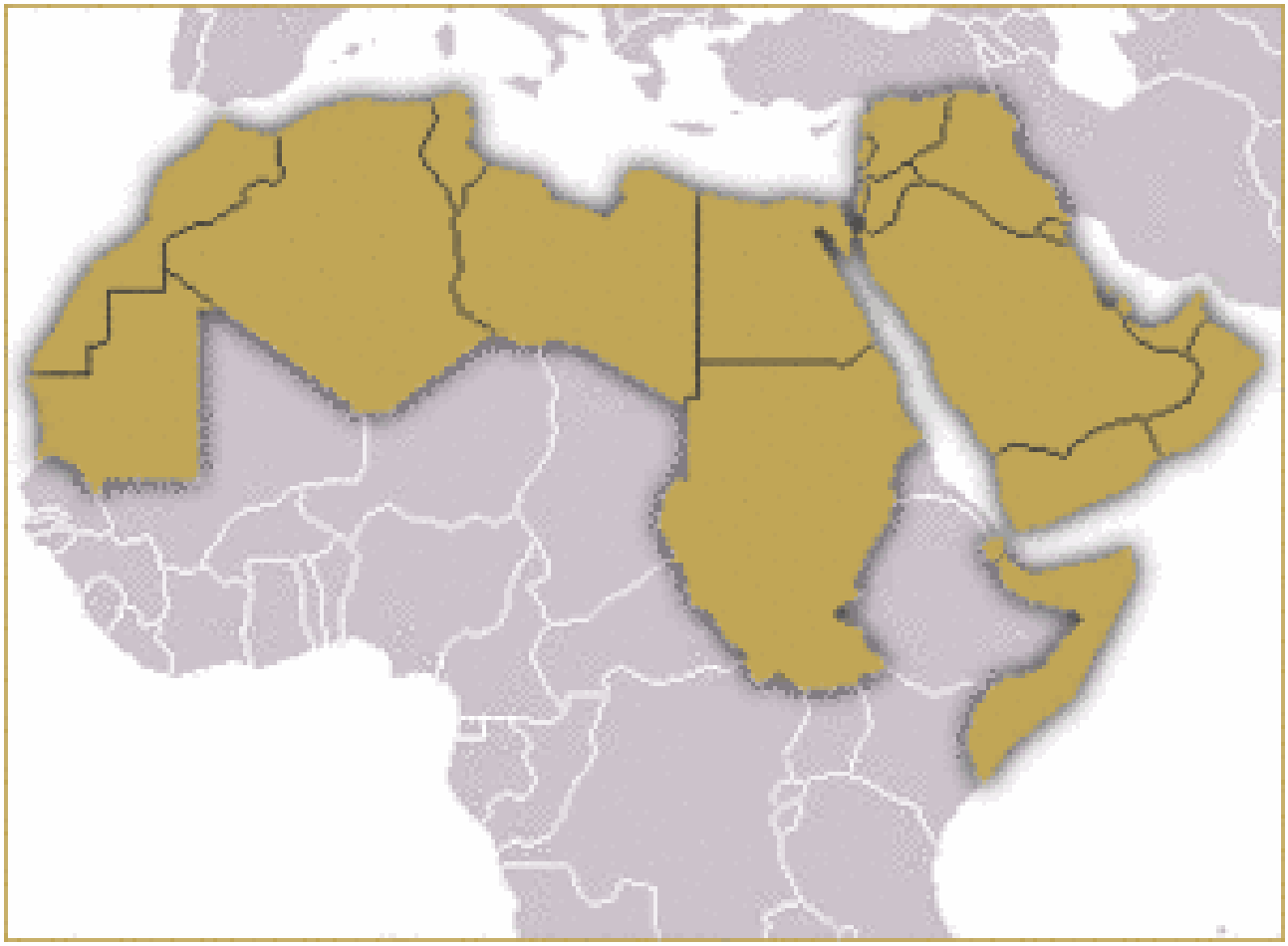
ACWUA Report

Wastewater Reuse in Arab Countries

Comparative Compilation of Information and Reference List



ACWUA Working Group on Wastewater Reuse, March 2010

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Introduction

The Arab Countries Water Utility Association (ACWUA) is a regional center of excellence, which partners with water supply and wastewater utilities in Arab countries to provide best practice service delivery to their customers. ACWUA aims to:

- Serve as regional platform for exchange of knowledge and best practice amongst member experts and professionals.
- Develop resources, facilitate training programs, and advocate for professional certification to enable member utility staff to perform their duties in a professional, reliable and cost-effective manner.
- Promote standards of performance for the governance, management, operation and maintenance of water supply and wastewater utilities.
- Support the interests of ACWUA members including the provision of advice and consultation in water legislation, policies, and sector management and reform.
- Develop, promote and disseminate publications and other knowledge products to meet the needs of members and other regional professionals.

ACWUA provides a regional advocacy platform for its members to interact effectively with each other and with governments, private sector suppliers and service providers, as well as foreign aid programs to the mutual benefit of all concerned.

Within this framework, the **ACWUA Working Group on Water and Health** started the compilation of experiences on Wastewater Reuse in Arab Countries. Local and International Experts and Agencies contributed to the data collection and provided various studies and publications on wastewater reuse. All publicly available documents are now provided on the ACWUA database for its members.

This report is a compilation of information from these various studies conducted in the Arab Region. It aims at providing a general overview and comparison of the state of wastewater treatment and reuse options in selected Arab Countries and draws conclusions from this information.

This report is as brief as possible to allow a quick overview on the state of wastewater treatment and reuse in the Arab World. It does not claim completeness as not all documents were publicly available. Therefore, it only mentions facts in a table format and provides links to already existing and very comprehensive reports and country case studies. Most of them are available as download from the ACWUA web site or web-sites from partners.

The information on Morocco, Tunisia, Lebanon, Egypt and Syria are mainly derived from a study financed by the European Investment Bank (EIB) and conducted by AHT Group AG and is called “Identification and Removal of Bottlenecks for Extended use of Wastewter for Irrigation or for other Purposes (2009)” The specific country reports and a summary is available online at http://www.aht-group.com/ww-reuse/index.php?id=4

The Information on Dubai, Abu Dhabi, Palestine, Jordan and Yemen are from various sources and expert interviews, which are summarised as country case studies on the ACWUA information platform. The authors would like to extent their sincere gratitude to all experts, who contributed to this work.

This document targets experts from Arab water authorities and utilities as well as bilateral and multilateral development agencies. But also NGOs working on water reuse might be interested in this overview.

Countries covered so far are Abu Dhabi, Dubai, Egypt, Jordan, Lebanon, Morocco, Syria, Yemen. The working group would like to extend the report to further Arab Countries and asks authorities, utilities and experts to contribute with latest information.

The editors invite experts to participate in the ACWUA working group and to contribute with missing information on other Arab Counties.

Summary

This overview report shows how the vast diversity of demography, climate, economy and status of sanitation in Arab Countries influences also the management and reuse of non-conventional water resources like wastewater.

Only a few countries like Lebanon are still blessed with sufficient renewable water sources and therefore do not consider wastewater reuse as a priority issue. Wastewater is hardly reused or controlled. Other countries like Jordan or Abu Dhabi reuse almost 100 % of the available/collected wastewater – however, for complete different purposes. Some country use treated wastewater and control its reuse others neither.

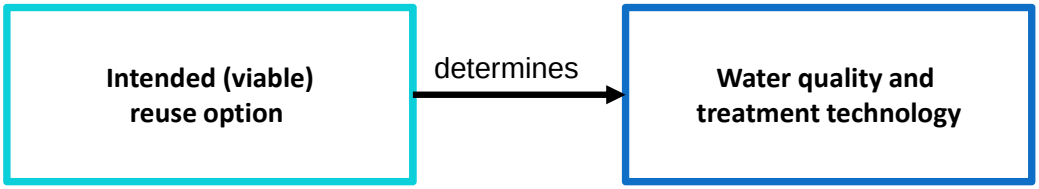
Generally, the save and efficient reuse of wastewater depends on an existing and well functioning sanitation infrastructure. Wastewater needs to be collected, treated before it can be safely redistributed to users.

Several driving forces for wastewater reuse have been identified (AHT/ EIM/FEMIP 2009):

1. The political will and commitment to promoting wastewater reuse
2. A clear sector policy
3. An institutional framework with clearly defined tasks and responsibilities (planning, funding investments, implementation, operation)
4. A clear legal and regulatory framework for wastewater reuse –including enforcement
5. Availability or non-availability of conventional water resources or extend of water scarcity
6. The state of sanitation and treatment infrastructure and its performance
7. The existing tariff level and structure in the water sector and their ability to cover sanitation costs
8. The willingness and capacity of end users to pay adequate water fees
9. The profitability of investments in wastewater reuse schemes
10. The availability of research results and the general know-how of users and consumers about crop production with treated wastewater.

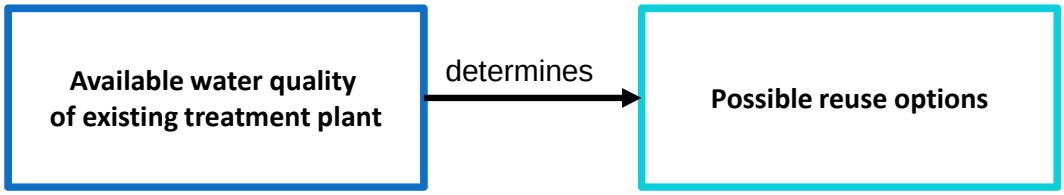
Two planning approaches for wastewater reuse are currently applied:

- Firstly, the intended reuse option determines the water quality and therefore the required treatment technology. This future oriented approach allows structured planning within a broader wastewater management master plan and gives the greatest flexibility for reuse.



⇨ Future oriented and flexible

- Secondly, the available effluent quality of existing treatment plants define possible reuse option. This pragmatic approach is widespread in Arab countries, but considerably limits reuse options and the development of new reuse options.



⇨ Status oriented and restrictive

Reuse options are manifold and strongly depend on a country's economic structure.

Agriculture plays a major role for reuse in Jordan, Egypt, Yemen, while the United Arab Emirates, Tunisia and Morocco focus on green space irrigation in urban centers and tourist facilities. Groundwater recharge is another option for wastewater reuse and is particularly considered in countries where sea water intrusion into freshwater aquifers is threatening the already scarce water resources.

Recycling for industrial and domestic reuse is another option. Recently, several municipalities facing water shortages consider high-tech wastewater treatment system in modern large housing complexes and high rise buildings to reuse the reclaimed water "in-house" for cooling purposes or toilet flushing.

One promising variation of this approach is **greywater recycling**. Water from showers and sinks is collected separately and treated in state-of-the-art greywater treatment systems with a disinfection unit. Such systems allow a cost efficient and safe reuse of high quality service water close to the point of generation. This technology is particularly on the rise in Jordan.

Quality parameters are set in most of the Arab countries, however only few have the capacity and means to meet these standards. Though certain quality control for irrigation water is in place, hardly any corrective measures are available in case of unacceptable pollution or misuse.

Jordan can be considered as the most advanced country with regard to quality control and safety schemes for reuse, as it has implemented a safety control system for agricultural produce grown on a mix of treated wastewater and freshwater. However, this scheme is currently limited to the Jordan Valley and requires further national up scaling. Other countries like Egypt or Tunisia have set very strict reuse standards, limiting reuse to forestry, green spaces and industrial crops). As many urban

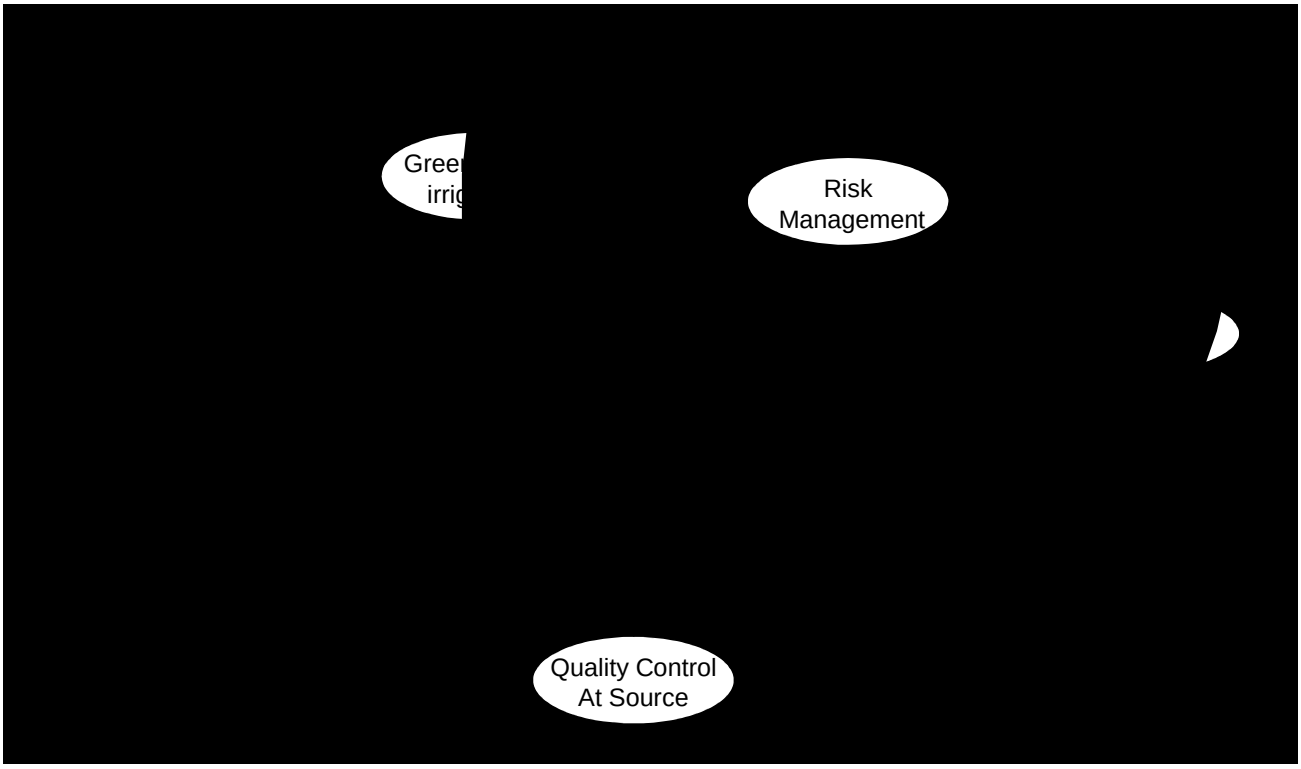
centers in Arab countries are located along coastal lines, a lot of wastewater is “lost” as outfall to the sea. Particularly Morocco (60%), Lebanon (80%) and Dubai (95%) are discharging the major amount of treated or untreated wastewater into the see.

In Morocco and Lebanon most of the treated or untreated wastewater is discharged into the sea. Both countries increased efforts in the construction and rehabilitation of WWTPs with the aim to reduce environmental pollution and protect the seashores. Reuse is not considered in all new projects.

Yemen is the least advanced country with regard to wastewater reuse and safety control as it has a predominantly rural setting, limited sewer connection, deteriorated WWTP which do not meet national quality requirement and reuse patterns which are completely uncontrolled as farmers illegally abstract water either directly from the plants or downstream from the effluent discharge point.

The United Arab Emirates (Dubai and Abu Dhabi) are hardly comparable with other countries in the region due to their smaller scale, predominantly urban setting and fast growing character. However, while Abu Dhabi has a strategy for its wastewater treatment and reuse, Dubai is still struggling with one overloaded WWTP and illegal dumping.

In all countries, a major quality concern for wastewater reuse is the high pollution load of industrial wastewater. It is mixed with domestic wastewater in almost all countries putting an additional burden on the already stretched capacities of existing WWTPs. Furthermore, many WWTPs cannot eliminate persistent chemical compounds or heavy metals. Besides organic pollutants, the high salt content of industrial effluents jeopardizes and efficient reuse as many plants are sensitive to excessive salt concentrations in irrigation water.



Recommendations

The following ten recommendations are adapted from recommendations which were elaborated during a workshop on *"Identification and removal of bottlenecks for extended use of wastewater for irrigation and for other purposes". (2009, Alexandria)* They are based on finding from country assessments in Morocco, Tunisia, Egypt, Lebanon and Syria. But most of the findings are more or less relevant for all other Arab Countries:

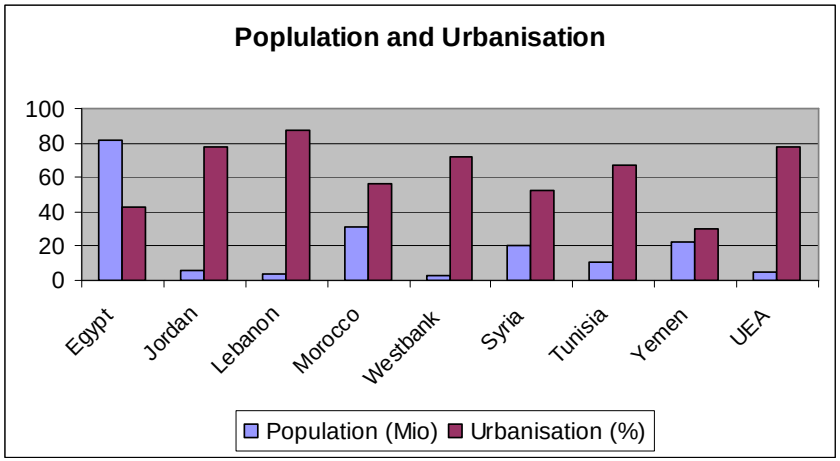
1. Governments require **master plans** for reuse of reclaimed water as part of an integrated water resource management approach. Such master plan comprises technical, institutional, legislative, social, economic, financial and O&M aspects. In many counties some aspects are already considered and just need to be reviewed and amended under the wastewater perspective.
2. Urban areas require loans and grants for infrastructure projects which comprise the construction or the rehabilitation of existing WWTP. Reuse options need to be considered in the planning stage already.
3. Rural areas, particularly small municipalities require funds to finance decentralized low-tech and low-cost technologies which proved to be reliable and allow local reuse. Such financial support requires as well technical assistance to ensure long-term sustainability and acceptance.
4. Introduce adequate project identification procedures
5. Industries require incentives and/ or guidance to establish pre-treatment facilities or internal recycling of water to reduce the pollution load to domestic WWTPs.
6. Investments in wastewater treatment facilities are only sustainable, if they are accompanied by institutional support and capacity development. Responsibilities have to be clarified, staff has to be trained and cost recovery for O&M ensured.
7. Governments require support for the development of cost-recovering water tariff systems. This highly political topic is crucial to a save and efficient reuse scheme in the long run.
8. Groundwater recharge schemes require hydrogeological studies as basis for the appropriate design and economic feasibility.
9. Water users and farmers require assistance to set up water user associations for a better and more efficient distribution and use of treated wastewater.
10. Further background studies are required to support sensible decision making. E.g. on groundwater regimes, reclaimed water conveyors (to limit sea outfalls), in-house reuse options, tariff structures, cost recovery, application of the polluter-pays principle, greywater reuse etc.)

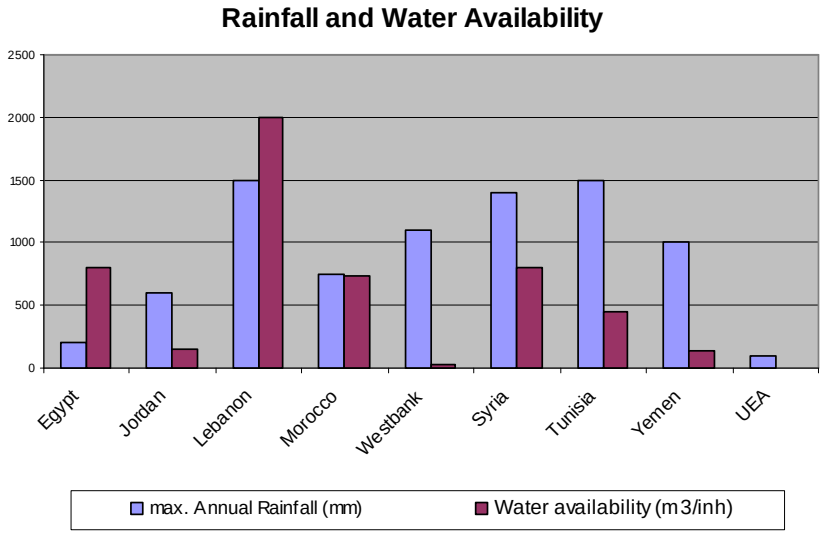
Additional comments and recommendations:

- The diversity of the countries geography, economy and culture requires individual solutions – even on national level. There is no "one fits all" solution.
- This summary report revealed that in all countries more than one study on wastewater reuse strategies has been elaborated. Certainly, some studies need to be updated, but it is now up to the governmental bodies and authorities to come up with actions to further enforce wastewater reuse to protect and use scarce freshwater resources more effectively.
- Wastewater reuse is part of a demand driven approach and allows the utilization of water which is already available, mostly at the right place. (compared to large desalination and conveyance projects)
- An international standardization of Wastewater Reuse has recently been launched by an ISO member. This standardization has very relevant implications for Arab Countries as it might affect export opportunities and tourism. ACWUA encourages all partner countries to take an active part in the formulation of these ISO Reuse Standards to ensure that they reflect the reality or give reasonable guidance towards an improvement in the Arab world.

1. General Information

Table 1 gives an overview of the general country indicators like population, population growth, state of urbanization, area, and GDP as an development indicator. The annual rainfall and water availability give further information about the current and future development potential. This comparison of general country indicators already gives an idea about the huge differences of the partner countries of ACWUA. Certainly, many countries face specific challenges, but the state of economic development and the availability of water resources mainly determine the extent of wastewater reuse. Lebanon for example has a high per capita GDP but hardly has any functioning sewer system, let alone wastewater treatment plants or a reuse scheme. Due to the available water resources and alternative income opportunities, reuse has no high priority in the governmental action plans. In contrast, Jordan has only half of the per capita GDP but a reuse rate of more than 90 % of its treated wastewater. Reasons are the severe water stress and political dependency on agriculture in the country. Countries with urban agglomerations along their sea shores (Morocco, Lebanon, Syria) tend to have less reuse due to high sea outfall and thus less need for treatment. Yemen faces an additional problem due to its low urbanization rate and scattered rural settlements. Wastewater reuse is common in many regions in Yemen, due to the increasing water scarcity. In contrast to Jordan where the major wastewater streams are generated in an agglomeration, Yemen requires a rather decentralized wastewater management strategy.



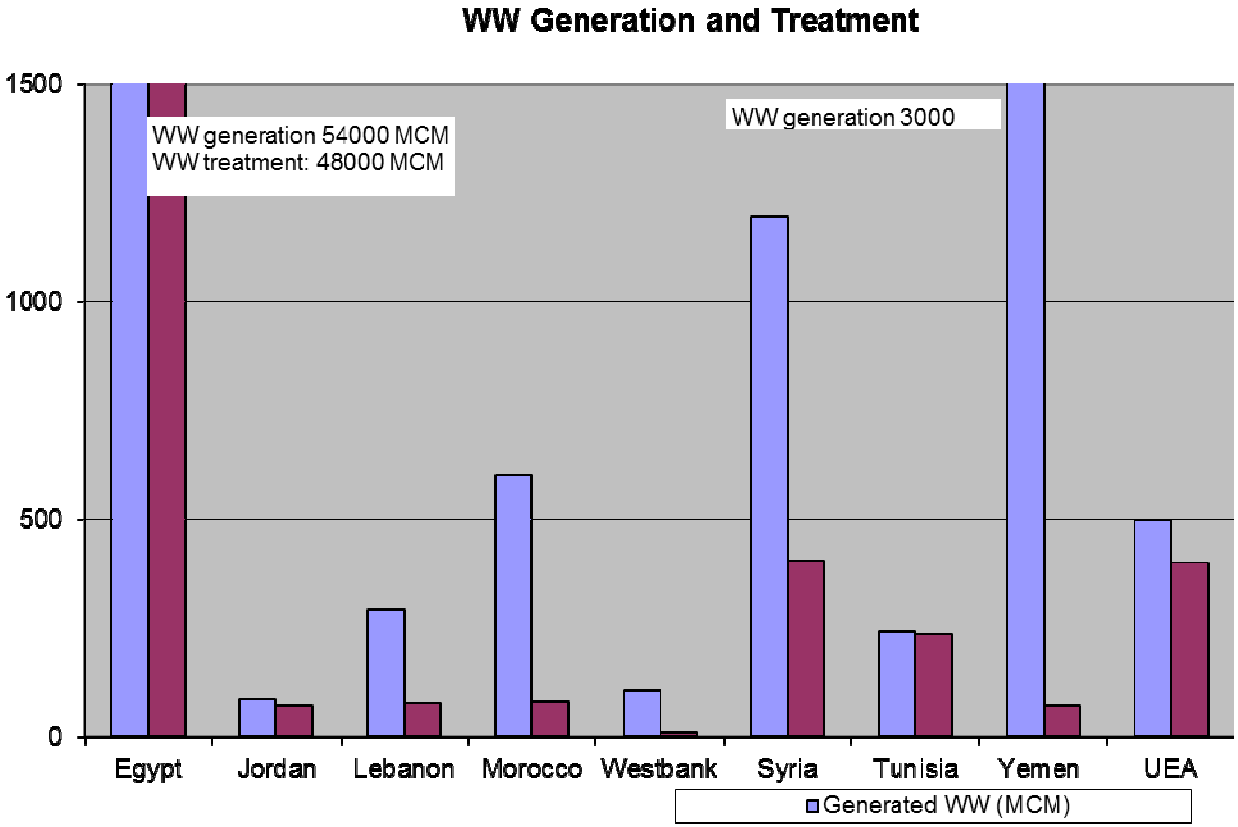


Country	Population (2009)	Population Growth	Urbanisation	Area (km^2)	GDP per capita ($) (2009)	Annual Rainfall mm/ year)	Water availability per capita* m3/ inhabitant
Egypt	82 Mio.	1.8%	43%	1 000 000 (only 40 000 km^2 inhabited along the Nile river)	6000	0-200	< 800
Jordan	6,3 Mio.	2.2%	78%	89 342	5300	120-600	147
Lebanon	4.2 Mio	1.3%	87%	10 452	11500	200-1500	1200-2000
Morocco	31.3 Mio	1.3%	56%	446 550	4600	150-750	730
Westbank	2.46 Mio	2.1%	72%	5 860	2900	100-1100	
Syria	20 Mio	2.5%		185 180	4700	100-1400	800
Tunisia	10.5 Mio	0.98%	67%	163 610	8000	100-1500	446
Yemen	22 Mio	Rural 2-3 % Urban 5-7 %	30%	555 000	2500	100-1000	137
UAE	4.7 Mio 0.9 Mio in Abu Dhabi 1.4 Mio in Dubai	3.6% (foreign work force migration)	78%	83,600	41800	100	

* Minimum according to WHO is 1000 m3 / inhabitant. Values less a classified as “water scarce countries”

2. Water Budget

The following table indicates the available water resources, water demands from the different sectors and additional relevant wastewater indicators. The comparison shows that despite the water scarcity in these countries and it's rather low contribution to the GDP, agriculture still is the main consumer of water with a share of about 80 %. This has mainly political reasons, which are challenging to overcome in all countries. Only Tunisia provides figures for the water demand in the tourism sector which gives an indication for the countries strategy to invest in tourism as alternative to agriculture. An assessment of water demand in the tourism sector for all Arab countries would be very useful for further long term planning strategies.



Wastewater Generation (blue) and Amount of treated wastewater (purple). The graph shows clearly the lack of sanitation strategies in most Arab Countries. Only Egypt and Jordan have more than 90 % sanitation coverage. Figures are difficult to compare, as some countries state only the generation and treatment of connected areas and neglect the rural and non-connected areas.

The improvement of sanitation services increases the potential for save and efficient reuse schemes.

Comparing the available water resources, demand and wastewater generation, it becomes obvious that the existing potential is untapped in most countries. Only Egypt, Syria and Jordan have a high reuse rate. Countries like Morocco, Lebanon and Tunisia have a much higher potential, but also face financial and practical constraints of reuse.

Country	Available Resources and Demand	Wastewater indicators
Egypt	Renewable sources are mainly the River Nile and minor precipitation in the north (200 mm/ year) Fossil aquifers in the desert provide additional water but are already heavily exploited. Current demand: 69.4 billion m^3 Agriculture: 82 % Industry 11 % Domestic: 6.7 % Water Deficit: unknown	Wastewater generation is estimated to 5.4 billion m3/year. Treated wastewater reuse estimates: 0.7 – 2.97 billion m3/year. (governmental schemes) (up to 92 % of the wastewater is collected) In the Nile Delta all wastewater is reused somehow, as both treated and untreated wastewater is drained into canals or the river Nile and again used further downstream. Current replacement of freshwater: no information available
Jordan	Rainfall varies from 100 mm in the south and east to 600 mm in the north-west. Total available water resources: 925 Mm^3 Groundwater: 450 Mm^3 Surface water (rivers and dams): 369 Mm^3 Reclaimed water from WWTP: 86 Mm^3 Desalinated water (sea and brackish): 20 Mm^3 Current demand: 1512 Mm^3 Agriculture: 64 % Domestic: 31 % Industry: 5 % Water Deficit: - 587 Mm^3	Wastewater generation: 86 Mm^3 90 % of the effluent is reused in agriculture. Mainly in the Jordan Valley after mixing with rainwater in the King Talal Dam. Current replacement of freshwater: 15 %
Lebanon	Rainfall varies from 200 mm to 1500 mm. Total available water resources: 2000 Mm3 Current water demand: 1530 Mm3 Agriculture: 58% Domestic: 31%	Wastewater generated: 292 Mm^3 (incl. 43 Mm3 industrial) Wastewater treated: 77 Mm^3 (26 % treatment) Wastewater reuse: negligible Except Beirut with a sewer connection rate of 98 %, the average connection rate is below 40 % in the country.

Country	Available Resources and Demand	Wastewater indicators
	Industry: 11% Lebanon is the only country with a positive water balance and is not considered as water scarce. However, it is estimated that by 2030 also Lebanon will have water stress. Sea water intrusion and groundwater pollution from polluted surface water already causes groundwater pollution.	It is estimated that 80 % of the wastewater (treated and untreated) is drained into the Mediterranean sea. (Most WWTP are located along the shoreline) There is almost no reuse in Lebanon. A unknown amount of raw wastewater is reused in the Beqaa valley.
Morocco	Rainfall ranges from 750 mm in the north to 150 mm in the south. Total available water resources: 22 billion m3 (of which is 18 billion m3 surface water) Current water demand: 14 billion m3 Agriculture: 87% Domestic 10% Industry: 3%	Wastewater generated: 600 Mm^3. Wastewater treated: 78 Mm^3. (only 13 % treatment) Wastewater reuse: unknown As most major cities are along the costal line, most WWT effluent is discarged into the sea. Reuse potential is high but not tapped. First projects for irrigation of golf courses implemented.
Syria	Rainfall varies from 100 mm in the north west to 1000 mm on the coast and 1400 mm in the mountains. Total available renewable resources: 15.6 billion m^3. (surface water, groundwater, wastewater, drainage water) Current demand: 17.7 billion m3 Agriculture: 88 % of total demand Domestic: 8 % Industry: 4 % Water Deficit: 14 %	Estimated Wastewater generated: 1194 Mm^3. Up to 406 Mm^3. (34 %) is treated but of poor quality Estimated 90 % of Wastewater (treated and untreated) is reused in agriculture, however only 183 Mm^3. are reported. Current replacement of freshwater: 3.5 %
Tunisia	Rainfall varies from 600 mm in the north to 100 mm in the south. Total available renewable water resources are estimated at 4.5 Mm3/ year Current water demand: 2 660 Mm3 Agriculture 80% Domestic: 14% Industry: 5 % Tourism: 1%	Wastewater generated: 240 Mm^3. Wastewater treated: 235 Mm^3. (98 % treatment) Wastewater reuse: 57 Mm^3. (23 %) • 39 Mm^3 reused in irrigation • 18 Mm^3. disposed into wetlands and rivers Wastewater reuse is mainly applied in agriculture (22 Mm^3.) but also golfcourses (10 Mm^3.) and green spaces (7 Mm^3.) are inclreasingly irrigated with WWT effluent.
Yemen	Total available renewable water resources are estimated at 4.1	Wastewater design capacity is 70 Mm3/ year which is only 2% of

Country	Available Resources and Demand	Wastewater indicators
	billion m3/ year Current water demand: 6.6 billion m3/ year Agriculture: 88% Domestic: 4% Industry: 1%	the total water consumption. (only 25%of population is connected to sewer system)
UAE	Despite the extreme water scarcity in the Gulf region, Abu Dhabi and Dubai have one of the highest per capita water consumption in the world. **Abu Dhabi** depends on its groundwater resources and desalinated water to meet its water demand. One additional water source is treated sewerage which is reused for green space irrigation mainly. Current demand: 763 Mm3/ year Per capita water consumption: 550 l/day **Dubai** mainly depends on its groundwater resources and desalinated water to meet its water demand. Additional dams in the north and the south store the scarce rain runoffs in the country. For the recent rain season about 4 Mm3 could be retained. Current demand: Per capita water consumption: 250 – 400 l/day (estimate)	**Abu Dhabi:** Daily wastewater production: 450 Mm3 (domestic) 54 Mm3 (industry) Wastewater is treated and reused for green space irrigation. **Dubai's** rapid growth means that it is stretching its limited sewage treatment infrastructure to its limits. Currently, human waste from Dubai's 1.3 million inhabitants is collected daily from thousands of septic tanks across the city and driven by tankers to the city's only sewage treatment plant at Al-Awir. Because of the long queues and delays, some tanker drivers resort to illegally dumping the effluent into storm drains or behind dunes in the desert. The result of sewage dumped into storm drains is that it flows directly into sea of the Persian Gulf, pollution the sea along tourist destinations.

3. Strategies, Laws and Actors

Several countries have water management strategies (Egypt, Jordan, Tunisia) consider wastewater as an important alternative water resource and also implemented measures accordingly. Other countries have set standards for WWTP effluents and irrigation water however, do not enforce or monitor them. Most countries follow the old WHO guidelines for wastewater reuse, that suggests high standards for water reuse. Recently, the new *WHO guidelines for the safe use of wastewater, excreta and greywater* (published in 2006) give the opportunity to adjust national laws and standards to the need of the respective country and should be more promoted among Arab countries.
Wastewater reuse is an issue which touches the responsibilities of many stakeholders – e.g. Ministries of Water, Irrigation, Health and Agriculture. Some countries have decentralized institutional setups that require an overall regulatory framework and clear regulations on the ground, that are suitable for decentralized structures. Therefore each country requires a thorough analysis of the situation and an action plan for improvements.

Jordan is considered the most advanced country with regard to wastewater reuse as they have implemented and enforced not only effluent standards but also have an established crop monitoring system for the Jordan Valley as well as a first strategy for a better cooperation amongst responsible authorities. Abu Dhabi has a clear strategy to reuse its WWTP effluent for urban greening.

Country	Strategies and Laws	Main Actors
Egypt	Reuse is a basic element in agricultural irrigation due to the Nile river. Egypt has implemented a Code of Reuse of Treated Wastewater in Agriculture (2001/ 2005) it regulates quality criteria for reuse in agriculture, requirements for irrigation techniques, requirements for health protection, enforcements, monitoring, inspection and corrective measures. According to the code no edible crops or export crops can be cultivated and irrigated on wastewater – regardless of the treatment level.	Ministry of Water Resources and Irrigation is the leading Ministry in water resources management. It developed the National Water Resources Plan as central strategy for more efficient water use in the country. National organization for Potable Water and Sanitary Drainage is responsible for the construction of water infrastructure Holding Company for Water and Wastewater (HCWW) is responsible for operation and maintenance of facilities. Their responsibilities will be extended to planning and construction of facilities as well as managing the governmental irrigation and reforestation programmes. Ministry of Health is responsible for Quality Control.

Country	Strategies and Laws	Main Actors
Jordan	Jordan considers wastewater as a crucial water resource and promotes reuse in irrigation. Other reuse options are currently considered (e.g. for in-house reuse and industrial reuse) Jordan has a set of laws and standards for the reuse of treated wastewater. The laws regulate monitoring duties and responsibilities, which are partly overlapping. Standards are set for WWTP effluents and and sludge quality. Further guidelines exist for wastewater reuse. These guidelines are currently under revision and planned to become standards as well. Additionally, a standard for greywater reuse in rural area exists, which is also due for a revision in order to keep up with the current development in the field of greywater reuse. Despite the existing regulations, no clear coordination among authorities exist which defines cooperation, data exchange and evaluation among these organisations. No institution signs responsible for overall coordination and guidance in case the public health is threatened by bad practices of reclaimed water use	Water Authority of Jordan (WAJ) is responsible for the operation and maintenance of WWTPs. Jordan Valley Authority (JVA) is responsible for the operation of the water canals and water distribution to farmers. They are in close cooperation with WAJ as they need to share the canal water between domestic demand and agricultural demand. Both organizations monitor water quality but for different purposes. Ministry of Environment controls water quality of all surface water bodies – the cooperation with WAJ and JVA is limited a the moment. Ministry of Agriculture is responsible for on-farm advice to farmers. However, farmers prefer advice of private extension officers. Jordan Food and Drug Administration is responsible for the lately implemented crop monitoring for fresh fruits and vegetables. Royal Scientific Society: Main actor for implementing monitoring programmes of surface and groundwater. Also active in standardization.
Lebanon	Wastewater reuse is not considered in the national water policy. Laws, standards and regulations for water management are outdated due to the political situation. Minimum standards exist to assure the quality of drinking water and environmental limit values for regulating the discharge of wastewater. Standards for the water used or reused for irrigation do not exist yet..	Due to the political situation, the roles and responsibilities for the water sector are fragmented and overlapping. The Ministry of Environment set the existing but not enforced quality standards. Wastewater management, meaning treatment, is responsibility of the municipalities. There is no regulation for reuse or safety control for reuse. Some research institutions consider wastewater reuse in their projects but they do not have an influence on the countries strategy.
Morocco	Wastewater reuse was just recently acknowledged as a strategy to combat the ever increasing water shortage. It will become part of an IWRM strategy. Laws and quality standards are sufficiently set with regard to wastewater reuse, however they are only partly enforced.	Responsibilities for wastewater management are not defined yet. Several ministries are involved in the water sector, but coordination is lacking. On local level, the Agences de Bassins Hydrauliques (ABH) are responsible but lack know-how and funds. The majority of WWTP are operated by Office National Eau Potable / Assainissement (ONEP) - Office *National*

Country	Strategies and Laws	Main Actors
		d'Assainissement (ONAS)
Syria	The Water Law of 2005 and other regulations are considering Water Demand Management, including Reuse of Wastewater. Strict quality standards exist but are hardly enforced and met by the plants.	Ministry of Irrigation: entire distribution of water resources Ministry of Housing and Construction: water supply and sewerage systems and WWTP (work is delegated to 14 Water Establishments in the Governorates for larger cities) Ministry of Local Administration: water supply, sewerage and WWTP in rural areas Ministry of Environment: quality control and protection of water resources, industrial wastewater Ministry of Agriculture: advisory services, water saving technologies. There is a lack of qualified staff for running WWTPs. Furthermore, quality control and enforcement is limited due to lack of funds for and skills of personnel.
Tunisia	Tunisas Government gives high priority to wastewater reuse as it is an important measure to safe and protect freshwater resources for drinking purposes. The legal framework (Water law) provides a good basis for wastewater reuse, but requires further definitions and amendments. Existing quality standards are not enforced due to a lack of treatment capacity.	The institutional framework is well developed with clearly defined responsibilities: Office Nationale de l'Assainissement (ONAS) – collection and treatment of wastewater. Operate WWTPs Ministère de l'Environment et du Dévelipment Durable Ministére de la Santé Publique – quality control, risk management Water police - enforcement and corrective measures
Yemen	Wastewater is considered as an important alternative water source in the new national water management strategy. Yemen has strict standards for water and irrigation water quality, however, they are neither met nor controlled. However, the lack of suitable treatment systems and distribution systems limits the current reuse.	Ministry of Water and Environment – legislative body Local Corporations – management of water supply and wastewater. Operators of WWTP in major cities. (in case they have one) Ministry of Agriculture and Irrigation – extension services and construction of retention reservoirs. Currently no involvement in wastewater reuse. The roles and responsibilities with regard to wastewater reuse are not clear.

Country	Strategies and Laws	Main Actors
UAE	**Abu Dhabi** has a clear reuse strategy for treated wastewater. The effluent is entirely redistributed to green spaces in the city. **Dubai's** laws and standards mainly regulate freshwater water supply and quality. Wastewater management is hardly considered due to the lack of available treated wastewater.	Abu Dhabi Sewerage Service Company (ADSSC) is an independent organization managing all aspects of wastewater in the city. The **Dubai** Water and Electricity Authority (DEWA) is responsible for water supply and wastewater management. The developer guideline only provides advice on water supply infrastructure. Dubai does not have a sewer system, but depends on septic tanks and suction trucks. Currently, only one WWTP exists and is operated by DEWA. A second plant is under construction.

4. Wastewater Treatment Technologies

WWTP Outflow/ Bypass, Sanaa, Yemen - Part of the wastewater is not treated and flows through a bypass where it is mixed with the treated effluent.

WWTP Sanaa, Aerators

Efficient wastewater treatment can only be realized if wastewater is also collected systematically. In most Arab Countries the sanitation systems do not cover more than 60 % of the households. Therefore, 40 % of wastewater is discharged with little or no treatment to the environment through dumping or soil infiltration.

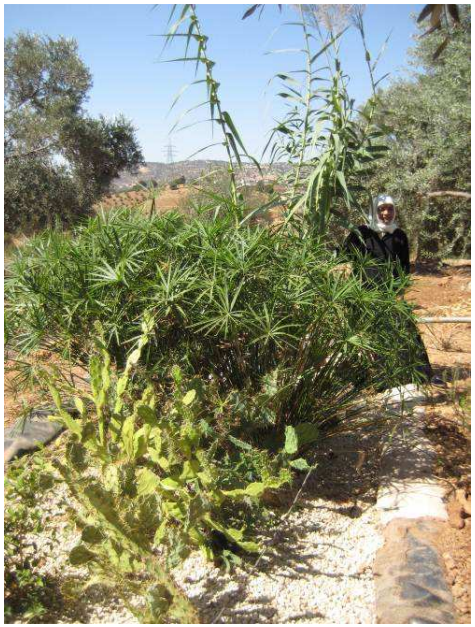
The major treatment technology found in Arab countries are stabilization ponds. Several countries like Egypt, Yemen, Morocco and Syria have sufficient available land for that technology, while other countries require other technologies (e.g. activated sludge) due to space constraints or too large urban agglomerations.

The overview revealed that all countries have problems with the performance of their systems. Only few (newer) systems meet the respective national standards for wastewater effluents. Main reasons are neglect of O&M routines, unskilled and unmotivated workers, overloaded systems and lack of funds from water fees.
Quality control is ensured in a few countries, but several countries neither enforce their standards or have the means to control the quality.

Country	Wastewater Treatment Technologies	Quality
Egypt	Egypt has about 240 WWTP – most of them in urban areas. Current treatment capacity is 4.56 billion m^3/year. In rural towns stabilization ponds are widespread. In urban areas other systems like aerated lagoons, activated sludge systems and trickling filters are applied. The effluents are fed into agricultural drainage canals or disposed of in the dessert.	The effluent quality from Egyptian WWTP hardly meets the strict quality standards set by the Code of Reuse. Most WWTP are in bad conditions due to insufficient O&M skills and lack of finances. Furthermore, quality control is limited which undermines the enforcement of the Code.
Jordan	Jordan has 22 wastewater treatment plants treating approximately 90 Mm3 per year. The new state-of-the-art treatment plant in As-Samra treats 80 % of the total generated quantity. (Activated sludge and lagoon). The remaining 20 % of wastewater is treated in smaller - mainly pond - systems or aerated sludge treatment systems with limited efficiency.	The upgrade of As-Samra treatment plant improved the water quality for irrigation in the Jordan Valley significantly. This is beneficiary for both the environment and agriculture, as the effluent is discharged into Zarqa River which is draining into King Talal Dam, where the effluent is diluted with rainwater. The high salt content is still a concern of farmers. This problem can only be tackled by improved source control in the industrial sector (particularly decentralized desalination plants in industries) The other WWTPs hardly meet the set standards.
Lebanon	Only 3 WWTP exist and have only a primary treatment stage and discharge the effluent into the sea. The WWTP of Beirut (Ghadir) is under rehabilitation and upgrading. Lebanon is currently focusing on the extension of the sewer systems along the shore in order to protect the Mediterranean Sea and its tourist locations. Several small scale systems on household levels were implemented by NGOs and research organizations. Greywater reuse is promoted within these projects.	Most wastewater is discharged raw or after primary treatment into the sea or surface water bodies.
Morocco	About 31 WWTPs are in operation with primary and secondary treatment. Most of the systems are lagoon systems. They serve only 0.03 % of the population. A huge sanitation investment Programme (Programme National d'Assainissement) shall improve the situation until 2020. The investment programme focuses on treatment and not on reuse.	Effluents from most WWTP do not meet the set quality standards, due to the bad state of most systems, an overload of systems and the mixing of highly polluted industrial wastewaster. The high organic load salt concentration prevent the reuse of effluents in irrigation. Upgrading of many systems is ongoing resulting in improved water quality in the future.
Syria	Information on WWTP and their performance are contradictory. Recent figures for 2007 estimate that there are 40 WWTP, which have a design capacity to treat 273 Mm^3 of wastewater. There are only three functional large scale WWTP in Damascus, Homs, and in Aleppo. On the other hand, it is estimated that in 2007 about 550 Mm^3 of treated wastewater are reused for irrigation. A recent research study estimates that 473 Mm^3 of wastewater are	Non of the systems meet the strict quality standards set in Syria, due to overloaded systems, outdated technology and lack of funds and maintenance. In some cities it is reported that untreated wastewater bypasses the systems and is directly used or discharged into rivers and the sea.

Country	Wastewater Treatment Technologies	Quality
	treated before used for irrigation, while 416 Mm^3 is used for irrigation without prior treatment and 311 Mm^3 are discharged into surface water bodies or into the sea without prior treatment.	
Tunisia	98 WWTP with primary and secondary treatment stages are in operation. Tertiary treatement is only provided in 5 WWTP. Many systems require rehabilitation or upgrading to meet existing national standards.	WWTP effluent often shows high salinity or changing water quality with limits its reuse potential in agriculture. This is mainly due to the combined collection of domestic and industrial wastewater. Furthermore, some WWTP show limited performance due to overload and bad O&M.
Yemen	20 WWTP exist or under construction in Yemen. Most systems are stabilisation pond systems but the major cities have activated sludge systems. Almost all systems are heavily overloaded leading to mediocre effluent quality or untreated wastewater is discharged via bypass into wadis.	The quality standards for Irrigation Water are very strict, however, neither met nor controlled. Yemeni laboratories are not equipped to measure all mentioned parameters. The very high BOD content causes an overload of most systems, resulting in limited effluent quality.
UAE	Currently ADSSC owns, operates and maintains - 2 main WWTP, 24 package WWTP, 236 pumping stations (80% in AD) and over 7400km of sewer mains (66% in AD). ADSSC is also responsible for planning and implementing system expansion required to support future growth. Dubai has one major WWTP (activated sludge system) which is heavily overloaded and/ or bypassed by many trucks which dump raw wastewater illegally in storm water drains.	No information available yet. (Update in April)

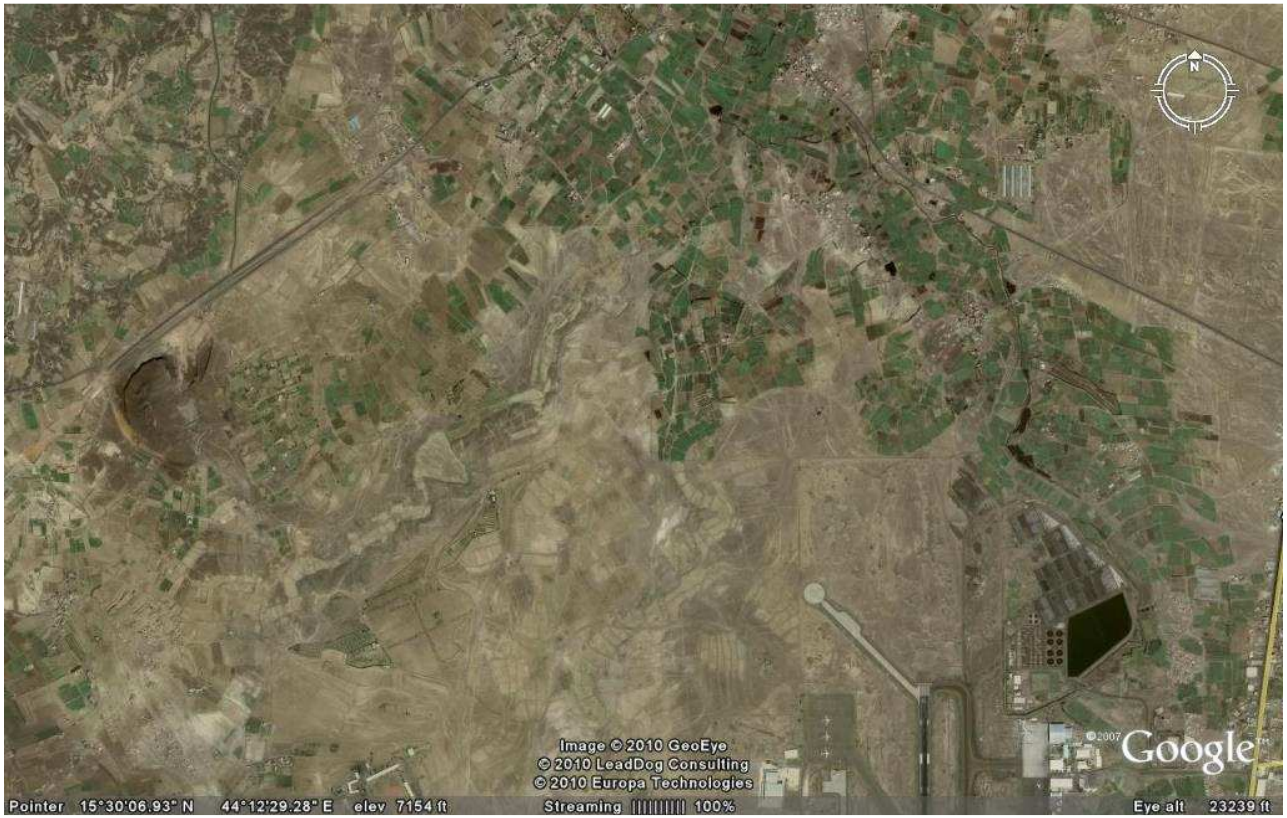
Greywater Treatment



Rural greywater treatment system. Horizontal flow constructed wetland. These systems can be constructed with local materials at moderate costs for the household. Households benefit from reduced water bills and costs for cesspit cleaning. Furthermore, they have direct financial benefits through increased crop yields. More than 500 such systems are installed in rural Jordan and used for **garden irrigation**.

Mechanical-biological greywater treatment systems allow greywater reuse **for toilet flushing and cleaning purposes and gardening** because they are more efficient and have a UV-disinfection device. Such systems require less space and are very suitable for hotels and multipurpose buildings. More than 30 systems are already installed in the Mediterranean Area and Jordan.

5. Wastewater Reuse



This photograph shows a good example of wastewater reuse in Yemen. The treatment plant (right below) is the source for irrigation water. The effluent is discharged in a little wadi, where it is pumped to the various fields along the stream.

Similar satellite pictures can be found in most Arab countries like Jordan, Egypt or Syria.

Most countries allow only restricted agriculture with WWTP effluent, meaning the irrigation of trees, forage and green spaces. However, in several countries these regulations are ignored or only partly enforced due to several reasons:

- Almost all countries have weak agricultural institutions and control and advice is lacking
- All large countries with predominant rural patterns show disperse agricultural activities that are difficult to control
- lack of awareness of farmers (Egypt)
- severe water scarcity, which force farmers to use effluents (Yemen)

This means that wastewater reuse is common in almost all Arab countries, also for crops that are excluded by law. The situation shows the huge gap between set regulations and the reality.
The reuse in industry is hardly known, but ongoing efforts in the field of Cleaner Production revealed high reuse and water saving potentials. These potentials often remain unexploited, as the water price is still low and payback for reuse investments are too long.

	Type of Reuse
Egypt	Agriculture (direct forage and trees, indirect vegetables)
Jordan	Agriculture (direct forage and trees, indirect vegetables), Greywater reuse
Lebanon	Agriculture (limited)
Morocco	Research and Pilot
Westbank	Agriculture and Greywater reuse
Syria	Agriculture - all crops
Tunisia	Irrigation of green areas, Agriculture, Wetlands
Yemen	Agriculture - all crops
UEA	Green space irrigation

Jordan developed a more pragmatic approach to meet the reality on the ground. It allows the reuse of WWTP effluent for vegetables in case it is diluted with rainwater and the irrigation water meets the irrigation water quality standards. This means, that the water quality at the point of use is relevant and not the effluent quality of the WWTP. This approach is closer to the stipulations of the new *WHO guidelines for the safe use of wastewater, excreta and greywater (2006)*

Abu Dhabi is the only city with a reuse strategy for green space irrigation. Tunisia has a special regulation for the reuse of wastewater on golf courses, which can also be considered as green space.

Country	Type of Reuse	Irrigation Techniques
Egypt	Reuse is currently limited to agriculture. But, two types of wastewater reuse can be distinguished: • Direct reuse of treated wastewater (forests and soil protection projects in the dessert). • Indirect and uncontrolled reuse of wastewater which is discharged into agricultural drainage canals and blended with irrigation water/ surface water.	In Egypt, flood irrigation and sprinkler irrigation are the predominant irrigation techniques. Consequently, the irrigation efficiency is medium and the crops get in direct contact with the irrigation water. Considering the hardly controlled quality of irrigation water, some health concerns remain in case of vegetables eaten raw.
Jordan	According to law, only non-edible crops are allowed to grow on reclaimed water. However, this is only controlled in the vicinity of WWTPs. As-Samra WWTP effluent drains into the Zarqa River and later	In most areas, mulch and drip irrigation is used for irrigation. Therefore, the produce does not get in contact with the reclaimed water. Farmers in the Jordan Valley are aware of the nutrient contents

Country	Type of Reuse	Irrigation Techniques
	into King Talal Reservoir. The effluent is diluted with rainwater and the quality allows the irrigation of vegetables as well. Almost 2/3 of the area in the Jordan Valley is irrigated with diluted reclaimed water. (middle and south JV) The WWTP in Wadi Musa provides irrigation water to extended areas for forage crops. Most of the remaining WWTPs irrigate fruit trees and forage crops on their own premises or on farms in the vicinity.	in reclaimed water and could reduce the fertilizer application by up to 60 % resulting in significant financial savings.
Lebanon	Lebanon drafted minimum standards for water quality and regulation of wastewater discharge. However the lawas and regulation are hardly enforced. In the Beqaa valley, farmers use raw wastewater for irrigation. Due to the political situation, it is not known which area is irrigated with this water and what crops are grown. Farmers opposed a planned WWTP, as they fear they would not get the water after treatment.	More and more farmers switch to irrigated agriculture as precipitation has dropped in previous years and more yield can be achieved. The gravity irrigation system is the least effective irrigation system, causing significant losses of water.
Morocco	Reuse has been limited to research and pilot projects. The acceptance of TWW for irrigation is limited and reuse is only practiced in areas where water scarcity is threatening agricultural production. First reuse projects focus on forestry, flower production and the rehabilitation of the palmerai oasis in Marrakech. First groundwater recharge projects are in preparation. A bilateral project plans to increase wastewater reuse to	Irrigation water is heavily subsidized resulting in a high water consumption and inefficient use of water. Most areas are irrigated by gravity irrigation or sprinkler irrigation.
Syria	Wastewater reuse has a long history in Syria and therefore is widely accepted. Despite strict reuse quality standards for WWTP effluents all available wastewater is reused regardless of the quality or crop types.	Currently, about 3 % of wastewater (treated or untreated) is reused in agriculture. However, studies show that potentially 20 % of freshwater could be substituted by treated wastewater.The irrigation technology in Syria is outdated adding to the severe water stress in the country. Therefore, the major saving potential for freshwater lays in an improvement/ modernisation of the irrigation system (reduction by 37 %).
Tunisia	Wastewater reuse: 57 Mm^3 (23 %) • 39 Mm^3 reused in irrigation • 18 Mm^3 disposed into wetlands and rivers Wastewater reuse is mainly applied in agriculture (22 Mm^3) but also golfcourses (10 Mm^3) and green spaces (7 Mm^3) are inclreasingly irrigated with WWT effluent.	In Tunisia most farmers use gravity irrigation and sprinkler irrigation. This practice limits the use of TWW as the contact between crop and water cannot be prevented.

Country	Type of Reuse	Irrigation Techniques
	Treated wastewater is not allowed for irrigation of fresh fruits and vegetables. Therefore, as these crops generate best profits, farmers have limited interest in using TWW.	
Yemen	Wastewater – either treated or untreated – is used in agriculture without any restriction. Wastewater reuse is mostly limited to the vicinity of the WWTP, as farmers either abstract water directly from stabilization ponds or from wadis downstream of the WWTP. No experience exist if treated wastewater can be used for the irrigation of the two main crops, namely cotton and qat.	Irrigation is traditionally gravity and flood irrigation, allowing direct contact between irrigation water and crop.
UAE	Abu Dhabi reuses almost all WWTP effluent for green space irrigation and sludge is reused in land reclamation and greenery.	

6. **Economic and financial aspects**

All assessed countries lack finances for a sustainable operation and maintenance of their wastewater treatment systems. If water tariffs exist, they hardly reflect the costs for wastewater treatment, thus resulting in continuously deteriorating treatment facilities. Several countries requested international funds for the rehabilitation of treatment systems not older than 10-20 years. Such huge investments could be redirected into new systems in case the existing systems are better managed by skilled and motivated (well paid) staff.
Due to the bad reputation of TWW farmers are reluctant or unwilling to pay for the irrigation water. In several countries (Syria, Lebanon, Yemen) farmers get the water for free. Other countries like Jordan and Tunisia charge farmers but at very low tariffs which do not cover the actual costs.
Furthermore, the low water tariffs do not give incentive for water saving measures in all sectors. Particularly in-house recycling technologies are financially not attractive for investors due to low water tariffs. Furthermore, the governments hesitate to impose more water saving regulations on new tourist and housing projects as they fear to loose potential investors. This approach puts another long term stress on the existing scarce water resources.

Country	Treatment Costs	Financing investments and tariff structures
Egypt	Only little information on treatment costs in Egypt are available, however it is obvious that water tariffs are too low to cover the treatment costs. Farmers do not pay for irrigation water by quantity but pay taxes charged on their farmland.	No information available
Jordan	Specific costs for wastewater treatment vary significantly between 3.9 and 680 fils/ m3 influent. The cost strongly is determined by the treatment technology: - Pond systems or aerated pond systems like in Wadi Es Sir, old As- Samra Ponds or Madaba have specific costs between 3.9 fils/ m3 and 100 fils/m3. - Activated Sludge systems have average treatment costs of 90 to 180 fils/ m3. - More sophisticated systems (e.g. combined technologies and trickling filters) have specific treatment costs from 180 up to 700 fils/ m3.	Jordans water tariff includes a wastewater levy which is based on the freshwater consumption. However, this is not sufficient to cover even the O&M cost of Wastewater Treatment. (systems are slowly deteriorating) Farmers are charged differently depending on the scheme they are connected. Some pay per m^3 consumed (JV) others have an allocated amount of water and pay a lump sum. However, the fee is little or nothing for reclaimed water, as it is considered as a bad alternative to freshwater. (particularly in the Jordan Valley) On the other hand, water is not wasted as it is too little anyway.
Lebanon	No information available.	Several plans and studies have been elaborated on the upgrading of wastewater management. Main focus is on main sewer connectors along the coastline. Furthermore, the Ministry of Water and Environment identified about 20 locations for WWTP inland in smaller towns. (further plans for 13 rural decentralized systems are available as well) Financing is realized mainly by international funds (soft loans and grants). All relevant

Country	Treatment Costs	Financing investments and tariff structures
		development and financing organizations are involved. Irrigation water is mainly charged with a flat rate based on irrigated area. Only the Litany River Authority meters irrigation water and charged accordingly.
Morocco	The treatment costs are comparable with other systems. The water tariffs are too low to cover O&M costs of the existing system, leading again to a fast deterioration of the schemes. As the bulk of wastewater is generated in the costal areas, reuse projects require a thorough planning as effluent conveyance systems to agricultural areas inland might cause very high costs (infrastructure and pumping)	ONEP has launched a huge investment programme for wastewater treatment. Reuse is currently not considered in this programme. Furthermore, the institutional responsibilities are not clear with regard to the management of the effluents and therefore, no organization is pursuing the concept.
Syria	The Ministry of Housing and Construction together with the Ministry of Finance and international financial cooperations are responsible for the investment in sewerage networks and WWTP. The Ministry of Irrigation set up a national fund for improvement of irrigation equipment in order to increase the irrigation efficiency.	Tariffs for sanitation do not exist but a share of the (low) water tariffs is diverted to the O&M of WWTP. This leads to a continuous deterioration of existing schemes. The current irrigation tariff is not volume related, but set according to the arable area or licences for drilling wells. Huge investments are under way or planned for 45 new WWTP in Syria (14 started operation in 2009) The government of Syria has established a credit fund for new irrigation technology. Furthermore, there is a plan to relocate industries to assigned areas, which will have adequate WWTP for industrial effluents.
Tunisia	The water tariffs do not cover the O&M costs of WWTP but costs are covered by the governmental sources. This leads to a continuous deterioration of the system and mediocre effluent quality. WWTP effluent is provided free of charge (from the outlet) to golf courses to encourage owners to replace freshwater with TWW.	New investments are planned by the government. As most water is generated in the coastal areas in the north, but water is required in the south, large conveyance projects are required.
Yemen	No information available on treatment costs. However, it is clear that the set tariffs do not cover O&M costs of the WWTP. Systems are deteriorating continuously due to neglect by staff and lack of spareparts.	Several new investments in wastewater treatment schemes and further sewer connections are planned. However, the government faces severe problems with regard to land tenure and resistance of neighbours. This problem has brought several extension projects and new projects to a standstill. Funding is provided mainly by foreign development agencies.
UAE	No information available	**Abu Dhabi:** Several new investments in sewerage and irrigation infrastructure are planned in Abu Dhabi. The investment plan is

Country	Treatment Costs	Financing investments and tariff structures
		currently under revision and no detailed information is available. The government is financing most of this investment from national funds. Dubai: New investments in an upgrade of the existing WWTP and a new WWTP is planned.

7. Safety Control and Risk Management

Safety control means a frequent control and monitoring of wastewater effluent and the implementation of corrective measures in case values do not meet the required irrigation water quality. Most assessed countries have laws for a safety control system, however did not implement it due to lack of funds and equipment or lack of skills. Mostly the press reveals severe violations with regard of illegal use or discharge of wastewater (e.g. Dubai or Jordan in the 90ies.)

Risk management means a more comprehensive approach considering the latest *"WHO Guidelines for the Safe Use of Wastewater Excreta and Greywater"* It considers the health implications of the relation between microbiological load and exposure. Meaning that water quality alone does not only determine the reuse option but also the protection measures are relevant. (e.g. irrigation with treated wastewater could be safe and feasible for vegetables, in case it is done with a drip irrigation under mulch).
Risk management also means the definition of clear roles and responsibilities of actors like ministries, authorities and monitoring agencies. Jordan just finalised the process of setting up a concept for Risk Management for irrigated crops. Ten organizations were involved and clarified their roles and responsibilities. This will lead to more efficient and effective monitoring as well as immediate action in case of violation.

Country	Safety Control	Risk Management
Egypt	Monitoring of TWW quality is limited and no corrective measures are known. The strict reuse regulations are meant to prevent any risk of contamination, however this applies only in case of direct reuse in governmental schemes and not for the effluent discharge and subsequent reuse in canals and the river Nile.	No Risk Management system is in place.
Jordan	Jordan has implemented a Crop Monitoring Programme for Fresh Fruits and Vegetables Produced in the Jordan Valley. The Jordan Food and Drug Administration is responsible for sampling, analysis and evaluation. Results show that the produce is safe. One reason is the modern irrigation technology with mulch and drip irrigation.	Many organizations have a stake in the quality control of wastewater effluent. Responsibilities are overlapping. Hence, a committee is currently reviewing tasks and responsibilities in order to clarify and document clear responsibilities and data exchange in routine work and cases of emergencies. Stakeholders are Water Authority of Jordan (WWTP), Jordan Valley Authority (Water Distribution), Ministry of Environment (Water Quality), Ministry of Agriculture (on-farm advice), Jordan Food and Drug Administration (Crop Monitoring)
Lebanon	Due to the lack of WWTP and the low relevance of wastewater reuse, no monitoring system or safety control system exists.	No Risk Management system is in place.
Morocco	ONEP does a general quality control of water resources, however nothing specific for wastewater reuse in place.	No Risk Management system is in place.
Syria	The Ministry of Environment is responsible for quality monitoring of water bodies. Irrigation water is monitored as well, however no	No risk management system is in place.

Country	Safety Control	Risk Management
	corrective measures are taken in case of pollution.	
Tunisia	WWTP effluent quality is monitored, but as most WWTP do not meet the national standards, enforcement and corrective measures are limited.	No explicit risk management system is in place, but responsibilities for quality management, public health are clear within governmental bodies.
Yemen	Some quality parameters for WWTP effluent are monitored. It is known that all systems do not meet the reuquirements, but due to lack of funds corrective measures are impossible.	No risk management system exists.
UAE	Abu Dhabi is frequently monitoring the effluent quality as water is distributed for green space irrigation purposes. No information available for Dubai.	No information available about risk management systems.

References

Abu Dhabi Sewerage Service Company, Annual Report 2007. http://www.adssc.ae

ACWUA (2009): Country Case Study on Water Reuse in Jordan. Compiled by Nayef Seder, Ahmad Uleimat and Silke Rothenberger. www.acwua.org

ACWUA (2009): Country Case Study on Water Reuse in Yemen. Compiled by Silke Rothenberger. www.acwua.org

AHT/ EIB/ FEMIP (2009): Identification and Removal of Bottlenecks for Extended Use of Wastewater for Irrigation and for other Purposes. Country Report for Egypt: http://www.aht-group.com/ww-reuse/index.php?id=4

AHT/ EIB/ FEMIP (2009): Identification and Removal of Bottlenecks for Extended Use of Wastewater for Irrigation and for other Purposes. Country Report for Morocco: http://www.aht-group.com/ww-reuse/index.php?id=4

AHT/ EIB/ FEMIP (2009): Identification and Removal of Bottlenecks for Extended Use of Wastewater for Irrigation and for other Purposes. Country Reports for Tunisia: http://www.aht-group.com/ww-reuse/index.php?id=4

AHT/ EIB/ FEMIP (2009): Identification and Removal of Bottlenecks for Extended Use of Wastewater for Irrigation and for other Purposes. Country Reports for Lebanon. http://www.aht-group.com/ww-reuse/index.php?id=4

AHT/ EIB/ FEMIP (2009): Identification and Removal of Bottlenecks for Extended Use of Wastewater for Irrigation and for other Purposes. Country Reports for Syria. http://www.aht-group.com/ww-reuse/index.php?id=4

AHT/ EIB/ FEMIP (2009): Identification and Removal of Bottlenecks for Extended Use of Wastewater for Irrigation and for other Purposes. Summary Report: http://www.aht-group.com/ww-reuse/index.php?id=4

BBC News, Dubai (2008): Raw sewerage threat to booming Dubai. http://news.bbc.co.uk/2/hi/middle_east/7663883.stm

CIA World Fact Book: https://www.cia.gov/library/publications/the-world-factbook/geos/le.html

EU/ EMWater (2004): Prospects of Efficient Wastewater Management and Water Reuse in Lebanon.

Government of Yemen. (2005) National Water Sector Strategy and Investment Programme (NWSSIP 2005-2009) www.acwua.org

Ministry of Water & Enviornment, KfW. (2005) Feasibility Study for Effluent and Sludge Reuse in Aden, Amran, Hajjah, Ibb and Yarim. Volume 1 and 2

Ministry of Water & Environment, GTZ. (2009) Yemen Urban Water Supply and Sanitation Sector Reform.

Ministry of Water & Environment, World Bank, GTZ. (2007) Yemen's Water Sector Reform Program – A Poverty and Social Impact Analysis

Badroudy et.al. (2007) Managing Water Demand, Policies, Practices and lessons learned from the Middle East and North Africa Forums, IDRC/ IWA Publishing

DWA (2008) Assessment of Process Steps for the Treatment of Wastewater for Reuse, Germany

DWA (2008) Treatment steps for Wastewater Reuse (Arabic, Chinese, German and French), Germany

McIllwaine,S. Redwood, M. (2010): Greywater Reuse in the Middle East, technical, social, economic and policy issues.

SHO (2006) WHO guidelines for the safe use of wastewater, excreta and greywater. Volumes 1-4, Switzerland, download: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html