Case Study 3: Tunisia

Sfax Sud wastewater treatment plant and El Hajeb public irrigated perimeter

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Acronyms

ANPE	National Environmental Protection Agency
CRA	Agricultural Outreach Unit
GDA	Agricultural Development Group*
CRDA	Regional Commission for Agricultural Development*
CTV	Territorial Extension Unit*
DGGREE	Directorate General of Rural Engineering and Water Management*
DHMPE	Directorate of Environmental Health and Environmental Protection
MALE	Ministry of Local Affairs and the Environment
MARHP	Ministry of Agriculture, Water Resources and Fisheries
MSP	Ministry of Public Health
ONAS	Official Sanitation Office*
WWTP	Wastewater Treatment Plant

**Translated from French*

History and project justification

The Sfax Governate is an arid to semi-arid zone on the east coast of Tunisia with an average temperature of 20°C. It has an annual negative water balance of 1,000 mm, which is when demand exceeds supply. This means that irrigation is necessary to help farmers achieve the best crop yields. Given the scarcity of natural water resources including both groundwater and surface water, recycled water from wastewater treatment plants provides a valuable new water source that can be used for irrigation. This approach forms part of the national strategy for agricultural water recycling and has been adopted in the Public Irrigated Perimeter of El Hajeb (hereinafter the El Hajeb Perimeter).

The El Hajeb Perimeter is the first of its kind in Sfax. It was developed in 1988 on state-owned land and covers 240 ha. It is irrigated by recycled water from the Sfax Sud Wastewater Treatment Plant (hereinafter Sfax Sud WWTP). Given the good results achieved in terms of agricultural development and both the ongoing and predicted climatic conditions in the area, the perimeter area was extended several times during the 1990s and 2000s and now covers 444 ha divided between seven farmers (Figures 3.1 and 3.2).

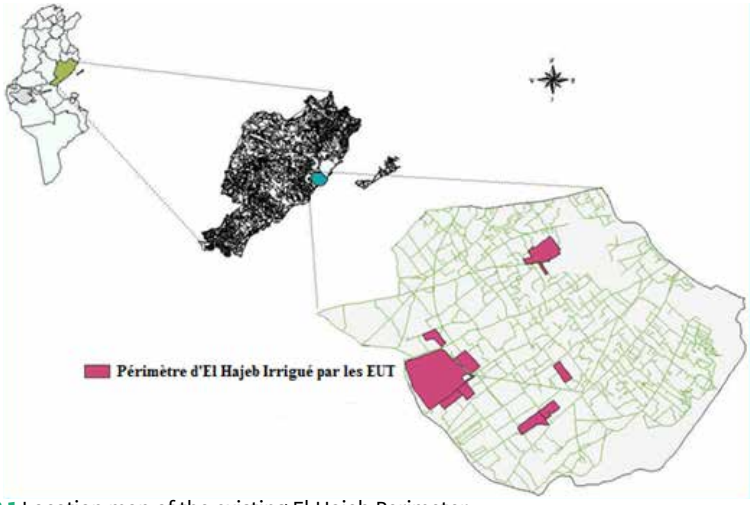

FIGURE 3.1 Location map of the existing El Hajeb Perimeter.

FIGURE 3.2 Map showing location of El Hajeb Perimeter and Sfax Sud WWTP. *SOURCE*: Google Earth.

Water reuse case description at a glance

Sfax Sud WWTP serves a population of around 526,800 people and is located 6 km south of Sfax city. Collected wastewater enters the station from basins in Sfax Centre and Sfax Sud from domestic (47%) and industrial water (21%) sources. Upon arrival, it is treated at a secondary level using a low-load activated sludge treatment system (Figure 3.3), which biologically removes biodegradable organics and nutrients.

Currently, Sfax Sud WWTP is undergoing rehabilitation works under the oversight and management of the National Office of Sanitation (ONAS) at an estimated cost of USD 2.8 million, financed by the African Development Bank. The size of the rehabilitation and expan-

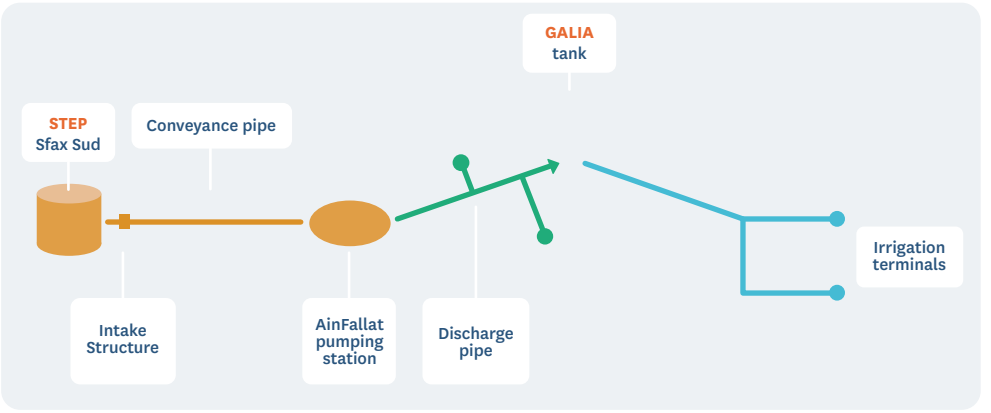

FIGURE 3.3 Sfax Sud wastewater treatment plant and water reuse system: Schematic diagram 1.

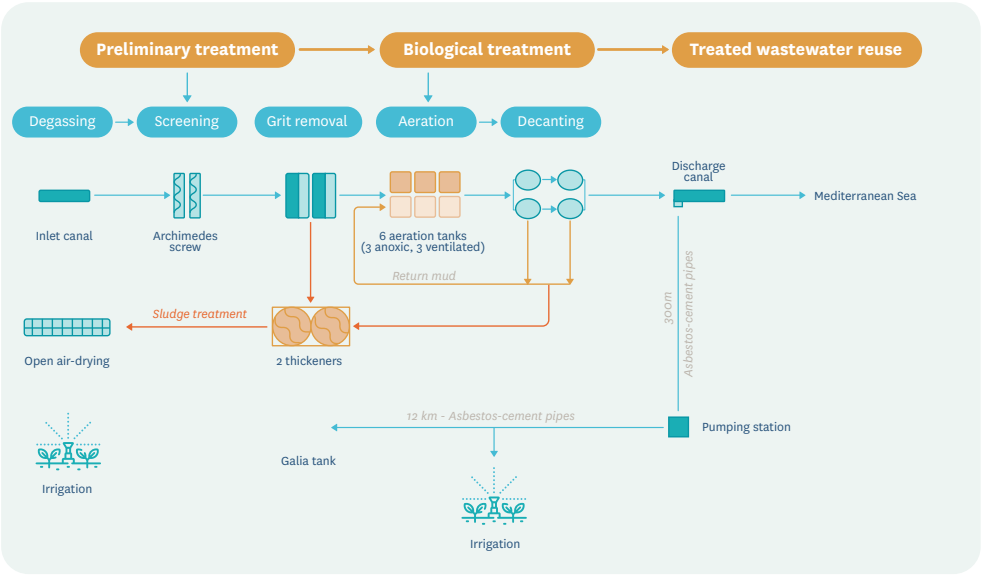

FIGURE 3.4 Sfax Sud wastewater treatment plant and water reuse system: Schematic diagram 2.

sion works are based on a projected average flow of 52,000 m^3/day by 2026. This compares to its current capacity of 49,500 m^3/day. Recycled water reaches the El Hajeb Perimeter from Sfax Sud WWTP (Figures 3.3 and 3.4, above) via:

- An intake structure that diverts part of the recycled water flow leaving Sfax Sud WWTP into a confined concrete inlet pipe that leads to the pumping station's suction tank.
- A pumping station that has a buried suction tank, a pumping room with four electric pumps and hydromechanical and electrical equipment.
- An asbestos-cement delivery pipe that is 12 km long and conveys the recycled water to a tank in a 14 m high tower located at the head of the perimeter.
- A distribution network from the tank consisting of asbestos-cement pipes equipped with irrigation hydrants.

The volume of water that is pumped to the perimeter varies between 1.4 m^3–3.7 m^3/year, giving a reuse rate of between 10–47% (Table 3.1). This figure is variable due to the frequent breakdown of the pumping units and deterioration in the quality of the recycled water. Service to the seven farms within the El Hajed Perimeter is on demand.

National institutional and policy environment

Wastewater discharge into the environment in Tunisia is regulated by Decree No 85-56 (January 2, 1985) with limits and quality standards set by the Ministry of Local Affairs and the Environment and the Ministry of Industry and Small and Medium Enterprises (March 26, 2018). It also requires authorization from the National Sanitation Office (ONAS) subject to its compliance with conditions for the discharge and disposal of non-domestic wastewater in the sewerage networks set out by Decree No. 94-1885 (September 12, 1994).

TABLE 3.1 Irrigable areas and land use of farms served by Sfax Sud WWTPs.

Perimeter or operator	Initial irrigable area (ha)	Current irrigable area (ha)	Land use
1 State domain	240	236	Fodder crops intercropped with olive trees
2 State domain	40	30	
3a Private plot	70	14	
4 Private plot	8	8	
5 Private plot	14	14	
3b Private plot	36	36	Fodder crops on bare land+
6 Private plot	72	72	
7 Private plot	12	12	
8 Private plot	22	22	Forages on bare land and inter-cropped with olive trees
9 (private plot)	70	0	Olive tree
Total area	584	444	

NOTES: + Bare land = land that does not contain trees.

In terms of water reuse for agricultural purposes and required measures to protect the health of consumers and the environment, regulations are set out in Decree No. 89-1047 (July 28, 1989) and modified by Decree No. 89-1047 (July 28, 1989) and Decree No. 93-2447 (December 13, 1993). The required quality of recycled water from wastewater treatment plants for agricultural use is set out in Standard NT106.03 (September 12, 1994). In addition, the list of crops that can be irrigated by recycled water was set out by the Ministry of Agriculture and Water Resources in 1994, which also ruled out its use in market gardening, meaning that it cannot be used on fruits and vegetables that can be eaten raw.

Recycled water from wastewater treatment plants is provided to the Regional Commissions for Agricultural Development (CRDA) free of charge by ONAS. The CRDAs then charge farmers a nominal fee of USD 0.0073/m^3 for water consumption. This pricing system was implemented by a presidential decision in 1998 to promote recycled water use for agricultural purposes.

At the institutional level, four actors play a key role in the field of recycled water reuse for irrigation:

- ONAS who owns and operates the wastewater treatment plants.
- The Ministry of Agriculture, Hydraulic Resources and Fisheries is the managing authority for recycled water reuse through the CRDA that first developed the areas to be irrigated with recycled water from the wastewater treatment plants. Direct contact with farmers is made through agricultural development groups.
- The CRDA as the distributor of recycled water and the Ministry of Health share monitoring of treated wastewater quality.
- The end-user.

Stakeholders involved and management model

The El Hajeb Perimeter was developed by the Regional Commission for Agricultural Development (CRDA) of Sfax under the supervision of the Ministry of Agriculture, Hydraulic Resources and Fishing.

Since the creation of the El Hajeb Perimeter, project beneficiaries have been organized into the El Moustakbal Agricultural Development Group (GDA). The management of the infrastructure and resources made available through the water reuse project is delegated by the CRDA Sfax to the GDA via a management contract that specifies which tasks are carried out by the GDA and which are carried out by the CRDA which includes regional representatives such as the Territorial Extension Unit (CTV), the Agricultural Outreach Unit (CRA) and others who provide technical assistance to farmers (Figure 3.5).

In 2015, in compliance with requirements governing the operation of treated wastewater concerning potential risks to human health, Sfax CRDA signed an agreement, which is renewable annually, with the Sfax Occupational Medical Group (Groupement de Médecine

de Travail), to provide medical services for El Hajeb Perimeter managers including periodic medical check-ups and annual medical examinations. It also signed a second agreement with El Hedi Chaker, a public health institution, and the National Engineering School of Sfax for the continuous monitoring of the recycled water quality that is supplied to El Hajeb Perimeter, according to reuse regulations.

The Ministry of Health also carries out periodic bacteriological analyses of the recycled water before it is transferred to the perimeter from Sfax Sud WWTP and of the crops irrigated by the recycled water. If standards are not met, the results are communicated to the CRDA so that it can stop supplying the recycled water until the required quality is restored. The National Office of Sanitation (ONAS) also controls the quality of the treated wastewater at the Sfax Sud WWTP. In the event of problems with quality, ONAS also informs the CRDA so that they can stop serving the perimeter.

However, in both cases, information is often late, or the water is not stopped in time, which means that recycled water that does not comply with standards is sometimes transferred to the perimeter.

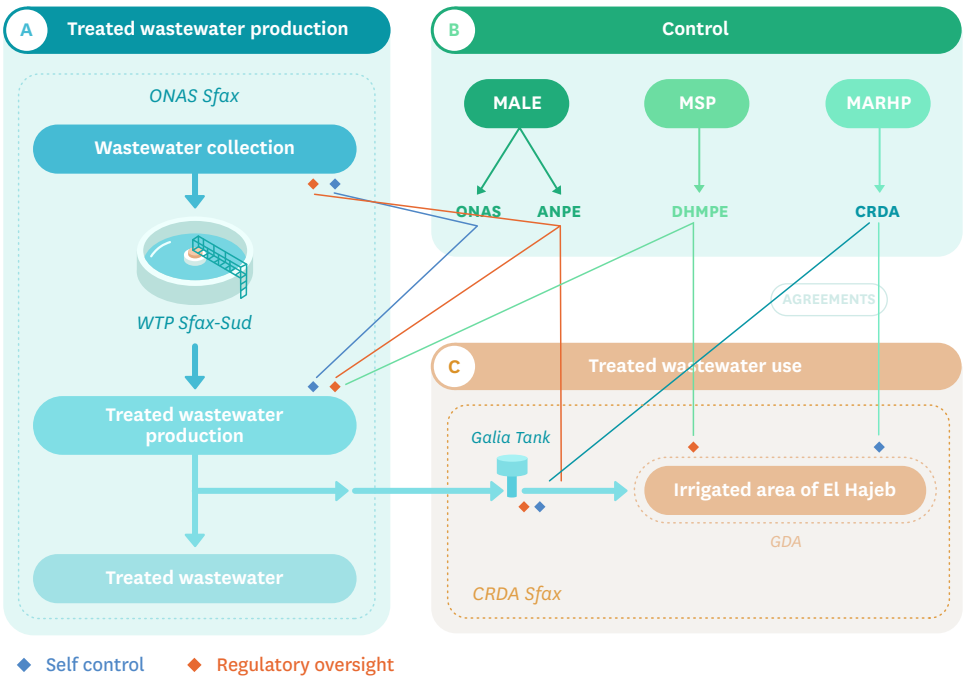

FIGURE 3.5 El Hajeb Perimeter management and stakeholder model.
NOTES: National Environmental Protection Agency (ANPE), Regional Commission for Agricultural Development (CRDA), Directorate of Environmental Health and Environmental Protection (DHMPE), Agricultural Development Group (GDA), Ministry of Local Affairs and the Environment (MALE), Ministry of Agriculture, Water Resources and Fisheries (MARHP), Ministry of Public Health (MSP), National Sanitation Office (ONAS), Wastewater Treatment Plant (WWTP).

Funding and financial outlook and cost recovery

Table 3.2 summarizes the capital expenditure, operating expenditure and cost recovery related to the Sfax Sud Wastewater Treatment Plant and El Jaheb Public Irrigated Perimeter Water Reuse Case.

Socioeconomic, health and environmental benefits and impacts

The transfer of recycled water from the Sfax Sud WWTP to the El Hajeb has meant a significant increase in the agricultural production of the irrigated farms. Current agricultural production includes 533.5 t of olives, 2,045 t of milk, 68.72 t of meat, 4165 t of manure and 150 heifers. This in turn increases farmers' incomes. Olive tree crops generate an income of USD 804/ha, while fodder crops are used to feed cattle. This herd generates a gross annual income of USD 2,574,615 through the sale of milk and meat.

The creation of the El Hajeb Perimeter has made it possible to recover an average of 30% of the treated wastewater discharge from the Sfax Sud WWTP, which would have gone into the

TABLE 3.2 Funding and financial outlook and cost recovery.

	Wastewater collection and transfer	Wastewater treatment	Wastewater conveyance	Wastewater distribution
Construction and equipment services (description and dimensions)	The collection network of wastewater, mainly domestic, of Sfax City and its surroundings, consists of 180 km of wastewater collectors, 140 km of combined collectors and 13 pumping stations.	Sfax Sud WWTP: Equipped to carry out treatment at a secondary level using a low-load activated sludge treatment system.	Intake structure. Asbestos-cement pipeline (AC) DN800 length 260 m. Pumping station equipped with 3 x 100 liters per second (L/s) - HMT: 120 m +1 emergency. Pressure pipe in AC DN500 length 12 km. 14 m high tower tank with a capacity of 250 m^3. A control station with four flow meters. A remote management system between CRDA, Pumping Station and Galia Tank.	Buried pipe distribution network serving seven current operators including: • Two distribution networks at the level of the state domain (236 ha + 30 ha) consisting of AC pipes and irrigation hydrants. • An AC pipeline (DN 500 to 300 – length 6 km) was installed in 2006 to serve a private plot (72 ha) and on which are grafted four unfinished irrigation terminals planned for extensions. • A small PVC distribution network serving a private plot, starting from the control station. These networks each start from the control station and are equipped with a flow meter (four flow meters in total): • An AC DN250 pipeline. • An AC DN150 pipeline. • A plug for a private plot onto the discharge pipe.

Mediterranean Sea. However, the aging of the pipes and the poor condition of the regulation tank are leading to leaks and losses. This water stagnates in the perimeter for long periods, especially in winter, which causes discontent among the population passing through the area because of the bad smells and the proliferation of insects. However, no water-borne diseases have been recorded in the area.

Similarly, the passage of the existing pressure pipe through densely populated areas recently built outside the confines of building regulations prevents intervention measures to be taken on the pipe for repair or maintenance constituting a risk to the health of the resident population.

The rehabilitation works to the infrastructure and extension of the irrigated perimeter will undoubtedly increase the agricultural production of the area, reduce the volume of treated wastewater discharged into the sea and avoid its stagnation in the perimeter caused by breakages and overflow in the Galia tank and bring additional income to the perimeter's operators.

TABLE 3.2 Funding and financial outlook and cost recovery (continued).

	Wastewater collection and transfer	Wastewater treatment	Wastewater conveyance	Wastewater distribution
Stakeholder providing the service	ONAS Sfax	ONAS Sfax	CRDA Sfax	CRDA Sfax
CAPEX in USD	Data not available	Data not available	3.75 million	1.5 million
Recovery CAPEX and % subsidy	State funding		State funding	State funding
Operations and monitoring (O&M) services (description)	Infrastructure maintenance, pumping costs, renewal, salaries	Infrastructure maintenance, pumping costs, renewal, salaries	Infrastructure maintenance, pumping costs, renewal, salaries	Infrastructure maintenance, renewal, salaries
Stakeholder providing the service	ONAS Sfax	ONAS Sfax	CRDA Sfax	CRDA Sfax and GDA
OPEX (USD/m^3)	Data not available	0.032	0.080	
OPEX recovery and % subsidy	Nearly 70% of ONAS's financial resources come from sanitation fees, mainly collected through SONEDE's invoicing: USD 0.02-0.05/m^3 according to the following principles: (i) beneficiary-payer; (ii) polluter-payer and (iii) solidarity between users. The rest of ONAS's budget comes from state subsidies (25.6%) and other related activities (5.4%). In the face of all its expenses, ONAS provides recycled water from wastewater treatment plants to CRDAs free of charge.		CRDA Sfax sells treated wastewater to the GDA for USD 0.016/m^3, which results in a significant subsidy of around USD 0.074/m^3 borne by the CRDA. Application of the reduced price is decided by the State and is to encourage the use of recycled water which is sold by the GDA to farmers at a unit price of USD 0.073/m^3.	

NOTES: Capital Expenditure (CAPEX), Regional Commission for Agricultural Development (CRDA), Agricultural Development Group (GDA), Total Pump Height (HMT), Official Sanitation Office (ONAS), Operational Expenditure (OPEX), Societé Nationale d'Exploitation et de Distribution des Eaux (SONEDE – National Water Company).

Gender equality

When the perimeter was created, both men and women were able to be potential beneficiaries under the terms of the CRDA, as long as they undertook to comply with legislation requirements. Yet despite this, currently, there are no women operators as although not excluded from the project, no women have applied to join it. Women do work occasionally on the farms as day laborers but there are no statistics on the frequency of this work.

Similarly, during the development of the rehabilitation and extension of the perimeter studies, the environmental and social evaluation of the project and the public consultations carried out by the Sfax CRDA, women played an important role in the meetings, taking part in discussions on different components of the project. Their opinions were also considered in the final design of the project. For example, during the design of the stage of the conveyance system, the proposed location and sizing of the storage tank on the perimeter were improved following a complaint presented by a woman representing a mixed group of 350 people (men and women). The complaint related to strong odors and the proliferation of insects.

Scalability and replicability potential

The El Hajeb Perimeter is located in an extensive agricultural area where both arboriculture, especially of dry-farmed olive trees and cattle rearing (without the use of a grazing area due to the lack of irrigation), and fodder production play an important role in generating income for the local communities. The lack of other sources of water and the arid climate makes it highly possible that the irrigated area will be extended, particularly in response to demand from a large proportion of the farmers in the area who deem it necessary. This model could work well in other areas where the general climatic and operating conditions are the same.

However, in addition to the development and rehabilitation of the irrigation networks of the El Hajeb Perimeter, the CRDA need also to:

- Program the installation of a complementary wastewater treatment system to remedy fluctuations in the quality of Sfax Sud WWTP discharges
- Revise the price of water sold to farmers to cover the operating costs of the installed network. The model followed at present is that of public financing without revenue from the sale of water, given the adoption of the low cost for recycled water sales. For the El Hajeb Perimeter, the supply of recycled water to the perimeter costs Sfax CRDA USD 0.080/m^3 while it sells the water to the GDA at USD 0.006/m^3, which generates a significant subsidy of USD 0.074/m^3, which is borne by the CRDA.

SWOT analysis

Table 3.3 summarizes the strengths, weaknesses, opportunities and threats observed in the Sfax Sud WWTP and El Hajeb case study.

Key factors for success along the project and lessons learned

During the design, construction and operation of the project, key factors of success include:

- Political will to promote the use of recycled water from wastewater treatment plants at the national level.
- The commitment of the ONAS to rehabilitate and increase the capacity of wastewater treatment plants and improve the quality of the recycled water, including rehabilitation of the Sfax Sud WWTP.
- The mitigation of environmental and health impacts of the treated wastewater discharges into the natural environment is one of the main driving forces in favor of recycled water use, as in the case of the El Hajeb Perimeter, which is resulting in a 30% discharge reduction into the Mediterranean Sea near the Sfax salt flats, a nature reserve designated as a RAMSAR site.
- The importance of crops in and around the project area that can grow well under the water reuse irrigation scheme, in this case, an extensive olive orchard and the cultivation of fodder crops, which is done in conjunction with dairy cattle rearing in the plots irrigated by water from the project.

Lessons learned include:

- Supervision and monitoring of farmers is an important factor in the success of public irrigated perimeters.
- The monitoring of treated wastewater shows quality fluctuations due to the existence of illicit polluted discharges in ONAS sewers despite continuous control of the networks. ONAS must commit to ensuring a good quality of treated wastewater and consider installing a complementary water treatment plant at the head of the perimeters irrigated through the water reuse project.

Methods and resources

This water reuse case was prepared in collaboration with:

- The Regional Commission for Agricultural Development (CRDA), Sfax Governorate: The two people contacted were the District Head of the Exploitation of Irrigated Perimeters and the District Head of Rural Engineering.

TABLE 3.3 Sfax Sud WWTP and El Hajeb Perimeter: SWOT analysis.

	HELPFUL TO ACHIEVING THE OBJECTIVES	**HARMFUL** TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ■ Commitment of ONAS in projects concerning the improvement of wastewater treatment and the important potential of water reuse from the Sfax Sud WWTP: currently an average of 42,000 m^3/day and planned to reach 52,000 m3/day by 2026. ■ Fertilizing power of recycled water: less mineral fertilizer inputs. ■ High potential for agricultural land to be irrigated by recycled water and high motivation of farmers in the area for the project. ■ No other source of water for irrigation near the existing perimeter. ■ Development of cattle breeding in the area and the presence of a milk collection center nearby as well as oil mills. ■ More than 30 years of experience with recycled water irrigation in the project area and a high rate of intensification in the existing perimeter (155%).	**WEAKNESSES** ■ Poor treated wastewater quality that does not meet the requirements of the discharge standard (NT106-02) and the standard for reuse in irrigation (NT106-03). ■ Lack of storage tanks at the head of the irrigation network. ■ Restrictive list of authorized crops with few high-value crops. ■ Low pricing set at USD 0.072/m^3. The costs of the reuse of the treated wastewater are largely borne by the CRDA. ■ Increased operating costs due to the degradation of existing facilities (for the Sfax Sud WWTP and the El Hajeb Perimeter). ■ Non-compliance with treated wastewater quality control frequencies and parameters to be analyzed, both at the Sfax CRDA and more recently at ONAS (since the launch of the Sfax Sud WWTP rehabilitation project in 2016). ■ At the operational level, few material and human resources were allocated to the treated wastewater operator, especially given insufficient flows transferred to the perimeter due to the failure of the existing infrastructure. ■ Lack of user awareness of the risks of treated wastewater and lack of resources to raise user awareness
EXTERNAL FACTORS ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ■ A political will to promote recycled water from wastewater treatment plants as a new source of water. ■ Many users are willing to pay more for the quality of recycled water. ■ Less discharge of treated wastewater into the sea reduces potential pollution, especially near the Sfax salt flats (RAMSAR site). ■ The El Hajeb Perimeter has been in operation for about 33 years and constitutes an extensive field of research on the reuse of treated wastewater in irrigation. ■ A desire on the part of the distributing body (Sfax CRDA) to promote the use of recycled water in the El Hajeb Perimeter and extend irrigated areas as a result of a general political will to promote the water reuse. ■ Climate change is reducing conventional water resources, with water stress affecting Tunisia, particularly in the Sfax area including the salinization of groundwater, meaning water reuse is becoming even more critical. ■ Flagship projects such as the Ouardanine Public Irrigation Perimeter for various fruit trees in addition to the El Hajeb Perimeter for fodder crops, dairy cattle breeding and olive trees.	**THREATS** ■ Low rate of progress in the rehabilitation of the Sfax Sud WWTP. ■ Illegal connection of polluting industries to the ONAS network affects the quality of treated wastewater. ■ The producer and the treated wastewater quality controller belong to the same ministry which can create risks of conflicts of interest. It is noted that the treated wastewater produced often does not comply with the NT106-02 discharge standard, yet it sometimes is discharged into the sea or transferred to the perimeter without immediately informing the CRDA. ■ Insufficient coordination amongst producers, distributors, managers and users. ■ A lack of control over the quality of the treated wastewater produced. ■ Difficulties in mobilizing funds for the upkeep and maintenance of existing installations and the realization of new complementary wastewater treatment projects provided by ONAS to address the majority of cases not compliant with the NT106-03 standard.

- The treated wastewater producers: ONAS and the Sfax Sud WWTP.
- The Public Irrigated Perimeter of El Hajeb management body: the Agricultural Development Group (GDA).
- Current perimeter operators.

The approach included:

- Analysis of documentation on the perimeter and the Sfax Sud WWTP 2019 studies on the rehabilitation and extension project of the El Hajeb Perimeter (feasibility study, detailed design study, execution study, and environmental and social impact study) and operating reports.
- Consultation with staff, resource persons and local populations to collect data on the Sfax Sud WWTP and the current state of the El Hajeb Perimeter. This consultation was to verify the collected information to accurately complete the data tables. Some data could not be collected, however, especially at the level of ONAS.
- Field observations, investigations and direct contact with the farmers at the site of the El Hajeb Perimeter were also carried out to determine which crops are grown and current resource and use constraints.
- ONAS (National Sanitation Office) operating reports of Sfax Sud Wastewater Treatment Plant, 2009–2013 and operating reports of the Sfax Sud WWTP (not complete reports), 2016–2017 and 2018.

Additional resources used in gathering data for this study include:

CRDA (Regional Commission for Agricultural Development). 2006. *Feasibility study of the extension project of the El Hajeb Perimeter irrigated by recycled water from Sfax Sud Wastewater Treatment Plant*. Tunisia. CRDA.

CRDA. 2019. *Feasibility study of the rehabilitation and extension project of the El Hajeb Perimeter irrigated by recycled water from Sfax Sud Wastewater Treatment Plant*. Tunisia. CRDA.

CRDA. 2020. *Detailed preliminary design study of the rehabilitation and extension project of the El Hajeb Perimeter irrigated by recycled water from Sfax Sud Wastewater Treatment Plant*. Tunisia. CRDA.

DGGREE (Directorate General of Rural Engineering and Water Management). 2020. *Environmental and social impact study of the rehabilitation and extension project of El Hajeb Perimeter irrigated by recycled water from Sfax Sud Wastewater Treatment Plant*. Tunisia. DGGREE.

MARHP (Ministry of Agriculture, Hydraulic Resources and Fisheries). 2017. *Fee policy evaluation study and review and implementation of new pricing schemes, Dual pricing of treated wastewater at the level of the Public Irrigated Perimeter – Phase 1 diagnosis*. MARHP; DGGREE (Directorate General of Rural Engineering and Water Management); KFW (Kreditanstalt für Wiederaufbau).

MARHP. 2018. *Preliminary study for a national plan Reuse of treated wastewater for Tunisia - Diagnosis of the existing situation*. MARHP; ONAS (National Sanitation Office); the Ministry of Health.