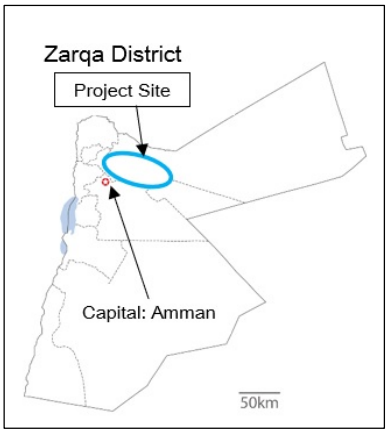
0. Summary

This project procured equipment, installed pumping and water distribution facilities, and provided technical assistance in the areas of operation and maintenance of the pumping facilities and operation of the water distribution system. The aim of the project was to improve operational efficiency of the pumping facilities as well as, with energy-saving measures, to stabilize and improve the water distribution systems at three pumping stations, Azraq, Hallabat and Zarqa in Zarqa District, located northeast of the capital city of Jordan, Amman. With respect to the development policy, documents developed by the Jordanian government such as *National Agenda 2006-2015* and *Water for Life: Jordan's Water Strategy 2008-2022*, list the water sector, climate change measures, supply of safe drinking water and sustainable water resource utilization as important issues. In addition, since the per capita water supply was limited for all of Jordan, including Zarqa District, there was a need for water resource development, the expansion of water distribution networks and the renewal of pumping stations. Furthermore, the project is in line with Japan's ODA policy. Therefore, its relevance is high. With regard to efficiency, the project outputs and costs were generally as planned. However, the project period exceeded the initial plan as it took longer to select and identify a contractor for the work to be carried out on the Jordanian side. Furthermore, it was decided to utilize the remaining budget for additional works such as installation of water pipes and management of reservoir sediments. Therefore, overall the efficiency is fair. As for quantitative effect indicators, "operational efficiency of the pumps" and "reduction in electricity consumption," the targets have been achieved through the implementation of this project. Whilst the target was met for "reduction in electricity costs," it is worth noting that the electricity price rose within Jordan. Additionally, it was confirmed through the qualitative interview survey that the project had contributed to reducing energy consumption (electricity costs), improving technical skills of the operation and management staff of the pumping facilities, establishing a stable water supply and improving water distribution, all with a reduced environmental load. Considering the above, the project's effectiveness and impact are considered to be high. There are no particular concerns regarding the institutional, technical or financial aspects of Miyahuna, the company responsible for the operation and management of the

pumping stations developed by this project. There are no issues concerning the operation and management of the other facilities and equipment. Therefore, sustainability of the project's effects is high.

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

1. Project Description



Project Location

Pumping Station Developed by This Project
(Zarqa Pumping Station)

1.1 Background

Jordan belongs to a desert area and evapotranspiration is high throughout the country. Before this project began, it was expected that securing drinking water would be difficult. Water used for domestic purposes was also limited, and effective and fair utilization of water resources was an important issue. In Zarqa District, per capita water supply was extremely low at approximately 140 L/day. The district's water supply facilities frequently had problems and the water distribution capacity was deteriorating due to issues such as aging of the pumps and inappropriate maintenance. Additionally, Jordan relied almost entirely on thermal power generation, and it was concerned that operating these aged inefficient pumps would not only increase electricity consumption but also increase greenhouse gas emissions. For this reason, there was an urgent need to realize efficient operation of pumps by replacing the existing pumping facilities and improving maintenance.

1.2 Project Outline

The objective of this project is to stabilize water distribution and to improve water supplies with more efficient pumping facilities and an energy-saving water distribution system by procuring equipment and installing pumping and water distribution facilities and by providing

technical assistance in the areas of operation and maintenance of the pumping facilities and the water distribution system at three pumping stations, Azraq, Hallabat and Zarqa, thereby contributing to the reduction in greenhouse gas emissions (a climate change mitigation measure).

Grant Limit / Actual Grant Amount	1,132 million yen / 1,109 million yen
Exchange of Notes Date /Grant Agreement Date	February 2010 / February 2010 (initial plan), October 2013 (revised[1])
Executing Agency	Water Authority of Jordan (hereinafter referred to as "WAJ")
Project Completion	February 2014
Main Contractors	Kubota Corporation (Japan), Emar Jordan Building Materials (Jordan), Dai Nippon Construction (Japan)
Main Consultant	Kyowa Engineering Consultants Co., Ltd.
Procurement Agency	Japan International Cooperation System
Preparatory Survey	February – November 2009 (preparatory survey)
Related Projects	[Japanese Grant Aid Projects] ・ Project for Improvement of Water Supply System for the Zarqa District (The notes were exchanged in 2003 for stage 1 and in 2004 for stage 2.) ・ Project for Improvement of the Water Supply for the Zarqa District (Phase 2) (The notes were exchanged in 2006, 2007 and 2008.)

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenichi Inazawa, Octavia Japan, Co., Ltd.

2.2 Duration of Evaluation Study

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

Duration of the Study: September 2019 – November 2020

Duration of the Field Study: 3 – 18 January 2020

[1] This refers to a revised grant period after it was decided that Lot 3 (laying of water transmission pipes, reservoir sediment measures and improvement) would be implemented using the remaining budget.

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

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of Jordan

At the time of the project planning, the government of Jordan had developed a comprehensive national strategy, *National Agenda 2006-2015*, which placed importance on the water sector and climate change measures. The government had also developed the *Strategic Plan 2007-2012* for the water sector entities, which listed reducing the gap between water supply and demand, as well as addressing the issue of non-revenue water, as urgent matters. The plan aimed to balance a reduction in greenhouse gas emissions and economic growth.

At the time of the ex-post evaluation, the government of Jordan has developed the *National Water Strategy 2016-2025*, aiming to strengthen the roles of water entities in the water and sewage service provision sector and to achieve efficient water supply operations by utilizing the private sector and others. In addition, the government has developed the *Water Sector Capital Investment Plan 2016-2025*, which aims to manage insufficient water in an efficient, effective and sustainable manner. Furthermore, the government has developed *Water for Life: Jordan's Water Strategy 2008-2022*, which sets goals for the supply of safe drinking water, sustainable water resource utilization, and climate change responses and adaptations. It identifies the following problems: exploitation of water beyond restoration capacity of the water resources, drying up of the freshwater resources,[4] rapid growth of the population including disaster victims, refugees and returnees, and aging of water distribution networks. To counter these issues, the document lists the following: supply of appropriate and safe drinking water, measures to reduce non-revenue water, effective utilization of existing water resources, introduction of the private sector's expertise to improve financial aspects, and expansion of water supply capacity by utilizing new technologies.

Based on the above, a stable supply of drinking water, the development of water resources, and climate change measures continue to be viewed as important in Jordan at the time of the ex-post evaluation. The project is in line with the development policies in place at the time of its planning as well as those in place at the time of its ex-post evaluation.

---

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

[3] ③: High, ②: Fair, ①: Low

[4] Jordan's renewable water resources (it refers to a maximum level of water resources that is theoretically available, also called water resource potential) is 129 m^3/year (source: Jordanian government data, 2014) which is less than 30% of the "severe scarcity" threshold of 500 m^3/year set by the UN. Jordan is categorized as one of the most water-scarce countries in the world.

3.1.2 Consistency with the Development Needs of Jordan

Before this project began, per capita water supply was extremely low at approximately 140 L/day in Zarqa District. The water supply facilities of this district had frequent problems, with the water distribution capacity deteriorating due to aging pumps, inappropriate maintenance, etc. There was a concern that these old pumps and their inefficient operations would not only increase electricity consumption but also greenhouse gas emissions. At Azraq pumping station, which was targeted by this project, all seven pumps were old. Only two of the pumps were operational and the rest were either broken or almost ready for disposal, having problems with power panels and/or electric motors. At Hallabat pumping station, four pumps were old, with traces of overhauls and deteriorated basic parts; most of the gate valves and check valves were almost non-operational, requiring urgent repairs. At Zarqa pumping station, the pumping facility was extremely old, and there was a serious problem with its operation and maintenance since some equipment had been replaced and installed as temporary measures.

At the time of the ex-post evaluation, per capita water supply of Jordan is 120 L/day in the capital Amman and Zarqa District, 100 L/day in other regional cities and 80L/day in rural areas.[5] The water supply in Zarqa District is limited compared to before the project. This is due to the population increase and influx of refugees from the neighboring Syria since 2011, together with limited water resources. As a result, the imbalance between water demand and supply has become serious. WAJ, the executive agency for this project, has been expanding water supply services, developing water distribution networks and promoting non-revenue water measures all over the country. As a result of these measures, the water supply has increased. Jordan's total population is approximately 10.66 million (source: Jordanian statistic agency (DOC), 2020 data), of which approximately 0.66 million[6] are Syrian refugees (source: The source of this figure is the United Nations High Commissioner for Refugees (UNHCR), 2018 data). This is considered to be one of the reasons of the increase in the water demand.[7] Furthermore, the total population of Jordan in 2000 (20 years ago) was approximately 4.86 million (source: DOC), which means by the time of the ex-post evaluation, the population had doubled. Thus, the population increase, together with the influx of Syrian refugees, has caused the high demand for water. For this reason, the need for water supply infrastructure, including development and repairs of pumping facilities, is

[5] Source is WAJ 2019 data.
[6] Source: https://www.unhcr.org/news/latest/2018/2/5a81bd504/unhcrs-grandi-hails-jordans-job-scheme-syrian-refugees.html (accessed on 5 August 2020)
[7] Although it is difficult to obtain accurate data on Syrian refugees, we used the information provided by UNHCR. Since the influx began, the number of Syrian refugees is thought to be on the decrease. However, it can be said that they continue to account for a large proportion.

chronically high. Based on the strategies above, WAJ has placed the importance on water resource development and management, expansion/improvement of water distribution networks and pipes, and promotion of private sector involvement. It is considering projects for new water resource development, including a water desalination project (in Aqaba).

Based on the above, per capita water supply per day is limited in Jordan including Zarqa District at the time of the ex-post evaluation, and there remains a need for water resource development and expansion of water distribution networks. Therefore, it can be said that the project is consistent with the development needs at the time of planning and at the time of the ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

Japan's ODA Charter approved by the cabinet in August 2003 listed four priority issues: (1) poverty reduction, (2) sustainable growth, (3) addressing global issues, (4) peacebuilding. With respect to issue (3), the policy says that in the light of "global issues such as global warming and other environmental problems, infectious diseases, population, food, energy, natural disasters, terrorism, drugs, and international organized crime, further efforts must be given immediately and in a coordinated manner by the international community." This project aims to reduce greenhouse gas emissions by reducing the energy consumption for water distribution, assisting Jordan in its efforts to stabilize water distribution and improve water supply. Thus, it can be judged that this project is in line with the mentioned assistance policy. Based on the above, the project is in line with Japan's ODA policy.

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

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

This project procured equipment, installed pumping and water distribution facilities, and provided technical assistance in the areas of operation and maintenance of the pumping facilities and operation of the water distribution system. This was done with a view to improving the efficiency of the pumping operations at three stations, Azraq, Hallabat and Zarqa. A detailed design was carried out after the project began. After the plan change, the procurement and

installation of the equipment listed in Table 1 were proposed as planned outputs and were implemented.

Table 1: Planned and Actual Outputs of this Project

At the time of Planning (2009)	At the time of the ex-post evaluation (2019-2020)
[Planned Outputs from the Japanese Side] 1) Civil engineering works and equipment to be procured ・Procurement and installation of pumping facilities at Azraq, Hallabat and Zarqa pumping stations (12 pumps) ・Procurement of valves and related materials for Khaw pumping station (four sets) ・Procurement and installation of water flow meters (eight sets) ・Procurement of water transmission pipes (4.1 km) ・Procurement of gate and air valves (220 and 15 pieces, respectively) 2) Consulting services / capacity building program (soft component) ・Detailed design, construction management ・Technical guidance on operation and maintenance of pumps for personnel operating pumping stations ・Technical guidance on operation management for personnel managing water distribution systems	[Actual Outputs from the Japanese Side] 1) Civil engineering works and procured equipment: <u>As planned</u> 2) Consulting services / capacity building program (soft component): <u>As planned</u>
【Inputs from the Jordanian Side】 ・Installation of other equipment and construction of facilities	【Actual Inputs from the Jordanian Side】 ・Installation of other equipment and construction of facilities: <u>As planned (details: installation/repair of transformers and water transmission pipes at Azraq, Hallabat and Zarqa pumping stations, installation of transmission pipelines, installation of chambers for water flow meters and valves, installation of valves and air valves in water distribution networks)</u>

Source: Documents provided by JICA, answers to the questionnaire

Photo 1: Pumping Facility at Hallabat Pumping Station

Photo 2: Control System at Azraq Pumping Station

3.2.2 Project Inputs

3.2.2.1 Project Cost

The total cost of this project was planned to be approximately 12.78 million yen (approximately 11.32 million yen from the Japanese side and approximately 1.46 million yen from the Jordanian side). The actual cost was approximately 12.4 million yen (of which 11.09 million yen came from the Japanese side and approximately 1.31 million yen came from the Jordanian side). These figures were within the plan (approximately 97% of the planned cost).

3.2.2.2 Project Period

The scheduled project period was from February 2010 to November 2012 (34 months). The actual period was from February 2010 to November 2015 (70 months), which was extended from the scheduled period (approximately 206% of the planned time).[8] Table 2 indicates the initially planned and actual project periods. The reasons for the delay are as follows. 1) Under this project, Lot 1 "materials and equipment for water transmission pumps" and Lot 2 "materials and equipment for water distribution networks" were initially planned and completed in January 2014. As the initial plan was expected to be completed by November 2012, the actual delay was one year and a few months. The main reason for this was that it took longer to select and identify a contractor for the work to be carried out by the Jordanian side. This in turn affected the project period of the work by the Japanese side (e.g., procurement of equipment). 2) As stated above, while Lot 1 and Lot 2 were the initial plan under this project, it was discovered during the project

[8] According to *JICA's External Ex-post Evaluation Reference*, the timing of the project's completion is defined as "at the time of the handing over." The project's beginning refers to the month/year in which grant agreement was signed, while the project's completion refers to the completion of Lot 3 (at the time of the handing over).

implementation that there would be some left-over budget. The utilization of the remaining budget was considered. As a result, the installation of water pipes as well as reservoir sediment measures and improvement were implemented. This was considered as Lot 3, which began in June 2013 while Lot 2 was under implementation. Lot 3 was completed in November 2015.[9]

Table 2: Initially Planned and Actual Project Periods

	Initial Plan	Actual
The overall project	February 2010 – November 2012 (34 months)	February 2010 – November 2015 (70 months)
Lot 1: Materials and equipment for water transmission pumps		
Detailed Design – Bidding – Contractor Signing	5.5 months	3.0 months (detailed design) 5.0 months (bidding – contractor signing)
Procurement of Equipment – Inauguration	26.5 months	35.0 months
Lot 2: Materials and equipment for water distribution networks		
Detailed Design – Bidding – Contractor Signing	3.5 months	2.0 months (detailed design) 5.0 months (bidding – contractor signing)
Procurement of Equipment – Inauguration	2.0 months	5.0 months
Lot 3: Installation of pipes and reservoir sediment measures and improvement		
Preparatory survey	-	9.0 months
Bidding – Contractor Signing	-	5.0 months
Construction – Inauguration	-	11.0 months
(Project period for the Jordanian side)	-	(February 2011 – February 2014)

Source: Documents provided by JICA (initial plan), Project Completion Report, answers to the questionnaire and interviews with WAJ (actual).

As discussed above, the outputs and cost of this project were almost as planned. The project period was longer than in the initial plan due to the fact that it took longer to select/identify the contractor for the work to be carried out by the Jordanian side. A decision was made to utilize the remaining budget for the installation of water transmission pipes and reservoir sediment measures and improvement. Therefore, although the project cost was within the plan, the project period exceeded the plan. Thus, efficiency of the project is fair.

[9] This additional work was done because the contractor found a problem in the pump shaft end during the inspection after the operation began at Azraq pumping station. The part inside the pump had a friction problem. It was suspected that sand that was contained in the transmitted water had caused the internal clogging. When the consultant and the contractor carried out a field status survey, it turned out that sand had accumulated in the reservoir and that a small amount of sand was flowing into the transmission pump. As a result, WAJ requested JICA's assistance in addressing the sediment issue. The Japanese side decided that this would be implemented as Lot 3.

3.3 Effectiveness and Impacts[10] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects

1) Operation Indicators

The quantitative effect indicators for operational efficiency of each pumping station at Azraq, Hallabat and Zarqa (baseline, target and actual) are shown in Table 3. The implementation was generally as per the initial plan. As for the unit electricity consumption at Azraq pumping station, the actual consumption was 1.48 kWh/m^3, better than the target of 1.58 kWh/m^3. The main contributing factor is that in 2016, after this project was completed, WAJ upgraded its electric power system of wells from 11kV to 33kV with its own fund.

Table 3: Quantitative Effect Indicators for Operational Efficiency of Each Pumping Station (Baseline, Target and Actual)

Indicator (Operational Efficiency of the Pumps)	Baseline (FY2009)		Target (FY2015) [Three years after project's completion]		Actual [Three years after completion: 2018]	
	Operation efficiency (Unit: %)	Unit electricity consumption (Unit: kWh/m^3)	Operation efficiency (Unit: %)	Unit electricity consumption (Unit: kWh/m^3)	Operation efficiency (Unit: %)	Unit electricity consumption (Unit: kWh/m^3)
Azraq pumping station	57	1.88	68	1.58	68	1.48
Hallabat pumping station (water destination: Khaw reservoir)	57	0.62	68	0.52	68	0.50
Hallabat pumping station (water destination: Hallabat village)	34	1.20	65	0.63	65	0.63
Zarqa pumping station	50	0.78	68	0.40	68	0.40

Source: JICA document (baseline, target), answers to the questionnaire (actual)

Table 4 shows outcome indicators that measure relationships between this project and electricity consumption as well as electricity charges. The actual "reduction in electricity consumption" was as per the target. Considering the fact that operational efficiency has improved with the introduction of the pumping facilities by this project, it can be judged that the annual electricity consumption was reduced by more than 8,687,000 kWh/year. The performance

[10] Sub-rating for Effectiveness is to be put with consideration of Impacts.

exceeded the target because electricity consumption at Azraq and Hallabat pumping stations improved (from 1.58 to 1.48 kWh/m^3 and from 0.52 to 0.50 kWh/m^3, respectively) as shown in Table 3.

It is possible to conclude that "reduction in electricity cost" outperformed the target. This is because there is a difference in the power rate before this project began (2009) and at the time of the ex-post evaluation (end of 2019). As will be elaborated in 3.4.3 Financial Aspects of Operation and Maintenance under "Sustainability" electricity rates have been revised multiple times and have been on the rise for the past 10 years (since this project began up until the time of the ex-post evaluation). The unit electricity charge is 0.115 JD at the time of the ex-post evaluation (end of 2019), whereas it was 0.043 JD before in 2009. Before this project began, it was expected that 8,687,000 kWh × 0.043 JD would equal a reduction in electricity costs of 374,000 JD. However, more than 8,687,000 kWh[11] × 0.115 JD equaling more than 999,000 JD annually is being achieved at the time of the ex-post evaluation. In other words, the reduction exceeded the target due to an external factor - a change in power rates. Electricity cost reduction scenarios with and without this project will be analyzed in 3.4.3 Financial Aspects of Operation and Maintenance under "Sustainability" taking into consideration the changes in water supply volumes and power rates.

Table 4: Outcome Indicators of Electricity Consumption and Costs

Indicator	Baseline (2009)	Target/year [Three years after project's completion]	Actual/year [At the time of the ex-post evaluation: 2019]
Reduction in electricity consumption (Unit: thousand kWh/year)	-	8,687	8,687 or more
Reduction in electricity cost (Unit: thousand JD)	-	374	999 or more

Source: JICA document (baseline and targets), answers to the questionnaire (actual)

[11] One can say it will be "more than" 8,687,000 kWh because the electricity consumption at Azraq and Hallabat pumping stations have improved as shown in Table 3 (Azraq: from 1.58 to 1.48 kWh/m^3, Hallabat: from 0.52 to 0.50 kWh/m^3). However, since it is difficult to obtain concrete numbers, it will be written as "more than."

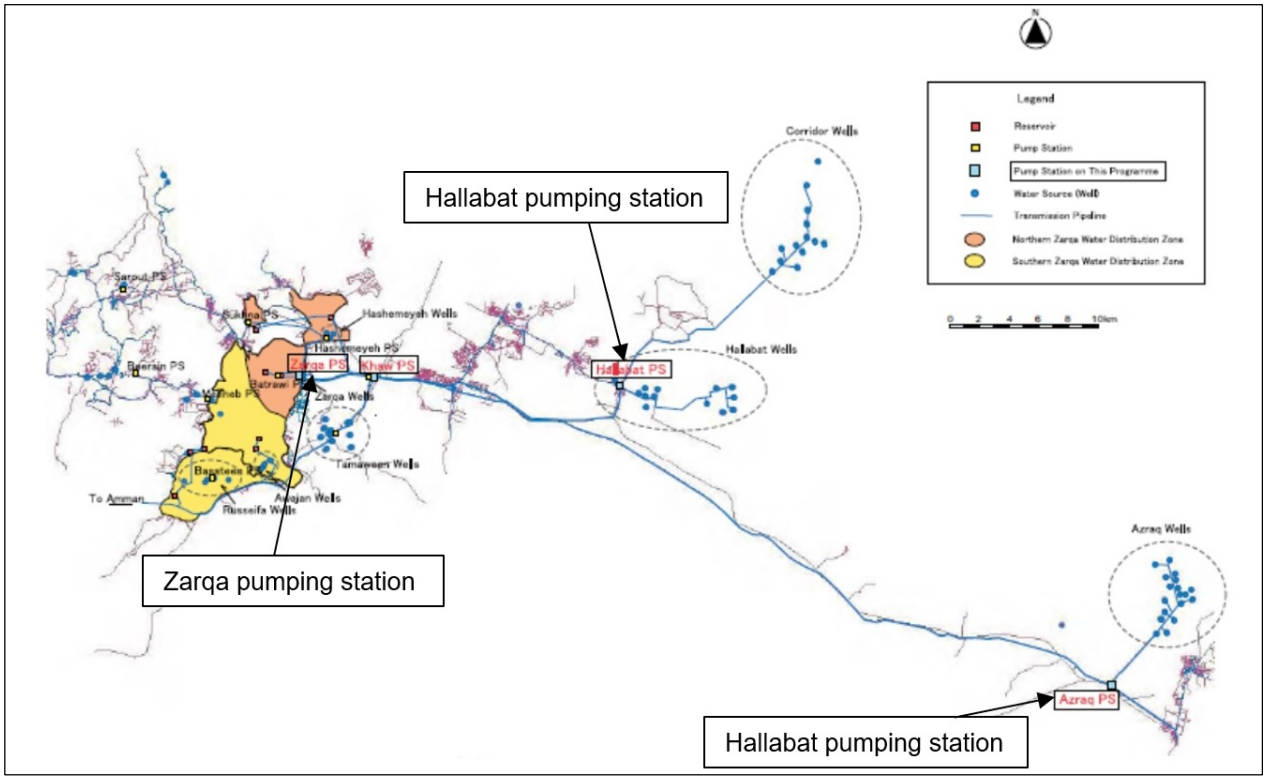


Figure 1: Locations of Project Sites[12]

3.3.1.2 Qualitative Effects (Other Effects)

Reduction in Energy Consumption on Water Distribution, Improvement in Technical Skills of WAJ's Operation and Maintenance Personnel with Realization of Stable Water Distribution, Stabilization of Water Distribution and Water Supply

As part of the field survey of this evaluation, interviews were carried out with employees of Miyahuna (the company responsible for the operation and management of the pumping stations developed by this project), and with headquarters staff of WAJ, an executing agency of this project.[13] Comments obtained through these interviews were as follows:

・ "Electricity consumption is large for operating pumping facilities. The power rate increased every year, and it is preferable to reduce electricity consumption and make the operation of the pumps more efficient. If this project wasn't implemented and we kept operating using the old existing pumping facilities, there is no doubt that electricity costs would have been high. While water demand increases throughout the nation, stable water transmission from the pumping

[12] It was taken from the map created by the main consultant.

[13] Group interviews and key informant interviews were conducted with 11 people: three people from each of the Azraq, Hallabat and Zarqa pumping stations and two WAJ headquarters staff members. The interviewees were selected based on the criterion that they had knowledge of the situation regarding the pumping stations and facilities before as well as after the implementation of this project.

stations is especially critical, and payment of electricity bills is a bottleneck for the organization management. Electricity costs account for about 60 to 70% of our entire operation and maintenance costs in recent years. The pumping facilities introduced by this project have achieved economized operations (as compared to the past), and we think it has led to a reduction in energy consumption." (Comments from WAJ headquarters staff, Miyahuna employees)

・ "The operation has become stable after replacing the pumping facilities. There have been no problems; the status of the operation is good. Made-in-Japan facilities are to be trusted. The water transmission from the pumping stations is stable, so are the water distributions from the reservoirs to downtown areas and the water supply to each household. While the water demand has been on the rise due to the population increase (with the increased influx of Syrian refugees), we consider the facilities of this project as one of the foundations for stable supply." (A comment from a Miyahuna employee)

・ "Miyahuna has a long history working on water supply projects. Most of its employees have been working at the firm for many years. We learned about the efficient operation of pumping facilities and periodic maintenance duties from Japanese contractors (through the capacity building/soft component training) during the implementation of this project. As an example, it enables us to judge the appropriate timing of oil changes and grease coating by listening to the sound of the pump's motor. We think that our knowledge and skills of operating and maintaining the pumps have improved through this project." (A comment from a Miyahuna employee)

Based on the comments above, it can be deduced that this project is contributing to a reduction in energy consumption, to improved technical skills of operation and maintenance staff, to a stable water supply, and to improved water distribution.

3.3.2 Impacts

3.3.2.1 Intended Impacts

Contribution to Reduction in Greenhouse Gas Emissions (climate change mitigation measure)

Table 5 shows the target and actual figures for a reduction in greenhouse gas emissions.

Table 5: Indicator of Effects from Reduction in Greenhouse Gas Emissions

Baseline (2009)	Target	Actual (2019)
-	5,386 tons CO_2/year	5,386 or more tons CO_2/year

Source: JICA document (target), answers to the questionnaire as well as results from interviews with WAJ and Miyahuna (actual)
Note: A specific year was not set for the target before this project began.

It is thought that the target has been achieved at the time of the ex-post evaluation. As explained in 3.3.1.1 Quantitative Effects, the “reduction in electricity consumption” was as planned. Calculating the actual reduction at the time of the ex-post evaluation using the calculation basis before this project began (8,687,000 kWh/year × 0.62kg - O_2/kWh), it is possible to say that the actual reduction was at least 8,687,000 kWh/year × 0.62kg - CO_2/kWh, which equals at least 5,386 tons CO_2/year. As a result of the interviews[14] with WAJ headquarters and Miyahuna staff on the reduction in energy consumption and climate change measures, the following comments were obtained. “We do not know if the greenhouse gas emissions and climate change impacts are related to this project, however, considering that this project has reduced electricity costs, we may be able to say that the project is contributing to the reduction in energy consumption (WAJ headquarters staff).” “Made-in-Japan pumping facilities are trustworthy. Since the operation efficiency is high, we think the environmental load surrounding this project has generally been decreasing (Miyahuna staff).” It is difficult to refer to the reduction in greenhouse gas emissions as directly correlated to this project due to many external factors. However, considering the comments above, it can be inferred that the project is contributing to reducing an environmental load by cutting down on electricity consumption.

3.3.2.2 Other Positive and Negative Impacts

1) Impacts on the Natural Environment

This project did not require any socio-environmental formalities because the replacement of the pumping facilities was the main project component. EIA was not implemented either.

It has been confirmed through the questionnaire, field visits, as well as interviews with WAJ and Miyahuna that there was no negative impact on the natural environment (e.g., air pollution, vibration, noise, ecosystem, etc.) during the project implementation or after the project’s completion. No negative impacts were observed during the field survey, which included visually checking the natural environment around each pumping station.

WAJ is responsible for the environmental monitoring related to the project’s facilities. However, periodic monitoring has not been conducted as there has been no negative environmental impact of any significance. If an environmental issue arises near any of the pumping stations, the

[14] As was the case for interviews mentioned in 3.3.1.2 Qualitative Effects, group interviews and key informant interviews were conducted with 11 people: three people from each of the Azraq, Hallabat and Zarqa pumping stations and two WAJ headquarters staff members. The interviewees were selected based on the criterion that they had knowledge of the situation regarding the pumping stations and facilities before as well as after the implementation of this project.

procedure will be that WAJ should consult the relevant department of Zarqa District and the Ministry of Environment and address the issue accordingly.

2) Resettlement and Land Acquisition

It has been confirmed through the questionnaire as well as interviews with WAJ and Miyahuna that there was no resettlement or land acquisition since replacement of the existing pumping facilities and water transmission pipes were the main component of this project.

<Conclusion on Effectiveness and Impacts>

With respect to quantitative effect indicators ("operational efficiency of the pumps" and "reduction in electricity cost"), the actual achievements are as targeted. While the actual figure exceeded the target in terms of "reduction in electricity costs," it is largely due to the increase in power rates. Considering the reduction in energy consumption (electricity costs), improved skills of the operation and maintenance staff at the pumping facilities, contribution to stable water supplies and distributions, and contribution towards the reduction in environmental load, this project has achieved its objectives. Therefore, effectiveness and impacts of the project are high.

3.4 Sustainability (Rating: ③)

3.4.1 Institutional/Organizational Aspects of Operation and Maintenance

The executing agency of this project is WAJ. Miyahuna's local staff is commissioned by WAJ to carry out and take charge of the operation and maintenance of the pumping facilities and water transmission pipes. Miyahuna is a semi-governmental company under the Ministry of Water and Irrigation, to which WAJ reports. It is also an entity affiliated with WAJ. Since 2015, this company has been carrying out operation and maintenance duties in Zarqa District, where this project's pumping stations are located. In reality, WAJ's Zarqa branch office, which had been operating and maintaining water supply works in Zarqa District until 2014, underwent restructuring and transferred its function to Miyahuna together with many of its employees. According to WAJ headquarters and Miyahuna, the organizational transfer and handover went smoothly.

Miyahuna has 205 employees (as of December 2019) for the operation and maintenance of the pumping stations, water transmission and distribution pipes, and well facilities. According to the site managers of the pumping stations, the number of staff is sufficient, and they do not foresee problems arising from staff shortages. In addition, Miyahuna reports to WAJ headquarters

periodically.[15] Moreover, headquarters visit Miyahuna regularly to check the implementation status of operation and maintenance. No significant problems were observed in the supervision system.

Therefore, it can be assumed that there are no significant problems with the organizational aspect of the operation and maintenance at the time of the ex-post evaluation.

3.4.2 Technical Aspects of Operation and Maintenance

According to Miyahuna, its staff working at Azraq, Hallabat and Zarqa pumping stations have 10 to 20 years of working experience. As mentioned above, WAJ's Zarqa branch office staff who had been responsible for the operation and maintenance until 2014 was transferred to Miyahuna and continued its work. Site visits and staff interviews confirmed that there were no particular technical or capacity problems. It was also observed that experienced personnel were assigned to appropriate jobs in appropriate places.

Miyahuna conducts regular training for its staff. Training is held at the headquarters (in the capital Amman) on different topics, such as how to use pipe leakage inspection equipment, financial plan development, management skills, computer skills and the operation of pumping facilities. Additionally, on-the-job training is given to newly recruited staff as appropriate.

As discussed in 3.3.1.2 Qualitative Effects under "Effectiveness" staff at each pumping station can now adhere to periodic maintenance requirements through the capacity building / soft component training conducted as part of this project. They are now able to judge the appropriate timing of oil changes and grease coating by listening to the sound of the pump's motor. It is evident that the knowledge and technical skills of operating and maintaining pumps have improved.

Based on the above, it can be concluded that there are no particular problems in the technical aspect of the operation and maintenance of this project.

3.4.3 Financial Aspects of Operation and Maintenance

Miyahuna allocates a budget for the operation and maintenance of the facilities and equipment developed by this project. Table 6 shows Miyahuna's operation and maintenance expenses for the entire Zarqa District, which includes the operation and maintenance expenses of Azraq, Hallabat and Zarqa pumping stations.

[15] They report every month or every three months depending on the content of the work.

Table 6: Miyahuna's Operation and Maintenance Expenses for Zarqa District
(Last three years) *Note 1

(Unit: thousand JD)

	2016	2017	2018	2019 *Note 2
1) General maintenance costs	179	93	78	Data not available
2) Vehicle maintenance costs	166	133	200	Data not available
3) Water distribution networks and pumping stations maintenance costs	1,417 *Note 3	1,097	1,069	Data not available
4) Electricity costs	N/A	9,358	12,149	11,113
5) Sewage facilities maintenance costs *Note 4	8,682	10,556	11,167	11,254

Source: Miyahuna
Note 1: These data include the operation and maintenance costs of Azraq, Hallabat and Zarqa pumping stations.
Note 2: Data until the end of November 2019 (provisional numbers)
Note 3: A large budget was allocated to the maintenance of water distribution networks and pumping stations for 2016 due to periodic maintenance work to be conducted every few years (large-scale works such as equipment replacement, overhaul). For this reason, the expenses for 2016 were greater than for 2017 and 2018. If a large budget is needed, the allocation is done accordingly.
Note 4: Although it is not related to this project, the numbers are shown here because the sewage maintenance costs, just like electricity costs, account for a large portion of Miyahuna's expenses.

According to WAJ and Miyahuna, with regard to the required works, sufficient budgets were allocated to general maintenance costs, vehicle maintenance costs, and the maintenance costs for water distribution networks and pumping stations. The interviews with the operation and maintenance staff of each pumping station also confirmed that the budgets were neither too large nor too small and that the facilities and equipment were in use. The operational status of the pumping facilities developed by this project remained good after the project's completion, and apparently, no major budgets were allocated to repairs or replacements. Miyahuna confirms that they would allocate a sufficient budget if there was a problem/breakage. Miyahuna also commented, "While costs of electricity needed for operating pumping stations are high and the influx of Syrian refugees is a big factor, the volume of water supplied has been increasing every year, and so has the revenue. We have no problem allocating budgets for operation and maintenance. Operating pumping facilities is a lifeline for Jordan. Its budget cannot be cut.[16]"

As a reference, Table 7 shows recent gross revenues and gross expenses (2017) of major water

[16] WAJ has not provided Miyahuna with any subsidy or fund since the separation. As WAJ is aware of the importance of the facilities and equipment developed by this project, it is inferred that WAJ will provide some form of assistance if Miyahuna becomes unable to operate or secure sufficient funds. For this reason, the understanding and importance of spending operation and maintenance budgets is considered to be high.

supply entities that operate in Jordan. Miyahuna operates the largest water supply businesses with the largest operating profit (gross revenue minus gross expenses). Considering this point, it can be concluded that there are no problems with the financial aspect of the operation and maintenance.[17]

(Reference) Table 7: Gross Revenues and Gross Expenses of Major Water Supply Entities Operating in Jordan (2017[18])

(Unit: thousand JD)

	WAJ Headquarters	Miyahuna	YWC	AWC	4 GWAs	Total
Gross Revenue	57,988	174,293	38,705	18,486	20,221	309,693
Gross Expense	54,488	167,300	62,917	14,993	36,259	335,957
Difference	3,500	6,993	-24,212	3,493	-16,038	-26,264

Source: WAJ documents

Note: YWC stands for Yarmouk Water Company, AWC for Aqaba Water Company, while 4GWAs refers to water supply entities of the four main districts.

Electricity costs account for a large proportion of expenditure. Since they continue to rise, an increase in electricity costs is considered to be a burden. According to WAJ and Miyahuna, current electricity costs account for about 60 to 70% of the operation and maintenance costs of the entire water supply operations. The electricity bills for the pumping facilities and equipment bills for this project have been paid without delay, and there have been no problems in terms of electricity supply. Nevertheless, it is a factor that is oppressing the water supply operations, and it continues to be an issue that requires close attention.

[17] If Miyahuna is unable to pay electricity bills or allocate sufficient budgets for maintenance work, it can be concluded that there are issues and concerns about the financial aspect. However, there are no delays or problems with their payment at the time of the ex-post evaluation, which is one of the reasons why this judgment was made.

[18] Only 2017 data could be obtained during this survey.

Box. The electricity consumption/rates/payments of the pumping stations in this project

Here we will examine the relationship between this project and electricity consumption/rates/payments of the pumping stations. Table 8 shows the changes in electricity consumption of Azraq pumping station, the power rates, and the electricity payments made by Miyahuna. (1) While electricity consumption fluctuates from month to month, the replacement of pumping facilities was carried out in this project in 2012. As a result, the operation became more efficient and electricity consumption decreased (from July 2011: 3,505,915 kWh to July 2013: 2,390,805 kWh). However, water demand increased sharply (mainly because of the influx of Syrian refugees since 2012), while operational hours of pumping facilities at Azraq station increased. As a result, water production also increased. According to Miyahuna, every pumping facility faced a production increase of 10 to 20% over the period 2012 to 2017. As the operational hours of the pumping facilities increased, the electricity consumption also increased (from July 2013: 2,390,805 kWh to June 2017: 2,827,750 kWh). (2) The power rate at the time of the ex-post evaluation (end of 2019) is 0.115JD per kWh. This means the rate has almost tripled over 10 years, with repeated increases in recent years.[19]

Based on (1) and (2) above, we can compare and verify the scenarios with or without this project. Applying the power rate at the time of the ex-post evaluation (0.115 JD / kWh) to the electricity consumption of July 2011, i.e., just before the introduction of pumping facilities by this project, we get 403,180 JD (i.e., 3,505,915 kWh × 0.115 JD). (3) According to Miyahuna, the actual electricity payment for July 2011 was 150,754.35 JD. This means the difference between this amount and 403,180 JD is approximately 250,000 JD (i.e., 403,180 to 150,754 JD). Although it is a retroactive perspective, the difference is not small. Therefore, if this project had not been implemented, with power rates being on the increase, it would have put further stress on the company's finances. With the pumping facilities of this project (introduction of newest equipment), highly efficient and stable operations became possible. The electricity payment by the operation and maintenance entity or energy consumption is reduced. Therefore, it can be said that this project is contributing to the "reduction in energy consumption," which was discussed in 3.3.1.2 Qualitative Effects.

[19] There are multiple factors behind the power rate changes. To cite a few, there were problems with procuring LNG used for thermal power generation, the oil price increased (the price was three to four times more than the level before the project commenced), etc.

(Reference) Table 8: Changes in Electricity Consumption at Azraq Pumping Station, Domestic Power Rate, Electricity Payment by Miyahuna

	Sep 2009	July 2011	July 2013	June 2017	March 2018
(1) Electricity Consumption (Unit: kWh)	2,639,747	3,505,915	2,390,805	2,827,750	2,759,400
(2) Domestic Power Rate (Unit: JD / kWh)	0.041	0.043	0.066	0.094	0.094 (As of the end of 2019, 0.115 JD)
(3) Electricity Payments by Miyahuna (Unit: JD) *(1) x (2)	108,229.63	150,754.35	157,793.13	265,808.50	259,383.60

Source: Miyahuna

Remark: Data were available only from Azraq pumping station. Data were not recorded at Hallabat and Zarqa pumping stations before the completion of this project.[20]

3.4.4 Status of Operation and Maintenance

At the time of the ex-post evaluation, there are no problems in terms of the operational status of Azraq, Hallabat, and Zarqa pumping stations nor the water transmission pipes developed by this project. There have been no problems or need for repairs in the period before the ex-post evaluation. According to Miyahuna, the system is in place to respond immediately to any breakage or damage should the need arise. Daily/monthly/annual inspections are conducted depending on the type of facility or equipment.

Currently, there are no problems with the status of storing and procuring spare parts. The field visits and interviews confirmed that the storage status and quantity stored was satisfactory at each pumping station at the time of the ex-post evaluation. For the pumping facilities in particular, procurement system from Japan is in place in case there is a necessity to replace the parts because of the breakages. The staff of each pumping station works in three shifts around the clock. A system is in place so that staff can come in at all times in case of an emergency.

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

[20] The reason is thought to be that records were not smoothly handed over at the time of the organizational transfer in 2015.

Photo 3: Pumping Facility at Zarqa Pumping Station

Photo 4: Safety Measure Board (At Each Pumping Station)

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project procured equipment, installed pumping and water distribution facilities, and provided technical assistance in the areas of operation and maintenance of the pumping facilities and operation of the water distribution system. The aim of the project was to improve operational efficiency of the pumping facilities as well as, with energy-saving measures, to stabilize and improve the water distribution systems at three pumping stations, Azraq, Hallabat and Zarqa in Zarqa District, located northeast of the capital city of Jordan, Amman. With respect to the development policy, documents developed by the Jordanian government such as *National Agenda 2006-2015* and *Water for Life: Jordan's Water Strategy 2008-2022*, list the water sector, climate change measures, supply of safe drinking water and sustainable water resource utilization as important issues. In addition, since the per capita water supply was limited for all of Jordan, including Zarqa District, there was a need for water resource development, the expansion of water distribution networks and the renewal of pumping stations. Furthermore, the project is in line with Japan's ODA policy. Therefore, its relevance is high. With regard to efficiency, the project outputs and costs were generally as planned. However, the project period exceeded the initial plan as it took longer to select and identify a contractor for the work to be carried out on the Jordanian side. Furthermore, it was decided to utilize the remaining budget for additional works such as installation of water pipes and management of reservoir sediments. Therefore, overall the efficiency is fair. As for quantitative effect indicators, "operational efficiency of the pumps" and "reduction in electricity consumption," the targets have been achieved through the implementation of this project. Whilst the target was met for "reduction in electricity costs," it is worth noting that the electricity price rose within Jordan. Additionally, it was confirmed through

the qualitative interview survey that the project had contributed to reducing energy consumption (electricity costs), improving technical skills of the operation and management staff of the pumping facilities, establishing a stable water supply and improving water distribution, all with a reduced environmental load. Considering the above, the project's effectiveness and impact are considered to be high. There are no particular concerns regarding the institutional, technical or financial aspects of Miyahuna, the company responsible for the operation and management of the pumping stations developed by this project. There are no issues concerning the operation and management of the other facilities and equipment. Therefore, sustainability of the project's effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

The power rate increases are significant in Jordan. At the time of the ex-post evaluation, electricity costs account for around 60 to 70% of WAJ's total expenses. This is significant for water supply operations, including the operation of the facilities targeted by this project. As there is no guarantee that the rate will not rise in the future, it is preferable that WAJ deepen cooperation with relevant government agencies, thereby preparing for the burden of such expenses.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Necessity to provide solid training when renewing facility/equipment

During the implementation of this project, generous training was given on the operations of facilities and equipment to be introduced. All operation and maintenance staff received training not only on efficient operation methods for the pumping facilities but also on preventative maintenance, such as a technique to determine the right timing for the maintenance. This has better prepared them for future maintenance. It has also helped them develop a habit of accurately monitoring the equipment/instruments, enabling them to carry out operations and maintenance work properly. The capacity building of the operation and of the maintenance staff was completed before the introduction of the pumping facilities, which enabled them to operate water distribution management around the clock. For future projects of a similar nature, it is preferable that JICA

and executing agencies explore ways to realize sustainable maintenance by taking appropriate measures at the right time, such as conducting training at the same time as the introduction of facility/equipment.