Wastewater Treatment Plant in Wadi Esseir ©Manfred van Afferden

Regional Wastewater Infrastructure Development Strategies for Jordan and Palestine

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KEY FINDINGS

The GIS-based tool SWAMP (Multi-Scale Wastewater Master-Planning) was developed within the SALAM Initiative to estimate the additionally required wastewater infrastructure at high temporal and spatial resolution.

By 2050 it is expected that 954 Mio. m^3 per year of wastewater will be generated in Jordan and the West Bank, Palestine, which represents a significant water reuse potential, provided that it is safely collected and adequately treated.

The SWAMP tool was used to develop two technical options -decentralized and centralized- for expanding wastewater infrastructure.

As results, the required infrastructure and costs of centralized and decentralized expansion options for wastewater treatment and reuse in the region were defined.

MOTIVATION

The increasing water deficit in the Middle East is due to a combination of a rapid increase in water demand and a rapid decline in available water resources. Against this background, the SALAM initiative explored sustainable options for the provision of additional freshwater resources to meet the region's future water needs. In the context of an Integrated Water Resources Management (IWRM), wastewater is a resource that has not been sufficiently tapped in the region so far. However, wastewater can only be considered a reusable source for irrigation and other purposes if it is properly collected and adequately treated, thus also protecting existing water resources from pollution. Within the SALAM Initiative, a GIS-based Multi-Scale Wastewater Master-Planning (SWAMP) tool was developed to i) quantify the current and future wastewater potentials with a spatial and temporal distribution, ii) develop country-wide expansion options for the wastewater management infrastructure, iii) estimate the infrastructure demand for the expansion options, and iv) estimate the related costs.

METHODOLOGY

The Global Human Settlement database (GHSL, 2019) provides data on population distribution at a 250 x 250 m resolution. These data were used as the main data base for the analysis and were cross-checked and supplemented with local information from Jordan and the West Bank such as population, villages, governorates, demand clusters, topography, connection degree, and water consumption. Within each grid cell, proxy data were generated e.g. a correlation between the street and the sewer network, to estimate the sewer demand for the areas, which currently lack infrastructure.

A strategic goal of the SALAM Initiative is to increase the population share connected to wastewater collection and treatment facilities to 95% by 2050. To achive this, two main development options were investigated: centralized and decentralized expansion of the wastewater management and reuse infrastructure. For both options, the sewer network requirements at settlement level were estimated. In the centralized expansion option, water flows by gravity through pipelines to a single wastewater treatment plant (WWTP) located near the outflow point of each surface

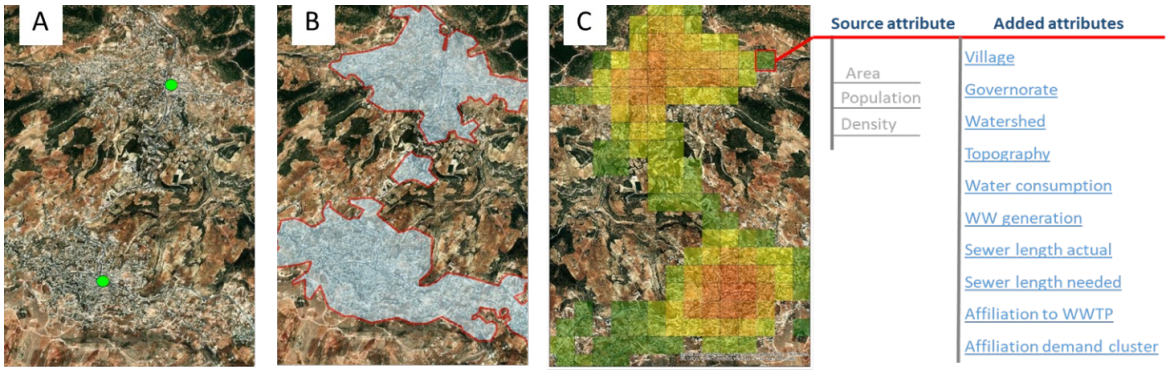

Figure 1: Various data representing the same settlement. A: Settlement is presented as a point Geo-data. B: Polygon Geodata showing the settlement. C: The settlement is shown as a combination of gridr cells, where the data of each cell is calibrated and supplemented with local data.

catchment. The surface catchments were defined by the location of the main dams and wadi outflow points with preference given to gravity sewer systems and consequently minimizing the need for wastewater pumping. The treated effluent is then to be used in the Jordan valley. In the decentralized expansion option, WWTPs are located in the immediate vicinity of the individual settlements. The treated wastewater is preferably reused locally or discharged into the wadis leading to the Jordan Valley.

Expansion costs were calculated using the estimated infrastructure requirements in terms of capital investment, reinvestment, and operation and maintenance (O&M) costs. Local and international benchmark cost data were used and the net present cost of the whole system was calculated over 60 years for each expansion option according to the DWA (2011) guidelines. Based on the calculated net present cost, the specific treatment costs for each surface catchment and expansion option are available to identify the most cost-effective option.

RESULTS

At different scales (regional, local), the SWAMP tool enables both an assessment of the current wastewater management situation as well as the development of technical expansion options and forecasts of the wastewater generation (year 2050).

Currently, Jordan has 33 centralized wastewater treatment plants, where approximately 65% of the total wastewater is treated (288 Mio.m^3 per year as of 2020). Reports indicate that approximately 90% of the treated effluent is reused in Jordan (MWI, 2015). In the West Bank 10 centralized wastewater treatment plants receive and treat 16% of the wastewater (60 Mio.m^3 per year as of 2020) with a 30% reuse rate (Figure 2) (HWE, 2012).

Assuming water supply increases by 2050 according to the [Water Production and Transfer Strategies, p. 22], Jordan and the West Bank will annually generate 666 Mio.m^3 and 286 Mio.m^3 of wastewater respectively. At the same time, the agricultural water demand will increase to 965 Mio. m^3 per year in Jordan and 787 Mio.m^3 per year in the West Bank [Future Freshwater Deficits in Palestine and Jordan, p. 18], meaning that up to 69% and 36%, could be covered by the reuse of treated effluent.

Although a significant part of the agricultural water demand can potentially be covered by the reuse of treated effluent, the spatial distribution of the treated effluent is a challenge to overcome (Figure 3). For instance, the

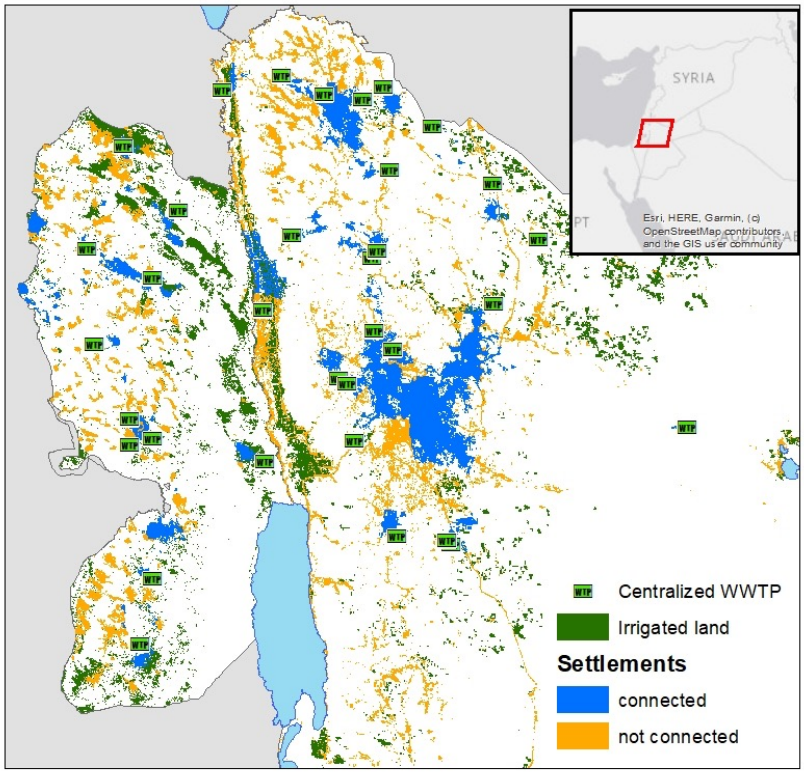

Figure 2: Current wastewater management in Jordan and the West Bank

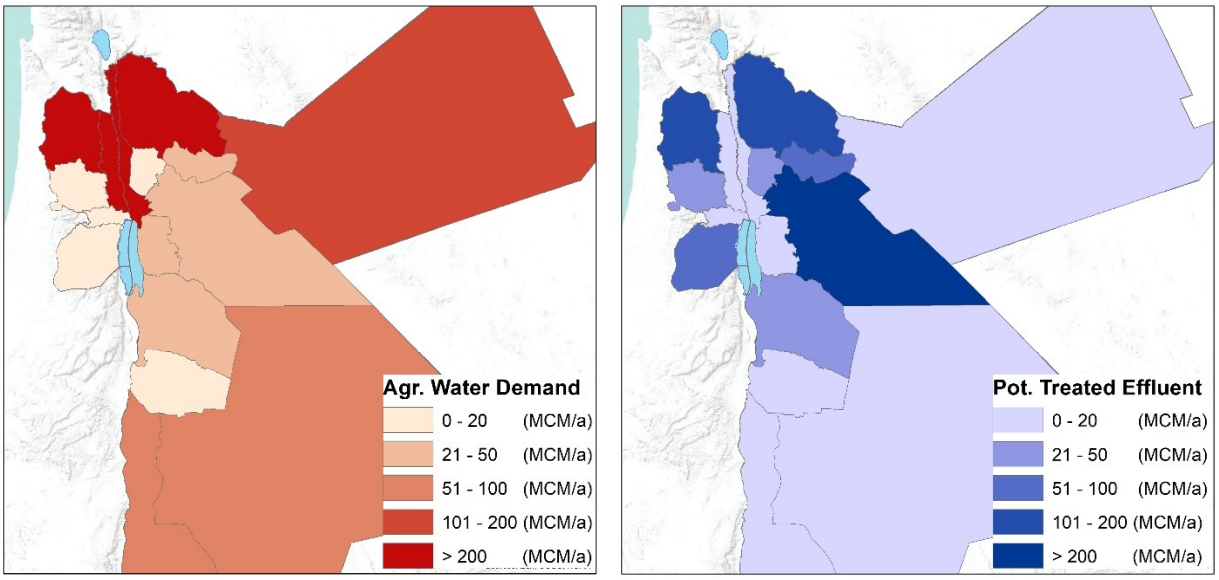

Figure 3: The agricultural water demand (left) and the treated effluent potential (right) of the region projected for 2050

southern clusters in the West Bank will produce more treated effluent than the agricultural water demand, while additional quantities of treated effluent will be required in the north for irrigation.

In Jordan the amount of treated effluent will exceed the agricultural water demand in the northern and central part of Jordan, so that the transport through trunk lines to areas with high agricultural water demand (e.g., Jordan Valley) might be a viable reuse solution. Considering that some clusters produce more treated effluent than their agricultural reuse demand, the combination of centralized and decentralized expansion options should be implemented. This way, surplus treated effluent can be transported to clusters with high demand to increase the reuse efficiency, while a local treatment and reuse level is suggested for the areas with high agricultural demand.

Table 1 shows the estimated infrastructure requirements for the centralized and decentralized expansion and management options for 2050.

CONCLUSIONS

Safe collection and adequate treatment of wastewater is of imminent importance in the Middle Eastern region, which suffers from increasing water deficits. A tool capable of planning wastewater infrastructure and estimating its cost is crucial for the successful implementation of sustainable water management. The SWAMP tool developed within the SALAM initiative allows an analysis and pre-planning process with high spatial resolution. For each settlement and city, demand cluster, and the entire region the demand for wastewater management and reuse infrastructure can be estimated. As a result, the projected wastewater potential for 2050 was assessed for both Jordan and the West Bank and the required wastewater infrastructure estimated. The SWAMP tool can be used as a preparation tool for investment projects in Jordan and Palestine and is transferable to other regions once the database is calibrated through region-specific data.

COUNTRY	EXPANSION OPTION	LOCAL SEWERS (KM)	TRUNK LINES* (KM)	WASTEWATER TREATMENT PLANTS**	TREATED EFFLUENT FOR REUSE (MIO.M³/A)	SPECIFIC TREATMENT COST (€/M³)
Jordan	Central	8,819	1,790	26	633	1.09
	Decentral	8,819	466	370	520	1.812
West Bank, Palestine	Decentral	6,576	-	243	272	0.99

*Trunk lines for raw wastewater for the centralized option and treated effluent for the decentralized option
**The sizes of the wastewater treatment plants range from 100 (Person Equivalent PE) to 370,000 PE

Table 1: Required infrastructure for the expansion options in 2050

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Funding code: 02WM1533C

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