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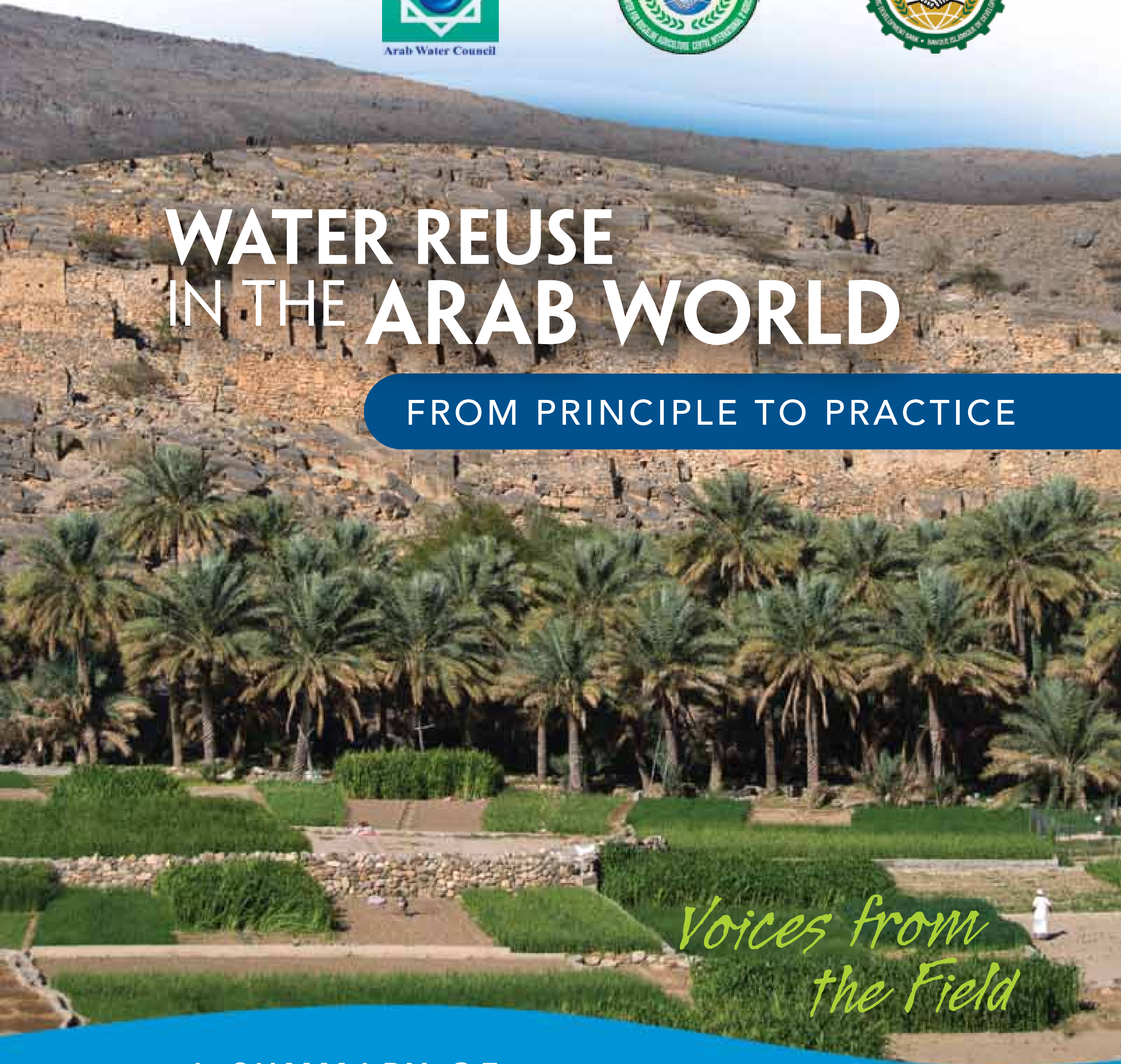
Arab Water Council

WATER REUSE IN THE ARAB WORLD

FROM PRINCIPLE TO PRACTICE



Voices from the Field

A SUMMARY OF PROCEEDINGS

Expert Consultation
Wastewater Management in the Arab World

22–24 May 2011
Dubai-UAE

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المجلس العربي للمياه
Arab Water Council

ACRONYMS

AWC	Arab Water Council
BCM	Billion cubic meters
BOOT	Build-Own-Operate Transfer
BOT	Build-Operate-Transfer
CA	Concession agreement
CEDARE	Center for Environment and Development for the Arab Region and Europe
CSP	Concentrated solar power
EPC	Engineering, procurement and construction
FAO	Food and Agriculture Organization
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GIS	Geographic Information Systems
ICBA	International Center for Biosaline Agriculture
ICT	Information and Communication technology
INRGREF	National Institute of Research for Rural Engineering, Water and Forestry
IWRM	Integrated Water Resource Management
Km	Kilometer
LAS	League of Arab States
MBR	Membrane bioreactor
MCM	Million cubic meters
MDGs	Millennium Development Goals
MENA	Middle East and North Africa
NRW	Non-revenue Water
PPP	Public private partnerships
SBR	Sequencing bioreactor
SPV	Special purpose vehicle
TSE	Treated sewage effluent
UAE	United Arab Emirates
UF	Ultra filter
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

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FOREWORD

Arab nations have historically played a lead role in the development of innovative water solutions with noteworthy achievements including global leadership in desalination, dam infrastructure and drip irrigation. Nonetheless, the challenge of optimizing water management remains an important priority across the Arab world.

Until recently, planned wastewater management in the Arab region focused on the conventional objectives of protecting public health and the environment. Pervasive water scarcity, urbanization and the increasingly obvious impacts of climate change however led to a shift in local perceptions of the importance of properly capturing and using reclaimed water.

Today, water reuse is regarded by most Arab nations to have great potential in significantly increasing available water resources. Arab states currently produce an estimated 10.8 km^3/year of wastewater, of which approximately 55% and 15% are reported to be respectively treated and reused in agriculture, landscape irrigation, industrial cooling and environmental protection. In some countries, water reuse in groundwater recharge is further used to protect freshwater.

In May 2011, the Arab Water Council, International Center for Biosaline Agriculture and Islamic Development Bank convened the **"Expert Consultation Meeting on Wastewater Management in the Arab World"**. The objective of the meeting was to better quantify the status and lessons learned on water reuse in the Arab world. Guided by the mission to maximize the economic, social and environmental benefits from water reuse in Arab countries, the Consultation provided a platform for dialogue among Arab water experts on priorities and synergies for advancing water reuse management in the Arab region.

This report thus: (i) summarizes principal messages and priorities on water reuse as communicated by Arab water experts in papers and presentations prepared for the Consultation (provided in the CD attached) and (ii) provides an overview of the current status and future potential of water reuse across the Arab region, as described by local experts and institutions.

Far from being an exhaustive treaty of the complex subject of water reuse, this short report was compiled—in partnership with the World Bank—in an effort to distill, summarize and convey the Arab experience with water reuse to date, as described by local practitioners. The report is thus structured around the following six common topics and will hopefully inform the many active discussions across the Arab world on how to move from principle to practice in water reuse:

- Current status of water in the Arab world;
- Basic economic considerations of water reuse;
- Infrastructure investments to enable sustainable reuse;
- Benefits of reuse in agriculture;
- Sustainable cost recovery models and
- Elements of a successful national water reuse strategy.

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CURRENT STATUS OF WATER IN THE ARAB WORLD

Arab countries, which cover about 10% of the area of the world, receive only 2% of the world's average annual precipitation and contain as little as 0.3% of the global annual renewable water resources. Although the average annual rainfall in the Arab region is about 250 mm, large areas of the region are very dry, with an annual rate of precipitation that does not exceed 5 mm.

Consequently, by 2015, almost all Arab countries are predicted to be below the level of severe water scarcity defined as less than 500 m³ per capita per year; with nine countries below 200 m³, and six below 100 m³ (El-Ashry et al, 2010). By 2025, only Lebanon and Iraq are expected to remain above the water scarcity level. Mauritania, Algeria, Morocco, Tunisia, Egypt, Sudan, Iraq, Lebanon and Syria further rely on river flows supplemented by limited groundwater sources, while many others depend mainly on shallow and deep groundwater sources supplemented by surface run off during floods (UNDP, 2009).

Surface water resources in Arab countries are estimated to be about 224 billion m³/year of which 77% comes from outside the region. Groundwater sources in the Arab region are quite limited, not exceeding a total of 50 billion m³/year (ESCWA, 2007). Desalinated seawater is further the main source of drinking water across GCC countries, due to limited groundwater availability with the overall capacity of new and existing desalination facilities is more than 3.4 billion m³ on average[1] (World Bank, 2005).

Agriculture is considered to be the top consumer of water resources, with a share of about 85% of available water resources in Arab countries. The major agricultural Arab countries, namely Egypt, Sudan Algeria, Morocco and Syria, contribute as much as 71% of total Arab agricultural output (Arab Fund for Economic and Social Development, 2010). Irrigation efficiency is very low however, at about 30% compared to a world average of about 45% (El-Ashry et al, 2010). It is further widely recognized that the agricultural sector only makes marginal contributions to national GDP's[2] across the region.

Demographic growth and economic and social development across Arab countries have contributed considerably to significant increases in water demand. (World Bank, 2007) producing around 10.85 billion m³/year of domestic wastewater (Table 1). Rapid urbanization[3] across most Arab countries further challenges efforts to meet increasing domestic water demands, especially for those countries with scarce public funds.

Approximately 83 million people in the Arab region do not currently have access to safe drinking water and about 96 million people need access to sanitation services. Most of these people live in lower income countries or are riddled by war and conflict. It is estimated that the total financial cost of providing the water supply and sanitation services required to halve the proportion of the population without sustainable access to safe drinking water and sanitation by the year 2015, would be about USD 100 billion and USD 62 billion, respectively (CEDARE and AWC 2006).

Average per capita domestic water consumption in the Arab region is about 200 liters/day (compared to a reported 525 liters/day in the United States[4]), but varies significantly among the countries of the region. Domestic water consumption in the Arab region escalated from

1 GCC countries are the main producer and consumer of desalinated water, with78% of overall capacity of desalination in the Arab countries, with Saudi Arabia alone having about one-third of the world's water desalination capacity.

2 In Jordan the agricultural sector accounts for 75% of all water consumption and produces only 2% of the GDP

3 According to UN estimates, the total population of Arab countries is further expected to reach about 420 million by 2020 as opposed to the 2008 Arab population, estimated at 343.8 million (AOADA 2009) with 55% located in urban areas.

4 UNDP Human Development Report 2006: Beyond Scarcity: Power, Poverty and the Global Water Crisis.

TABLE 1 Total water withdrawal , raw wastewater and treated waster in the different Arab countries in 10^9 m^3/year

Countries	Total water withdrawal (10^9 m^3/ year)	Total wastewater produced (10^9 m^3 year)	Volume of Treated Wastewater (10^9 m^3/year)	Volume of Treated Water reused (10^9 m^3/year
Algeria	6,07	0,82	0.7**	0.051
Saudi Arabia	23,67	0,73	0,652*	0.166
Bahrain	0,3574	0,0449	0,076*	0.0163
Comores	0,3574	—	—	
Djibouti	0,019	—	0	
Egypt	68,3	3,76	2,971**	0.700
United Arab Emirates	3,998	0,5	0,454*	0.248
Iraq	66	0.575	0.098**	0.0055
Lybia	4,326	0,546	0,04***	0.04
Jordan	0,941	0,117	0,111**	0.102
Kuweit	0,913	0,25	0,239*	0.078
Lebanon	1,31	0,31	0,004***	0.002
Morocco	12,6	0,700	0,177**	0.080
Mauritania	1,7	—	0,0007***	0.00035
Oman	1,321	0,098	0,037*	0.0023
Qatar	0,55	0,444	0,066*	0.043
Syria	16,7	1,37	0,550***	0.550
Somalia	3,298	—	0	
Sudan	37,32	—	—	
West Bank & Gaza	0,418	0.05	0.03***	0.00544
Tunisia	2,85	0,461	0,240**	0.068
Yemen	3,4	0,074	0,046***	0.006
TOTAL	**256,303**	**10,85**	**6,492**	**2.164**

*GCC water statistics book, 2010, ** Dubai Expert meeting, ***FAO-AQUASTAT 2009

about 12,000 million m^3 in 1995 (CEDARE and AWC 2004), to about 16,000 million m^3 in 2002 (FAOSTAT 2008). This represents more than a 30% increase in water consumption in less than a decade, a trend expected to persist in the Arab region in the future. Currently, domestic water consumption represents about 7% of the total water used in Arab countries. Domestic water consumption in the Gulf Cooperation Council (GCC) countries however ranges from 300–750 liters/capita/day, some of the highest in the world.

The total volume of wastewater generated by the domestic and industrial sectors in Arab region is 10.85 km^3/year; of which 6.49 km^3 are reported to undergo treatment. The annual volume of wastewater discharged in an untreated form in the Arab countries is 4.36 km^3, equivalent to 40% of the total reported wastewater produced in the region.

WATER ISSUES IN ARAB COUNTRIES

In most Arab countries, the chronic imbalance between available water supply and demand is expected to increase in the future, unless major positive steps are taken to rationalize and manage water demand, augment water supply, and impose realistic controls on water use. The supply-driven approach to water management has demonstrated its inability to deliver substantial degree of water sustainability or security to the water-stressed Arab countries to date.

A major review and shift in water policies of Arab countries, emphasizing conservation and demand management is thus urgently needed, with the overall objective of securing long-term water supplies while meeting strict criteria for socio-economic, financial and environmental sustainability and public health requirements.

Water issues in the Arab region can thus be summarized in five major points, further discussed below:

- **More than half of surface water in Arab countries originates from outside the region**. These resources could be significantly affected by prevailing and future political tensions and conflicts, which can threaten water security.
- **A large proportion of groundwater in Arab countries is non-renewable**, and often used in an unplanned manner.
- **Weak baseline water quality regulations and overall low capacity to regulate and enforce those regulations further exacerbates the issue.** Excessive use of chemical products in the agricultural sector[5] and uncontrolled disposal of domestic and industrial wastewater pose a serious water resources management challenge in Arab countries.
- **Climate change** serious threatens water security in the Arab region.
- **Food security is a serious issue:** Arab States import about half of food demand and are the main world importers of cereals. In the Middle East and North Africa, Algeria, Egypt, and Morocco are among the top 10 countries importing grains although they are among the main grain producers. Net cost of food commodities imported by Arab States increased from USD 10.2 billion in 1980 to USD 28 billion in 2009 of which USD 16.3 billion for grains[6].

Due to growing water stress, many governments have been prompted to look for more efficient uses of water resources, and to develop interventions to narrow the gap between supply and demand. Extended reuse of reclaimed wastewater is thus perceived to hold great potential to considerably reduce water scarcity especially when designed to be a part of an integrated water resources management approach.

Climate change induced water scarcity and environmental sustainability are some of the main drivers for augmenting supply through treated water reuse. A number of Arab countries have recently enacted drought decrees and plans that foresee water use restrictions and allocation of scarce water resources to drinking water supply, the most prioritized use. This opens the door for more effective implementation of water reuse schemes.

The successful and efficient reuse of treated wastewater, particularly in agriculture will depend on a multitude of strategies, which include increasing the reliability of reclaimed water as an alternative source to groundwater in irrigation, improving public awareness and attitudes towards reclaimed water, setting national public health and environmental standards for reuse, and implementing effective utilization plans in terms of increasing crop value and groundwater conservation (Al-Zubari, 2001).

Total reuse is estimated at 2.17 km^3 per year. Egypt, Syria, the United Arab Emirates and Saudi Arabia are the largest users, accounting for 75% of the Arab region in term of the total domestic water reuse. Irrigation for landscaping and golf courses is also increasing in the GCC and North African countries. However, several constraints including economic, institutional, health and environmental problems restrict the sustainable and safe reuse of wastewater. This will require concerted efforts, supported by regional and international organizations, to make a real

5 The rate of consumption of fertilizers and pesticides per hectare in Arab countries is one of the highest in the world (Brooks, 2007)

6 The percent of imported commodity for cereals is 50%, for sugar is 72%, for vegetable oil is 68%, for dairy products is 31% and for meat is 14%.

change and increase the low volume of treated water reused, which currently represents 20% of the total generated wastewater in the Arab region.

KEY MESSAGES FROM ARAB EXPERTS—MOVING FORWARD WITH SUSTAINABLE REUSE

"Most treated water reuse activities are driven by water scarcity and in turn strive for efficiency in terms of both allocation and more rational use of water." Marginal cost pricing can reduce excessive water use and pollution and can ensure the sustainability of wastewater treatment projects. Setting appropriate tariffs for treated wastewater thus provides an important incentive mechanism to encourage its reuse.

"From a planning viewpoint, Arab governments should concentrate on demand-driven planning of reuse projects". A good example for this is the Moroccan partnership developed between the golf courses of Agadir and Marrakech and the water agencies in those cities who supply them with continuous reclaimed water. This demand for treated effluent is driven by water scarcity across Marrakech, and high salinity of the groundwater in Agadir.

BOX 1 THE POTENTIAL OF RENEWABLE ENERGY DESALINATION TO CLOSE THE MENA REGION'S WATER GAP

As water scarcity becomes a more pressing concern throughout the Arab region, water managers are afforded two options to ensure greater water security: demand management and supply augmentation. Efforts to manage demand have been underway throughout the region by reducing waste in irrigation, addressing leakage in water supply networks while introducing incentives and adopting schemes to promote water savings. But for many countries, supply augmentation is still a necessary step—with the two most common approaches being water reuse and desalination.

In a recent study commissioned by the World Bank titled *Middle East and North Africa (MENA) Regional Water Outlook—Desalination and Renewable Energy Nexus*, water stress in the region is assessed (including the associated marginal cost of water supply to meet water supply needs) while the prospect of desalination to close MENA's water gap is explored. Importantly, this report goes a step further by assessing the potential application of renewable energy to desalination processes. As solar energy is widely abundant in the MENA region, finding ways to harness its potential—particularly through utilization of concentrated solar power (CSP)—can be especially useful. The report generates knowledge in this field while providing potential policy recommendations for Arab countries seeking to harness renewable energies for desalination. The environmental implications associated with desalination—and the discharge of residual generated from production—is of grave concern and the ways in which such environmentally-adverse impacts can be managed and reduced are also addressed.

Desalination technology is fast evolving making desalinated water progressively cheaper. The energy intensity of desalination is of concern for *all* Arab countries—whether due to competing demands on energy from various sectors in rapidly-growing and industrializing economies or general efforts to reduce fossil fuel consumption in countries seeking to export energy resources. Understanding current trends in the renewable energy sector—and its potential application to the desalination sector in MENA—is therefore of particular importance. Concentrated solar power (CSP) is beginning to demonstrate great promise; but the economic, financial, technical and environmental feasibility of its application in the MENA region is yet to be determined and is therefore explored within this report as well.

Refer to *Middle East and North Africa (MENA) Regional Water Outlook—Desalination and Renewable Energy Nexus, The World Bank, 2012* for a full copy of the report.

"Knowing how much different users are thus willing to pay for reclaimed water is critical." Rates for treated wastewater would be based on what the market could uphold, without taking into account the costs required. The willingness to pay for different customers varies depending on the expected economic return. Moreover an increased public awareness of the benefits of water reuse can lead to increased demand and also induce consumers to state a higher willingness to use and pay for reclaimed water.

"Reclaimed water is a valuable but limited water resource and investment costs should be proportional to the value of the resource." The selection of technologies should be environmentally sustainable, appropriate to the local conditions, acceptable to the users, and affordable to those who have to pay for them. Anaerobic treatment technologies are very useful to reduce operation and maintenance costs.

"The reuse of treated wastewater in the Arab region needs clear political support and promotion within local water resources strategies." Commitment to water reuse should be part of the proclaimed water policy and strategy in all countries of the Arab region.

"Arab countries should allocate funds to support applied research on sustainable wastewater treatment processes adaptable to the socioeconomic and climatic conditions of the region." The selection of reuse technologies should be determined by cost-effectiveness, relative ease of replicability and the capacity of local community to operate and maintain the infrastructure. A comprehensive cost-benefit analysis of various water reuse technologies can also have a major impact in selecting and investing in appropriate wastewater treatment technology.

"One of the most important lessons learned is that, to enable local end-users to feel confident with reclaimed water for irrigation, it is imperative to establish trusted institutions to ensure the highest standards of health and safety". Institutional strengthening of the water sector is required to instill and enforce standards, regulatory oversight and monitoring. It is important to note that those countries which have made most significant strides with water reuse (including Tunisia, Jordan, Gulf countries), fully fledged local or state regulations are supported by national guidelines and set the basic conditions for wastewater treatment and safe reuse.

"Arab countries should also develop a platform of dissemination of lessons learned from existing facilities in the Arab region" leading to improved information on the economic and financial benefits of reuse.

BASIC ECONOMIC CONSIDERATIONS OF WATER REUSE

Water reuse combines the benefits of freshwater conservation, surface and groundwater resource protection, and total water supply augmentation. Indeed, water reuse allows the preservation of freshwater resources for higher quality uses (such as potable water supply) and postpones potentially more costly water supply approaches (e.g., storage, transfer or desalination schemes). As such, water reuse is emerging as an established water management practice in several water-stressed regions of the world.

The spread of water reuse has been surprisingly uneven and slow across the Middle East and North Africa (MENA), despite its ranking as the most arid and water-scarce in the world. In the region to date, many reuse projects are either (i) pilot scale projects whose sustainability and replicability are uncertain or (ii) involve unplanned reuse of wastewater that is not treated to meet standards, such as those set by the World Health Organization (WHO). Further, even in locations with a policy climate favorable to water reuse, many of these projects face serious operational, financial and environmental obstacles.

In general, the development and implementation of water reuse strategies across the Arab world is challenged by a complex set of factors, described in more detail in the sections below:

- High cost of wastewater treatment and conveyance infrastructure;
- Insufficiency of economic analysis on wastewater treatment infrastructure projects;
- Technical and social issues affecting the demand for reclaimed water
- Low pricing of irrigation water that does not adequately reflect its cost;
- Difficulty in creating financial incentives allowing safe and efficient reuse;

HIGH COST OF WASTEWATER TREATMENT AND CONVEYANCE INFRASTRUCTURE

A major prerequisite to the development of water reuse schemes is upstream investment in adequate wastewater treatment, rates of which continue to lag behind those of wastewater col-

BOX 2 WATER REUSE TERMINOLOGY

Reclaimed water is wastewater that has gone through various treatment processes to meet specific water quality criteria with the intent of being used in a beneficial manner (e.g. irrigation). The term recycled water is used synonymously with reclaimed water.

Planned reuse is the planned use of treated wastewater for a beneficial use, such as agricultural irrigation and industrial cooling.

Ref: Asano et al, 2007

Unplanned reuse is the application or discharge of untreated sewage onto agricultural lands or into surface waters.

Direct reuse implies construction of storage and conveyance infrastructures that transport effluents from treatment works straight to the site of application.

Indirect reuse refers to the planned incorporation of reclaimed water into a raw water supply such as in potable water storage reservoirs or a groundwater aquifer, resulting in mixing and assimilation.

lection. Though countries across the Middle East and North Africa have made significant progress in extending wastewater collection services to urban populations in particular, significant gaps remain. Wastewater treatment plants, if they exist at all, are further often overloaded, under-designed and, plagued by poor operation and maintenance, do not consistently provide water quality that can be safely reused. The cost of transferring reclaimed water from urban centers (where most of the wastewater is produced) to agricultural areas (typically located in more distant, rural settings) is a further investment cost that can significantly impact the total cost of water reuse planning.

INSUFFICIENCY OF ECONOMIC ANALYSIS ON WASTEWATER TREATMENT INFRASTRUCTURE PROJECTS

Economic analyses of new wastewater infrastructure projects typically do not reflect water reuse as an end goal. Though most policymakers in the Arab world seem to be in favor of water reuse in principle, it is often included in the economic analysis of wastewater collection and treatment projects in hindsight, thus rendering economic justification of reuse investments much more challenging.

Cost-benefit analyses of water reuse policies and investments can be particularly complex given the number of costs and benefits that are not easily quantifiable. While some benefits have measurable market value (increase in crop

BOX 3 WHO GUIDELINES FOR THE SAFE USE OF WASTEWATER, EXCRETA AND GREYWATER

The WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater were published in 2006, with supplemental updates in 2008 and 2010. They were motivated by the adoption of the Millennium Development Goals in 2000, which include the eradication of extreme poverty and hunger, reducing childhood mortality, and ensuring environmental sustainability. Nutrient and water recycling can contribute to increased food security and nutrition and reduce environmental concerns related to waste disposal. This is only a credible strategy however if the health of farmers, their families, local communities and consumers is simultaneously ensured.

The Guidelines cover a range of policy, regulatory, standard-setting, and monitoring options based on a risk assessment and risk management approach that balance the benefits and risks of reuse. They do more than assess the risk and benefits of existing practices; the guidelines provide a framework for assessing and reducing risks with consideration of local social, economic, cultural, and environmental circumstances. The guidelines are evidence-based; created in a participatory process to achieve scientific consensus and assemble the best available evidence.

The Guidelines are built around a health component and an implementation component. The health component identifies health hazards and establishes an acceptable risk level. This risk level is used to define a level of health-based target for each risk which, in turn, is used to determine the appropriate health protection measures. The implementation component establishes monitoring and assessment activities, defines responsible institutions, and determines needed documentation and a means of independent confirmation through surveillance.

The Guidelines explicitly recognize that making targets too severe results in their not being widely adopted, leaving unsafe practices in place. By providing the methods, data, and references to allow standards tailored to each setting, the guidelines allow for the creation of a system that maximizes public health benefits and the utilization of scarce resources.

Courtesy of: The Water Institute at the University of North Carolina, 2012 yield and sales due to additional water supply for example), others are more difficult to measure (avoided cost of environmental degradation). Furthermore, many of the costs of planned reuse, including those of regulation, monitoring, training and awareness-raising etc are often overlooked in project planning and excluded entirely from the cost-benefit analyses.

TECHNICAL AND SOCIAL ISSUES AFFECTING THE DEMAND FOR RECLAIMED WATER

Despite the potential for reducing fertilizer costs and promoting higher yields, demand for reclaimed water in the Arab world is generally lower than that of alternative sources of freshwater. Consistent with economic theory, the relative demand for reclaimed water depends on the availability of substitutes. In the West Bank and Gaza for example, where farmers frequently lack water supply, surveys suggest that 80% of farmers accept reuse. Similarly, farmers living on the northern coast of Tunisia also accept water reuse because they have no alternative water source for irrigation due to groundwater salinity. In contrast, farmers who have a choice between reclaimed water and other sources consistently prefer to use the alternatives in spite of higher costs, because of social stigma and crop restrictions associated with reuse.

The role of social marketing and awareness-raising is thus critical in reducing opposition to water reuse in the Arab world. Though the involvement of religious authorities in awareness-raising activities has strongly diminished opposition to such projects for example, the pervasive lack of consumer awareness of water scarcity in general remains a major obstacle in many cases across the Arab world.

LOW PRICING OF IRRIGATION WATER THAT DOES NOT ADEQUATELY REFLECT ITS COST

Water prices in the Arab world generally do not reflect the cost or scarcity of water, especially in the agriculture sector. Partly as a result of low water prices and a reluctance to meter usage, most countries in the region utilize often non-renewable surface and groundwater at unsustainable rates. A market-based approach to managing a scarce resource would dictate that this practice would in turn push prices up. However, in the majority of Arab nations, this does not occur. While political pressures to keep prices low are well known, it is critical to implement pricing and sector reforms which better incentivize users (in agriculture and beyond) to conserve and optimize the use of local water resources, both fresh and reclaimed.

DIFFICULTY IN CREATING FINANCIAL INCENTIVES ALLOWING SAFE AND EFFICIENT REUSE

The difficulty in creating financing mechanisms for an investment in infrastructure and

regulation that provides combined public and private benefits (many of which are difficult to capture) is a major constraint to reuse projects. This can be seen in the fact that while most Arab countries have tackled the problem of wastewater collection and conveyance away from urban zones, (with substantial private benefits to connected households), the investment, operation and maintenance costs of wastewater treatment are often limited by financing constraints despite the significant environmental and public health benefits that ensue. Water reuse, which requires both collection and treatment upstream, thus presents further challenges.

Moving forward, constraints in the water sector make it unlikely that there will be a reuse revolution in the Arab world, but the importance of this policy option will surely increase over time. Despite the many challenges to the sustainable implementation of water reuse described above, evolving conditions across the Arab world will encourage a more systematic consideration and implementation of water reuse. Urbanization and its associated increased demand for domestic water and production of wastewater, along with continued reduction in available freshwater, increasing tourism and the preferences of a more educated urban population will all play a critical role in affecting plans for wastewater treatment, increasing demand for locally produced safe and high-value agricultural products, and in encouraging ecological and recreational uses of water.

INFRASTRUCTURE INVESTMENTS ENABLING SUSTAINABLE REUSE

Expanding wastewater collection, treatment and storage capacity has been a national priority of a number of Arab countries. Such infrastructure investments have been particularly useful in overcoming challenges that inhibit realization of water reuse's full potential.

In the case of Tunisia (Case Study 1), for example, locations where the bulk of wastewater is generated (the urban north) tend to be far from where it is most needed (the rural center and south). Tunisia has thus invested in piped infrastructure and storage capacity. Examples such as the As Samra wastewater treatment plant in Jordan (Case Study 2) further show that methane collection at wastewater treatment plants can significantly offset energy requirements. The case of Oman (Case Study 3) further demonstrates that utilization of high-tech solutions such as membrane bioreactors can overcome space constraints commonly faced in densely populated urban environments, while the case of Morocco and Tunisia demonstrate the value of pilot projects to determine proper infrastructure solutions for wastewater treatment and reuse.

Successful upgrades of infrastructure have also demonstrated the value of partnerships—between the state and civil society, the private sector and research community. A number of examples from the region, highlighted below, showcase the importance of brokering research and pilot projects in determining ideal wastewater treatment and reuse solutions.

CASE STUDY 1

TUNISIA: EXPANSION OF PIPE INFRASTRUCTURE AND STORAGE CAPACITY

In Tunisia, all large and medium sized cities (up to 30,000 inhabitants) maintain sewage treatment facilities, with 109 plants currently in operation. Treatment plants are being initialized for small urban and rural localities (less than 5,000 inhabitants). By the end of 2010, the volume of treated wastewater reached 240 million m^3, which represents 5% of available water resources; the volume is expected to grow to 500 million m^3 by 2021.[7]

Most treatment plants are located along the urban coast to prevent marine pollution and protect coastal resorts. Tunis and its four wastewater treatment plants (total capacity of 97 million m^3 per year) produce most of the country's treated wastewater (42%), while the North, the Center and the South produces 20%, 22% and 16% respectively. Treated wastewater is primarily reused for agricultural irrigation, golf courses irrigation, landscape irrigation in urban areas and for artificial groundwater recharge. The total area equipped for irrigation with treated wastewater is 8065 hectares. While this area is spread over the entire country, 53% (4300 ha) are located near Tunis. The Cap Bon region in particular is a major consumer of treated wastewater for irrigated agriculture. For the period 2000–2009, the area effectively irrigated represents on average 47% of the total area equipped for irrigation with treated wastewater which is relatively low.

As most of the treated wastewater is produced in greater Tunis, a study of its transfer to other zones of high water demand was undertaken.[8] This study identified potential zones for agricultural reuse and evaluated the technical,

7 Municipal wastewater is mainly domestic (80%). The proportions of wastewater from industries and from tourism are of 15% and 5% respectively. A small portion (20–30%) of the treated volume is reused while the majority is released into natural water bodies (i.e. rivers, the Mediterranean Sea).

8 Tunisia's freshwater resources are primarily concentrated in the country's North (roughly 60%) while the Center and the South maintain 18% and 22% of freshwater resources respectively. In terms of surface water, the distribution is more heavily skewed 81% of surface water resources concentrated in the North.

economical and environmental feasibility of the transfer. From 2009–2014, a national agricultural reuse initiative aims to develop 18 new irrigated projects on 7010 hectares as well as extend and rehabilitate existing irrigated projects by 1480 and 5000 hectares respectively. A major project for transfer of treated wastewater from Tunis to the country's arid interior is also planned for the period 2016–2021 and will include irrigation of 25,000 ha as well as aquifer recharge of 30 million m^3.

Successful expansion of future water reuse infrastructure (particularly for irrigation purposes) is contingent on a number of conditions, which include the following:

1. **If treated wastewater is to be reused for agricultural irrigation, the quality is absolutely imperative**. Treatment facilities should therefore include disinfection treatment of secondary effluents to increase the quality and mitigate farmer reticence.
2. **Storage facilities are necessary** to balance a constant supply of treated wastewater with agricultural demand which varies by season. As irrigation is practices for only limited months of the year, such facilities enable regulation of supply and reduce effluent discharges to the environment when supply exceeds demand.
3. **When irrigation is being expanded to new domains, farmers should be provided with a single choice of treated water reuse alone**. Experience from Tunisia would come to show that when farmers are given a choice between freshwater and treated wastewater, farmers tend to opt for the latter.

Under the National Rural Sanitation program, the country aims to increase water reuse capacity in rural areas as well. New construction of piped sewerage infrastructure and wastewater treatment plants is included in housing developments accommodating 210,000 inhabitants in 47 different rural sites. Projects are currently underway and expected to be completed by 2017.

BOX 4 INDUSTRIAL WASTEWATER MANAGEMENT IN TUNISIA

In Tunisia, industrial wastewater is closely managed and monitored with the concerted aim of (a) meeting the needs of industrial development, (b) avoiding the discharge of raw industrial effluents into the environment, (c) preventing the contamination of potable water resources and (d) eliminating adverse agents found in industrial effluents and its by-products.

To achieve such aims, Tunisia identifies industries with high pollutants loads and either requires pre-treatment of effluent prior to discharge into the sewerage network or connection to a specialized treatment facility. Industrial units producing effluent with pollutant loads similar to domestic users are allowed to discharge effluents into the conventional sewerage network.

An example of an industrial wastewater treatment facility includes Ben Arous, located in the Medina Jadida zone (a southern suburb of Tunis). Commissioned in 2001, the facility treats highly toxic effluents, which cannot by treated by conventional wastewater plants. As the industrial activity is diverse and include leather tanning, printing, metal working, battery manufacture, textiles and food processing, effluent is treated in two separate plants: one dedicated for the chemical treatment of the industrial wastewater containing heavy metals and another dedicated for biological treatment of industrial wastewater primarily of an organic nature. The treatment capacity is 520 m^3/day for chemical treatment and 5000 m^3/day for biological treatment. The plant is designed for an organic load of 3000 Kg/day and is also equipped for treatment of odors.

The Tunisian government expects to conduct a number of technical and financial feasibility studies to expand the country's industrial wastewater treatment capacity. Treatment plants are planned for industrial sites at Utique, Moknine, Sfax, Bassin d'Oued Bey, Enfidha and Fejja.

CASE STUDY 2

JORDAN: AS SAMRA WASTEWATER TREATMENT PLANT

With rapid urban population growth in Amman, Zarqa and Russeifa, the Jordan Ministry of Water and Irrigation rehabilitated the existing As-Samra Stabilization Pond-Wastewater Treatment Plant and expanded treatment capacity from 68,000 m^3/day to 268,000 m^3/day. Such an expansion would accommodate flows estimated at 186,000 m^3 while leaving room for expected population growth.[9]

As-Samra's expansion included construction of a new mechanical treatment plant equipped with state-of-the-art technology able to treat effluent for agricultural reuse, produce fertilizer from sludge as well as generate clean energy. Treated effluent is sold to the Ministry of Water and Irrigation, to be used by farmers in the Wadi Dhleil, the Jordan Valley and the King Talal Reservoir areas. And given the scarcity of fossil fuels in Jordan and the high cost of energy, the ability of the plant to generate energy from sewage is particularly significant as it offsets the energy required for treatment.

Operational since 2007, As Samra is considered a national milestone in urban sanitation. However, while current capacity is expected to accommodate the sanitation needs of up to 2.5 million Jordanians, additional expansion of capacity is anticipated. USAID has therefore financed the design of a Master Plan covering the period between 2000 and 2028. Recommendations include provision of conveyance lines (connecting the Zarqa River, most towns in the Zarqa Governorate and Greater Amman Municipality) as well as a two-phase solution for As-Samra. With Phase 1 already accomplished with construction of 267,000 m^3/day capacity, Phase 2 is to include construction of a second plant meant to accommodate increased loads from Zarqa, Russeifa and select areas of Amman. Based on current projections, the new As-Samra plant will require expansion by 2015.

9 The United States Agency for International Development (USAID) was the primary financier of the As Samra rehabilitation and expansion. While the project was financed under a Build—Operate—Transfer (BOT) scheme, USAID issued a grant to cover 47% of total construction cost. The As Samra project is considered the first BOT scheme to be implemented in Jordan.

CASE STUDY 3

OMAN: IMPLEMENTING HIGH-TECH SOLUTIONS FOR WATER REUSE

Haya Water, the water authority of Oman's capital, Muscat, has implemented a number of high-tech solutions to increase energy and space efficiencies of wastewater treatment, while complying with quality standards to ensure treated effluent is reused for irrigation and eventually aquifer recharge. In addition to water quality compliance, Haya is also required to meet the compliance with respect to sludge quality and odor emission norms.

The Standard for wastewater treatment as enforced in the Concession Agreement for the New Sewage Treatment Plant and by the Ministry of Regional Municipalities, Environment and Water Resources is one of the major criteria for adoption of appropriate technology.

Technologies for sewage treatment processes are selected such that they shall be capable of consistently producing a treated effluent with constituent concentrations less than the allowable concentrations as per the Agreement.

An example of innovative technologies includes membrane bioreactors (MBRs) used at the Al Ansab and Darsait wastewater treatment plants. Utilization of MBR significantly reduces the required geographic footprint of the facility. This is especially useful in situations where wastewater treatment is carried out in urban environments and land is limited. In the case of Al Ansab, the treatment plant's capacity was expanded to become currently the world's largest

MBR plant in terms of capacity without requiring further land acquisition.

Sequencing batch reactor (SBR) process and ultra filter (UF) memebrane systems are other noteworthy technologies utilized at the A'Seeb wastewater treatment plant. SBR is particularly effective in nutrient removal for irrigation purposes and producing sludge for fertilizers. UF is effective in producing treated effluent of a particularly high quality.

Along with increasing energy efficiency of the wastewater sector by maximizing the use of gravity-flow, the Quriyat wastewater treatment plant utilizes screw press dewatering technology. Such a technology has demonstrated particular energy efficiency in separating suspended solids from sewage.

In the near future, a number of upgrades are foreseen with plans to invest an estimated USD 4.3 billion to expand wastewater collection, transmission and treatment in Muscat. USD 634 million is earmarked towards the construction of new wastewater treatment plants alone. Planned activities include expansion of the A'Seeb plant, construction of an additional wastewater treatment plant at Darsait as well as new constructions at Amerat and Qurayat.

PARTNERSHIPS WITH CIVIL SOCIETY AND THE PRIVATE SECTOR

Experience from the region demonstrates that the development and success of water reuse infrastructure partially rely on a participatory approach to planning. In Tunisia, for example, inclusion of farmers associations in the planning of wastewater infrastructure made such civil society groups more willing to offer support in activities related to operations, maintenance and supervision of infrastructure.

Similarly, the private sector can play a significant role in ensuring the long-term success of infrastructure. Tunisia for example has built partnerships with the private sector in the operations and maintenance of infrastructure. In recent years, plants have been made to increase the number of delegated treatment plants from 10 to 47, with many sub-contracting agreements evolving into concessions. Such a move increases

BOX 5 MAJOR URBAN SANITATION IMPROVEMENT IN POST-CONFLICT IRAQ

After several decades of conflict and economic sanctions, Iraq faces a major sanitation challenge. Only 17% of wastewater currently undergoes treatment, a major setback from 1990 when sanitation services covered nearly 75% of the urban population (25% through sewage systems and 50% through on-site septic tanks) and close to 40% of the rural population. (UNESCO, 2010; the World Bank, 2006). Inadequate funding and maintenance, poor planning and design as well as an ageing infrastructure have led to a significant reduction in rates of wastewater collection and treatment (Bakir, 2001; Fund 0.2006). In Baghdad, wastewater infrastructure is particularly overloaded. While the capital's three wastewater treatment plants have a total design capacity of 680,000 m^3 per day, actual capacity is nearly double at 1,325,000 m^3 per day.

To address such challenges, the Baghdad Sewage Directorate has embarked on several projects including:

- Construction of 2 wastewater treatment plants under the Karkh Sewage Project with a combined capacity of 200,000 m ^{3}/day.
- Construction of 13 new wastewater treatment plants in areas far from main carrier lines and existing treatment facilities.
- Construction of several pumping stations and sewer mainlines along Al Quds Street, within the Karkh district, from Al Rabie district to Tunisia district and from Al Habibiya station to Rustumiya wastewater treatment plant.

the likelihood of private sector participation in the financing, expansion and construction of new infrastructure. By June 2009, the private sector operated 2206 km of sewers and 17 wastewater treatment plants. Pursuant to the new regulations, the Tunisia's National Sanitation Utility, ONAS, has entrusted a specialized consultancy firm to design concession contract model specifications (ONAS, 2009b).

RESEARCHING THE POSSIBILITIES OF WATER REUSE FOR AGRICULTURE

Since the 1990s, Morocco has pursued a number of pilot projects to determine and design appropriate infrastructure for water reuse. Some noteworthy pilots include projects carried out in Agadir and Khouribga. In the former, lessons learned from the Ben Sargao pilot project[10] were expanded upon to determine the technical and economic feasibility of a commercially viable water reuse scheme in Agadir as well as the feasibility of using sand beds to treat wastewater. In the latter locale, a pilot project was carried out to determine potential water reuse application for industrial activity—a first in Morocco. As the city's main economic activity—phosphates processing—requires considerable amounts of water, treated wastewater was seen as a viable alternative to drawing from scarce freshwater resources. Commissioned in 2010, this pilot continues operations today and produced 18,000 m^3 of treated wastewater per day.

In Tunisia, a research program co-financed by UNDP (OPE/RAB/80/011) was undertaken between 1981 and 1987 by a multi-disciplinary team from the National Institute of Research for Rural Engineering Water and Forestry. The objective was to determine the conditions to use reclaimed wastewater and sewage sludge in agriculture taking into account their composition, soil types, different crops and sanitary aspects. The experiments led to the set up of specific methodologies, especially for the physical, chemical, and biological analyses and tests carried out in the field. The results of work were published in a final report and helped clarify the chemical and

10 The town of Ben Sargo located near the city of Agadir produces about 750 m^3/day of sewage. The WWTP has a pre-treatment unit, primary treatment by anaerobic settling ponds, and then further treatment on infiltration sand beds. The investment cost of this method of treatment were found to be 3 to 4 times lower than that of an activated sludge treatment and cost of operation and maintenance almost $ 0.8 Dh/m^3 treated water with water quality meeting WHO standards.

biological composition of Tunisian wastewater before and after treatment. The impacts of treated wastewater and sewage sludge applications on to the water-soil-plant system were also established. Recommendations were formulated for safe agricultural reuse of reclaimed wastewater and were further used in the preparation of sector regulations.

Research continued within the framework of different programs carried out with national or international funds including (a) the optimization of chemical fertilization of crops irrigated with reclaimed wastewater, (b) seasonal storage and its effects on wastewater futures,[11] and (c) the role of micro-irrigation techniques in mitigating the health risks associated to water reuse for crop irrigation.

11 The work confirmed that storing reclaimed water in basins is of particular interest for water resources management. It constitutes further treatment which reduces the microbial contamination of water to a level where it can be used for the irrigation of all crops, without restriction.

KEY MESSAGES FROM ARAB EXPERTS

While a number of successes can be noted in the water reuse sector of the Arab region, various challenges nevertheless exist which have prevented a high proportion of water reuse from being implemented throughout the region. The experiences of Jordan, Morocco, Oman and Tunisia nevertheless demonstrate some general lessons learned which include the following:

- **The importance of considering a wide variety of technologies** for infrastructure investments and upgrades to include aerobic and anaerobic processes, advanced and simple technologies. Sludge management should also not be overlooked.
- **The importance of civil society partnerships**: Alongside the development of concrete infrastructure is the significance of engaging civil society. A participatory approach to planning infrastructure can result in long-term

payoffs especially when considering shared responsibilities in operating and maintaining infrastructure. Cultivating a local buy-in is key in this regard and can have wide ranging implications for the long-term sustainability of water reuse.

- **The promise of public private partnerships**: Examples such as Oman and Tunisia demonstrate the potential of private sector engagement in terms of financing as well as building, operating and maintaining infrastructure. Concession agreements with the private sector therefore should be considered as a potential option when upgrading infrastructure.
- **The value of brokering research**: Examples such as Morocco and Tunisia exhibit the importance of brokering research and piloting projects to determine geographically, socially, and economically appropriate infrastructure. It is important to note that even within the MENA region, a prototype or technology successfully implemented in one geographic context does not necessarily translate into success in another. Partnerships with research institutes and the academic community—both in-country and regionally—can prove particularly useful. Partnerships with international development agencies as well as international research institutes can be leveraged to carry out research.


2000

BENEFITS OF REUSE IN AGRICULTURE

Planned water reuse for agriculture and irrigation is emerging as an established water management practice in several water-stressed countries of the Arab region. Use of reclaimed water is an attractive option and entails a number of benefits for several reasons, including:

- **Reduction of surface water pollution** commonly resulting when wastewater is discharged into the environment;
- **Postponement of potentially more costly water supply augmentation projects** (i.e. storage, transfer and/or desalination schemes);
- **Nutrients in treated wastewater** can reduce the need for applying chemical fertilizers, thereby reducing costs and potentially adverse effects associated with fertilizers;
- **Savings of high quality freshwater** since reclaimed water can be further used in industrial cooling; landscape irrigation; fire protection; and toilet flushing beyond irrigation.
- **Greater water security** given the stability of wastewater supply.

Nevertheless, a number of risks are associated with water reuse and warrant specific attention in agriculture. Such potential risks include:

- **Health risks to agricultural workers** resulting from fields irrigated with untreated or inadequately treated wastewater.
- **Health risks to consumers** of agricultural goods produced from untreated or inadequately treated wastewater.
- **Contamination of soils and plants** through introduction of chemicals found in inadequately treated wastewater.
- **Ground and surface water pollution** from infiltration of contaminated irrigation water.

Though concerns over the environmental and health implications of reuse are constant, Arab countries have demonstrated success in irrigating marginal desert lands, man-made forest plantations, golf courses and urban landscapes with reclaimed water. A number of success stories, are highlighted in the case studies below.

CASE STUDY 1

EGYPT: REUSE OF WASTEWATER FOR AGRICULTURE

Agriculture is the largest water consumer in Egypt with its share exceeding 80–85% of the total demand for water. By 2017, the National Water Resource Plan estimates that total water requirements will exceed 90 billion cubic meters (BCM). Therefore, Egypt is faced with a strategic challenge as its renewable water supplies cannot be expanded. Increased levels of compromised water quality may further diminish available water suitable for some purposes.

To cover the growing shortfall, the National Water Resources Plan calls for increased use of fossil desert aquifers—rising from 0.9 BCM in 1997 to 4 BCM in 2017. However, exploiting non-renewable groundwater is unsustainable. Ensuring positive, long-term water outlooks for Egypt therefore depends on finding solutions for reducing freshwater extractions of its agriculture sector. Non-conventional water resources can therefore play a larger role in fulfilling Egypt's growing water demands. Potential non-conventional water resources for Egypt's agriculture sector include the following:

- Agricultural drainage water reuse could be increased from 4.7 to 9.0 BCM/year by 2017
- Reuse of treated wastewater could be increased from 0.70 to 2.97 BCM/year by 2017.

Use of treated wastewater has become increasingly important in water resources management for both environmental and economic reasons. Since 1980, interest in the use of treated wastewater as a substitute for fresh water in irrigation has accelerated. The capacity of wastewater treatment plants has increased by more than six times in the last two decades with current capacity estimated at 12 million m^3/day. At present, 323 wastewater treatment plants exist across the country. The length of wastewater collection networks increased from 28,000 km in 2005 to 34,000 km in 2010.[12] By 2017, the coverage rate is expected to increase significantly in areas outside large urban centers.

Significantly, alongside instituting a policy to officially include water reuse in the national water portfolio,[13] the Government of Egypt has also implemented a number of institutional reforms, which include newly issued guidelines for mixing drainage water with fresh water, regulations for sewage and industrial effluents, water reuse, cropping patterns, and health protection measures and standards specifications. With relation to institutional and financial aspects, the Holding Company for Water and Wastewater—along with 23 subsidiary companies—was established in 2004 by presidential decree to expand service delivery, introduce modern wastewater treatment and reuse technology, as well as increase the role of private sector actors in the operations and maintenance of wastewater infrastructure.

While still limited in its relative scope, Egypt has nevertheless embarked on a number of large-scale, planned and regulated water reuse applications in agriculture. Large scale pilot projects include sites in East Cairo, Abu Rawash, Sadat City, Luxor, and Ismailia totaling 167,000 feddan. In 14 governorates and 2 districts, 80,000 feddan of marginal desert land have been allocated for 63 tree plantations irrigated with treated wastewater. Actual cultivated area totals roughly 12,000 feddan while fallow area is roughly 68,000 feddan.

12 While the Government of Egypt has made significant progress in providing sanitation services for its citizens, domestic and municipal wastewater collection systems and treatment facilities remain largely concentrated in major urban centers (i.e. Cairo, Giza, Alexandria and cities along the Suez Canal). The low coverage rate and sub-optimal treatment has therefore resulted in serious water quality problems in rural areas in particular.

13 Water reuse is an old practice in Egypt. Treated wastewater (after primary treatment) has been in the Gabal Al Asfar farm (3,000 fedans) since 1911, while sandy soils in Al Gabal Al Asfar and Abou Rawash near Cairo have been irrigated since the 1930s.

BOX 6 CENTRALIZED OR DECENTRALIZED? THE BENEFITS OF DECENTRALIZED WASTEWATER MANAGEMENT IN RURAL AND PERI-URBAN ENVIRONMENTS

Recent studies in Egypt have indicated that for economic reasons, it may not be possible to provide sewerage facilities for all residents of rural and peri-urban areas—either now or in the near future. As a result, the Government of Egypt has begun considering refocusing its wastewater management strategy from the construction and management of regional sewerage systems to that of decentralized wastewater treatment facilities. Given the fact that in the near future, increasing demands are being made on freshwater supplies, it is clear that decentralized systems will increase opportunities for localized reclamation/reuse.

Unbundling sanitation projects into smaller-scale projects can bring benefits at an affordable cost to those in greatest need. In the case of rural Egypt, decentralization enables the division of investments into more realistic and manageable components. From a technical perspective, decentralized sewerage is also appropriate in areas with flat terrain and a high groundwater table such as the Nile Delta region. Dividing such areas into self-contained zones eliminates the need for expensive pumping stations and interceptor sewers required to serve the whole area with a regional sewerage system.

CASE STUDY 2

TUNISIA: WATER REUSE FOR AGRICULTURE

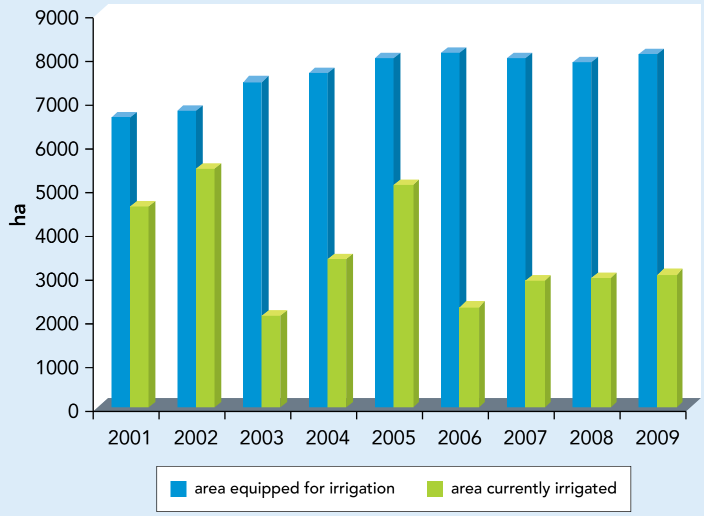
In Tunisia, the total area equipped for irrigation with treated wastewater has increased steadily, while the actual area irrigated with wastewater has varied significantly from year to year (Figure 1). The disconnect in trends can largely be explained by the variability in rainfall over the years with increases and decreases in areas corresponding with increases and decreases in surface water availability.

From 2000–2009, the area effectively irrigated with treated wastewater represents on average 47% of the total area equipped for irrigation—a relatively low figure. Currently, the best levels of reclaimed water reuse are recorded on fruit orchards and in the arid zones of the centre and the south of the country. Among 8065 ha that may be irrigated with reclaimed wastewater, 4646 ha (representing 59% of the total area) are equipped with saving water techniques.[14] The rest is irrigated following the traditional practice of furrows and flooding.

Future programs for agricultural reuse for the period (2009–2014) include the development of 18 new irrigated schemes on 7010 ha and the extension (1480 ha) and rehabilitation (5000 ha) of select irrigated schemes currently in operation.

14 The main saving water techniques used on reclaimed wastewater irrigated areas are: (1) improved surface irrigation, (2) sprinkler irrigation and (3) drip irrigation. These three techniques are used on 66, 32 and 2% of the equipped area respectively.

FIGURE 1 Evolution of treated wastewater irrigable and irrigated area



Significantly, efforts are underway for the transfer of treated wastewater from Tunis to the country's arid interior—with a long-term goal of irrigating over 25,000 ha and recharging aquifers with 30 million m^3. In a recent study on the transfer of Tunis' wastewater to other zones of high water demand, potential zones for agricultural reuse were identified while the technical, economical and environmental feasibilities of wastewater transfer were evaluated.

CASE STUDY 3

JORDAN: WATER REUSE IN THE JORDAN VALLEY

The Jordan Valley Authority (JVA) has been an integral part of water reuse activities in Jordan. Established in 1977, the Authority is responsible for socio-economic development in areas that surround the Jordan River and extend into the Yarmouk and Zarqa basins, northern reaches of the Dead Sea and down to the northern border of Aqaba.

The Jordan Valley serves as one of the Hashemite Kingdom's primary agricultural regions and comprises of 33,000 hectares of irrigated land. Yet large tracts of arable land (particularly surrounding the Dead Sea (roughly 10,000 hectares) remain to be irrigated. To expand irrigated lands and safeguard existing groundwater resources, treated wastewater effluent has increasingly been tapped for agricultural purposes. It is expected that treated wastewater effluent will comprise a significant portion of irrigation water in the future.

However, the JVA maintains an outlook to ensure treated wastewater is used towards the highest value purposes. Along with instituting a number of irrigation efficiency measures, the JVA looks to allocate water towards activities demonstrating the highest financial and social returns. Such a stipulation helps promote greater water efficiency, productivity and competitiveness of the Jordanian agriculture sector.

Since 2002, the Government of Jordan has been implementing several agricultural pilot projects utilizing treated wastewater with the support of international organization (i.e. Aqaba and Wadi Musa projects). The overarching objective is to demonstrate that water reuse can be reliable, commercially viable, socially acceptable, environmentally sustainable and safe. In this particular project, fodder crops (namely alfalfa) and fruit trees were irrigated. The boosted productivity of the treated wastewater irrigated lands is significant with the direct beneficiaries being farmers whose income, standards of living and economic status were elevated—thereby reducing unemployment and poverty.

CASE STUDY 4

ALGERIA: HEALTH REGULATIONS AND MONITORING OF WATER REUSE FOR IRRIGATION

The Algerian Ministry of Water Resources is entrusted with the task of elaborating regulations of the water sector. Amongst the 5 technical and 4 administrative departments included within the ministry, the Department of Purification and Environmental Protection and the Department of Regulation and Litigation help ensure safe regulation of water reuse—both from the technical and administrative management and monitoring of water reuse.

Law No. 05-12 (August 2005) allowed for the use of treated wastewater effluent for irrigation purposes. In May 2007, procedures and specifications detailing under what conditions wastewater could be reused for irrigation purposes were detailed. In December 2008, the Ministry of Water Resources conducted a study on reuse (at the national level) with four concerted objectives: (1) recognition and collection of all data for the development of the study, (2) study of a master plan for reuse of treated wastewater, (3) development of a pilot study for the reuse of treated wastewater for agricultural purposes while defining the types of crops and industrial purposes water reuse would be appropriate. Attention was also paid towards other items such as groundwater recharge, and (4) development of draft standards for reuse.

Significantly, an inter-departmental decree was established to (i) detail exact crops which can be irrigated with treated wastewater, (ii) establish a list of laboratories responsible for carrying out quality monitoring of treated wastewater for irrigation and (iii) set the specifications of treated wastewater used for irrigation.[15]

Monitoring is carried out at the local level. Hydraulic services of the wilaya are required to monitor and control (i) the quality of treated wastewater for irrigation, (ii) changes in water quality of groundwater, and (iii) conditions of storage facilities and distribution. With relation to agriculture, wilayas are also responsible for monitoring the development of crops irrigated by treated wastewater as well as the soil quality of plots irrigated by treated wastewater. Wilayas are also made responsible for monitoring the health of laborers involved in the agricultural plots involved in irrigation.

Currently, 15,770 hectares are being irrigated with treated wastewater, with plans to grow this number to 40,000 hectares during the period from 2010 to 2014. And as climate change has proven to have increasingly adverse impacts on regularity of freshwater supply, demand for treated wastewater has increased. It is because of this demand that nearly 100 wastewater treatment plants have been constructed. The demand for wastewater has therefore helped propel Algeria in meeting in Millennium Development Goal for Sanitation.

15 Crop varieties which have been allowed to be irrigated by treated wastewater are (1) fruit trees, (2) citrus, (3) fodder crops and shrubs, (4) industrial crops (i.e. cotton, tobacco, flax), (5) cereal crops, (6) seed and tuber crops (i.e. potatoes, beans, peas), and (7) herbs to be dried or industrially processed.

BOX 7 EXPERIENCE FROM OUTSIDE THE REGION: SINGAPORE'S SUCCESS IN WATER REUSE REGULATION

Singapore has long-suffered from water scarcity, with a history of relying on Malaysia to make up for its water supply-demand gap since 1961. Water reuse has therefore increasingly become a viable option in closing this gap. Under this scheme, the Government of Singapore has embarked on treating wastewater to produce high-quality **NEWater.**

By utilizing a combination of microfiltration/ultrafiltration, reverse osmosis, and ultraviolet disinfection, Singapore has been able to convert wastewater into high quality NEWater. Currently Singapore has 5 water reclamation plants: Kranji, Seletar, Jurong, Ulu Pandan and Changi. However, reaching such success has required many years of experimentation and monitoring to ensure safe results.

While the use of water reuse technologies has been tested since 1974, the lack of reliability of membranes and their associated high cost made it implausible to utilize until the 1990s. Initiated in 1998, a two-year NEWater study was launched to ascertain the suitability of using high-quality reclaimed wastewater as a source of raw water. The first demonstration plant had a capacity of 10,000 m^3/day. The quality of reclaimed water produced was consistently tested while the capability and reliability of membranes was consistently monitored.

Under the Sampling and Monitoring Program (SAMP), a total of 205,000 analysis tests have been conducted to date. Treated effluent is tested for 296 parameters—with 96 parameters stipulated by United States Environmental Protection Agency and 113 specified by the World Health Organization. The Health Effect Testing Program (HETP) compliments SAMP by assessing the quality of NEWater against reservoir water while monitoring the short and long term health effects NEWater may have on animal species—with possible carcinogenicity, toxicology, and estrogenic potential monitored.

Assessments carried out by international expert panels have noted in their audit that (a) NEWater quality is well within international drinking water standards, (b) NEWater is as suitable as raw reservoir water, and (c) NEWater bears no adverse health concerns which can be noted. Such endorsement has lent substantial credibility to the safety of NEWater.

CASE STUDY 5

EGYPT: WASTEWATER IRRIGATION TO COMBAT DESERTIFICATION

As an active participant in the formulation of the UN Convention to Combat Desertification (UNCCD) adopted in Paris in 1994, Egypt has placed great emphasis on the (a) prevention and reduction of land degradation, (b) rehabilitation of partly degraded land, (c) reclamations of desertified land. As part of its commitment to the UNCCD, Egypt has prepared a National Action Plan (NAP), which identifies factors contributing to desertification and prescribes practical measures to combat it. Priority actions under the NAP include the following:

- Transform 400,000 feddans desert lands into ecologically rich areas.
- Reduce the climate in arid and semi-arid areas adjacent to desert boundaries and protect cities from sand and dust storms.
- Increase air quality and absorption capacity of carbon dioxide.

To achieve such objectives Egypt established a number of forest plantations and roadside forests irrigated with wastewater. While producing high-quality timber, such projects expand the green stretch into deserts and stabilize sand dunes. Also significant is that such plantations find uses of wastewater, while limiting unregulated discharges into the environment.

An innovative afforestation scheme includes the Jatropha Curcas plantation in the Luxor Desert, which is irrigated by treated wastewater from Luxor city and produces crops used for biofuel. The yearly yield per hectare is up to 5 tons of seed, which can produce up to 1.85 tons of oil. Given the success of such a project, the Central Administration for Afforestation at the Ministry of Agriculture and Land Reclamation (MOALR) has begun efforts to expand cultivation of Jatropha curcas to other sites in the country, especially in the South. Importantly, such a scheme has not only had positive environmental benefits but has also generated jobs for unemployed rural youth.

CASE STUDY 6

TUNISIA: WASTEWATER IRRIGATION OF TOURISM INFRASTRUCTURE

In Tunisia, water reuse has bolstered the country's high-value agricultural production and contributed to the country's overall economic development. Treated wastewater is primarily used to irrigate fruit orchards (citrus, grapes, olives, peaches, apples and pears), fodder crops (sorghum, alfalfa, maize), cereals, and industrial crops such as tobacco. However, Tunisia has also found other high-value applications of reclaimed wastewater—particularly towards irrigation of golf courses and urban landscapes. Of the 8065 hectares irrigated with treated wastewater, golf courses comprise 11% (Tunis, Hammamet, Tabarka, Sousse, Monastir, Djerba, Zarzis) and green areas (i.e. hotel grounds) comprise 4%.

Other associated benefits of water reuse include cost savings and increased reliability. With relation to the former, quantities of chemical fertilizers required for production are significantly reduced with substation of nutrients draws from treated wastewater while with relation to the latter, treated wastewater supply is significantly more consistent than the rain. Such benefits have been particularly useful for Tunisia in its efforts to develop its tourism industry.

CASE STUDY 7

UNITED ARAB EMIRATES: ABU DHABI MUNICIPAL WATER REUSE FOR AGRICULTURE

In the United Arab Emirates (UAE), water demand is expected to double (from 4.5 BCM to 9 BCM) between 2010 and 2030. Much of this demand is primarily attributed to agriculture irrigation needs. Such a reality has proven difficult for the UAE, where groundwater resources are limited and urban population is increasing. As urban populations increase however, so do the volumes of wastewater; and, there lies great potential in the UAE for reusing urban wastewater for agricultural purposes.

In Abu Dhabi, urban areas generate roughly 550,000 m^3 of wastewater daily and are treated in 20 wastewater treatment plants. All facilities are equipped to treat effluent for reuse in irrigation. While most wastewater treatment plants are publicly owned and operated by the Abu Dhabi Water and Electricity Authority, four large-scale plants were built in joint ventures with the private sector under build-own-operate-transfer (BOOT) arrangements. Successful construction and operation of facilities at Al Wathba, Allahamah and Al Saad are testament to successful public private partnerships in providing irrigation water from treated urban wastewater.

With further urban growth in Abu Dhabi city, there is a very large increase in urban wastewater expected. The Abu Dhabi government has therefore embarked on the Strategic Tunnel Enhancement Program which will construct a new 40-kilometer long wastewater tunnel meant to accommodate increased wastewater flows. The opportunities for reuse in agriculture are therefore expected to increase.

KEY MESSAGES FROM ARAB EXPERTS

The use of treated wastewater should be considered an integral component in a country's agriculture and irrigation strategy. However, in order to bolster water reuse, regional experience offers a number of factors which are important to consider and include the following:

- Despite the many benefits of water reuse for agriculture and irrigation purposes, regional experience also demonstrates a number of constraints namely:
  - **Financial constraints** (i.e. high construction costs of treatment systems and sewerage networks, high operational costs especially for electricity, low prices of freshwater relative to treated wastewater, and low user willingness to pay for reclaimed wastewater).
  - **Health impacts and environmental safety** especially linked to soil structure deterioration, increased salinity and excess of nitrogen.
  - **Standards and regulations**, which are in some cases too strict to be achievable and enforceable and, in other cases, not adequate to deal with certain existing, reuse practices.
  - **Absence of monitoring and evaluation capacity** in both treatment and reuse systems, often related to lack of qualified personnel, lack of monitoring equipment or high cost required for monitoring processes.
  - **Technical constraints**, including insufficient infrastructure for collecting and treating wastewater, inappropriate set up of existing infrastructure (not designed for reuse purposes), improper functioning of existing infrastructure.
  - **Institutional set-up** and poor coordination of appropriate personnel
  - **Lack of political commitment** and of national policies/strategies to support treatment and reuse of wastewater.

– **Lack of communication and coordination** among the many authorities working in wastewater treatment and reuse of treated effluents.
– **Lack of public acceptance and awareness**, related to low involvement and limited awareness of both farmers and consumers of crops grown with reclaimed wastewater (and/or sludge).

- **"It is imperative that treated wastewater be allocated to areas and contexts of high demand**" The experience from Jordan shows that allocating treated effluent towards activities which demonstrate the highest financial and social returns helps ensure that the benefits derived from water reuse are maximized. Such a measure can help ensure greater productivity of the agriculture sector. Similarly, in Tunisia, piped infrastructure of treated effluent was connected to locales demonstrating high demand for water and freshwater alternatives are unavailable.
- **"Determining specific crop varieties is critical"** When wastewater is reused for irrigation of food crops, Egypt's example demonstrates that differentiating which types are appropriate for treated effluent irrigation is useful. Particularly when crops are expected to undergo an additional step of processing (i.e. cooking) or are not edible, less stringent standards can be applied to the quality of treated effluent used for irrigation.
- **"The importance of health regulations and monitoring cannot be overemphasized"** While water reuse for agriculture and irrigation purposes requires less stringent standards than for potable water use, it is nevertheless important to establish a baseline of standards to regulate wastewater. The experience of Algeria demonstrates the importance of implementing official statutes and monitoring treated wastewater quality to insure the continued health of agricultural workers as well as the safety of the agricultural products themselves. Throughout the region, weak regulatory compliance and enforcement remains a major challenge.
- **"Regulations should be harmonized and streamlined"**: In many Arab countries, regulations and standards related to water reuse have been implemented in a piece-meal fashion. It is therefore worth considering an overhaul of regulations and standards to be harmonized and simplified. Such an effort helps ensure ease of following and enforcement.
- **"Regulations and Standards are only enforced with regular monitoring"** A regulation only bears weight when effectively and consistently enforced. Further to this point, political commitment to enforce such standards is also important.
- **"Pilot projects are highly valuable"** While useful in determining appropriate prototypes and technologies to implement, pilot projects also have the added benefit of showcasing results to direct beneficiaries which helps overcome stigmas and reservations associated with using treated effluent for irrigation purposes.
- **"Communication is key**". Communicating between authorities as well as those engaging in water reuse is important to success of enforcing such regulations.

SUSTAINABLE COST RECOVERY MODELS TO SUSTAIN WATER REUSE

A number of the Arab region's public water supply and sanitation utilities suffer from weak performance, insufficient funds, a lack of qualified personnel and deteriorating infrastructure. Often, such challenges originate in poor governance, ineffective and misdirected policies as well as a lack of competition amongst service providers. Increasingly, governments throughout the region have come to consider the private sector as a possible partner in improving public service delivery.

Public private partnerships in the Arab region's water and sanitation sector are a relatively recent phenomenon—primarily implemented over the past two decades. Various country experiences with public private partnerships (PPP) are diverse and an overarching verdict on the region's experience with PPP is yet to be determined. Nevertheless, PPPs in a variety of forms have been implemented—with a variety of options identified amongst the finance, operations and maintenance and capital investment agreements forged between the public and private sectors. While PPPs initially began in the potable water sector, such partnerships are expanding into the wastewater treatment and reuse sectors.

While PPPs are not necessarily an all-encompassing solution to cure all challenges faced by public utilities, select experiences from the region have demonstrated the great promise of the private sector in improving service delivery, increasing efficiency and achieving financial solvency. Examples include Oman (Case Study 1) where a 30 year concession established in 2003 is already demonstrating positive outcomes for Muscat. In Saudi Arabia (Case Study 2), special purpose vehicles are proving to be a useful form of PPP, while in Jordan (Case Study 3), micro-private sector partnerships in water reuse are delivering results. Issues of financing and pricing are also important as demonstrated in Algeria and Morocco. Together, these experiences offer some snapshots on experiences within the Arab region with PPPs and offer some lessons learned for other governments seeking to pursue coordination with the private sector in water reuse delivery.

CASE STUDY 1

OMAN: MUSCAT AND HAYA WATER

As part of the Sultanate of Oman's Vision 2020 Development Plan,[16] the Government formed a number of limited liability companies with a mandate to takeover wastewater services for major cities. For the capital city Muscat, the Oman Wastewater Services Company—also known as Haya Water—was formed in 2003 and made responsible for daily operations, maintenance and management of the city's wastewater management system. However, as the city required expanded wastewater services, Haya Water was also responsible for planning, designing and implementing state-of-the-art wastewater collection, treatment and disposal systems. Heavy emphasis was placed on inclusion of water reuse in such infrastructure investments.

In the past, the Governorate of Muscat's five wastewater catchments (Bawsher, As Seeb, Al Amerat, Darsait and Quriyart) were served by standalone systems with limited networks, conveyance provided by tanker services and smaller treatment plants. Haya Water current Master Plan aims to provide more comprehensive coverage by increasing connectivity and wastewater treatment capacity. Figure # shows the five wastewater catchments of Muscat as of 2010.

While the current level of connectivity in Muscat Governorate is roughly 20%, Haya Water aims to achieve 80% connectivity by 2018 and 93% connectivity by 2035. Such aims are to be achieved under the Capital Works Programs for Treatment Plants and Networks (CAPEX). By 2025, Haya Water will operate 6 major wastewater treatment plants in Muscat Governorate, 23 smaller treatment facilities in surrounding villages as well as 2200 km of sewer and 320 km of treated effluent networks. The Haya Water Preliminary Master Plan (2004) was developed on historical census data and the Master Plan Study for Drinking Water (June, 2000). The revised Master Plan (2010) was altered to account for projected population growth and expected waster demand increase through 2035.

16 Initiated by His Majesty, Sultan Qaboos, the Vision 2020 Development Plan aims to modernize, improve the quality of life and institute environmentally sustainability throughout the Sultanate of Oman. The Vision 2020 Plan is a continuation of a long-term national development strategy pursued since 1975.

CASE STUDY 2

SAUDI ARABIA: ENGAGING THE PRIVATE SECTOR TO IMPLEMENT THE TREATED SEWAGE EFFLUENT INITIATIVE

To support the future success of public private partnerships in wastewater treatment and reuse, the Kingdom of Saudi Arabia's National Water Company (NWC) pursues a three-pronged approach.

- To ensure financial sustainability, NWC works to establish revenue streams prior to privatizing a utility.
- To ensure guaranteed revenue streams, NWC signs long-term agreements with major water customers—particularly when a new site seeks to connect a site to the treated wastewater network. The contracts, generally for terms of up to 25 years, are fully bankable sales agreements which will provide an early revenue stream for the anticipated special purpose vehicles (SPVs). To date, it is believed that NWC has signed agreements for TSE worth in excess of SAR 5 billion.
- To ensure infrastructural sustainability, NWC awards engineering, procurement and construction (EPC) contracts to either re-furbish or enhance capacities of existing wastewater treatment plants.

Currently, the Kingdom of Saudi Arabia's National Water Company (NWC) is developing a clear business plan for privatization of wastewater treatment and reuse infrastructure through the special purpose vehicle (SPV) model, which is relatively new to Saudi Arabia. SPVs offer great potential in isolating and managing potential financial risk, allowing access to new revenue streams and wider markets, enabling the encashment of assets and contracts via transfer to the SPVs, and increasing opportunity to embrace global best practice. NWC holds firm to the belief that a market-led approach, with suitable protections that reflect NWC's goals and objectives, will allow the market to maximize reuse and optimize arrangements for the benefit of all. Nevertheless, the process is still ongoing to quantify and structure the precise arrangements to ensure effective cost recovery, while staying true to NWC's principles of improving KSA's macroeconomic environment, promoting sustainable development, and promoting citizens' welfare.

CASE STUDY 3

JORDAN: MICRO-PRIVATE SECTOR PARTICIPATION IN WATER REUSE

In Jordan, the Ministry of Water & Irrigation (MWI) and the Water Authority of Jordan (WAJ) have developed a concept of Micro Private Sector Participation (PSP), which engages the Jordanian private sector to take on specific activities. General responsibilities include functions such as billing and revenue collection, water loss reduction, leak repair, geographic information systems (GIS) and information and communication technology (ICT) management and development, amongst other activities. With this approach, local expertise is utilized and built, dependence on foreign assistance is reduced and preparatory work for more macro PSP contracts models is achieved.

The commercialization and participation of Jordanian private sector companies in the operations and management of water supply and wastewater disposal systems has been an important element of the Ministry of Water and Irrigation (MWI), Water Authority of Jordan (WAJ) and the whole water sector strategies. Responsibilities taken on by the private sector include the following:

- All customer service operations (i.e. new water/wastewater customer connection, meter reading, reading assessment, billing, field inspection, bill distribution, collection and debt management)
- GIS & ICT Units (management & updating of all water and wastewater mapping information, GIS applications backstopping & development of further business tools, ICT infrastructure and applications)
- Implementation of GIS based tools in customer management, management of redesign CIS and sewerage data base.

In the Madaba Governorate, a relatively small-scale model of public private partnership (PPP) has been pursued since 2006. The Micro PSP involved outsourcing customer service operations to Engicon Company. Aims of the partnership were to improve water and wastewater revenue, to increase the billing rate and to develop the customer management organization thereby improving efficiency. To achieve this, staff training and customer surveys and maps were implemented to facilitate metering.

By downscaling the geographic reach of the utility, the Madaba Water Administration was able to issue its own bills instead of having to rely on government channels. The accuracy of meter reading improved and net billed water increased by 75%. Net collections increased from (0.9) million in 2005 to (1.9) million in 2008. The levels of nonrevenue water (NRW) initially dropped from an average of 45% to 34%, but in 2009 they were back at 40% due to an increase in water pumping pressure. Advantages of the Micro-PSP model include the fact that the Water Authority of Jordan maintained asset ownership and that all revenue collected went to the Authority, so that investment costs could be fully recovered within 13 months of operation. A performance-based contract further set strong incentives for the private operator to deliver concrete results.

SELECT MENA COUNTRY EXPERIENCES WITH FORMING A CONCESSION

CASE STUDY 1

OMAN AND HAYA WATER

In Oman, the wastewater sector operates within an intricate statutory, regulatory, environmental and political landscape. Working under a 30-year concession, Haya Water has begun to prove itself as an innovative example of the government partnering with private finance to develop wastewater infrastructure. Established in accordance to the Commercial Companies Law in the Sultanate of Oman, Haya Water tariffs and service charges are defined in the Concession Agreement and can only be adjusted using the specifications and procedures stated in the Concession Agreement.

Company objectives as defined under the Concession Agreement are as follows:

- Development of organizational structures and the appointment of appropriate staff to manage and operate the system with the possibility of entering into a contract with a company or a separate specialized company to do the work in part or in full.
- Design and development of programs to ensure the highest level of services for project beneficiaries as well as operation and maintenance. Haya Water is further granted the ability to subcontract operation and maintenance to specialized subcontractors.
- Implementation of awareness-raising and health education programs.
- Collection of tariffs and development of appropriate mechanism for coordination with the competent authorities in the collection of revenues.
- Control of the quality of treated wastewater.

CASE STUDY 2

ALGERIA: DIFFERENTIAL PRICING FOR SANITATION SERVICES

In Algeria, the National Office of Sanitation (ONA) is entrusted with issuing concessions of public service sanitation by the Ministry of Water Resources (ADE). Under such concessions, either part or all of the management of a sanitation system can be delegated to public or private parties on the basis of a convention. An August 2005 law has defined the procedures for granting and delegation activity of sanitation. Currently, five wilayat (Algiers, Oran, Constantine, Annaba and Tarf) are governed by a management contract established between ONA / ADE and foreign private operators. Important to this scheme is pricing, which is set by the state according to the cost of providing such wastewater services. These costs take into account geographic concerns and therefore employ differential pricing based upon geographic zone (Algiers, Oran and Constantine, Chlef, and Ouargla). Differential pricing also takes into account different categories of water consumers (i.e. Category 1: Households, Category 2: Government, Artisans and Services Sector and Category 3: Industrial and Tourism entities). Significantly, sanitation pricing also corresponds to the volume of water supplied to users of drinking water.

CASE STUDY 3

MOROCCO: JOINT PUBLIC-PRIVATE FINANCING OF WATER REUSE INFRASTRUCTURE

In Marrakech, a partnership between the Government of Morocco, the State Board of Marrakech (RADEEMA) and tourism / golf course developers launched a joint wastewater treatment and reuse project. Under this scheme, treated wastewater (approximately 90,720 m^3/day) will be routed to irrigate golf courses and the palm groove as well as urban green spaces. The project will allow the city to triple its area dedicated to golf courses, with long-term plans to irrigate golf courses exclusively with treated wastewater. The project's treatment process utilizes activated sludge followed by tertiary treatment by rapid filtration and UV disinfection.

Investment costs as well as those of the complementary treatment of the STEP were insured by the State and RADEEMA (70%) through its own financing and a loan from the Communal Equipment Fund (FEC). The remaining investments (30%) were borne by the private sector. Operating expenses related to tertiary treatment, pumping and transportation of treated wastewater to golf courses will subsequently be subject to an agreement between RADEEMA and the private promoters.[17]

17 A similar partnership between the government and private sector is demonstrated in a pilot project carried out in the 1990s related to water reuse for golf courses. As part of a public-private partnership between the municipality of Benslimane, ONEP and a private operator managing a golf club in the city, a wastewater treatment facility processes a flow of 5600 m^3/d (aerated lagoons and operational ponds). Treated wastewater meets WHO standards and is transported to irrigate the golf courses. The private operator, owner of a golf club, pays all operating expenses of the wastewater treatment plant.

KEY MESSAGES FROM ARAB EXPERTS

Among the diverse experiences with PPPs across the MENA region, a number of general conclusions can be drawn including:

- **The importance of strong political support**: Examples such as Oman and Saudi Arabia demonstrate how important it is to create an environment which enables the private sector to achieve success in wastewater treatment and reuse. An enabling environment entails legislative change, regulation and political commitment (sometimes in the form of an initiative or master plan). Responsibilities cannot simply be handed over from the public to private sector with the expectation that positive outcomes will inevitably result.
- **PPP do not need to be large-scale**: Experience from Jordan comes to show that PPPs need not be carried out on a broad scale. Many successful PPPs can be noted from downscaled, decentralized and more localized service provision provided by the private sector.
- **Differential pricing offers potential promise**: The case of Algeria demonstrates that differential pricing of sanitation services can help ensure cost-recovery while allowing for individuals and organizations of diverse economic means to pay at different rates.
- **End users can also be potential investors in WWR infrastructure:** The example of Morocco and Saudi Arabia comes to show that the end user can also be tapped in certain instances to finance infrastructure expansions. If demand for treated effluent is high enough, the end user should also be considered as a potential investor in infrastructure expansions as well as operations and maintenance

ELEMENTS OF A SUCCESSFUL NATIONAL WATER REUSE STRATEGY

Conflicting demands on increasingly scarce water resources have warranted a number of Arab countries to establish a national water strategy to manage existing water resources. The intrinsic connection between water and economic development throughout the Arab region adds greater urgency to properly allocating water resources and considering inclusion of treated wastewater to grow a national water portfolio.

CASE STUDY 1

MOROCCO

In Morocco, to consolidate past successes and to overcome a number of emerging challenges, the National Water Strategy was drafted. Included within this Strategy are the following three points:

- **Protection of the quality of water resources and prevent pollution**: This action is based on knowledge of current quality of water resources and an overarching goal of preventing pollution. Specifically, it consists in

BOX 8 INFRASTRUCTURAL IMPROVEMENTS TO MAKE WATER REUSE A NATIONAL PRIORITY: EXPERIENCE FROM KUWAIT

As one of the only countries in the world without natural lakes or perennial rivers, Kuwait has long sought alternative water resources. A combination of a harsh climate and rapid growth of demand on freshwater resources due to increasing urbanization and agricultural expansion have further added to this grave need. The Ministry of Public Works—through its sanitary engineering sector—has therefore prepared a number of technical studies and provided technical assistance to develop and renew wastewater infrastructure for water reuse.

Current work includes renovation of old networks (i.e. replacement of damaged pipes and manholes) as well as improvements to the sewerage distribution networks. Also in plans are efforts to expand the capacity of existing wastewater treatment plants (WWTP) while also building new ones. Activities include expansion of the Umm Al Hayman WWTP from 20,000 m^3/day to 650,000 m^3/day to help relieve stress on the Riqqa WWTP and expansion of the Sulaibiya WWTP (which already is the world's largest RO WWTP) from 425,000 m^3/day to 600,000 m^3/day. Such activities run in line with the Kuwait Sanitary Master Plan, which lays out a strategy for the development of Kuwait's sanitary system until 2045. The Plan will incorporate strategy related to the development of sewers, pumping stations and sewage treatment plants, as well as the interaction with final effluent distribution and sludge management.

Significantly, as demand for treated wastewater has been so high, Kuwait has found it necessary to also construct an extensive treated sewage effluent distribution network which consists of a data monitoring center, holding tanks of various sizes, pumping station as well as extensive pipe infrastructure.

accelerating the pace at which national goals for sanitation coverage and wastewater treatment rates are met.

- **Further regulatory and institutional reforms**: Since the early 1990s, Morocco has been equipped with a modern legislative arsenal through the enactment of significant laws, especially Law 10-95 on water and the environment. However, enactment of such a law must also be complemented with completing the legal framework necessary for the implementation of all provisions of Law 10-95, particularly the polluter pays principle.
- **Supply management and development**: Morocco has invested extensively in water resource mobilization, and these efforts are to be expanded to a larger scale by the mobilization of non-conventional water resources which include desalinated sea water, demineralized brackish waters, and the reuse of treated wastewater. 300 Mm^3/year of treated wastewater is planned to be reused in the watering of golf courses and green space, in addition to reuse in crop irrigation.

CASE STUDY 2

SAUDI ARABIA

Saudi Arabia's Treated Sewage Effluent Initiative (TSEI) provides large volumes of treated wastewater to customers for uses including agricultural, industrial, commercial, and district cooling uses among other non-potable purposes and has created an environmentally friendly and financially sustainable long-term market for treated sewage effluent.

TSEI benefits include: (i) addressing the water shortage challenges in KSA and conserving scarce water resources, (ii) developing new infrastructure and operating it efficiently and (iii) providing environmental benefits such as net carbon reductions, by indirectly contributing to lesser capital requirements for power and water generation. To maximize the potential of water reuse

BOX 9 THE UNITED NATIONS SECRETARY GENERAL'S ADVISORY BOARD ON WATER AND SANITATION (UNSGAB)

The objectives of the UNSGAB are to (a) help mobilize resources for water and sanitation towards achievement of the Millennium Development Goals (MDGs), (b) publicly mobilize support while advocating for actions and ensuring political visibility, (c) assessing progress made towards the water and sanitation goals and (d) advocating for improving the capacity of governments and the international system. HRH Prince Willem-Alexander of the Netherlands is Chair of the Board while HIH The Crown Prince of Japan serves as the Honorary President of the Board.

In 2010, the United Nations lent significant support towards expanding sanitation services in developing countries. While the world is on track to meeting its drinking water targets, it is well behind meeting its sanitation targets. For this reason, the Sustainable Sanitation Half Decade—The 5 Years Drive to 2015 initiative has been launched. In a high-level plenary meeting on the MDGs, it is noted that concerted efforts will be made in "redoubling effort to close the sanitation gap through scaled-up ground-level action, supported by strong political will and increased community participation, in accordance with national development strategies, the mobilization and provision of adequate financial and technological resources, technical know-how and capacity building for developing countries, to increase the coverage of basic sanitation, noting the global efforts to realize 'Sustainable Sanitation Half-Decade—5 Years Drive to 2015.

and bolster TSEI activities, the National Water Company (NWC) further created TSE Business Development Unit which better pave the way for special purpose vehicles (SPVs) formation.

Experience from Saudi Arabia and TSEI comes to show that public private partnerships (PPPs) offer great promise in delivering a national strategy for water reuse. While discussed in the previous chapter in more detail, it is important to note that Business Development Department has been successful in improving the sale of treated wastewater and creating private sector investment opportunities for the private sector in the field of water reuse in developing and constructing new treatment plants with the purpose of increasing the overall capacities of treating domestic wastewater.

CASE STUDY 3

JORDAN

In Jordan, the inclusion of water reuse in its National Water Strategy in 1998 was a signal of placing high priority on the value of reclaimed water. Wastewater represents 10% of Jordan's total water supply (WaDImena, 2008) and up to 95% of its treated wastewater is currently reused (MED WWR WG, 2007). While the Government of Jordan has carried out significant and comprehensive plans to expand wastewater treatment throughout the country, the Ministry of Water and Irrigation prioritization of expanding water reuse capacity and inclusion of treated effluent in its overall water strategy is deeply significant.

As national efforts to develop the agriculture sector in the Jordan Valley requires availability of water resources, inclusion of treated wastewater in irrigation portfolios has added greater pressure to pursue a national strategy for water reuse. Three government agencies are therefore tasked with the responsibility of incorporating water reuse within a country's water strategy: (1) the Ministry of Water and Irrigation (MWI), the Water Authority of Jordan and the Jordan Valley Authority (JVA). A brief description of each agency is as follows:

- **Ministry of Water and Irrigation (MWI)**: Established in 1988, the Ministry of Water and Irrigation is the official body responsible for the overall monitoring of the water sector, water supply and wastewater system and the related projects, planning and management, the formulation of national water strategies and policies, research and development, information systems and procurement of financial resources. Its role also includes the provision of centralized water-related data, standardization and consolidation of data. Establishment of MWI was in response to Jordan's recognition of the need for a more integrated approach to national water management. MWI has developed applicable strategies and programs for the implementation of water policy. More specifically the Ministry seeks to address critical issues facing Jordan's water sector which include the imbalance between growing demand and diminishing supply as well as to properly allocate water resources which account for the development of the domestic, industrial, agriculture and tourism sectors conjunctively.

- **Water Authority of Jordan (WAJ):** Established in 1983 as an autonomous corporate body, with financial and administrative independence, WAJ is directly linked with the Prime Minister. The Water Authority was responsible for the public water supply and wastewater services, as well as for the overall water resources planning and monitoring. In 1988, the Water Authority linked with the Minister of Water and Irrigation. WAJ carries full responsibility for the public water supply, wastewater services and related projects as well as for the overall water resources planning and monitoring, construction, operations and maintenance.

- **Jordan Valley Authority (JVA):** Established in 1977, JVA carries out integrate socio-economic development of the Jordan Valley area. Main responsibilities include: (a) the study, design, implement, operate and maintain irrigation projects, dams and water harvesting in Kingdom, (b) survey, classify and identify lands in addition to reclaim and divide these lands into agricultural and residential units and set up the organizational, structural and detailed layout for lands located off the planning boundaries of the municipalities, (c) preservation of Jordan rights in transboundary waters through joint regional water committees with neighboring countries, and (d) bulk water supplier for different uses, according to priorities and adopted water policies for domestic, industry and irrigation purposes. JVA also develops water resources for irrigated agriculture, which include treated wastewater. JVA also conducts studies to assess water resources, settles disputes amongst water users.

Also significant are a number of limited liability companies which operate and maintain infrastructure while carrying out the actual water reuse goals set out by the three Jordanian agencies entrusted with guiding the country's national strategy on water reuse. These companies include the Jordan Water Company—Miyahuna, the Aqaba Water Company and the Yarmouk Water Company.

Currently, Jordan has more than 20 wastewater treatment plants which are equipped with reuse capability and include As Samra, Wadi As-Sir, Abu Nuseir, Aljiza and Talbiya, Mechanical and Natural Wastewater Treatment Plants in Aqaba, Wadi Mousa, Ma'an, Baqa'a, Salt, Fuhais and Mahis, Madaba, Tafileh, Karak, Jarash, Kufranja, Irbid, Wadi Arab, Ramtha, Mafraq, and Wadi Hassan. All treated effluent is used towards safe irrigation.

BOX 10 NATURAL WASTEWATER TREATMENT IN AQABA

In Aqaba, a natural wastewater treatment plant was established in 1986 according to a designed capacity of (9000) cubic meters per day, and receives nearly 40% of the wastewater produced by the city. In this station wastewater is purified by oxidizing organic matter naturally.

Currently, work is underway to upgrade the existing plant to accommodate a daily flow of (24,000 m^3) in 2020. Half the effluent water will be reused for irrigation. The remaining effluent is mechanically treated for industrial use (2.5 MCM/year).

Significantly, this wastewater treatment plant answers environmental needs as well. Wild life flourishes next to the settlement tanks around the natural treatment plant where migrating birds of various species have found an oasis along avian migratory paths. The Jordanian Society for Sustainable Development (JSSD) has a location in this area to monitor the migrating and domestic birds which also many researchers and investigators visit for the same reason..

KEY MESSAGES FROM ARAB EXPERTS

The region's experience with creating a national strategy for water reuse is diverse. Nevertheless a number of items are identified as factors to consider for creating a national strategy which include:

- **"A National Strategy requires a complimentary investment planning and budgeting strategy"** The experience of Algeria demonstrates that in order for a National Strategy to be successful, a parallel investment planning and budgeting scheme needs to be devised to ensure success.
- **"Anticipate a need to spend much time coordinating amongst institutions"**. Implementing a National Strategy is likely to involve a large number of institutional actors. It is advised that when implementing such a strategy that proper time be allocated and anticipated for coordinating between various actors. Consensus building approaches to decision-making can be useful in this regard.
- **"Partnerships with the Private Sector can be useful and should not be overlooked".** The example of Saudi Arabia demonstrates that the private sector can be considered a possible partner in implementing a national strategy

MOVING FROM PRINCIPLE TO PRACTICE

This short report provides a snapshot of the reality of water reuse in Arab countries and communicates key messages and priorities from water sector experts in the region.

The emerging recommendation of the Expert Consultation Meeting recommend a holistic risk-analysis to set up guidelines adapted to each country's social, economic, and environmental circumstances. The various country case studies further demonstrate the wide range of water reuse practices around the Arab region, and illustrate the futility of prescribing a single, rigid management approach. These recommendations summarize the lessons learned in different Arab countries, and point to future steps to be taken for safe and sustainable water use under the local and regional diverse conditions.

Explore, adapt and adopt efficient and environmentally appropriate technologies

Technology selection should focus on the type of reuse anticipated, proximity to source of effluent, environmental sustainability, local conditions, and affordability. Simple solutions that are easily replicated, that allow further up-grading with subsequent development and that can be operated and maintained by the local community are often considered the most appropriate and cost effective.

Apply realistic standards and regulations and promote appropriate monitoring and evaluation mechanisms to minimize its risks to public health and the environment

An important element in sustainable water reuse is the formulation of a framework of realistic, achievable and enforceable standards for treated wastewater quality and applications. Monitoring and evaluation of water reuse programs and projects are fundamental and thus must overcome the Arab region's challenges of weak institutions, shortage of trained personnel, lack of monitoring equipment and the relatively high cost required for monitoring processes. Two types of monitoring are recommended: first, process control monitoring to provide data to support the operation and optimization of the system in order to achieve successful project performance; the second, compliance monitoring to meet regulatory requirements and not to be performed by the same agency in charge of process control monitoring.

Strengthen the legal and regulatory environment regarding water reuse

The establishment of clear policies with regard to wastewater management and water reuse across Arab countries is required in order to guide programs, projects and investments relating to wastewater collection, treatment, re-use and disposal in a sustainable manner. These policies should be compatible with other local policies including those on national water management and irrigation, health, sanitation, agriculture and the environment. Policies of water reuse and strategies for its implementation should be part of water resources planning at the national level. At the local level, individual reuse projects should be part of the overall river basin planning effort.

Improve coordination and networking among Arab institutions involved in the water sector

The responsibilities of the various organizations involved in wastewater collection, treatment and reuse must be considered and reconciled by improving coordination among stakeholders and the donor community. Improved participatory approaches (especially with farmers) are further needed including raising the awareness of the general public on the benefits of water reuse.

Enhance public awareness, participation and dissemination of best practices

To achieve general acceptance of re-use schemes, it is of fundamental importance to have active public involvement from the planning phase through the full implementation process.

Encourage demand-driven planning of water reuse.

Demand management and water conservation strategies remain the most cost effective approaches to reduce withdrawals. Water reuse should thus be oriented to demand-driven planning of reuse projects, and commitment to the reuse.

Mobilize financial resources for wastewater treatment and reuse and encourage public-private partnerships in wastewater treatment and reuse.

Adopting an adequate policy for the pricing of water is of fundamental importance in the sustainability of water reuse systems even if subsidizing reuse system may be necessary at the early stages of system implementation, particularly when the associated costs are very large.

Identify a center of excellence for regional programs on wastewater treatment and reuse for the Arab region including training and capacity building.

Arab countries should designate a center of Excellency, specialized in wastewater treatment and reuses technologies with the aim of (i) organizing regional training courses for exchange of experience (ii) establishing a joint regional data base for water reuse projects and (iii) establishing a website for communications and dissemination of information.

Support research and innovation in wastewater treatment and reuse.

Arab countries should allocate the required funds to support applied research to find sustainable wastewater treatment processes adaptable to the socioeconomic and climatic conditions of the Region.