Water

Arab Forum for Environment and Development (AFED)

I. INTRODUCTION

If "water is life" and adequate clean water is a "fundamental human right" as argued in international forums, why is the progress in dealing with the water crisis in Arab countries so slow? One reason is inadequate finance. The funding in most national budgets and international assistance loans or grants is surprisingly low. There is a discrepancy between commitments and actions, between needs and actual spending.

A combination of national government budgets, international and bilateral funding, debt relief, private sector investments and community-level resources are required. Arab governments must also establish the enabling institutional framework for encouraging private investments and public-private partnerships for clean water and sanitation. Another key source of funding is revenues from water pricing.

Artificially low prices for water services (and sometimes no pricing at all) are at the root of inefficiency, overuse, excessive pollution releases and environmental degradation. Simply put, free water is wasted water. While water pricing has been advocated for a long time, particularly in irrigation, it is seldom enacted even though it is central to increased investment in the sector. Arab governments cannot meet the investment demands for water services now, let alone in the future. And the private sector will not invest unless it can be assured a reasonable return. Yet Arab governments continue to resist water pricing and the phase-out of subsidies, arguing that the poor cannot afford to pay. In fact, middle class areas pay low prices for networked water services, while the poor pay much higher prices for poorer quality water from street vendors.

This chapter is compiled from the comprehensive report on Arab water published by Arab Forum for Environment and Development (AFED) in 2010, entitled Water: Sustainable Management of a Scarce Resource, and recommendations of the 2010 AFED annual conference which debated the report's findings. It also refers to the flagship report on Green Economy published in 2011 by the United Nations Environment Programme (UNEP).

While substantial financial resources are needed, finance alone will not solve the water crisis. Moreover, experience shows that technological or engineering solutions by themselves will not be effective without the necessary policy, institutional and legal reforms. Land tenure reforms, demand management practices, transparent water rights and allocation systems, economic incentives, improved legal and regulatory frameworks, creation of basin management authorities, and public participation are all necessary pieces of the policy reform. Empowering women's groups, the poor, youth, and community-based groups to have an adequate voice in participatory decision-making is also essential.

Ultimately, the water crisis cannot be addressed in isolation from other crises such as land degradation, deforestation and ecosystem loss. Taking an integrated approach that considers the links between water, land and people, and making the necessary reforms and investments in all these areas can go a long way towards sustainable water management. Deforestation and degradation of watersheds mean that less fresh water is available. Conserving fresh water ecosystems through better management would not only help maintain the quantity of available water, but its quality as well.

In water management, the task sometimes seems overwhelming. How to coordinate services, industry, trade, transport, agriculture, fisheries, science, environment, development goals, waste management and diverse populations? How to involve various international agencies, levels of government, the private sector and non-governmental organizations (NGOs)? How to forge international action when upstream nations see little direct benefit in preventing pollution that affects downstream users; when coastal nations see little incentive for protecting wetlands that sustain fisheries used by other nations; when countries with trans-boundary groundwater aquifers feel no obligation to protect recharge zones from degradation that affects the wells of their neighbors?

These are not insignificant questions since 43% of the world's population lives in international river basins, which cover almost half the planet's land surface and contain over 80% of the fresh water river flow. There are also countless aquifers that cross political boundaries. Water scarcity has the potential to increase tensions among nations that share water resources. The water crisis, however, has many dimensions and varies across regions. Water supplies are scarce in some regions and relatively abundant in others. And the effects of long-term climate change are also likely to vary across regions.

All features of the global water crisis manifest themselves in the Arab region. The state of water resources and management in most Arab

countries is precarious. Population growth and escalating demand for water in the region have reduced per capita supply to one-fourth of its 1960 levels. Without fundamental change in policies and practices the situation will get worse with both political and economic ramifications.

The 2010 annual report of the Arab Forum for Environment and Development (AFED), Water: Sustainable Management of a Scarce Resource, highlighted the state of water management and use in Arab countries and articulated the policy reforms needed. This chapter is a summary of its findings and suggested recommendations.

II. WATER SECTOR OVERVIEW

The water sector in Arab countries suffers from multiple strains. Arab countries rank last in renewable freshwater availability per capita compared to other regions of the world. Currently, 13 Arab countries are among the world's 19 most water-scarce countries. Per capita water availability in 8 Arab countries is below 200 m^3 per year. By 2015, it is expected that average annual freshwater availability in Arab countries will be below 500 m^3 per capita, designated the severe water scarcity mark. In 2025, only Sudan and Iraq are expected to be above the water scarcity level. In some Arab countries, total water withdrawals already exceed available renewable water resources. In fact, internal renewable freshwater resources per capita in most Arab countries are already below the water scarcity level of 1,000 m^3, compared to a world average of over 6,000 m^3. More than 45 million people in the Arab world still lack access to clean water or safe sanitation. The growth in population in the coming two decades, 90 percent of which will occur in urban areas, will increase the political pressure to meet these demands especially for domestic and industrial use.

TABLE 1 **WATER AVAILABILITY AND USAGE IN ARAB COUNTRIES**

	Annual Availability						Annual Water Usage		% Use by Sector		
Country	Natural Renewable Resource Bm^3/year	Desalinated End Water Bm^3/year	Wastewater Reuse Bm^3/year	Per Capita Renewable Availability m^3 (2006)*	2015** (AFED) m^3	2025** (AFED) m^3	Bm^3	As a % of Total Water Resources	Domestic	Industry	Agriculture
Algeria	11.50	0.07	Neg.	350	297	261	4.59	40	25	15	60
Bahrain	0.11	0.14	Neg.	157	125	106	0.25	170	26	3	71
Djibouti	0.02	0.00	Neg.	367	306	260	0.02	113	88	0	12
Egypt	61.90	0.06	5.90	773	641	552	73.10	108	6	8	86
Iraq	80.00	0.03	n.a.	2652	1989	1551	42.80	48	3	5	92
Jordan	0.87	0.00	0.07	164	114	98	0.98	104	26	7	68
Kuwait	0.11	0.65	0.12	7	5	4	0.76	87	37	2	60
Lebanon	3.20	0.00	n.a.	1110	999	919	1.29	40	28	4	68
Libya	0.80	0.03	n.a.	99	80	67	3.89	469	9	4	87
Morocco	20.00	0.02	0.07	940	620	558	16.84	84	5	-	95
Oman	1.60	0.12	0.02	550	440	365	1.22	74	9	1	93
Qatar	0.05	0.12	n.a.	71	50	40	0.28	n.a.	23	3	74
Saudi Arabia	2.50	2.28	0.15	96	77	64	17.00	506	15	1	84
Sudan	24.00	0.00	0.00	1711	1369	1122	19.00	5	6	5	89
Syria	18.70	0.00	0.26	865	650	550	14.70	78	9	1	87
Tunisia	3.35	0.00	0.14	450	405	373	2.53	72	12	4	84
UAE	0.20	0.95	0.14	35	26	20	1.60	180	24	10	67
West Bank & Gaza	0.76	0.00	0.01	215	160	120	0.44	57	51	49	58
Yemen	2.50	0.02	0.03	97	70	50	3.20	126	5	2	93

Source: World Bank, 2003
(Figures collected in 2002-2003)

Neg: negligible volume of used water
n.a: Not available

* *Total Actual Renewable Water Resources (TARWR) per capita figures from World Water Development Reports 2 (2006) and 3 (2009), UNESCO. TARWR tables are based on AQUASTAT FAO. Index web-update site accessed on 19 July 2010. http://www.unesco.org/water/wwap/wwdr/indicators/pdf/Table_4.3_Updated.pdf*

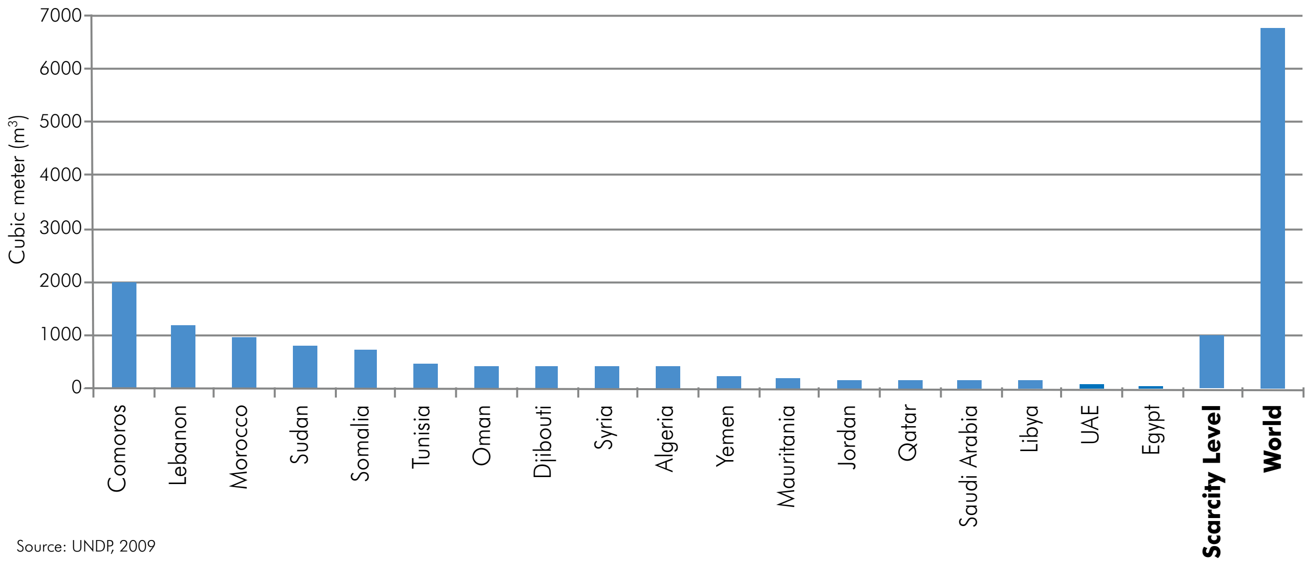
** *2015 and 2025 projections developed by AFED, based on actual changes between 2000-2006, and average projected rate of population growth for each country, as per data of the UN Population Division, published in the World Population Prospects, 2008 revision http://esa.un.org/unpp/index.asp?panel=2*

The figures are mainly indicative trends because of the different methods and tools used to calculate the aggregate main source of water. The projections take the lower side of population growth in the region, and do not take into account the impact of increase in GDP and other variables which push the demand upward, nor factors such as increasing drought and other climate change impacts which drive water availability downward.

However, public budgets are already constrained and can hardly sustain efficient levels of water services to current populations, which are growing at 2-3% annually. Most of this growth is adding pressure to already crowded and inadequately serviced cities and towns. Ambitious plans for rapid economic growth and increased pace of industrialization will further add to water shortages.

The political economy of low water tariffs and high fuel and water subsidies in Arab countries has contributed to overuse of scarce water resources and has deprived providers of desperately needed

FIGURE 1 ARAB INTERNAL FRESHWATER RESOURCES ARE OFTEN BELOW SCARCITY LEVELS AND THE WORLD AVERAGE, 2005 (CUBIC METERS PER CAPITA)



Source: UNDP, 2009

revenues to maintain the financial health and physical condition of urban and rural water supply networks. The price charged for water is estimated to cover only about 35 percent of the average cost of supply, and charges in many irrigation systems are much less.

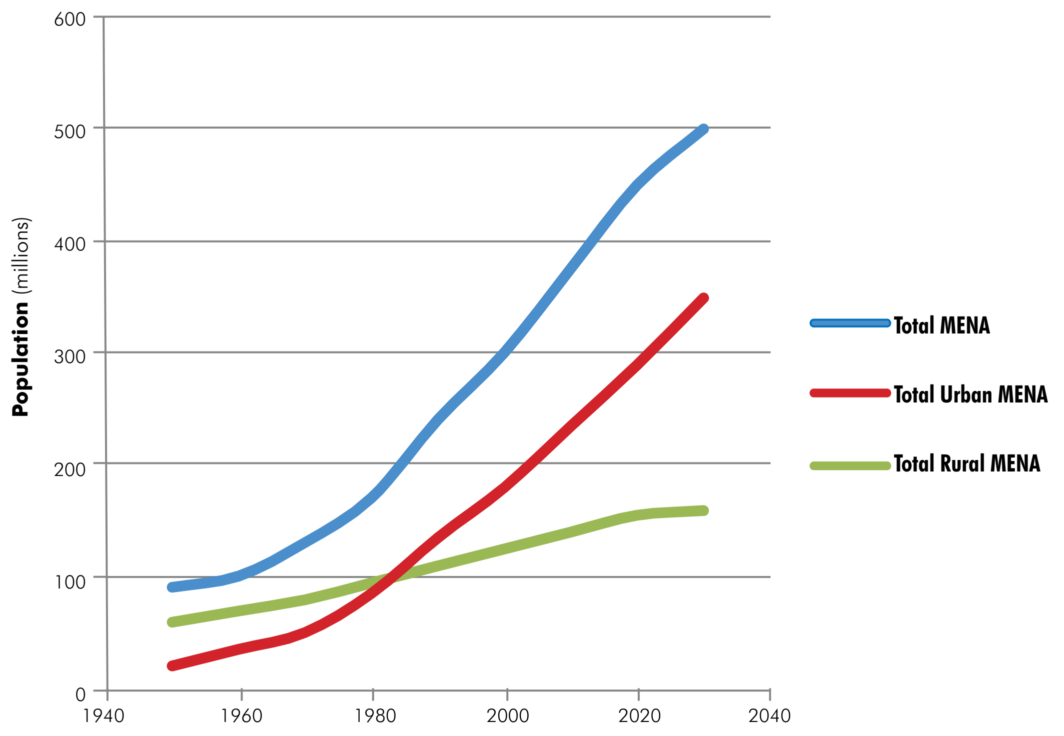
Because renewable water resources cannot meet growing demand, governments have often encouraged the over-exploitation of groundwater resources. For example, the average annual abstraction from groundwater in all sub-basins in Jordan is about 160% of the annual renewable average of recharge. In Yemen, groundwater is being pumped at a rate that is four times greater than natural recharge, forcing farmers to abandon once productive valleys. The over-extraction of groundwater beyond safe yield levels has resulted not only in dramatic declines in the water table, but also in the pollution of groundwater aquifers in coastal areas by saline seawater. Some countries are expanding investment in desalination of seawater and in wastewater treatment and reuse. Proper treatment of wastewater and controlled reuse, however, continue to be of high concern posing serious risks to public health and the environment.

Water pollution is also a serious challenge in the region, attributed to the use of high levels of chemicals in agriculture as well as to increasing inflows of domestic and industrial wastewater into water bodies. The lack of sanitation facilities for large segments of the population contributes to water pollution by raw sewage. The discharge of brine effluents from seawater desalination plants causes degradation to coastal marine areas. The Gulf countries flush about 24 tons of chlorine, 65 tons of pipe-cleaning anti-scaling agents, and about 300 kg of copper into the Gulf daily.

Quick fixes and short-term solutions are not adequate to address the challenges of the water sector in Arab countries. Policy-makers need to change course and adopt policy reforms that address key strategic issues. They need to make a strategic shift away from investing in the development of water supplies to efficiently managing the available supply of water resources. Water demand management has proved to yield significant benefits and may often be more cost-effective than traditional supply management measures. Managing demand will provide policy-makers with the opportunity to create mechanisms to adjust water allocation more equitably, rationally, and sustainably. The water needs of the municipal, industrial, and agricultural sectors are legitimate, but so are the priorities to maintain water flows to wetlands, aquifers, river basins, and other ecosystems.

When introducing new policy frameworks, a

FIGURE 2 **MORE PEOPLE WILL LIVE IN URBAN AREAS**



Source: World Bank, 2007

high priority should be given to articulating and measuring reliable performance indicators to monitor the effects of policy reforms. Reliable accounting of the economic, social, and environmental effects of new policies provides useful guideposts for navigating a transition to a sustainable water future.

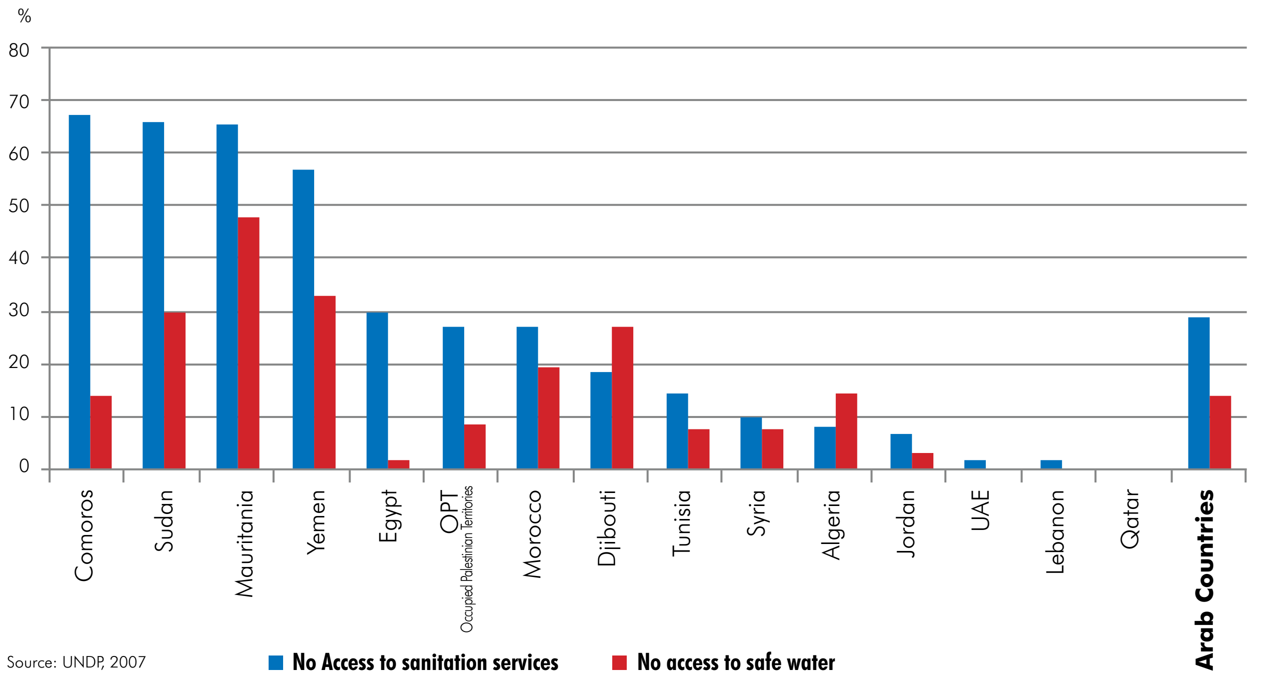
The UNEP flagship report on transitioning to the green economy (UNEP, 2011) points out that greening the water sector provides numerous opportunities. One such opportunity is investing in biodiversity and ecosystem services, as global assessments of the health of the world's water river systems and aquifers suggest that the aggregate trend is one of decline in terms of ecosystem health and function. Another opportunity is the investment in sanitation and drinking water supply. The UNEP report estimates the cost of achieving the 2015 Millennium Development Goals (MDG) at US$142 billion per year for providing sanitation services and US$42 billion per year for drinking water supply to households. Although the amount of funding needed seems massive, the Organization for Economic Co-operation and Development (OECD) estimates that in Ghana, for example, "investment of US$7.40 per person per year over a decade would enable the country to meet its MDG target" (UNEP, 2011).

The UNEP report also highlights the fact that there is a flow of benefits from investment in the water supply and sanitation sector. The returns to investment in the water sector are often indirect. As stated in the report: "Build a toilet for girls in a school and they are more likely to go to school. This simple statement highlights the fact that investment in water opens up other opportunities for development."

A. Water Resources and Climate Change

As a result of climate change, the atmospheric processes responsible for the aridity of the Arab region are projected to intensify. By the end of the 21st century, Arab countries are predicted to experience an alarming 25% decrease in precipitation and a 25% increase in evaporation rates, according to climate change models. As a

FIGURE 3 PERCENTAGE OF POPULATION WITHOUT ACCESS TO SAFE WATER AND SANITATION SERVICES, 15 ARAB COUNTRIES, 2007



Source: UNDP, 2007

result, rain-fed agriculture will be threatened, with average yields declining by 20% in Arab countries overall, and by 40% in Algeria and Morocco. Water deficits, already a fact driven by natural water scarcity and unrelenting rising demand in the region, will be exacerbated. Failing to develop adaptation strategies now will contribute to greater suffering in the future.

In addition to climate disruption, water resources in Arab countries are vulnerable to other stresses such as population growth, changing land use patterns, variable rainfall, and natural water scarcity. Vulnerabilities to these stresses are not unlike those to climate change. Therefore, a vulnerability-based approach would be most effective in advancing targeted intervention policies to address existing vulnerabilities (e.g., inherent aridity) as well as future ones (e.g., climate change). It would also permit policy-makers to formulate strategies based on accumulated knowledge of the region's resiliency factors and adaptive capacity.

B. State of Freshwater Ecosystems

Freshwater ecosystems supply the Arab region with water and provide critical habitats for aquatic biodiversity. Therefore, information about the condition of freshwater ecosystems matters. Arab countries for the most part have been unable to provide systematic, reliable, and up-to-date information on the state of wetlands, marshes, lakes, river basins, oases, and their biological endowments. Arab governments are thus urged to provide support and to commit resources to establish an evaluation, monitoring, and reporting mechanism for conducting assessment studies about the state of freshwater ecosystems. To ensure their effectiveness, the assessment studies have to be scientifically credible and relevant to decision-makers' needs.

As human interactions with freshwater ecosystems accelerate in Arab countries, assessment studies will be needed to address how freshwater ecosystems are changing, whether they are thriving or diminishing, what new challenges they are facing, and whether policy-makers are addressing these ecosystem challenges effectively. They should also highlight the threats to biodiversity and ecosystem sustainability.

Arab governments are also urged to increase their

Virtual water (also known as embedded water, embodied water, or hidden water) refers, in the context of trade, to the water used in the production of a good or service. The precise volume can be more or less depending on climatic conditions and agricultural practice.

WATER NEEDED TO PRODUCE... (LITERS)

Apple
70 L/apple

Orange
50 L/orange

Cheese
5000 L/kg

Milk
1000 L/1 litre

Wheat
1300 L/kg

Bread
40 L/slice

Coffee
140 L/cup

Tea
30 L/cup

Rice
3400 L/kg

Chocolate
2400 L/100 grams

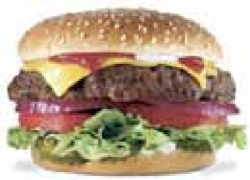
Jeans
10855 L/pair of jeans

Paper
10 L/sheet of paper. (A4)

Goat meat
4000 L/kg

Beef Meat
15500 L/kg

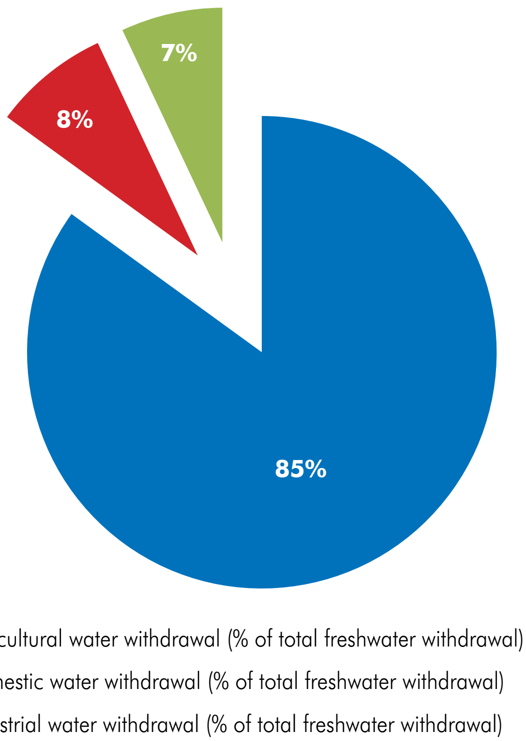
Sheep Meat
6100 L/kg



Hamburger
2400 L/hamburger

capacity to utilize that knowledge and muster the political will to transform this knowledge into action. This will enhance the ability of water resources professionals to design, implement, and evaluate effective interventions for the sustainable management of freshwater ecosystems.

FIGURE 4 **WATER CONSUMPTION (%) BY SECTOR IN ARAB COUNTRIES, 1999-2006***



*Latest values for all 22 Arab countries

Source: UNDP, 2009

C. Agricultural Water Management

Agriculture accounts for over 83% of water use in the Arab region, reaching 90% in some countries, against a world average of 70%. Despite serious water shortages, irrigation efficiencies remain at 30-40%, low water prices are still common, groundwater reserves are fast depleting, and incentives for irrigation improvements are lacking. The demands placed on the agricultural sector are plenty, almost unrealistic. Arab agriculture is expected to contribute to food security, reduce the Arab world's food import bill, provide rural employment, redirect some of its share of fresh water to municipal and industrial use, acclimatize to marginal-quality water for irrigation, and adapt to climate change. Agricultural practices are also blamed for increased soil and water salinity, toxic pollution from the use of agro-chemicals, damming of rivers, and the loss of biodiversity associated with wetlands destruction.

These concerns, though serious and multi-dimensional, can be addressed through a mix of institutional reforms, changes in incentive structures, and technical innovations. A mix of economic mechanisms such as rebates, reduced taxes, targeted subsidies, price signals, access to water rights, tradable water permits, and other economic incentives should be considered by policy-makers to persuade farmers to adopt irrigation-efficient technologies, change cropping patterns, improve irrigation scheduling, reduce over-abstraction, and in general shift agricultural activities towards higher-value crops. For Arab countries, where water resources are scarce, increasing crop productivity per unit of water consumed rather than per unit of land is a necessary step towards the shift to a green economy.

Arab governments should also provide financial support to research efforts focused on developing new local crop varieties tolerant to aridity and salinity conditions. For countries that rely on rain-fed agriculture, a new drive to improve and invest in rainwater harvesting systems is highly recommended.

In effect, these policy reforms would result in a new political economy of water. This change requires Arab governments to consider the wisdom of acquiring water 'virtually' through the import of, say grains, from water-rich countries, while allocating scarce water resources to low-water consuming, high value-adding crops that can generate foreign exchange. It is more realistic to attain food security through trade policies.

D. Wastewater Treatment and Reuse

The volume of wastewater generated by the domestic and industrial sectors in Arab countries is approximately 10 km^3/year, of which 5.7 km^3 undergoes treatment. These figures suggest that on average 43% of annually generated wastewater is discharged in untreated form. Of the volume of wastewater that is treated, only one third is

STRATEGIC WATER RESERVE IN ABU DHABI: AQUIFER STORAGE AND RECOVERY

Mohamed A. Dawoud

Abu Dhabi depends on desalination of seawater and brackish groundwater to meet the Emirate's main water domestic supply. The total present desalination capacity is about 635 million gallons per day (MGD). The Abu Dhabi Water and Electricity Authority (ADWEA), which is responsible for providing water and electricity for the Emirate, uses a number of desalination technologies to produce water including multi stage flash (MSF), reverse osmosis (RO), and multi effect distillation (MED). MSF is the main technology used because it is mature and reliable, produces high quality water with low total dissolved solids (TDS) (2-150 mg/l) in large quantities, and has a low risk of bacterial or pathogenic contamination. At each desalination plant, there are water storage tanks for back-up use. The size of potable fresh water tanks at the desalination plants varies between 0.2-0.4 million m^3. The total amount of storage at all plants is 1.51 million m^3, which is less than one day's production. The arid climate of the Emirate results in increased consumption in the summer months, which is reflected in production data. In the winter months of January and February, production declines slightly and then gradually increases through the spring months of March and April. Water production during the hot summer season from May through August shows another gradual increase. Thereafter, the production attains constancy until the end of December.

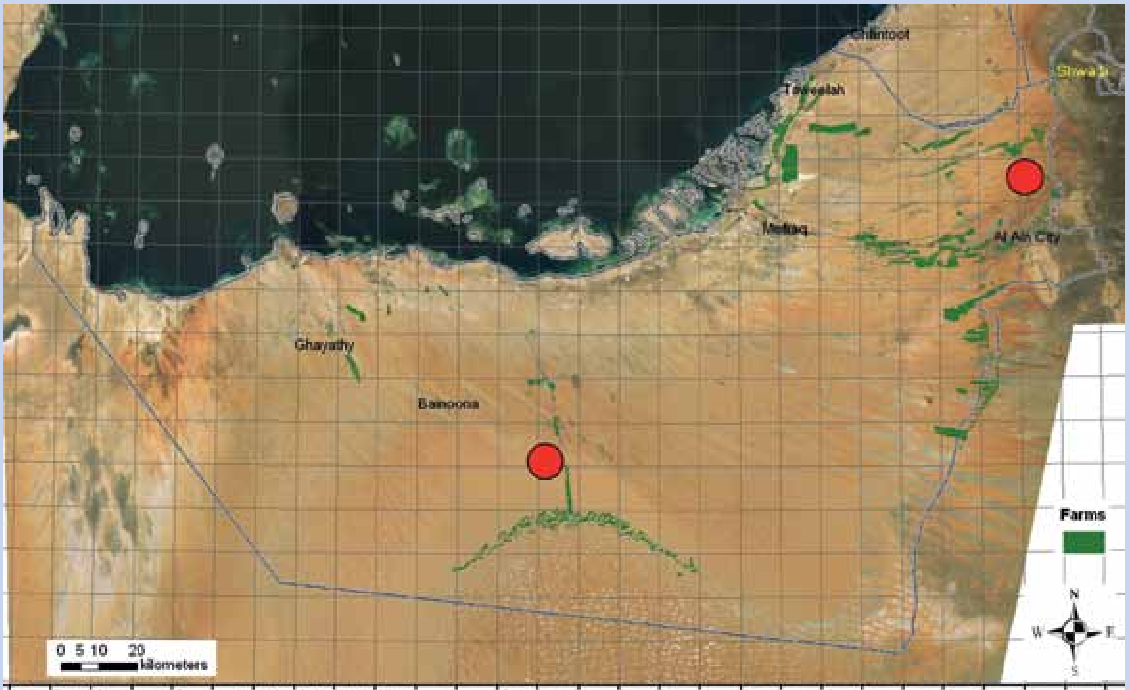
During the peak summer season, desalinated water is directly consumed, while in the winter months there is excess production. This excess is used for the irrigation of green landscaped public spaces throughout the Abu Dhabi Emirate. An alternative option would be to store this excess water in aquifers during the winter months to be recovered when demand rises. In addition, to maintain an uninterrupted water supply during times of emergency (natural disasters, industrial accidents, war, or other crises), Abu Dhabi needs to have long-term storage capacity equivalent to at least 1 year's fresh water demand. To study the feasibility of underground water storage in aquifers, two sites were selected as pilot projects in 2002. The first one is in Al Shweib in the Eastern Region and the other is in the Western Region as shown in Figure B1.

For the Eastern Region, water from the Qedfaa plant was injected in the shallow alluvial aquifer system. The results of the study indicate that aquifer storage and recovery (ASR) is a viable alternative for augmenting the depleted aquifer. The second project was located in the Western Region between Madinat Zayed and Meziyrah. It was designed for an infiltration capacity of 500 m^3/h and recovery capacity of 750 m^3/h. A shallow to medium-deep aquifer north of the Liwa Crescent was selected as the study area for the following reasons: (1) existence of a large natural fresh groundwater lens, with salinity less than 1,500 ppm, partly meeting the TDS-limit of the international World Health Organization drinking water standard of 1,000 ppm, (2) sufficient lateral extension and aquifer thickness, (3) sufficient depth of groundwater table, (4) relatively homogenous lithology, (5) far from already existing well fields, and (6) favorable hydro-chemical conditions. This study has clearly indicated that the recharge of desalinated water into and efficient recovery from an existing freshwater aquifer are feasible on a large scale.

reused. The volume of generated wastewater in Arab countries is expected to grow quickly due to increased utilization of water by rising populations, industrialization, and higher standards of living. The quality of treated wastewater in Arab countries must also be questioned. Wastewater treatment plants in Arab countries have highly variable efficiency. They are allowed to handle waste loads that exceed their capacity limits, hampering their effectiveness. The practice of combining domestic and industrial wastewater for treatment imposes limitations on the ability of plants to operate satisfactorily. In some Arab countries, crop irrigation by untreated wastewater is practiced due to the unavailability of fresh water.

The untapped potential of wastewater treatment and reuse for augmenting Arab countries' water supplies requires appropriate policy interventions. Policy-makers need to demonstrate a long-term political commitment to a national strategy for the utilization of wastewater treatment and reuse and to establishing proper institutional structures and water reuse policies. The development of appropriate policies for promoting reuse should include economic analysis of treatment and reuse options, dissemination of practical knowledge, development of best practices, cost recovery mechanisms, professional training, public awareness campaigns, and the adoption of adapted standards and guidelines that take into consideration reuse

FIGURE B1 **SITES OF PILOT PROJECTS**



Source: Environment Agency - Abu Dhabi (EAD), 2008

Countries of the Gulf Cooperation Council (GCC) rely on desalinated water as a main source of domestic water supply. The maximum capacity of the emergency water reserve in surface ground reservoirs and distribution networks ranges between 2 to 5 days. This storage capacity is insufficient during weeks or months-long crises. Increasing the storage capacity via surface reservoirs is costly and not environmentally friendly. Groundwater storage using artificial recharge can be a promising tool for strategic water reserve. Storing fresh water in groundwater aquifers is safer and more reliable and fixable for use in terms of time and location. It is recommended to conduct more extensive studies to further establish the feasibility of artificial recharge schemes.

Dr. Mohamed Dawoud is Manager, Water Resources Department, Environment Agency - Abu Dhabi

schemes and technical and financial resources.

Because reclaimed wastewater represents a valuable resource in a water-scarce region, it is desirable to treat all generated wastewater and to reuse all treated water. Beyond meeting quantitative goals, however, judicious planning calls for wastewater to be properly treated and suitably reused according to requirements for protecting health and the environment.

Viable options based on different treatment levels and different end-uses of wastewater (including food and non-food crops, landscaping, or groundwater recharge) should be assessed. Treatment options should consider the ease of replication and upgrading as well as the availability of a local trained workforce to operate, monitor, and maintain plant facilities. For reuse in agriculture, selection criteria for crops, irrigation methods, and application periods should be considered. Wastewater treatment technologies should be suitable to local conditions, acceptable to users, and affordable to those who will pay for them. Finally, reuse must be part of a larger water strategy that manages and regulates demand effectively.

E. Desalination

Shortages in renewable and non-renewable

GREYWATER IRRIGATES A FRUIT GARDEN IN SOUTH LEBANON

Boghos Ghougassian

In the water-scarce town of Aitaroun, located in the border zone of South Lebanon Province, Mrs. Adla Taubeh has been reusing treated greywater (GW) to irrigate fruit trees in her garden since 2008.

Mrs. Taubeh has been growing fruit tress for 15 years with very unsatisfactory results. Due to the lack of sufficient irrigation water, the fruit used to dry before maturation and fall down. This changed four years ago, when she began recycling treated greywater (coming from her kitchen, showers and sinks) to irrigate her garden. The trees look healthier and are giving good yields. Mrs. Taubeh's home garden boasts 50 fruit trees including lemon, apricot, plum, mulberry, quince, and apple trees, in addition to old olive trees. Mrs. Taubeh can now harvest good quality fruit trees sufficient for home consumption and for sharing with friends and neighbors.

The greywater treatment system and the drip irrigation network in Mrs. Taubeh's garden were installed in 2008 by Civil Volunteers' Group (GVC), an Italian nongovernmental organization, and the Lebanese Appropriate Technology Association (LATA).

The greywater system has made Mrs. Taubeh's gardening task far easier. Greywater from the kitchen reaches the treatment tanks by gravity, where particulates and floatable material are filtered out. Greywater is treated by anaerobic digestion in barrels for two days, after which the treated effluent is automatically pumped through the drip irrigation network to various parts of the garden. Because treated greywater contains nutrients that are useful for plant growth, fertilizers are not used.

Mrs. Taubeh has since enlarged the original capacity of the treatment kit to allow her to accommodate greater quantities of greywater for treatment and reuse. The capacity expansion has allowed her to enlarge the garden and plant additional fruit trees. Today, the amount of greywater reused in irrigation exceeds 500 m^3 per year. The GW treatment system and the drip irrigation network are kept in good shape by regular maintenance. There has not been any observed leakage of greywater in any part of the treatment or irrigation system. During the pumping cycle, which lasts for less than 10 minutes per day, a weak odor is detected, which is quite normal since anaerobic digestion is taking place in the GW tanks. The odor is not considered a nuisance. In addition, the greywater treatment system is water-tight, insect-proof, and odor-proof, and complies with the international standards for safe reuse of greywater in irrigation. Only greywater is used for treatment and recycling. Wastewater (blackwater) from the latrines is not utilized and is directed through a separate piping system to the septic tank.

Mrs. Taubeh has also been able to improve the irrigation network by installing branch valves, so that she can irrigate her target crops on demand. She is now planning to upgrade the site of the GW treatment kit.

In addition to fruit trees, the availability of more irrigation water has allowed Mrs. Taubeh to grow vegetable seedlings at a rate of 20 to 30 thousand seedlings per year. She uses 50% of the seedlings for growing thyme (zaatar) and tobacco and sells the other 50% to farmers, which brings earnings to her large family.

In addition to the income generated from the sale of crops, the GW treatment system has brought about significant financial savings directly and indirectly. The ability to recycle

water sources have compelled a number of Arab countries to rely on desalination for supplying the bulk of their municipal and industrial water needs. Arab countries, with 5% of the world population, have a 50% share of all cumulative desalination capacity contracted for in the world since 1944. The high rate of annual increase in contracted capacity will be maintained over the next decade, doubling current capacity by the year 2016. This comes at a high cost. Annual investments to produce, manage, and operate seawater desalination plants in the Arab world are predicted to reach US$15 to US$20 billion in the next decade. At present, 25% of Saudi oil and gas production is used locally to generate electricity and produce water. With present growth rates for demand, this fraction will be 50% by 2030, according to Saudi officials. Despite the high cost incurred in producing desalinated water, there is no relief from the demand side. Water tariffs cover on average 10% of cost. Water subsidies, if they continue to be unchallenged, could consume up to 10% of oil revenues in some countries of the Gulf Cooperation Council (GCC) by 2025. Water leakage rates in the distribution network are estimated to be 20-40%. In countries of the GCC, average daily water consumption per capita has reached 300-750 liters, the highest in the world.

GW for reuse has relieved Mrs. Taubeh's family of the annual purchase cost of 500 m^3 of water for irrigation. Over the past four years, Mrs. Taubeh has saved $1,200 in water bills.

Because greywater is no longer mixed with blackwater, the quantity of wastewater pumped to the septic tank is significantly less. Prior to installing the GW treatment system, the septic tank used to be emptied with vacuum trucks monthly, at a cost of $50. With GW diversion for reuse, the septic tank needs to be emptied only once per year.

In addition, the septic tank does not overflow anymore, which goes a long way to improve the sanitary, hygienic, and environmental conditions.

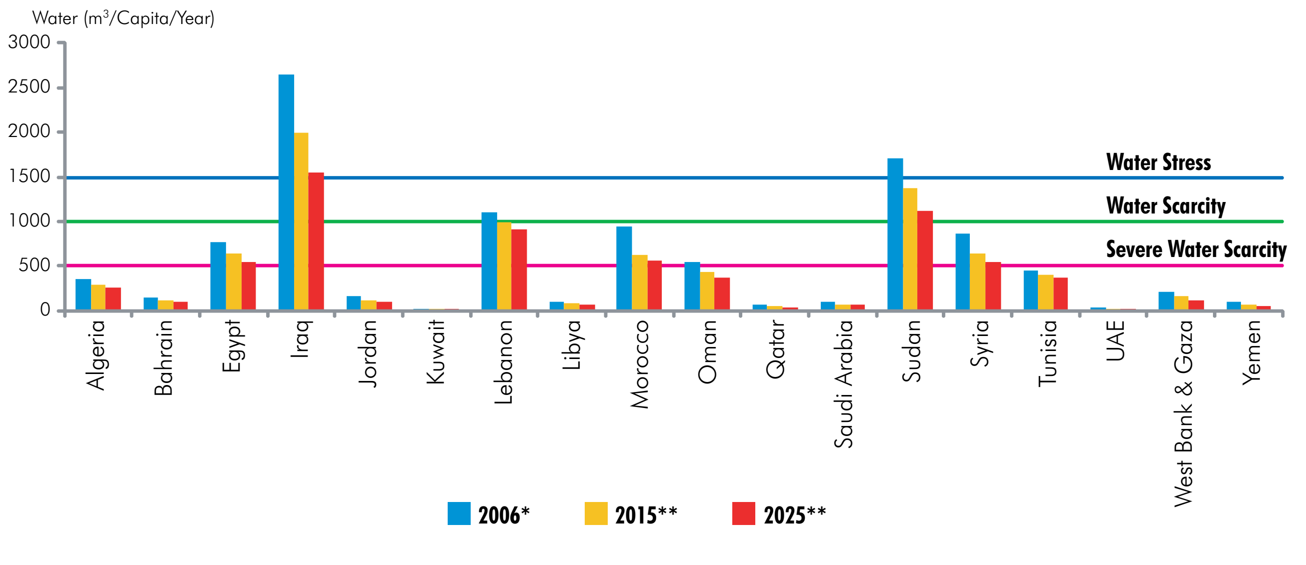
Given all of these positive characteristics, Mrs. Taubeh believes that every family in water-scarce regions can benefit from installing a greywater treatment system — both financially and environmentally.

Boghos Ghougassian is president, Lebanese Appropriate Technology Association (LATA)

These high costs are untenable in the long term, necessitating bold reforms to allay concerns about the sustainability of the desalination sector. Before sinking large capital in desalination plants, managing costs by reducing distribution water losses and promoting efficiency in water production and use should be given a high priority by water governing institutions. This is the least expensive option for meeting rising demand. Governments should re-think their pricing strategies by charging tariffs that recover costs while offering rebates to consumers as incentives for efficient water use.

Taking a longer-term perspective, governments are urged to divest from plant ownership and operation and assume the role of a regulator. This shift would automatically provide opportunities for the private sector to develop, with government incentives, a more competitive locally and regionally-based desalination industry encompassing design, manufacturing, construction, operation, and research and development (R&D). Given the large market size and the strategic role of desalination in some Arab countries, the economic benefits cannot be overestimated. To address concerns about carbon emissions, Arab governments should link any future expansion in desalination capacity to heavy

FIGURE 5 PROJECTIONS OF FRESHWATER AVAILABILITY IN ARAB COUNTRIES



* 2006 figures are from FAO/UNESCO
** 2015 and 2025 figures are projections prepared by AFED, See table 1

investments in abundantly available renewable sources of energy.

F. Water Laws and Customary Water Arrangements

With very few exceptions, Arab states do not yet have well-defined water legislation. Different water-related legislations have been drawn up over time to address different or specific water issues. Still, the substance and scope of most of their respective mandates tend to be limited and fragmented. The result has been either only minimal legislation dealing with water resources, or overlapping laws that are outdated and do not satisfy current requirements.

Although diverse customary arrangements have been demonstrated to effectively complement formal legal arrangements for utilizing water resources in some Arab countries (e.g., Oman), several Arab states continue to focus on the use of statutory arrangements. Many Arab countries seem not to appreciate the relevance of their societies' rich tradition of customary arrangements to provide guidance to today's issues of water governance, regulation of services, management of water resources, water allocation, conflict mediation, infractions and sanctions, and conservation and protection of water resources and ecosystems.

Arab governments should enact comprehensive national water legislation that can facilitate institutional reforms and provide legal protection for more bottom-up forms of participatory water governance. In doing so, legal experts and water managers need to heed the living legacy of customary water arrangements and institutions and identify possibilities for incorporating this tradition into water legislation in harmony with statutory water laws.

Responsive water legislation in Arab states must address existing gaps in current laws. Water laws should establish mechanisms to control and regulate water access, promote water use efficiency through a system of economic instruments and incentives, enable pollution control and environmental impact assessment enforcement, facilitate institutional arrangements, establish protected areas vital to water resources, provide for land use planning, and set enforceable penalties for violations that cause damage to water resources. Finally, the realities of climate change dictate that provisions in water laws not be set in stone. Because water availability and quality will be more subject to climate-induced variations that cannot be predicted with confidence, water legislation needs to cater for these uncertainties.

G. Trans-boundary Water Resources

Most Arab states depend for their water supply on rivers and/or aquifers that are shared with neighboring countries. Of all renewable water resources in Arab countries, two thirds originate from sources outside the region. And yet not a single formal agreement for joint management of shared water resources exists in the region. Only seven Arab states have ratified the UN Convention on the Non-Navigational Uses of International Watercourses, which codifies the core principles of International Water Law and is often used to conclude joint management and water sharing agreements.

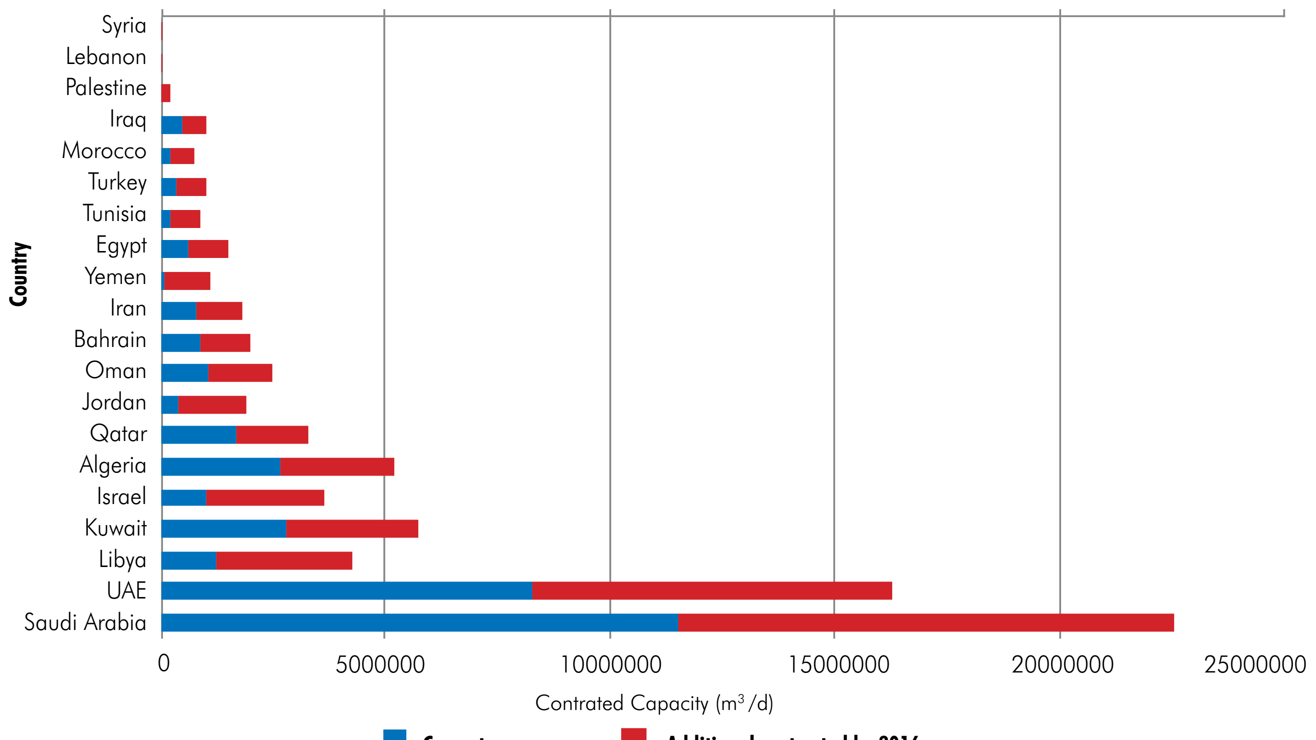
To foster joint management of shared water basins or aquifers, Arab countries should pursue cooperative agreements drawing on principles of the UN Convention on the Law of Non-Navigational Uses of International Watercourses. It is prudent to move beyond data sharing and basic consultations and take bold steps to identify a sustainable formula for sharing waters guided by legal principles of equitable and reasonable use and the obligation not to cause harm, rather than relying on existing power imbalances. Arab countries which are not parties to said UN Convention should sign and ratify the Convention.

Managing shared water resources should not be left within the domain of only water resources professionals, but should also be placed on the agenda of the country's top diplomats and foreign affairs specialists. Decision-makers at the highest levels in Arab countries should review the constraints to concluding effective and fair agreements on sharing and managing trans-boundary water resources and take steps to provide the country's water professionals the mandate as well as the administrative and financial resources needed to draft and execute such agreements.

H. Water Governance

The development of the water sector in Arab countries has been associated with a weak water governance structure. Large public water sectors, subsidies, and unhelpful political economies have conspired to limit public voice, accountability, and participation. This is reflected in inequitable allocation, wasteful use, increasing pollution trends, lack of transparency, and inefficient water services. Although water user associations (WUA) have been established in a number of countries as a form of participatory irrigation management, adequate legal mandates to support and empower their mission are still lacking or slow in the making. This despite the evidence that WUAs do contribute to a more efficient sector including

FIGURE 6 **ACCUMULATED CURRENT AND NEAR TERM TOTAL CONTRACTED CAPACITY IN MENA**



Source: GWI, 2010

improved collection of charges for infrastructure, operation, maintenance, and use.

Most public sector organizations in Arab countries (serving both irrigation and urban water supply needs) do not function properly and have been unable to serve their customers efficiently. Responsibility for managing water and water services is dispersed across multiple institutions, which rarely coordinate among themselves. Decision-making processes take top-down direction with absent or ineffective stakeholders' participation. Information is hardly shared between policy makers and authorities charged with implementation or between governmental and non-governmental actors. Apart from efficiency concerns, there are serious equity problems with current water practices, with the poor, women, and children suffering the most. Moreover, the water sector in the region has not recognized that many of the decisions governing its performance are made outside the sector.

The 2011 UNEP report on the green economy stresses the fact that establishing a high-level political support for arrangements that boost

effective governance is essential to investment in water infrastructure. Good governance should be seen as a vehicle to improve water resources management. Arab policy-makers should put in place institutional processes to permit all communities of water users and beneficiaries to participate in water decision-making as well as management. Public sector reforms need to be introduced to increase decentralization and promote the transfer of responsibility and authority to local user groups. More effective institution-strengthening measures and legal frameworks are needed to expand public-private partnership (PPP) capacity, while managing risks and social equity.

III. RECOMMENDATIONS

AFED's Annual Conference in November 2010, during which the Water Report was presented and debated, came out with a set of recommendations to governments and various sectors.

1. Arab governments are urged to:

a. Commit to cutting to half the 45 million lacking access to clean water and sanitation in Arab countries by 2015.

b. Make a sustained effort to introduce policy, institutional, and legal reforms to enable a shift from a culture limited to securing more supplies through expensive water development, to one which manages demand, by improving efficiency, cutting losses, protecting water from overuse and pollution, and changing consumption patterns to more sustainable practices.

c. Adopt economic criteria for enabling water efficiency and prioritizing the allocation of the available supply of water resources among competing sectors. Governments are urged to introduce water tariffs that rationalize water use, achieve cost recovery in a gradual manner, and promote equity through targeted subsidies.

d. Support new agricultural policies by offering economic incentives, research assistance, training, and public awareness campaigns to persuade farmers to improve irrigation

MEMBRANE DISTILLATION OF REVERSE OSMOSIS BRINE

Amir Basha

Membrane Distillation (MD) is a new technology that can become an energy saving alternative to presently existing water separation technologies. MD works at ambient pressures and can be run on low-grade waste heat. The process exhibits a high level of rejection and produces high quality permeate. The concentration efficiency of MD has been proven in many laboratory experiments.

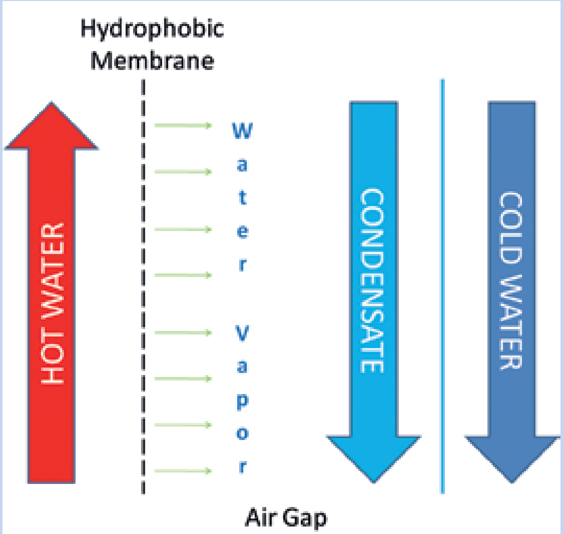
The production of permeate in a standard reverse osmosis (RO) unit is about 40-50% of the seawater feed. Since MD can be operated close to saturation, MD can be a good complement to RO. Treating and concentrating the brine will increase the recovery ratio and may also, if complemented with crystallization or evaporation, be used as a base for zero liquid discharge.

An industrial-size demonstration MD unit was supplied by Xzero AB of Stockholm, Sweden, to Moya Bushnak's WESSCO desalination plant in Jeddah, Saudi Arabia, in order to jointly test the performance of membrane distillation for the first time.

The test equipment was of the air-gap type, as shown in Figure B1.

In the pilot test skid, RO brine is heated and passed on one side of the membrane. Water vapor diffuses across the membrane and the air gap and condenses on a surface that is cooled by water. The overall process is driven by a gradient in water vapor pressure, rather than a difference in total pressure. Thermal energy is required to elevate the vapor pressure of water in the hot stream.

FIGURE B1 AIR GAP TYPE MD MEMBRANES



The demo skid supplied by Xzero had a capacity of producing 0.2-1 m^3/day high quality permeate from RO concentrate. The membranes are hydrophobic with pore sizes in the range of 0.05 to 0.2 μm—the same range as microfiltration. The module has a membrane area of 2.8m^2. Auxiliary equipment consists of a tank (boiler) for hot water, variable flow gear pumps to drive the hot and cold water, digital pressure transducers to measure pressure drop, digital thermo probes to measure temperatures, and a personal computer (PC) for data logging and control.

A process flow diagram of the demo unit is shown below

efficiency, change cropping patterns, improve irrigation scheduling, shift toward higher-value adding crops and agricultural activities, and decentralize management of irrigation projects.

e. Develop adaptation policies to climate change predicated on using saline water in agricultural production, developing new local crop varieties tolerant to aridity and drought conditions, and rehabilitating water harvesting systems.

f. Reorient the role of state water authorities from that of a water provider to that of an effective regulator and planner, including establishing legal frameworks that enable private investments and public-private partnerships to provide clean water and safe sanitation, while maintaining transparency and accountability.

g. Promote, through a mix of economic incentives and publicly sponsored research programs, opportunities for the private sector to assist in developing locally-based competitive desalination technologies, while encouraging the application of solar energy.

h. Commit to a national strategy for tapping

FIGURE B2 **PROCESS FLOW DIAGRAM OF THE MD UNIT**

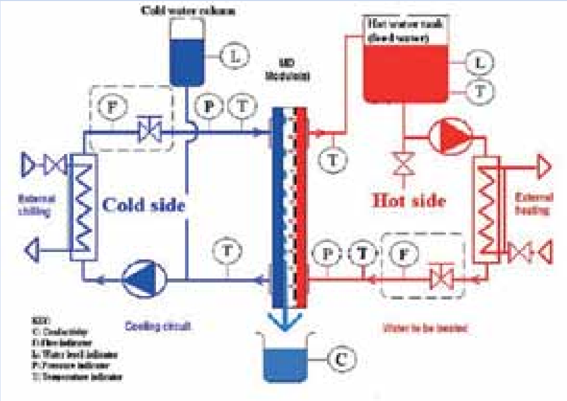


FIGURE B3 **PHOTOGRAPHS OF MD PILOT PLANT**

in Figure B2, which describes the basic set-up of the hot and cold water flow circulation. Permeate is measured and collected in the conductivity vessel.

The major purpose of the test was to: (a) increase feed water concentration to measure permeate stability, (b) assess the technology's performance over a range of operating parameters, and (c) attempt to deduce controlling factors based upon experimental results. A secondary goal was to evaluate membrane stress and the durability of the module.

No pre-treatment with acid dosing or coagulant dosing was provided for the water other than basic media pre-filters. Flows and temperatures were recorded directly by a computer. Distillate production was measured in a volumetric flask.

The total running time for the demonstration was 170 days.

For the first two weeks, the permeate flux was measured between 4.6 and 6.0 liters per hour (in one module). The degree of separation measured by comparing the conductivities of feed water and permeate was 99.99%.

The feed water concentration was increased gradually from 39.5 g/l to 136.8 g/l during the test period by adding salt. The degree of separation achieved was over 99%. The quality of the permeate remains constant regardless of increases in feed water concentrations.

This demonstration has proved that membrane distillation can be successfully employed for the concentration of RO brine to increase the recovery of potable water using very low power input and low-grade heat. The test results obtained thus far will motivate further development of the MD technology on a larger scale.

Amir K. Syed Basha is Senior Vice President, Moya Bushnak

the underutilized potential of wastewater reclamation as well as greywater recycling to augment Arab countries' water supply. The strategy should commit to strong institutional coordination and planning to ensure that wastewater is properly treated and suitably reused according to requirements for protecting health and the environment.

i. Commit to investing in scientifically credible and policy-relevant research that addresses the practical problems of water management in Arab states.

j. Enact comprehensive national water legislation that addresses existing gaps in current laws and establishes mechanisms to control and regulate water access, promote water use efficiency, enable pollution control regulations, establish protected areas vital to water resources, provide for land use planning, and institute enforceable penalties for violations that cause damage to water resources.

k. Foster joint management of shared river basins or aquifers and identify a sustainable formula for sharing trans-boundary waters, fairly guided by customary legal principles of 'equitable and reasonable use' and

the 'obligation not to cause harm'. Arab governments are also urged to sign and ratify the UN Convention on the Law of Non-navigational Uses of International Watercourses, and draw on its principles for concluding effective and fair water sharing agreements.

l. Launch sustained public awareness campaigns, starting from schools, to cultivate a water ethic of care among the public, inspire behavioral changes, and inform water users about economic incentives for achieving water efficiency targets. Civil society, including non-governmental organizations, academia, and the private sector groups, should be included in water reform planning. Water user societies should be encouraged and enabled.

m. Allocate sufficient funds for research and development in water efficient technologies and in locally-based desalination technologies and know-how.

2. Private industrial enterprises should apply extensive water efficiency measures to substantially reduce the quantity of water used per unit of output, prevent pollution at the source, make process changes whenever possible to minimize the volume of wastewater generated, and ensure that wastewater is treated to meet strict regulatory standards prior to disposal.

3. Real estate developers and users, and municipalities should accord water efficiency a high priority in the design and operation of buildings and take advantage of water retrofits to make existing buildings water efficient.

4. Nongovernmental organizations, academia, and the private sector should cooperate fully in the implementation of these recommendations.

IV. CONCLUSION

The Arab world is already witnessing a water crisis. Comprehensive and sustained water policy reforms are still lacking. Can the trend in deteriorating water quantity and quality be stopped or better yet reversed? Can an impending, or rather present water crisis be averted?

AFED's water report has pointed to policy and institutional reforms underway in some Arab countries. These reforms, however, are in their infancy and it will take a number of years before their outcomes materialize. Abu Dhabi has recently commissioned the preparation of a Water Resources Master Plan to introduce reforms and guide a strategy for integrated management of the Emirate's water resources. The Arab Water Academy is leading inspiring efforts to redefine the development of human capital and institutional capacity in Arab countries. Water user associations are now established in Egypt, Jordan, Libya, Morocco, Oman, Tunisia, and Yemen. In some countries, the private sector is making strident contributions in water services provision. Tunisia and Jordan have made remarkable progress in wastewater treatment and reuse. Traditional water management systems, such as the Aflaj in Oman, have been uniquely successful in instituting effective water governance systems based on customary arrangements. Universities and regional water research centers are becoming more committed to conducting high quality research to develop and strengthen the region's adaptive capacity.

Despite these positive efforts, Arab countries are slow in adopting more far-reaching water reforms. Water tariffs remain below cost and irrigation efficiency is stubbornly low. Underground water aquifers are being over-exploited and freshwater ecosystems are being destroyed. Pollution of water calls for serious remedies. Some Arab countries still boast the highest annual per capita water consumption rates in the world. Arab governments' growing investments in tourism, raw materials extraction, and power, to name a few sectors, do not bode well for the future of water in the region.

The 2011 UNEP green economy report outlines several market-based instruments that can be harnessed to foster a green economy. These instruments include payments for ecosystem services, and strengthening consumer-driven accreditation schemes. Furthermore, recommendations are made for

improving entitlement and allocation systems. Well-designed systems must be established to define rules to determine how much water is to be allocated to each part of a river or aquifer, and an entitlement system is then used to distribute this water among users. Reducing input subsidies and charging for externalities is another condition necessary for the development of a green economy. Water charging and finance arrangements must also be improved should a green economy be established, taking into consideration how to finance access to water and sanitation services for the poor (UNEP, 2011).

Given the severity of water strains, it is difficult to pin hopes on partial solutions. Public-private partnerships cannot succeed if current water pricing structures remain unaltered. Water user associations cannot succeed if legal protection is not accorded. Water use efficiency will not improve if across-the-board subsidies are not removed or significantly reduced. Wastewater treatment plants cannot be effective if industries continue to discharge their waste streams untreated. Are these reform efforts then a case of too little, too late? It does not have to be so if Arab leaders make a commitment to launching and sustaining a genuine and comprehensive policy reform effort. The starting point for transformation rests with commitment and action at the highest political level.

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