Case Study 4: Tunisia

Ouardanine wastewater treatment plant and public irrigated perimeter

Chokri Saffar and Ibticem Chamtouri

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 Ouardanine Public Irrigated Perimeter (Ouardanine Perimeter) is an agricultural area created in the Monastir Governorate in central-eastern Tunisia planted to fruit trees, fodder crops and olives. Initially the perimeter covered an area of more than 50 ha. It was extended in 1997 to 74 ha. Today the land is owned by 42 farmers (Figure 4.1).

The area is considered a pilot site in that it was created in an agricultural area that lacks freshwater, and that also experiences flooding problems from the discharge of treated wastewater from the Ouardanine Wastewater Treatment Plant (Ouardanine WWTP) into the Oued El Guelta *wadi* (valley).

The Ouardanine WWTP was established in 1993 with a design flow of 1,500 m^3/day. The plant uses a medium-load activated sludge treatment system and is currently undergoing rehabilitation works through the National Sanitation Office (ONAS) to expand capacity by almost double. In 2006, a filtration station and a storage tank were installed by the Regional Commission for Agricultural Development (CRDA) Monastir to improve the quality of the discharged recycled water. They are located upstream of the pumping station toward the perimeter.

The Ouardanine Perimeter is an active location for scientific research and studies on irrigated agriculture in the Republic of Tunisia (Tunisia) and the first at the national level to use sludge as organic fertilizer to fertilize the land.

FIGURE 4.1 Location map of the Ouardanine WWTP. *SOURCE*: Google Earth.

Water reuse case description at a glance

The Ouardanine Perimeter is irrigated by recycled water from the Ouardanine WWTP, which is located 2 km north of Ouardanine town in the Monastir Governorate. Wastewater collections come from predominantly domestic sources in the town, although some wastewater comes from industrial sources, for example, car washes and slaughterhouses. The Ouardanine WWTP was built with a design flow of 1,500 m^3/day, which is expected to be increased to 2,900 m^3/day when the current extension project is completed.

Wastewater is treated at a secondary level by a medium-load activated sludge treatment system at the plant and then conveyed to the Oued El Guelta *wadi* upstream of the Ouardanine Perimeter (Figure 4.2) by means of:

- A storage basin with a capacity of 1,000 m^3 that is located near the Ouardanine WWTP's discharge point into the El Guelta *wadi*.
- A filtration plant consisting of two gravel filters, two screen filters and two disc filters.
- A pumping station with a suction tank equipped with three 20 L/s pumps of 40 m in height, one of which is an emergency pump.
- A 2.4 km long DN250 asbestos cement delivery pipe.
- A semi-underground reinforced concrete regulation tank with a capacity of 500 m^3 is located at the head of the perimeter.
- A buried piping distribution network fed by gravity from the regulation tank equipped with 22 irrigation hydrants. The irrigation hydrants are reinforced concrete manholes with tamper-proof closures and equipped with valves and a meter, although it is noted that these meters are generally out of order. The payment of volumes used by each farmer is made on a flat rate basis in relation to the irrigated area. A common fee is applied corresponding to an annual amount of USD 99/ha/year/farmer.
- Plot networks with buried PVC pipes installed by farmers.

The irrigation techniques used are localized for arboriculture while sprinkler irrigation is used for forage crops.

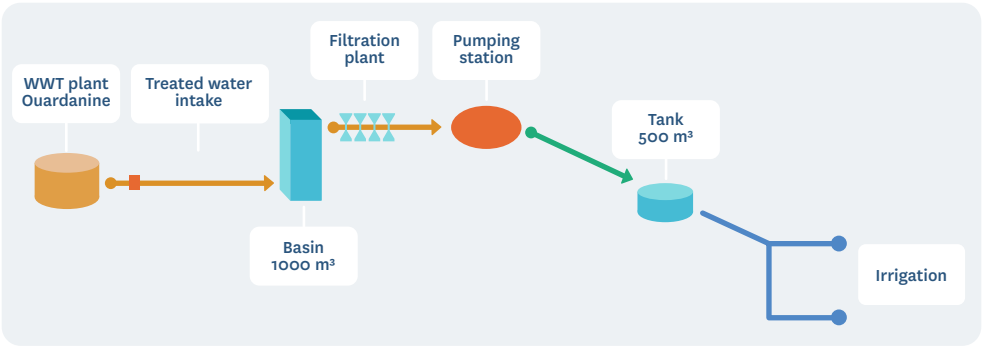

FIGURE 4.2 The Ouardanine WWTP and Public Irrigated Perimeter: Schematic diagram.

National institutional and policy framework

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 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).

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 public irrigated area of Ouardanine was developed by the Regional Commission for Agricultural Development (CRDA) Monastir. The recycled water from the Ouardanine WWTP that is transferred to the Ouardanine Perimeter is produced and supplied free of charge by ONAS.

Project beneficiaries have been organized into an Agricultural Development Group (GDA). The management of the infrastructure and resources provided through the water reuse project

is delegated by the CDRA Monastir via a management contract that specifies which tasks are carried out by the GDA and which are carried out by CRDA Monastir. The main tasks carried out by the GDA are limited to distributing water to the farmers, reading meters, collecting water payments and carrying out minor repairs to the irrigation network within the perimeter. Since the sale price of the recycled water is very low and does not cover the necessary expenses such as energy, maintenance and personnel costs, CRDA Monastir covers the energy costs related to the pumping of water through WWTP invoices, as well as major repairs of the transfer network from the intake structure to the regulation tank. Since January 2021, the GDA has been asked to contribute to energy costs by paying an annual amount of USD 2,150/year.

The CRDA Monastir and its representatives at the regional level including the Territorial Extension Unit (CTV), the Agricultural Outreach Unit (CRA) and others provide technical assistance to farmers and supervise the GDA.

Quality control of the recycled water from the WWTP is carried out by ONAS, the CRDA and the Ministry of Public Health according to the schedule set by current legislation (Figure 4.3).

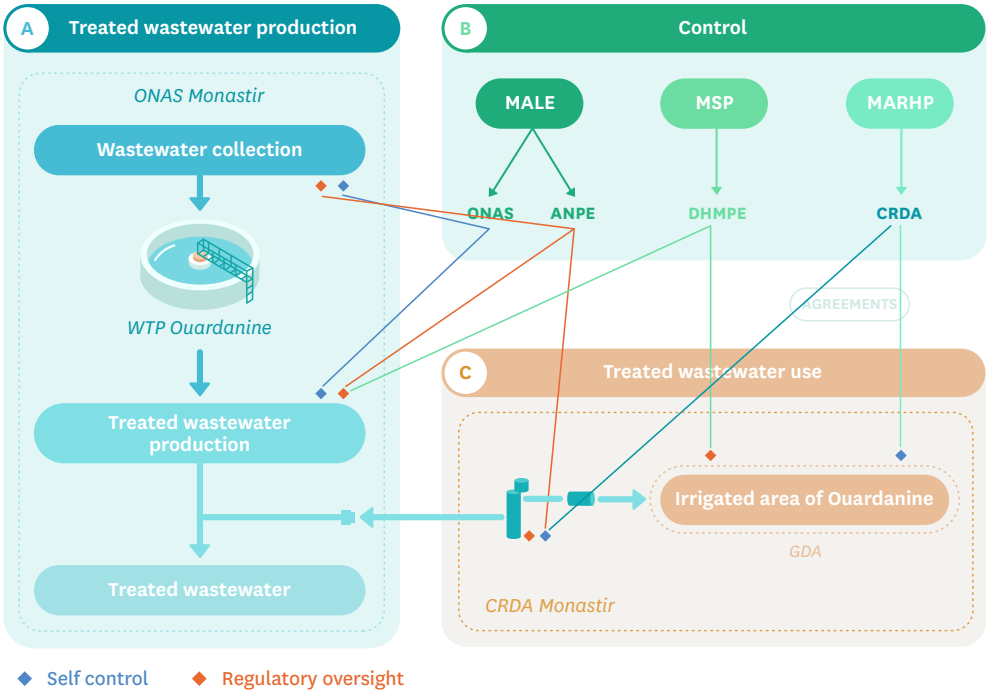

FIGURE 4.3 Ouardanine WWTP and Public Irrigated Perimeter: Stakeholder and management model.
NOTES: National Environmental Protection Agency (ANPE), Regional Commission for Agricultural Development (CRDA), Directorate of Environmental Health and Environmental Protection (DHMPE), Agricultural Development 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 4.1 summarizes the capital expenditure, operating expenditure and cost recovery related to the Ouardanine WWTP and Perimeter.

Socioeconomic, health and environmental benefits and impacts

The creation of the Ouardanine Perimeter has resulted in significant socio-economic, health and environmental benefits.

Economic benefits include an increase in the value of agricultural land. The price of an irrigated hectare increased from USD 1,800 in 1996 to USD 1,364 in 2014. It is currently valued at USD 7,182.

There has also been an increase in the agricultural production of the irrigated farms, which represents triple the average recorded in the whole of the Republic of Tunisia including:

- 25 ha of peach trees with an average production of 30 tons/ha.
- 10 ha of fig trees with an average production of 10 tons/ha.
- 15 ha of pomegranate trees with an average production of 40 tons/ha.
- 24 ha of olive trees intercropped with various fruit trees.

TABLE 4.1 Funding and financial outlook and cost recovery.

	Wastewater collection and transfer	Wastewater treatment	Transfer of treated wastewater	TWW Distribution
Construction and equipment services (description and dimensions)	Wastewater collection network of the city of Ouardanine	Ouardanine WWTP	A storage basin with a capacity of 1,000 m^3 located near the discharge point of the WWTP into the El Guelta *wadi*, fed from the discharge pipe of the WWTP in DN300 asbestos-cement A filtration plant consisting of two gravel filters, two screen filters and two disc filters A pumping station with a suction tank equipped with three 20 L/s pumps of 40 m HMT, one of which is an emergency pump A DN250 asbestos-cement delivery pipe with a length of approximately 2.4 km	A semi-buried reinforced concrete regulation tank of circular shape and capacity of 500 m^3 is located at the head of the perimeter A buried asbestos cement pipe distribution network (2.7 km) of DN150 and 300 mm, served by gravity from the regulation tank 22 irrigation posts

	Wastewater collection and transfer	Wastewater treatment	Transfer of treated wastewater	TWW Distribution
Stakeholder providing the service	ONAS Ouardanine/ Monastir	ONAS Ouardanine/Monastir	CRDA Monastir	CRDA Monastir
Capital Expenditure (CAPEX) (in USD)	No access to this data	No access to this data	Perimeter development in 1994: 0.5 million Storage basin creation in 2006–2007: 100,000 Installation of a filtration plant in 2006–2007: 80,000 Rehabilitation of the pumping station in 2016: 20,000 Construction of 1.7 km of agricultural tracks within the perimeter: 25,000	Rehabilitation of the distribution network in 2012: 20,000
Recovery CAPEX and % subsidy	100% subsidy ONAS provides free recycled water to the CRDA of Monastir		State funding	State funding
Operating & Management (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 Ouardanine/ Monastir	ONAS Ouardanine/Monastir	CRDA Monastir	CRDA Monastir and GDA
Operating expenses (OPEX) (in USD/m^3)	Data not available		Water costs of CRDA Monastir 0.090	
OPEX recovery and % subsidy	Nearly 70% of ONAS's financial resources come from sanitation fees, mainly collected through SONEDE's billing: USD 0.02 to 0.05/m^3 according to the following principles (i) beneficiary-pays; (ii) polluter-pays and (iii) solidarity between users. The rest of ONAS's budget is financed by the State (25.6%) and other related activities (5.4%). Given all its expenses, ONAS provides the recycled water from the WWTP to the CRDAs free of charge.		CRDA Monastir sells the recycled water to the GDA at USD 0.016/m^3, which results in a significant subsidy of USD 0.074/m^3 borne by the CRDA. In application of the reduced price decided by the State to encourage the use of recycled water, it is sold by the GDA to the farmers at a unit price of USD 0.0073/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).

Jobs have also been created for young people in the project area as the number of working days has increased from 20 days/ha in 1996 to 155 days/ha just four years after the perimeter was irrigated.

Environmental benefits include minimizing the discharge of recycled water from Ouardanine WWTP into the El Guelta *wadi*. In 2019, between March to September, all of the recycled water was used within the perimeter as a result of a significant lowering of the water table, which is an ongoing challenge. This enabled the return of agricultural activity on 7.2 km of land located near the *wadi* that had been previously damaged because of discharge (Image 4.1). Other benefits include the use of treatment sludge from the plant as an organic fertilizer.

The Ouardanine Perimeter also plays an important role in raising awareness of irrigation by recycled water from wastewater treatment plants at the local as well as national levels. It receives an average of 1,000 visitors each year.

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.

Currently, out of a total of 42 farmers, there are two female heads of household. This equates to about 5%. In contrast, in terms of women's participation in agricultural work, the numbers are quite substantial. For half of the farmers in the project area, working the land is a family tradition in which women and even children take part. It is also reported that, in addition to household members, the heads of farms also use female labor from neighboring areas when necessary. At least four women per farm are occasionally assigned to the perimeter.

IMAGE 4.1 Stagnation of treated wastewater in the El Guelta wadi at the Ouardanine perimeter (June 2021). *SOURCE*: I. Chamtouri, Hydroplante, Tunis.

Scalability and feasibility potential

The Ouardanine Perimeter is located in an extensive agricultural area where both arboriculture (especially dry-farmed olive trees) and cattle rearing (without a grazing area owing to the absence of irrigation and fodder production) play an important role in generating income for the population. The absence of other sources of conventional water and the aridity of the climate makes the possibility of extending the irrigated area highly probable, particularly given the demands made by a large proportion of the farmers in the area who deem it necessary.

SWOT analysis

Table 4.2 summarizes the analysis of the strengths and weaknesses of using recycled water from wastewater treatment plants and the opportunities and threats that may be observed in the Ouardanine WWTP and Perimeter case study.

TABLE 4.2 The Ouardanine WWTP and Public Irrigated Perimeter: SWOT analysis.

	HELPFUL TO ACHIEVING THE OBJECTIVES	**HARMFUL** TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ■ A significant potential in continuous recycled water availability throughout the year. ■ Fertilizing power of recycled water means less mineral fertilizer use. ■ High potential for agricultural land to be irrigated and high motivation of farmers in the area for the project. ■ No other continuous source of water for irrigation near the existing perimeter. ■ More than 24 years of experience with recycled water for irrigation in the project area and a high rate of intensification in the existing perimeter (140%).	**WEAKNESSES** ■ Restrictive list of authorized crops with few high-value crops. ■ Poor pricing, set at USD 0.072/m^3, which means costs of reusing treated wastewater are largely borne by the CRDA. ■ Frequencies of non-compliance with recycled water quality control and all other parameters to be analyzed, at the CRDA and the ONAS. ■ Poor management of the additional treatment equipment installed at the head of the perimeter including algal growth in the storage tank. This tank is very deep (3 m), which favors the development of septic conditions.
EXTERNAL FACTORS ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ■ A political will to promote water reuse. ■ Many users are willing to pay more for recycled water from wastewater treatment plants to get better quality water. ■ Less discharge into the *wadi* and sometimes all of the recycled water produced is used (from March to September).	**THREATS** ■ Poor flow of the El Guelta *wadi* following discharges of treated wastewater and sludge which generate the development of vegetation formed by reeds and other halophilic plants which slow down water flow. This causes a rise in the static level of the water table which can asphyxiate the fruit trees, salinization of the soil and proliferation of insects, as well as odor nuisance. ■ Difficulties related to the quality of the recycled water.

Key factors for success along the project and lessons learned

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

- The 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 extend WWTPs and improve the quality of treated wastewater.
- The mitigation of the environmental and health impacts of treated wastewater discharges into the natural environment, which is one of the main driving forces for its reuse. In the case of the Ouardanine Perimeter, irrigation using recycled water enables the preservation of agricultural land located near the discharge outlet of the plant at the Oued El Guelta.
- The strong and important fertilizing power of recycled water from the WWTPs is significantly increasing agricultural production. The Ouardanine Perimeter is one of the successful water reuse sites in Tunisia, particularly in terms of the development of irrigated arboriculture (Image 4.2).

Lessons learned include:

- The supervision and monitoring of farmers is an important factor in the success of public irrigated perimeters.
- The quality of the water produced by the WWTPs and supplied for irrigation must comply with at least the NT106-02 discharge standard to ensure efficient operation of the public

IMAGE 4.2 Fig tree plot irrigated by TWW–Quardanine irrigated perimeter. Photo: I. Chamtouri.

irrigated perimeters. The installation of a complementary treatment plant at the head of the perimeters, as in this case, is becoming a necessity given the fluctuations in the quality of treated wastewater throughout the operation of the WWTPs and illicit polluted discharges into the ONAS sewers despite continuous control of the networks.

Methods and resources

This water reuse case was prepared in collaboration with:

- The treated wastewater distributor: The Regional Commission for Agricultural Development (CRDA) Monastir.
- The treated wastewater producer: The National Sanitation Office of Ouardanine (ONAS), Ouardanine WWTP.
- The Ouardanine Public Irrigated Perimeter management body: the Agricultural Development Group (GDA).
- Current perimeter operators.

The approach included:

- Analysis of documentation concerning the Ouardanine Public Irrigated Perimeter and the Ouardanine WWTP.
- Consultation with staff at local structures, resource persons and local populations to collect required data on the plant and the current state of the existing perimeter. Note that some data could not be obtained, especially concerning ONAS.
- Field observations and investigations, which were carried out on June 17, 2021, at the Ouardanine Public Irrigated Perimeter. The investigations included direct communication with farmers to determine crops grown and current operating constraints.

Additional resources used in gathering data for this study include:

CDRA (Regional Commission for Agricultural Development). 2020a. *Irrigated Perimeter, Follow up sheet*. Ouardanine. CRDA.

CRDA. 2020b. *Physico-chemical and bacteriological analysis sheets for treated wastewater collected from the Ouardanine Public Irrigated Perimeter storage basin (2019 and 2020)*. Monastir. CRDA.

MARHP (Ministry of Agriculture, Hydraulic Resources and Fisheries). 2017. F*ee 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*. Tunisia. MARHP; DGGREE (Directorate General of Rural Engineering and Water Management); KFW (Kreditanstalt für Wiederaufbau).

ONAS (National Sanitation Office). 2003. *Feasibility study for the development of treated wastewater reuse in the Ouardanine region*. Republic of Tunisia. ONAS.

ONAS. 2018a. *Preliminary study for a national plan: Reuse of treated wastewater for Tunisia - Diagnosis of the existing situation*. Tunisia. MARHP (Ministry of Agriculture, Hydraulic Resources and Fisheries); ONAS; the Ministry of Health.

ONAS. 2018b. *Ouardanine wastewater treatment plant activity report*. Ouardanine. ONAS.