Facility for Euro-Mediterranean Investment and Partnership • Facility for Euro-Mediterranean Investment and Partnership

FEMIP

Identification and removal of bottlenecks for extended use of wastewater for irrigation or for other purposes

European Investment Bank

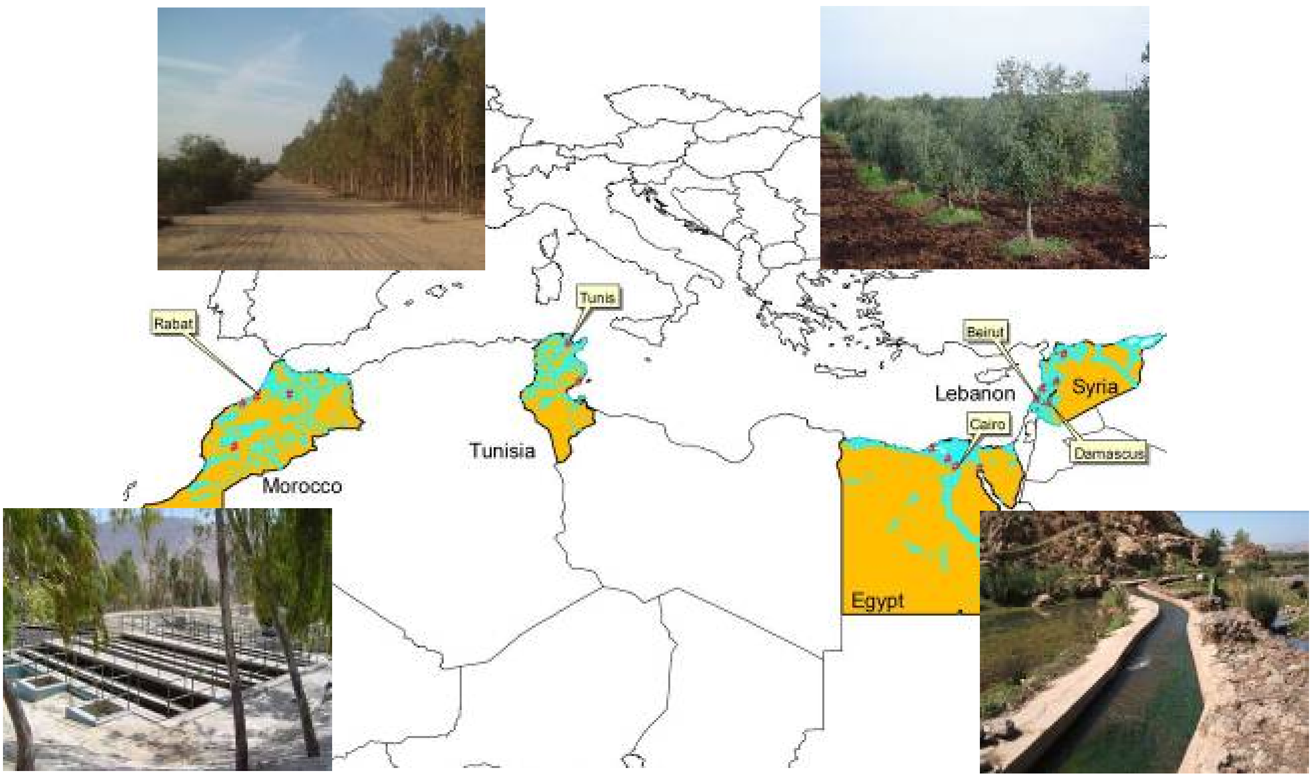
MEDA-Countries
(Egypt, Lebanon, Morocco, Syria and Tunisia)

Identification and Removal of Bottlenecks for extended Use of Wastewater for Irrigation or for other Purposes

RG/2008-01/FTF

SUMMARY REPORT

Brief Version



AHT GROUP AG
Management & Engineering

September 2009

The study is financed under the FEMIP Trust Fund. This Fund, which was established in 2004 and has been financed – to date – by 15 EU Member States and the European Commission, is intended to support the development of the private sector via the financing of studies and technical assistance measures and the provision of private equity.

Table of Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DWPC	Dynamic Water Production Costs
EIB	European Investment Bank
ELV	Emission Limit Value approach
EPA	(US) Environmental Protection Agency
FAO	Food and Agriculture Organisation of the UN
FYP	Five Year Plan
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
N	Nitrate
NGO	Non Governmental Organisation
O&M	Operation and Maintenance
P	Phosphate
PPP	Public Private Partnership
TWW	Treated Wastewater
UNEP	United Nations Environment Programme
UNESCO	UN Educational, Scientific and Cultural Organization
UV	Ultraviolet
WDM	Water Demand Management
WFD	Water Framework Directive
WHO	World Health Organisation
WQO	Water Quality Objective approach
WWR	Wastewater Reuse
WWTP	Wastewater Treatment Plant

Executive Summary

The extended reuse of reclaimed (treated) wastewater could contribute considerably to the reduction of ‘water stress’ and ‘water scarcity’ in arid and semi-arid countries as part of an Integrated Water Resources Management (IWRM) approach focusing on wastewater reuse for irrigation and other purposes.

In the target countries, agriculture is by far the main water consumer, accounting for about 80% of the total water supply in Tunisia and up to 90% in Syria. In terms of quantity, the greatest potential for wastewater reuse is through using properly treated wastewater for irrigation purposes, as substitute for conventional ground and surface water sources.

The reuse of reclaimed wastewater is complex. It is necessary to consider not only the relevant treatment infrastructure and applied treatment technology, but also other **key parameters** such as the quality of influents and the subsequent reuse options according to current quality standards as defined in the national legislation.

Wastewater Quality – Influents

The quality of wastewater produced and the origin of influents have an important impact on the achievable quality of effluents. Industrial wastewater is particularly problematic, being very diverse and often toxic, to a degree that disrupts biological treatment procedures. This is a typical problem of large urban agglomerations and should best be addressed by on-site pre-treatment facilities in the industrial plants concerned. For this, the industries will need technical and financial support, which could be provided for example by a ‘Decontamination Fund’.

Wastewater Treatment Facilities

The next parameter is the quality of effluents, which can be achieved by applying a particular treatment technology, together with the quantity produced. In most of the South Mediterranean countries, number and capacities of existing WWTPs are far from meeting the requirements. Most of the plants need extension, rehabilitation or upgrading, and in some cases, new facilities need to be constructed. This is the case in both urban and rural areas, even though potential solutions are different. In urban areas, emphasis has to be put on large, central WWTPs with more sophisticated technology, whereas in rural areas decentralised, low-tech and low-cost facilities are required, possibly promoted by means of a ‘Municipal Fund’.

Reuse Options

The potential reuse options depend mainly on water needs and quality requirements. There are two planning approaches: ‘Bottom-up’⇔‘Top-down’

The bottom-up approach defines the intended reuse options first and then the required treatment technologies, allowing the structured planning of future infrastructure within the context of a broader wastewater management master plan. If economically feasible, this approach offers the greatest variety of reuse options, tailored to the specific local conditions by integrating future end users in the planning process.

The top-down approach takes a starting point the available quality of existing treated wastewater and defines possible reuse options on that basis - a pragmatic approach taking into account the existing sanitation infrastructure. This approach, however, limits the potential reuse options considerably.

Location of Wastewater Production

Most of the target countries have a more or less elongated, densely populated coastal strip, with sufficient rainfall and limited agricultural activities. Wastewater reuse options in these areas are limited to landscape irrigation (e.g. for golf courses, hotel gardens, forest, green belts and similar), groundwater recharge (e.g. to combat saltwater intrusion and replenish over-exploited aquifers) and all types of industrial reuse.

Inland rural areas are often characterised by water scarcity and hence an urgent need for additional non-conventional water sources, in particular for agricultural irrigation. Since wastewater is generally generated in distant urban agglomerations, reuse for irrigation purposes in rural areas would require long-distance transportation networks, which might not always be economically feasible.

Consequently, two different investment approaches are needed, i.e. central WWTPs for urban agglomerations with restricted reuse potential, and decentralised WWTPs in rural areas, tailored to the respective demands by providing direct reuse for agricultural purposes.

Legal Aspects

The most relevant piece of international legislation, being accepted and implemented by all international key institutions in the sector, is the third edition of the 'WHO Guidelines for the Safe Use of Wastewater, Excreta and Grey Water in Agriculture and Aquaculture', published in 2006 by WHO jointly with FAO and UNEP. These guidelines are recommendations only, having no legal status under any jurisdiction. Governments can either adopt them as standards in their national legislation or simply refer to them as non-enforceable recommendation, giving authorities the flexibility to set health-based targets in line with what is realistic in the national socio-economic context.

Based on the **comparative sector analysis of the five target countries**, the following main bottlenecks and recommendations were identified for the successful and extended reuse/recycling of treated wastewater:

Bottlenecks

- The majority of South Mediterranean countries have no explicit national or government strategy (master plan) for the extended reuse of wastewater to efficiently address the local water scarcity/stress problems. The potential for TWW reuse is still underexploited. However, some countries are more advanced than others;
- Various site-specific parameters, leading to the fact that there is no 'one fits all' solution;
- Inadequate treatment facilities and capacities, resulting in insufficient water quantities of appropriate quality for reuse;
- Inadequate pre-treatment of industrial wastewaters, which are often directly discharged into the general sewerage systems and mixed with domestic wastewaters, thereby either limiting the reuse potential or exceeding the treatment capacity of the WWTPs;

- Limited cost recovery via water fees/tariffs and/or governmental subsidies for operation and maintenance of treatment facilities or reuse schemes; this has a negative effect on the performance of WWTPs and limits the reuse potential;
- Weak enforcement of existing legislation; insufficient quality control and monitoring;
- Partially fragmented institutional set-up, with limited coordination and cooperation, further aggravated by the lack of qualified staff and financial resources at different levels;
- Insufficient information on and knowledge of the overall water/groundwater regime to facilitate the design of appropriate solutions for aquifer recharge;
- Weak or non-existent organisation of the users of treated wastewater;
- Limited acceptance of products irrigated with TWW by the end consumer.

Removal of Bottlenecks

- Support of national and regional governments in the development of master plans for the reuse of reclaimed wastewater (including technical, institutional, legislative, social, economic, financial and management aspects) via technical assistance;
- Provision of loans/grants for sanitation and treatment infrastructure in urban areas;
- Mobilisation of funds for municipalities to finance decentralised low-tech and low-cost treatment facilities with adjacent reuse schemes in rural areas;
- Support of industries, e.g. by setting up a decontamination fund for financing on-site treatment/pre-treatment facilities for internal recycling of water and for reducing the polluting load of their effluents; also, application of the ‘polluter pays’ principle;
- Strengthening of institutions involved at all levels – capacity development and technical assistance;
- Support for the development of cost-recovering water tariff systems in the water supply, sanitation and irrigation sector, perhaps involving governmental subsidies and private contributions (PPP);
- Financing of hydrogeological studies to design appropriate reuse schemes for groundwater recharge;
- Support for the set-up of water user associations.

In principle, technical solutions are available but need to be adapted to the specific local conditions. Bigger challenges are the ‘political’ and ‘organisational’ bottlenecks, which require capacity building at different levels (ministries, agencies, water utilities etc.) and public awareness campaigns.

1 Rationale

Water resources on a worldwide scale are limited and threatened by anthropological influences such as overexploitation. The situation is exacerbated by strong population growth in certain countries of the South. Furthermore, water resources are unevenly distributed, leading to dramatic regional and local **water shortages**. The problems are often reinforced by surface and groundwater pollution and by unsustainable water resources management.

According to the prognoses given in the World Water Report (UNESCO, 2006) as to existing consumption habits, some seven billion people in 60 countries will experience water shortages by the middle of the current century. This figure is based on the most unfavourable extrapolation. In the best-case scenario, there would still be at least two billion people in 48 countries short of water. Experts on the Intergovernmental Panel on Climate Change (IPCC, 2007) forecast a further aggravation of the global water shortage due to the effects of world **climate change**.

Water availability per capita in countries of the North is on average 58% higher than in countries in the South, but water intensity use is similar in both groups. The situation is particularly dramatic in the Middle East and North Africa, where only about 12% of the European water resources are available and **negative water balances** are predicted countrywide for the next 15 to 20 years.

In many South Mediterranean countries, local and regional water scarcity is already leading to a depletion of groundwater resources through overexploitation. In those areas, the reuse of non-treated or insufficiently treated wastewater dominates agricultural irrigation. This water is available free of charge, is not affected by dry periods and has a high value as fertiliser. **Agricultural irrigation** - by far the biggest water consumer in the South Mediterranean countries – offers the greatest potential for implementation of wastewater reuse schemes. Although legal constraints (crop restrictions) and quality standards often exist, in practice the reuse of water is largely uncontrolled and does not comply with minimum hygiene requirements.

Controlled and **safe reuse** of reclaimed and treated wastewater can help to improve agricultural production. Its economic advantages in the agricultural sector lie in contributing to local food security, mitigating effects of climate change, expanding irrigated areas and the range of cultivable crops, saving fertilizer, increasing yields and thus improving the economic situation of the farmers. This in turn leads to higher production, more employment and less rural exodus. Prevention of current unsafe wastewater reuse practices would improve the public health situation by reducing the level of waterborne diseases.

However, water resources are unevenly distributed among the South Mediterranean countries. There is often sufficient rainfall in the densely populated coastal strips and inherent water scarcity inland, where most of the agricultural production is located. The urgent need for additional (non-conventional) water resources is the most decisive driving factor for the reuse of treated wastewater. This disparity can be resolved either by **transfer** of TWW from the big agglomerations to the agricultural areas or by **alternative reuse options** such as groundwater recharge and industrial reuse or simple discharge of treated wastewater in order to fight environmental pollution.

Other options for **substituting TWW for scarce fresh water resources** are landscape irrigation, e.g. sport facilities like golf courses, hotel premises, public parks/forests and greenbelts, as well as groundwater recharge and industrial reuse.

The **potential** for **safe wastewater reclamation** and reuse is currently far from being fully exploited in the South Mediterranean region. With regard to the amount of treated wastewater reused per capita, Qatar ranks highest with 170,323 m^3/day per million capita, followed by Israel with 166,230 and Kuwait with 163,330. Syria ranks ninth worldwide with 55,109 m^3/day per million capita, Tunisia 11^{th} with 51,233, Egypt 15^{th} with 26,301, Morocco 32^{nd} with 3,358 and Lebanon 39^{th} with 1,528.

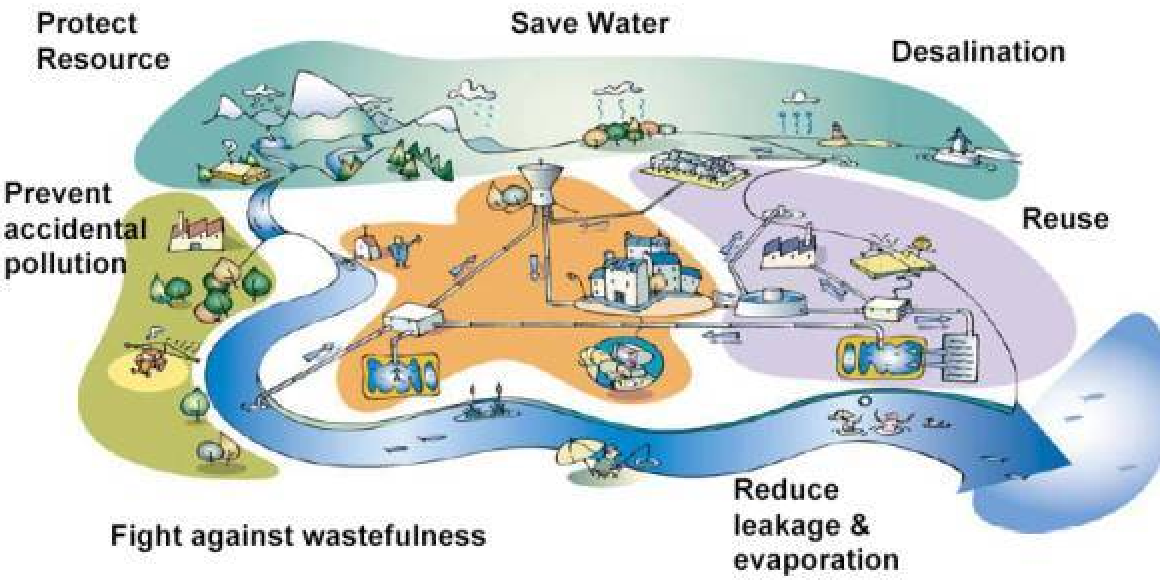
The **objective** of this study is to identify both the **driving forces** and **bottlenecks** for wastewater reuse on a broader scale, in order to contribute to the creation of favourable circumstances. These may already exist or may have to be created to allow the implementation of investment projects aimed at the mitigation of the water problems faced by the five target countries.

In order to better understand the five country analyses, this document will first present a general description of wastewater reuse options in different sectors, the technical preconditions for safe application and the institutional, economic and socio-cultural framework conditions needed for the successful implementation of wastewater reuse schemes.

2 Wastewater Reuse as Part of IWRM

Integrated water resources management (IWRM) is a fundamental approach to address current and future water problems, taking into account available quantities of water and their levels of pollution.

Figure 1: General water regime



The water cycle has to be seen as a whole, including both surface and groundwater resources, in order to develop appropriate measures for fighting pollution and reducing overexploitation. The vision of comprehensive water cycle management includes the recycling of parts of the water streams for different purposes. The reuse of reclaimed wastewater should always be considered as part of an **Integrated Water Resources Management** (IWRM) plan.

2.1 Technical Options

2.1.1 Planning Approach

The multiple use of parts of the water stream requires tailor-made wastewater treatment technologies, which can be planned by applying two different approaches:
'Bottom-up'⇔'Top-down'.

The **bottom-up** approach defines the intended reuse options first and then the required treatment technologies, representing the basis for the structured planning of **future infrastructure** within the context of a broader wastewater management master plan. If economically feasible, this approach offers the greatest variety of reuse options tailored to the specific local conditions.

The **top-down** approach considers first the available quality of existing treated wastewater and defines then possible reuse options on that basis. It is a pragmatic approach taking into account the **existing infrastructure.** This situation applies to most of the countries where the existing infrastructure (with its probable shortcomings) limits the potential reuse options.

Annex 1 presents an example of a stepwise (bottom-up) planning approach for typical wastewater reuse schemes.

2.1.2 Types of Wastewater

The more heavily and diversely contaminated the influents into a wastewater treatment facility, the more technically sophisticated and financially demanding the required technology has to be. It may even make any subsequent reuse impracticable.

A particular problem in most of the South Mediterranean countries is **industrial wastewater**, often discharged untreated into nearby recipients, despite being toxic. Biological (activated sludge) processes can react very sensitively to certain toxic substances, such as persistent organic pollutants or heavy metals. In some cases, parts of the microbiological fauna may even die off. This problem has to be addressed down at the industrial site level, by enforcing existing laws on compulsory on-site pre-treatment of wastewater and by providing financial and technical support to the most polluting industries to establish cleaner production processes.

The major potential source for water reclamation is **municipal wastewater**, which consists mainly of domestic wastewater containing hygienically critical human excreta.

One of the safest sources for water reclamation is the so-called '**grey water**', a part of domestic wastewater collected separately from bathroom showers, sinks, kitchen use and all kinds of washing procedures – except for toilets - and hence not containing hygienically critical human excreta.

Storm and drainage water can also be reclaimed quite safely, depending on the actual source (in the case of drainage water) and on the collection and storage method which could influence its quality.

A crucial prerequisite for the reuse of grey and storm water are separate collection and distribution facilities/systems (such as separate pipes and sewers), which are normally not available in the target countries and which could represent an important cost factor.

2.1.3 Treatment Technologies

The different qualities of wastewater influents and resulting reuse options call for different treatment technologies if they are to be a safe source for wastewater reclamation. The available technological options are varying with respect to their purification/decontamination potential, their respective costs (investments and operation and maintenance) and the need for qualified personnel for operation and quality monitoring. The more efficient a technology is, the more demanding it is with respect to qualified personal.

Wastewater – depending on its origin and treatment – is a potential source of harmful contamination with pathogens, heavy metals and a variety of organic chemical substances. There are important health risks associated with the use of wastewater, such as gastro-intestinal infections caused by viruses, bacteria, protozoan and metazoan parasites. To reduce the risks to human health and the environment to a minimum, the following **treatment options** are currently applied under different circumstances:

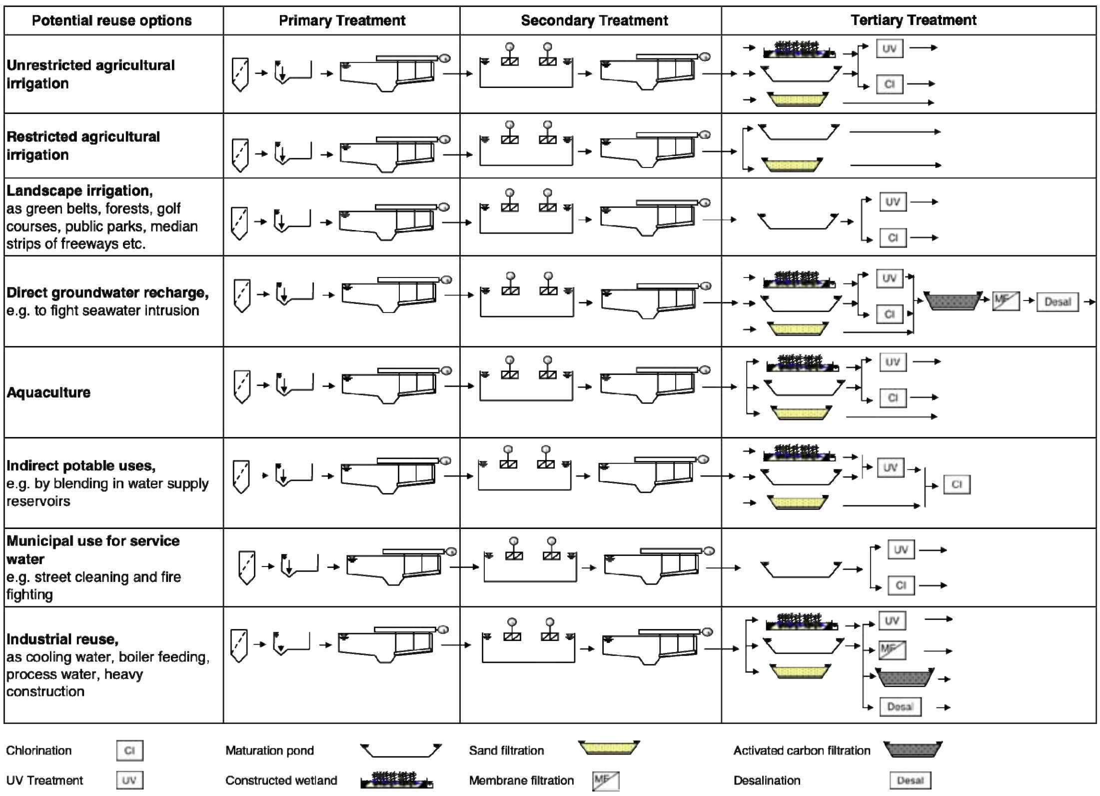
Mainly in ***rural areas*** and/or small settlements without any important industrial activity:

- **Lagoons** or pond systems, leading to sedimentation and partial biological degradation, occasionally followed by chlorination for (restricted) irrigation use: typically used in Mediterranean countries with moderate treatment facilities;
- **Constructed wetlands**, wastewater treatment in a planted filter bed, mainly for smaller treatment plants; removal of organic load and partial removal of pathogens and nutrients: used in Northern Europe (The Netherlands) and Southern Europe (Spain);

In densely populated **urban areas**, which require large central treatment facilities (WWTPs):

- **WWTP Primary treatment**, including mechanical screening and sedimentation: removal of particles and grease, solubilisation of constituents; often applied in coastal towns where wastewater is disposed via sea outfalls;
- **WWTP Secondary treatment**, removal of BOD, COD, N and P by activated sludge or fixed bed technology: only partially operational in South Mediterranean countries;
- **WWTP Tertiary treatment**, advanced treatment processes for removal of nutrients and salts or suspended solids, e.g. additional maturation ponds, sand filtration, different kinds of membrane filtrations (surface, micro, ultra, nano), flocculation/precipitation, ion exchange, reverse osmosis;
- **Disinfection**, e.g. by ozone, chlorine dioxide, chlorine gas, and UV radiation.

Figure 2: Example of a treatment matrix for reuse



Note: This figure has been adapted, based on the source AQUAREC, Deliverable D17, May 2006.

The matrix provides an overview of possible treatment technologies for an intended reuse of treated wastewater. Since the efficiency of treatment technology is highly dependent on the quality of operation and maintenance as well as on the quality of influents, its final appropriateness has to be verified and monitored for each reuse option by **analysing the crucial parameters** according to current **national quality standards**.

Secondary treatment (partially in lagoons and constructed wetlands) can be considered as a sufficient basis for subsequent reuse of treated wastewater, provided that industrial influents to the WWTP are very limited. However, even for restricted irrigation, some kind of additional tertiary treatment will be necessary, e.g., disinfection and maturation to reduce pathogens and/or sand filtration in the case of intended drip irrigation.

Although some nutrient content is beneficial to agricultural reuse, elevated salt contents in treated wastewater represent a particular problem leading to **salinisation of soils** and **yield reductions**. Salt content reduction in treated wastewater can best be addressed by influent control. Efficient desalination of wastewater requires expensive high-tech methods.

For other reuse options, such as direct groundwater recharge and specific industrial reuse, quality requirements are even higher, especially with regard to salts/nutrients, which have to be removed by **tertiary** chemical **treatment** (e.g. ion exchange and flocculation/precipitation) and/or tertiary physical treatment (e.g. all kinds of filtrations, including reverse osmosis). These types of tertiary treatment are very costly and need expensive high-tech equipment, large quantities of consumables/auxiliary chemicals and high energy supply.

2.1.4 Reuse Options

At present the most promising reuse options in South Mediterranean countries are the use treated wastewater for restricted agricultural and landscape irrigation and - to some extent - indirect groundwater recharge and specific industrial recycling.

In the arid and semi-arid countries of the Middle East and North Africa, **agriculture** is by far the **main water consumer,** accounting for almost 80% of the total water supply in Tunisia and up to 90% in Syria. The **greatest potential** for wastewater reuse, in quantitative terms, is the use of properly treated wastewater for irrigation purposes as substitute for conventional ground and surface water sources.

Agricultural Irrigation

Wastewater reuse for agricultural irrigation involves three major challenges:

1. **Quality requirements**, to limit all kinds of negative impact on human health and the environment/water cycle. This would necessitate appropriate treatment of water to be reused and the application of safe irrigation techniques.
2. **Seasonal demand:** wastewater is produced constantly, but irrigation is only needed seasonally, thus intermediate storage facilities would be required.
3. **Location of production**; the greatest amount of wastewater is generated in large agglomerations/cities, whereas agricultural areas are mostly located in rural areas. Consequently, long-distance transportation networks and pumping would be needed.

The technical and economic feasibility has to be studied for every specific location, especially when larger infrastructure such as storage reservoirs and long-distance transportation networks with pumps are involved.

With respect to the irrigation of crops intended for direct human consumption, the application of reclaimed wastewater in South Mediterranean countries should be restricted to:

- crops that are not grown on or under the soil and therefore not directly exposed to potentially harmful wastewater, e.g. trees, as in orchards.
- crops that are eaten cooked or processed in a way that reduces hygienic risks.
- non-food crops and/or industrial crops, e.g. for biofuel.

Besides **wastewater treatment,** engineering practices for the safe reuse of wastewater include appropriate **irrigation methods and techniques**, which can further reduce any potential health risks.

Sub-surface and **drip irrigation** can provide the highest degree of health protection, as well as using water more efficiently and often producing higher crop yields. However, highly reliable wastewater treatment (e.g. additional tertiary treatment by sand filtration) is required to prevent the clogging of emitters.

In addition to the risks for humans, potential risks for the environment should be considered and properly addressed. High levels of salts and nutrients (N and P) and other potential contaminants in irrigated soils pose a threat to groundwater aquifers and surface waters. These risks of salinisation, eutrophication and contamination (heavy metals and organic pollutants) can be mitigated or even prevented by an appropriate monitoring system. This needs to regulate and restrict the application of reclaimed wastewater to an affordable extent and to deal with adequate drainage of soils and leaching fractions in the irrigation dose.

Landscape Irrigation / Environmental Irrigation

The term landscape irrigation means irrigation of surfaces not used for direct agricultural cultivation, such as green belts, public parks/gardens, forestry plantations and median strips in avenues and highways, together with sport facilities (e.g. golf courses) and hotel gardens.

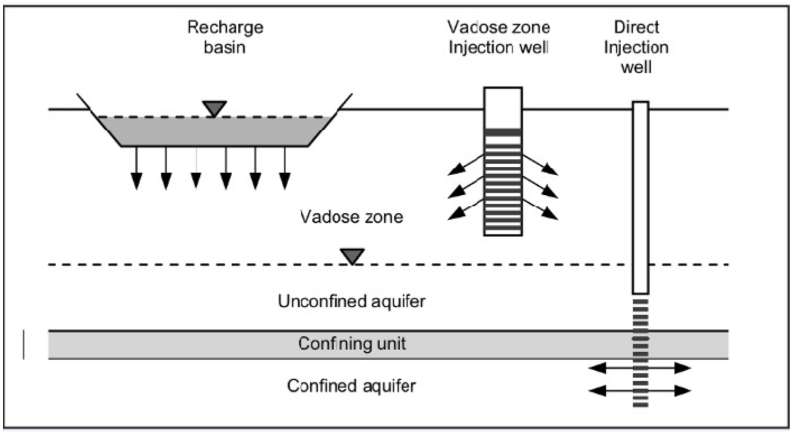
In Egypt, the reuse of treated wastewater is currently limited to **governmental schemes** such as the establishment of forests in the desert and green belts around Cairo. In the future it is planned to attract private investors, e.g. for the cultivation of industrial crops such as jatropha and others.

Private investors in the tourist sector are already using and paying for treated wastewater to irrigate e.g. their golf courses and hotel gardens. In Morocco, following a royal decree, the reuse of treated wastewater has now become a standard for the irrigation of golf courses

Groundwater Recharge

Groundwater recharge intends to preserve groundwater levels, prevent land subsidence, protect coastal aquifers against saltwater intrusion, and store reclaimed wastewater and surface runoff for future use (called aquifer storage and recovery). Recharge methods commonly used include surface spreading in basins, direct injection into groundwater aquifers and riverbank infiltration.

Figure 3: Types of groundwater recharge



The vadose zone, also termed 'the unsaturated zone', is the layer of earth between the land surface and the phreatic zone or zone of saturation. It extends from the top of the ground surface to the water table. Groundwater recharge, as an important process that refills aquifers, generally occurs through the vadose zone from precipitation.

Groundwater recharge is a particularly sensitive practice, requiring high quality treatment and thorough infiltration solutions for reclaimed wastewater to avoid negative impacts on soil and groundwater through high nutrient levels, salts, pathogens, or chemical contaminants such as heavy metals. More information on required quality standards is presented in the Draft California Regulations for Groundwater Recharge into Potable Aquifers[1].

A further indispensable prerequisite for the planning of efficient and safe groundwater recharge options is an **in-depth knowledge of the overall hydrogeological system** to design the required recharge systems in terms of quantity and quality.

Recycling for Industrial Use

Water used for industrial purposes has different quality requirements than drinking water. Therefore, much of the industrial wastewater generated can be used again in the same location (usually referred to as recycling) or collected from one or more utilities that generate wastewater for use elsewhere (referred to as reuse). By using water several times, industries can increase the productivity of each litre of water used in the production process, thereby lessening the need to mobilise new water supplies and hence conserving water resources.

[1] http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Recharge/DraftRechargeReg2008.pdf

Wastewater is increasingly used by the industrial sector to supplement or replace freshwater. Industrial reuse has a dual advantage: a generally continuous demand and the ability to utilise wastewater that has undergone secondary treatment. The major factors that influence industrial wastewater reuse include the availability and reliability of the water source, the industry's discharge requirements, and the required water quality and quantity. Membrane technologies (ultra filtration and reverse osmosis) are being more and more used, opening up the possibility of producing high quality water from conventionally treated wastewater.

Taking into account the diversity of the industrial sector and the resulting diversity of wastewater qualities produced, recycling for industrial reuse consists primarily of individually designed solutions for the specific industries concerned. Major uses in industry include cooling system augmentation and (once through cooling systems) process water, boiler feed water, wash down water and miscellaneous applications such as fire protection and dust control.

Although industry-specific pre-treatment of wastewater is mandatory in all the countries concerned, it is often enforced to a limited extent only. The recycling and reuse of industrial wastewater results in the containment of polluted waters, preventing the pollution of municipal wastewater and making it more easily reusable.

More specific information on the reuse of cooling water/boiler make-up water and the reuse options in some selected industries (pulp and paper, chemical, textile, petroleum and coal industries) are given in the 'Guidelines for Water Reuse' of the U.S. Environmental Protection Agency (EPA, September 2004)[2]. The Australian NSW (North South Wales) Food Authority has set out 'water reuse guidelines' for food businesses in NSW considering reusing water (May 2008)[3], stating that 'any reuse of water must be limited to industrial wastewater originating from a food production process'.

2.1.5 Location of Wastewater Production and Demand

Water stress and water scarcity are very unevenly distributed among (and even inside) the South Mediterranean countries. This also applies to the sites where wastewater is generated and where the demand for water is.

Most of the target countries have a more or less elongated, densely populated coastal strip often with sufficient rainfall and limited agricultural activities. Direct potential wastewater reuse options are limited to either landscape irrigation (e.g. for golf courses and hotel gardens, forest, green belts and similar), groundwater recharge (e.g. for combating saltwater intrusion and replenishing over-pumped aquifers) and all kinds of individual industrial reuse. In and around urban areas, irrigation of profitable vegetables using TWW is generally forbidden due to crop restrictions. The demand for TWW is therefore low in these areas.

---

2 http://www.epa.gov/nrmrl/pubs/625r04108/625r04108.pdf

3 http://www.foodauthority.nsw.gov.au/_Documents/industry_pdf/water-reuse-guidelines.pdf

The inland rural areas are often affected by water shortage and are therefore in need of additional water sources for agricultural irrigation. As the greatest amount of wastewater is generated in urban agglomerations/cities, reuse for irrigation often requires long-distance transportation networks. Subsequently high investments and high operation and maintenance costs for water pumping are required.

2.2 Economic Aspects

Economic aspects of wastewater reuse projects depend on the specific local/regional framework conditions and can differ considerably even within one country. The most decisive factors are the availability of water resources, their accessibility, the distance between the production and reuse of TWW and the availability of treatment facilities. Other major factors include the general infrastructure, climatic conditions, agricultural production, other economic sectors (such as industry, tourism etc.), institutional landscape (governmental, private), policy and strategy in the water sector, enforcement of legislation, general income level of the population/farmers, existing water tariff structures and/or governmental subsidies.

In agriculture – at present the major sector for reuse of reclaimed wastewater – one of the fundamental obstacles for the sustainable financing of wastewater reuse schemes is that irrigation water provided from public schemes is either free or underpriced. Free or cheap water for farmers is an ingrained habit, and in many countries, it is considered a necessity for achieving the objectives of cheap food production and food self-sufficiency. Such policies have a strong emotional and political appeal, but the ongoing highly subsidised provision of cheap water makes it extremely difficult to introduce market prices for fresh water. It is even more difficult to do so for reclaimed wastewater.

The following figure gives a comparative overview of spatial requirements and investment and operational costs per inhabitant for the different treatment technologies. These parameters are suitable for making investment decisions on wastewater treatment infrastructure based on economic criteria, i.e. considering both initial investment costs and long-term annual operational costs.

Figure 4: Economic considerations for different wastewater treatment systems

System	Land Requirements (m^2/inhabitant)	Construction Costs (€[4]/inhabitant)	O&M Costs (€/inhabitant/year)
Conventional primary treatment	0.02 – 0.04	9 – 15	0.4 – 0.8
Facultative pond	2.0 – 4.0	11 – 23	0.6 – 1.2
Anaerobic pond + facultative pond	1.2 – 3.0	9 – 23	0.6 – 1.2
Anaerobic pond + facultative pond + maturation pond	3.0 – 5.0	15 – 30	0.8 – 1.5
Facultative aerated lagoon	0.25 – 0.5	15 – 27	1.5 – 2.7
Constructed wetlands	3.0 – 5.0	15 – 23	0.8 – 1.2
Rapid infiltration	1.0 – 6.0	9 – 23	0.4 – 1.2
Overland flow	2.0 – 3.5	12 – 23	0.6 – 1.2
Conventional activated sludge	0.12 – 0.25	31 – 50	3.0 – 6.1
Activated sludge + extended aeration	0.12 – 0.25	27 – 38	3.0 – 6.1
Conventional activated sludge + tertiary filtration	0.15 – 0.30	38 – 58	4.6 – 7.7
Trickling filter	0.12 – 0.3	38 – 46	3.0 – 4.6

Source: Adapted from WHO Guidelines for the Safe use of Wastewater, Excreta and Greywater (2006) – Volume 2

Tariff Calculation and Cost Recovery

Revenues raised through appropriate water tariffs are – alongside long-term government subsidies – the most sustainable source of funds for recurrent operations and a grossly undertapped source of finance. All South Mediterranean countries subsidise water prices, either directly and/or by financing main investments (such as dams, central networks etc), considered as ‘sunk costs’. It is not possible to exactly specify the respective levels of subsidies. Generally, only part of the operation and maintenance costs are covered by water tariffs, either for political (social) reasons to support farmers or to combat rural exodus etc.

However, the ‘real costs’ have to be known prior to any investment in wastewater treatment and/or reuse projects in order to guarantee their economic sustainability. The economic approach to be applied is the ‘**dynamic cost technique**’.

The **dynamic water production costs per m^3 (DWPC)** reflect the full costs of water provision over the lifetime of an investment project. They can be expressed at full cost (investment and O&M) or at O&M cost recovery level only. As such, they form the basis for calculating the water tariff levels and/or the amount of additional governmental subsidies

[4] Currency exchange rate March 2009 applied: 1.30 $ = 1.00 €

needed to guarantee long-term operation and maintenance of investment projects, including capital cost recovery.

Allocation of Wastewater Reclamation Costs

Although wastewater collection and treatment are a prerequisite for subsequent reuse, the related costs cannot be charged to the end user (e.g. the farmer) alone. For sewerage and treatment up to standards for discharge into the environment the **'polluter pays' principle** has to be applied, meaning that the costs for decontamination have to be covered by the polluter, i.e. the freshwater consumer. The extent to which wastewater has to be treated before being discharged into the environment is country specific and the relevant interface between 'polluter' and 'user' has to be defined accordingly.

The reuse of reclaimed wastewater includes the following processes, which have to be sustainably financed in order to guarantee the provision of safe and sufficiently treated wastewater for irrigation and other purposes:

- Wastewater collection and treatment (generally up to secondary level) => costs to be allocated to the wastewater producer/freshwater consumer according to the 'polluter pays' principle, e.g. through (preferably) cost-covering sanitation tariffs differentiated by sector and polluting load.
- Additional wastewater treatment (up to tertiary level, if required for the particular reuse option) and intermediate storage and distribution => costs to be covered by the reclaimed wastewater users, e.g. through **irrigation water tariffs** which may require governmental subsidies as the costs may exceed the users' payment capacity.

Comparison of Wastewater Treatment Costs and Reuse Fees

Costs for wastewater treatment and reuse and for conventional irrigation water (by far the major reuse option in the target countries) are summarised and compared in the following table, expressed as dynamic water production costs (DWPC) in €/m^3.

Table 1: Comparison of wastewater treatment costs and user fees

Polluter pays = freshwater consumer		**User pays = e.g. farmer**		**User pays = farmer**	
Wastewater Treatment Costs		**Water Reuse Costs**		**Irrigation Water Fees**	
Ordinary concrete pipelines + ww stabilisation ponds	~ 0.8 €/m^3	Real costs in Morocco (only O&M)*	~ 0.11 €/m^3	Real costs for water provision from dams in Morocco*	0.25 – 0.64 €/m^3
Good quality sewers + advanced treatment processes	3 – 5 €/m^3	Real costs in Tunisia (only O&M)*	0.06 – 0.11 €/m^3	Charged in Morocco	0.09 – 0.14 €/m^3
Collection and secondary treatment in Tunisia	~ 2.7 €/m^3	Irrigation fees for treated ww in France, Spain, Jordan, Morocco and Tunisia	0.02 – 0.08 €/m^3	Charged in Tunisia	~ 0.077 €/m^3

* Figures taken from current feasibility studies in the countries concerned

Among existing wastewater reuse projects, the price of treated wastewater for reuse (additional treatment if needed, intermediate storage, distribution networks, pumping) is not necessarily higher than of conventional irrigation water (dams, wells, reservoirs, distribution networks, pumping). In this context, the following question has to be asked: Is it justified to charge cost-recovering tariffs for treated wastewater for reuse (= ‘user pays’) when this principle is not applied for conventional irrigation water systems? Assuming the answer is no, the additional costs for **wastewater reclamation** could be financed through mechanisms similar to those applied for **conventional irrigation water**.

Since typical **agricultural reuse** projects are seldom profitable on their own, water tariffs can cover only part of the financing and should be matched by governmental subsidies, as is the case for conventional irrigation water.

Landscape irrigation for urban parks, green belts, forests, highway median strips etc., constitutes a public duty and should be financed from the governmental budget.

Wherever reuse options are **profitable** and certain quality standards have to be met, the aim should be ‘financing by the end users’ via full cost recovery (incl. investment costs) for additional treatment, storage and distribution infrastructure. This principle could be applied for operations such as the irrigation of touristic establishments, golf courses and hotel resorts and for profitable industrial crops, for example through PPPs (Public Private Partnerships).

Wastewater is often produced in large quantities far away from the intended agricultural reuse schemes, e.g. in big cities on the coastline. Its transfer to inland locations affected by water scarcity requires large **pipelines**. The economical feasibility of these is – under most circumstances – highly questionable. Tunisia is the first country in the region to carry out in-depth studies on the long-distance transfer of treated wastewater, e.g. the ‘Tunis-Kairouan pipeline’.

To cover recurrent costs as far as possible, operators of wastewater treatment plants (water establishments and utilities) may apply a global approach to tariff setting by allowing cross subsidies between different service sectors such as drinking water, sanitation, electricity supply, connection fees, etc. However, there is a general need for stepwise tariff reforms and better water demand management, e.g. via higher (drinking and irrigation) water and sanitation tariffs and by introducing block tariff systems.

Willingness and Ability to Pay

The willingness to pay for any goods depends on the following criteria:

- **Scarcity** of the resource: the more limited or less available conventional water resources are, the higher the price that is acceptable to users.
- **Costs** of conventional water resources: the higher the costs (pumping from wells), the more the consumer is willing to accept alternative sources at similar prices.
- **Quality** of the resource: the better the water quality provided, the more the consumer is prepared to pay for it.
- **Service provision**: farmers and other consumers of treated wastewater could be more willing to pay higher charges if there is a good prospect of improved services.

The criterion of **scarcity** is met in the majority of the target countries whereas the criteria **quality** and **service** are often not sufficiently addressed to justify higher water prices. Improvements in these areas could therefore be a decisive factor.

But even if the quality of treated wastewater and the services related to it are considerably improved, not all end consumers/farmers may be able to afford the higher water prices. The **willingness** and **ability** to pay may differ, particularly in low-income countries. In these cases, **subsidised prices** for treated wastewater could be applied effectively in order to expand the adoption of wastewater reuse.

2.3 Wastewater Reuse Standards, Legal Aspects and Institutional Setting

Wastewater reuse, in contrast to potable water, has no universal standards. However, a clear legal framework is needed for any reuse of wastewater. Without a clear legal basis, wastewater reuse has proved to be potentially dangerous to health and the environment. In the absence of a regulatory framework, wastewater is frequently used illegally for irrigation, due to the lack of sufficient fresh water. A legal basis for reuse should define clear and precise consent procedures, standards and responsibilities, together with enforcement mechanisms. It should also address the competent authority's responsibilities.

Frequently the laws and regulations governing the water sector are not specific enough with regard to reusing treated wastewater. Sectoral water legislation is often outdated. Even where adequate legislation is in place, monitoring and enforcement have proved to be a major problem.

EU Legislation

No specific legislation on reuse of wastewater exists in the **EU**. However, EU water legislation contains general principles as well as specific standards for specific uses, which are applicable in EU member states. Of relevance is the **EU Water Framework Directive** (WFD) (2000/60/EC) as amended by Decision 2455/2001 where in Annex VI Part B the **reuse of wastewater,** dealing with 'reuse measures' and 'water-saving irrigation techniques', is encouraged.

At member state as well as at European level, there are two different approaches to tackle water pollution:

1. The **Water Quality Objective approach** (WQO) defines the minimum quality requirements of water to limit the cumulative impact of emissions, both from point sources and diffuse sources.
2. The **Emission Limit Value approach** (ELV) focuses on the maximum allowable quantities of pollutants that can be discharged from a particular source into the aquatic environment.

WHO Guidelines

The main **international institutions** promoting the **safe** reuse of treated wastewater for irrigation are the World Health Organisation (**WHO**) and the Food and Agriculture Organisation **(FAO)** of the United Nations.

In 2006 **WHO** jointly with **FAO** and **UNEP** published the third edition of the 'Guidelines for the Safe Use of Wastewater, Excreta and Grey Water in Agriculture and Aquaculture', which considers wastewater treatment as one component of an integrated risk management strategy, proposing minimum verification monitoring of microbial performance targets for wastewater reuse in agriculture and aquaculture. These revised **WHO guidelines**[5] are the **most relevant international piece of legislation**, being accepted and applied by all international key institutions in the sector.

The WHO guidelines are **recommendations only**; they have **no legal status** under any jurisdiction. Governments can either adopt them as national legislation or simply refer to them as non-enforceable recommendation, giving authorities the **flexibility** to set health-based targets in line with what is realistic in the national socio-economic context.

The guidelines provide orientation on the reuse of wastewater in practice; but they cannot replace clear national legislation. Some of the **MEDA countries** – including Egypt, Morocco, Tunisia and Syria – have already introduced legislation on reuse of wastewater. In others, such as Lebanon, there is no explicit legislation. The **Egyptian 'Code for Reuse'** is of particular interest.

Institutional Setting

The institutions involved in wastewater reuse are:

- the **national governments**, represented by the ministries, which are responsible for the overall policy and strategy (e.g. IWRM) in the sector as well as for the necessary legislation and the enforcement of regulations and standards;
- subordinate **authorities** and **agencies**, such as municipalities, water utilities and agricultural and health agencies, which are responsible for the execution, monitoring and supervision of wastewater reuse schemes;
- end users or **organisations of end users** such as Water User Organisations (WUA).

The challenge in the target countries is that responsibility for water management on a national level is shared between different ministries. For water and sanitation, it is either the **Ministry of Water Resources** itself - if there is any - or other ministries to whom responsibility is assigned, such as the **Ministry of Environment** or **Infrastructure** or others (this is very country specific). In addition, the **Ministry of Health** is involved because of the general hygiene and health related aspects of wastewater, and also the **Ministry of Agriculture** and/or **Irrigation** owing to the fact that agriculture is the biggest consumer of water and therefore also of reclaimed wastewater in the target countries.

At implementation level, it is mainly the **water utilities/establishments** being responsible for all water and sanitation related issues. They play a key role in the reuse of reclaimed wastewater. These water utilities/establishments often suffer from significant shortage of funds to cover operating costs and limited personnel with insufficient qualification.

To improve this situation and create suitable preconditions for the successful and sustainable implementation of wastewater reuse schemes, changes and reforms in these water utilities/establishments are needed. Therfore, future projects should place strong emphasis

[5] http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html

on **capacity development**, including participation, empowerment, technical assistance and organisational development. The re-education and training of staff is a central element.

Furthermore, better **inter-sectoral coordination** on all levels in planning and management is required among the institutions involved, as wastewater collection and treatment are usually under the jurisdiction of a different sector (such as urban water supply and sanitation) than the reuse sectors (such as agriculture and the municipalities).

Water user associations and consumer **NGOs** can play an important role in the dissemination of information on successful approaches. First successful examples can be observed in Jordan.

2.4 Consumer Acceptance

Public acceptance is a prerequisite for the successful implementation of wastewater reuse schemes on a broader scale. Achieving the necessary acceptance is particularly challenging in the case of agricultural reuse, though less so for other applications such as irrigation for recreational purposes, groundwater recharge etc.

The public perception of agricultural products irrigated with reclaimed wastewater is generally negative, mainly because of hygiene and health concerns, together with a natural aversion to foodstuffs that have potentially been in contact with human excreta. This could lead to farmers being unable to sell their products, even if relevant quality criteria are met, making them in turn reluctant to use reclaimed wastewater for crop irrigation.

These (partially justified) fears can only be overcome by **substantial information campaigns** – including pilot projects such as demonstration farms – on the important environmental and economic benefits of wastewater reuse in agriculture. It can increase the reliability of production (food security) and render production for local markets cheaper by reducing expenditure on expensive fertilizers. Other aspects for inclusion in information campaigns could be the precautions taken to make TWW reuse reliably safe.

Besides general misgivings with respect to hygiene and health, **religious beliefs** can play an important role in the acceptance of wastewater reuse. For example, Islamic religious beliefs require cleanliness and ‘purity’ of water, which can affect attitudes toward wastewater reuse. The fulfilment of religious requirements for water purity has been a controversial issue among religious scholars in the Islamic world since the introduction of wastewater reuse programmes. After a thorough investigation in 1978, which included both scientists and specialists, the Council of Leading Islamic Scholars of Saudi Arabia expressed its approval of wastewater reuse - after proper treatment - for all purposes. Nevertheless, the Council also declared that it preferred to avoid using treated wastewater for drinking purposes.

3 Bottlenecks and Driving Forces for their Removal

The main obstacles/**bottlenecks** for the extended reuse of treated wastewater in most of the South Mediterranean countries can be summarised as follows:

1. Differing status of national strategies on wastewater reuse, leading to **a need** for further development of national and/or regional '**master plans**' as part of an **integrated water resources management** concept. The potential for the reuse of TWW is still underexploited, though some countries are more advanced than others.
2. **Site-specific parameters** (quantity and quality of TWW, availability of conventional sources of water, intended use, location, climate, soil, availability of land, economic conditions etc.) determine the potential for implementing treated wastewater reuse schemes. There is **no 'one fits all' solution**.
3. **Insufficient treatment facilities** (at least for secondary treatment plus potential disinfection); sanitation infrastructure and its operation often need improvement, in particular in rural areas but also in the cities, resulting in limited quantities of wastewater of appropriate quality for reuse.
4. **Industrial wastewater** constitutes an important threat to reuse as, despite existing legislation, they are often discharged into the general sewerage systems without proper pre-treatment. This hampers proper operation of municipal WWTPs and limits the reuse potential.
5. Economic constraints, in particular regarding **investment funding and** the **long-term, financially viable operation** of reuse schemes. This also results in insufficient quality control and monitoring due to the prevalence of non cost-covering water fees/tariffs and/or lack of sufficient governmental subsidies as well as limited willingness and ability to pay for treated wastewater.
6. Appropriate legislation and standards are generally in place. However, the **enforcement** of **legislation** and **guidelines/standards** is often weak and accompanied by limited quality monitoring.
7. Fragmented **institutional set-up** in the water and related sectors, characterised by an unclear delimitation of responsibilities and tasks. This is often an indicator for differing interests (environment/water ⇔ agriculture) and limited coordination and cooperation; further aggravated by the lack of qualified staff and financial resources at different levels.
8. Insufficient information/knowledge on the **overall water and groundwater regime;** this hampers the design of appropriate solutions for aquifer recharge.
9. Limited self-organisation of users/farmers in **water user associations**; these could promote and organise the extended use of reclaimed wastewater and advocate their interests.
10. Low **acceptance** of products irrigated with treated wastewater and lack of trust in public quality monitoring.

Removal of Bottlenecks for the Extended Reuse of Wastewater

The following actions address bottlenecks for the extended reuse of wastewater and can serve as a basis for the development of concrete projects:

1. Support of national and regional governments in the development of **master plans** for the reuse of reclaimed wastewater, as part of an integrated water resources management approach, via studies and technical assistance, capacity development in the institutions concerned, considering all necessary aspects (technical, institutional, legislative, social, economic, financial, management and operation).
2. **Cities/big agglomerations**: provision of loans/grants for infrastructure projects, which could include the construction of new WWTPs as well as the rehabilitation and extension of existing ones. Installation of intermediate storage facilities and primary distribution networks at those locations where reuse options have been identified.
3. **Rural areas**: set-up of a fund for municipalities to finance decentralised low-tech and low-cost treatment facilities with adjacent reuse schemes, including a project management unit in those utilities where technical assistance and local capacity development is needed.
4. Introduction of **adequate project identification procedures** (refer to the scheme presented in Annex 1).
5. **Industries**: support of industries, e.g. by setting up a decontamination fund for financing of on-site (pre-)treatment facilities for internal recycling of water and for reducing the polluting load of effluents, including a project management unit in the managing institution. Technical assistance and local capacity development will be needed.
6. Investments in wastewater treatment facilities and reuse schemes address only part of the problem and should be accompanied by **institutional support** and **capacity development** as well as technical assistance. It is recommended that the **institutions** involved are strengthened on all levels, e.g. by setting up a capacity development centre/research institute for staff training in all tasks and responsibilities related to the wastewater reuse sector, i.e. institutional coordination, technical, economic, financial, management and operation.
7. Support for the development of **cost-recovering water tariff systems**, including governmental subsidies and private contributions (PPP) and allowing cross-subsidies between different service sectors.
8. Financing of **hydrogeological studies** as the basis for the design of appropriate reuse schemes, especially for groundwater recharge.
9. Provision of technical assistance to water users/farmers to set up **water user associations** for a better and more efficient distribution and use of treated wastewater, including promotion of improved irrigation practices.
10. Provision of technical assistance to line ministries to carry out **background studies** on topics such as groundwater regimes (for recharge options), reuse options for wastewater currently disposed of via sea outfalls (transfer pipelines) and reform of water tariffs (demand management, recovery of O&M costs, application of the ‘polluter pays’ principle).

Technical solutions are in general easily available; they only have to be adapted to the specific local conditions. Bigger challenges are the ‘political’ and ‘organisational’ bottlenecks, which require **capacity development** at different levels (ministries, agencies, water utilities etc.) and **public awareness campaigns**.

Public awareness and trust is a prerequisite for successful marketing of for example crops irrigated with treated wastewater. Adequate campaigns to increase consumer acceptance have to be an integral part of each reuse project.

Sustainable **long-term financing** of operation and maintenance has to be guaranteed either by cost-covering water tariffs or by additional governmental subsidies.

Furthermore, farmers should be able to generate enough income by selling their products so that they can afford irrigation water costs, e.g. through a ‘better prices for better products campaign’. **Microfinance projects for farmers** can help them to invest in more efficient and water saving technologies such as drip irrigation.

The following matrix presents a summary of major bottlenecks and recommendations on how to remove them.

Figure 5: Summary of major bottlenecks and recommendations on how to remove them

Recommendations / **Bottlenecks**	Investigation/studies / master plans => concrete recommend-dations	Construction of needed infrastructure	Rehabilitation/ exten-sion of existing infra-structure	Capacity development at different levels	Public awareness campaigns	Set-up of water user associations	Set-up of funds, such as Municipal Fund or Industrial Fund	Promotion of IWRM and decentral solutions
No 'master plans' for IWRM, incl. reuse:								
• Limited knowledge on the overall (ground-) water regime	•			•				
• No explicit national water policy/political commitment	•			•				•
Lacking infrastructure:								
• Not enough WWTPs of needed quality		•	•				•	•
• No/limited reuse infrastructure		•	•				•	•
Deficient legal framework:								
• Lacking laws, guidelines, standards	•			•				
• No/limited enforcement				•				
• No/limited monitoring & evaluation				•				
Fragmented institutional set-up:								
• Overlapping institutional responsibilities	•			•				
• No/limited operational water utilities				•			•	•
No/limited consumer acceptance					•	•		•
No long-term financial viability:								
• Irrigation water provided for free	•			•	•			
• No cost covering water tariffs	•			•	•			
• Limited governmental subsidies				•	•			
• No/limited investment support				•			•	

4 Sector and Country Specific Findings and Proposed Actions

4.1 Water Sector and Water Balance

Located on the southern side of the Mediterranean Sea and in the Near East, the five target countries – with the exception of Lebanon – are all characterised by low **annual precipitation**, ranging on average from 200 to 350 mm/yr, and substantial differences in regional and seasonal rainfall patterns. There are also signs of increasing variations in inter-annual precipitations, often aggravated by years of subsequent droughts, put down to the effects of climate change. Over the next 20 years, further increases in average temperature and a reduction of annual precipitations of up to 20% are expected. Key sector figures for all five countries are presented in Table 2.

In terms of water availability from renewable resources, the threshold for **'water scarcity'** is set internationally at 1,000 m^3/habitant/year. All countries, except Lebanon, are already below this level with Tunisia ranking lowest with 446 m^3/habitant/year, which is defined as 'absolute water scarcity'.

While the mobilisation of conventional renewable water resources faces increasingly its limits, there is a more acute need for the application of **water demand management** instruments and the **mobilisation of non-conventional water resources** (TWW reuse, desalination). Taking into account the expected development of water demand by the three main consuming sectors (agriculture, domestic water supply and industry); it becomes obvious that all the countries will have a **negative water balance** in the next 15 to 20 years (2025 to 2030). Even at present, in certain regions or during the summer period, water demand exceeds available water supplies, requiring transfer systems from areas of surplus.

The agricultural sector is the biggest consumer, accounting for 80 to 88% of the **total water demand** (except for Lebanon totalling only 64%), followed by domestic demand (7 - 15% though 26% in Lebanon) and industrial demand (3 - 10%). While agricultural demand is expected to decline relatively (and even absolutely) due to the introduction of water saving technologies, domestic demand will show the highest proportional increase in the future. The driving forces here are the annual population growth, urbanisation, economic development and a growing tourism sector in the five countries.

Water demand management strategies are being applied increasingly in most of the countries. These involve introducing block tariff systems and volumetric charging. Egypt, however, avoids almost any intervention in current consumption patterns or existing tariff systems. All the countries **subsidize irrigation water prices,** thus not reflecting the actual scarcity of water or reducing irrigation water consumption via economic incentives. However, in countries like Tunisia and Morocco, the national governments do subsidize on-farm investments in water-saving irrigation technologies.

Table 2: Key parameters: water sector and wastewater reuse in five countries

Parameter	Unit	Egypt	Lebanon	Morocco	Syria	Tunisia
Annual rainfall	mm/an	0 - 200	200 - 1 500 (av. 840)	150 - 750 (av.200 / 346)	100 - 1 400 (av. 252)	100 - 1 500 (av. 230)
Water Stress	m³/habitant	800	1 200-2 000	730	800	446
Water demand - agriculture - domestic - industry	 % % %	 82 7 10	 64 26 9	 87 10 3	 88 8 4	 80 15 5
Water balance	negative in	since 1990	2030	2030	since 2001	2025
WW generated	Mm³	4 939	292	600	1 194	240
WW treated	Mm³	4 560	77	78	406	235
WW treated in % of generated	%	92	26	13	34	98
TWW reused	Mm³	700 - 2 970	<1	under investigation	183	57
TWW reused in % of generated	%	14 - 60	< 1	under investigation	15	23
Sea outfall	Mm³	unknown	~233	360	49 -169	173
Sea outfall in % of generated	%	unknown	80	60	4 - 14	72
Types of reuse - agriculture - golf courses - green spaces - water bodies		 indirect no 10 Mm³ indirect	 marginal marginal marginal yes	 > 70 Mm³ yes yes yes	 695-889 Mm³ marginal marginal 311 Mm³	 22 Mm³ 7 Mm³ 10 Mm³ 18 Mm³

Source: Country Reports

4.2 Wastewater Management and Reuse

The safe and controlled reuse of TWW requires the existence of a **functioning sanitation infrastructure** (collection and treatment). However, only Egypt and Tunisia have a dense sanitation network allowing treatment of 92% and 98% respectively of all wastewater generated in their treatment plants. Morocco ranks lowest at 13%, followed by Lebanon and Syria at 26% and 34%. The increasing pollution of surface and underground water resources and the insufficient treatment capacities have led in all three countries to the formulation of ambitious plans to expand and rehabilitate the existing sanitation infrastructure. While in these countries decontamination is the primary issue to date, Egypt and Tunisia give special attention to the reuse of TWW, but they too have to take more action to meet the growing challenges in the sector and invest in the extension, rehabilitation and new construction of WWTPs.

The **quantities of wastewater reused** for different purposes are relatively small and do not exceed 10 to 23% of the wastewater generated. In four of the five countries, the majority of the population live in urban centres along the coastal areas. Therefore a huge proportion of the wastewaters generated are **discharged** more or less untreated **via sea outfalls** into the Mediterranean Sea or the Atlantic Ocean. The respective percentages vary between 60%

(Morocco) and 80% (Lebanon). Only in Syria the figure is smaller, due to its urban settlement pattern. These quantities are currently lost for any reuse. All the signatories of the ‘Barcelona Convention’, however, are committed to contributing to the decontamination of the Mediterranean Sea, either by applying additional treatment levels or by considering transporting TWW to end users in the interior of the country (e.g. Tunisia). In other areas, raw sewage is discharged directly into inland watercourses.

In all five countries, the legal framework provides an adequate definition of the **quality parameters** to be respected in treating wastewater and disposing of it into the environment after treatment. Where WWTPs exist, effluents receive at least primary (in Lebanon currently only primary treatment!) and secondary treatment; additional (tertiary) treatment levels are rare (only in Tunisia and Morocco). With the exception of newly constructed WWTPs, wastewater quality often does not conform to the standards, due to overloading of the plants, unsuitable treatment technology, insufficient staff skills, **insufficient cost recovery for O&M costs**, and the mixing of untreated industrial effluents with those from domestic sources. Although quality control mechanisms are in place in all the countries, the responsible institutions seldom enforce the standards. Insufficient treatment and in some cases high salinity levels prevent wastewater reuse for the different purposes.

Untreated industrial wastewaters[6] and non-application of the ‘polluter pays’ principle are the main reasons why the quality standards are not achieved. None of the countries has set sanitation **tariffs for industrial effluents** according to their pollutant load. Insufficient sanitation tariffs lead to poor performance of WWTPs with regard to quality and part of the operational costs has to be covered by cross subsidies from other services provided by the operator or by public subsidies.

Only Egypt and Tunisia dispose of **controlled reuse schemes** of major importance and clear rules and regulations on the irrigation of agricultural and agroforestry crops. The focus is on risk minimisation (e.g. reuse for trees and certain industrial crops/biofuel in Egypt; no reuse for vegetables in Tunisia). The main areas of application are in the agricultural sector, the irrigation of golf courses, hotel complexes and other green spaces, and to some extent industrial reuse (washing of phosphates in Morocco). Due to the lack of sanitation infrastructure in Morocco and Syria, there are no larger-scale controlled reuse schemes, though this situation is currently changing with the stepwise implementation of new investments in wastewater collection and treatment systems that envisage agricultural reuse. Due to Lebanon’s specific post-war situation, it has other priorities for current infrastructural developments and TWW reuse is not a subject for much discussion.

However, in all countries, especially in regions with a water deficit, **illegal and uncontrolled reuse of raw sewage**, directly or indirectly, is common practice - sometimes, as in Syria, dating back to ancient times. Reuse for agricultural irrigation is the main application, and the health risks for producers and consumers are substantial when crop restrictions are not respected. In Lower Egypt, where effluents are discharged into drainage channels, it is impossible to control the reuse of this water. General experience has shown that the more critical the water scarcity is, the higher the extent of wastewater reuse, irrespective of its quality parameters.

---

[6] However, in Morocco and Tunisia, efforts are undertaken to achieve a cleaner industrial production via the creation of special decontamination investment funds (FODEP) for small and medium industries.

Although the use of TWW can help reduce the pressure on conventional water resources, its **effective fresh water saving potential is limited** and this may explain the low rate of TWW reuse. Compared to the irrigation water quantities consumed by the agricultural sector, the total TWW quantities generated can satisfy only 2 to 5% of the total national irrigation water requirements at the most.

These low rates can be explained by the limited TWW quantities, losses due to sea outfalls, evaporation, seasonality of demand and the high cost of inter-seasonal storage and pumping and conveyance to end users located at a long way from the TWW production sites. Much more significant water savings can therefore be expected from investments in modern irrigation technologies and improved water management in irrigation schemes.

4.3 Driving Forces in Treated Wastewater Reuse

The different extent of wastewater reuse in the five target countries led to the need to define the driving forces favouring or impeding the controlled and safe reuse. The five countries can be divided into **three categories** according to the degree of importance they attach to the development of non-conventional water resources:

1. Countries already practising controlled reuse (Egypt and Tunisia);
2. Countries willing to apply and extend controlled reuse (Morocco and Syria);
3. Countries so far ignoring the potential of this water resource (Lebanon).

The **key factors** influencing the controlled and safe reuse of treated wastewater are of multiple origin, requiring combined and sometimes complementary interventions at different levels. They cannot be confined to the creation of a functioning sanitation infrastructure, but require coordinated interventions in an enabling environment, which involves political, institutional, legal, financing and capacity building issues. This enabling environment has to be created first before any investment is made in sanitation infrastructure considering the reuse of treated effluents.

The **driving forces** allowing a comparison between the five countries were identified as follows:

1. The political will and commitment to promoting and applying wastewater reuse.
2. A clear sector policy promoting IWRM, reflected in National Water Master Plans.
3. An institutional framework with clearly defined responsibilities for the planning and funding of investments, and coordinated interventions by the line ministries in charge of the water sector (sanitation and irrigation).
4. A clear legal and regulatory framework for wastewater reuse with the institutional capacity to enforce the legislation.
5. The availability or non-availability of conventional water sources and the extent of ‘water stress’ or ‘water scarcity’.
6. The existence of a countrywide sanitation and treatment infrastructure and the efficiency of its performance.
7. The existing tariff level and structure in the water sector (water supply, sanitation, irrigation water and TWW tariffs) and their ability to recover O&M costs for wastewater treatment and irrigation scheme operation.

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 and awareness of users and consumers about the production of crops irrigated with TWW and related risks.

Based on the country specific analyses and by applying the parameters influencing the reuse of treated wastewater, the resulting findings allow the identification of required policy action and investment requirements.

Table 3 presents the main findings of the comparative analysis of the driving forces for TWW reuse. More details are given in the respective 'Country Reports'.

Table 3: Comparative analysis of driving forces for TWW reuse

Driving forces	**Egypt**	**Lebanon**	**Morocco**	**Syria**	**Tunisia**
Political commitment to implement IWRM and demand management oriented policies in the water sector	high	low	moderate,reuse strategy under preparation	moderate	High
Institutional responsibilities for reuse planning, cooperation and coordination of institutions involved	clearly defined	not defined	moderate, more precision required	moderate, more precision required	clearly defined
Legal framework for wastewater reuse and water quality standards	clearly defined	outdated	clearly defined	partially too strict, more flexibility required	clearly defined
Funding of investments (additional treatment and reuse schemes)	clearly defined with high sub-sidies for investments	lacking	unclear, need to be defined	moderate, more precision required	clearly defined with high sub-sidies for investments
Treatment of industrial effluents and application of 'polluter pays' principle	insufficient to lacking	lacking	insufficient, but FODEP	insufficient to lacking	insufficient, but FODEP
Sanitation and irrigation water tariffs and cost recovery	too low, highly subsidized	too low, no cost recovery, subsidized	too low, no cost recovery, subsidized	low, no cost recovery, subsidized	no cost recovery, TWW tariffs too low
Availability of cheap conventional water resources / sufficient rainfall around TWW production sites	lacking	high in western Lebanon	high in northern parts	lacking	high in northern parts

4.4 Key Areas of Intervention

Based on the analyses of current constraints and bottlenecks hindering enhanced wastewater reuse, targeted recommendations were formulated and concrete investment proposals identified for each country.[7]

Wherever **direct wastewater reuse schemes** are planned (Tunisia, Egypt, Morocco, and Syria), the implementation of feasibility studies is a prerequisite for later funding of the identified investments in:

- Creation of new reuse irrigation schemes;
- Rehabilitation of existing reuse schemes;
- Required storage, transfer and distribution network infrastructure.

Wherever the **preconditions** for extended reuse still have to be created or improved (all countries), investment requirements were identified for:

- Sanitation infrastructure investments (WWTPs, sewer systems) including creation of new facilities, extension of existing ones and additional treatment levels;
- Pre-treatment of industrial effluents.

However, these investments in sanitation and irrigation infrastructure alone will not be sufficient to ensure sustainability in wastewater reuse. The following **accompanying measures** were identified for all countries, though their scope differs according to the extent of support required:

- Formulation/elaboration of National Water Master Plans, considering TWW as an integral part of the water cycle and of an Integrated Water Resources Management strategy, enhancing the shift from water supply orientation towards water demand management;
- Institutional strengthening and capacity development in the responsible line ministries and agencies, including better coordination of planning and funding of wastewater reuse schemes; improved enforcement of effluent quality standards by independent institutions;
- Capacity development and training for WWTP operators and their staff;
- Water sector studies, especially for groundwater recharge;
- Studies on water tariff reforms (potable, sanitation, irrigation), improving recovery of O&M costs and application of the 'polluter pays' principle;
- Applied research on wastewater reuse;
- Public information and awareness campaigns.

[7] For further details, please refer to the general recommendations as well as to the 'project profiles' in the respective 'Country Reports'.

Annex 1: Stepwise Approach for the Identification of Potential Wastewater Reuse Projects

To be investigated		Result		Potential projects (subject to feasibility studies)
1) Regional/local **need** for wastewater reuse (water scarcity/water stress) = **inventory** of potential demand (e.g. agriculture)	→	No water scarcity/no water stress/no demand for reclaimed water	→	None, or just as a disposal strategy
	→	Conventional water supply does not cover the needs, e.g. from agriculture		
		↓		
		Continue investigation		
2) Potential **sources** for reclaimed water, such as operational WWTPs including the required sewage collection network	→	No operational WWTPs in **big agglomerations**/ cities	→	None, but construction of large central WWTPs and potential **distribution to agro-industrial sites** outside, if economically feasible
	→	No wastewater treatment in **rural areas**	→	Construction of small-scale, low-tech WWTPs; introduction of a **Municipal Fund**
	→	WWTP exists but is not operational due to lack of central sewers and/or household connections	→	**Construction** of central sewers and/or household connections; introduction of a **(micro) Finance System/Fund**
	→	WWTP exists, but is not fully operational or does not provide the required quality (e.g. only primary and/or secondary treatment)	→	**Rehabilitation** and/or extension of the existing WWTP, **Capacity building**, Training of operators
		↓		
		Continue investigation		

To be investigated		Result		Potential projects (subject to feasibility studies)
3) Legal framework => do laws and regulations allow the potential reuse application?	⇨	No legal framework, no enforcement of (international) guidelines	⇨	Provide **technical assistance** for the development of an appropriate legal setup
	⇨	Legal framework exists. International safety guidelines are applied		
⇩				
Continue investigation				
4) Institutional setup => clear definition of responsibilities within the governmental structures; existing water utilities/establishments	⇨	Responsibilities are not clearly defined between the different government ministries and/or agencies	⇨	Only if a concrete counterpart institution can be identified
	⇨	Water utilities are not able to fulfil their tasks, e.g. due to the lack of qualified personnel	⇨	**Capacity development** within the water utilities incl. their subordinate bodies
	⇨	Responsibilities are clearly assigned to the respective government ministries/agencies		
	⇨	Water utilities/ establishments are operational		
⇩				
Continue investigation				
5) Demand by users exists and **end consumers** accept the products	⇨	Agricultural land for irrigation with wastewater is located near to the source	⇨	**Technical assistance** for farmers, setting up/ organising of **Water User Associations Public awareness raising campaign**
		Other reuse options (such as e.g. landscape irrigation, municipal use, groundwater recharge) are identified		

To be investigated		Result		Potential projects (subject to feasibility studies)
Continue investigation				
6) Long-term financial viability => water tariffs and/or government subsidies	⇒	No water tariffs, no political will to introduce them nor government subsidies	⇒	None
	⇒	No adequate water tariffs	⇒	**Technical assistance** for the development of a sustainable water tariff system
	⇒	Adequate water tariffs and/or a government subsidy policy		
⇓				
Continue investigation and carry out feasibility studies				
7) Concrete **needs assessment** for wastewater reuse schemes for different purposes and assessment of potential effluent quality	⇒	Need for additional wastewater **treatment capacities** (in rural areas)	⇒	**Construction** of small-scale (decentralised) **WWTPs** and capacity development of operators
	⇒	Need for **storage** and **distribution** systems for agricultural use	⇒	**Construction** of **storage** facilities and **distribution** networks
	⇒	Need for improved **irrigation** techniques	⇒	Implementation of **efficient irrigation techniques** and capacity development of farmers
	⇒	Need for **municipal water** and/or landscape irrigation (golf courses etc.)	⇒	**Construction** of **storage** facilities and **distribution** networks
	⇒	Need for reuse in **house-holds** and/or public establishments	⇒	**Promotion of grey water reuse systems**

To be investigated		Result		Potential projects (subject to feasibility studies)
7) Concrete **needs assessment** for wastewater reuse schemes for different purposes and assessment of potential effluent quality	⇨	Need for **depollution of industrial wastewaters** as influents into surface waters and WWTPs	⇨	Promotion of industrial on-site WWTPs for water recycling; establishment of an **Industrial Decontamination Fund**
	⇨	Need for **surface water** improvement	⇨	Implementation of surface water **recharge systems** (rivers, lakes and reservoirs)
	⇨	Need for **groundwater recharge** and/or combating salt water intrusion	⇨	Implementation of a groundwater recharge system after careful investigation and a **comprehensive study** of the aquifer regime

European Investment Bank

Facility for Euro-Mediterranean Investment and Partnership

The extended reuse of reclaimed (treated) wastewater could contribute considerably to the reduction of 'water stress' and 'water scarcity' in arid and semi-arid countries as part of an Integrated Water Resources Management (IWRM) approach focusing on wastewater reuse for irrigation and other purposes.

In the target countries, agriculture is by far the main water consumer, accounting for about 80% of the total water supply in Tunisia and up to 90% in Syria. In terms of quantity, the greatest potential for wastewater reuse is through using properly treated wastewater for irrigation purposes, as substitute for conventional ground and surface water sources.

The reuse of reclaimed wastewater is complex. It is necessary to consider not only the relevant treatment infrastructure and applied treatment technology, but also other key parameters such as the quality of influents and the subsequent reuse options according to current quality standards as defined in the national legislation.

Press contacts and general information

Anne-Cécile Auguin
(+352) 43 79 - 83330
(+352) 43 79 - 61000
a.auguin@eib.org

European Investment Bank
98 -100, boulevard Konrad Adenauer
L-2950 Luxembourg
(+352) 43 79 – 1
(+352) 43 77 04
www.eib.org/femip – info@eib.org