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INTEGRATED WASTEWATER MANAGEMENT IN THE MEDITERRANEAN

Good practices in decentralised & centralised reuse-oriented approaches

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Agence du Bassin Hydraulique
du Souss Massa et du Drâa

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ABOUT SWIM-SUSTAIN WATER MED

The SWIM-Sustain Water MED project involves a network of demonstration activities for sustainable integrated wastewater management and reuse in Jordan, Egypt, Tunisia and Morocco. The project is part of the Sustainable Water Integrated Management (SWIM) Programme, a regional technical assistance programme launched by the European Commission to contribute to the extensive dissemination and effective implementation of sustainable water management policies and practices in the Southern Mediterranean Region. Sustain Water MED is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH together with 7 national, regional and European partners.

For more information see *www.swim-sustain-water.eu*

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INTRODUCTION

Egypt, Jordan, Morocco and Tunisia belong to some of the most water-scarce regions in the world. In addition to this, they face high population growth, accompanied by increased rates of water consumption due to urbanisation and expansion in agriculture. All four countries have gradually invested in wastewater treatment plants, but still lack infrastructures to treat the amount of wastewater produced, especially in rural areas. Besides the collection and treatment of wastewater, other major challenges include connecting the population to sewerage systems, and the installation of sanitation facilities in public buildings and private households. The countries have already adopted policies and plans to improve the situation of wastewater treatment and to make better use of non-conventional water resources. However, the practical implementation of these policies is often still lacking.

Against this background, the project Sustain Water MED implemented pilot projects with the aim of demonstrating the potential of integrated wastewater management, including decentralised treatment systems, ecological sanitation, and water reuse. More specifically, Sustain Water MED seeks to demonstrate effective and cost-efficient wastewater management, treatment technologies, and reuse practices through four pilot projects implemented in Egypt, Jordan, Morocco and Tunisia. The demonstration projects were accompanied by assessments of environmental and socio-economic effects, and capacity development measures for decision-makers and technical staff in the relevant institutions at national and local level. Another objective was to reach out to water users through targeted events and information centres. These were intended to provide valuable opportunities to raise awareness among the local population in each pilot project on potential benefits of integrated wastewater management and effluent reuse technologies in terms of increased agricultural production as well as improvement of sanitary and environmental conditions. Through regional networking and knowledge exchange between the four pilot projects implemented within Sustain Water MED, and via the formulation of policy recommendations, this project hopes to encourage integrated wastewater management and reuse in the Southern Mediterranean region.

Each pilot project within Sustain Water MED took a different approach, adapted to the local needs and conditions. In Egypt, the project is establishing a decentralised wastewater treatment unit at village level in a rural area. In Jordan, a decentralised wastewater treatment unit has been constructed for a building complex in a semi-urban area, and a reuse scheme has been developed for landscape irrigation. A different approach was adopted in Morocco, where the project is implementing a comprehensive strategy for eco-sanitation in a village, demonstrating the benefits of locally adapted technologies. In Tunisia, the project is implementing a wastewater quality surveillance system at the level of an existing wastewater treatment plant, enabling data sharing between water users and providers, in order to promote the safe usage of treated wastewater for agricultural purposes.

The main objective of this Compendium is to present these four pilot projects in greater detail, and more specifically to:

MAIN OBJECTIVES OF THIS COMPENDIUM ARE TO:

Describe the local challenges faced starting from the context of each project, the technologies chosen to overcome these specific challenges and the respective project realization in terms of institutional structure.

Present potential benefits and risks in terms of environmental and socio-economic effects, as well as specific lessons learned from each pilot project.

Draw overall lessons learned from project implementation, considering all four pilot projects in terms of challenges and good practices.

Formulate recommendations for policy-makers on how to create an enabling environment for integrated wastewater management and reuse in the Mediterranean.

This Compendium was compiled based on baseline assessments and other project reports provided by the project partners, including documentation of the final adjustment of the four pilot projects, technical descriptions, and first performance results of the technologies applied in each pilot project. Valuable additional information was gathered during meetings with the national steering committees and interviews with stakeholders on the local level which took place in each country to study social, environmental and economic effects of the four pilot projects.

INTEGRATED WASTEWATER TREATMENT & REUSE

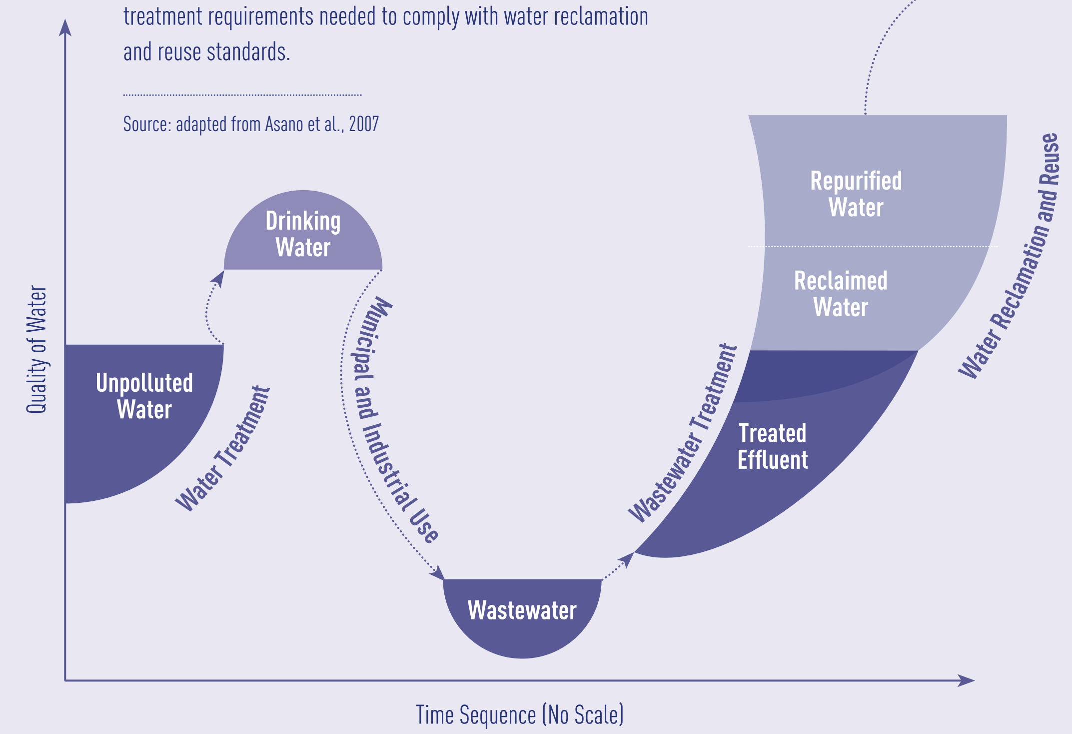
GENERAL CONCEPTS

Wastewater reclamation and reuse practices consist of the treatment or processing of wastewater in order to make it reusable in a variety of beneficial ways. Generally, any water reuse project ought to provide a reliable wastewater treatment in order to comply with water quality requirements for the intended reuse application and to ensure public health protection. At the same time, a successful longterm water reuse project should seek to gain public acceptance as well as economic sustainability. The overall goal of any water reuse initiative is to close the hydrological cycle on a much smaller, local scale. In this way, after proper treatment, the used water becomes a valuable resource, instead of merely waste to be disposed of.

In the planning and implementation of water reuse, the intended applications govern the degree of wastewater treatment required and the reliability of wastewater treatment processing and operation. In principle, wastewater or any marginal quality water can be used for any purpose, as long as adequate treatment is provided to meet the water quality requirements for the intended use. The dominant applications for the use of reclaimed water include agricultural irrigation, landscape irrigation, industrial recycling and reuse, and groundwater recharge. Of these applications, agricultural and landscape irrigation are widely practiced throughout the world, with well-established health protection guidelines and agronomic practices *(Asano et al., 2007)*.

In general, the success of a reuse initiative requires several levels of assessment related to: public health, infrastructure and facilities planning; the intended reuse of the reclaimed water; wastewater treatment plant (WWTP) location; reliability of the treatment process; economic and financial feasibility; and water utility management. The varied interests of different stakeholders including those representing the environment must also be considered.

In order to respond to short-term needs, as well as to increase the reliability of long-term water supplies, public policies (e.g. water resources planning) need to be implemented so as to promote water conservation and reuse rather than the costly development of additional water resources with considerable environmental expenditures. There is a growing trend to consider water reuse practices as an essential component of integrated water resources management. The quality of reclaimed water represents one of the main determinants for the feasibility of any water reuse initiative, as it defines the requirements of the treatment facilities for upgrading wastewater quality to the standards stipulated by regulatory agencies for protecting the environment and health.



Over the past decades, treatment requirements for wastewater discharge and reuse were met following a conventional centralised approach consisting of the construction of a sewer network connecting several scattered communities to a centralised wastewater treatment facility. However, due to large investment costs (especially for the conventional sewer systems, which become even higher when provided to sparsely populated small communities) and related operation and maintenance (O&M) costs, this type of approach does not guarantee affordability – especially in the context of rural wastewater management.

In order to overcome these economic constraints in rural areas that still suffer from inadequate sanitation, wastewater needs to be managed as close as possible to its source and where its beneficial reuse is located. In a decentralised treatment approach, the transporting of wastewater from generating communities should be minimised in order to reduce the spread of pollution and the associated costs for pumping and pipes *(Bakir, 2001)*.

Ecological Sanitation offers a comprehensive package of sustainable solutions for rural areas (as well as in urban areas), providing a sustainable, closed-loop system, which closes the gap between sanitation and agriculture. The underlying aim is to close (local) nutrient and water cycles with as little expenditure on material and energy as possible to contribute to sustainable development. Human excreta are treated as a resource and are usually processed on-site and then treated off-site. The nutrients contained in excreta are then recycled – primarily through use in agriculture *(Langergraber et al., 2005)*.

BENEFITS & RISKS OF WASTEWATER REUSE

With many countries approaching the limits of their readily available water supplies, water reclamation and reuse has become an attractive option for preserving and extending available water supplies. When integrated into water resources management, water reuse may be considered as an integral part of an environmental pollution control and water management strategy, fostering benefits to public health, the environment, and economic development. Reclaimed water may provide significant additional amounts of renewable and reliable water, and contribute to the conservation of freshwater resources. Furthermore, it may be considered as a valuable source of water and nutrients in agricultural schemes and therefore contribute to reducing the use of chemical fertilisers and to increasing agricultural productivity.

The reuse of reclaimed water, if properly managed, may alleviate pollution of water resources and sensitive receiving bodies. It may also contribute to desertification control and desert reclamation. Saline water intrusion may be controlled in coastal aquifers through groundwater recharge operations. Other social and economic benefits may result from such schemes, including employment and products for export markets.

In brief, the main benefits potentially ensured by implementing water reuse practices can be summarised as follows – and nevertheless, a number of risks are associated with water reuse and warrant specific attention in agriculture:

BENEFITS

Saving high quality freshwater, by substituting it with reclaimed water for applications that do not require high-quality water supplies;

Augmenting water sources and providing an alternative source of supply to assist in meeting both present and future water needs;

Protecting aquatic ecosystems by decreasing the diversion of freshwater, and reducing the quantity of nutrients and other toxic contaminants entering waterways;

Reducing the need of chemical fertilisers for agriculture due to the nutrient content in treated wastewater;

Complying with environmental regulations by better managing water consumption and wastewater discharges.

RISKS

Health risks to agricultural workers resulting from the irrigation of fields with untreated or inadequately treated wastewater, and to consumers of agricultural goods produced using untreated or inadequately treated wastewater;

Environmental risks related to the contamination of soils and plants through the introduction of chemicals in inadequately treated wastewater and ground/surface water pollution from the infiltration of contaminated irrigation water.

Any wastewater reuse project has to prevent negative effects on public health since wastewater content in mineral and organic trace substances and pathogens represents a risk for human health. The reuse of inadequately treated wastewater may entail direct and indirect risks to human health caused by the consumption of polluted crops and fish. It may also represent a risk for farmers, who are in direct contact with wastewater and contaminated soil. In addition, the reuse of unsuitable wastewater in agriculture may also lead to livestock infections.

Furthermore, it must also be taken into consideration that municipal wastewater is increasingly loaded with further potentially harmful substances such as heavy metals, trace pollutants including organic and inorganic compounds, and emerging contaminants such as pharmaceutical substances, all of which must be removed prior to wastewater reuse. Of course, the uncontrolled discharge of untreated industrial streams into the sewerage network may also further impair treated wastewater quality, according to the type of industrial process and the contaminants discharged.

In environmental safety terms, unregulated irrigation with wastewater may lead to problems such as the deterioration in soil structure (soil clogging due to high content of suspended solids (SS) in treated wastewater), which results in poor infiltration, soil salinisation, and phytotoxicity. An example is given by Jordan, where salt levels in the soil tend to increase in areas that are irrigated with treated wastewater. This is attributed to the salinity of wastewater as well as on-farm management. Higher salinity implies that a certain number of less resistant crops cannot be irrigated by wastewater. Potential environmental impacts from the reuse of wastewater in agriculture may also include groundwater and surface water contamination, as well as the degradation of natural habitats and ecosystems. In Tunisia, for instance, the main environmental quality constraint to the reuse of wastewater is the excess of nitrogen, from fertilizer usage in agriculture and causing environmental pollution.

In order to prevent any type of impact on the environment and to minimise related health risks, any wastewater reuse initiative must put in place a safety control programme, including the frequent control and monitoring of wastewater effluent and the implementation of corrective measures in case values do not meet the required irrigation water quality. In some cases, laws for a safety control system have been issued, however they have not been fully implemented due to insufficient funds and equipment or a lack of skills.

However, water quality alone is not enough to determine the reuse option; protection measures must also be considered according to the more comprehensive risk management approach introduced by World Health Organisation (WHO) Guidelines aimed at considering the health implications of the relation between microbiological load and exposure (e.g. irrigation with treated wastewater could be safe and feasible for vegetables, if it is done with drip irrigation under mulch). Risk management also means that clear roles and responsibilities need to be defined for involved actors like ministries, authorities and monitoring agencies.

WATER & WASTEWATER FRAMEWORK IN THE MENA REGION

Water reuse is particularly attractive in situations where available water resources are already overcommitted and cannot meet expanding water demands in a growing community. Indeed, the development of wastewater reclamation and reuse in many countries is driven by efforts addressing water scarcity, water pollution control measures and obtaining alternative water resources *(Asano et al., 2007)*.

At a global level, the total volume of renewable freshwater in the planet's hydrological cycle is several times more than is needed to sustain the current world population. However, only a small amount – about 31 per cent – of annual renewable water is accessible for human uses due to geographical and seasonal variations associated with the renewable water *(Shiklomanov, 2000)*.

Countries of the Middle East and North Africa (MENA) are among those with the lowest freshwater availability, due in large to climate-induced impacts on water resources, coupled with inefficient water use, especially in the agricultural sector, and fast growing populations. About three quarters of the land of the MENA region is arid, making it one of the driest in the world *(LDK-EKO, 2006)*. *Table 1* shows the amount of water resources by country and by inhabitant in the Mediterranean region.

TABLE 1

RENEWABLE WATER RESOURCES (THE TARWR INDICATOR) AND WATER WITHDRAWAL FOR AGRICULTURE BY COUNTRY AND BY INHABITANT, IN MEDITERRANEAN ARAB COUNTRIES.

COUNTRY	TOTAL POPULATION * [1000 inhab]	TOTAL ACTUAL RENEWABLE WATER RESOURCES (TARWR) PER CAPITA ** [m^3 $inhab^{-1}$ yr^{-1}]	TOTAL WATER WITHDRAWAL AS PERCENTAGE OF TARWR	AGRICULTURAL WATER WITHDRAWAL AS PERCENTAGE OF TOTAL WATER WITHDRAWAL
ALGERIA	39,208	297.6	49.0 % (2001)	61.2 % (2001)
EGYPT	82,056	710.5	–	–
JORDAN	7,274	128.8	100.0 % (2005)	65.0 % (2005)
LEBANON	4,822	933.8	29.0 % (2007)	59.5 % (2005)
LIBYA	6,202	112.9	–	–
MOROCCO	33,008	878.6	36.0 % (2010)	87.8 % (2010)
PALESTINE ***	4,326	193.5	49.9 % (2005)	45.2 % (2005)
SYRIA	21,898	767.2	99.7 % (2005)	87.5 % (2005)
TUNISIA	10,997	419.7	61.7 % (2001)	76.0 % (2001)

* Data referred to 2013 / ** Data referred to 2014 / *** Occupied Territory of Palestine.

Source: FAO AQUASTAT Database (last accessed on February 2015. All data derived from FAO's source and are deemed accurate as such).

In the last decades, the MENA region has witnessed growing water stress, in terms of water scarcity compounded by quality deterioration from pollution and increasing salinity. Pollution is caused by point sources (e.g. sewage discharge or leakage from unsanitary landfills), as well as by non-point sources (e.g. fertiliser and pesticides due to unsustainable practices in agriculture). The increasing salinity of both surface and groundwater is a consequence of the overexploitation of aquifers, as well as seawater intrusion and wastewater return flows. In many countries in the region, untreated municipal and industrial sewage is released into the environment, either into the sea or into the beds of wadis, as is the case in the West Bank, Lebanon and Morocco. In some other cases, as for instance in Egypt, untreated or inadequately treated sewage is often reused for irrigation in an uncontrolled manner, which inevitably entails substantial health risks. Wastewater treatment is often inadequate, because treatment plants are not well maintained. Unsanitary landfills represent another source of pollution, with the potential to seriously impact the quality of aquifers that are used as a source of municipal water supply.

Given this situation, it is not surprising that environmentally-efficient management of urban sewage (collection, treatment and reuse) is recognised as a priority issue for all MENA countries. These environmental concerns arise in an overall situation of water scarcity, which is aggravated by a continuously rising population and an ever-growing demand for water, thus affecting the availability and quality of freshwater resources in the whole region. Indeed, water consumption is high due to increasing water demands for domestic, municipal, and industrial use fuelled by rapid urbanisation, industrialisation and rural migration to towns and cities. The agricultural sector accounts for about 86 per cent of the total water balance *(Qadir et al., 2009)*. Based on FAO AQUASTAT estimates, the total volume of wastewater generated in different MENA countries by the domestic and industrial sectors is shown in *Table 2*.

TABLE 2

TOTAL WATER WITHDRAWAL, MUNICIPAL WASTEWATER PRODUCED, AND TREATED MUNICIPAL WASTEWATER IN MEDITERRANEAN ARAB COUNTRIES.

COUNTRY	TOTAL WATER WITHDRAWAL [BCM*/year]	TOTAL MUNICIPAL WW PRODUCED [BCM*/year]	VOLUME OF TREATED MUNICIPAL WW [BCM*/year]
ALGERIA	5.723 (2001)	0.820 (2012)	n.a.
EGYPT	68.300 (2000)	7.078 (2012)	3.711 (2012)
JORDAN	0.941 (2005)	0.180 (2002)	0.111 (2010)
LEBANON	1.310 (2005)	0.310 (2011)	0.056 (2001)
LIBYA	4.326 (2000)	0.546 (1999)	0.040 (2008)
MOROCCO	10.430 (2010)	0.700 (2010)	0.124 (2010)
PALESTINE **	0.418 (2005)	0.071 (2001)	n.a.
SYRIA	16.760 (2005)	1.370 (2012)	0.550 (2012)
TUNISIA	2.850 (2001)	0.287 (2009)	0.226 (2010)

* BCM = billion cubic meter / ** Occupied Territory of Palestine / n.a. = data not available

Source: FAO AQUASTAT Database (last accessed on February 2015. All data derived from FAO's source and are deemed accurate as such).

Low water availability, in combination with a fast-growing population and inefficient water use – especially in the agricultural sector – leads in many places to an average availability of water per capita that is far below the scarcity level. Total water demand is forecast to increase by 50 per cent between 2000 and 2025, while per capita water availability will fall by half by 2050. Water availability is expected to fall below absolute water scarcity levels of 460 m^3 per capita per year by 2023 *(Wingqvist, 2010)*.

Although much has been accomplished in providing people with access to improved water supply and sanitation facilities, about 45 million people in the region (16 per cent of the total population) still lack adequate access to safe drinking water, and more than 80 million people lack safe sanitation (LDKEKO, 2006). This situation mostly affects rural populations, although inhabitants of poor urban neighbourhoods also do not have access to adequate water supplies from piped connections or standpipes, and have to rely on water vendors. Central sewer collection systems represent a costly option and large treatment plants feel the effect of rapid urbanisation in terms of proper operation and management. This situation will either lead to negative environmental impacts and health hazards from the agricultural reuse of insufficiently treated wastewater, or to the unavailability of this increasingly important water resource for irrigation.

IMPLEMENTATION OF WASTEWATER TREATMENT & REUSE IN THE MENA REGION

Seeking to face this looming water crisis, many governments in the MENA region introduced adaptivemeasures aimed at narrowing the gap between water supply and demand.

One key element of adaptation is to diversify water management strategies. Indeed, municipal wastewater reuse is one potential intervention strategy for developing non-conventional water resources. As part of an Integrated Water Resources Management (IWRM) approach, the extended reuse of reclaimed (treated) wastewater for irrigation and other purposes can contribute considerably to the reduction of water stress and water scarcity *(Choukr Allah, 2010)*.

In most of the countries of the Mediterranean region, wastewater is reused to differing extents within planned or unplanned systems. Wastewater reuse has traditionally been reserved for agricultural use (Fatta et al., 2005), although several MENA countries have been progressing to include urban and industrial applications as well. Experience with wastewater reuse for irrigation or environmental purposes is widespread in the MENA region since nearly all MENA countries are involved in some reuse initiative – each one with its own character.

Nevertheless, in some countries the share of reused wastewater is still low because of inadequate wastewater treatment and concerns about the marketability of agricultural products irrigated with wastewater. Few Mediterranean countries (such as Cyprus, Israel, Jordan and Tunisia) have included water reuse in their water resources planning and have respective official policies in place. A wide variety of approaches to water reuse policy may be found, reflecting differences in the capacity to implement such policies, and depending on the socio-economic, institutional and technological conditions. Differences between countries also occur in their environmental and public health policies. Notable progress has been achieved especially in severely water-scarce countries such as Jordan, where wastewater reuse practice has been integrated into the national water schemes with emphasis on wastewater reuse for irrigation purposes as well as on industrial wastewater recycling (e.g. cooling water). In support of these efforts, wastewater reuse regulations have been adopted.

In many cases, raw or insufficiently treated wastewater is applied due to the lack of sanitation facilities, especially in rural areas, or even due to the inappropriate maintenance of existing facilities. Consequently, the discharged effluents are generally not suitable for reuse applications, causing environmental impacts as well as a prevalence of health risks and water-related diseases. In some other situations, where conditions for reuse are met, wastewater is then submitted to adequate treatments with the effluents being reused for different purposes without presenting any risk for human health. In these cases, reclaimed water represents an important alternative resource for sustainable development and food production *(Kamizoulis et al., 2003)*.

The significance of water reuse may be evaluated through the comparison of the total amount of wastewater produced, representing the water reuse potential, with total water use. The rate of water recycling and reuse is generally small compared with total water use, but it is expected to increase significantly. Two major hurdles currently impede the potential for planned reuse applications, represented by the low rates of a) collection and b) treatment of wastewater in the region *(see Table 3)*. The Wastewater Reuse Index (WRI; rate of actual amount of reuse water over the potential amount) depends on both of these factors as well as on the fraction of treated wastewater that is actually reclaimed *(Kamizoulis et al., 2003)*. Thus, insufficiency in any one of these dimensions drives down reuse rates.

TABLE 3

SEWERAGE COVERAGE IN URBAN AND RURAL AREAS, AND WASTEWATER TREATMENT AND REUSE RATES IN MEDITERRANEAN ARAB COUNTRIES.

COUNTRY	SEWERAGE RATE TO PIPED NETWORK % OF HOUSEHOLDS CONNECTED URBAN / RURAL / OVERALL	TREATMENT RATE % OF WASTEWATER BY VOLUME COLLECTED / TOTAL **	REUSE EFFICIENCY % OF TREATED WASTEWATER BY VOLUME	WRI * % OF TOTAL WASTEWATER BY VOLUME **
ALGERIA	92 % / 50 % / 77 %	73 % / 56 %	n.a.	n.a.
EGYPT	74 % / 18 % / 42 %	79 % / 33 %	24 %	9 %
JORDAN	67 % / 5.9 % / 54 %	88 % / 47 %	76 %	39 %
LEBANON	100 % / 22 % / 89 %	2 % / 2 %	50 %	1 %
LIBYA	54 % / 54 % / 54 %	7 % / 4 %	100 %	5 %
MOROCCO	86 % *** / 3.3 % *** / 73 %	20 % / 3 %	6 %	0 %
PALESTINE ****	57 % / 7 % / 43 %	n.a. / n.a.	n.a.	n.a.
SYRIA	96 % / 45 % / 72 %	40 % / 29 %	78 %	27 %
TUNISIA	79 % / 8.9 % / 54 %	79 % / 43 %	20 %	11 %

* Wastewater Reuse Index / ** Estimate only since the sewerage rate does not correspond to the volume collected but rather to the % of households connected / *** Old data / **** Occupied Territory of Palestine / n.a.: data not available

Sources: Jeuland 2011, using data from Aquastat database (FAO 2010), Kfouri et al. (2009), Jimenez and Asano (2008), Global Water Intelligence 2010 (www.globalwaterintel.com), and country reports from the JMP (World Health Organization and UNICEF 2010).

Countries in the MENA region vary largely with regard to treatment levels and reuse operations. In most of the cases, a conventional technology approach has been adopted for treating wastewater independently of the type of reuse. The general approach adopted up to now is based on producing an effluent in compliance with water quality requirements for discharge into the environment.

It should also be noted that several research activities and pilot studies have been conducted in the region. The information gained from such activities has allowed the adaptation of treatment and reuse practices to the specific conditions of the region. The implementation of large-scale reuse schemes has also resulted in a significantly increased level of technical and operational experience.

CURRENT CHALLENGES & CONSTRAINTS

As stated above, the large-scale application of water reuse practices may provide an opportunity to reclaim municipal and industrial effluents as a non-conventional water source to be used in irrigating agricultural land and green areas or replenishing groundwater resources.

The implementation of water reuse initiatives may indeed represent a chance to provide a supplementary treatment to urban, peri-urban and rural effluents, thus overcoming the environmental problems related to their disposal without adequate treatment. Especially when approaching rural communities, the overall benefits may be maximised if water reuse is implemented through a decentralised management system, which may comprise several smaller subsystems for wastewater collection, treatment and reuse (the smallest system may even serve a single household). Decentralised management may employ a combination of cost effective solutions and technologies that are tailored to the prevailing conditions in the various sections of the community *(Bakir, 2001)*.

Most documented experiences of treated wastewater reuse in the MENA region are on a pilot scale, thus suggesting that the challenge of scaling up this technology has not fully been met. It is possible to state that concerns for human health and the environment are the most important constraints in wastewater reuse. Irrigation with inadequately treated wastewater poses serious public health risks, as wastewater is a major source of excreted pathogens – bacteria, viruses, protozoa, and helminths (worms) that cause gastro-intestinal infections in human beings.

Despite the many benefits of water reuse for agricultural and irrigation purposes, treated wastewater is currently only reused to a limited extent.

FACTORS

Financial constraints, due to high construction and operational costs for treatment systems and sewerage networks, low prices of alternative sources of water supply for irrigation, and low user willingness to pay for reclaimed wastewater with its attendant risks (real and perceived) to health.

Food security and related concerns about the marketability of agricultural products irrigated with wastewater.

Health impacts and environmental safety – especially linked to soil structure deterioration, increased salinity and excess of nitrogen.

Standards and regulations, which are in some cases too strict to be achievable and enforceable and, in other cases, not adequate to deal with certain existing reuse practices.

Absence of monitoring and evaluation capacity in both treatment and reuse systems, often related to a lack of qualified personnel, a lack of monitoring equipment or the high cost of monitoring.

Technical constraints, including insufficient infrastructure for collecting and treating wastewater, inappropriate set up of existing infrastructure (not designed for reuse purposes), improper functioning of existing infrastructure.

Lack of political commitment and of national policies/strategies to support the treatment and reuse of wastewater.

Lack of communication and coordination among the many authorities working in wastewater treatment and reuse of treated effluents.

Lack of public acceptance and awareness, related to low involvement and limited awareness of both farmers and consumers of crops grown with reclaimed wastewater (and/or sludge).

The difficulty in creating financing mechanisms for an investment in infrastructure and regulation that provides combined public and private benefits (many of which are difficult to capture).

Identifiying and implementing a sustainable management model (determining ownership and thereby responsibility for O&M of the treatment and reuse facilities).

FINANCIAL ASPECTS OF WASTEWATER REUSE IN MENA COUNTRIES

One of the main constraints to the large-scale implementation of water reuse are the low rates of collection and treatment infrastructure in the MENA region, as shown in *Table 3*. This gap represents a significant hurdle to a conventional centralised approach, due to the relevance of the investments in piped sewerage and wastewater treatment, which add on average about 1.1 USD per m^3 to the cost of water delivered to households. This amount is slightly more than half of the total cost of network water and sanitation services, which cost about 2.0 USD per m^3 of water on average in the MENA region *(Jeuland, 2011)*.

In the absence of strong government enforcement or regulation of wastewater discharges, the publi acceptance and motivation towards investments for wastewater reuse initiatives risk being low. Indeed, in urban areas, upstream water users have few incentives to pay for wastewater collection and treatment since they do not directly perceive their benefits. The positive effects are mainly for people living in low-lying urban areas or downstream of large municipalities, who benefit from the ensured removal of wastewater from the immediate household and community environment.

This situation may compromise the possibility to implement initiatives aimed at using reclaimed wastewater safely and effectively, especially in countries with relatively low rates of sewerage and wastewater treatment. Similarly, additional complications occur where the O&M of conveyance and treatment infrastructure are neglected, as these may compromise the ability to meet reuse standards. With the cost of wastewater conveyance and centralised treatment exceeding the 0.5-1.5 USD per m^3 costs of alternative options such as desalination, the direct consequence is that financing wastewater collection and treatment through a project for wastewater reuse will be extremely challenging unless the marginal product of reused water is very high *(Jeuland, 2011)*.

The other important cost of reuse, which will vary across supply alternatives depending on the relative distances to the reuse sites, is the distribution of treated water back to demand locations. This varies from 0.05–0.36 USD per m^3, and represents a lower limit on the cost of reuse in places where sewers and treatment are already in place (Jeuland, 2011). The low WRI values in so many MENA countries with water scarcity problems are not only related to the lack of wastewater conveyance and treatment, but also to factors connected to reclaimed water demand, such as a) the marginal product of reused water is lower than the cost of delivering, b) distortions of the prices for alternative sources (policies, subsidies, which brought down the freshwater tariffs to very low levels), and c) users' perception of differences in quality between conventional and reuse supplies.

Given the general framework described above, the decentralised approach may indeed provide an effective option to increase the WRI in MENA countries. Such an approach may be implemented in particular for small and rural communities by managing wastewater as close as possible to its source and to where its beneficial reuse is located. Decentralised management is appropriate for waterstressed areas such as MENA, where water supplies are intermittent and water consumption is low, reducing the need for large investments in main trunk sewers and lift stations to transport wastewater away from the communities to the wastewater treatment plants. Moreover, the decentralised approach makes it possible to increase opportunities for wastewater reuse by keeping wastewater as close as possible to the generating community. Reuse opportunities in the region's small communities are often located within the generating community for landscaping, or near the generating community for agriculture and groundwater recharge *(Bakir, 2001)*.

INTRODUCTION TO THE FOUR PILOT CASES

The following chapters present the four pilot projects implemented within Sustain Water MED, introducing their respective contexts, the local challenges faced, technologies chosen and project realisation in terms of institutional structure. Furthermore, each chapter puts forward potential benefits and risks in terms of environmental and socio-economic effects, as well as specific lessons learned and next steps.

TABLE 4

OVERVIEW OF THE PILOT ACTIVITIES' FOCUSES

	WASTEWATER MANAGEMENT APPROACH	TECHNOLOGY	FINAL GOAL OF WATER REUSE	INNOVATIVE ASPECT
MOROCCO	Tackling wastewater at its source, col-lecting and treating it depending on end-use, use of sanitation products	Biogas digesters, anaerobic baffled reactor, urine diverting dehydrating toilets	Use of treated waste-water for irrigation and fertilisation, use ofbiogas for domestic purposes	Holistic ecological sanitation (ECOSAN) concept to increase the level of sanitation and reduce risks for human health and the environment in oasis communities
TUNISIA	Introducing a tertiary treatment unit and monitoring treated wastewater quality at utilisation point	Central conventional treatment plus additional slow sand filter, monitoring and early warning system	Providing reliable water resources for irrigation and ensur-ing sustainability of underlying aquifers	Joint monitoring of irrigation water quality by provider and end-user, including an online system for early warning based on instantaneous quality monitoring
EGYPT	Decentralised sec-ondary treatment of primary effluents for discharge in agricultural drains (indirect reuse)	Compact aerobic-anoxic activated sludge reactor	Indirect reuse for agricultural irrigation as treated wastewa-ter is discharged into agricultural drains	Decentralised waste-water treatment to increase the level of sanitation in remote communities and to improve drainage water quality
JORDAN	Decentralised tertiary treatment of primary effluents for reuse in landscape irrigation	Sequencing batch reactor plus sand filter and disinfection facility, additional remote monitoring system	Irrigation of existing and planned green areas of a building complex, transfer of excess effluent to other users for landscape irrigation	Decentralised waste-water treatment in a peri-urban area combined with irrigation of on-site green areas

KEY DATA

LOCATION: AIT IDIR VILLAGE, RURAL COMMUNE OF AIT SEDRATE JBEL SOUFLA, TINGHIR PROVINCE

TECHNOLOGY: A) SANITATION: URINE DIVERTING DEHYDRATING TOILETS (UDDT), AGRICULTURAL DIGESTERS, ANAEROBIC BAFFLED REACTORS;
B) RAINWATER MANAGEMENT: RETAINING WALLS, RAINWATER COLLECTION

USE OF TREATED WASTEWATER AND SANITATION PRODUCTS: FOR IRRIGATION AND FERTILISATION

USE OF BIOGAS: FOR DOMESTIC PURPOSES (COOKING, HEATING)

IMPLEMENTING PARTNERS: ABH SMD, GIZ

PILOT CASE MOROCCO

INTRODUCTION

The pilot project carried out in Morocco as part of the Sustain Water MED scheme is implemented by the Integrated Water Resources Management Programme (AGIRE). This is managed by the Department for Water under the Ministry for Energy, Mines, Water and the Environment (MDCEau) and by the GIZ, in collaboration with the Souss-Massa Drâa River Basin Agency (ABH SMD). The measures implemented under this pilot project concern seven sites in the village of Ait Idir in the rural commune of Ait Sedrate Jbel Soufla (RC-ASJS), Tinghir Province. The village is situated in the Dadès oasis valley in the southwest of Morocco, at the foot of the High Atlas Mountains.

The main aim of this project is to improve sanitary conditions and reduce environmental pollution at the sites selected. This requires a sustainable concept for the decentralised management, treatment and reuse of wastewater and human excreta. Furthermore, such a concept should be implemented with methods that are adapted to suit the local conditions. To this end, the following measures were selected for this pilot project:

- *Preliminary survey and analysis: GIZ has carried out site exploration and conducted a field survey in order to ensure a comprehensive analysis that covers socio-economic and environmental aspects of the village of Ait Idir;*
- *Construction: installing ecological wastewater infrastructure (semi-collective and individual systems) for two communal establishments and five detached houses, which were selected as pilot sites in the Ait Idir village, as well as rainwater management measures;*
- *Supporting the project with training and awareness-raising activities to improve acceptance and to provide the skills required for a sustainable transition towards the reuse of products from ecological sanitation and their integrated management in the RC-ASJS.*

The pilot project chosen for Ait Idir is a good example of how the concept of ecological sanitation can be put into practice. The scheme applies various technologies to meet the needs of rural communities, including generating energy from biogas and making use of the fertilising properties of human excreta in agriculture. This type of project [1] has the potential to be replicated at other sites and on a larger scale, as part of the implementation of the National Programme for Sanitation in Rural Areas (PNAR), which is currently launched by the Moroccan government.

[1] During the planning phase for the project at Ait Idir, a number of lessons were drawn from a previous project completed in Morocco under the AGIRE programme at a sitein Dayet Ifrah in the Middle Atlas. More information is available at: www.agire-maroc.org.

PROJECT SETTING

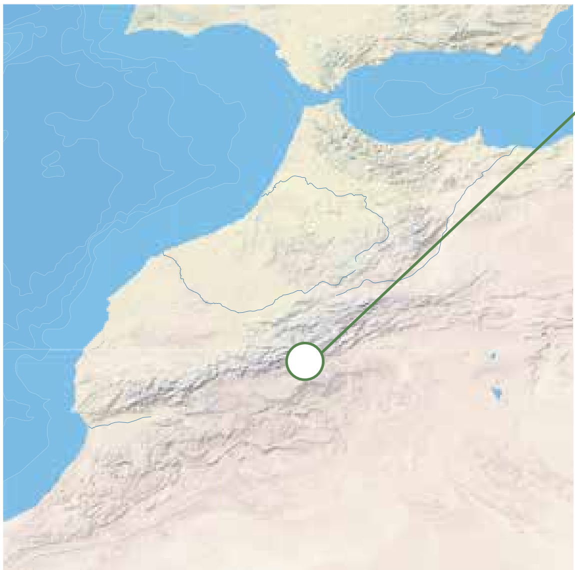
The region of the Dadès Valley is characterised by a lack of sanitary infrastructure, which is generally limited to individual soak pits. These have a tendency to contaminate water resources by infiltrating into aquifers, which provide the main source of drinking water. This pilot project should enable an improvement to sanitary infrastructure and to the living conditions of the local population, while also making it possible to limit groundwater degradation.

LOCATION OF THE SITE

The RC-ASJS is a commune in the province of Tinghir, located to the east of the High Atlas mountain range, 133 km to the north-east of the town of Ouarzazate. The Dadès wadi crosses the RC-ASJS, which has an area of 332 km. The commune encompasses 8 douars, including the village of Ait Idir where the pilot project is situated. The village of Ait Idir has a land area of 105 ha, of which 30.9 percent is used for agriculture. The housing in the village can be considered semi-modern, with traditional adobe houses and modern constructions.

View of the village Ait Idir showing the local market.

Source: GIZ-AGIRE



Source: Made with Natural Earth, 2015.

SOCIO-ECONOMIC CHARACTERISTICS

Ait Idir currently has a population of approximately 1,000 inhabitants, of which 49 percent are male and 51 percent are female. The village is a Berber community of Muslim faith and comprises 121 households. The illiteracy rate is approximately 43 percent, while 67 percent of that figure is female. The population of the village of Ait Idir is relatively poor, with an average income per household of 1,300 Moroccan Dirhams (MAD) per month (approximately 118 Euros (EUR) per month). This amounts to around 1,950 MAD per person per year (approximately 177 EUR per person per year), while the poverty line according the Higher Planning Commission in Morocco is 3,569 MAD per person per year (approximately 324 EUR per person per year).

The main economic activity in Ait Idir is agriculture. However, the local climate is arid, and agriculture relies heavily on irrigation, which is provided by traditional, non-mechanised methods. The village's agricultural land extends along the Dadès wadi and occupies an area of 30 ha (approximately 28 percent of the land).

The size of each plot of land varies from 0.05 to 0.5 ha. The main types of crops grown in the village are cereals (wheat, corn etc.) and forage crops (alfalfa). Other agricultural practices in the village include growing fruit trees (fig trees, peach trees etc.) and scented roses (rosa damascena). In addition to this agricultural land, many of the households also have a garden area reserved for market gardening and fruit trees. Irrigation for the agricultural land is ensured by water from the Dadès wadi via irrigation channels, called »targas« in the Berber language. These channels are fed by diversion dams known as »ogougs«, which the village's inhabitants have built along the wadi. 97 percent of the farmers use fertilisers (potassium nitrate and magnesium sulphate) and 20 percent use fungicides.

Livestock farming also accounts for a significant proportion of the farmers' revenue. The herds in the village are mainly cattle and sheep, which are farmed traditionally in barns. In addition to livestock, each family has a donkey and/or a mule for working the fields. In general, no specific manure management is provided: the ground beneath the barns is bare, meaning the animals' liquid waste infiltrates into the soil. The manure is usually stored beside the barn until it is used in the fields and it is often kept in the open air, with no treatment, on permeable ground. In addition, a number of households in the village compost their manure in a pit, and each household calculates the quantity it contributes in wheelbarrows.

The village of Ait Idir is easily accessible via a well-constructed road network, which has led to a development in trade. Commercial activity is centred around the souk each Sunday. The village also has a few grocery shops and an abattoir. Tourism is poorly developed, yet the village Ait Idir offers a lot of potential for growth in the sector; the canyons of the Dadès Valley are located only 4 km away and the village even has tourist infrastructure, as well as two historic kasbahs.

ENVIRONMENTAL SETTING

The village of Ait Idir has a cold arid climate, with usually humid winters and dry summers. The hottest month is July with an average maximum temperature of 24.6 °C. The coldest month is January, with an average minimum temperature of 4.6 °C. The average level of precipitation is 200 mm per year, with October being the rainiest month.

WATER RESOURCES

Measuring a length of approximately 200 km, the Dadès sub-catchment area stretches from the High Atlas Mountains through the Dadès sub-drainage basin, covering an area of 6,678 km^2. The main source of surface water in the village of Ait Idir is therefore the Dadès wadi, which crosses the village along a distance of 2.6 km. The water from the wadi is of average quality and is mainly used for irrigating agricultural land.

As for groundwater resources, the site has a number of discontinuous unconfined aquifers, similar to a monolayer with a folded or fractured structure. The depth of the water table in the village varies between 20 and 36 metres. The groundwater is of average quality and is used for domestic purposes, for irrigating gardens and for watering livestock. The wells are dug either by individual families, or groups of families.

The water resources available to the village are compromised by the arid local climate. The village's elevated topography combined with the severe droughts results in a dry period in the wadi bed, generally in July and August. Equally, a number of human activities have a negative impact on the quality of the local water resources. Hotels located in the villages upstream of Ait Idir discharge their wastewater into the wadi, and women in the villages wash laundry on the banks of the wadi, resulting in an increased quantity of detergents in the water. In addition, the illegal dumping of solid waste also poses a considerable risk of pollution to groundwater and the wadi.

Despite its arid climate, the region also experiences occasional heavy rainfall. Consequently, Ait Idir is susceptible to flooding, following high water levels in the Dadès river and the two ravines in the north and south of the village. This was the case in the years 2008, 2012 and 2014. As a result, the soil suffers from the type of water erosion that formed these ravines. Two gabions have been built in order to limit expansion of the ravine to the north, as well as to protect the local community and the village school.

DRINKING WATER SUPPLY

The supply of drinking water in the village of Ait Idir is ensured by two water towers built by the CRASJS communal council. A third water tower was built but has not yet been connected to the distribution system. These towers are fed only by groundwater, with the addition of chlorine tablets by the council. The quality of this treated water is not monitored subsequently and is therefore unreliable. This water is provided to the village's inhabitants via a water distribution system. Each house is connected to the distribution system and is fitted with a water meter. The water rates and average consumption levels are presented in *Table 5*.

TABLE 5	WATER RATES IN THE VILLAGE OF AIT IDIR		
CONSUMPTION	Less than 30 m^3	Between 30 & 60 m^3	> 60 m^3
RATES	2.15 MAD/m^3	4 MAD/m^3	5 MAD/m^3

Source: Sustain Water MED 2013a.

The supply of drinking water is hampered by a number of problems including leakages in the distribution system. In summer, the high demand for water combined with leakages results in limited access to water for certain households located on higher sites of the village. Water consumption is billed for on a quarterly basis. *Table 6* shows the average consumption per household for the year 2012.

TABLE 6

AVERAGE WATER CONSUMPTION PER HOUSEHOLD PER QUARTER FOR THE YEAR 2012

QUARTER	JANUARY–MARCH	APRIL–JUNE	JULY–SEPTEMBER	OCTOBER–DECEMBER
AVERAGE CONSUMPTION	30 m^3	20 m^3	40 m^3	30 m^3

Source: Sustain Water MED 2013a.

SANITATION & ENERGY

The sanitation system in the village of Ait Idir is individual rather than collective, and consists of disposing wastewater (grey and black) in soak pits. The households in the village have squat toilets with pour-flush and one or two soak pits. When the soak pits are full, some families discharge the resulting sludge into the ravines in order to empty the pits. The sanitary conditions in Ait Idir prior to the pilot project pose a risk of groundwater pollution because of the difficulties to drain ditches. There are currently no statistics on the consequences (e.g. waterborne diseases) these sanitary conditions have on public health in the village, but it can be assumed that polluted groundwater, used for drinking purposes, poses major health risks for the villagers.

The entire village of Ait Idir is connected to the national energy grid. Electricity is the main source of energy and is used for lighting and for various household electrical appliances. The average electricity consumption per household is 156 kWh per month. *Table 7* shows the electricity rates in the village. Other sources of energy are also used, such as butane and wood for cooking, heating and water heaters. Only two houses are fitted with solar water heaters.

TABLE 7

ELECTRICITY RATES IN THE VILLAGE

BRACKETS	0 to 100 kWh	101 to 200 kWh	201 to 500 kWh	Over 501 kWh
RATES	0.75 MAD/kWh	0.85 MAD/kWh	0.92 MAD/kWh	1.26 MAD/kWh

Source: Sustain Water MED 2013a.

LEGAL & POLICY FRAMEWORK

Issues concerning water in Morocco are governed by Law 10.95. This includes two decrees of particular importance for this project: on setting limit values for domestic disposal applicable to wastewater disposal by urban areas (Decree 1607-06 of 26 July, 2006) and on setting quality standards for water intended for irrigation (Decree 1276-01 of 17 October, 2002). *Table 8* shows limit values for domestic discharges from the years 2013 and 2017 onwards.

TABLE 8

LIMIT VALUES FOR DOMESTIC DISCHARGES

PARAMETERS	LIMIT VALUES FOR DOMESTIC DISCHARGES 2013	LIMIT VALUES FOR DOMESTIC DISCHARGES 2017
BOD_5 mg O_2/l	120	300
COD mg O_2/l	250	600
SUSPENDED SOLIDS mg/l	150	250

Source: Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement 2012.

In Morocco, collective sanitation is the responsibility of the National Office of Energy and Drinking Water (ONEE), while on-site sanitation is ensured at the commune level. The law does not demand any quality control for water in on-site sanitation, and these systems generally suffer from poor maintenance. The use of wastewater must be authorised by the water agency in charge at the local level. The agency must comply with a number of criteria, which are shown in *Table 9*.

A National Water Strategy has been introduced in 2009 and the National Water Plan is currently being updated. In this context, reuse practices are an important aspect as rural sanitation in particular will be covered by the law under the PNAR. The latter is led by the Directorate General for Local Authorities in the Ministry of the Interior. The European Union and the GIZ provide support through the programme AGIRE, in cooperation with the Department for Water under the MDCEau, and the Ministry of the Interior.

Experience from a previous project completed as part of the AGIRE programme at Dayet Ifrah shows that there is generally quite high acceptance for individual and semi-collective sanitation systems and that it seems more efficient for the villages to manage the facilities independently rather than having a central operation and management. AGIRE therefore encourages the introduction of simplified authorisation procedures for individual and semi-collective sanitation systems within the new legislation being drafted.

TABLE 9

WATER QUALITY ACCORDING TO ARTICLE 4 OF DECREE 1.276-01

CATEGORY	CONDITIONS OF APPLICATION	AT-RISK GROUP	GASTROINTESTINAL NEMATODES * (ARITHMETIC MEAN NUMBER OF EGGS PER LITRE **)	FAECAL COLIFORMS (GEOMETRIC MEAN NUMBER PER 100 ml **)	OPTIMUM METHOD OF WASTEWATER TREATMENT FOR ASSURING THE DESIRED MICROBIOLOGICAL QUALITY
A	A Irrigation of: crops intended to be consumed in a raw state, sports grounds, public gardens ***	Agricultural workers, public consumers	absence	< 1,000 ****	A series of stabilisation stages designed to obtain the desired microbiological quality, or any other equivalent treatment
B		Agricultural workers	absence	No recommended standard	Storage in stabilisation pond for 8–10 days, or any other method that eliminates helminths and faecal coliforms
C	Localised irrigation of crops in Category B if the agricultural workers and the public are not at risk	None	n/a	n/a	Preliminary treatment according to the type of irrigation, but at least primary sedimentation

* Roundworms, whipworms and hookworms / ** During irrigation period / *** A strict directive (200 faecal coliforms per 100 ml) is justifiable for lawns that the public may come into direct contact with, such as hotel lawns. / **** For fruit trees, irrigation must end two weeks before harvesting and no windfall fruit may be included. Spray irrigation is not permitted.

Source: Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement 2012.

DESCRIPTION OF THE PILOT PROJECT

CHALLENGES

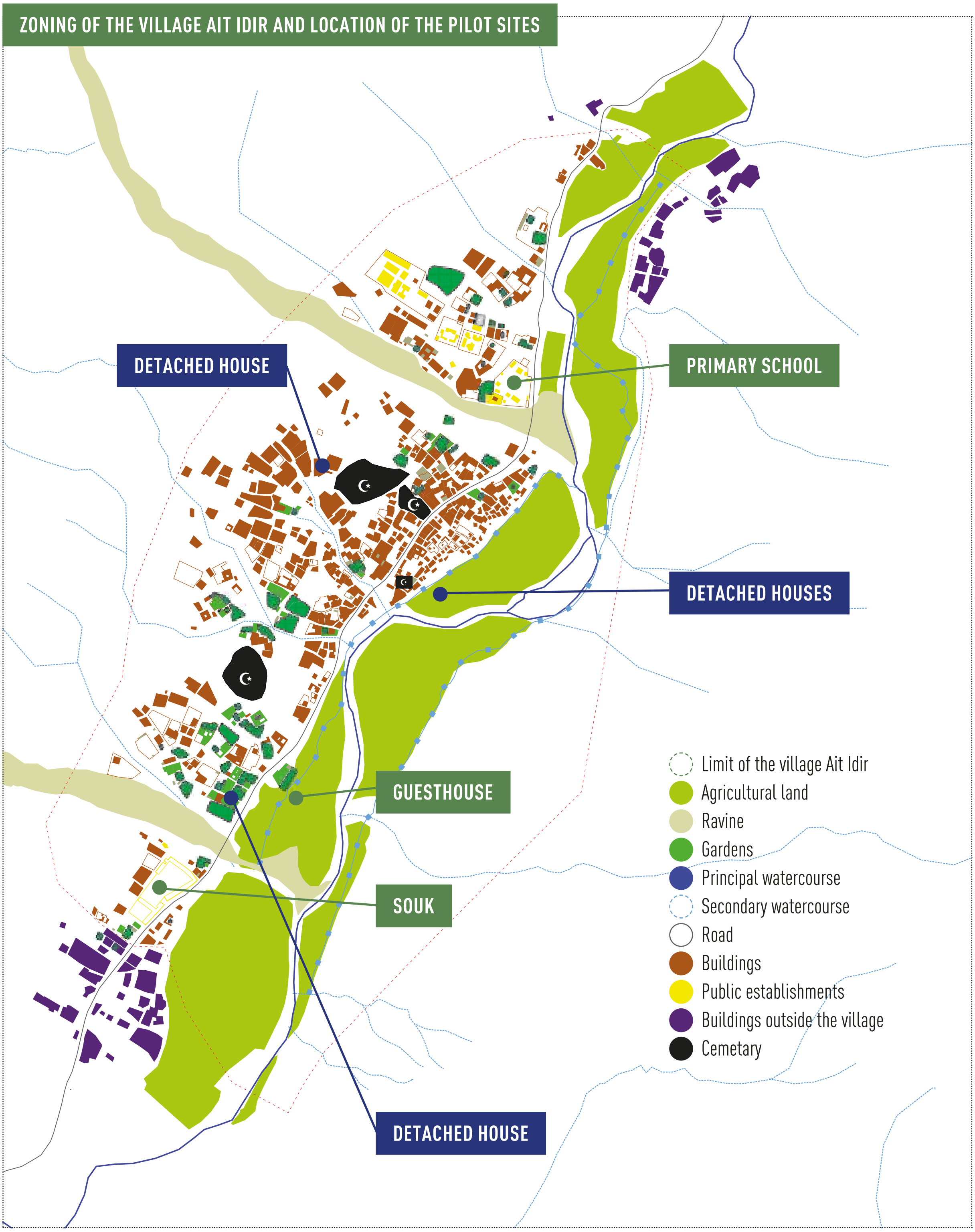
Different options were considered for carrying out this pilot project. Due to technical difficulties linked to the topography of the village and the distribution of the housing, and with no available site in the village to construct a centralised WWTP, a collective sanitation system was ruled out. Also, such a system would have involved an investment beyond the scope of this project. Individual sanitation systems were therefore the preferred choice, as these also allow improved reuse of treated wastewater. A first step was to zone the village in order to select the appropriate technology according to the type(s) of housing concerned, the density and the participants in each zone.

Each zone in the village was therefore analysed and technologies that were considered "compatible" were proposed:

- **ZONE A** *Dispersed housing built on large sites (not in agricultural use) located mainly in the south of the village, as well as a few isolated households in the northern part, on the wadi's left bank. The dwellings should be designated for individual sanitation with the potential reuse of products (treated water/urine/dry faecal matter/digestate) on the site or in the field.*
- **ZONE B** *Large housing area with dwellings with gardens that could be designated for individual sanitation with the reuse of products in the garden. To the south-west, a guesthouse with around ten rooms and an area of stables, as well as a large garden.*
- **ZONE C** *Grouped housing situated at the centre of the village. Only dwellings located on the outskirts are less densely developed. Slopes here make it difficult to provide a single gravity-fed network. Sub-zones are therefore required with solutions that may differ. The most densely developed zones should be provided with semi-collective systems or with compact individual systems. Dwellings on the outskirts that keep livestock could be equipped with digesters.*
- **ZONE D** *Zone of public establishments (commune, secondary school, primary school, nursery, clinic, youth centre) and neighbouring households. The souk and the abattoir to the south are communal properties. The sanitation systems proposed for the various establishments could also serve the neighbouring housing.*

Subsequently, model sites in these zones were chosen in cooperation with the local authorities to be equipped with various technologies. The model sites include two communal establishments, the primary school and the weekly market (souk), as well as five detached houses.

ZONING OF THE VILLAGE AIT IDIR AND LOCATION OF THE PILOT SITES



Source: GIZ-AGIRE

TECHNOLOGIES CHOSEN

SANITATION

Different possible methods of sustainable sanitation were studied for Ait Idir and zoning of the village was devised. Pilot sites were chosen in cooperation with the local authorities and will be equipped with various technologies. These measures will demonstrate the different types of decentralised technology that can ensure sustainable sanitation and optimise the reuse of products.

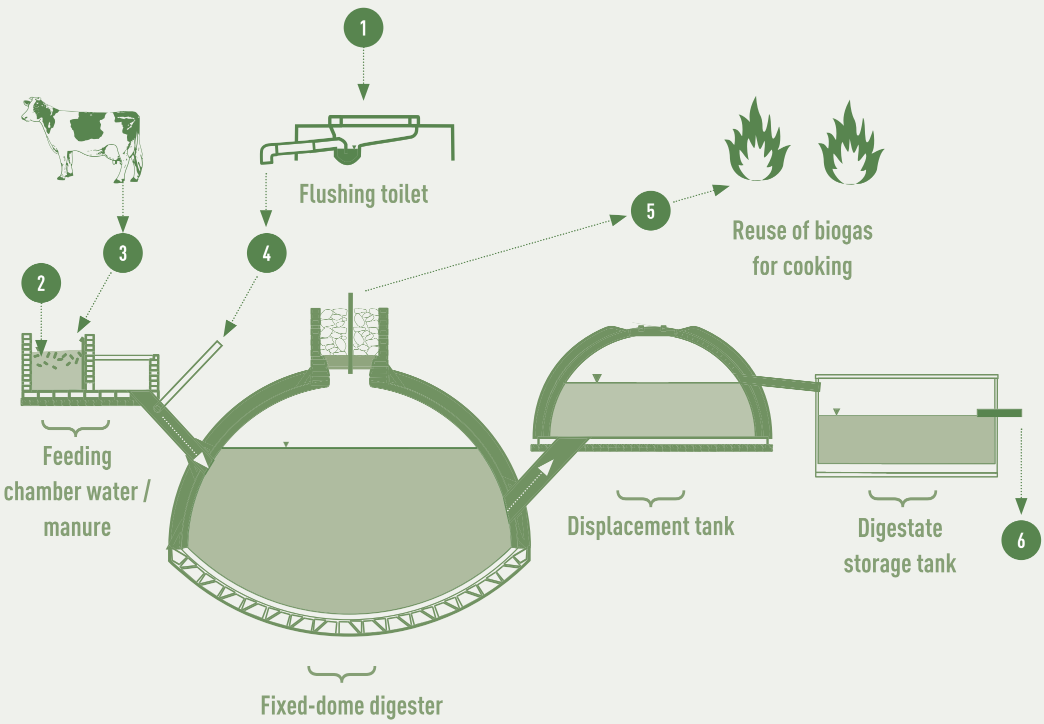
TABLE 10

OUTLINE OF THE DIFFERENT ECOLOGICAL SANITATION SYSTEMS

CATEGORY	DESCRIPTION	PILOT SITES
METHANE DIGESTER	Biogas is produced in sealed underground constructions, working as methane digesters. Many different types of organic waste can produce biogas; all it takes is the right conditions for digestion to take place. It is recommended to feed digesters with: • animal excrement • the organic fraction of household waste • domestic wastewater	Mogador Guesthouse: 20 m³ digester for manure and wastewater with use of biogas (cooking and heating) and digestates (fertilising fields) Household 1: 50 m³ digester for manure and wastewater with use of biogas (cooking and water heating) and digestates (fertilising fields) Household 4: 30 m³ fixed dome digester, brick design, for manure and wastewater with use of biogas (cooking and water heating) and digestates (fertilising fields)
ANAEROBIC BAFFLED REACTOR (ABR)	An anaerobic baffled reactor is an improved septic tank with a series of baffles under which wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved wastewater treatment.	Household 2: ABR for wastewater and storage tank with reuse of treated wastewater in the house's gardens
URINE DIVERTING DEHYDRATING TOILETS (UDDT)	Toilets that separate faeces, urine and grey water (from hand washing, showers, laundry). The toilet bowl is equipped with 2 to 3 holes (1 for urine, 1 for faces, 1 for anal cleansing water). The faeces falls directly into a dehydration compost pit fitted with a vent. The urine is collected in barrels before being used as nitrogen fertilizer on crops. The wastewater is treated in filter beds or biomass zones.	Primary school: UDDT with girls', boys' and disabled toilets, reuse of dry faeces and urine in agriculture and of greywater in a garden Weekly market: Public UDDT for visitors to the market, reuse of dry faeces and urine in agriculture Household 3: UDDT with reuse of products (urine, faeces) in agriculture and of greywater in a garden

Source: Compiled by GIZ AGIRE based on Sustain Water MED 2013b.

REUSE SYSTEM OF FIXED-DOME TYPE AGRICULTURAL DIGESTER



1. URINE, WATER FROM ANAL CLEANSING, EXCRETA
2. WATER
3. MANURE
4. WASTEWATER
5. BIOGAS
6. DIGESTATE

Construction of the fixed-dome type agricultural digester in the village Ait Idir.

Source: GIZ-AGIRE

Source: GIZ-AGIRE

CONSTRUCTING INSTALLATIONS FOR RAINWATER MANAGEMENT

As with the issue of sanitation, the possible systems aimed at rainwater management to be used in the village of Ait Idir were studied in detail. This involved zoning the village into more or less homogenous areas.

TABLE 11

OUTLINE OF INFRASTRUCTURE FOR RAINWATER MANAGEMENT IN THE VILLAGE OF AIT IDIR

INFRASTRUCTURE	DESCRIPTION
RETAINING WALLS	Restoring and extending the existing retaining walls on the banks of the northern ravine in order to protect the nearby buildings on both sides of the ravine from the problem of flooding and erosion.

Source: Compiled by GIZ AGIRE based on Sustain Water MED 2013c.

CAPACITY BUILDING PROGRAMME

The pilot project includes a capacity building programme targeted at Moroccan national institutions and local stakeholders concerned with the village of Ait Idir. The project also involves awarenessraising campaigns aimed at those who will benefit from the scheme.

At the national level, representatives from the ABH SMD and the Environmental Department took part in regional training workshops and regional meetings. At the local level, various awareness-raising efforts have been conducted. Three excursions to the Dayet Ifrah site were organised with delegations from the village and the steering committee. In addition, meetings of the steering committee had a learning effect and enabled the stakeholders to make informed decisions concerning the general usefulness of this pilot project and its methods in particular.

Lastly, various awareness raising workshops were organised for the local population, including workshops to present the results from the initial site analysis and workshops to finalise planning and site selection with the population. Other training sessions are planned for the households benefitting from the scheme so they are able to maintain the individual systems installed once the project is completed. At the commune level, training sessions are also planned to ensure the maintenance of collective installations. Furthermore, GIZ will assist households benefitting from the project in monitoring the installations during at least two gardening seasons after the end of the project. This measure aims to ensure the development and acceptance of the installations.

PROJECT IMPLEMENTATION: INSTITUTIONAL STRUCTURE

The pilot project in Ait Idir is managed by GIZ in close cooperation with the ABH SMD, in particular concerning studies, visits to construction sites and the validation of technical reports. The pilot project is coordinated with the relevant stakeholders on three levels: at the local level with Tinghir Province, at the regional level at the ABH SMD in Agadir, and at the national level through the steering committee.

At the local level, the Tinghir Province authority (governor) has to authorise official meetings between GIZ, the ABH SMD and the commune. The technical service of the commune and the village association are the main users of the collective and individual sanitation systems provided for in the project.

At the regional level, the ABH SMD coordinates the communication of results from the project to the Environmental Department and the Water Service in Ouarzazate. The ABH SMD also coordinates the steering committee meetings. The actors concerned in these meetings are the ONEE, responsible for producing and distributing drinking water in urban centres, the Agadir Institute of Agriculture, the Ouarzazate Regional Office of Agricultural Development, responsible for irrigation water, and the Belgian Development Agency (CTB), which conducts projects to install sanitary facilities in 300 rural schools in Morocco using conventional sanitation systems (flushing toilets, septic tanks followed by soak pits). The CTB plans to use UDDT technology as used at the school in the pilot project in Ait Idir for some of their schools.

1 Building of Urine Diverting Dehydrating Toilets of primary school.

2 Urine Diverting Dehydrating Toilets for the primary school.

Source: GIZ-AGIRE

POTENTIAL BENEFITS & RISKS

BENEFITS FOR PUBLIC HEALTH & ENVIRONMENT

According to tests conducted by the Ministry for Health, the Ait Idir region is a zone affected by waterborne diseases. However, there is no data on the exact number of diseases. At the regulatory level, the law does not provide for any systematic monitoring of the quality of drinking or irrigation water. Currently, groundwater is treated with chlorine tablets before being used as drinking water by households. However, there are no further measures in place to protect public health. The installation of the sanitation systems in the pilot project will have positive effects on public health and the environment compared to the current situation as the technology proposed offers considerable potential for reuse, while limiting health risks. The proper treatment and reuse of wastewater will alleviate the pressure on the environment, mainly on groundwater, caused by the uncontrolled disposal of domestic and livestock wastewater.

The ecological sanitation (ECOSAN) approach, consisting of a series of individual and tailored treatment solutions, will represent a case study of sustainable solutions to be implemented in order to overcome the problems caused by the inappropriate management of wastewater in the region of Ait Idir. The ECOSAN approach also foresees the recovery of nutrients directly usable for the local agricultural activities; the activation of this virtuous system will reduce the transport and the use of synthetic fertilizers, contributing to a general environmental benefit.

BENEFITS LINKED TO IMPROVING SANITARY CONDITIONS

As outlined above, collective sanitation in Morocco is the responsibility of the ONEE, while on-site sanitation is ensured at the village level (cf. Law 10.95). The law does not demand any quality control for water in on-site sanitation, and these systems generally suffer from poor maintenance. The provision of simple systems for individual sanitation for the selected sites in the village of Ait Idir should make it possible to improve this situation considerably. For the detached houses concerned, the sanitation systems under construction should improve quality of life for the population thanks to the installation of infrastructure such as toilets.

It should also be possible to considerably reduce the environmental risks associated with the previous practice of discharging untreated wastewater. As for the communal establishments and the schools in particular, a further benefit of the project is that it may be used to raise awareness in the community on how to improve hygiene practices and reduce environmental pollution. In addition, a long-term benefit might be better school attendance among girls as the project plans to improve the sanitary conditions at the local primary school.

BENEFITS IN TERMS OF AWARENESS-RAISING & KNOWLEDGE SHARING

The regional training measures and the project meetings at the national, regional and local levels were of benefit to staff from the ABH SMD and the Environmental Department. These institutions state that they are now in a position to assist the communes and engineering companies in their work on ecological sanitation.

At the local level, the construction company completing the sanitation infrastructure benefits from the direct support of the GIZ team. The individual households involved in the scheme and the commune also benefit from close monitoring by GIZ and from training sessions on maintaining the infrastructure installed. In addition, a contract has been signed with the participants covering the issue of maintenance, which obliges them to ensure the upkeep and proper usage of the sanitation system. A further condition is that the infrastructure should be shown to visitors as part of research projects, even beyond the end of the project. Experiences from the previous project conducted in Dayet Ifrah show that this type of cooperation works well and may continue beyond the end of projects and contracts. It can therefore be hoped that similar results will be possible for the project at Ait Idir.

There is a greater understanding of the possibilities for reusing wastewater thanks to the training and awareness-raising conducted as part of this pilot project. Initial reluctance to reuse products from sanitation systems for agricultural purposes was overcome after participants from Ait Idir visited the site in Dayet Ifrah. The population was also made aware of the types of human behaviour that present a risk of environmental pollution, such as washing laundry and discharging wastewater in the wadi.

BENEFITS IN TERMS OF TRANSPARENCY AND EXCHANGE OF INFORMATION

Through the steering committee meetings, the pilot project enabled a regular exchange of information between the Moroccan institutes concerned on possible measures for ecological sanitation. It was also possible to involve other actors conducting similar projects such as CTB. In the village of Ait Idir itself, the project seems to have helped strengthen the role of the village association as a result of its commitment to involve the community in the process. Those who benefitted from the measures under the project are very keen to ensure the maintenance of the systems installed. As for the schools, the parents' association is also collecting money to cover the cost of maintaining the installations and landscaping the garden.

Training excursion with interested actors regarding reuse systems in Dayet Ifrah.

Source: GIZ-AGIRE

ECONOMIC BENEFITS

In addition to the improvement in quality of life through the creation of green spaces (particularly at the school), the project also enables savings in energy costs. Households can use the biogas produced for cooking or heating, instead of having to rely on butane cylinders. The current average consumption of butane per household is two large and one small cylinder per month (at a cost of approximately 100 MAD per month). The previous project in Dayet Ifrah achieved promising results in this area.

In general, the local population has expressed interest in the project and further demand is expected from other members of the village, and even from surrounding villages. The local population seem ready to invest in this type of ecological sanitation system, even without subsidies or external financing. Currently, constructing of an entire bathroom with a UDDT and shower costs 8,500 MAD, and installing biogas facilities costs 15,000 MAD. The prices for these installations are therefore competitive, considering the price of a septic tank is also 15,000 MAD. The prices for new installations are also likely to fall as the local contractors gradually gather experience in this type of construction. In addition, the State will subsidise such construction costs in the future under the PNAR currently in development.

The project has made it possible to involve local service providers (engineering companies and construction firms) through temporary contracts, and has contributed to knowledge building on ecological sanitation at the local level. If demand for this type of construction grows after the end of the project, it is likely that jobs will be created in the building sector in the medium/long term. In general, there would appear to be considerable economic potential for this type of development in Morocco. GIZ has received requests for training on the issue from various Moroccan foundations, and in particular from training centres.

POTENTIAL RISKS FOR HEALTH AND THE ENVIRONMENT

Although there were promising results from the previous project in Dayet Ifrah, there is still the risk of maintenance not being carried out appropriately after the end of the project, in the long term, when the systems shall be managed at the local level. This is a vital aspect for ensuring the sustainability of the installations and their ability to limit risks to health and the environment. A good level of training to the beneficiaries based on simple but effective protocols has to be assured in order to guarantee a reliable maintenance, avoiding any possible health risks for operators.

POTENTIAL ECONOMIC RISKS

The project also presents an economic risk for the local construction company, which does not necessarily have the required technical skills and must develop these gradually throughout the project. Moreover, in order to ensure the economic sustainability of the individual wastewater treatment and management systems installed, an affordable economic model involving local authorities needs to be defined.

LESSONS LEARNED

GAIN ACCEPTANCE FOR THE IDEA OF DECENTRALISING ECOLOGICAL SANITATION IN RURAL AREAS & INTRODUCE SIMPLIFIED AUTHORISATION PROCEDURES

The pilot project conducted at Ait Idir shows that there is quite high acceptance for individual and semi-collective sanitation systems among the local population concerned. The project has made it possible to demonstrate treatment systems at source and prove the advantages offered by independent management of this type of equipment. Moroccan authorities should be persuaded of the advantages of independent sanitation in villages instead of centralised management, which can be difficult and costly in rural areas. The AGIRE programme therefore encourages the introduction of simplified authorisation procedures for individual and semi-collective sanitation systems within the new legislation being drafted.

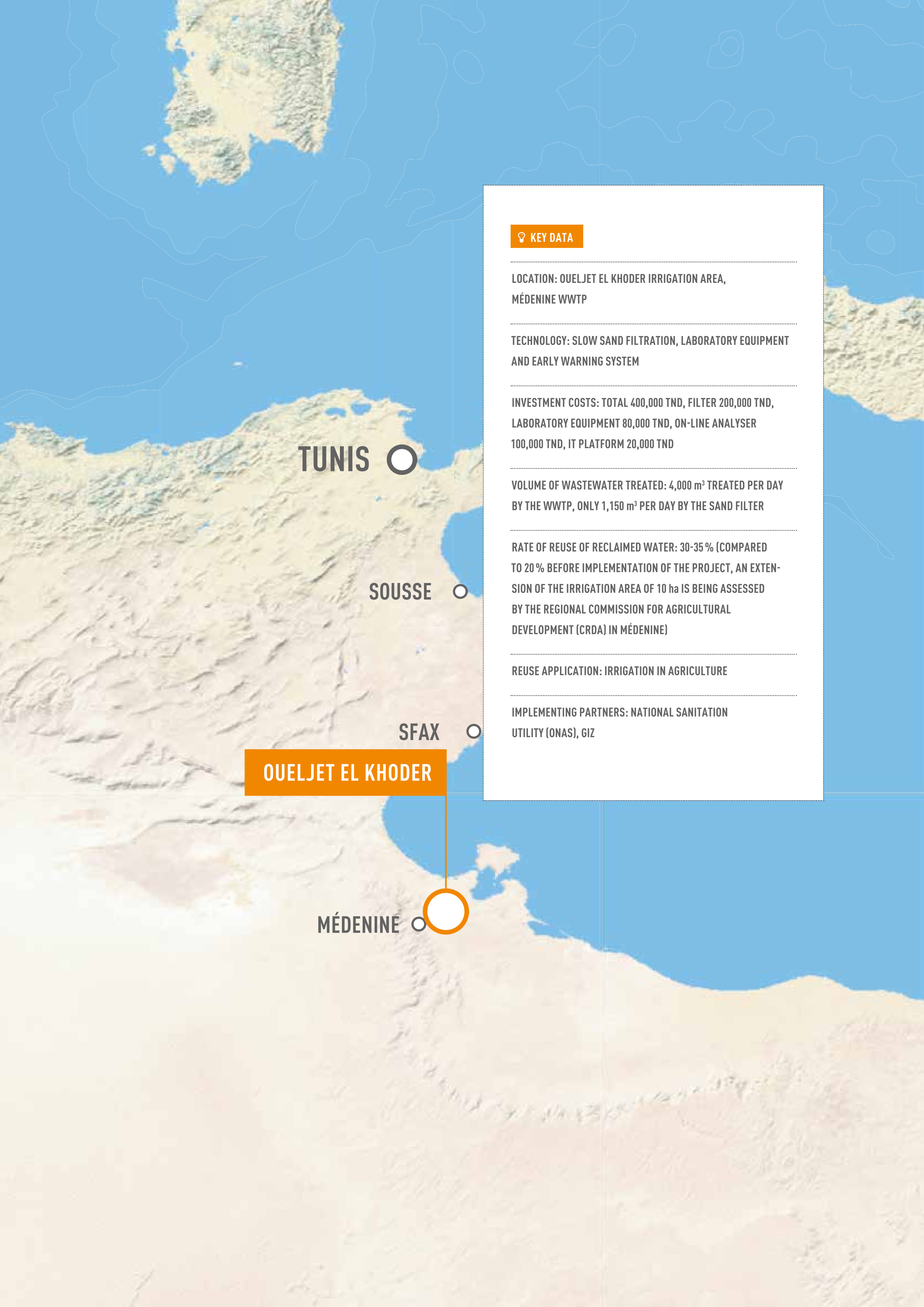
INCREASE CAPACITIES OF LOCAL TECHNOLOGY PROVIDERS

It appeared difficult at first to find local construction companies willing to bid in the tendering procedure, as this type of pilot project entails an economic risk for local construction companies which do not necessarily have the required technical skills and must develop these gradually throughout the project. This challenge has to be taken into account when designing this type of pilot project, including close support to the construction company during project realisation.

NEXT STEPS

With the revision of the National Water Plan, reuse practices are an important aspect as rural sanitation in particular will be covered by the law under the PNAR. Through the AGIRE programme, GIZ is cooperating with the Department for Water under the Ministry for Energy, Mines, Water and the Environment on decrees to be incorporated into law, on capacity building, and on drafting a catalogue of rural sanitation systems, including documentation on best practices. This type of pilot project should assist the Moroccan government in achieving its target of increasing the rate of treated wastewater reuse by 30 percent by 2018.

It was possible to draw on lessons learned from the previous project carried out in Dayet Ifrah for the pilot project in Ait Idir. For example, technologies were adapted to suit the local context, which enabled cost savings. GIZ and the Ministry for Energy, Mines, Water and the Environment are currently researching the possibility of adopting a similar approach for another pilot site near Marrakesh. The pilot project in Ait Idir is therefore helping to spread this type of approach to other sites around Morocco and may serve as a practical example for the implementation of the PNAR. The ABH SMD is also currently working on a comprehensive plan of action for ecological sanitation throughout the entire Dadès Valley.



KEY DATA

LOCATION: OUELJET EL KHODER IRRIGATION AREA, MÉDENINE WWTP

TECHNOLOGY: SLOW SAND FILTRATION, LABORATORY EQUIPMENT AND EARLY WARNING SYSTEM

INVESTMENT COSTS: TOTAL 400,000 TND, FILTER 200,000 TND, LABORATORY EQUIPMENT 80,000 TND, ON-LINE ANALYSER 100,000 TND, IT PLATFORM 20,000 TND

VOLUME OF WASTEWATER TREATED: 4,000 m^3 TREATED PER DAY BY THE WWTP, ONLY 1,150 m^3 PER DAY BY THE SAND FILTER

RATE OF REUSE OF RECLAIMED WATER: 30-35 % (COMPARED TO 20 % BEFORE IMPLEMENTATION OF THE PROJECT, AN EXTENSION OF THE IRRIGATION AREA OF 10 ha IS BEING ASSESSED BY THE REGIONAL COMMISSION FOR AGRICULTURAL DEVELOPMENT (CRDA) IN MÉDENINE)

REUSE APPLICATION: IRRIGATION IN AGRICULTURE

IMPLEMENTING PARTNERS: NATIONAL SANITATION UTILITY (ONAS), GIZ

PILOT CASE TUNISIA

INTRODUCTION

Conducted as part of the Sustain Water MED scheme, the pilot project aims to improve a number of aspects at the chosen site in Médenine:

- *Overcoming risks to human health and the environment: this involves improving treatment and monitoring, as well as the control of the quality parameters of reclaimed water; a reliable system for detection and instant warning if limits are exceeded; systematic monitoring of current target values, as well as preventive safeguards for targets.*
- *Maximising water reuse in agriculture and ensure the careful and appropriate use of reclaimed water: this means considering the nutrients that reclaimed water provides for local farming practices, as well as potential impacts on groundwater caused by the leaching of harmful substances.*
- *Improving institutional organisation to assure the sustainability of water reuse projects in the region: this implies recovering costs for each actor, strengthening coordination between actors and enhancing the capacities of all involved in wastewater reuse at the national, regional and local levels.*

As part of this pilot project, the following measures were selected:

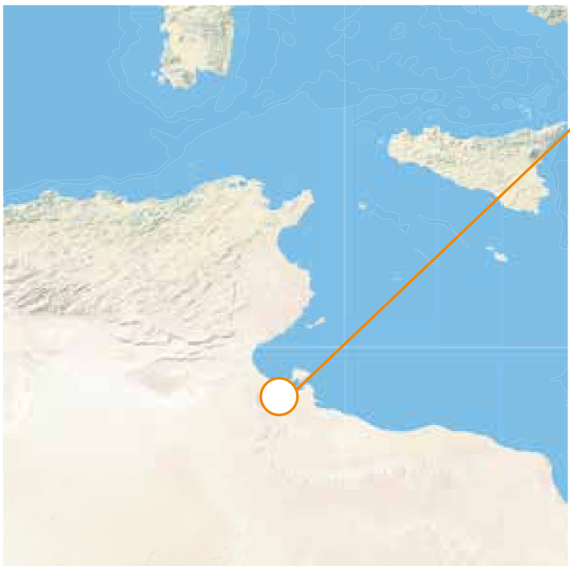
- *Evaluation of the baseline situation;*
- *Introducing a tertiary treatment unit, through slow sand filtration;*
- *Acquiring laboratory equipment and a computerised early warning system in order to ensure water quality monitoring;*
- *Adopting an environmental management plan to regenerate the area and create a green space;*
- *Adopting a programme to strengthen the stakeholders' technical and organisational capacities in order to respond to the need for training and awareness-raising among staff of the WWTP and users of reclaimed water.*

The pilot scheme is being carried out at the Médenine WWTP, built in 2000 and designed for a treatment capacity of 8,870 m³ per day. The plant currently produces some 4,000 m^3 of reclaimed water per day that has undergone secondary treatment (extended aeration, low load). In 2011, only 238,000 m^3 of reclaimed water were reused out of a total of 1,466,000 m^3 of wastewater, amounting to merely 16 percent. The pilot scheme aims to improve water reuse, as this non-conventional source of water is currently not exploited to its full potential.

The measures chosen for the Médenine site are a good example of the simple and relatively low-cost solutions available for improving and standardising the way in which wastewater is reused in Tunisia. Indeed, the construction of a sand filter and the installation of an information and monitoring system are measures that could potentially be replicated with little effort at other sites in Tunisia. Furthermore, at an institutional level, the organisations participating in the steering committee emphasised the usefulness of the meetings held as part of this project, which enable regular exchanges on the respective responsibilities and the various interests of the national institutions involved in wastewater reuse, as well as on possible ways to improve and replicate this type of project.

Existing treatment facilities of Médenine Wastewater Treatment Plant.

Source: GIZ



Source: Made with Natural Earth, 2015.

PROJECT SETTING

The Médenine region suffers from on-going groundwater degradation as a result of overexploitation, as well as water stagnation and eutrophication downstream of the WWTP. Moreover, current reuse practices might cause health risks as the quality of reclaimed water is not monitored. This project for reclaiming water in Médenine WWTP intends making it possible to further exploit potentials for reuse. The measures implemented aim to overcome current health risks and limit the tendency towards environmental degradation.

LOCATION OF THE SITE

Médenine WWTP is located to the east of the city of Médenine. The irrigation area of Oueljet El Khoder has an extension of 30 ha, and is comprised of four separate zones, three of which are located close to the WWTP, forming part of the Médenine East sector (Oueljet El Khoder, Oueljet El Gumemda and Ettemtem). The fourth zone is located approximately 3.5 km away and forms part of the Amra Jdida sector. In terms of administrative responsibility, the entire irrigation area is located within the delegation of Médenine South.

Wastewater that is not reused after treatment in Médenine WWTP is discharged into the Smar wadi, flowing close to the plant. Several areas of groundwater are most likely impacted by the discharge of treated wastewater, in particular the Triassic sandstone, Mio-Plio-Quaternary (MPQ) and Zeuss Koutine aquifers. The two large faults in the region (Tejra and Médenine) characterise the local hydrogeological setting. Several communities are affected by the WWTP and the treated wastewater discharged into the Smar wadi. These areas include Gumemda, Ettemtem, Amra Jdida, Hassi Médenine and Dargoulia.

SOCIO-ECONOMIC CHARACTERISTICS

The project area is predominately agricultural. The agricultural land is often discontinuous due to topographical conditions, although there is a tendency for farms to expand as a result of the privatisation of common land. Most farms in the target area are small or micro-sized.

Cropping areas are often located within wadis, in the valleys and on terraces along slopes, where the edaphic conditions are somewhat better. The main types of farming are rain-fed tree crops, forage crops and small-scale livestock farming. Tree crops are mostly comprised of olive groves for oil and table olives, almond trees, fig trees and pomegranate trees. The forage crops are intercropped with fruit trees, but suffer from shortages of water. Currently, there are 27 ha of land planted with olive groves (with an average density of 40 plants/ha), cultivated by 18 farmers. Forage crops cover approximately 10 ha. Most of this crop farming is rain-fed, with occasional irrigation from reclaimed water in dry periods. Livestock farming is only practised by approximately 20 percent of farmers in the irrigation area.

Farming is the main occupation for only 30 percent of the farmers, while 69 percent of farm owners have another main occupation. The average farm size within the project area is 1.5 ha.

ENVIRONMENTAL SETTING

The project zone is located in the south-east of Tunisia, in a semi-arid region where the influence of the sea can be clearly seen in the vast Jeffara basin, even though the climate is dryer than in coastal regions. The average temperatures range between 27 °C and 30 °C during summer months and between 12 °C and 14 °C during the winter. The total annual rainfall is very low, with an average of 157 mm per year, of which 75 percent is recorded during the months from October to March. Levels of rainfall fluctuate considerably from year to year and season to season – a feature that is intensified by the region's exposure to Saharan influences. This rainfall is typically concentrated on periods of around twenty days, along with stormy or torrential weather. This occurs in particular during the autumn months, when 42 percent of the annual rainfall is recorded. Evapotranspiration in Médenine varies depending on the method of calculation from 1,112 mm *(Thornthwaite)* to 1,568 mm *(Turc)*, which results in a rainfall deficit of between 954 mm and 1,410 mm.

WATER RESOURCES

In the region of Médenine, the drainage system is very dense and is composed of a network of wadis with intermittent water flows, with the Smar being the main collecting wadi. The source of this wadi is located at the confluence of a number of wadis downstream of Médenine that drain the elevated areas to the west of the city.

The project zone features an aquifer system comprising three interconnected aquifers, which are accessed via surface wells or deep drilling, depending on the depth of the water table. The overall usage of the aquifer system amounts to an overexploitation of renewable resources, which has the result of increasing the salinity of the pumped water, essentially for the MPQ aquifer. The discharge of reclaimed water directly into the Smar wadi helps to recharge the aquifer system, however it entails the risk of groundwater contamination and damage to farm activities. This is a particular concern for agricultural products that are consumed raw.

Salinity in the catchment basin of the Smar wadi increases nearer to the wadi and towards the wadi mouth. Along the bed of the Smar wadi, salinity levels are at around 4 g/l, and exceed 5 g/l on the right bank. This increase in salinity results from evaporation where the groundwater surfaces at the wadi, and probably also from an intrusion of salt through discharged wastewater.

SEWAGE SYSTEM, DESIGN OF THE WWTP & IRRIGATION AREA

In 2011, ONAS in Médenine managed 11,084 customers, including domestic, tourist and industrial ones, encompassing a population equivalent (PE) of 63,738. The development of raw sewage quantities, and its quality, between 2007 and 2011 is recorded in *Table 12*.

TABLE 12	DEVELOPMENT OF THE NUMBER OF CUSTOMERS, VOLUME OF WASTEWATER & CONCENTRATION OF BOD_5			
YEAR	NO. CUSTOMERS	POP. EQ.	VOLUME OF WASTEWATER (m^3/yr)	AVERAGE CONCENTRATION OF BOD_5 AT ENTRY (mg/l)
2007	9548	50514	122151	329
2008	9690	51702	1084724	357
2009	10312	54968	1173079	484
2010	10820	57687	1282912	461
2011	11084	63738	1466787	452
2012	–	–	1382264	520

Source: Sustain Water MED 2013a.

The scale of operations at the Médenine WWTP is as follows:

- *Throughput: 8,870 m³ per day*
- *BOD_5 load: 3,500 kg BOD_5 per day*
- *PE: 81,000*

The WWTP currently handles an average daily throughput of approximately 4,000 m³ per day, equalling around 50 percent of its capacity.

The treatment process of Médenine WWTP is composed by the following treatment units:

- *Pumping station;*
- *Pre-treatment units (degritting, sand removal unit, oil and grease removal);*
- *Biological treatment units: contact tank and extended aeration tank (composed of an anoxic zone, an aerated zone and a post-denitrification zone);*
- *Secondary settling (circular tanks fitted with a scraper bridge);*
- *Sludge treatment line: sludge concentration unit fitted with a scraper bridge, drying beds.*

The treatment process at Médenine WWTP is based on an extended aeration (low load) process. The untreated wastewater flows into the plant through a reinforced concrete structure and is then transferred to the pumping station. From this station, the raw wastewater is pumped towards the pretreatment unit (de-gritting and de-oiling) at a throughput rate of 410 m³ per hour and a TDH of 14 metres. After pre-treatment, the wastewater is gravity-fed towards the biological treatment units, consisting of aeration tanks equipped with two sludge recirculation pumps and a post-denitrification zone comprising a 3,600 m³ tank equipped with an aerator (62 kg O_2 per hour) and two agitators. The wastewater is then sent to two settling tanks. The excess sludge is transferred to the sludge concentrator to be then channelled back towards the drying beds by a thick-sludge pump. The treated water is either stored in the reservoir managed by the Médenine CRDA to be reused in agriculture, or it is discharged into the natural environment (Smar wadi). A proportion of the treated water is also reused in the wastewater treatment process.

The irrigation area is divided into four sectors, with each being controlled by a zoning valve. The four sectors are divided as follows: one sector for the Ettiss family (Amra Jdida sector), one sector for the El Khoder family, one sector for the El Gumemda family, and one sector for the Ettemtem family. The cultivated land measures 30 ha, with 39 beneficiaries and 27 hydrants. The throughput in the irrigated area is currently 20 litres per second, shared amongst four lots of 5 litres per second. The irrigation technique used is gravity-fed irrigation. Farming activities are currently low, with a reduced number of farmers (approximately 5 to 10 farmers). There are currently inconsistencies in data on consumption: reports by the Directorate General for Rural Engineering and Water Use (DGGREE) state that there is an average annual consumption of approximately 35,000 m³, while data provided by ONAS report an annual average of 200,000 m³. A lack of transparency can be detected in the management of the irrigation area. The main problems are illegal water withdrawals within the distribution system, and defective meters. In addition, it is likely that the distribution system suffers from considerable water losses, given the lack of operation and maintenance.

POTENTIAL FOR REUSE

In the irrigation area of Oueljet El Khoder, farming activity is of a low intensity due to a number of structural problems. Approximately 30 percent of the farmers do not use the reclaimed water from the irrigation area, 50 percent use a low volume of this water (generally in back-up irrigation), while 20 percent use it regularly.

Around 50 percent of the farmers have access to other sources of irrigation water, usually surface wells and/or drilled wells, purchased water tanks, or water from the National Water Distribution Utility (SONEDE). Given that in 2011 the rate of reuse of reclaimed water in the Médenine WWTP was as low as 16 percent, there is considerable potential to further develop this non-conventional water resource. When asked why they refuse to use reclaimed water for irrigation, the farmers currently blame the foul smell it gives off and the risk of diseases. Further limiting factors are the regulations associated with reuse; the users must themselves finance the vaccinations and special clothing recommended.

LEGAL & POLICY FRAMEWORK

The reuse of reclaimed water in Tunisia is regulated by the Water Code. The quality of reclaimed water must adhere to the Tunisian standards NT 106.02 (discharge into the natural environment) and NT 106.03 (use in agriculture). Compared to NT 106.02, NT 106.03 includes one additional microbiological parameter (gastrointestinal nematode eggs), which must be observed for use in agriculture *(see Table 13)*.

TABLE 13

STANDARD NT 106.03

PARAMETER	UNIT	MAXIMUM CONCENTRATION
PH		Between 6.5 & 8.5
EC	uS/cm	7,000
COD	mg O_2/l	90
BOD_5	mg O_2/l	30
SUSPENDED SOLIDS	mg/l	30
CHLORIDES	mg/l	2,000
FLUORIDES	mg/l	3
ORGANOCHLORIDES	mg/l	0.001
ARSENIC	mg/l	0.1
BORON	mg/l	3
CADMIUM	mg/l	0.01
COBALT	mg/l	0.1
CHROMIUM	mg/l	0.1
COPPER	mg/l	0.5
IRON	mg/l	5
LEAD	mg/l	1
MANGANESE	mg/l	0.5
MERCURY	mg/l	0.001
NICKEL	mg/l	0.2
SELENIUM	mg/l	0.05
ZINC	mg/l	5
GASTRO. NEMATODE EGGS		<1/1,000 ml

Source: Sustain Water MED 2013a.

Currently, a project is being undertaken to update the standard NT 106.03. This proposes classifying areas of use of reclaimed water according to the following categories:

- **CATEGORY I** *The use of reclaimed water in agriculture, in accordance with the list of authorised crops specified by the Decree of the Minister of Agriculture of 21 June 1994;*
- **CATEGORY II** *The irrigation of golf courses, sports grounds, urban parks and green spaces in urban areas;*
- **CATEGORY III** *Recharge of groundwater destined for use in agriculture.*

A number of incoherencies exist in Tunisian legislation regulating the reuse of reclaimed water. Indeed, a number of parameters cannot be optimised to respond to both environmental concerns and the requirements for reuse in agriculture. For example, a level exceeding a particular parameter may be favourable for reuse in agriculture, while this should be prohibited for discharges into the natural environment (such as nitrogen, phosphorus, potassium or organic matter). Other substances may not have harmful impacts in discharges, but should be prohibited in reused water (e.g. salinity).

DESCRIPTION OF THE PILOT PROJECT

CHALLENGES

A preliminary analysis was conducted on the process of reusing reclaimed water from Médenine WWTP in the irrigation area Oueljet El Khoder. A number of risks were detected for both public health and the environment. The aim of the pilot project is to overcome these risks, in particular by providing advanced (tertiary) wastewater treatment, and by establishing a reliable system for water quality control and early warning.

Regarding improving the quality of reclaimed water, the microbiological content is not negligible; even though the standard NT106.03 is adhered to, with the mean reading for gastrointestinal nematode eggs being less than 1 per litre. This parameter is insufficient, and it is essential that the bacterial load in the water is analysed in order to measure the risk of infection for water users. Moreover, the analyses by the Ministry of Health reveal that the standard NT106.02 is not consistently adhered to, as the maximum monthly concentrations of BOD_5 and of suspended solids at times exceed discharge standards. Monitoring of the other parameters shows that salinity levels vary from 3,500 to 4,500 µs/cm. Data on microbiological quality also indicates excessive levels of coliform bacteria and faecal streptococci.

In addition to the measures implemented under the pilot project to improve the quality of reclaimed water through advanced treatment, a further challenge is to enhance coordination between stakeholders concerned with the irrigation area of Oueljet El Khoder. The information system installed as part of the project should respond to the lack of transparency in data on the quality of reclaimed water, and provide a solid basis for a reliable exchange of information. This should enable trusting cooperation between ONAS, CRDA and the users of the reclaimed water.

Irrigation with reclaimed water will be practised in olive groves that are mostly rain-fed, where additional irrigation so far is only provided during the dry season. Currently, a volume of 100,000 m³ of reclaimed water is distributed annually throughout the irrigation zone in dry seasons. The results from a series of physico-chemical and bacteriological analyses of the soil, groundwater and crops in the Oueljet El Khoder irrigation area have yielded encouraging results. The samples of olive oil obtained from olives irrigated by reclaimed water are of a high quality (high oleic acid content) and, in general, no major other differences were observed compared to the quality of oil obtained from olives harvested from plants irrigated traditionally. This is likely to prompt other farmers to request connection to the reclaimed water distribution system, which would lead to an increase in the volume of reclaimed water distributed for use in irrigation.

TABLE 14

DEVELOPMENT OF CONCENTRATIONS OF BOD_5, COD & SUSPENDED SOLIDS

YEAR	BOD_5 (mg/l)			COD (mg/l)			SUSPENDED SOLIDS (mg/l)		
	AVERAGE	MAX.	STANDARD	AVERAGE	MAX.	STANDARD	AVERAGE	MAX.	STANDARD
2007	23.0	29.0	30.0	58.0	84.0	90.0	21.0	27.0	30.0
2008	23.0	31.0	30.0	61.0	77.0	90.0	24.0	30.0	30.0
2009	23.0	30.0	30.0	55.0	69.0	90.0	26.0	42.0	30.0
2010	19.0	23.0	30.0	51.0	68.0	90.0	21.0	29.0	30.0
2011	21.0	28.0	30.0	55.5	64.0	90.0	21.8	27.0	30.0
2012	18.3	20.0	30.0	57.1	62.0	90.0	20.3	22.5	30.0

Source: Sustain Water MED 2013a.

THE TECHNOLOGY CHOSEN: SLOW SAND FILTRATION

The technology chosen in this pilot project to provide advanced treatment for wastewater in the Médenine WWTP is slow sand filtration. This is due to its effectiveness in drastically reducing bacteriological load and suspended solids, through a simple and low cost technology.

Slow sand filtration is a physical-biological wastewater treatment system where the wastewater to be treated passes through a bed of filtering material at a rate of 0.1 to 0.2 metres per hour. The most suitable filtering material for this process is sand. This gradual process considerably improves the quality of the water by reducing the amount of micro-organisms (bacteria, viruses, microbial cysts), and eliminating suspended solids and colloidal particles.

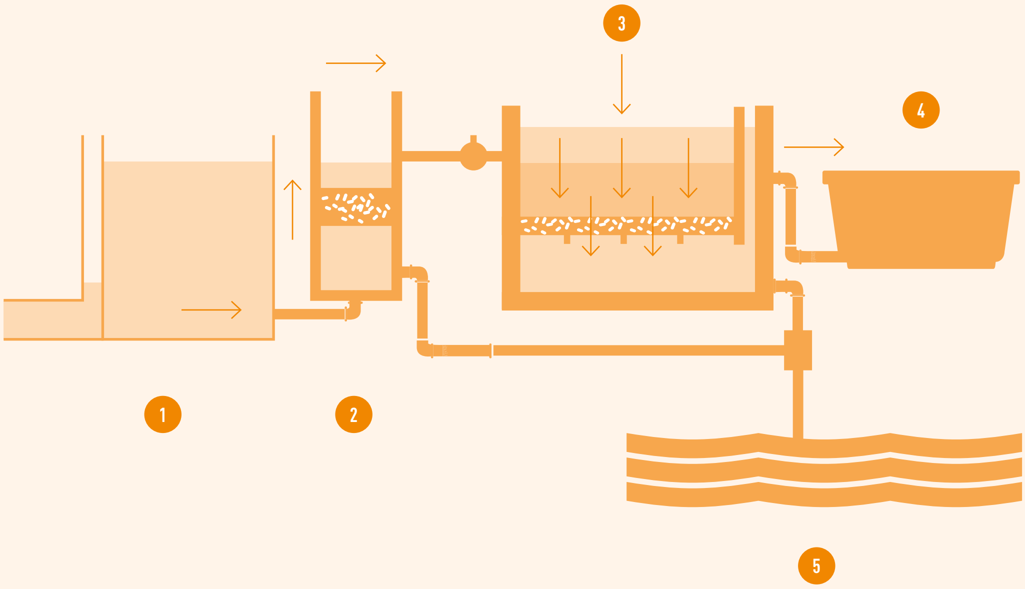
The filter is comprised of four elements: a pre-filter and three individual bio-filters arranged in succession, yet independent of each other.

WWTP effluent is gravity fed to the sand filtration according to the specific demand. It first enters a pre-filter from below, which then feeds two parallel filters from above. The third filter is either idle or under maintenance, acting as a contingency filter. Finally, the sand filter outlet is directly connected to the treated water storage tank with a capacity of 1,000 m^3. No mechanical force is required.

Sand filtration is a simple and economical treatment system, with the advantage to be a highlyeffective and easy-to-operate solution. It is constructed out of high quality concrete, and is therefore a very robust structure. Thus it makes it possible to improve water quality in terms of physical, chemical and bacteriological characteristics, while offering the option of involving the local community in managing, maintaining and operating the installations.

The reported data concerning the performance of the sand filter shows its capability in removing the suspended solids, the organic material – both in terms of Chemical Oxgen Demand (COD) and Biochemical Oxygen Demand (BOD) – and the bacteriological pollutants still present in the treated water of the WWTP of Médenine. The removal abatement efficiency measured on 24-hour samples are 93.8 percent, 92.8 percent, 73.3 percent and 99.5 percent for Suspended Solids, Colour, BOD and enterococci respectively. The sand filtration process has also shown a good capability in removing some heavy metals (aluminium and zinc).

SCHEMATIC ILLUSTRATION OF THE TREATMENT SYSTEM



1. ONAS WWTP
2. FIRST FILTRATION
3. SLOW SAND FILTRATION: 1250 m^3/day
4. STORAGE BASIN CRDA
5. EXCESS DISCHARGED INTO THE RIVER

Constructed sand filter of Médenine Waste Water Treatment Plant.

Source: GIZ

MONITORING RECLAIMED WATER QUALITY & THE EARLY WARNING SYSTEM

The frequency of quality controls for reclaimed water is defined by the Tunisian legal framework (monitoring and control programme for irrigation water, Decree n°89-1047, 28/07/1989 and Decree n°936447, 13/12/1993). The controls must be overseen by ONAS and CRDA. In practice, it is not possible to conduct the analyses with regularity or in a transparent way due to a lack of means and capacity within these institutions. A number of analyses even have to be outsourced to a private external laboratory. Furthermore, for certain parameters there is currently no early warning mechanism in place, should limits be exceeded.

These aspects are vital for ensuring an optimised process in the reuse of reclaimed water. In order to improve these aspects, ONAS' laboratory at the Médenine WWTP will be upgraded with the following equipment:

· *Oximeter;*

· *pH-meter/conductometer;*

· *COD reactor;*

· *BOD incubator;*

· *Full equipment for bacteriological analyses;*

· *Automatic sampler;*

· *An online multi-parameter analyser that will enable online analyses of reclaimed water quality at the sand filter's outlet, as well as transmitting the data to a computer application (outlined below).*

In addition, the Agricultural Development Group (GDA) must be equipped with a mobile laboratory that enables sampling of the entirety of the irrigation area. This will include the following equipment:

· *Complete, portable oximeter;*

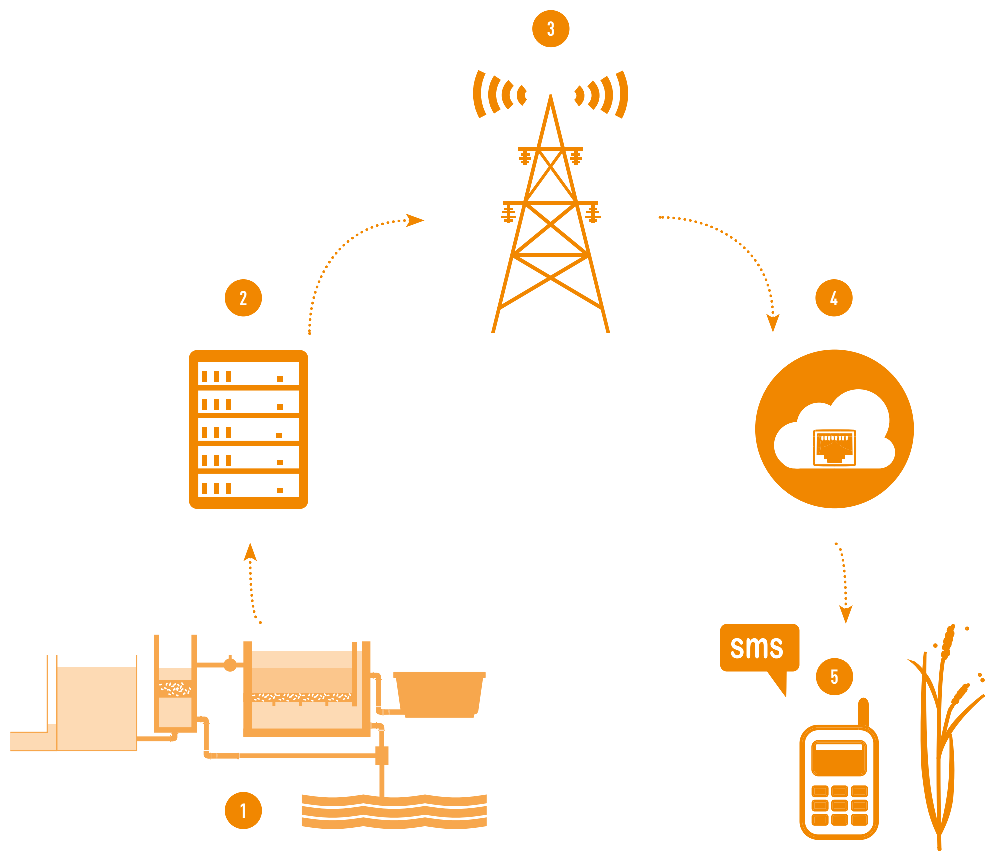
· *Portable pH/mV meter with ready-to-use case kit;*

· *Precision portable conductometer (± 0.5 percent precision) complete, in case;*

· *Portable turbidimeter.*

This new equipment will make it possible to carry out the necessary analyses for regular monitoring of water quality. These direct measures on-site will eliminate the kind of delays associated with outsourcing analyses to private external laboratories. The on-line multi-parameter analyser provides immediate results, which are transmitted to a database where they can be compared directly with the prescribed limits. The database is accessible to all stakeholders concerned (ONAS, CRDA, GDA, Directorate for Environmental Health and Protection (DHMPE), National Agency of Environment Protection (ANPE), and in case limits are exceeded, the system provides an early warning to the farmers via SMS.

SCHEMATIC ILLUSTRATION OF THE QUALITY MONITORING & EARLY WARNING SYSTEM IMPLEMENTED IN OUELJET EL KHODER IRRIGATION AREA.



1. ONAS WWTP, SAND FILTER & STORAGE TANK 1,000 m³ (ANALYSES CONDUCTED IN WWTP LAB)
2. ON-LINE MULTI-PARAMETER ANALYSER (BOD, COD, SS, PH ETC.)
3. TRANSMISSION OF ANALYSIS DATA
4. DATA SHARING & EARLY WARNING SYSTEM
5. EARLY WARNING TO FARMERS

Source: GIZ

ENVIRONMENTAL MANAGEMENT PLAN

The environmental management plan proposed within this pilot project aims to improve the quality of life of the local community in the irrigation area of Oueljet El Khoder. It is primarily a plan to restore the local environment, including waterweed cutting and dredging the area surrounding the WWTP at the Smar wadi, creating a green space in the vicinity, embanking the pumping station, and constructing fencing.

WATERWEED CUTTING & DREDGING THE AREA SURROUNDING THE WWTP AT THE SMAR WADI

The Smar wadi is overgrown with reeds along a distance of approximately 4 km. The overgrown zone is an area prone to stagnant water (and the foul smells it emits) and infestations of mosquitos. Thus it is essential that urgent action is planned. This must go beyond current efforts by ONAS to transfer water discharged from the WWTP 2 km downstream via a pipeline. The zone downstream of the route (approximately 16 ha) will have to be treated.

CREATING A GREEN SPACE IN THE AREA SURROUNDING THE WWTP

It would be greatly beneficial to create a green space around the WWTP. Discharged water could be used to grow ornamental and silvopastoral species, to embellish the countryside and to create a source of income. ONAS is able to grant a quantity of water to a private developer to establish a plant nursery at the base of the WWTP. The developer may also take responsibility for landscaping the WWTP.

EMBANKING THE PUMPING STATION AND FENCING

Embanking the pumping station is a necessary measure to protect the site from flooding from the Smar wadi. The embankment is at the foot of the WWTP, near to the mouth of a small stream on the left bank of the Smar wadi. This earth bank is 2 metres high, 75 metres long and 3 metres wide at its ridge. It has a side slope ratio of 3:2 and is constructed out of a total of 900 m^3 of earth.

CAPACITY BUILDING PROGRAMME

The pilot project includes a capacity building programme targeted at the Tunisian national institutions and the local stakeholders concerned with the Oueljet El Khoder irrigation area (ONAS, CRDA, GDA and reclaimed water users). The project also involves awareness-raising campaigns aimed at local populations.

At a national level, representatives from the Tunisian Ministries of Health and the Environment, ONAS, ANPE and CRDA participated in three regional training sessions. At a local level, the staff at the Médenine WTTP benefitted from training on monitoring water quality and on the new early warning system. They were also given specific training on the equipment for bacteriological analysis. The GDA received training aimed at improving its community, administrative and financial management. The farmers themselves benefitted from two awareness-raising activities looking at using the information and early warning system.

These measures complement awareness-raising measures previously conducted at a local level. Since 2004, CRDA has regularly organised awareness-raising campaigns concerning hygiene and protection in the reuse of reclaimed water in agriculture (around 3 to 5 days per year). The Tunisian Ministry of Agriculture is currently developing other awareness-raising programmes on this issue at a local level. This was considered important because, even though farmers are aware of the risks associated with water reuse, most of them still do not observe recommendations for vaccinations and the use of protective equipment.

PROJECT REALISATION: INSTITUTIONAL STRUCTURE

At a local level, the pilot project in the Oueljet El Khoder irrigation area is managed in close cooperation with the stakeholders directly concerned. At a national level, a steering committee was founded, which is composed of the Tunisian ministries and institutions involved in the reuse of reclaimed water.

ONAS is responsible for providing reclaimed water. Its mission is to promote the distribution and sale of purified water, sludge from WWTPs and all other by-products. The CRDA, under the supervision of the Ministry of Agriculture, Water Resources and Fisheries (MARHP), are responsible for the distribution of reclaimed water. Thus, they are in charge of distributing the reclaimed water from the outlet of ONAS' WWTPs to the irrigation areas. It is their function to install pumping stations and the distribution system, as well as to operate and maintain them. A number of actors are responsible for monitoring the reuse of reclaimed water, notably:

- *The Ministry of Public Health through the activities of:*
  - *The DHMPE, which supervises hygiene conditions and is responsible for evaluation, monitoring, technical assistance, public awareness-raising, and research;*
  - *The National Agency for the Sanitary and Environmental Control of Products (ANCSEP), which ensures compliance with regulations and national and international standards, and also oversees training and information on the sanitary and environmental control of products.*
- *The Ministry of the Environment via the National Agency of Environment Protection (ANPE), whose mission is to tackle all sources of pollution and environmental degradation, thereby ensuring a consistent quality of water discharged into the natural environment. It is also charged with endorsing studies on the environmental impacts of reuse projects.*

The steering committee is not only comprised of representatives from the aforementioned institutions, but also from the Directorate General for the Environment and Quality of Life (DGEQV), under the supervision of the Ministry of the Environment, as well as the DGGREE, under the supervision of the Ministry of Agriculture. The latter are involved in strategic development and public awareness-raising concerning the reuse of treated wastewater in Tunisia. The users of reclaimed water are farmers, represented by the GDA.

POTENTIAL BENEFITS & RISKS

BENEFITS FOR PUBLIC HEALTH & ENVIRONMENT

The pilot project is expected to achieve a considerable improvement to the quantity and quality of the treated wastewater reclaimed from the Médenine WWTP and a higher use of treated wastewater. The use of this non-conventional resource of water could alleviate the pressure on groundwater caused by the over exploitation and prevent its salinization due to seawater intrusion. The installation of a slow sand filtration as tertiary treatment step will make it possible to overcome the risks to human health and the environment since the quality of the reclaimed water should reliably adhere to the standards NT 106.02 and NT 106.03. Therefore, reclaimed water will be suitable for use in irrigation. In particular, this technology is suitable to the local context since it can guarantee high removal efficiency for suspended solids, organic substance and microbiologic pollutants at reasonable capital and O&M costs. Thanks to the installation of the on-line information system and the early warning system, data on water quality are easily accessible to all relevant actors in the reuse process. This represents considerable progress, as prior to the pilot project, the reclaimed water was used by certain farmers in the Oueljet El Khoder irrigation area without any real monitoring of its quality or its compliance with standards. Such practices entail a risk of contamination.

The new technical equipment (the laboratory in the Médenine WWTP and the mobile laboratory) as well as the information and early-warning system will enable an improvement in monitoring and controlling pathogens. The responsibility of each institution involved in monitoring the quality of reclaimed water is defined in detail in this system. This is an improvement on the situation prior to the project where the institutions had neither the technical capacity to carry out the necessary monitoring, nor any effective platform for sharing analysis data on a regular basis.

BENEFITS FOR THE PRACTICE OF REUSE IN AGRICULTURE

The pilot project positively affects the practice of water reuse in agriculture. The first series of physic chemical and bacteriological analyses of the soil, groundwater and agricultural products conducted in the Oueljet El Khoder irrigation area in 2014 yielded encouraging results. The samples of olive oil obtained from olives irrigated by reclaimed water are of a high quality (high oleic acid content). The farmers concerned have confirmed this result and have stated that they are very satisfied with the quality of the olives irrigated by reclaimed water. These promising results demonstrate that good quality of crops can be achieved through irrigation with reclaimed water. These results will convince other farmers of the benefits of reuse practices in agriculture, potentially increasing the rate of reuse of reclaimed water for irrigation in the region. A certain word-of-mouth effect would also seem to apply already as CRDA has already received requests for connection to the reclaimed water distribution system from farmers beyond the irrigation area.

BENEFITS IN TERMS OF KNOW-HOW & AWARENESS

The level of technical know-how and awareness of the potential for reuse in agriculture has increased among the actors concerned thanks to the training programme proposed within the pilot project. At a national level, representatives from the Tunisian Ministries of Health and the Environment, from ONAS, ANPE and CRDA participated in a regional training session on water quality management held in Djerba in 2013. At a local level, the staff at the Médenine WWTP (regional body of ONAS) benefitted from general technical training on the new system and from specific training on bacteriological analysis.

The pilot project also includes plans for awareness programmes, including two awareness-raising campaigns aimed at farmers in the irrigation area on the information and early warning system being implemented. The aim of these programmes is to increase awareness and acceptance for the reuse of treated wastewater in irrigation among the users concerned. In general, the GDA and the farmers concerned find that reclaimed water will receive more and more acceptance as a water resource for irrigation if reclaimed water from the Médenine WWTP is of a more reliable quality as a result of the measures planned under this pilot project.

BENEFITS IN TERMS OF TRANSPARENCY & EXCHANGE OF INFORMATION

At a national level, the pilot project contributes to a regular exchange of information and to coordination between the national institutions concerned with water reuse in agriculture in Tunisia. The institutions represented in the steering committee stress that the meetings organised at regular intervals under the pilot project provide a valuable platform for discussing the institutions' respective responsibilities and interests. The meetings also offer opportunities to consider how this type of pilot project could be improved and replicated. Indeed, because the activities chosen for the pilot project in the Médenine site are relatively simple and low-cost, it should be possible to replicate them at other sites in Tunisia. In addition, the representatives of the national institutions also appreciated the exchanges concerning other experiences with treated wastewater reuse which were possible during the regional training activities.

At a local level, quality improvement of the reclaimed water and the availability of information should help to establish more trusting relations between ONAS, CRDA and the farmers as the results of water quality analyses will be accessible in a transparent manner.

ECONOMIC BENEFITS

The increase in the reuse of reclaimed water for irrigation should enable savings in water costs for the users. The price of reclaimed water, at approximately 0.02 Tunisian Dinar (TND) per m^3, is considerably lower than the price of conventional water, at approximately 0.08 TND per m^3. In addition, reusing treated wastewater in agriculture also usually enables greater yields and better quality of agricultural products. Water reuse therefore makes it possible to increase the volume of water available for irrigation, while the reclaimed water itself contains nutrients beneficial to crops. Thanks to these added nutrients, farmers can also save on the cost of fertilisers.

The pilot project currently concerns an irrigation area of 30 ha. However, this area may expand as further farmers seem to be interested, given the economic advantages the project offers. Within the irrigation area itself, a number of farmers even plan to increase the size of their farm, as the new system would make it possible to regularly irrigate land that has so far been predominantly used for rain-fed farming.

POTENTIAL HEALTH RISKS

A problem remaining after the completion of the pilot project is the non-compliance with guidelines concerning essential hygiene precautions for users of reclaimed water. On several occasions before and during the pilot project, the farmers in the irrigation area were made aware of the need for protective equipment and vaccinations for people who come into contact with reclaimed water. Despite this, the majority of farmers in the irrigation area were not convinced these protective measures were necessary and were not prepared to invest in them (approximately 50 TND per person). So far, no health problems associated with reuse have been reported. Nonetheless, the risk to health will increase if more and more farmers reuse reclaimed water as a result of the pilot project.

POTENTIAL ENVIRONMENTAL RISKS

A long-term wastewater use in agriculture may cause leaching and build-up of salts and other small sized particles, with the consequent effect of a soil permeability reduction, water logging and breakdown of soil structure. The conservation of the soil characteristics is a key factor for the sustainability of the system. This can be obtained through the implementation of a correct irrigation schedule as well as good management of the infrastructures.

POTENTIAL ECONOMIC RISKS

Despite the promising economic opportunities offered by the pilot project, a structural aspect of how water resources for irrigation are managed in Tunisia makes it difficult to compare the real costs of irrigation by reclaimed water with those of conventional water. Thus it is difficult to evaluate the real economic benefits of reusing treated wastewater. Even though reclaimed water resources are theoretically less expensive than conventional water resources, in practice conventional water is often supplied more or less without charge. Water meters frequently do not work, there is the problem of illegal connections to the distribution system, and users do not always pay their water and electricity bills. These aspects prevent reliable monitoring of the quantities of water consumed by each farmer.

Visit of the pilot site in Médenine organised during the regional training in Djerba, Tunisia.

Source: GIZ

LESSONS LEARNED

EASE THE TUNISIAN STANDARD REGARDING THE REUSE OF TREATED WASTEWATER

The institutions interviewed as part of the assessment of the pilot project stressed that the Tunisian standard on reuse should be revised, and that this would go hand-in-hand with an improvement in the quality of reclaimed water. The current standard is very strict and calls for a level of water quality monitoring that the existing institutions cannot realistically provide due to a lack of capacity. As a result, the analyses are not carried out at regular intervals by the producers and providers of reclaimed water, and there is a lack of reliability and transparency regarding its quality. This lack of reliability on the quality of reclaimed water does not raise the acceptance of reclaimed water as a viable resource for use in irrigation by potential users.

FIND A WAY TO ENCOURAGE THE RECLAIMED WATER USERS TO ACCEPT THE GUIDELINES & LIMIT HEALTH RISKS

In practice, guidelines concerning health protection for persons coming into contact with reclaimed water are often not observed in practice. The Ministry of Agriculture is currently increasing its efforts to conduct awareness-raising campaigns targeted at farmers involved in reusing reclaimed water. A further tool could be to provide the GDAs with the means to finance the protective equipment and vaccines recommended for the users.

IMPROVE INSTITUTIONAL ORGANISATION AT THE LOCAL LEVEL (CRDA/GDA/ONAS) TO ASSURE THE SUSTAINABILITY OF REUSE PROJECTS

Currently, there is a lack of transparency in the management of the Oueljet El Khoder irrigation area under the system comprised of CRDA, GDA and ONAS. This concerns monitoring of both the quantity as well as the quality of the water resources distributed. A transfer of certain tasks related to the monitoring and surveillance system to the GDA, as well as reliable recovery of costs for water and electricity bills would enable better management of the irrigation area, and ensure the sustainability of this type of reuse project.

NEXT STEPS

In the long term, it will be necessary to carry out analyses of the effects of the pilot project in order to monitor developments in its impact on health, the environment and the agricultural products grown. As this pilot project proposes relatively simple and low-cost solutions, it will also be of great value to explore possibilities to extend this type of system to other sites in Tunisia. ONAS is studying the possibility of using the information platform for other WWTPs, and the Ministry of Agriculture has proposed to replicate the slow sand filtration system in other irrigation areas, under the supervision of the relevant GDAs.

At the political level, reclaimed water will henceforth be included in the new Water Code currently in development in Tunisia as a fully recognised water resource. This political step should contribute to a more efficient use of the water resources available in the country.

KEY DATA

LOCATION: AL GOZAYYERA VILLAGE, ISMAILIA GOVERNORATE

TECHNOLOGY: COMPACT AEROBIC-ANOXIC ACTIVATED SLUDGE REACTOR

INVESTMENT COSTS: 207,621 EUR

AMOUNT OF WASTEWATER TREATED: 140 m^3 PER DAY

REUSE APPLICATION: INDIRECT REUSE FOR AGRICULTURAL IRRIGATION

IMPLEMENTING PARTNERS: HOLDING COMPANY FOR WATER AND WASTEWATER (HCWW), GIZ

PILOT CASE EGYPT

INTRODUCTION

The aim of the pilot project conducted as part of Sustain Water MED in the selected site of Al Gozayyera village is to demonstrate the feasibility of implementing a decentralised WWTP in an Egyptian rural area of the Nile Delta. Like many other areas in Egypt, the site is characterised by serious environmental pollution caused by the uncontrolled discharge of raw sewage into agricultural drains, resulting in their degradation. This is due to the common sewage disposal system based mainly on cesspits and open trenches. Often, however, when water from the Nile is lacking, water in drains is the only resource available to ensure agricultural production, forcing farmers into unsafe practices. The adoption of decentralised treatment plants for wastewater treatment will generate, if widely spread in the region, a general improvement of drainage water quality and a reduction of the health risks related to its use. Egypt's national water strategy identifies decentralised wastewater treatment systems as the only solution to overcome this situation. However, few decentralised treatment plants exist as yet.

The installation of innovative decentralised treatment technology will represent a positive driver to transfer appropriate expertise to local operators and to support national efforts in upscaling the decentralised wastewater management approach.

The technology identified as the most suitable option for the pilot location is a compact treatment unit applying an aerobic-anoxic activated sludge reactor. This technology has been chosen according to its ability to ensure high treatment performance, even in the presence of hydraulic shock loads, which are typical in small communities with short sewer systems, at low-to-medium running costs.

Al Gozayyera village is one of the Al Rayah villages of West Kantara City, in Ismailia Governorate. The pilot activity is located in the eastern part of the Nile Delta, about 4 km from El-Salam bridge over the Suez Canal. Therefore, the main beneficiaries of the pilot activity are the inhabitants of Al Gozayyera, whose current discharge system – based on cesspits and open trenches – is the cause of a high pollution potential.

PROJECT SETTING

The area where the pilot project is being implemented is characterised by small farming villages, like Al Gozayyera, where the main form of agriculture is vegetable production (e.g. tomatoes, cucumbers, green peppers and fruits). The Governorate is also known for fishery and tourism. In this context, the availability of good quality water resources is critical. Yet there is currently depletion in the quantity of water available, induced by the high water demand from agriculture in the region. At the same time, the quality of water resources is also suffering as a result of the common sewage disposal system consisting mainly of cesspits and open trenches without any treatment. The project aims to demonstrate the feasibility of a decentralised approach for wastewater treatment in small communities as the best available solution to this dilemma.

SOCIO-ECONOMIC CHARACTERISTICS

Al Gozayyera village is located in the eastern part of the Nile Delta. It has about 190 houses and its residential area extends to approximately 100,000 m^2. It is surrounded by two water bodies; the North Al Rayah Drain and the Irrigation Tertiary Canal. It is located at the end section of the irrigation canal, thus the farmers suffer from a scarcity of irrigation water. Al Gozayyera currently has 1,138 inhabitants. Most of the village residents work in the agricultural sector, on their own farms or with their neighbours. The village receives drinking water from the main treatment plant of West Kantara City. The average daily drinking water consumption is about 50 litres per person per day. Based on the current population (1,138 inhabitants) and an annual growth rate similar to West Kantara (3.5 percent), the current discharge is estimated to be 56.9 m^3 per day and should reach about 76.8 m^3 per day after ten years. The government and public buildings such as the mosque, primary school and guesthouse use about 10 m^3 per day.

Source: Made with Natural Earth, 2015.

Irrigation channel in Al Gozayyera village and prospected site for the treatment plant.

Source: GIZ

ENVIRONMENTAL SETTING

The local climate in Ismailia Governorate is arid and characterised by a long, hot and rainless summer and a mild winter. The average maximum monthly temperature is 35.1 °C in July and August while the average minimum is 7.1 °C in January. The average annual rainfall is about 30 mm (precipitation rarely exceeds 50 mm per year) and occurs with low intensities during the months from October to March. There is practically no rainfall during the summer months. The average daily evaporation varies between 4.8 mm per day in winter and 12.4 mm per day in summer. The region largely features low and flat land areas with some comparatively elevated areas known as "turtles", which have historically been used as residential areas. Al Gozayyera village is situated on one of these elevated areas. The lowland flat areas are covered by fertile Nile Delta soils, offering arable land. Other parts of the lowland areas are either clay swamps or fish farms.

WATER SUPPLY & SANITATION

Ismailia Canal is the main source of freshwater, carrying water from the Nile River to two other Governorates, Port Said and Suez. From Ismailia Canal, water flows to the village through a series of secondary and tertiary branches. Drinking water is produced by the main water treatment plant of West Kantara City, withdrawing raw water from the secondary Port Said Canal. In the past, the village residents used to rely on groundwater as a drinking water supply. Nowadays, they have given up their hand pumps and closed their wells completely. Most of the village houses have water storage tanks in order to overcome the frequent cut-offs due to supply service failures. The average drinking water consumption in the village is about 50 litres per person, per day.

The village is surrounded by two agricultural drains: the North Ismailia drain and the North Al Rayah drain. The tails of the irrigation canal often suffer from water shortages, so that farmers usually also use agricultural drainage water for irrigation. Due to the high salinity of the North Ismailia drain, they only use water from the North Al Rayah drain for irrigation. The water quality of the surrounding water environment is shown in *Table 15*. The three freshwater canals (Ismailia, Port Said, Irrigation Tertiary Canal) have similar water quality as they come from the same source (Nile River). The water quality of the agricultural drains is very different: one (the North Ismailia drain) has high salinity (EC = 10,160 µS/cm) and the other (North Al Rayah) has lower salinity (EC = 1,622 µS/cm). Both drains have a high count of pathogenic bacteria. The groundwater salinity is below 500 mg per litre, with a high content of ammonia (*Table 15*). The groundwater is at shallow depths and is therefore affected by leaks from the existing sewage disposal systems that discharge directly underground.

There is no wastewater treatment in the village. The pilot activity therefore foresees the implementation of an internal sewage network connecting all buildings to the decentralised treatment plant installed in the village.

TABLE 15

WATER QUALITY CLOSE TO THE PILOT PLANT SITE

PARAMETER (UNIT)	ISMAILIA CANAL	PORT SAID CANAL	IRRIGATION TERTIARY CANAL	NORTH AL RAYAH DRAIN	NORTH ISMAILIA DRAIN	GROUND-WATERWELL
Temp. (°C)	26.9	25.3	30.4	30.2	27	24.2
pH (-)	7.82	8.31	7.89	7.6	7.44	7.86
EC (uS/cm)	394	444	379	1622	10160	613
O_2 (mg/l)	3.88	5.32	4.35	2.25	3.31	2.9
Fe total (mg/l)	0.03	0.05	0.08	0.09	0.08	0.19
Mn total (mg/l)	0.2	0.3	0.1	1.3	0.4	0.6
NO_3-N (mg/l)	0.6	4.5	1.0	0.9	2.5	3
NH_3-N (mg/l)	0.2	< 0.1	< 0.1	< 0.1	< 0.1	1.16
Br (mg/l)	<5	<5	–	–	–	<5
Ca (mg/l)	35.1	38	–	–	–	30.7
Mg (mg/l)	11.9	15	–	–	–	14.2
Na (mg/l)	35.6	39	–	–	–	135
K (mg/l)	5.5	6	–	–	–	5.9
Cl (mg/l)	26	28	–	–	–	86.7
SO_4 (mg/l)	30	34	24	114	653	90
DOC (mg/l)	4.3	3.5	–	–	–	1.8
UV-254 (1/m)	6.2	5.6	–	–	–	2.7
TFC * (cfu/100 ml)	600	1200	1600	$2*10^3$	$6*10^3$	n/a

* Total faecal coliform

Source: Sustain Water MED 2013.

LEGAL & POLICY FRAMEWORK

The legal basis for controlling water pollution in Egypt exists through a number of laws and decrees, in particular Law 48/1992 regarding the protection of the Nile River and other waterways from pollution.

Law 48 is the main instrument for water quality management. It defines three categories of water body functions:

- *Freshwater bodies for the Nile River and irrigation canals;*
- *Non-fresh or brackish water bodies for drains, lakes and ponds;*
- *Groundwater aquifers.*

This law prohibits discharge into the Nile River, irrigation canals, drains, lakes and groundwater without a license issued by the Ministry of Water Resources and Irrigation (MWRI). Licenses may be issued as long as the effluents meet the standards required by law. The license states both the quantity and quality of discharge permitted. The discharge of treated sanitary effluents into the Nile River and canals is not allowed at all (cf. Article 63) and any discharge of sanitary waste into other water bodies should be chlorinated (cf. Article 67).

Beyond this law, there are many institutions involved in water quality management in Egypt. The MWRI is responsible for formulating the national water policy. The Ministry of Health and Population is entrusted with safeguarding drinking water quality and is involved in standard setting as well as compliance monitoring for wastewater discharges. The Ministry of Agriculture and Land Reclamation (MALR) is responsible, among other bodies, for research on water use in agriculture and the reuse of sewage wastewater in irrigation. The Ministry of Housing, Utilities and New Communities (MHUNC) issued the Code for the Reuse of Treated Wastewater in Agriculture. This Code classifies wastewater to be discharged into water bodies into four grades (designated A, B, C and D) as follows, depending on the level of treatment it has received, and specifies the maximum concentrations of specific contaminants consistent with each grade *(Table 16)*:

GRADE A *effluent is produced after mixing treated water of Grade B with suitable quality freshwater;*

GRADE B *is effluent from advanced or tertiary treatment that can be attained through the upgrade of secondary treatment plants (i.e. Grade C) by including sand filtration, disinfection and other processes;*

GRADE C *represents effluent from secondary treatment performed at most facilities serving Egyptian cities, townships and villages. It is provided through any of the following techniques: activated sludge, oxidation ditches, trickling filters, and stabilisation ponds;*

GRADE D *is effluent from primary treatment that is limited to sand and oil removal basins and the use of sedimentation basins.*

TABLE 16

LIMIT VALUES FOR WASTEWATER REUSED IN AGRICULTURE (mg/l) DEPENDING ON TREATMENT GRADE

PARAMETER	LEVEL A	LEVEL B	LEVEL C	LEVEL D
TSS *	≤ 10	≤ 30	≤ 50	≤ 300
Turbidity	5	n.a.	n.a.	n.a.
BOD_5 **	≤ 10	≤ 30	≤ 60	≤ 350
FC *** (100 ml)	100	100	5000	n.a.
Intest. nematodes (l)	≤ 1	≤ 1	≤ 1	n.a.

* Total Suspended Solids / ** Biochemical Oxygen Demand / *** Faecal coliforms / n.a. = data not available

Source: HCWW 2014.

Based on these four levels of treated wastewater, the code also categorises the plants and crops irrigable with treated wastewater into four main groups and 17 branch groups, as in *Table 17*. Vegetables eaten raw are not allowed to be irrigated with treated wastewater, whatever the treatment level. The code also sets out guidelines and regulations for different irrigation methods.

TABLE 17

CLASSIFICATION OF PLANTS & CROPS IRRIGABLE WITH TREATED WASTEWATER, DEPENDING ON TREATMENT GRADE

TREATMENT LEVEL	AGRICULTURAL GROUP	DESCRIPTION
A	Green landscapes	All types of grass and flowers
B	B-1 Cereal crops, and crops processed at high temperatures before consumption	All types of cooked vegetables and all types of cereal crops such as corn, maize, rice, barley malt, sesame, lentils and beans
	B-2 Fruits	All types of citrus fruits, olives, palms and mangos
	B-3 Medical plants	Caraway, roselle, anise, fenugreek and fennel
C	C-1 Cereal crops, crops processed at high temperature before consumption, fruits and medical plants, as in group B	The same types in addition to sunflower but without using the sprinkler irrigation method
	C-2 Seeds	All seeds for main crops including corn, maize and vegetables
	C-3 Transplantations	All transplantations for citrus fruits, banana, apple, mango, olive, palm and fig
	C-4 Flowers	Egyptian roses, bulbs including gladiola, crane flower and all ornamental plants
	C-5 Trees suitable for highways and green belts	Alcazurina, camphorwood, and nerium
	C-6 All fib crops	Cotton, flax and hemp
	C-7 Poaceae and bean family fodders	All types of sorghum and clover
	C-8 Berries for sericulture	All types of berry
	C-9 All seedbeds for ornamental plants	Such as rubber plant, ruscus and acacia
D	D-1 Bioenergy crops (solid)	All biofuel crops such as soybean, jojoba, jatropha and castor
	D-2 Bioenergy crops (liquid)	All biofuel crops such as soybean, jojoba, jatropha and castor
	D-3 Crops for cellulose production	All nutritional crops for glucose production and its derivatives such as ethanol
	D-4 Wood trees	Kaya and mahogany

Source: HCWW 2014.

DESCRIPTION OF THE PILOT PROJECT

The aim of the pilot activity is to demonstrate the feasibility of decentralised wastewater treatment units in remote rural areas in improving the sanitation level and the quality of reclaimed water used for irrigation purposes. This will be achieved by replacing the trench based wastewater collection system with a piped sewerage network and by treating the collected sewage, which was previously discharged into the drainage channels in an untreated state by vacuum pumping trucks. The pilot activity in the village will serve as a case study model to more than 4,500 rural areas in Egypt that still lack wastewater treatment and reuse services/facilities.

WASTEWATER CHARACTERISTICS & REUSE POTENTIAL

All houses inhabited by the 1,138 residents of Al Gozayyera will be connected to the public sewer. The expected amount of wastewater is 140 m³ per day, while the treatment plant is designed with a capacity fixed at 170 m³ per day, assuming an annual population growth of 3.5 percent. The quality characteristics of the influent to the pilot treatment plant are considered to be as follows *(Table 18)*:

TABLE 18

INFLUENT WASTEWATER CHARACTERISTICS & LOADING

PARAMETER	INFLUENT CONCENTRATION	LOADING*
BOD_5	≤ 600 g/m³	84 kg/d
SS	≤ 800 g/m³	112 kg/d
COD	≤ 1100 g/m³	154 kg/d
TN	≤ 100 g/m³	14 kg/d
TP	≤ 25 g/m³	3.5 kg/d

* Based on an average flow of 140 m³ per day

Source: Sustain Water MED 2014a.

As treated effluent is firstly discharged into the drain and not reused directly, the effluent quality only needs to comply with Law 48/1982, for which the standards are as follows *(Table 19)*:

TABLE 19

EFFLUENT WASTEWATER CHARACTERISTICS & LOADING

PARAMETER	EFFLUENT CONCENTRATION	LOADING*
BOD_5	≤ 40 g/m^3	5.6 kg/d
SS	≤ 30 g/m^3	4.2 kg/d
COD	≤ 80 g/m^3	11.2 kg/d
TDS	≤ 2000 g/m^3	280 kg/d
DO	≤ 4 g/m^3	0.56 kg/d
NO^3-N	≤ 50 g/m^3	7 kg/d

* Based on an average flow of 140 m^3 per day

Sources: Sustain Water MED 2014a.

According to the Code for the Reuse of Treated Wastewater in Agriculture *(Table 16)*, this quality is equivalent to the treatment Grade B of the old levels and to Grade C of the new levels. The proposed track of the main collection sewer pipes follows the main roads in the village and within the residential area.

TECHNOLOGY SELECTED: SEWERAGE NETWORK & COMPACT AEROBIC-ANOXIC ACTIVATED SLUDGE REACTOR

Focussing on the objectives of providing improved sanitation as well as improving the water quality of the drain canals, the project involves two main measures: building a sewerage system and building a WWTP.

SEWERAGE SYSTEM

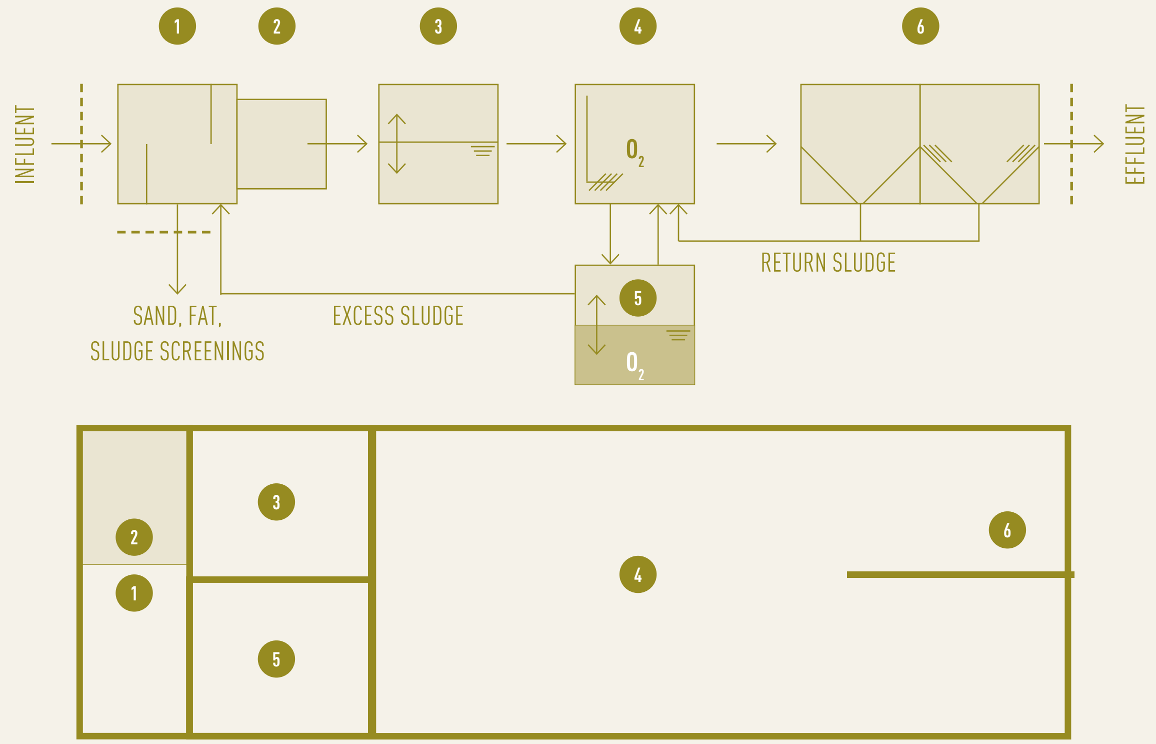
The 3,160 metres of gravity-based sewer is a combined system of conventional and shallow sewer systems. Shallow sewers are constructed in the narrow streets, whereas the two main streets are equipped with conventional gravity sewers. The entire system has 57 inspection chambers and 160 manholes. A gravity pipeline crosses the North Al Rayah drain to the wastewater treatment plant on the other side of the channel *(Sustain Water MED 2014b)*.

WASTEWATER TREATMENT PLANT

After the municipal wastewater is collected from the area through a separate gravity drainage system, it is fed to the pilot plant through a sewage-pumping pit. The treatment process consists of a first section equipped with a screen and a mechanical sand, oil and grease trap, followed by a buffer tank with mixing and balancing purpose. The first basin also provides storage for the removed sludge. The biological step consists of a membrane aeration tank where the oxidation and nitrification processes are completed; downstream, an anoxic denitrification stage is planned, from which part of the sludge is returned to the first basin. The biological step is followed by a two-step clarification/sedimentation basin, from which the sludge is also returned to the first biological basin. The treated sewage from the sedimentation basin is discharged into the nearby agricultural drain (Al Rayah drain). Disposal of the effluent meets Egyptian Law 48/1992 on discharge into drains.

As the area where the treatment is to be provided is limited to only 350 m^2, a compact unit with a small footprint was deemed preferable to an extensive basin treatment system, such as an aerated lagoon. Among possible compact systems, those based only on an anaerobic treatment stage without any aerobic treatment step performed poorly compared to the other selected systems. At the end of the selection process, a compact treatment unit applying an aerobic-anoxic activated sludge reactor proved to be the most suitable option, matching the required level of performance, low-to-medium running cost and footprint.

GENERAL LAYOUT & TOP VIEW OF THE COMPACT TREATMENT PLANT.



1. SAND & FAT TRAP, EXCESS SLUDGE STORAGE
2. SCREEN
3. MIXING & BALANCING REACTOR
4. BIOLOGY
5. ARS & DENITRIFICATION REACTOR
6. SEDIMENTATION (SECONDARY CLARIFICATION)

Construction of the compact treatment plant.

Source: GIZ

Source: TIA

REUSE APPLICATION

Treated wastewater should be suitable for reuse in the irrigation of category C and D crops according to the Code for the Reuse of Treated Wastewater in Agriculture. Due to the existing drain canal system, which provides a convenient irrigation network, it is not expected that the treated water will be piped to the irrigated fields directly in future. The current decentralised practice of pumping water from the drain canals will most probably continue to be the standard method. Nevertheless, the quality of the drain water will potentially be improved, especially if this kind of project is replicated in other villages in the region.

PROJECT IMPLEMENTATION: INSTITUTIONAL STRUCTURE AND CAPACITY BUILDING

A steering committee was formed at the national level including, among others, representatives from the relevant ministries and authorities, such as the Ministry of Water and Irrigation and the National Research Centre. At the local level, an association was formed consisting of members representing all the families in the village. The association collects fees in the village and will take care of the day-to-day O&M once the new system is in place. In addition, an O&M contract will be set up between the affiliated company, the Holding Company for Water and Wastewater, and the village association. This contract ensures the sustainable O&M of the project technologies. Thus the decentralised setup will also be looked after by the affiliated company in case technical challenges cannot be overcome by the local association.

Training sessions will take place for members of the association on business management and operating and maintaining the WWTP. Three training days will take place on civil society activities, society cooperation, financial management and sustainability, and wastewater management and treatment. This will be in addition to ten days training on operating and maintaining the wastewater treatment unit.

1 Example of a compact treatment unit over ground.

2 Example of a compact treatement unit half in ground.

Source: TIA

POTENTIAL BENEFITS & RISKS

BENEFITS FOR PUBLIC HEALTH & THE ENVIRONMENT

The upgraded sewerage system will have a positive impact on the health and hygiene conditions of the inhabitants in the village. Washing and bathing in particular will no more be constrained due to the limitations of wastewater storage in cesspits, which must be emptied at high costs for the villagers. At the village level, treated wastewater will be discharged into the drain canal, stopping the illegal discharge of untreated wastewater. Greater usage of treated wastewater is expected to reduce the pressure on the drainage canal, generating benefits for the crops to be irrigated. A reduction of health risks for farmers is also expected.

If this type of project is replicated in other villages in the region, pathogen concentrations in the drainage canal could be reduced and the population living near the drains would be less exposed to potential infections, as well as the farmers using the reclaimed wastewater. As these benefits become clearer, a greater interest in reuse practices in agriculture will be observed.

BENEFITS IN TERMS OF AWARENESS-RAISING & KNOWLEDGE SHARING

Interactions between the village association, the project team and other stakeholders involved will lead to knowledge sharing and local capacity building, mainly raising environmental awareness among the participants of the training measures. The new approach of cooperation between the local affiliated company (representative of the HCWW in Ismailia) and the village association through a contract will ensure the sustainable O&M of the project technologies. The inhabitants in the village are very interested in this project, as shown by their involvement in the newly created association and their motivation to contribute to setting up the sewerage system.

ECONOMIC BENEFITS

Currently, each household in the village pays Egyptian Pound (EGP) 50 to 100 per month for the emptying of the trenches. First estimations for the new sewerage and wastewater treatment system show that it should be more economic for the inhabitants of the village. In the long run, this will depend on the final contract agreement between the affiliated company and the association. The decentralised system has a certain economy of scale, as the expenses for manpower for O&M only become competitive when many of the same types of unit are operated. Thus the economic evaluation of a single unit is not representative for the technological approach. On the other hand, figures for electricity and chemical consumption levels are representative, as they might only slightly decrease once experience has been gained in handling the unit and the unit can be run more efficiently.

Indirect economic benefits are related to the improved health of the inhabitants of the village as well as the local farmers. Other benefits are related to the potential increase in the provision of ecosystem services due to the improved water quality of the drainage channels, if the system is replicated in other villages of the region. Creation of new local jobs in the WWTP may lead to employment opportunities for villagers. In addition, professional technical capacities are built within the village for the operators of the WWTP.

Free capacities in the WWTP can be used for treating wastewater from neighbouring communities from where the water can be transported by tankers. This could possibly generate income for the local water association. The market value of the land may potentially rise due to better infrastructure (sewerage connection), as well as better conditions for building structures, which were previously affected by seepage and moisture from the high level of wastewater in the trenches underneath village houses.

POTENTIAL SOCIAL RISKS

The village association has expectations regarding the project activities that might be higher than its possible achievements. The delay in the construction of the sewerage system might discourage further involvement of the association members. Moreover, if the interaction between the involved stakeholders within the association and the affiliated company does not lead to fruitful agreements for both sides, the association members might lose faith in the participatory approach. Consequently, future projects involving local stakeholders might face difficulties. The poor enforcement of Law 48, which regulates the disposal of wastewater, might lead to improper operation of the treatment plant as there are no consequences for violating the discharge standards. Due to the indirect impact of poor discharge quality, the rules might be the only reason for the operators to maintain treatment performance.

POTENTIAL ECONOMIC RISKS

High expenses for O&M due to small-scale application of the technology and the necessity of employing operators to ensure continuous running and upkeep are financial risks of the decentralised setup of this pilot project. Depending on the final predominant treatment process, the energy costs of continuous aeration can be very high, leading to either higher fees for the inhabitants of the village or higher subsidy requirements. Should no additional financing be found to cover higher energy costs, the result may be improper treatment of the wastewater by omitting the aeration.

The cooperation contract between the affiliated company and the local association might need to be revised after the first period of running the WWTP and after confirming the expenses for O&M. This is an economic risk for the viability of the system if costs exceed the level any of the partners are willing to pay. Against the background of a highly subsidised water sector in Egypt where water fees do not reflect the actual production costs, decentralised systems cannot compete without receiving support from the government. Village associations left on their own economically will have to collect much higher fees from their members than the water corporations. Consequently, they might have difficulties in justifying their fee structure when end-consumers learn about much lower fees from other communities.

LESSONS LEARNED

EXPLOIT THE POTENTIAL FOR REPLICATION FOR OTHER REMOTE COMMUNITIES IN THE REGION

The close cooperation of the public and private stakeholders involved in this project has led to a sustainable solution that responds to urgent local needs, and which is set up in a way that the organisation responsible for the technical performance can ensure O&M. This new approach bears a high potential for replication by other remote communities in the region for which connection to the centralised sewerage systems is not viable. Regions of Egypt where wastewater discharge regulations could not be complied with until now could potentially meet these standards.

In order to avoid delays and shortcomings in the construction phase, the approach of having a prefabricated unit will ensure that timelines can be maintained and resources can be better estimated at the beginning of the project. Unforeseen complications should thus be limited and the quality of the construction should be ensured.

ENSURE THE ACCEPTANCE OF THE SOLUTION PROPOSED BY VARIOUS STAKEHOLDERS INVOLVED IN THE PILOT ACTIVITY, ESPECIALLY TAKING INTO ACCOUNT REAL & URGENT NEEDS OF END USERS

The implementation phase of the project showed that certain flexibility is necessary to address the exact requirements at the field level, and that an adaptation of original plans to tailored solutions leads to a sustainable overall setup. The acceptance of the solution by the various stakeholders might even be more important for the success and sustainability of the project than the technical performance potential.

Treatment of wastewater as such did not seem to have the highest priority for the villagers until the start of the project. In their specific case, a more pressing need was to have a sewerage network to take care of collecting the wastewater and creating a more hygienic environment in the village. Taking into consideration the related urgent needs of the villagers enabled to motivate the villagers to participate in the project implementation, while aiming at a more holistic solution for the treatment of wastewater.

PLAN THE LONG-TERM ECONOMIC FEASIBILITY FROM THE BEGINNING OF THE PILOT ACTIVITY IN ORDER TO ENSURE THE SUSTAINABILITY OF THE SYSTEM

The economic feasibility of the pilot project has to be looked into from the beginning of the planning phase in order not to encourage wrong expectations on the side of the users and also to have realistic commitments from the side of the technical supporting organisation. Awareness of the expenses related to an efficient O&M needs to be created among the stakeholders in order to ensure a prolonged performance of the system.

Provision of services like wastewater collection and treatment cannot be solely run by fees collected from the direct beneficiaries. These services have a variety of external effects benefitting the overall public. Thus the willingness to pay of the direct beneficiaries of the wastewater connection will be limited and might be significantly lower than the actual public benefits created. A suitable framework for the calculation of appropriate governmental subsidies for the decentralised technology setup will need to be in place for a successful launch of the new approach.

NEXT STEPS

Continuous support of the new partnership between the local association, the affiliated company and the HCWW will ensure the proper functioning of the project. A mediator might be necessary for achieving future agreements between the three stakeholders regarding the sharing of expenses for O&M and also in provision of resources.

The supplier of the prefabricated WWTP must provide support services, especially in the beginning of the commissioning period, in order to overcome unforeseen technical hurdles and find suitable solutions for necessary adaptation of the technology to site specific requirements. The performance of the WWTP must be monitored for at least one year in order to ensure proper treatment processes. Conclusions concerning the further upscaling of the solution in the region should be drawn after having confirmed the performance as well as the expenses for O&M, and with a long-term evaluation of environmental and socio-economic effects.

KEY DATA

LOCATION: PUBLIC SECURITY DIRECTORATE (PSD), MOQABLANE, AMMAN

TECHNOLOGY: SEQUENCING BATCH REACTOR (SBR) FOLLOWED BY SAND FILTRATION AND DISINFECTION

INVESTMENT COSTS: 332,000 JOD FOR THE TREATMENT PLANT, 35,000 JOD FOR THE IRRIGATION SYSTEM

OPERATIONAL COSTS: 0.86 JOD PER m^3 (INCL. ELECTRICITY, OPERATION AND MAINTENANCE, SPARE PARTS)

AMOUNT OF WASTEWATER TREATED: UP TO 150 m^3 PER DAY

REUSE APPLICATION: LANDSCAPE IRRIGATION (REUSE RATE: UP TO 100 % IN SUMMER TIME)

FRESHWATER SAVINGS: 4,378 m^3 PER MONTH OR 52,536 m^3 PER YEAR

IMPLEMENTING PARTNERS: AL-BALQA' APPLIED UNIVERSITY (BAU), INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE (IUCN), GIZ

PILOT CASE JORDAN

INTRODUCTION

The aim of the pilot activity is to demonstrate the feasibility of decentralised wastewater treatment units and effluent reuse in urban areas as methods to reduce freshwater consumption, while upholding health and environmental standards. In a first stage, the applicability of reclaimed wastewater is tested for landscape irrigation. The system complements the existing centralised wastewater treatment and reuse systems in Amman with an effective and context-adaptive decentralised unit. Ultimately, the unit aims to provide recommendations on how to promote decentralised wastewater treatment and reuse at a national level, and to enhance the policy-making process in Jordan.

The technology identified as most suitable and applied at the pilot location is the sequencing batch reactor (SBR). This technology has been selected based on its advantages with regard to simple O&M, small footprint, high quality effluent, and its flexibility in operation, scaleup and extension. The SBR is complemented by a sand filter as tertiary treatment to meet relevant water reuse standards.

The pilot activities, which include a decentralised wastewater treatment unit as well as an irrigation scheme for green areas, were implemented at the newly constructed Public Security Directorate (PSD) compound, located in Moqablane, Amman. While most of the treated effluent is used for irrigation within the PSD compound, excess effluent is transferred to other users including the Great Amman Municipality (GAM) where recently an agreement in this regards between PSD and GAM was signed. The project enables PSD and other users to reduce their freshwater consumption, and thus generates environmental as well as economic benefits. Further, decentralised wastewater treatment reduces the risk of pollution from the current practice of using septic tanks or cesspools as storage/disposal systems for untreated raw wastewater.

The project is the first on-site treatment plant in an urban area in Jordan. Lessons learned from this project will feed into the National Water Master Plan and support national efforts in upscaling decentralised wastewater management.

PROJECT SETTING

The Amman area is suffering from scarce water resources and over-exploited groundwater aquifers. Urbanisation processes further increase pressure on existing water resources, while the expansion of sanitation infrastructure fails to keep pace with the rapid urban development. This results in insufficient and improper wastewater management, posing risks for the environment, water sources and human health.

SOCIO-ECONOMIC SETTING

Located in the urban area of Amman, the PSD compound is embedded in an area with increasingly diverse human activities. While during the last three decades, lands in the vicinity of the compound have been traditionally cultivated by rain-fed agriculture, the expansion of the urban areas of Amman led to a shift favouring residential areas. Today, the area has become a heterogeneous mix composed of residential, commercial and administrative (public) buildings.

The PSD compound comprises an area of 150,000 m^2, whereof approximately 12 percent (18,500 m^2) is currently used as green areas. An additional 15,500 m^2 of the PSD compound could be turned into green areas in the future. The built area of the PSD compound includes a number of buildings, among them the headquarters, offices, recreation building, command and control centre, internal affairs building, a mosque and an energy centre. The recreation building contains the main kitchen, restaurants and a laundry. The PSD compound is developed to accommodate up to 2,466 persons. Around 10 percent of the total employees are expected to be on duty over 24 hours. However, being a security directorate – in certain cases – all employees could be instructed to remain on duty 24 hours. The PSD community has a variety of education levels, which ranges from non-skilled labour to staff members holding higher university degrees.

Workers on future green area in front of the PSD in Moqablane, Amman.

Source: GIZ

Source: Made with Natural Earth, 2015.

ENVIRONMENTAL SETTING

In terms of hydrology and environmental settings, the pilot area is located in the Wadi Al Bniyat subcatchment, within the northern parts of the larger Wadi Wala watershed. The climate in this area is semi-arid to arid, with dry hot summers and cold rainy winters. The recorded mean maximum and minimum temperatures, as recorded at the nearest meteorological station are 35 °C in July and 4.4 °C in January, respectively. The area receives an average annual precipitation of about 400 mm, most of which occurs during the rainy season extending from October to April. The potential evapotranspiration rate of around 6 mm per day is relatively high. Due to the high variability in rainfall throughout the year, the wadis in the catchment only carry water during limited periods of the year. The area is characterised by relatively deep, unconfined groundwater levels. The discharge of the groundwater is through springs and seepage zones. The Wadi Al Bniyat sub-catchment itself does not include springs, yet there are 12 wells of which two are governmental (belonging to the Water Authority of Jordan) and the remaining are private. Salinity of the groundwater ranges from 304 mg Total Dissolved Solids (TDS) per litre to 768 mg TDS per litre, and is thus within Jordanian drinking water quality standards, which request that water TDS should not exceed 1,000 mg per litre.

There are major problems with groundwater depletion in the region. For example, groundwater levels decline at a high rate of around 4 metres per year due to excessive groundwater abstraction. In addition, existing water resources are threatened by pollution, mainly caused by improper sanitation. The residential areas surrounding the PSD are not connected to a central sewer system. Instead, wastewater is discharged and collected in cesspools and/or septic tanks. The possible infiltration of raw wastewater threatens groundwater resources, depending on the soil and geological structure.

At the pilot site, the top soil structure layer extends to about 2 metres and is composed of dark brown, highly plastic silty clay with pebbles and gravels of limestone. The permeability of this soil type is classified as slow to very slow; infiltration rates measured at the site vary from 30 to 60 mm per hour. This favourable characteristic, in addition to the non-existence of faults at the site, can be considered beneficial for the safe management of wastewater at the site.

WATER SUPPLY & SANITATION

The PSD compound is connected to the water supply network and receives municipal water twice a week. In addition, the compound relies on water supplied by private companies via tankers to satisfy its overall demand including landscape irrigation. Water from private tankers is a costly alternative, considering the fact that water from private sources is provided at a minimum of 3 Jordanian Dinar (JOD) per m^3, while municipal water is provided at a fee of 1 JOD per m^3.

The premises of the PSD compound and all buildings are connected through an internal sewerage network. However, the area is not connected to a central sewerage network. Before the Sustain Water MED project, the collected wastewater was discharged into a cesspool. This cesspool had to be emptied every other day by tankers that transported the sewage to the Ain Ghazal pre-treatment facility, from where it was conveyed by a main sewer line to the Khirbit As-Samra centralised WWTP. The costs for this sewage service were 2 JOD per m^3.

LEGAL & POLICY FRAMEWORK

In Jordan, decentralised wastewater management and reuse is promoted by the National Water Strategy 'Water for Life' 2008–2022. According to this strategy, by 2022 the amount of treated wastewater for reuse should reach 15 percent of the total renewable water resources available. Moreover, the strategy stresses the need to build decentralised treatment plants to serve semi-urban and rural communities, in addition to exploring the potential for using treated wastewater for aquifer recharge. The Government of Jordan has ruled that all new wastewater treatment projects must include feasibility aspects for water reuse, and as early as in 1995 it set standards for the reuse of treated domestic wastewater effluent *(Jordanian Standards (JS) 893/1995, revised in 2002 and 2006)*. The Jordanian standards for water reuse are based on reuse categories depending on the type of crops and areas to be irrigated *(see Table 20)*. The standard prohibits the use of reclaimed water for irrigating vegetables to be eaten raw. Furthermore, it is prohibited to employ sprinkler irrigation for applying reclaimed water, except for irrigating golf courses. In addition, the Jordanian standards provide guidance values for a range of chemical wastewater components. Should these values be exceeded, "the end user must carry out scientific studies to verify the effect of that water on public health and the environment and suggest ways and means to prevent damage to either." As the PSD is located within the peri-urban area of Amman, the wastewater for reuse within the compound must meet Category A quality limits, i.e. highest standards.

TABLE 20

ALLOWABLE LIMITS FOR SELECTED PARAMETERS IN THE JORDANIAN REUSE STANDARD (JS 893/2006)

PARAMETER	CATEGORY (A)*	CATEGORY (B)**	CATEGORY (C)***	WATER DISCHARGE TO WADIS, STREAMS & VALLEYS
BOD_5 (mg/l)	30	200	300	60
COD (mg/l)	100	500	500	150
DO (mg/l)	>2	—	—	>1
TSS (mg/l)	50	200	300	60
pH (mg/l)	6–9	6–9	6–9	6–9
NO_3 (mg/l)	30	45	70	80
Total Nitrogen (mg/l)	45	70	100	70
E. COLI (MPN****/100 ml)	100	1,000	—	1,000
IHE***** (egg/litre)	≤ 1.0	≤ 1.0	≤ 1.0	≤ 0.1

* Cooked vegetables, parks, playgrounds and sides of roads inside cities / ** Fruit trees, sides of roads outside of cities, green areas / *** Field crops, industrial crops, and forest trees / **** Most Probable Number / ***** Intestinal helminth eggs

Source: JSMO 2006.

In terms of institutional responsibilities, water supply and wastewater management is under the administration of the Water Authority of Jordan (WAJ) as per the Law of WAJ of 1998. Private plants require WAJ permission if they discharge into a public sewerage network or into a water body, and WAJ is responsible for performing routine checks on the performance of the treatment units to ensure compliance with the relevant standards (JS 893/2006). In addition to WAJ, the Ministry of Health and/or the Ministry of Environment are involved in the monitoring of the WWTPs.

The 2009 Water Strategy states that all new wastewater projects require an Environmental Impact Assessment (EIA) study. According to regulations/instructions of the Ministry of Environment (MoEnv), the PSD wastewater treatment project is classified as environmental category “A”, which requires a full EIA. The MoEnv. is then responsible for monitoring the implementation of the Environmental Management Plan that is being developed on the basis of the EIA.

DESCRIPTION OF THE PILOT PROJECT

With the expansion of the PSD compound, an on-site, small-scale WWTP combined with treated wastewater reuse systems was implemented. This project has the potential to reduce the consumption of freshwater and overall costs for the PSD. The compound provides ideal preconditions for a decentralised WWTP, as it offers sufficient space for the treatment plant as well as for the reuse of reclaimed water.

WASTEWATER CHARACTERISTICS & REUSE POTENTIAL

The expected water demand of the PSD compound has been estimated to be 87.9 litres per capita per day for domestic purposes. At full occupancy of the compound (about 2,466 persons), the PSD water demand for domestic use was calculated to reach 217 m^3 per day. Assuming that the generated wastewater is 70 percent of the total water consumption for domestic use, the treatment unit has been designed to treat 150 m^3 of treated effluent per day. Average values of influent characteristics of the wastewater flowing into the current collection tank are shown in *Table 21*. The raw wastewater shows characteristics typical for domestic wastewater, as indicated by the ratio of COD to BOD. Nitrogen levels, however, seem to be higher than average values in domestic wastewater, most likely due to high urine content, which may require frequent monitoring of the effluent wastewater. Trace metal concentrations in the raw wastewater are within the allowable limits set by the aforementioned Jordanian standards for reuse of treated wastewater and thus do not need to be removed from the effluent.

For irrigating the current green area of 18,500 m^2, water consumption of about 900 m^3 per month was estimated. In addition, the PSD plans to further develop another 15,500 m^2 of green areas on the compound. Assuming the same water consumption rate for all green areas, a total irrigation water demand of approx. 1,654 m^3 per month has been calculated. This number will however vary significantly according to the season.

TABLE 21

WASTEWATER CHARACTERISTICS USED FOR THE DESIGN OF WWTP

PARAMETER	AVERAGE VALUE (TOTAL WW)	AVERAGE VALUE (WITHOUT WW) OF RESTAURANT
pH	8.33 *	–
COD (mg/l)	1,725	1,262
BOD_5 (mg/l)	745	320
TSS (mg/l)	788	225
TVSS (mg/l)	590 *	200
TKN (mg/l)	175	210
NH_4^+-N (mg/l)	133	190
T-P (mg/l)	52 *	49
PO_4-P (mg/l)	12 *	–
FOG (mg/l)	43	9
MBAS (mg/l)	0.75	0.57
SO_4^- (mg/l)	34	33
Cl^- (mg/l)	203	217
E. coli (MPN/100ml)	5.7×10^7	2.4×10^7
HCO_3^- (mg/l)	759	835
Mg^{++} (mg/l)	18	9
Ca^{++} (mg/l)	76	28
Nematode eggs (egg/5 litre)	Not seen	Not seen

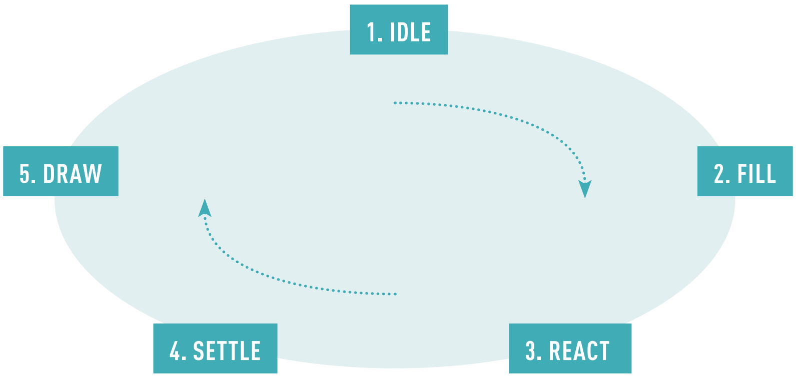
* Based on one measurement.

Source: Sustain Water MED 2013.

TECHNOLOGY SELECTED: SEQUENCING BATCH REACTOR

The SBR technology was chosen for the pilot project in Jordan based on the technology's advantages with regard to simple operation and maintenance, small footprint, high quality effluent, and its flexibility in operation, scale-up and extension. Furthermore, some experiences with the technology had already been gained in Jordan, and Jordanian companies have already developed expertise in constructing and operating such systems.

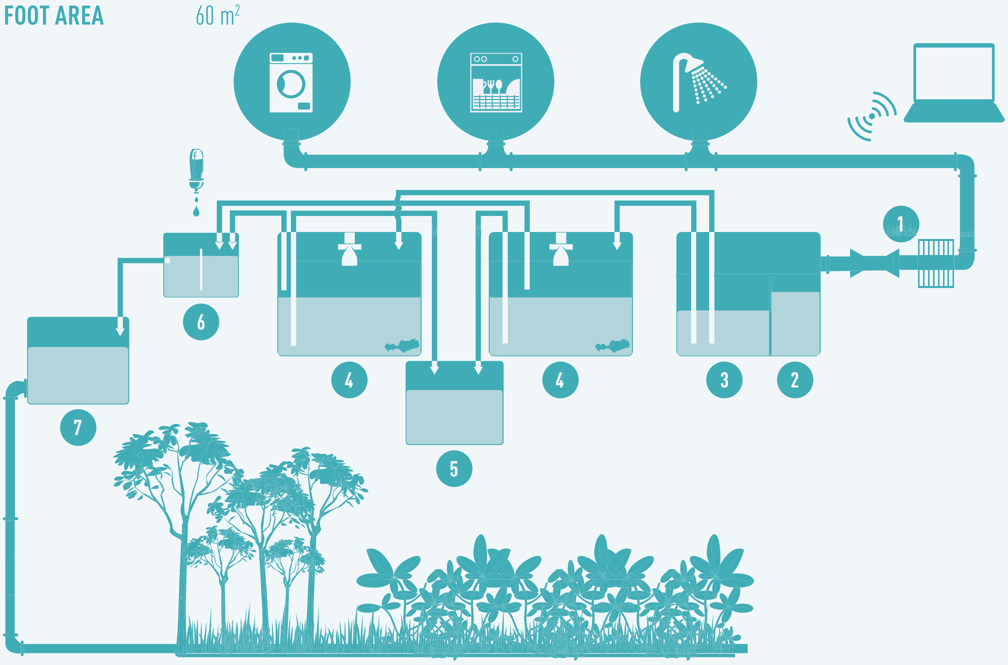
A SBR is an activated sludge system where all wastewater treatment processes are accomplished in a single reactor, i.e. equalisation, aeration and clarification. SBR systems are uniquely suited for small communities where wastewater treatment applications are characterised by low or intermittent flow conditions, as in the case of the PSD. The operation of the SBR technology is based on the fill-and-draw principle, which consists of the following five basic steps occurring in the same tank reactor according to a specific time sequence:



Significant operating flexibility is associated with SBR systems. An SBR can be easily set up to simulate any conventional activated sludge process, including biological nutrient removal systems, only by modifying the time duration/sequence of each process step. For example, holding times in the aerated react mode of an SBR can be varied to achieve simulation of a contact stabilisation system with a typical hydraulic retention time (HRT) of 3.5 to 8 hours or, on the other end of the spectrum, an extended aeration treatment system with a typical HRT of 18 to 36 hours. In addition, the aerated react mode (toxic conditions) and the mixed react modes (anoxic conditions) can be alternated to achieve nitrification and denitrification. The mixed fill mode and mixed react mode can be used to achieve denitrification using anoxic conditions. In addition, these modes can ultimately be used to achieve an anaerobic condition where phosphorus removal can occur. Conventional activated sludge systems typically require additional tank volume to achieve such flexibility. SBRs operate in time rather than in space, and the number of cycles per day can be varied to control desired effluent limits, offering additional flexibility with an SBR.

SCHEMATIC ILLUSTRATION OF THE WASTEWATER TREATMENT PLANT OF THE PSD

INVESTMENT COST 332,000 JOD
CAPACITY OF PLANT 150 m^3/day
FOOT AREA 60 m^2



1. GRIT REMOVAL CHANNEL & MANUAL BAR SCREEN
2. PRIMARY SETTLING TANK (m^3)
3. BALANCING TANK (m^3)
4. SEQUENCING BATCH REACTOR TANK
5. EXCESS SLUDGE STORAGE TANK (m^3)
6. HYPOCHLORITE DISINFECTION CHANNEL
7. REUSE / IRRIGATION TANK (m^3)

Filtration unit of the SBR.

Source: GIZ

SBR SYSTEM AT THE PSD

Within the PSD compound, raw wastewater is collected by an internal sewer system and conveyed to the pilot plant. The pre-treatment step is carried out in an underground structure designed in two levels. The upper level (preliminary treatment) includes a bar screen and grit channel. The bottom level (primary treatment) consists of two tanks (primary compartment and a balancing tank), from which wastewater is pumped to the SBR units, representing the main component for the secondary process (realised as underground structure as well).The secondary (biological) treatment step consists of two identical SBR units working in parallel, so that each unit receives half of the average daily flow (about 75 m^3 per day). Both SBRs have a maximum refill volume of 37.5 m^3 and a working volume varying from 75 to 156 m^3. An automatic control system adapts the SBR cycle duration (8 to 12 hours) according to the actual inflow of wastewater. During each treatment cycle, organic matter and nitrogen are removed in order to comply with the Jordanian standards for wastewater reuse.

The SBRs at the PSD are equipped with superficial aerators, slow mixers and floating pumps for treated wastewater discharge, and submerged pumps for excess sludge disposal. The SBR system is complemented with further tertiary treatment units consisting of sand filtration through a pressurised filter and disinfection through hypochlorite dosage into a dedicated contact (zigzag) canal. Such steps ensure that reclaimed water meets hygiene standards for landscaping reuse in urban areas in line with JS 893/2006. Finally, treated wastewater is stored in a 150-m^3 separate tank, ensuring about a 1-day retention time. Sludge from primary and secondary treatment is stored in a dedicated underground tank made of reinforced concrete and with a working volume of about 75 m^3. Supernatant is pumped upstream to the balancing tank (pre-treatment stage). The settled sludge is then hauled by tankers to the nearest centralised treatment facility (Madaba).

REUSE APPLICATION

Treated effluent from the PSD WWTP will be used to irrigate existing and planned green areas within the PSD compound. Due to seasonal variability, the amount of treated wastewater is expected to exceed the internal water demand for on-site landscape irrigation. This is the main reason why further reuse options have been considered, including the transfer of reclaimed water to the GAM for the irrigation of urban green areas. Aside from landscape irrigation, agricultural land is cultivated in the proximity of the compound and may provide future reuse options.

The PSD irrigation system includes treated wastewater as well as rainwater collected from rooftops, streets and parking lots in the compound. Rainwater is collected in a 5,000-m^3 dedicated storage tank. According to the adopted irrigation management system, collected rainwater will be used for three main purposes: I) to prevent salt accumulation in the soil caused by the prolonged application of treated wastewater; II) to clean the drip irrigation system in order to prevent its clogging; and III) as a water reservoir in times where treated wastewater is not sufficient or not suitable for irrigation. Irrigation is performed using the existing irrigation system, which was specifically adapted and modified in order to make it suitable for treated wastewater. This required nozzles to be adapted and sprinklers to be removed from the system in order to comply with Jordanian law, which prohibits sprinklers for the use of reclaimed water.

PROJECT IMPLEMENTATION: INSTITUTIONAL STRUCTURE & CAPACITY BUILDING PROGRAMME

The project was developed in close cooperation with relevant stakeholders. A steering committee was formed including, among others, representatives from relevant authorities and ministries such as the Ministries of Water and Irrigation, Environment, and Agriculture respectively. The plant was handed over to the PSD after a transitional phase in which the construction company operated the plant to ensure functionality in the beginning. PSD has contracted a private entity for O&M of the system. Quality of the reclaimed water was initially monitored by the project partners BAU and the IUCN. Afterwards, PSD became responsible for quality monitoring.

The treatment plant is expected to produce more treated wastewater than needed for irrigation within the PSD compound. Therefore, a Memorandum of Understanding was concluded with the GAM. GAM will haul reclaimed water from the PSD treatment plant by tankers to use it for the irrigation of nearby green areas and roadside trees. The monitoring is being carried out regularly by the local partner Al-Balqa' Applied University, the Water Authority of Jordan and the Royal Scientific Society. Samples were taken and analysed every month and reported to the GIZ.

The pilot project was flanked with a capacity building programme including training for PSD staff on the safe use of reclaimed water in irrigation and the components of the PSD irrigation system. In addition, a demonstration garden was established, including information signs in the Arabic language, which were installed to prevent any misuse of the treated wastewater, and indicated that the water is not for drinking purposes. Additionally, the signs give detailed information on the reuse purposes and the economic and environmental benefit of the reuse activities.

In the future, the plant will also be available for research programmes by, for example, Al-Balqa' Applied University. Additionally, the pilot plant will be used as modules for other planned decentralised activities in Jordan. The PSD has already constructed a similar treatment plant with an SPR system in their compound in Aqaba city.

1 Drip irrigation system in the demonstration garden of the PSD.

2 Trainings on the safe use of reclaimed water in irrigation and the components of the PSD irrigation system are being offered for PSD staff, for research programmes and other interested parties.

Sources: GIZ, adelphi

POTENTIAL BENEFITS & RISKS

ENVIRONMENTAL BENEFITS

From the environmental point of view, many direct and indirect benefits can be expected from the pilot project. The main benefits are:

- *Reclaimed water will become available for irrigation purposes, thus alleviating the stress on the country's scarce freshwater resources; it is estimated that once green areas within the PSD premises are fully developed, the reuse of treated wastewater for irrigation within the PSD compound will save up to 52,536 m³ of freshwater per year.*
- *At full capacity, the treatment plant will provide controlled management (collection and treatment) of up to 4,500 m³ of wastewater per month, thus avoiding disposal in cesspools and related risks of groundwater pollution.*

SOCIAL BENEFITS

As stated above, the pilot project directly results in the saving of freshwater resources. Freshwater will thus become available for other uses in benefit of society. The project further sets a practical example for decentralised wastewater management including the reuse of reclaimed water. As such, the project supports the implementation of the national water strategies towards the utilisation of non-conventional water resources by demonstrating how related policy goals can be achieved in practical terms. Through the demonstration garden, the project can act as knowledge transfer and a public awareness opportunity. The project thus contributes to the promotion of the safe reuse of wastewater and ultimately sustainable development in Jordan.

ECONOMIC BENEFITS

The project will have significant economic benefits for the PSD. While the costs for sewage services related to hauling sludge from cesspools were 2 JOD per m³, operational costs of the on-site treatment plant are only 0.86 JOD per m³. Once the plant runs at its full capacity of 150 m³ per day (4,500 m³ per month) the project will thus save up to 5,100 JOD per month (61,200 JOD per year) in running costs for wastewater services.

Moreover, the PSD will save expenses for freshwater for irrigation purposes. Currently, the price for water used for irrigation is 3 JOD per m³. In the near future within the PSD premises, 34,000 m² are planned to be irrigated using an estimated 1,654 m³ per month. The related costs for freshwater would thus amount to 4,962 JOD per month (59,544 JOD per year), and once green areas within the PSD are fully developed to an estimated 90,000 m², as much as 13,134 JOD per month (157,608 JOD per year). In addition, reclaimed water contains important nutrients for plants, and the use of fertilisers can thus be reduced resulting in additional savings.

These numbers clearly show that the investment costs of 332,000 JOD for the treatment plant and 35,000 JOD for adapting the irrigation system for the use of reclaimed water will have charged-off in a relatively short time.

ENVIRONMENTAL RISKS

Potential adverse effects of the pilot project on the environment have been carefully evaluated, both during the construction phase of the treatment plant and during its operation, through a complete EIA. The risk of water pollution mainly regards groundwater, since in the project area no surface water is present and no discharge to the close wadis is expected. The EIA study and baseline study concluded that groundwater levels are significantly deep and the top soil is clay to silt with very low permeability. Hence, groundwater is not vulnerable to pollution from accidental seepage or leaking.

In order to minimise the risk of flooding or accidental percolation, the following precautions have been taken:

- *proper design of concrete structure and skilful supervision to ensure sustainable and reliable tanks with no chance for wastewater seepage;*
- *proper run-off diversion channels designed to eliminate flood risk and protect the treatment units from overflows;*
- *separate networks for wastewater and rainwater run-off, in order to avoid overloading of the treatment plant during heavy rain events;*
- *redundant power supply and redundant equipment in order to guarantee the functioning of the system even in the event of a black-out.*

Nevertheless, percolation of treated wastewater into groundwater could occur where irrigation exceeds the needs of the green areas. This risk is avoided not only as a result of the geological site characteristics, but also through the adoption of an adequate irrigation scheme/schedule taking into account the crop pattern and type as well as the potential evapotranspiration rates. The use of treated wastewater may involve a risk of depletion of soil characteristics, in particular due to the increase in salinity and to the loss of permeability caused by clogging phenomena.

In this project, soil salinity is not expected to be a major issue for the following reasons:

- *the freshwater supplied has low salinity levels (TDS = 350 mg per litre on average);*
- *TDS content in untreated wastewater is on average 1,405 mg per litre, below the JS 893/2006 standards (1,500 mg TDS per litre);*
- *top soil will be treated with organics and sandy material to make it more permeable (loamy);*
- *on a seasonal basis, the area receives a relatively good amount of rainwater, which will contribute to refreshing/washing the soil from salts.*

Soil clogging may occur when the Total Suspended Solids (TSS) in irrigation water is higher than 100 mg per litre. However, as most of the irrigation will be carried out as drip irrigation, a pressurised sand filter has been included in the treatment system in order to keep the TSS concentration below 10 mg per litre and consequently avoid any clogging of the irrigation system. In addition, in order to improve soil quality, PSD gardeners will move the soil's top layer seasonally as part of their gardening work. The potential effects of oil and grease have been minimised through the installation of an oil/grease trap upstream to the treatment plant.

HEALTH RISKS

One of the principal concerns associated with wastewater reuse is the possibility of infectious disease transmission. Health risks of this nature are particularly present when untreated wastewater is reused for crop irrigation. However, in this pilot project treated wastewater is only reused for landscaping purposes, adopting the drip irrigation technique so as to avoid any aerosol generation. There could be residual health risks related to the direct contact with wastewater and excess sludge. Specific devices have been adopted in order to prevent exposure to sludge or wastewater during the operation stage: the design of the plant stipulates closed tanks, and the risk of exposure during the sludge hauling operations is mitigated and reduced through adopting and complying with relevant reuse standards and reuse practices (well trained staff/operators, installation of warning signs around the treatment units, use of protective clothing, proper demarcation of the area, and controlling access by nonauthorised people).

LESSONS LEARNED

NEED FOR SIMPLIFIED PROCEDURES FOR SMALL-SCALE WASTEWATER TREATMENT PLANTS

Jordanian regulations currently require a fully-fledged EIA for all kinds of wastewater treatment plants. Since full EIAs are cost and time intensive, this requirement constitutes a significant hurdle for the implementation of decentralised wastewater treatment plants. In view of the national strategy to promote decentralised wastewater treatment, simplified procedures should be established for small-scale projects. A respective initiative had already been launched by the Ministry of Environment but did not succeed. If decentralised approaches really are to be implemented more often, it is questionable whether the responsible departments at the Ministry of Environment will have the required capacities to follow-up on full EIA implementation at all small-scale plants.

WATER QUALITY MONITORING: NEED FOR UNIFORM PROCEDURES & A SINGLE RESPONSIBLE AUTHORITY

There is currently an overlap in responsibilities for monitoring effluent quality at decentralised treatment plants; the Ministry of Environment, the Water Authority of Jordan as well as the Ministry of Health are responsible for water quality monitoring in reuse projects. In order to facilitate implementation of decentralised wastewater treatment and reuse, responsibilities should be clarified, and consistent requirements and procedures should apply. In view of the expected increase in decentralised treatment plants in line with the national strategy, there is also a need to increase capacities at the responsible authorities to fulfil their monitoring duties.

ENHANCE 'TECHNOLOGY SUPPLY' BY STRENGTHENING PRIVATE SECTOR CAPACITIES

Only very few construction companies in Jordan have the capacities to plan and implement decentralised wastewater treatment plants. In order to ensure that technologies can be procured nationally, private sector capacities in this regard need to be strengthened.

INCREASE ROLE OF DECENTRALISED ENTITIES TO FACILITATE IMPLEMENTATION OF SMALL-SCALE PLANTS IN SEMIURBAN AREAS

Responsibilities for permission, EIA approval and monitoring of decentralised wastewater management projects currently lie with national authorities. In order to facilitate procedures and to encourage implementation of decentralised plants, authorities and entities at governorate level should receive more responsibilities and take an active role in promoting decentralised reuse-oriented wastewater management in Jordan.

NEXT STEPS

In the near future, not all of the reclaimed water generated at the PSD treatment plant will be required for irrigation on-site. Therefore, an agreement has already been concluded and signed with the GAM that also aims to use the water for irrigation. It is, however, expected that irrigation water needs in winter time will be limited. Therefore, other uses and users will be identified to avoid discharge of water into the nearest wadi.

It would be of great benefit to increase the awareness raising effect of the PSD pilot plant and to further encourage the reuse of wastewater within Jordanian society. To this end, the site at the PSD will be linked to similar demonstration and awareness raising activities within the framework of future GIZ cooperation programmes, as well as the programmes “Sustainable Management of Available Water Resources with Innovative Technologies” (SMART) and the National Implementation Committee for Effective Decentralised Wastewater Management in Jordan (NICE). These have already been successfully promoting decentralised sustainable wastewater management for the past years.

Additionally, the GIZ has started new projects with a focus on decentralised wastewater management for the adaptation to climate change in Jordan (ACC Project) and a further project on decentralised wastewater in schools (WASH Project). Both projects will build upon the experiences of the PSD WWTP. Lessons learned in regards to the technology selection, investment cost, Environmental Impact Assessment, and O&M will be applied to support the development of decentralised wastewater management in Jordan.

LESSONS LEARNED & POLICY RECOMMENDATIONS

The Sustain Water MED project implemented different types of decentralised and centralised reuseoriented approaches and successfully demonstrated tangible benefits of integrated wastewater management and sanitation approaches:

MORROCO

In Morocco, the pilot project demonstrates that decentralised solutions are more effective and less costly to realise than centralised systems in rural areas. The project partners also created sufficient acceptance for individual ecological sanitation systems in the local population.

TUNISIA

In Tunisia, Sustain Water MED partners convinced farmers of the benefits of using treated effluents for irrigation, and demonstrated a relatively simple and low-cost solution to the recurrent problem of unreliable effluent quality. The project thereby increased trust between key actors at the local level.

EGYPT

In Egypt, the project partners successfully involved the local community, creating ownership and commitment for the project. The pilot bears huge potential for replication in the large number of remote communities in the region and could thus significantly contribute to reducing health and environmental risks related to the reuse of water from drainage canals.

JORDAN

In Jordan, the Sustain Water MED partners successfully demonstrated the feasibility of implementing a decentralised treatment system and water reuse in a peri-urban area. The project provides clear evidence of the economic benefits that on-site water treatment arrigating green areas can offer.

Despite these successes, the Sustain Water MED partners also experienced several challenges in implementing pilot plants. This chapter summarises some general lessons learned from the project implementation in the four countries, pointing to common challenges but also to good practices for how to overcome some of the challenges. These could guide planning for similar projects in the future or facilitate the replication of approaches in different contexts. Finally, recommendations targeted towards policy- and decision-makers are formulated on how to create conducive framework conditions for approaches on wastewater and sanitation management.

LESSONS LEARNED – CHALLENGES

EXISTING LEGAL FRAMEWORKS RELATING TO WASTEWATER MANAGEMENT AND REUSE, AS WELL AS PERMITTING PROCEDURES AND REQUIREMENTS ARE OFTEN UNCONDUCIVE FOR INNOVATIVE REUSE-ORIENTED PILOT PROJECTS

In most of the case studies presented here, pilot projects faced challenges in complying with permitting procedures, including EIA requirements for example, and/or existing legal frameworks relating to allowed practices for water reuse in agriculture, effluent quality standards or monitoring. This refers especially to cases where pilot projects involved decentralised systems. In Jordan, for example, national requirements for EIAs have been formulated in view of large-scale wastewater treatment plants and were found to be overly comprehensive and thus costly and time-consuming for the small system implemented within Sustain Water MED. Moreover, existing institutions in the pilot countries did not always have the necessary human and/or technical capacities to realistically provide for frequent effluent quality monitoring at the level of pilot projects. For instance in Tunisia, producers and providers of reclaimed water do not carry out analyses at regular intervals, resulting in a lack of reliability and transparency regarding its quality. Similarly, in Jordan, unclear responsibilities for monitoring effluent quality at decentralised treatment plants complicate compliance with existing regulations. Pilot projects' limited compliance with quality standards and monitoring requirements should however be viewed against the backdrop of actual practices: in several of the Sustain Water MED pilot cases, unofficial and thus uncontrolled reuse or effluent discharge had sometimes taken place for many years before the pilot projects had started. Consequently, even though pilot projects sometimes faced challenges in fully complying with existing regulations, they still could contribute to reducing health risks and environment pollution compared to the existing practice of unofficial water reuse and discharge of effluents.

Limited compliance with legal requirements should be viewed against the backdrop of actual unofficial and thus uncontrolled wastewater practices.

POOR ENFORCEMENT OF REGULATIONS AT LOCAL LEVEL RESULTS IN DISINCENTIVES FOR USE OF RECLAIMED WATER

Another challenge often encountered within the pilot projects presented here is that regulations existing in the countries are not enforced, or only partially enforced, especially at the local level or in remote communities. For instance in Egypt, quality standards for the discharge of effluents into drainage canals are regulated by law. This law is however poorly enforced, meaning that there are no consequences for violating the discharge standards. Consequently, there is limited economic incentive to invest in or pay fees for well-functioning wastewater treatment services. Another example is in Tunisia, where even though a pricing scheme has been defined for the supply of conventional and reclaimed water, in practice freshwater is often used more or less without charge as there are many illegal connections to the distribution system, and bills are not always paid. Therefore, even if fees for reclaimed water are lower than those for freshwater, there are only limited economic incentives to use – and pay for – reclaimed water if freshwater fees are not enforced. This makes it difficult to evaluate whether the pilot project will create real economic benefits for the beneficiaries, which is an important precondition to ensure the long-term viability of the system. The main challenge in this context is to realistically assess the baseline situation in the pilot area, which however plays a crucial role in ensuring that wastewater management projects are efficient and address real needs of the target group.

There are only limited economic incentives to use – and pay for – reclaimed water if freshwater fees are not enforced.

LIMITED CAPACITIES OR LACK OF LOCAL TECHNOLOGY PROVIDERS COMPLICATES PROCUREMENT AND IMPLEMENTATION OF DECENTRALISED SYSTEMS

Several of the pilot projects encountered difficulties in finding local suppliers and/or skilled construction companies to implement the planned systems. This has major implications in terms of what type of system can be realised within the pilot project. In Morocco for instance, it was difficult at first to find local construction companies willing to bid in the tendering procedure, as the innovative nature of the pilot project entailed an economic risk for local construction companies. On top of this, local companies do not necessarily have the required technical skills and must develop these gradually throughout the project. This challenge could only be overcome by reformulating the tendering documents and closely accompanying the construction company during the implementation of the project. While a capable construction company was identified for the pilot project in Jordan, the market for local technology suppliers is very limited. Moreover, the lack of experiences and eventually the low quality of construction design and work could weaken the case for decentralised systems in general. In Egypt, the approach adopted to overcome this challenge was to have a prefabricated unit of a type that has already proven successful in other countries and for similar settings. However, the challenge of limited local capacities still remains with respect to O&M, as local operators will be needed to ensure continuous running of the pilot plant.

The lack of experiences and eventually the low quality of construction design and work could weaken the case for decentralised systems in general.

LACK OF RESOURCES AND HUMAN CAPACITY CONSTRAINS OPERATION AND MAINTENANCE OF DECENTRALISED SYSTEMS

A challenge for all the case studies presented here is the question of how proper O&M of the implemented decentralised systems can be ensured beyond the timeframe of the financed pilot project. Local institutions, which will take over the responsibility for the implemented decentralised systems, often have limited resources and capacity, adding to the fact that their responsibilities are not always clearly defined. Ensuring that O&M are carried out appropriately in the long-term is however a vital aspect to ensure the ability of the decentralised system to limit risks to health and the environment. In Morocco, this challenge was addressed by providing technical trainings for owners, or other responsible persons, of the ecological sanitation systems. Experience in previous projects, however, showed that continued support is needed to ensure the functioning of the systems. In the pilot project in Egypt, the necessity of employing operators to ensure the continuous running and upkeep of the decentralised system results in high expenses for O&M due to the small-scale application of the technology. Should the local institutions taking over the decentralised treatment system not be able to provide additional financing to cover these costs, the result may be improper treatment of the wastewater because of insufficient O&M.

Continued support is needed to ensure the functioning of the systems.

TIMEFRAME OF THREE YEARS IS TOO LIMITED FOR A WHOLE PROJECT CYCLE

Any wastewater treatment project should ensure sustainability in the long term, not only within the timeframe of the financed pilot project. A whole “project cycle” should systematically include an initial stage of developing solutions adapted to the needs of the local population, an implementation stage of tendering and construction of the systems, and a monitoring stage looking at short- to middle-term socio-economic, health and environmental effects. Only a complete cycle will properly demonstrate the performance of the installed systems and introduced management model. From the experience of the pilot projects carried out within Sustain Water MED, it seems however that a typical project timeframe of approximately three years is too short for a whole "project cycle", as delays in tendering and constructions cut short the period initially foreseen for the monitoring stage of the project. Moreover, the economic viability of a pilot project may only be achieved in the longer term, or if the pilot activity is replicated in other sites of the same region. However, before attaining this stage of potential replication, it has to be ensured that local institutions will keep supporting the pilot activity beyond the timeframe of the pilot project in order to make sure the local population still benefits from its positive effects in the long term. Finally, only a long-term follow-up on the project will enable reliable conclusions regarding the performance of the system, expenses for O&M, as well as tangible environmental and socio-economic effects.

Only a complete cycle – from developing appropriate solutions until monitoring of short- to middle-term effects - will properly demonstrate the performance of the installed systems.

LESSONS LEARNED – GOOD PRACTICES

INVOLVEMENT OF LOCAL STAKEHOLDERS BASED ON A THOROUGH STAKEHOLDER ANALYSIS FACILITATES COMMUNICATION WITH COMMUNITIES AND ACROSS SECTORAL AGENCIES

A thorough stakeholder analysis was conducted at the very start of each of the pilot projects to identify relevant actors at the local level who should be involved in the implementation of the project. In Morocco and Egypt, involving local community development associations proved helpful for communication with the beneficiaries, especially with respect to assessing their needs in terms of sanitation and creating local level support for the pilot projects. Moreover, these associations proved to be valuable partners in awareness-raising activities for the beneficiaries, e.g. on the potential benefits of the pilot projects with respect to reducing environmental pollution and necessary hygiene practices when using treated wastewater in agriculture. Involving different sectoral institutions has further generated benefits in cross-sectoral coordination and understanding. In the case of Tunisia, for example, involving the local level organisations of the ONAS, the CRDA responsible for the distribution of reclaimed water, and the GDA representing the farmers, has contributed to more trustful relations between these institutions. Responsibilities for monitoring quality of the wastewater treated within the system were clearly defined in the pilot project and the results of water quality analyses are now accessible to all in a transparent manner.

Local associations proved to be valuable partners in raising awareness of beneficiaries.

ADDRESSING REAL NEEDS OF THE END-USERS INCREASES OWNERSHIP OF THE PROJECT AT THE LOCAL LEVEL

Building on a thorough baseline and needs assessment, the pilot projects addressed real and urgent needs of the local population. This proved to be a crucial aspect in ensuring the relevance of the project and creating ownership of the pilot projects among the beneficiaries. In Morocco, a series of individually tailored treatment solutions were identified to address urgent needs of the local population in terms of access to sanitation and reducing environmental pollution. In the pilot case in Tunisia, reliability of effluent quality was identified as the main reason for the need to foster wastewater reuse. Unreliable quality had resulted in limited acceptance of wastewater reuse, while several farmers had actually used reclaimed water of unreliable quality before, taking major health risks for themselves as users of reclaimed water and for consumers of their crops. In Egypt, the pilot project also addresses urgent needs of the local population in terms of sanitation and reducing environmental pollution caused by the uncontrolled discharge of raw sewage into agricultural drains. The association representing the beneficiaries from the village has developed ownership for this pilot project, as can be seen in their motivation to contribute financially to setting up the sewerage system.

Thorough baseline and needs assessments are crucial steps to ensure the relevance of the project.

DEMONSTRATING TANGIBLE ECONOMIC BENEFITS INCREASES ACCEPTANCE OF REUSE

Demonstrating tangible economic benefits can significantly increase acceptance of wastewater reuse. An important dimension in the planning of such pilot projects is thus thinking about how to make economic benefits visible to the beneficiaries. In Morocco, the ecological sanitation (ECOSAN) approach adopted foresees the recovery of nutrients for direct use in local agricultural activities, which should reduce the beneficiaries' spending for transport and purchase of synthetic fertilisers. In addition, the capture and use of biogas produced could save costs for bottled gas. Initial reluctance to reuse by-products from sanitation systems for agricultural purposes was overcome after participants from Ait Idir visited another Moroccan pilot site, Dayet Ifrah, and could grasp concretely the extent to which savings in energy and fertiliser costs could be realised. This helped beneficiaries of the project in Ait Idir to realise which environmental, health and socio-economic benefits they could expect from the pilot project in the long term, enhancing acceptance and ownership for the installations by the local population. In Tunisia, studies were carried out on the pilot site to analyse the quality of olives from trees irrigated with reclaimed water as well as microbiological parameters of olives and soils. The study obtained promising results, demonstrating that an even better quality of crops could be achieved through irrigation with reclaimed water. Tangible economic benefits of reusing effluents of a decentralised treatment plant were also demonstrated in Jordan. Considering the relatively high costs of freshwater provided by tankers in Amman, additional costs for wastewater treatment and adapted irrigation systems are expected to pay off in a relatively short period. In the long term, using the pilot plants as demonstration sites to showcase the economic benefits of water reuse can increase acceptance of such systems in future projects. Economic benefits could also be increased by involving other users in the project. In Morocco for example, sanitation system owners at the demonstration site of Dayet Ifrah could generate additional income by selling the sanitation by-products as fertilisers to a neighbour. In Jordan, excess effluent is transferred to the Greater Amman Municipality for irrigation of urban green areas. While for now, this happens without remuneration, this could be an option for increasing economic benefits from integrated wastewater management. In planning reuse projects, broader options of generating income or reducing costs should thus be considered to achieve maximum benefits and therefore incentives for integrated wastewater management and sanitation systems.

Using the pilot projects as demonstration sites to showcase the economic benefits of water reuse can increase acceptance of such systems in future projects.

REMOTE MONITORING CAN SAVE COSTS FOR OPERATION AND MAINTENANCE AND PREVENT HEALTH AND ENVIRONMENTAL RISKS RESULTING FROM MALFUNCTIONING OF THE TREATMENT SYSTEM

The treatment and/or reuse systems adopted within Sustain Water MED provide a reliable solution to overcome some of the problems caused by the inappropriate management of wastewater. Operation, maintenance and quality monitoring, however, often present a challenge, especially for decentralised treatment systems where it is not financially viable to have operators permanently present on-site. Remote monitoring of water quality and functioning of the treatment system can help overcome these challenges. In Jordan, for example, a remote monitoring system informs the plant operator of any malfunctioning of the system, so he or she can send staff to solve the problem and prevent health and environmental risks resulting from the discharge of insufficiently treated effluent. A similar system could be well-suited in the case of Egypt, as a remote monitoring system could potentially be managed from the local affiliated company located in the next city. This solution would be especially convenient if decentralised treatment systems are replicated in other villages of the same region, which could then all be monitored by the local affiliated company. In Tunisia, the new laboratory in the local WWTP, the mobile laboratory, and the information and early-warning system will improve monitoring and control of pathogens in reclaimed water. The pilot project strengthened the technical capacity to carry out the necessary monitoring and established an effective platform for sharing analysis data with all stakeholders concerned on a regular basis. The early-warning system implemented in particular should contribute to preventing health and environmental risks, as farmers receive immediate notification via SMS should unexpected pollution of the reclaimed water for irrigation be detected by the remote monitoring system.

Remote monitoring systems can inform plant operators or farmers of any malfunctioning of the system.

HIGH-LEVEL SUPPORT FROM POLICY-MAKERS FACILITATES SUCCESSFUL PROJECT IMPLEMENTATION AND IN TURN FOSTERS THE POLICY INFLUENCE OF THE DEMONSTRATION PROJECTS

In all four countries, high-level steering committees were established to accompany project implementation. High-level support from policy-makers on the national level proved very helpful for the success of the pilot projects. In Morocco, for example, representatives from the authorities involved in the project at national and local level stated that the regional training measures and project meetings that took place within Sustain Water MED at national, regional and local levels were very useful and enabled them to assist municipalities and engineering companies in their work on ecological sanitation. This is a virtuous circle, as highlighting the success of this type of pilot project also helps to persuade the Moroccan authorities of the advantages of decentralised sanitation in villages instead of centralised management. The Department for Water under the Ministry for Energy, Mines, Water and the Environment will promote the replication of this type of decentralised system in other rural areas. In Tunisia and Jordan, the pilot project was also very much supported by the institutions concerned with wastewater treatment and water reuse in agriculture at the national level, including those responsible for environment, agriculture, water resources and health. These institutions formed very active steering committees that welcomed the opportunity to hold meetings at regular intervals during the lifetime of the project, providing a valuable platform for discussing not only the progress of the pilot project, but also more generally the institutions' respective responsibilities and interests. Moreover, these stakeholders highlighted that their joint work in the projects’ steering committees had contributed to better cross-sectoral exchange of experiences and understanding. Consequently, barriers and diverging interests in implementing decentralised wastewater treatment and reuse projects could be identified.

Joint work of national policy-makers in the projects’ steering committees contributed to better cross-sectoral exchange of experiences and understanding.

POLICY RECOMMENDATIONS

In all four of the Sustain Water MED target countries, water reuse, and to some extent also decentralised wastewater treatment, are officially supported by national policies and strategies. Nevertheless, in implementing demonstration projects for decentralised and centralised reuse-oriented approaches, the Sustain Water MED pilot projects faced several challenges, as elaborated above. Based on the lessons learned from the pilot projects, the following recommendations can be made to support an enabling environment for integrated wastewater management in the Mediterranean, including conducive regulatory and institutional frameworks.

LEGAL FRAMEWORKS AND PERMISSION PROCEDURES SHOULD BE ADAPTED TO FACILITATE IMPLEMENTATION OF INNOVATIVE PILOT PROJECTS

If national strategies and policies are to promote reuse-oriented wastewater treatment and decentralised management, they need to be accompanied by measures to facilitate implementation of integrated and small-scale systems. Overly strict regulations and administrative hurdles often impede implementation of projects and thus learning from practice and finally transfer of integrated approaches. For example, legal requirements could define simplified permitting procedures including different levels of EIA for projects of different scales, and determine a level of water quality monitoring that can be realistically provided by the existing institutions. International experience has further shown that overly strict regulations for wastewater management can even be counterproductive: where legal requirements do not seem achievable under local circumstances, people do often resort to unofficial effluent discharge and/or reuse. This unofficial practice then takes place beyond any control, potentially leading to health and environment risks. Legal frameworks and requirements should therefore be based on a realistic assessment of which level of regulation is appropriate and feasible considering the existing situation and capacities.

INCREASE RESPONSIBILITIES AND DEFINE THE MANDATE AND CAPACITIES OF LOCAL AUTHORITIES IN TERMS OF PERMISSION AS WELL AS MONITORING OF WASTEWATER TREATMENT AND REUSE SCHEMES

National policies to promote integrated wastewater management, and especially decentralised management approaches, need to be matched by human capacities and mandates to administer related programmes. Local authorities need to be enabled to assess local needs and to accompany municipalities, villages and construction companies to implement feasible solutions. However, it is also important to define their responsibilities and mandate. Empowering local authorities to play an adequate role in terms of permission as well as monitoring of wastewater treatment and reuse schemes can play an important role in facilitating implementation of wastewater systems. Such efforts can also assist in addressing the challenge of poor enforcement of regulations at a local level. However, care must be taken in order to avoid overlaps of national- and local-level responsibilities.

DEVELOP CAPACITIES OF LOCAL TECHNOLOGY PROVIDERS AND CONSTRUCTION COMPANIES

The Sustain Water MED demonstration projects often faced difficulties in finding local technology suppliers and construction companies. The scaling–up of pilot efforts to promote reuse-oriented wastewater management and sanitation approaches therefore needs to be complemented by measures to support the national supply side. These could include capacity-building measures for local technology providers and construction companies, as well as awareness-raising measures on new market opportunities emerging from these new approaches. This can be realised by ensuring close support to local technology providers throughout demonstration projects, by offering specific training measures, as well as continuous on-site technical advice and opportunities for knowledge exchange with companies contracted in similar projects. Supporting the creation of new businesses that provide the technologies needed in these new reuse-oriented wastewater management and sanitation approaches can also help strengthen the supply side. Local capacity building is a crucial aspect also in terms of potential replication of the technology in other areas of the same region, which may have similar needs.

DEFINE CLEAR RESPONSIBILITIES FOR OPERATION AND MAINTENANCE

In order to ensure the functioning of wastewater management and sanitation systems in the long term, and thus the achievement of policy goals related to the protection of human health and the environment, strategies and policies need to also address the crucial issue of O&M. Responsibilities for O&M must be clearly defined between the local and national level. It is also possible to transfer the responsibility for O&M to village associations, private contractors, or local branches of national utilities. In any case, a sufficient level of human capacities to carry out O&M related tasks needs to be ensured, and training must be provided accordingly. However, it also has to be ensured that local and/or national institutions have the financial resources to cover expenses for O&M. Permitting procedures for wastewater management systems should thus require elaboration of an O&M plan, including responsibilities, maintenance schedules, and a clear and affordable economic and management model for long-term operation of the system.

DEVELOP PRACTICAL GUIDANCE FOR THE IMPLEMENTATION OF (SMALL-SCALE) INTEGRATED WASTEWATER MANAGEMENT PROJECTS (INCLUDING TECHNOLOGY SELECTION, TENDERING, OPERATION & MAINTENANCE, AND LICENSING)

Practical guidance documents for responsible authorities at the national and local level can further facilitate permitting and implementing integrated wastewater management projects. Up to now, most of the wastewater management systems implemented in the Sustain Water MED countries reflect centralised large-scale approaches. Therefore, responsible authorities have limited experience and capacities in overseeing and approving the design and implementation of small-scale and alternative solutions. National efforts to promote integrated wastewater management should therefore also involve providing practical guidance on how to select technologies adapted to local needs, on how to formulate comprehensive terms of references and evaluate offers during the procurement process, as well as on review criteria for licensing new systems, etc. Practical guidance should be provided in the form of, for example, approved checklists for design, implementation as well as O&M of systems, defined evaluation criteria for the assessment of technical and financial offers and applications for licenses, standard designs and technical drawings of different types of systems, models for financial management and O&M plans, and templates for service and other contracts.

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ABBREVIATIONS

ABH	SMD Souss-Massa Drâa River Basin Agency (Morocco)
ABR	Anaerobic baffled reactor
ANPE	National Agency of Environment Protection (Tunisia)
RC-ASJS	Rural commune of Ait Sedrate Jbel Soufla
AGIRE	Integrated Water Resources Management Programme (Morocco)
ANCSEP	National Agency for the Sanitary and Environmental Control of Products (Tunisia)
BAU	Al-Balqa’ Applied University (Jordan)
BOD_5	Biochemical Oxygen Demand 5-day test
CMA	Centre Méditerranéen d’Analyses environnementales et industrielles
COD	Chemical Oxygen Demand
CTB	Belgian Development Agency
CRDA	Regional Commission for Agricultural Development (Tunisia)
DGEQV	Directorate General for the Environment and Quality of Life (Tunisia)
DHMPE	Directorate for Environmental Health and Protection (Tunisia)
EC	Electrical conductivity
ECOSAN	Ecological Sanitation
EGP	Egyptian Pound
EIA	Environmental Impact Assessment
EUR	Euro
GAM	Great Amman Municipality
GDA	Agricultural Development Groups (Tunisia)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HCWW	Holding Company for Water and Wastewater (Egypt)
HRT	Hydraulic Retention Time
IUCN	International Union for the Conservation of Nature
IRCWEE	International Research Center for Water, Environment, and Energy (Al-Balqa’ Applied University, Jordan)
JOD	Jordanian Dinar
JS	Jordanian Standard
MAD	Moroccan Dirham
MDCEau	Ministry for Energy, Mines, Water and the Environment (Morocco)
MENA	Middle East and North Africa
MOENV	Ministry of Environment (Jordan)
MWRI	Ministry of Water Resources and Irrigation (Egypt)
NICE	National Implementation Committee for Effective Decentralised Wastewater Management in Jordan
ONAS	National Sanitation Utility (Tunisia)
ONEE	National Office of Energy and Drinking Water (Morocco)
O&M	Operation and Maintenance
PNAR	National Programme for Sanitation in Rural Areas (Morocco)
PSD	Public Security Directorate (Jordan)
SBR	Sequencing Batch Reactor
SMART	Sustainable Management of Available Water Resources with Innovative Technologies Project (SMART)
TARWR	Total actual renewable water resources
TDS	Total dissolved solids
TSS	Total Suspended Solids
TND	Tunisian Dinar
USD	United States Dollar
UDDT	Urine Diverting Dehydrating Toilets
WAJ	Water Authority of Jordan
WHO	World Health Organisation
WRI	Wastewater Reuse Index
WW	Wastewater
WWTP	Wastewater Treatment Plant