CASE

Wastewater and biosolids for fruit trees (Tunisia)

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Supporting case for Business Model 17	
Location:	Ouardanine near Monastir, Tunisia
Waste input type:	Domestic wastewater
Value offer:	Secondary treated wastewater sold for reuse in farmer-managed tree crop system (peaches, olives, grapes, grenades)
Organization type:	Public-private
Status of organization:	Plant set up in 1993, irrigation scheme operational since 1997
Scale of businesses:	Small: 1,590m^3/day treatment; reuse on 65–75 ha
Major partners:	National Sanitation Utility (ONAS); Regional Offices of Agriculture Development (CRDA); Groups of Agricultural Development (GDA) and local farmers

Executive summary

The National Sanitation Utility (ONAS) is a public institution in charge of the Tunisian sanitation sector and operates the small Ouardanine wastewater treatment plant near Monastir city (328mm annual rainfall), treating mostly domestic (non-industrial) wastewater from about 3,400 households. About a quarter of the reclaimed water is used by the nearby Ouardanine tree plantations (65–75 ha), managed by about 40–46 private farmers to produce olives, peaches and pomegranates to sell at the local market. In the case of irrigation, the downstream infrastructure is managed by the Governmental Commissariat Régional de Développement Agricole (CRDA), which receives the water from ONAS free of charge and is responsible for distributing and billing reclaimed water to end users (farmers' collectives or Water User Associations called Groupement de Développement Agricole; GDA). CRDAs charge the GDA a subsidized water price which is fixed by the government as an incentive for reuse and low compared to the value it is creating. The Water User Associations then distribute the water among their members/ farmers, while collecting an annual subscription fee, and also charging a mark-up on the water price to undertake routine repairs of the distribution network. The Ouardanine plant also supplies biosolids (sludge) on-demand as soil conditioner free of charge. ONAS recovers 40% of operation and management (O&M) costs from wastewater transfer to the irrigated plots (with the balance buffered by the CRDA), and has an overall operational cost recovery of 56% for the total wastewater treatment system when adding sewage taxes levied on households (FAO, 2014).

KEY PERFORMANCE INDICATORS (AS OF 2013)						
Land use:	65–75 ha under fruit trees					
Wastewater treated and reused:	Treated: 1,590m^3/day wastewater; 2050t/year sludge produced; of this reused: up to 410m^3/day wastewater; about 105t/year of treated sludge					
Capital investment:	USD 1.2 million for the treatment plant (1993) USD 337,000 for agroforestry system (1997)					
Labor :	About 46 farmers at the plantation; additional seasonal harvester					
O&M cost:	USD 30,500/year for treatment plant USD 11,700/year for wastewater transportation to the irrigated 65 ha					
Output:	USD 17,000/year from household sanitation fees (USD 5 per household and year) USD 1,950/year from CRDA selling water to GDA; sludge valued at USD 1,270 (data from Egypt) but uncounted as free USD 2,780/year from GDA selling water to farmers USD 817,000/year from fruit sales by farmers, not counting further gains along the value chain					
Potential social and /or environmental impact:	Water savings, public health and marine environment protection, nutritious food, carbon sequestration					
Financial viability indicators:	Payback period:	Depends on tree growth rate	Post-tax IRR:	N.A.	Gross margin:	N.A.

Context and background

In Tunisia about 84% of the generated wastewater is collected and treated at least 109 wastewater treatment plants. Nearly all (95%) of this water is treated at secondary level. A key motivation is the preservation of Tunisia's marine environment and coastal resorts, given the national importance of the tourist sector as part of Tunisia's overall commitment to prevent pollution in the Mediterranean Sea. As a semi-arid country, Tunisia is also aware of the pressure on its existing water resources and as many resources are saline, authorities are determined to increase water reuse.

In 2009, about 63 million m^3 (i.e. 26% of the annually treated 238 million m^3 wastewater) have been reused directly (agriculture, landscaping) or indirectly (aquifer recharge, etc.). The total agricultural area equipped for irrigation with treated wastewater was about 8,065 hectares (ONAS, 2009), although not all of this land might be actually irrigated. In addition, wastewater use has been reported for landscape irrigation such as golf courses (1,040 ha) and green areas (450 ha). The main crops irrigated across the country with treated wastewater are fruit trees (29%), fodder crops (45%), cereals (22%) and industrial crops (4%) (Bahri, 2002; Abid, 2010). In 2021, the plans are that 172 million m^3 would be made available for reuse on 40,500 ha farmland, 50 million m^3 for landscaping of 3,500 ha, and 25 million m^3 for aquifer recharge (ONAS, 2009).

Reuse has been regulated under the 1975 Code des Eaux (Water Code) and several more detailed decrees which are setting norms for chemical and biological loads in reclaimed water, prohibit the use of untreated effluents for irrigation and stipulated that reclaimed water could be used on a range of crops except vegetables or fruits that are consumed raw, such as tomatoes, lettuces, carrots and berries. The list of crops which could benefit from treated wastewater remains valid and includes industrial crops (e.g. cotton, tobacco, flax, jojoba and castor oil plant), grain crops (e.g. wheat, barley, oat), fodder crops (e.g. clover, corn, alfalfa), fruit trees (e.g. date palms, citrus trees, olive trees, vines), forest trees, flowers and herbs (e.g. rose, lily, jasmine, marjoram and rosemary).

The Ouardanine case is an example of a small and decentralized wastewater treatment plant which is serving about 3,400 households. Until 1993, the town of Ouardanine had to cope with the impacts of untreated sewage discharge. Environmental degradation combined with limited employment opportunities contributed to many local youth leaving this rural town. Called to remediate the untreated discharge situation, ONAS was met with pressing demands by local farmers to reclaim the water for irrigation. While ONAS implemented the treatment system, the CRDA elaborated the irrigation scheme with the farmers regrouped in a formal water user association, responsible for site selection, land rights resolutions and plant culture selection. This has allowed to ease use restrictions and avoid rejection of reclaimed water by users.

About 26 % of the secondary treated wastewater is reused by about 46 farmers for different fruit trees in an irrigation scheme set up in 1997 at a cost of USD 337,000, as part of the national water reuse program. Of the 65 (max 75) ha allocated for reuse, 34–45 ha were in recent years under peaches, 20–21 ha under olives and a small area under grapes, barley, alfalfa, cut roses and pomegranates. Drip and furrow irrigation are used. The wastewater treatment plant also produces sludge, but so far only a small percentage gets composted and recycled in agriculture in a free of charge pilot program. The application of biosolids on agricultural land is by law limited to experimental plots conducted as demonstration pilot projects.

Market environment

With some geographic variability, water scarcity is the defining feature of the agricultural economy in Tunisia. Against this backdrop Tunisia has since the mid-1960s increasing experience in wastewater reuse with a strong supporting legal framework and political commitment that has led to continuous expansion of wastewater treatment and reuse in the country. Perception studies show a reasonably high level of farmers' hypothetical acceptance to use reclaimed wastewater (80%), preferably without restrictions, and public acceptance (71%) to consume crops irrigated with treated wastewater (Abu-Madi et al., 2008). However, despite increasing water shortages and substantial economic incentives, actual demand for reclaimed water between 2001 and 2009 plateaued at around 25–30% of treated wastewater. According to Abu-Madi et al. (2008) and GWI (2010), factors that fuel the farmers' hesitation are: (i) availability of or accessibility to freshwater; (ii) distrusted water quality; and (iii) worries about crop/fruit marketing and acceptance. Less important are however concern for public criticism, concern for health impacts, religious prohibition, or psychological aversion. Reasons for water quality concerns which led farmers to fall back on conventional resources include (GWI, 2010):

- Plant saturation (particularly in coastal areas and in summer when tourist numbers put a strain on capacities) and ageing.
- Industrial pollution due to poor upstream pre-treatment (a legal requirement for industrials but often poorly observed in practice) which refers in particular to salinity in central and southern Tunisia.

The existing system for crop marketing in which crops produced with reclaimed-water crops are on offer together with freshwater irrigated crops 'facilitates' marketing although some consumers seem to be able to distinguish between the crops. However, there are calls for more transparency and monitoring, also to increase the confidence of the consumer. So far only the national market is targeted. According to Abu-Mari et al. (2008) Tunisia has not yet reached a stage where the crops irrigated with reclaimed wastewater can be exported.

Sludge reuse has been tested on pilot farms (about 300 ha) for several years, in line with the national standards (Normes Tunisiennes (NT) 106.20 – 2002) (MAERH, 2003; ONAS, 2009). Also at Ouardanine soils were amended under the regular monitoring of the Ministry of Agriculture as one of the demonstration projects. The estimated amount of 6 t sludge/ha is expected to be spread over five years.

Macro-economic environment

All of Tunisia's infrastructure has been financed by the state, usually with a combination of loans and grants from state finance and international lenders. Tunisia has good links, e.g. with the European Investment Bank, the Agence Française de Dévloppement, the German KfW, the Japan International Cooperation Agency, etc. Most new wastewater treatment plants are medium-sized plants (15,000m³/day), built on a turnkey contract basis and financed by ONAS with international loans. But also different financing and procurement avenues are being explored, including a 25-year BOT contract for the construction of two large WWTPs.

Tunisia is determined to reduce the discharge of the wastewater to the sea, and to develop water reuse. The government policy strongly supports wastewater treatment and incentivizes wastewater reuse. Sanitation charges for domestic users, industry and tourist establishments vary according to water consumption and the principle of 'polluter pays' and do so far only cover about 60–65% of ONAS's operational costs, which comprise personnel salaries (about 30%), energy (60%) and equipment repairs and replacements (10%). The rest is financed by the state.

Cost recovery via wastewater use is constrained by water pricing. The tariff set by the Government in 1997 demanded Tunisian dinar (TND) 0.02/m³ (ca. USD 0.02/m³ at that time, or USD 0.015/m³ in 2010). The target is to keep the price for reclaimed water significantly below the one of the subsidized freshwater[1] which was about 3 to 4 times higher for irrigation, and 7–40 times higher for domestic and industrial use in the year 2000 (Bazza and Ahmad, 2002; GWI, 2010). The price for reclaimed water has remained unchanged since 1997 and covers only a fraction of the real cost of wastewater treatment, estimated at TND0.3–0.7/m³ (GWI, 2010).

Despite the low price charged to Tunisian farmers for reclaimed water compared to conventional water supply, the demand for reclaimed water remained so far modest (Qadir et al., 2010). The mismatch has (i) in part geographical reasons with most wastewater being produced in the Greater Tunis area and along the coast, i.e. not where it is mostly needed; (ii) is supported by the availability of alternative water sources like shallow groundwater which only attracts pumping costs until a depth of 50m (FAO, 2009); and (iii) is also driven by seasonal demand–supply gaps.

Business model

The treated wastewater coming for free from the wastewater treatment plant of Ouardanine is pumped to a ground reservoir which is under the supervision of the Regional Offices of Agriculture Development (Commissariat Régional de Développement Agricole, CRDA). The CRDA also operates the pumps and wastewater distribution network connecting to the irrigation scheme. CRDA sells the water in bulk to the Water User Associations (Groupement de Développement Agricole, GDA), at a price of TND 0.02/m³ (2013: USD 0.012/m³) which recovers about 17% of the costs of CRDA to convey the water to the irrigation scheme; the balance is covered by the Ministry of Agriculture.

The GDA then sells the water to the farmers at TND 0.035/m³ (USD 0.022/m³), thus earning a mark-up of about USD 0.01/m³. Besides wastewater sales to the farmers, the GDA also raises revenue (about USD 1,250) from the annual subscription fees paid by farmer (USD 32 per farmer) which allows them to support CRDA with minor maintenance of the irrigation network at farmers' end. According to FAO (2014) farmers are the main beneficiary of the irrigation system with an annual income from their production sale of about USD 5/m³ or USD 12,570/ha. Moreover farmers engaging in reuse are entitled to purchase irrigation equipment at a 30% discount, or use for free treated sludge (Figure 211).

FIGURE 211. BUSINESS MODEL CANVAS OF ONAS SUPPORTED WATER REUSE FOR GROWING FRUIT TREES IN OUARDANINE, TUNISIA

KEY PARTNERS

- Regional Offices of the Agriculture Department (CRDA)
- Water User Associations (GDA)
- Fruit market and consumers (public acceptance)
- Sewer connected households
- ANPE and DHMPE as monitoring agents

KEY ACTIVITIES

- Collection and treatment of wastewater
- Sludge drying and composting
- Maintenance of irrigation supply network (via CRDA)
- Collection of water fees and charges

KEY RESOURCES

- Treatment plant and treated wastewater
- In and outflow network
- Interested farmers in vicinity
- Land (or machinery) for sludge drying and composting

VALUE PROPOSITIONS

- To transform wastewater and sludge into safe products for reuse in peach and olive orchards

CUSTOMER RELATIONSHIPS

- Government to government contract (ONAS/ CRDA)
- Automated system for tariff payment (ONAS/ Households)
- Government to private sector contract (via CRDA to GDA)

CHANNELS

- Roundtable (water reuse)
- Online payment (house-hold sanitation fees)

CUSTOMER SEGMENTS

- Regional Offices of the Agriculture Department (CRDA)
- Water user association (GDA) and its farmers
- Private sector (golf resorts)

COST STRUCTURE

- Treatment plant, capital cost and operational costs including in-house monitoring of water and sludge quality
- Water conveyance to CRDA reservoir (or water user association)
- Opportunity costs of idle reuse capacity
- Customer service and fee collection

REVENUE STREAMS

- Household wastewater fees (via water bill)
- Bulk sale of wastewater (and potentially sludge)
- Governmental subsidy; carbon credits (potential)

SOCIAL & ENVIRONMENTAL COSTS

- Possible long-term risk for groundwater and food safety
- Occupational risks
- Monitoring failure can lead to loss of trust with high costs across all reuse schemes

SOCIAL & ENVIRONMENTAL BENEFITS

- Year-round water reuse resulting in less discharge into water bodies
- Nutritious fruits from wastewater irrigation
- Orchard amenity value and ecosystem functions
- Less human exposure to untreated waste
- Created a new resource and employment

Available data compiled by FAO (2014) indicate that the treatment system in Ouardanine is recovering about half of its operational costs from household fees, while the CRDA as intermediary recovers about 17% via the internal contribution of the water user associations. Other sources mention 25%. Governmental subsidies remain crucial for the remaining pumping and maintenance work. The Water User Associations (GDA) itself is in a better position to charge its members enough to break even, whereas the individual farmers make profit.

Value chain and position

There are four main ‘business’ segments in the value chain. These include the wastewater treatment plant; bulk sale of treated wastewater by the local agricultural authorities to the water user association; and distribution and resale of wastewater to its members. The resource recovery cycle gets closed with the irrigated fruits entering the market. Each segment also has responsibilities for the operational aspects of the transformation from wastewater to fruit. The key business activities for the wastewater treatment plant are the treatment of wastewater to obtain its environmental sustainability objectives. A secondary objective is recovering costs. The involvement of intermediaries between ONAS and farmers makes much sense as the treatment plant has neither capacity nor expertise in dealing with farmers. Water sale to farmers generates revenue for CRDA and the water user association. CRDA is in charge of water transfer (2.5 km pipeline), pumps and routine maintenance work. Farmer and traders up the value chain make net profits (Figure 212). The business activity also involves production and treatment of sludge for composting and fertilizer yet generates no revenue but saves disposal costs.

The value chain and market position could be elevated through better collection and rationalization of sewage taxes, water pricing to achieve full cost recovery, sludge sale to outside buyers (potential) and channelling a larger part of farmer revenues to investment in the maintenance of the pumps and water transport. Additional revenue from forest carbon sequestration would depend on the size of the plantation and could be explored. With households being the source of the water and recipient of the fruits, it is obvious that an important component is the compliance with health standards, i.e. the monitoring responsibilities of the involved actors.

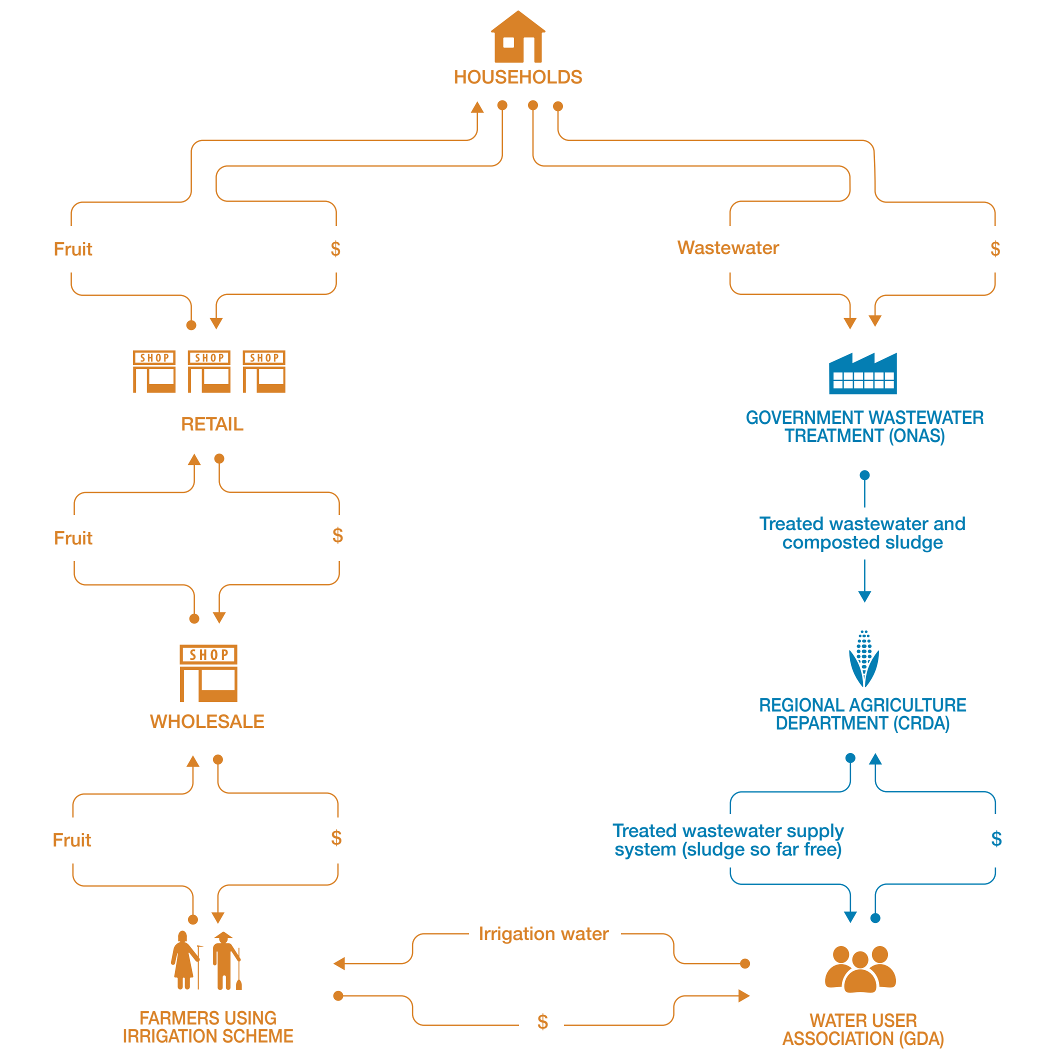
Institutional environment

Under the Ministry of Environment and Sustainable Development, ONAS is the central authority charged with protecting water resources and for this with managing the wastewater systems from collection to treatment and disposal. ONAS is in charge of sanitation planning to operation and maintenance throughout Tunisia. However, the monitoring of wastewater treatment plants, i.e. treatment standards and discharge quality, is with the National Environmental Protection Agency (ANPE) and the Department of Hygiene and Environmental Protection (DHMPE). Several other ministries (see Box 7) are also involved in wastewater reuse. The private sector plays a role where wastewater is reused, e.g. for golf courses, which for their part, own and operate their infrastructure ensuring the transfer of treated effluents from the treatment plant to the field.[2] All investment and operational costs must be met by the golf course operators, but they do not pay for the water provided by ONAS.

From a scale perspective, water used for irrigation is managed at three levels: at the national level are the Ministry of Environment and Sustainable Development and its sanitation utility ONAS; at the regional level the 24 Regional Offices of Agriculture Development (CRDA); and at the local level the Water User Associations (GDA) whose objective is to ensure self-management of the hydraulic systems established by the state for irrigation.

Operation and maintenance costs are covered by the governmental budget as well as by the farmers. CRDA, under the supervision of Ministry of Agriculture, Hydraulic Resources and Fisheries, is the main

FIGURE 212. BUSINESS PROCESS FLOW OF THE OUARDANINE TREE CROP SYSTEM



responsible entities for operation and maintenance of the wastewater distribution network. The GDA are essentially associations of farmers that take responsibility for minor maintenance of the irrigation systems, as well as selling water, collecting water fees and keeping accounts. The GDA also sets fees and users' contributions to cover all the costs of running the association. This kind of regulatory structure and the devolution of management responsibility for wastewater treatment and supply to the user level has enabled significant improvements in terms of a participatory reuse planning and management.

Considering the strong Governmental support of both public entities, ONAS and CRDA in this context and the lack of financial transaction between both, it might be justifiable to say that both entities co-convene the business model.

Box 7. Main government bodies and institutions for wastewater treatment and reuse in agriculture in Tunisia (updated from GWI 2012)

Ministry of Agriculture, Water Resources and Fisheries: formulates regulations on water resources, including irrigation and water reuse in agriculture.

Regional Offices of Agriculture Development (CRDA): under Ministry of Agriculture, and responsible for the distribution of treated wastewater from the plants to irrigated perimeters through pumping stations and a supply network while coordinating the monitoring of water quality.

Ministry of Public Health: sets standards for drinking water and effluent discharge to the environment with the focus on human health protection.

Department of Hygiene and Environmental Protection (DHMPE): a division of the Ministry of Health which controls the sewage system and purification stations as well as irrigation water to ensure compliance with public health standards.

Ministry of the Environment and Sustainable Development: formulates regulation for environmental protection and the prevention of pollution, including effluent discharge standards and reuse standards.

National Environmental Protection Agency (ANPE): in charge of preventing and controlling pollution and sole body controlling direct discharge of effluents from an environmental health perspective, including monitoring of ONAS's treatment plants. Like ONAS, ANPE works under the Ministry of the Environment and Sustainable Development.

National Sanitation Utility (ONAS): responsible for the country's wastewater infrastructure. It collects, treats and discharges municipal (and some industrial) effluents and sells (heavily subsidised) treated wastewater for reuse.

National Water Supply and Distribution Company (SONEDE): Tunisia's bulk water supplier and main drinking water utility, which serves all urban areas and about half the country's rural areas.

Ministry of Tourism and Handicrafts: supervision of societies in charge of golf courses including irrigation.

Wastewater reuse is covered under Tunisia's Water Code from 1975, which is the overarching legislation covering the water sector. Different supporting decrees define norms for chemical and biological loads in reclaimed water (based on FAO and WHO recommendations), those crops that could benefit from reclaimed water and the terms and conditions and precautions required for using reclaimed water in agriculture (such as cattle not grazing on land that has been irrigated with reclaimed water, or sprinklers not being used for the irrigation of fruit trees). Excluded from reuse are vegetables or fruits that are consumed raw. However, as exactly vegetables are a key cash crop, there is a strong call for high quality treatment to include also vegetables. As there is also a call to extend aquifer recharge with treated wastewater, Tunisia started recently revising its reuse norms to reflect quality norms for different applications (irrigation, landscaping, aquifer recharge, industrial use, etc.).

While effluent quality is monitored by ONAS and ANPE, an explicit risk management system is missing and enforcement of corrective measures remains limited given that one Governmental body is monitoring another, in part under the same ministry (ANPE and ONAS). Theoretically, if treated effluents fail to comply with the standard NT106.03, CRDA has to notify ONAS to turn down the treated effluents. If other water supplies are scarce (notably in summer) it is not unusual for CRDAs to accept below par treated effluents. On the other hand, it is interesting to note that sector performance seems to be motivated by the 'carrot' rather than the 'stick': the impact that poor water quality, environmental pollution and scarce water resources have on the economy and society seem to be enough to keep the sector on its toes (GWI 2012).

Sludge reuse as a fertilizer for agricultural purposes is permitted as long as it derives from urban wastewater treatment plants, i.e. not from pre-treatment by commercial and industrial facilities to remove harmful pollutants, or is recovered from cleaning of wastewater infrastructure. Sludge cannot be applied to land used for the cultivation of vegetables (GWI 2012).

Technology and processes

Reclaimed water receives in 95% of all cases secondary treatment in Tunisia, mostly via activated sludge systems. Tertiary treatment is seldom (5%) and was so far only considered in exceptional circumstances for specific uses because of its cost. Treatment technologies comprise low (56%) and medium load (30%) activated sludge plants, stabilization ponds (lagoons 14%) and in a few cases trickling filter and others systems making treated wastewater sufficiently safe for reuse as permitted in the Water Code. In general, ONAS's compliance with environmental discharge standards is with 80–90% high (GWI, 2012; Table 48).

In Ouardanine, the treatment process consists of preliminary, primary and secondary treatment (activated sludge process). The Ouardanine wastewater treatment plant supplies secondary treated wastewater to the Ouardanine peach, olive and pomegranates orchards. The plant receives raw wastewater from 3,400 households (around 17,000 citizens) and the daily treatment capacity is around 1,000 to 1,590m^3. The collected wastewater is to 91% of rural and domestic origin (residential, commercial and institutional), to 9% of industrial sources. The following Table 48 reports some key indicators of raw and reclaimed water discharged from the Ouardanine wastewater treatment plant compared to the agricultural reuse standard.

After primary treatment, the secondary step consists of an aeration tank with activated sludge in which the organic content of the sewage is digested by microorganisms. The remaining wastewater is subsequently pumped to a final clarifier which allows the sludge to settle. Parts of the secondary

TABLE 48. AVERAGE ELEMENT CONCENTRATION FOR TREATMENT PLANT INFLOW AND OUTFLOW

PARAMETER	BEFORE TREATMENT	AFTER TREATMENT	TUNISIAN STANDARD*
pH	7	8	6.5 – 8.5
Total Suspended Solids (TSS)	386	28	30 mg/L
Chemical Oxygen Demand (COD)	1,131	80	90 mg/L
Biological Oxygen Demand (BOD)	472	31	30 mg/L
Chloride	622	426	2,000 mg/L

* Tunisian Standards NT 106.03, 1989

Source: Salem et al., 2011

sludge is (usually mechanically) dried and composted to be used as a soil conditioner at rates of 6–11t/ha/year.

The irrigation scheme of Ouardanine was set in 1997 as a part of the national water reuse program and covers 65–75 ha of irrigated land and orchards cultivated by about 40–46 independent farmers. The CRDA operates the wastewater distribution network and is responsible for the organization of water quality monitoring. About 70% of the total irrigated area are cultivated with peaches and the remaining area with olives, grapes and pomegranates. A young peach tree begins fruiting by the third year after planting, which keeps the investment period much lower than for wood plantations (e.g. Egypt). Mature crop yields can reach up to 35t/ha for peaches and 7t/ha for olives.

The treated wastewater coming from the wastewater treatment plant is pumped during 20 hours/day to feed a ground reservoir with a capacity of 1,000m^3. According to Decree No 89–1047, CRDAs must test the quality of the treated effluents before using them, with regular controls from ANPE and DHMPE. The water must be tested for bacteriological load fortnightly. Tests for the water's pH, BOD, COD, TSS, chloride, sodium, ammonia, nitrogen and electrical conductivity must be carried out at least monthly. And tests for a broad range of heavy metals and other potential contaminants must be carried out at least once every six months (GWI, 2012). From the reservoir the water is then pumped to the distribution system of the orchard passing a battery of sand and gravel filters. The pumping station is not supplied with potable water. The total amount of treated wastewater used to irrigate the field is estimated at 2,300m^3/ha/year. Drip irrigation is the most frequent irrigation systems adopted in Ouardanine: about 60% of the field is irrigated by drip irrigation and the rest is irrigated using furrow irrigation. As the water still contains pathogens (Salem et al., 2011), irrigation remains restricted to certain crops. Some slight restrictions also derive from water salinity, which is moderate.

Funding and financial outlook

The funding and financial outlook for the Ouardanine wastewater treatment plant and agroforestry systems is positive due to clearly defined institutional responsibilities and opportunities for cost recovery within a regulatory framework which supports commercial reuse. Although public sector subsidies are well justified given the strong policy support and environmental and economic benefits (tourist sector) of wastewater treatment and reuse, charging for wastewater is an important step towards cost recovery. While cost recovery for water treatment and transport is still sub-optimal, there are options for improvement.

A higher cost recovery rate will be possible, e.g. via the sewage tax paid by the households, which could reflect more on the treatment costs rather than just the connecting fees. Wastewater charges paid by the farmers could also be adjusted to further support cost recovery for water conveyance. This could be at the end of the CRDA if it is allowed to revise the 1997 fixed rate of TND0.02/m^3 or at the end of the water user associations. A preliminary analysis based on the data reported in FAO (2014) shows significant scope for improving cost recovery. In general, it would be useful to learn from irrigation systems with higher than average cost recovery rate. Between different reuse schemes cost recovery can vary in wide margins (e.g. 13–63%) (Chenini et al., 2003). A third important step is to cut costs. ONAS has launched a comprehensive programme to rehabilitate and extend 19 of its treatment plants (including Ouardanine) in a bid to improve their compliance with standard NT106.02. Aside increasing the plants' capacity, ONAS plans to retrofit the plants with fine bubble aeration systems and/or biogas co–generation facilities to cut back on energy costs while improving water quality. A fourth opportunity is to start selling the treated and composted sludge to farmers and for landscaping.

The willingness to pay for treated wastewater is mostly undermined by the ability of many farmers to fall back on groundwater use, which is free of charge if found above a depth of 50m (FAO, 2009). However, extraction is increasingly unsustainable and there are options to regulate this, e.g. via pumping (electricity) charges. On the other hand, farmers' willingness to pay is increasing if water quality could allow growing vegetables which are the most appreciated cash crop (Abu-Madi et al., 2008).

Socio-economic, health and environmental impact

The Ouardanine project has eliminated raw wastewater discharges to the environment/ocean, while sustaining a strong new economic activity for a local farmer association. This is an example how investments in comprehensive wastewater collection, treatment and reuse can lead to positive impacts, locally and beyond, as marine pollution gets reduced which positively affect the overall economy given the importance of the tourist sector. About 70% of all treatment plants are located in towns and cities along the urban coast. Other positive impacts in the Ouardanine case relate to savings of freshwater, including the stressed groundwater reserves, local employment and support of economic activities and gains along the fruit value chain.

The trust in reclaimed water in Tunisia is based on comprehensive research on the possible impact of irrigation on crops, soils, groundwater and human health, which showed that in general the concentrations of almost all regulated elements in reclaimed water are below the maximum concentration recommended for agricultural reuse by the Tunisian standards (Bahri, 2002; Berglund and Claesson, 2010). However, different treatment processes show different results, with stabilization ponds performing best for microbial indicators, offering opportunities for unrestricted irrigation. Other treatment systems only support restricted irrigation unless other options (e.g. the multi-barrier approach) for pathogen reduction are put in place as promoted by WHO (2006) and IWMI (Amoah et al., 2011). Where crop choice is restricted, like in the example of citrus fruits, care has to be taken that the fruits are not in contact with the soil. To minimize risks, a non-irrigation period of 10–14 days is used in Ouardanine before crop harvest to support natural die-off (Berglund and Claesson, 2010), which is however not always easy as some fruits need regular watering. Occupational risk mitigation options and fencing against third parties will be routine measures to control related impacts. ONAS embarks also on a program to mitigate bad odor (via filtering, spraying, treatment plant coverage) and treats possible mosquito breeding grounds within its treatment premises and canals (MAERH, 2003).

Application of reclaimed water on different soils showed little modifications of their physical and chemical properties, except for a normal increase of salinity as also observed under irrigation with freshwater. However, there are regional differences in salinity level (see above) which can also be influenced by the treatment process making treated water less preferred than groundwater. Aside from salinity, also nutrient supply can be higher in reclaimed water resulting in better annual and perennial crop yields, but might also affect the balance of vegetative growth vs. fruit development. Therefore, irrigation with reclaimed water (and also sludge application) has to be considered as a complementary fertilization that has to be taken into account when calculating fertilizer application rates (Bahri, 2002; Mahjoub, 2016).

Scalability and replicability considerations

Tunisia is setting an exceptional example with higher investments in sanitation than drinking water, which is normally the opposite in the region. It is thus no surprise that it is the most advanced country in North Africa with regards to water and wastewater infrastructure, including regulation. The Ouardanine case, also small in scale, is in this context an excellent example of a decentralized treatment for reuse scheme. Key drivers for the success of the business are:

- A clear regulatory framework permitting reuse for a wide variety of seasonal and perennial crops against the payment of a water fee.
- Governmental will, financial support and inter-institutional cooperation down to water user associations.
- Early participation of the users.

In view of a more or less stagnant reuse rate, Tunisia's plans to multiply the volume of reclaimed water it uses in the years to come, targeting a 60% reuse rate, appears very ambitious, but not totally unrealistic since Tunisia is addressing head-on some of the main challenges that have delayed the development of the reuse sector until now – geographic imbalance, water tariffs, treatment quality and related reuse standards: (i) The geographic challenge is that most water needs are inland while most wastewater generation and easy disposal is along the coast. A major project for 2016–2021 is the planned transfer of treated wastewater from Tunis to the country's arid interior which will include irrigation of 25,000 ha as well as aquifer recharge of 30 million m^3 (World Bank, 2011). This builds on recharge experiments which started already in 1992. (ii) Compared to Egypt, where in the aftermath of the Arab spring authorities are thinking twice about any changes of tariffs, Tunisia used the wind of change to address chronic deficits in its national utilities by raising tariffs. The benefits of a rational increase of freshwater tariffs are threefold: first, it would make reclaimed wastewater more attractive. Second, it may help in saving water. Third, it could be used to recover part of the costs of conveyance and distribution of reclaimed wastewater. (iii) The quality challenge ONAS tries to address through the rehabilitation and extension of its treatment plants. ONAS has identified 48 plants (including Ouardanine) that it wants to equip with tertiary treatment facilities. The plants are located in areas with significant irrigation needs and the programme's objective is to produce 150 million m^3 of effluents treated at tertiary level (GWI, 2012) which would support unrestricted irrigation if the newly revised (but not yet published) reuse standards provide space for this option. For about 96% of the surveyed farmers by Abu-Madi et al. (2008) improving the quality of treated wastewater and allowing unrestricted irrigation have the power to change the negative attitudes of farmers with respect to reuse.

However, these measures might not be sufficient and attention will also be required to address other reasons for low reuse demand. Farmers complain for example about a mismatch in seasonal supply and demand which requires more investments in inter-seasonal storage facilities. Another key challenge is that compared to, for example, Jordan or Israel, many irrigators in Tunisia have more choices about which type of water to use than wastewater. In distinct contrast to, e.g. Israel and Jordan, reclaimed wastewater in Tunisia has not been mixed into reservoirs or aquifers or is by law replacing freshwater, thus many farmers can simply avoid using it, and opt for shallow groundwater which only costs pumping (FAO, 2009; Kfouri et al., 2009). To allow reuse to boom, the use of alternative water sources has to be restricted, like through higher electricity or diesel charges for pumping or aquifer protection by delineating perimeters where the quantity and quality of groundwater is compromised. Shallow groundwater accounts for 40% of groundwater use. This is now used almost exclusively for agriculture and it is being over-exploited nationally as demand exceeds supply. Faced with this situation, the government already decreed that a number of aquifers would be protected and drilling would be subjected to prior approval. The government also subsidizes water saving techniques up to 60% of the investment costs in irrigation systems when switching from traditional furrow irrigation to more water-saving methods like sprinklers or drip irrigation (Mahjoub, 2016).

Summary assessment – SWOT analysis

The strength of this business case is in its inter-departmental institutional setup with representation from the sanitation sector, environmental protection, health, agriculture and water users, a clear regulatory framework, charges for reclaimed water and promising options for increasing cost recovery

aside a strong governmental will to support treatment and reuse. The regulatory framework is offering a variety of crop options although it could be extended in line with WHO (2006). Figure 213 presents the SWOT analysis of the Ouardanine case within its larger context.

FIGURE 213. SWOT ANALYSIS FOR OUARDANINE WASTEWATER AND AGROFORESTRY SYSTEM

	HELPFUL TO ACHIEVING THE OBJECTIVES	**HARMFUL** TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ▪ Sound institutional arrangements across agriculture–sanitation sectors ▪ Multiple choices of crops and high economic benefits to farmers ▪ Early farmer participation and sale of treated wastewater at reduced price ▪ Reasonable O&M cost recovery with options for improvement ▪ Continuous availability of wastewater, especially if inter-seasonal storage is supported ▪ Investments in cutting energy costs ▪ High compliance with safety standards	**WEAKNESSES** ▪ Use of reclaimed water remains under potential ▪ Tertiary treatment needed to support water acceptance and unrestricted reuse ▪ Sludge use undervalued ▪ No legal provision for risk management to allow unrestricted irrigation of vegetables ▪ Monitoring of heavy metals should not be underestimated
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ▪ Political commitment with increasing private sector support ▪ Current revision of reuse standards, planned investments in tertiary treatment, and transfer of reclaimed water to high demand areas ▪ Willingness to increase freshwater tariffs to make reclaimed water more attractive ▪ Opportunity to sell treated sludge ▪ Cost recovery for reclaimed water supply would increase by restricting groundwater access	**THREATS** ▪ Mismatch between governmental push for reuse and public perception of reuse ▪ Monitoring failure can lead to loss of trust with high costs beyond this reuse scheme ▪ Availability of alternative water sources with less risk (seasonal variation in quantity and quality, public perception)

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Case descriptions are based on primary and secondary data provided by case operators, insiders or other stakeholders, and reflect our best knowledge at the time of the assessments 2014/16. As business operations are dynamic data can be subject to change.

Notes

1 In 2007 average public irrigation costs with freshwater were USD 0.097/m^3 and the average tariff applied was USD 0.084/m^3 – a national average cost recovery rate of 87%. Total cost recovery, however, based on infrastructure and operating cost remains low at 25% (FAO, 2009).

2 As at end of June 2009, the private sector operated 2,206 km of sewers and 17 wastewater treatment plants. It is also worth mentioning that the new regulations stipulate the adoption of concession contracts that can extend the contracts up to 30 years (ONAS, 2009).