Case Study 7: Jordan

Wadi Musa wastewater treatment plant and the Sadd al Ahmar alfalfa irrigation area

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Acronyms

ADC	Aqaba Development Corporation		
ASEZ	Aqaba Special Economic Zone		
ASEZA	Aqaba Special Economic Zone Authority		
AWC	Aqaba Water Company		
MWI	Ministry of Water and Irrigation		
JPTD	Jordan Projects for Tourism Development		
USAID	United States Agency for International Development		
WAJ	Water Authority of Jordan		
WWTP	Wastewater Treatment Plant		

History and project justification

Jordan's *National Water Strategy* underlines the important role of water recycling in meeting Jordan's water needs including the need to use treated wastewater as an additional source of water that can be used for irrigation purposes. The Water Authority of Jordan (WAJ) estimates that by 2025 treated wastewater will form 16% of its annual water budget.

The Wadi Musa Wastewater Treatment Plant (Wadi Musa WWTP) is central to this strategy. It is in the southern part of Jordan, close to the historic city of Petra, and is owned by the Aqaba Governorate. It started operations in 2001 to serve 20,000 inhabitants with its main purpose being to treat collected wastewater from hotels in Petra and nearby residential areas. The plant services four communities which are adjacent to the Petra Archaeological Park – Wadi Musa, Taiba, Umm Sayhoun and Beidha (AWC 2021; WAJ 2021).

Wadi Musa WWTP's design capacity is 3,400 m³/day while the current amount of wastewater treated is 2,796 m³/day. Recycled water is used for irrigation by agricultural communities in Sadd al Ahmar area as part of the reuse project. These communities depend mainly on livestock and fodder cultivation and have historically relied on groundwater and discharged treated wastewater as a water source. The idea to create a water reuse project to benefit these communities was developed and later implemented by WAJ with the support of USAID funds (AWC 2021; WAJ 2021). It is the first community-based project established in Jordan.

The reuse area is located 10 km north of Petra and is adjacent to the Wadi Musa WWTP where up to 100 ha are irrigated using reclaimed water (Figure 7.1). This is benefiting 80 farmers and



FIGURE 7.1 Wadi Musa WWTP location map. SOURCE: Google Earth.

their families whose land is mainly cultivated with fodder crops, mostly alfalfa. The farmers practicing reclaimed water irrigation belong to the Sadd al Ahmar Farmers' Association as part of the project.

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Reuse case description at a glance

Wastewater is collected from hotels in Petra city and nearby areas via a wastewater collection network that serves a population of 20,000. Once collected, the wastewater is transferred to the Wadi Musa WWTP (AWC 2021).

Collected water undergoes three stages of mechanical treatment at the plant: primary (grit removal and sedimentation tanks), secondary (biological activated sludge and nitrogen removal) and tertiary (polishing ponds followed by chlorination disinfection) (Figure 7.2) (Image 7.1). Over time, the plant efficiency has dropped with farmers who use its recycled





FIGURE 7.2 Wadi Musa WWTP: Schematic diagram for the treatment process and reuse discharge areas.

IMAGE 7.1 Aeration tanks (left) and storage tanks (right) at Wadi Musa WWTP.

water for irrigation complaining of a decrease in water quality, particularly its increased salinity, which affects drip irrigation systems.

Wadi Musa WWTP produces 2,796 m³/day of treated wastewater. This water is transferred to 80 farms around Sadd al Ahmar, an area of 100 ha, to be reused to irrigate fodder crops, mainly alfalfa. The water is given to the farmers at no charge as part of the community-based project's aims to encourage new businesses. The farmers use a drip irrigation system to save water (ACW 2021; WAJ 2021).

This new water source is helping the local community in the Sadd al Ahmar area to work in farming and is creating jobs for the local community including women who are employed for crop harvesting. It is important to note, however, that full gender-disaggregated data is not yet available.

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National institutional and policy environment

The Ministry of Water and Irrigation (MWI), which is currently undergoing restructuring, has set guidelines in its *National Water Strategy* that move Jordan toward establishing an institutional capability to monitor, regulate and enforce wastewater regulations including:

- Expanding wastewater collection and treatment capacity to cover all of Jordan as set out in the 2013 National Wastewater Master Plan.
- Expanding the decentralized wastewater systems.
- Involving the private sector in the operation and maintenance of the wastewater treatment plants.
- Ensuring that treated effluent complies with recently established national standards (JS893- 1995).
- Increasing the use of recycled water for irrigation including for selected crops that suit the irrigation water quality.
- Minimizing environmental risks including specific risks to groundwater aquifers in the development of water reuse systems.
- Setting standards for the construction and management of septic tanks where it is not feasible to have sewerage collection systems and treatment facilities.

In addition, it is a legal requirement that:

- Any building served by a wastewater collection network must connect to the collection system if available.
- An industrial entity cannot connect to the domestic collection system unless its effluent quality is accepted.

The WAJ is responsible for the implementation of Jordan's national wastewater policy and strategy and is currently working as a regulator for the wastewater sector. Operations are

carried out by governmental companies (Yarmouk, Miyahuna and Aqaba Water Companies). Within the WAJ, the Planning and Management Department coordinates and monitors wastewater treatment plants. The Aqaba Water Company (AWC) manages the Wadi Musa WWTP (AWC 2021; WAJ 2021).

Stakeholders involved and management model

In Jordan, the MWI is responsible for strategy and donor cooperation including overall planning in the water and sanitation sectors. The WAJ is responsible for the service providers, while the AWC is responsible for water and sanitation services in the southern governorates.

The Wadi Musa WWTP plant is operated by the AWC, which operates and maintains the plant and the sewerage network serving the Petra and Wadi Musa areas (WAJ 2021). It cooperates with all relevant stakeholders in the area to improve water and sanitation services. For example, there is a cooperation agreement with the Royal Scientific Society for testing services for pumps, pipes and other tools and equipment, and similarly, one with the Jordan Standards and Metrology Organization on adopting water quality standards. Both the Ministry of Environment and the Ministry of Health have a monitoring role to protect the environment and human health (Figure 7.3).



FIGURE 7.3 Stakeholder and management model: Schematic diagram.

The AWC manages the Wadi Musa WWTP as well as the transmission line and booster stations along the line to the Sadd al Ahmar area. The recycled water's distribution to the farms is managed by the Sadd al Ahmar Farmers' Organization, which also manages the marketing and sales of the alfalfa crops at local markets.

The Ministry of Agriculture supports the farmers with training programs on using the drip irrigation system and about the nutrients contained in the recycled water. The high nutrient content of the recycled water means that they no longer need to use fertilizers on their alfalfa crops (as revealed during meetings with Sadd al Ahmar representatives).

Funding and financial outlook and cost recovery

The construction of the Wadi Musa WWTP, reuse transmission line, booster stations, storage tanks and irrigation network were funded by USAID. The operation and maintenance (O&M) costs for the plant and transmission line are covered by the AWC and includes staff salaries, electricity, fuel, spare parts and chemicals (Table 7.1).

The capital expenditure (CAPEX) of the wastewater infrastructure including the sewerage network and the treatment plants is mainly covered by donors' grants with a 10–20% government contribution. The estimated percentage of cost recovery for operation and maintenance cost ranges from 50-70% collected from two sources. The first source is subscription fees while the second source is water consumption bills where a cost percentage that varies from 0.04-1.1% is added to domestic water consumption costs for sanitation services. The government estimated subsidy ranges from 30-50%.

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Socioeconomic, health and environmental impacts and benefits

It is clear that the sewerage network and wastewater treatment are helping to protect human health and the environment in Petra city and Wadi Musa, minimizing the number of septic tanks still in use to just a small area not connected to the sewerage network. Another major health and environmental benefit is the reduction of risk of microbial contamination to groundwater, soil and crops from the septic tanks or raw wastewater discharge in the *wadis* – valleys, rivers and channels that are dry outside the rainy season.

In terms of socioeconomic impact, this new water source is bringing opportunity to 100 farms that are now using it to cultivate alfalfa crops for fodder, creating jobs for 200 to 300 people, including opportunities for women. The families working in the farming activities have been able to generate income from the farms, which is helping them to settle in their areas instead of moving to the big cities for work. In addition, the location of the Wadi Musa WWTP near the reuse project has created jobs for the local community in the operation and maintenance of the plant and the transmission lines.

As the recycled water is rich in nutrients, there are also savings from fertilizer costs. Yields are also increasing by 10 to 15%. Charging fees are also minimal at less than USD 0.2/m³.

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Gender equality

A study led by the Women Studies Unit of the Ministry of Water and Irrigation in Jordan (USAID 2018) assessed the status of more than 1,200 women working in the water supply and sanitation services across the country. The study revealed that only 11% of employees in the water sector are women and recommended that improved facilities such as nurseries and additional training could help increase this number, particularly in operations where the percentage is much less. There is also a perception of the water sector as a masculine area of work, particularly when it comes to the long hours and physical fieldwork. At the Wadi Musa

	Wastewater collection and transport	Wastewater treatment	Transport of recycled water	Additional waste- water treatment for reuse	Distribution of reclaimed water to end-users
Construction and equip- ment services (description and dimensions)	90 km of 200- 500 mm di- ameter sewers and four pump stations	Extended Aer- ation	Water pumped 10 km to farming project	None	Water pump for 10 km transmis- sion to storage tanks on the farms
Stakeholder that delivers the service	Aqaba Water Company	Aqaba Water Company	Aqaba Water Company	None	Sadd al Ahmar Organization
CAPEX (in USD)	26,000,000	19,100,381.61	*2,000,000	None	*350/1,000 m²
CAPEX recovery and % of sub- sidy	X recovery % of sub- % government contribution of 10–20%			Farm drip irri- gation systems funded by farmers	
O&M services (description)	Jet System, Closed-circuit Television (CCTV), man- hole covers, replacement of damaged or corroded sewers	Replacement of damaged parts, removal of grit, oil screenings and sludge	Fix booster sta- tions/ transmission lines leakage	None	Fix drip irrigation blockages and distribution lines leakage
Stakeholder that delivers the service	Water Authori- ty of Jordan	Aqaba Water Company	Aqaba Water Company	Aqaba Water Company	Sadd al Ahmar Association
OPEX (in USD/ year)	65,000	500,000 /year	None	None	*35/1,000 m2
OPEX recovery	*50-70%				
sidy	*Subsidy 30 to 50%				

TABLE 7.1 Wadi Musa WWTP: Funding and financial outlook and cost recovery.

SOURCE: AWC 2021, WAJ 2021. Notes: Capital Expenditure (CAPEX). Operations and Maintenance (O&M), Operating Expenditure (OPEX). *= Estimated figures.

WWTP, all the operation and management work is done by men. One major reason for this is that the location of the plant is far from Petra city, combined with the type of work, the long hours and the night shifts.

The potential for increased employment opportunities for women through water reuse cases is promising. A UN study showed that women's participation in the agricultural sector remains a critical source of employment for the country's poorest citizens and a major source of food security (UN Women and REACH 2018). The percentage of women working in farming activities as part of the Sadd Al Ahmar reuse project ranges from 10 to 15% (UN Women and REACH 2018).

Resilience to COVID-19

In 2020, the working hours and movements of staff and farmers were restricted due to the COVID-19 pandemic, including a period of full lockdown from February to April. During that period only key staff members were allowed to work. This was followed by a period where staff capacity was reduced to 50%. However, the Wadi Musa WWTP was able to stay functioning and farmers stayed working and irrigating their farms as usual but with less labor.

Scalability and replicability potential

Every newly constructed WWTP in Jordan has an associated water reuse plan. Most plants discharge their treated wastewater to the *wadi*, which goes on to be stored in dams. From the dams, the recycled water is mixed with stormwater, and transferred to the Jordan Valley for irrigation purposes. A few plants like Wadi Musa WWTP have a specific reuse project for their water, where in this case, 100% of recycled water is transferred to the reuse project.

The Wadi Musa WWTP and Sadd al Ahmar reuse model can be considered a success. Having a new source of water has enabled farmers to cultivate their land and generate income for their livelihoods. It is helping the local community stay in their area and build their own farming business. This is an approach that can be replicated in other areas. However, this model relied on full governmental support and donor support to fund the infrastructure for the wastewater treatment plant and the reuse transmission and distribution network. Other elements contributing to this success is the minimal charging fees for the reuse of water (less than USD 0.2/m³) and the establishment of the Sadd al Ahmar Farmers' Association, which helped the farmers with technical assistance on how to start and maintain their projects and how to market their farm products.

SWOT analysis

The strengths, weaknesses, opportunities and threats (SWOT) analysis for the Wadi Musa WWTP and Sadd al Ahmar alfalfa irrigation area is shown below (Table 7.2). The main analysis outcomes are that the reuse water project has helped to create jobs for the local community, saving groundwater for drinking uses and protecting the environment.

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Key factors for the success along the project and lessons learned

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

- Governmental support at all levels including funding of main lines and distribution networks.
- No charging fees.
- The close location of the farms to the treatment plant requires a 10 km transmission line.
- The topography of the area is almost flat so minimal pumping is required.
- Suitable crops such as alfalfa grow in the area producing good yields.
- A drop in fertilizer use and cost due to water type that is rich in nutrients.

TABLE 7.2 Wadi Musa WWTP and Sadd al Ahmar reuse case: SWOT analysis.

	HELPFUL TO ACHIEVING THE OBJECTIVES	HARMFUL TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	 STRENGTHS Availability of a new source of water (3,000 m³/day) Farming opportunities for the local community. Jobs and a source of income for the local community (200 to 300 people have benefited from the Sadd al Ahmar reuse project so far Visible environmental benefits by increasing the green area Saved groundwater for drinking purposes Less use of fertilizers 	 WEAKNESSES Dependency on governmental funding Farmers pay minimal charges for treated wastewater Limited crops are suitable Surplus water in winter with no use
XTERNAL FACTORS TTRIBUTES OF THE ENVIRONMENT	 OPPORTUNITIES Investment opportunities in agriculture and industry High potential for energy recovery and organic fertilizer production Rural development (land and infrastructure) New settlements 	 THREATS Project sustainability Environmental/health risks due to poor maintenance Odor problems Drop in land value due to the existence of the wastewater treatment plant Blockages in the drip network due to salinity increase

Lessons learned include:

- The local community is cooperative with such projects once there is governmental support.
- Farmer awareness about efficient irrigation will decrease used water amounts and reduce operation and maintenance costs.
- Facilitation of governmental procedures will encourage farmers to benefit from governmental support.

Methods and resources

Wadi Musa WWTP is managed and operated by the AWC. To access data about the plant, an official request needs to be sent through the WAJ who forwards it to the AWC. Once the requested information is prepared by AWC, it must be processed and screened through the WAJ's Rights to Information Section in Amman before it is released. Direct communication with staff at the plant is not allowed.

For this purpose, a letter requesting the required data for plant characterization was sent to the Secretary-General of the WAJ in May 2021 using the required template. Other sources of information used in this water reuse case study include published WAJ reports, the AWC website and other related websites, and information from previous studies.

It took two weeks for the data request to be processed, approved and delivered. The consultant reviewed the data and compiled it as needed into the template. Where data were missing, the consultant made an informed judgment based on experience, and by comparing information about Wadi Musi WWTP with other similar plants.

Other sources of information used to gather data for this case study included the WAJ's website, meetings with Sadd al Ahmar representatives and various WAJ publications.

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