Republic of Tunisia

FY2017 Ex-Post Evaluation of Japanese Grant Aid Project

"The Project for Desalination of Groundwater in Southern Region"

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

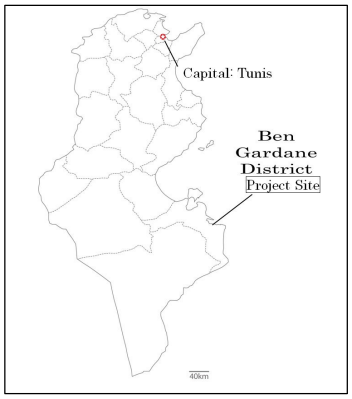
0. Summary

This project constructed the desalination system of groundwater by reverse osmotic membrane method to increase the amount of water supply and improve water quality, salinity concentration, in Ben Gardane district in Medenine Governorate located in the coastal region of southern Tunisia, and to contribute to stability of the living environment of residents around the district. To raise water supply rate, to secure drinking water and to improve water quality in urban and rural areas are presented in the *11th Social-Economic Development Five-Year Plan (2007-2011)* formulated by the Tunisian government and the *Five-year Development Plan* formulated by the Water Resources Development Corporation (Société Nationale d'Exploitation et de Distribution des Eaux), hereafter referred to as "SONEDE", the executing agency of the project. In addition, the development needs for expansion of water supply demand around the district have been confirmed. It was also confirmed that this project was relevant to Japan's ODA policy. Therefore, its relevance is high. Regarding efficiency, the outputs were largely as planned, and the project cost was also within the initial plan. On the other hand, regarding the project period, it exceeded the initial plan as the construction of the pump station by Tunisian side required the time to assemble the drilling equipment and to join underground cable buried at the pumping station. Therefore, its efficiency is fair. Regarding the quantitative effect indicators of the project such as data of supply and quality of water to Ben Gardane district, after the completion of the project, the amount of daily average water supply has reached the initial target amount, while the water quality, salinity, has not been achieved the target. In addition, in the interview survey to residents around the district, there were dissatisfied opinions that "salinity concentration was high, amount of water supply was low, and pressure of water supply was low", and additionally, it was confirmed that the non-revenue water rate in the district was also high. Thus, it is assumed that its impact is limited. Therefore, its effectiveness and impacts of this project are fair. There is no particular concern in terms of institutional, technical and financial aspects of the Desalination Service Station of Ben Gardane District Regional Branch Office of Medenine Governorate, and Southern Regional Branch Office of Sfax which are responsible for the operation and maintenance of this project. There is no particular problem in the operation and maintenance status of other facilities and equipment.

Therefore, the sustainability of effects developed by the project implementation is high.

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

1. Project Description



Project Location

Desalination Facilities Developed by the Project

1.1 Background

Prior to the start of this project, in Ben Gardane district in Medenine Governorate in the southeastern part of Tunisia close to the border town with neighboring Libya, there were concerns about the increase in water demand due to the rapid population increase and the land degradation due to the desertification presumed to be caused by the recent climate change. The water supply to the district which did not have water source in the vicinity depended on the long-distance water supply from the well water sources more than 60 km away and from the water distribution network in the southern area. However, the amount of water source tends to be insufficient year by year according to the demand. Especially during the dry season, a large amount of water was consumed when the water was divided into the surrounding areas in the pipeline section supplying water to the district, and a long-term water outage occurred around the district. For this reason, it was assumed to be difficult to continue to secure a sufficient amount of water in the future. In addition, as its salinity concentration was rising, the water quality sent from the other districts did not meet 1.5g per liter, the target of SONEDE's water quality. For this reason, it was also an urgent task to respond to salinization.

1.2 Project Outline

The objective of this project is to increase amount of water supply and improve water quality, salinity concentration, in the Ben Gardane district in Medenine Governorate located in the

coastal region of southern Tunisia by constructing the groundwater desalination system by reverse osmotic membrane method for new water sources, thereby contributing to stabilize the living environment of residents around the district.

Grant Limit/ Actual Grant Amount	1,000 million yen (Initial), 1,023 million yen (After revision) / 1,023 million yen
Exchange of Notes Date /Grant Agreement Date	March 2010 (Initial), March 2014 (After revision) /March 2010 (Initial), September 2010 (1st revision), December 2014 (2nd revision)
Executing Agency	SONEDE
Project Completion	June 2013
Main Contractor	Takaoka Engineering Co., Ltd. & Suido Kiko Kaisha, Ltd. (JV)
Main Consultant	Ingérosec Corporation& Nihon Techno Co., Ltd. (JV)
Procurement Agency	Japan International Cooperation System
Preparatory Survey	November 2009 – August 2010 (Preparatory Survey)
Related Projects	【ODA Loan Project】 "Rural Water Supply Project (1)" (L/A signed in 2000) "Rural Water Supply Project (2)" (L/A signed in 2003) "Water Supply and Sewage System Improvement Project in South-Tunisia" (L/A signed in 1995) "Sfax Sea Water Desalination Plant Construction Project" (L/A signed in 2017) 【Other Donors' Cooperation】 "Water Supply Improvement Plan in Southern Tunisia", Kreditanstaltfür Wiederaufbau Bankengruppe (KfW)(2004) "Rural Water Supply Plan and Modernization Support of SONEDE", Agence Francaise de Developpement (AFD) (2003) "Urban Water Supply Improvement Plan", World Bank (IBRD) (2005) "Program of Improvement of Water Quality in the South II" (PNAQ2), KfW (2015-2020 scheduled)

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, 2017 - December, 2018

Duration of the Field Study: January 6-18, 2018 and April 9-13, 2018

2.3 Constraints during the Evaluation Study

In this study, since the external evaluator was unable to enter the project site for security reasons, the evaluator scrutinized information and data, etc, obtained by the collection and interview survey done by the local assistant who was employed under this survey. Then, analysis and judgment of this evaluation was conducted.

3. Results of the Evaluation (Overall Rating: B[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Plan of Tunisia

At the time of project planning, the Tunisian government formulated the *11th Socio-Economic Development Five-Year Plan (2007-2011),* and it was intended to raise the water supply rate of household served to 97% at the national level and at least to 85% in whole rural area by 2011. Moreover, in addition to effective utilization of water resources, etc, through water saving, the plan has positioned the expansion of water supply and the improvement of water quality in the southern region as one of the development plans.

At the time of the ex-post evaluation, the Tunisian government has formulated the *Strategic Development Plan of Tunisia (2016-2020),* and the stable drinking water supply is positioned as one of the major pillars to improve the living standards of residents, especially to contribute to that of rural residents. As of 2014, the water supply rate throughout the country is 98.2%, while the water supply rate in rural areas remains at 94.6%, and the government aims to raise the water supply rate of rural areas to 96.0% in the plan. In addition, SONEDE has formulated the *Five-Year Development Plan (2016-2020)* and emphasized securing drinking water, improving water quality, efficient and rational use of water, and conservation of water resources, etc, in urban and rural areas, especially in villages.

In view of the above, even at the time of ex-post evaluation, Tunisia continues to place importance on stable water supply, improvement of water quality, increase of water supply rate in rural areas, etc. Therefore, consistency with policies and measures in the national plan, sector plan, respectively are recognized both at the time of planning and at the time of ex-post evaluation.

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[2] ③: High, ②: Fair, ①: Low

3.1.2 Consistency with the Development Needs of Tunisia

Prior to the start of this project, the population of Ben Gardane district[3] was 64,000 in 1994, but it increased to 73,000, about 14,000 households, in 2008.There was concern about the increase in water demand due to the population increase and the progress of desertification and deterioration of land presumed to be caused by the climate change. Although SONEDE had been conducting water supply projects in the district, the water supply to the district without a source of water in the vicinity was obliged to rely on well water sources more than 60 km away and a long-distance water supply from other distribution networks. However, such water distribution from wells and a long-distance water supply was becoming insufficient year by year against the water demand. Particularly during the summertime, a long-term water outage was confirmed around the district because a large amount of water was consumed as water was divided into the surrounding areas of the pipeline section supplying water to the district. For this reason, it was predicted to be difficult to secure a sufficient amount of water in the future. In addition, the salinity concentration of the water to be sent increased from 1.4g per liter in 1999 to 1.7g per liter in 2004, exceeding the SONEDE's standard (target) of water quality of 1.5g per liter. In addition, around the district, it was regarded as an urgent task to respond to the salination because further aridification and instability of rainfall influenced by the climate change was expected and because it was disadvantaged to have groundwater with good quality, salinity concentration is high[4]. Therefore, the needs for water source development and water quality improvement around the district were high.

At the time of ex-post evaluation, SONEDE has conducted the *Program of Improvement of Water Quality in the South II or Amélioration de la Qualité des Eaux du Sud,* hereafter referred to as "PNAQ2"[5] for the purpose of increasing amount of water supply and decreasing salinity in response to changes in the demand for water supply due to population increase[6] in the south

[3] The Ben Gardane district is located near the border with Libya. It is a town where a lot of household goods and appliances are flowing in from Libya, and commercial business is popular.

[4] The south of Tunisia is disadvantaged with water resources, and even for meager water resources, surface water concentrated in the north. And it has to rely on groundwater resources in the central and south. The aquifers with low salinity concentration suitable for drinking water are localized unevenly. Especially in the southwestern region, the amount of water source was insufficient against the water demand year by year, and the salinity concentration was high. (Source: JICA Preparatory Survey Report)

[5] Mainly, being implemented by the support of German Reconstruction Finance Corporation or Kreditanstaltfür Wiederaufbau (KfW). Mainly construction of 8 deep wells and 1 desalination treatment facility, capacity: 9,000 m³/day. The budget amount is 171 million Tunisian Dinar. It started in 2015 and is planned to be completed in 2020.

[6] As of the time of ex-post evaluation, the number of residents in the Ben Gardane district is 82,560 people. (Source: Estimated value of 2017 by the evaluator based on the 2014 census.). Before the project started, it was 73,000 people (Source: 2008 census).It can be seen that the growth rate is about 13% in 6 years and is high (= about a little over 1.5% per year). It can be said that this growth rate explains the increase in demand for water supply.

of Tunisia including Ben Gardane district. As described later in the “3.3.1.1 Quantitative Effect, Operation and Effect indicators”, regarding the water quality supplied to the district, the salinity decreased at the commencement of service of the project facilities, June 2013. However, the high situation of the salinity continues as the demand for water supply in the district increases after that.

In view of the above, even at the time of ex-post evaluation, the program to improve water quality such as efforts to increase amount of water supply and decrease salinity have been implemented in the Ben Gardane district. Therefore, it can be said that consistency with development needs is recognized both at the time of planning and at the time of ex-post evaluation.

3.1.3 Consistency with Japan’s ODA Policy

In the *Country Assistance Program for Tunisia* formulated by the Ministry of Foreign Affairs in October 2002, (1) support for upgrading industries, (2) support for water resource development and management, and (3) support for environmental initiatives were listed as the priority fields and task-based assistance policy. Among them, regarding (2) support for water resource development and management, it was proposed that “the cooperation is promoted by making full use of Japan’s experience and technology for not only the support to development of water resource but also the support leading to the comprehensive management of water resources including the management of water supply and demand and the management of surface water and underground water. From the viewpoint of the promotion of rural areas and poor areas that are lagging in development, consideration will also be given. Therefore, the project corresponds to Tunisia with the above-mentioned prioritized fields and task-based assistance policy, (2) support for water resource development and management in the above, and its consistency with Japan's assistance policy is recognized.

Based on the above, the implementation of the project has been highly relevant to Tunisia’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 constructed a desalination plant at a location about 7 km north of the center of Ben Gardane district in Medenine Governorate for the purpose of lowering the salinity concentration of the water supply and eliminating the long-term water outage in summertime. Table 1 shows the planned and actual outputs of this project. It is judged that actual result was mostly as originally planned.

Table 1: Planned and Actual Outputs of This Project

At the time of planning (2010)[7]	Actual: At the time of project completion (2013)
【Planned Inputs from Japanese side】 (1)Development of main facilities related to a desalination plant (amount of desalinated water: 1,791 m³/day, RO membrane method (installation series: 2 series)) and related equipment (2) Installation of water tanks (raw water adjustment tank: 500m³, filtered water tank 150m³, desalinated water tank 170m³, and waste water tank 70m³) (3) Construction of concentrated water treatment facility (Size: 11.9ha) (4) Construction of a concentrated water drain pipeline (about 0.1 km & piping 150 mm) and a solar evaporation pit. (5) Development of a solar power generation system (system with 30kW outputs as auxiliary for commercial power)	【Actual Results from Japanese side】 (1)(2)(3)(4)(5): Mostly as planned. (For (1), the number of installed RO membranes has been increased from 2 series of initial plan to 3 series, and for (5), the outputs of the solar power generation system has been increased from 30 kW of initial plan to 210 kW.)
【Planned Inputs from Tunisian side】 (1) Laying a desalinated water transmission pipeline (about 6 km) from a desalination plant to the existing distribution pond (2) Development of pumping of raw water wells and deep wells (pumping capacity: 37 liters per second or more)	【Actual Results from Tunisian side】 (1)(2): As planned.

Source: JICA documents, answers on questionnaire

The outputs of Japanese side were mostly implemented as planned. The differences between planned and actual are as follows; Since the bid price was lower than the estimated price at the price opening bid of the contractors, December 2012, and the remaining money was generated,

[7]There was no change in the output plan at the time of detailed design (D/D).

1) as for the Reverse Osmosis Membrane[8], hereinafter referred to as “RO membrane”, the number of series of installed membrane was increased from two series of initial plan to three series, and 2) as for the solar power generation system, such change as the output expansion from 30 kW of initial plan to 210 kW, etc, was done. Regarding the number of series of installed membrane of 1), specifically, the system was changed to a system in which one series was prepared for back up for emergencies and the remaining two series were for the desalination treatment. It is because it was judged that preparing for failure and emergency was a stable operation although it was planned to have no backup initially. Amid the growing demand for water supply in Ben Gardane district, there is also a background that the stable operation of desalination facilities of the project was regarded as important. Regarding the expansion in output (210 kW) of the solar power generation system of 2) also, there is a background that it was aimed at executing stable operation of the equipment of the project although it plays a role as an auxiliary for the main power supply for the relevant equipment in the desalination plant. The outputs of Tunisian side were also carried out as planned.

Photo1: Inside of Desalination Plant Facilities

Photo 2: Solar Power Generation System

3.2.2 Project Inputs

3.2.2.1 Project Cost

Regarding the total project cost of this project, the initial plan was about 1,183 million yen, the amount to be borne by Japanese side was 1,023 million yen[9] and the one by the Tunisian

[8] The RO membrane is a semi permeable membrane that allows only water to pass through without passing salt and the like. It is also used when taking out fresh water from seawater. The method using the RO membrane, RO membrane method, has a feature that energy consumption necessary for obtaining fresh water is smaller than that in the evaporation method.

[9] The initial plan of project cost was 1,000 million yen. After the project started, the amount of G/A was changed to 1,023 million yen. The circumstances are as follows: due to the impact of attack incident to the natural gas plant in Algeria in January 2013, the security deterioration in the neighboring country of Tunisia was also assumed. According to the instruction of Ministry of Foreign Affairs of Japan, the concerned Japanese evacuated from March 6

side was 160 million yen, whereas actual amount was about 1,103 million yen, actual amount of the Japanese side was 1,023 million yen and that of the Tunisian side was about 80 million yen. It was almost as initially planned (about 93% of the plan).

3.2.2.2 Project Period

This project was planned to be completed from March 2010 to April 2012 (26 months)[10]. The actual period was from March 2010 to June 2013 (40 months) and exceeded the plan (about 154% compared to the plan). The main reason for the excess is that concerning the improvement of pump station by Tunisian side, it took time to assemble drilling equipment and to join the underground cable at the pumping station, and the construction work of Japanese side was also affected (a total of 14 months[11]). About one year since its launch in June 2013, SONEDE was coordinating the grid connection of the solar power generation system and commercial power supply, mainly verification of standard and procedure of electrical system connection, with Tunisian Corporation of Electricity & Gas (Société Tunisienne de l'Electricité et du Gaz; STEG)[12]. However, such delay did not affect the start of service in June 2013.

In view of the above, this project outputs were mostly as planned, and the project cost was within the plan. The project period exceeded the initial plan due to the fact such as that it took time to assemble the drilling equipment mainly concerning maintenance of the pump station and to join the underground cable for the pumping station on Tunisian side, etc. Accordingly, although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

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to April 5 in the year. The persons evacuated in the project were the consultants for construction supervision. The payment of additional expenses, evacuation and overhead expenses, that occurred during the temporary evacuation period was approved by JICA and was paid to the consultants. Based on the revised G/A, 23 million yen was increased. Although there was no increase in outputs, it can be said that the increased amount, the increase in the planned project cost, caused by the evacuation instruction was inevitable.

[10] The initial project period was 25 months in total, but as stated in 3.2.2.1 Project cost, according to the instruction of the Ministry of Foreign Affairs of Japan, the concerned Japanese were due to evacuate between March 6 and April 5, 2013, approx. 1 month. The analysis was done after resetting the project period being 26 months in total by adding about one month to the project period of the initial plan.

[11] It was not possible to confirm the breakdown of the14 months.

[12] In other words, it was originally scheduled to be completed in June 2013, in a total of 26 months with the addition of 1 month, as same as the construction period of the Japanese side. However until June 2014, the work continued on Tunisian side.

3.3 Effectiveness and Impacts[13] (Rating: ②)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

1) Operation Indicator

In this project, major facilities related to desalination plant and the related various equipment were developed. Table 2 shows the trend of the amount of daily average water supply, baseline, target, and actual value, which are the quantitative effect indicators.

Table 2: Amount of Daily Average Water Supply (baseline, target, and actual value)

(Unit : m³/day)

Baseline (2009)	Target (3 years after completion)	Actual		
		2012 (Before completion)	2013 (Completion)	2014 (1 year after completion)
7,690 *Note 1	9,481 *Note 2	10,021	11,869	12,687
		2015 (2 years after completion)	**2016*Note3 (3 years after completion)**	2017 (4 years after completion)
		12,250	12,233	12,821

Source: SONEDE

*Note1: The breakdown of the baseline was 4,530 m³/day of water from the southern distribution network, 3,160 m³/day of water intake from the deep wells of Maouna, 4 wells, and 7,690 m³/day in total.

*Note 2: It was expected that the total would be 9,481 m³/day by additional 1,791 m³/day (see Table 1) of the design treated volume by the desalination plant of this project to 7,690 m³/day.

*Note 3: The black bold frame shows the actual target year (3 years after project completion, 2016).

(Reference) The breakdown of the amount of daily average water supply (actual) of Table 2 is as follows;

Table 3: Amount of Daily Average Water Supply (Actual)

(Unit : m³/day)

Water source	Actual*Note 1				
	2012	2013			2014
		Up to June	July Completion *Note 3	From August *Note 4	
Southern Distribution Network	5,544	5,493	4,768	5,145	5,518
Maouna deep wells	4,075	4,369	3,486	3,744	3,903
Marsa deep well (SDBG*Note2)	-	-	1,519 (Start)	1,494	1,608

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

Ourasnia deep well	-	-	-	1,161 (Start)	1,229
Sayah deep well	402	355	295	327	429
Total	**10,021**	10,217	10,068	**11,869**	**12,687**

Water source	2015	2016	2017	
			Up to August	In/After September *Note5
Southern Distribution Network	5,829	5,783	5,958	5,438
Maouna deep wells	3,120	3,550	4,097 *Note 6	3,898 *Note 6
Marsa deep well (SDBG*Note 2)	1,551	1,375	1,344	0
Ourasnia deep well	1,661	1,202	1,422	943 *Note 7
Sayah deep well	89	323	-	-
Total	12,250	12,233	**12,821**	10,279

Source: SONEDE

*Note1: It shows the peak water supply throughout the year.

*Note2: SDBG is abbreviation of Station de Dessalement Ben Gardane (This project: Desalination plant of Ben Gardane).

*Note3: The completion of this project, commencement of the service, is at the end of June 2013. On the other hand, in Table 2, for the sake of convenience, the completed month is set as July. The reason for this was that actual data of Marsa deep wells began to be measured (= water intake was started from a new well in earnest) in July.

*Note4: Because water intake from a new well occurs in July and August in 2013, the periods are described separately as "up to June", "in July", and "from August".

*Note5: The Marsa deep well was connected to the desalination plant of this project and the desalination treatment was carried out. But on September 6, 2017, water intake was stopped as it became difficult to use the well as a large amount of sand blew out. After that, water supply from the Ourasnia deep well is connected to the facility and the desalination treatment is carried out. For this reason, the data of daily average water supply at the peak time up to August and the peak time in/after September is described separately.

*Note6: The water intake of the Jallel deep well is added to the data of daily average water supply of the Maouna deep wells since January 2017.

*Note7: Numeral values underlined in the table indicate the actual value of treated volume connected to SDBG.

Table 4: Forecasts of Future Water Supply Demand in Ben Gardane District
(Daily Average Water Supply During Peak Month)

(Unit : m^3/day)

2018	2019	2020
12,954	13,602	14,282

Source: SONEDE

As shown in Table 2, the actual amount of the daily average water supply is higher than the target (9,481 m^3/day) of that in Ben Gardane district from 2012 which is before the completion of the facility. The reason for this is that, as pointed out in 3.1.2 Consistency with Development Needs, there is an increase in demand for water supply in the district due to the population increase. In other words, SONEDE has established a system to increase the amount of water

supply against the increasing demand of water supply[14]. As shown in Table 3, SONEDE has increased the number of water sources, deep wells, year by year. As a concrete measure, from the start of operation of this project facility to the time of ex-post evaluation, SONEDE has invested its own budgets, developed two deep wells of Ourasnia and Jallel, and distributed water to the district. In other words, although it cannot be said directly that the target value exceeds the initial plan due to this project implementation as the demand for water supply is increasing, it can be said that this project is contributing to the stable supply of water considering that the water taken from the deep wells is desalinated and constitutes the water supply amount for the entire district. In addition, the amount of desalinated water at the facility of this project achieves around 80% of the initially assumed treated volume, 1,791 m³/day, until the Marsa deep well described below stops water intake. In view of this, it can be said that there is almost no problem as a driving function of the facility.

To further describe the breakdown of Table 3, after this project completion, the water taken from Marsa deep well was sent to the facility of this project for desalination. However, it was stopped to take water from the well which became difficult to use as a large amount of sand blew out on September 6, 2017. This was an unexpected event, but as a countermeasure to this, SONEDE had to switch the line of RO membrane series used for water supply from the Marsa well until then to the water supply from Ourasnia deep well, and the desalination treatment was started. With regard to the water supply from Marsa deep well, two RO membranes series were used, and the treatment of desalinated water was carried out for the water supply of 30 liters per second[15], 15 liters per second × 2 series, before the suspension of water intake. On the other hand, since the amount of water sent from the Ourasnia deep well was as small as 19 liters per second, SONEDE judged that there was no operational problem by coping with one series after switching, 19 liters per second × 1 series. In other words, as of the time of ex-post evaluation, two series of RO membranes, 1 series for all times + 1 series for backups, are not used. According to SONEDE, in the near future, it is considered to increase the treated volume of water desalination by drilling and starting water intake from anew deep well around the Ourasnia deep well and by a system of three series in total using also one series for back up[16].

Table 4 shows the forecasts of future demand for water supply, amount of daily average water

[14] Since SONEDE supplies and distributes water according to the demand for water supply in Ben Gardane, the data of amount of water supply in the table indicates that it is synonymous with the actual demand for water supply.
[15] It was designed to be 31 liters per second in the JICA preparatory survey (Source: Preparatory Survey Report) conducted before the project started.
[16] SONEDE is focusing on intensive operation in summer time especially when the demand for water supply increases.

supply, in Ben Gardane district, which is expected to continue to grow for the foreseeable future. Looking at this trend, it can be said that SONEDE is required to increase the amount of water supply in the future.

2) Operation Indicators

Table 5 shows the transition of water quality (salinity). The baseline, target, and actual value in the table indicate the water quality of the supplied water which is mixed with the desalinated water of this project and the water of other water sources and is distributed to entire Ben Gardane district. Regarding the target value among them, according to the ex-ante evaluation sheet, the desalinated water produced in this project has a salinity of 0.3g per liter (design value). By mixing this with the existing drinking water with high salinity, it was expected that the final salinity for drinking would be reduced to 1.8g per liter[17].This project was expected to contribute to realization of the target.

The basis of calculation of actual water quality, salinity, of each timing in Table 5 is shown in the appendix at the end.

Table 5: Water Quality (Salinity) *Note 1

(Unit: g/liter)

<table>
<tr><td rowspan="3">Baseline
（2009）</td><td rowspan="3">Target
(2015:
<u>3 years after completion</u>)</td><td colspan="5">Actual</td></tr>
<tr><td colspan="2" rowspan="2">2012
(Before completion)</td><td colspan="3">2013</td></tr>
<tr><td>Up to June</td><td>July(Completion) *Note2</td><td>From August</td></tr>
<tr><td rowspan="4">2.1</td><td rowspan="4">1.8</td><td colspan="2">2.6</td><td>2.4</td><td>2.0</td><td>2.8</td></tr>
<tr><td>2014
(1 year after completion)</td><td>2015
(2 years after completion)</td><td>2016
(3 years after completion)
*Note3</td><td colspan="2">2017
(4 years after completion)</td></tr>
<tr><td></td><td></td><td></td><td>Up to August</td><td>In/After September</td></tr>
<tr><td>2.8</td><td>2.8</td><td>3.0</td><td>2.7</td><td>2.1</td></tr>
</table>

Source: SONEDE

*Note1: This table is consistent with the notation of Table 3 as much as possible. In addition, the basis for calculating the actual value is shown in the appendix at the end.

*Note 2: The completion of this project, commencement of service, is at the end of June 2013. On the other hand, in Table 2, the completion month is July. The reason is as in Table 3.

*Note3: The black bold frame shows the actual target year, 3 years after project completion, 2016.

As mentioned above, the desalination facility of this project was connected to the Marsa deep

[17] The water quality standard of Japan is 0.5 g per liter. The salinity standard in Tunisia is 2.5g per liter, but in the*11th Socio-Economic Development Five-Year Plan* announced by the government in 2007, in districts where water with a salinity of 2.0g per liter or more was produced, the target was specified to decrease to 1.5g per liter or lower, lower than the standard of the country.

well and carried out desalination treatment. At the completion of this project in July 2013, the salinity concentration decreased to 2.0g per liter due to the start of water intake of the deep well and the water desalination. On the other hand, the salinity concentration rose to 2.8g per liter from August the same year. The reason for this is the use of the Ourasnia deep well has started (see Appendix at the end).Even after 2014, the target value has not been attained because it is distributed by being mixed with the Sayah deep well and the Jallel deep well which are not desalinated with high salinity concentration.

In reality, while the demand for water supply in Ben Gardane district is increasing, SONEDE has no choice but to give priority to measures to increase the amount of water supply and the salinity concentration has not been reduced yet. In other words, it is in a situation that the increase of the amount of water supply and decrease of the salinity cannot be simultaneously achieved. As already mentioned, the Marsa deep well has been stopped in September 2017 and the desalination treatment is carried out by switching the line to the water supply from the Ourasnia deep well. In any case, as shown in Table 5, the salinity of the entire water supply distributed to the district is 2.1g per liter, and it has not reached the target value. The reasons why it decreased from 2.7g per liter to 2.1g per liter in/after September 2017can be because the water intake from the Marsa deep well was stopped, the line was switched to the water supply from the Ourasnia deep well, and the desalination treatment at this project facility has been started, etc. For this reason, as shown in Table 3, the amount of daily average water supply is decreasing compared to the previous period, 12,821 m^3/day to 10,279 m^3/day.

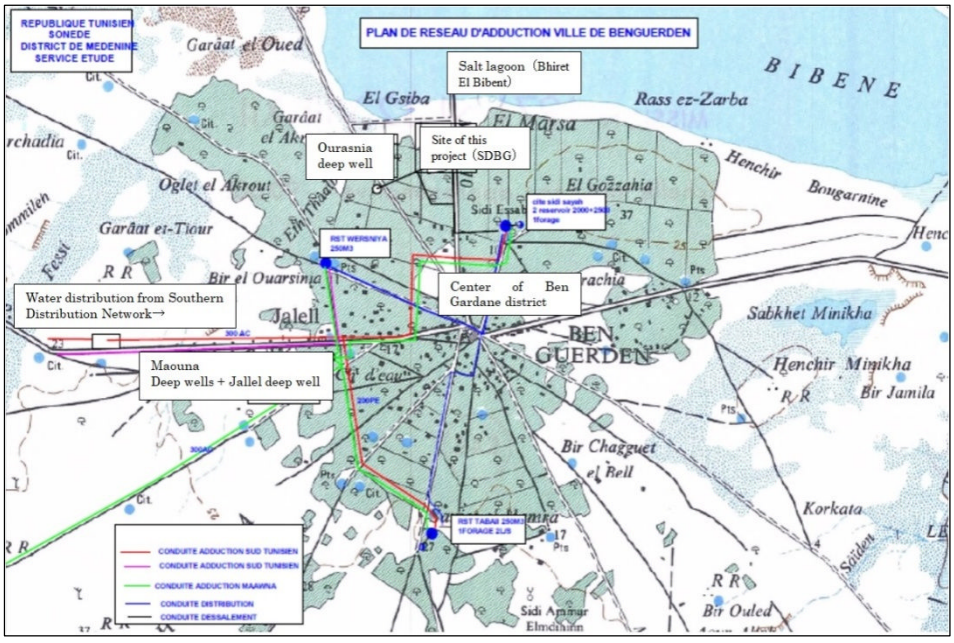


Figure 1: Location of Project Sites

3.3.1.2 Qualitative Effects

Realization of stable water supply

At the time of ex-post evaluation, the water supply from the Ourasnia deep well connected to the desalination facility prepared by this project is desalinated, distributed to the entire Ben Gardane district, and is thought to have contributed to the stable supply. On the other hand, the salinity concentration of water supply as a whole amount is high as already mentioned, and it can be said that further improvement is required[18].

3.3.2 Impacts

3.3.2.1 Intended Impacts

Contribution to the stability of living environment of residents around Ben Gardane district (improvement of long-term water outage in summer)

Prior to the start of this project, as explained in 3.1.2, in Ben Gardane district, it was assumed that it would be difficult to secure the adequate amount of water in the future. Regarding the condition at the time of ex-post evaluation, in this study, an interview survey was conducted to the residents living around Ben Gardane district in order to complementarily explore the actual state of data of 3.3.1.1 Quantitative effects (Operation and effect indicator)concerning the water supply condition, especially outage, hour, pressure, taste, turbidity, smell, color of water supply, etc. Table 6 and 7 show the results. First of all, at SONEDE, data on the long-term water outage was not managed. Therefore, it was unknown by the quantitative data as to how long the water outage occurred, however, as shown in Table 6, it turned out that the occurrence of the water outage itself increased with the timing of completion of this project, June 2013. From the residents, many comments as “there are many water outages in the hot season from every June to September. The frequency of water outage is increasing year by year. Improvement in water supply situation is not seen” were obtained. In addition, as shown in Table 8, items other than turbidity, color and smell tend to be largely dissatisfying. In this interview survey, as the size of survey against the residential population (a population) is small, and it is difficult to be conclusive. However there is a high possibility that the residents are not satisfied with the condition of water supply such as the pressure and amount of water supply. As for the salinity

[18] As of the time of ex-post evaluation, SONEDE has implemented PNAQ2 as already mentioned. Construction of facilities such as 8 deep wells and 1 desalination treatment facility, etc., (capacity: 9,000 m³/day, planned to be completed around 2020) in the district is planned to be implemented full-scale from now on. After completion, the salinity concentration of the water distributed to the district would also decline, and SONEDE expects to improve the pressure, amount and hour of water supply, etc.

concentration and taste, it is considered to be a major factor that the salinity is not improved as already mentioned.

Further, regarding the pressure and amount of water supply, it is inferred that there are problems in the environment surrounding the distribution network around Ben Gardane district. Specifically, as shown in Figure 2, the non-revenue water rate in the district tends to be higher than the nationwide standard of Tunisia. The factors for high non-revenue water rate are considered to be 1) the water distribution pipeline being aged, 2) the water meter not being functioning satisfactorily, 3) the connection being illegal, and 4) the influence from water fee not being paid, etc. It is necessary for SONEDE to make countermeasures after the detailed investigation of the actual situation.

Table 6: Results of Interview to Residents around Ben Gardane District on Water Outage
(28 Interviewees)

Frequency	Before project start (Before June 2013)	After project completion (In/After July 2013)
Everyday	2	11
Twice/ Week	3	2
Once /Week	9	6
Once /2-Weeks	3	2
Once /Month	1	2
None	10	5

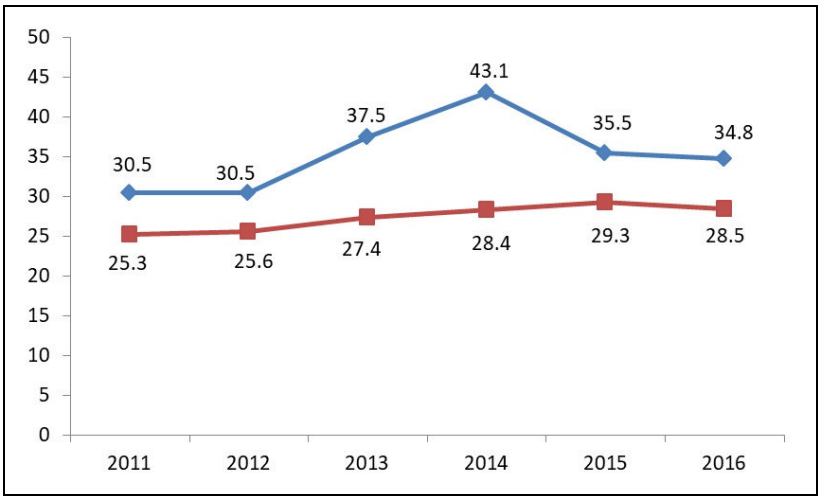
Source: Results of interview to 28 beneficiaries
Remarks: It was questioned whether there were any changes in the situation of water outage occurrence on the timing of project completion of this project facility, before June 2013 and in/after July 2013.

Table 7: Results of Interview Survey on Water Supply to Residents around Ben Gardane District
(28 Interviewees)

Item	Satisfied	Normal	Unsatisfied
Salinity Concentration	0	4	24
Taste	0	4	24
Turbidity	2	18	8
Color	5	16	7
Smell	27	1	0
Water Supply Pressure	2	8	18
Water Supply Amount	0	10	18

Source: Results of interview to 28 beneficiaries

[Unit: %]



Source: SONEDE (The upper row is calculated based on data retained (≒amount of water supply –amount of revenue earning water))

Figure 2: Trends in the Non-Revenue Water Rate in Ben Gardane District and Across Tunisia (The upper row is non-revenue water rates of Ben Gardane district and the lower row is that of the nationwide average)

3.3.2.2 Other Positive and Negative Impacts

1） Impacts on the Natural Environment

The environmental impact assessment (EIA) of this project was approved by the Tunisian Environmental Protection Agency (ANPE) in May 2011 before the project started. In addition, it was confirmed by interview to SONEDE that during the project implementation and after completion of the project, the negative impact on this natural environment, e.g. air pollution, vibration, noise, and ecological effects, etc, by this project did not occur. In this field study, the impact on the natural environment around each site was visually checked, but no particular problem was found.

The upper row of Table 8 shows data of the water quality treated in the desalination plant, and the chlorine is within the standard of water quality in Tunisia. As of the time of ex-post evaluation, the chlorine is zero as it was not injected in the desalination plant facilities. On the other hand, water after desalination treatment is mixed with water from other deep wells, and chlorine is added at that stage. The middle row shows data of the quality of water supply to Ben Gardane district, chlorine at this stage is between 0.85 to 0.95mg per liter, which is within the standard of water quality shown in the lower row. Other data of water quality is generally within the standard as well. As for the hardness, as the numerical values of other deep wells are high, it exceeds the standard[19].

[19] The numerical values of hardness are 253-269 °F at the Ourasnia deep well, 90°F at the Maouna deep wells, and 130°F, etc, at the southern distribution network. Those are mixed with water of 0.2-0.6 °F of this project and became

Table 8: Quality of Water Desalinated at the Project Facility (upper row), Quality of Water Sent to Ben Gardane District (middle row), and Standard Quality of Water of Tunisia (lower row)

Item	Chlorine	PH	Turbidity	Hardness	Color
Water quality desalinated at this project facility *Note 1	0	7.6-8.4	0.1-0.6NTU	0.2-0.6°F	Normal
Water quality sent to Ben Gardane district *Note 2	0.85-0.95 mg/liter	7.2-7.9	0.15-0.6NTU	113-123 °F	Normal
Standard water quality of Tunisia*Note 3	0.5-1.0 mg/liter	6.5-8.5	3.0NTU	90°F	No specific standard

Source: Collected data from SONEDE
*Note1: Data at the end of 2017
*Note2: Water quality data measured from 2015 to 2017 (minimum to maximum)
*Note3: Standard water quality (NT09.14-2013)

Regarding the environmental monitoring system related to this project facility, the Desalination Service of SONEDE is responsible. The field staff is patrolling and monitoring around the facility every day. Although there has been no major negative impact on the environment until now, if it occurs around the facility, it is supposed that the field staff reports and shares information to the Regional Branch Office of Medenine Governorate of SONEDE to respond to it.

2） Resettlement and Land Acquisition

According to SONEDE, the area of this project site as a whole is 160,000m^2, of which 158,217m^2 was a state-owned land not requiring payment of compensation. As the remaining 1,783$m^2$of land was private land, SONEDE negotiated and processed acquisition procedure with the holders, civilians, in accordance with the domestic law and paid for the expenses. The total payment was 71,333 Tunisia Dinar (TND). The acquisition procedures and payments have progressed smoothly. Since there were no residents in the site, relocation of residents was not accompanied.

Regarding data of water supply and water quality to Ben Gardane district, the amount of daily average water supply has reached the initial target value after the project was completed, while the water quality, salinity, has not achieved the target value. As the background, the new deep wells were developed by SONEDE to meet the water supply demand which is on an increasing

113-123 °F. However, no health damage or the like have occurred.

trend in the district. However, the salinity of water intake from these deep wells remains high and the desalination treatment has not been done. As far as the desalination facility of this project is concerned, the salinity concentration is lowered with the expected capacity[20]. However, as the initial project objective was “improvement of water supply circumstances of the whole district”, based on the set effect indicators and actual values, it cannot be said that the degree of achievement at the time of ex-post evaluation is high. Based on the above, it is considered that the effectiveness and impacts of the project are fair.

3.4 Sustainability (Rating: ③)

3.4.1 Institutional / Organizational Aspect of Operation and Maintenance

The executing agency of this project is SONEDE. The management and daily operation and maintenance of the constructed facilities are carried out by the Desalination Service Station of Ben Gardane District. At the time of ex-post evaluation, there are 5 staff members (breakdown: 1 chief, 2 technical management staffs, and 2 facility operation and maintenance staffs). The work shift of the desalination facility is in a three-shift system, in 24-hour duty. In addition, the operation and maintenance of this facility and equipment: replacement and cleaning of filter cartridges, cleaning by chemicals, and applying grease to machine parts, etc, are carried out for each item on a daily and a regular basis. From the interview to the Regional Branch Office of Medenine Governorate of SONEDE, it is confirmed that the placement of staff is the right person in the right job. Furthermore, it is considered to increase the number of staff for further stable operation in the future.

The Regional Branch Office of Medenine Governorate of SONEDE, which is the upper organization of the Service Station, is in charge of check, management and repair of the water pumps connected to the desalination plant facilities. In addition, the Southern Regional Branch Office of Sfax, which is further upper organization of the Branch Office, is in charge of operation and maintenance and repair of each deep well in addition to the large-scale overhauling of the facilities and equipment of the project.

From the above, it is considered that there is no particular big problem regarding the institutional aspect of operation and maintenance at the time of ex-post evaluation.

[20] In other words, it is not that there is no effect of this project. If this project were not implemented, it is clear that the water intake from the Marsa deep well and the Ourasnia deep well would have been distributed with even higher salinity concentration to Ben Gardane district.

3.4.2 Technical Aspect of Operation and Maintenance

The staff members belonging to the Desalination Service Station of Ben Gardane District, the Regional Branch Office of Medenine Governorate and the Southern Regional Branch Office of Sfax are regularly taking studies and trainings, handled by SONEDE headquarters, necessary for operation and maintenance work. Such examples are the “Work improvement in desalination facility site”, 10 participants, conducted in October 2016, and the “Remote water supply network management”, 4 participants, conducted in March 2017. In addition, OJT for new staff members is also implemented on a timely basis, and the contents concerning the operation of pump facilities, the technical operation of desalination facility, and the remote control of water supply network are handled. In the above organizations, it is confirmed that experienced staff members are allocated at the right place through the questionnaire and the interview with the staff. It is confirmed that the manual concerning the operation and maintenance of the project facility has also been prepared in the Desalination Service Station of Ben Gardane District and it is being utilized on a timely basis.

From the above, it is judged that there are no particular problems concerning the technical aspect of operation and maintenance of the project.

3.4.3 Financial Aspect of Operation and Maintenance

Table 9 shows the operation and maintenance expenses (last 4 years) of the facilities and equipment developed in the project. The operation budget is the budget amount required for filter cartridges, osmotic membrane modules, and detergents, and the maintenance budget are the budget amount required for water supply pumps and related accessories.

Table 9: Operation and Maintenance Budget of Facilities and Equipment Developed by this Project

(Unit: Tunisian Dinar (TND))

	2014	2015	2016	2017
Operation Budget	12,000	65,000	10,000	45,000
Maintenance Budget	-	-	10,000	10,000

Source: SONEDE

According to SONEDE, regarding the increase and decrease of the opeartion budget, there were the expenses for the periodic replacement of parts of the desalination plant. The reason why the operation budget in 2015 increased in comparison with the previous year is due to the

expense to replace some parts of the osmotic membrane modules. The reason why the operation budget in 2017 similarly increased in comparison with the previous year is due to the expense to replace the filter cartridges. The operation budgets for 2014 and 2016 are mainly only the expenditure required for cleaning detergents and cleaning works. Further, the reason why the operation and maintenance budget did not occur before 2016 is that new facilities and equipment after completion did not require work as they were new. From 2016 onwards, the fixed amount is applied every year. According to the Desalination Service Station of Ben Gardane District and the Regional Branch Office of Medenine Governorate, regarding the operation and maintenance budget, there were such comments as “the necessary budget has been appropriated for the operation and maintenance work every year. There has been no shortage of works due to a budget shortage”.

Based on the above, it is judged that there are no particular problems related to the financial aspect of the operation and maintenance of the project.

3.4.4 Status of Operation and Maintenance

At the time of the ex-post evaluation, the situation of the facilities and equipment maintained in the project has no problem and there is no record of repairing. According to the Desalination Service Station of Ben Gardane District, it is said that cases of actual incompleteness or damage will be immediately responded. The daily, monthly, and annual inspections have been carried out according to the contents of facilities and equipment. It is also confirmed that there were no impacts on facilities and equipment due to natural disasters and no concern to the operation and maintenance through the interview to the Station.

There is no problem in the storage and procurement status of spare parts. There is a procurement system of supplies being done by local suppliers. There are track records that the filters necessary for desalination have been delivered from the UK and the other RO membrane related products have been delivered from South Korea.

Regarding the solar power generation systems, the operation and maintenance and cleaning are properly carried out. The output is 210 kW, and it is functioning normally as an auxiliary role of main power supply for related equipment in the desalination plant.

【About treated saline water by the solar evaporation pit and the RO membranes】

At the time of ex-post evaluation, the water level in the solar evaporation pit is kept stable. However, the following circumstances have occurred with regard to the treated saline water by

the pit and the RO membrane from before implementation to after completion of the project.

1) In the initial design of the project, it was decided that the raw water (salt concentration 14g/liter) from the Marsa deep well was to be treated by the RO membrane, 70% is desalinated (0.3g/liter) and 30% was to be concentrated wastewater (47g/liter), and the latter concentrated wastewater of 30% was to be evaporated in the solar evaporation pit (Photo 3). Based on that proportion, the scale of solar evaporation pit (11.9 ha) was also designed. However, SONEDE has set the percentage of treated volume at the RO membrane as 64%:36% after operation of the facilities, June 2013. This is because it was expected that the load on the desalination treatment in the RO membrane could be mitigated by reducing the proportion from 70% to 64%. More specifically, since the load is continuously applied to the filters and cartridges attached to the RO membrane, there were concerns for the continuity of operation and maintenance in the future, protection of the RO membranes and related attached equipment including purchase of parts and the cost, and the possibility of not being able to treat smoothly and technically. As a result, the proportion was declined to 64% and that of the highly-concentrated saline water sent to the pit was raised to 36%. However, in that case, the rise of water level inside the pit (design standard of 1.3m to maximum 1.7m) was concerned. The consultant of construction supervision of the project expressed concerns about this SONEDE's policy, the operation of pit in particular.

2） Before the start of the project, there was discussion among the concerned parties of the project that the highly-concentrated saline water discharged by the treatment of the RO membrane was to be drained through the drain pipe, about 1 km long from the desalination plant, to the neighboring salt lagoon (Bhiret El Bibent, Photo 4).However, fishermen around the salt lagoon expressed concerns to the drainage of the highly-concentrated saline water. However, as a matter of fact, there was no big difference between the salinity concentration of the drained and that of the salt lagoon, but the fishermen were concerned and opposed as they understood that highly-concentrated saline water would flow into the salt lagoon, and therefore, the agreement was not settled before the start of the project. Since the salt lagoon was also a place registered in the Ramsar Convention[21] in 2007, environmental clearance could not be obtained from the administrative organization, "Organization for Protection and Development of Coastal Region" (L'Agence de Protection et d'Aménagement du Littora (APAL)), which is responsible for the environmental permission on coastal areas. Therefore, SONEDE suggested to develop the solar evaporation pit before the start of the project. On the other hand, as mentioned above, SONEDE focused setting the operation of the RO membrane as the proportion of 64%: 36%. As

[21] The official title is the *Convention on Wetlands of International Importance especially as Waterfowl Habitat.*

a result, there was concern that the water level of the pit often rises, exceeding the designed maximum water level of 1.58 m. Particularly when a strong wind blows, there is concern about the possibility of overtopping from within the pit.

3) Amidst such concerns, an agreement on the drainage of saline water into the salt lagoon between SONEDE, related organizations and the fishermen was established in the second half of 2016. SONEDE and related organizations have held meetings with the fishermen a couple of times and persistently explained that drainage to salt lagoons has a little negative impact (there is no difference in the salinity concentration in drained water and in the water in salt lagoons)[22], and that it is based on the scientific evidence, and fishermen finally accepted. At the time of the ex-post evaluation, the saline-treatment is carried out in the pit, but SONEDE has a policy to drain via a drain pipe, about 1km long, into the salt lagoon in the near future[23]. In response to this circumstance, in October 2016, SONEDE and JICA agreed on the two operating policies of the above-mentioned 1) the drainage of saline water treated at the project facility to the salt lagoon and 2) change of recovery rate of the RO membrane from 70% to 64%. In the near future, drainage to the salt lagoon is scheduled to be carried out while utilizing the pit. At the time of the ex-post evaluation, the water level of the pit is stably maintained at 1.3 m, and it is estimated that if the drainage to the salt lagoon is realized in the future, the burden on operation and maintenance will be further reduced. Either way, as of the time of the ex-post evaluation, no particular problems have occurred in the pit.

From the above, there are no problems in the institutional, technical and financial aspects of the operation and maintenance. Therefore sustainability of the project effects is high.

Photo 3: Solar Evaporation Pit

Photo 4: Salt Lagoon (Bhiret El Bibent)

[22] As supplementary information, as for this matter, it was approved by the Tunisian Environmental Protection Agency (ANPE).

[23] At the time of the ex-post evaluation, about 500m of the drainage pipe has already been laid, and installation of the remaining about 500m will be advanced in the future.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project constructed the desalination system of groundwater by reverse osmotic membrane method to increase the amount of water supply and improve water quality, salinity concentration, in Ben Gardane district in Medenine Governorate located in the coastal region of southern Tunisia, and to contribute to stability of the living environment of residents around the district. To raise water supply rate, to secure drinking water and to improve water quality in urban and rural areas are presented in the *11th Socio-Economic Development Five-Year Plan*(2007-2011) formulated by the Tunisian government and the Five-year Development Plan formulated by SONEDE. In addition, the development needs for expansion of water supply demand around the district have been confirmed. It was also confirmed that this project was relevant to Japan's ODA policy. Therefore, its relevance is high. Regarding efficiency, the outputs were largely as planned, and the project cost was also within the initial plan. On the other hand, regarding the project period, it exceeded the initial plan as the construction of the pump station by Tunisian side required the time to assemble the drilling equipment and to join underground cable buried at the pumping station. Therefore, its efficiency is fair. Regarding the quantitative effect indicators of the project such as data of supply and quality of water to Ben Gardane district, after the completion of the project, the amount of daily average water supply has reached the initial target amount, while the water quality, salinity, has not been achieved the target. In addition, in the interview survey to residents around the district, there were dissatisfied opinions that "salinity concentration was high, amount of water supply was low, and pressure of water supply was low", and additionally, it was confirmed that the non-revenue water rate in the district was also high. Thus, it is assumed that its impact is limited. Therefore, its effectiveness and impacts of this project are fair. There is no particular concern in terms of institutional, technical and financial aspects of the Desalination Service Station of Ben Gardane District, Regional Branch Office of Medenine Governorate, and Southern Regional Branch Office of Sfax which are responsible for the operation and maintenance of this project. There is no particular problem in the operation and maintenance status of other facilities and equipment. Therefore, the sustainability of effects developed by the project implementation is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

It is desirable that SONEDE take measures on the actual condition of water leakage in Ben Gardane district. Because even if SONEDE takes the measures to increase the amount of water supply based on the demand of water supply, unless water is distributed without leakage to each home or the commercial facilities of end users, it cannot be said that safe and reliable water supply is carried out. At the time of the ex-post evaluation, SONEDE is implementing PNAQ2 aiming at lowering the salinity concentration and increasing the amount of water supply, and in addition, it is recommended to make efforts to improve the non-revenue water rate in the district.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Importance of obtaining consensus among concerned parties

As of the time of the ex-post evaluation, there is no particular problem in the solar evaporation pit. On the other hand, if it could take time, it is thought that the environmental clearance by having consultations among the project related parties should have been obtained before the start of the project, concerning drainage to the salt lagoon. Thus, it is thought that focusing on consensus formation as much as possible about wastewater treatment of highly concentrated salt water was desirable. Although it may not be easy to obtain consensus among the related parties including local residents, in a similar project in the future, when one is aiming to reduce concerns of the side who is responsible for operation and maintenance, it is meaningful to have an agreement steadily by taking as much time as possible.

Appendix: Table 5 Basis for Calculating Water Quality (Salinity)

2012

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	**Monthly production total (㎥)**	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	Salinity concentration in each month
January	153,368	73,569	12,073	239,010	3	0.9	10.5	2.7
February	139,951	61,609	12,473	214,033	3	0.9	10.5	2.8
March	150,774	62,279	11,827	224,880	3	0.9	10.5	2.8
April	153,781	82,996	12,452	249,229	3	0.9	10.5	2.7
May	164,791	101,231	12,960	278,982	3	0.9	10.5	2.6
June	164,069	121,710	12,528	298,307	3	0.9	10.5	2.5
July	161,838	113,199	13,500	288,537	3	0.9	10.5	2.5
August	171,875	126,333	12,450	310,658	3	0.9	10.5	2.4
September	136,980	105,961	11,250	254,191	3	0.9	10.5	2.5
October	167,031	112,095	8,560	287,686	3	0.9	10.5	2.4
November	162,278	108,397	9,089	279,764	3	0.9	10.5	2.4
December	146,123	98,946	9,619	254,688	3	0.9	10.5	2.5
								2.6 Annual average

Source: Summarized based on SONEDE data

Remarks: Although the salinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

January – June, 2013

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	**Monthly production total (㎥)**	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	Salinity concentration in each month
January	162,757	93,100	9,619	265,476	3	0.9	9	2.5
February	144,741	75,184	9,619	229,544	3	0.9	9	2.6
March	168,901	111,589	10,523	291,013	3	0.9	9	2.4
April	158,971	100,216	10,835	270,022	3	0.9	9	2.5
May	171,067	114,565	10,051	295,683	3	0.9	9	2.4
June	164,784	131,084	10,641	306,509	3	0.9	9	2.3
								2.4 6 months average

Source: Summarized based on SONEDE data

Remarks: Although the salinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

July, 2013

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4))/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	SDBG (D)	**Monthly production total (㎥)**	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	**SDBG (4)**	Salinity concentration
July	147,818	108,033	9,159	47,094	312,104	3	0.9	9	**0.3**	2.0

Source: Summarized based on SONEDE data

Remarks: Although the salinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ This project

※Supplementary information: If the project is not implemented, 14 g/liter

(→If not implemented, it exceeds 4.0 g/liter.)

August – December, 2013

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4)+(E)*(5)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	SDBG (D)	Ourasnia deep well (E)	Monthly production total (㎥)	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	SDBG (4)	Ourasnia (5)	Salinity concentration in each month
August	159,493	116,055	10,124	46,273	36,000	367,945	3	0.9	9	**0.3**	10.5	2.9
September	149,388	104,961	10,358	40,386	34,158	339,251	3	0.9	9	**0.3**	10.5	3.0
October	150,622	105,361	10,052	45,078	39,558	350,671	3	0.9	9	**0.3**	10.5	3.0
November	138,620	98,253	9,832	44,024	19,310	310,039	3	0.9	9	**0.3**	10.5	2.6
December	121,776	95,587	9,947	45,394	6,000	278,704	3	0.9	9	**0.3**	10.5	2.2
												2.8 5 months average

Source: Summarized based on SONEDE data

Remarks: Although the salinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ **This project**

※Supplementary information: If the project is not implemented, 14 g/liter

(→If not implemented, it exceeds 4.0 g/liter on average 5 months.)

2014

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4)+(E)*(5)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	SDBG (D)	Ourasnia deep well (E)	Monthly production total (㎥)	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	SDBG (4)	Ourasnia (5)	Salinity concentration in each month
January	132,522	104,995	14,763	36,427	3,165	291,872	3	0.9	9	**0.3**	10.5	2.3
February	131,085	102,421	14,823	9,491	0	257,820	3	0.9	9	**0.3**	10.5	2.4
March	154,163	102,668	13,578	27,136	0	297,545	3	0.9	9	**0.3**	10.5	2.3
April	160,319	93,145	13,964	43,789	20,880	332,097	3	0.9	9	**0.3**	10.5	2.8
May	154,304	102,068	13,547	45,271	23,022	338,212	3	0.9	9	**0.3**	10.5	2.8
June	154,787	105,228	13,283	43,269	39,060	355,627	3	0.9	9	**0.3**	10.5	3.1
July	171,055	121,002	13,280	49,855	38,102	393,294	3	0.9	9	**0.3**	10.5	2.9
August	162,922	111,724	14,005	48,351	38,000	375,002	3	0.9	9	**0.3**	10.5	3.0
September	188,793	105,153	13,220	47,715	37,448	392,329	3	0.9	9	**0.3**	10.5	3.0
October	160,098	107,383	13,182	50,029	37,001	367,693	3	0.9	9	**0.3**	10.5	3.0
November	153,847	105,174	12,952	49,609	20,700	342,282	3	0.9	9	**0.3**	10.5	2.6
December	165,000	105,708	12,173	39,105	14,040	336,026	3	0.9	9	**0.3**	10.5	2.6
												2.8 Annual average

Source: Summarized based on SONEDE data

Remarks: Although the salinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ **This project**

※Supplementary information: If the project is not implemented, 14 g/liter

(→If not implemented, it exceeds 4.0 g/liter.)

2015

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4)+(E)*(5)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	SDBG (D)	Ourasnia deep well (E)	Monthly production total (㎥)	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	SDBG (4)	Ourasnia (5)	Salinity concentration in each month
January	133,446	110,136	1,837	28,077	0	273,496	3	0.9	9	**0.3**	10.5	1.9
February	135,254	96,406	70	24,704	10,030	266,464	3	0.9	9	**0.3**	10.5	2.3
March	176,405	96,375		27,074	9,659	309,513	3	0.9	9	**0.3**	10.5	2.3
April	151,206	109,743	1,998	27,117	39,000	329,064	3	0.9	9	**0.3**	10.5	3.0
May	165,803	110,586	2,784	45,580	27,359	352,112	3	0.9	9	**0.3**	10.5	2.6
June	154,787	110,969	2,550	46,643	32,258	347,207	3	0.9	9	**0.3**	10.5	2.7
July	180,684	96,733	2,781	48,067	51,487	379,752	3	0.9	9	**0.3**	10.5	3.2
August	152,499	107,969	1,500	45,369	46,661	353,998	3	0.9	9	**0.3**	10.5	3.0
September	167,383	99,880	10,427	44,228	38,661	360,579	3	0.9	9	**0.3**	10.5	3.1
October	163,045	106,671	3,393	35,911	43,810	352,830	3	0.9	9	**0.3**	10.5	3.1
November	142,324	105,639		25,811	28,728	302,502	3	0.9	9	**0.3**	10.5	2.7
December	134,931	119,026		21,204	30,915	306,076	3	0.9	9	**0.3**	10.5	2.8
												2.8 Annual average

Source: Summarized based on SONEDE data

Remarks: Although the salinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ **This project**

※Supplementary information: If the project is not implemented, 14 g/liter

(→If not implemented, it exceeds 4.0g/liter.)

2016

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4)+(E)*(5)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna deep well (B)	Sayah deep well (C)	SDBG (D)	Ourasnia deep well (E)	**Monthly production total (㎥)**	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	Sayah (3)	**SDBG (4)**	Ourasnia (5)	Salinity concentration in each month
January	133,446	120,007		22,095	39,066	314,614	3	0.9	9	**0.3**	10.5	2.9
February	138,670	100,301		23,398	41,746	304,115	3	0.9	9	**0.3**	10.5	3.1
March	144,618	103,438		29,684	44,900	322,640	3	0.9	9	**0.3**	10.5	3.1
April	144,600	104,963	7,183	42,940	40,528	340,214	3	0.9	9	**0.3**	10.5	3.0
May	161,320	108,568	9,930	43,665	40,752	364,235	3	0.9	9	**0.3**	10.5	3.1
June	166,156	100,424	10,687	42,733	39,212	359,212	3	0.9	9	**0.3**	10.5	3.1
July	179,276	110,049	10,034	42,614	37,254	379,227	3	0.9	9	**0.3**	10.5	3.0
August	172,889	111,112	9,723	43,736	40,000	377,460	3	0.9	9	**0.3**	10.5	3.0
September	161,300	109,409	5,137	42,785	43,215	361,846	3	0.9	9	**0.3**	10.5	3.0
October	156,169	108,783		43,849	44,059	352,860	3	0.9	9	**0.3**	10.5	3.0
November	170,835	108,280		41,038	42,921	363,074	3	0.9	9	**0.3**	10.5	3.0
December	158,276	108,082		25,993	46,615	338,966	3	0.9	9	**0.3**	10.5	3.2
												3.0

Annual average

Source: Summarized based on SONEDE data

Remarks: Although the salilinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ This project

※Supplementary information: If the project is not implemented, 14 g/liter

(→If not implemented, it exceeds 4.0g/liter.)

-August, 2017

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna & Jallel deep wells (B)	SDBG (C)	Ourasnia deep well (D)	**Monthly production total (㎥)**	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	**SDBG (3)**	Ourasnia (4)	Salinity concentration in each month
January	158,097	105,668	35,481	40,500	**339,746**	3	0.9	**0.3**	9	2.8
February	145,146	91,690	37,763	38,707	**313,306**	3	0.9	**0.3**	9	2.8
March	172,070	113,316	41,537	43,983	**370,906**	3	0.9	**0.3**	9	2.8
April	162,265	118,836	28,473	36,721	**346,295**	3	0.9	**0.3**	9	2.7
May	168,408	127,816	41,124	43,746	**381,094**	3	0.9	**0.3**	9	2.7
June	168,408	125,816	41,251	42,600	**378,075**	3	0.9	**0.3**	9	2.7
July	181,709	124,293	39,624	43,490	**389,116**	3	0.9	**0.3**	9	2.7
August	184,709	127,010	41,652	44,095	**397,466**	3	0.9	**0.3**	9	2.7
										2.7

8 months average

Source: Summarized based on SONEDE data

Remarks: Although the salilinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ This project

※Supplementary information: If the project is not implemented, 14 g/liter

(→If not implemented, it exceeds 4.0 g/liter on average 8 months.)

September, 2017 -

☆Calculation formula for salinity concentration =((A)*(1)+(B)*(2)+(C)*(3)+(D)*(4)/Total monthly production (㎥))

Month	Monthly production (* It is not peak production amount) Southern distribution network (A)	Maouna & Jallel deep wells (B)	SDBG (C)	Ourasnia deep well (D)	**Monthly production total (㎥)**	Salinity content of each water source (g/litter) Southern distribution network (1)	Maouna (2)	**SDBG (3)**	Ourasnia (4)	Salinity concentration in each month
September	163,296	127,010	26,089	11,865	**328,260**	3	0.9	**0.3**	9	2.2
October	168,585	120,834	0	29,241	**318,660**	3	0.9	0	**0.135**	2.0
November	166,723	122,151	0	27,347	**316,221**	3	0.9	0	**0.135**	2.0
December	171,584	122,287	0	28,678	**322,549**	3	0.9	0	**0.135**	2.0
										2.1

4 months average

Source: Summarized based on SONEDE data

Remarks: Although the salilinity content (g / liter) of each water source in the table is not measured periodically, it is nearly constant.

↑ This project ↑ This project

- Early Sept. Mid Sept.-

※Supplementary information: If the project is not implemented, SDBG is 14 g/liter and Ourasnia is 9g /liter.

(→If not implemented, it exceeds 2.9 g/liter on average 4 months.)