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WATER DEMAND MANAGEMENT AND POLLUTION CONTROL: KEY TO SECURING AND SAFEGUARDING THE WATER SUPPLIES OF MENA IN THE 21ST CENTURY

by

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Water Demand Management and Pollution Control: Key to securing and safeguarding the water supplies of MENA in the 21st Century

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Abstract

The supply driven approach has effectively demonstrated its inability to deliver water security to the water stressed countries of MENA. The natural water shortages have been made even worse by the supply driven water policies and management practices. Accessible water sources are tapped beyond their virtual capacity. Securing additional water sources from across national borders, while achievable, remains costly and carries a great deal of security risks. Turning to the sea for additional water sources is also achievable, but remains costly and within the near future, it will not be affordable to most MENA countries.

A new approach to water resources management in the region is needed. The demand centered approach focuses on manipulating the demands in a serious attempt to match them with the available water resources. Each nation's water resources must be protected, conserved, developed, managed, used, and controlled in ways which ensure efficient, sustainable and beneficial use of water in the public interest. Efficient allocation amongst the competing groups of users is the tool to ensure that water supplies are used wisely in the public interest.

Every drop of water including wastewater, must count. The water resources and wastewater management policies must come together in addressing the water cycle in a holistic manner within the umbrella of integrated water resources management processes. Water must be used efficiently to reduce the consumptive use of water and wastewater flows. Wastewater flows must be managed effectively to safeguard public health, and protect the freshwaters from pollution. They must be reintegrated safely in the water cycle and accounted for in the water budget of the household, community, industry, and the agriculture.

The recommended approach stipulates that new water sources and additional supply facilities will be developed only after exhausting all the available possibilities for reducing the demand on water to match the existing supplies.

INTRODUCTION: Trends in water management

Management of the water sector generally comprises four groups of functions that make up the integrated water resources management processes:

1. Water resources assessment and development to augment and enhance availability of water. (groundwater, surface water, non-conventional water sources)
2. Water resources allocation to the competing groups of water users in the society (municipal, commercial, industrial, agricultural)

3. Water utilization by the various groups of water users which comprises the delivery, consumptive use, and waste generation. (the ways water could be conserved and wastewater generation reduced)
4. Environmental protection and pollution control to stop the consumption of freshwater by pollution and to return wastewater to the water cycle as a beneficial source of water.

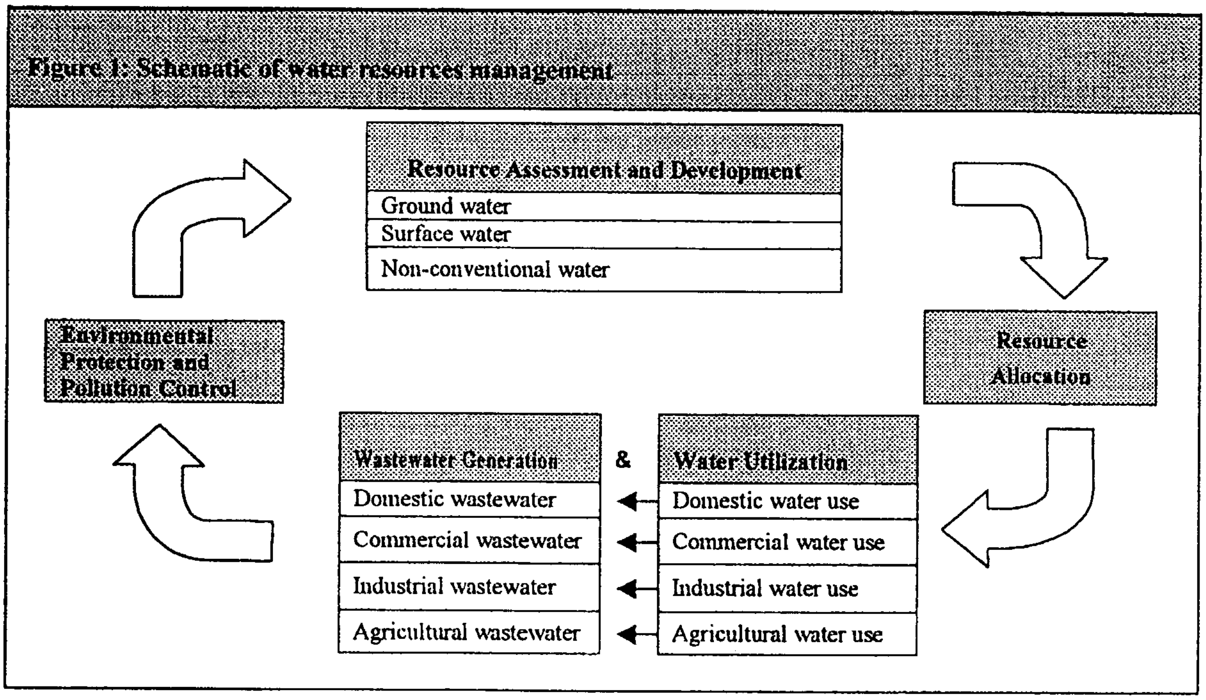


Figure 1: Schematic of water resources management

Source: Bakir, 1999

Employing a combination of the four groups of functions, water mangers try tirelessly to strike a balance between the available water resources and the demands on water by either:

- Supplying more water (supply management) to match the demand focusing mainly on the assessment and development of new water source

or

- Manipulating the demand (demand management) to match the available supplies focusing mainly on other three groups of functions namely allocation, efficient water utilization and effective pollution control and recovery of wastewaters.

Historically, water resources policies and management practices were supply driven. To meet the perceived rising demand, intensive efforts were placed in the assessment and development of new water sources and installation of delivery systems. Little or no attention was placed on the other three groups of functions. The main features of the supply approach are the utilization of freshwater sources beyond their renewable capacity leading to their depletion. Nearby and better quality sources are first used. Distant sources are sought at higher cost. Nonrenewable groundwater is mined, and lesser quality water is used. When we run dry, we turn to the sea for a source of water.

As the demand on water goes unchallenged so does the production of waste. Water management practices historically paid little or no attention to safe management of the huge volumes of wastewater. The collection and disposal mind-set prevailed because of concerns over public health protection. Cesspits were built to make wastewater disappear in the ground. Water intensive and

centralized sewer systems were built to remove wastewater from the immediate environment of the communities using water as a transportation medium. When rivers, lakes, and accessible groundwater became polluted, wastewater treatment plants were built. In many developing countries however, centralized wastewater systems have actually aggravated the problem they were designed to solve. A significant proportion of the scarce water sources continue to be consumed by pollution and the much needed water conservation drives can not be accommodated because of the intense water requirements for flushing the sewer system.

Even in the economically enabled and water rich nations, no supply strategies could keep pace with the present rate of population growth and demand. Fortunately, there is a shift towards manipulation of the demand on water before embarking on costly development of new sources. Water is now recognized as: a valuable resource for the health and well-being of the society; a finite resource which must be used efficiently and wisely; a renewable resource which must be kept clean and its quality protected; and a shared resource which must meet the needs of competing current users (humans and non-humans) and future generations.

Water management practices now explore efficiency and demand management solutions to reduce the wasteful consumption of water. Water allocation between water users is increasingly used to ensure optimal, efficient, sustainable, and beneficial use of water in the public interest with emphasis on meeting the basic human needs for domestic water supplies. Attempts are made to develop water resources within their renewable capacity and to repair the damage caused by decades of ever-exploitation. Environmental protection and pollution control policies are increasingly being considered within the framework of the integrated water resources management processes. Wastewater is being considered within the total water cycles and pollution control policies not only aim at stopping the pollution of the scarce water sources but also maximizing recycling and reuse of wastewater within the water budget of the households, communities, industries, commercial establishment and agriculture. Decentralized wastewater management offers greater protection and many more opportunities for reducing the nonproductive consumption of water and maximizing the recycling opportunities.

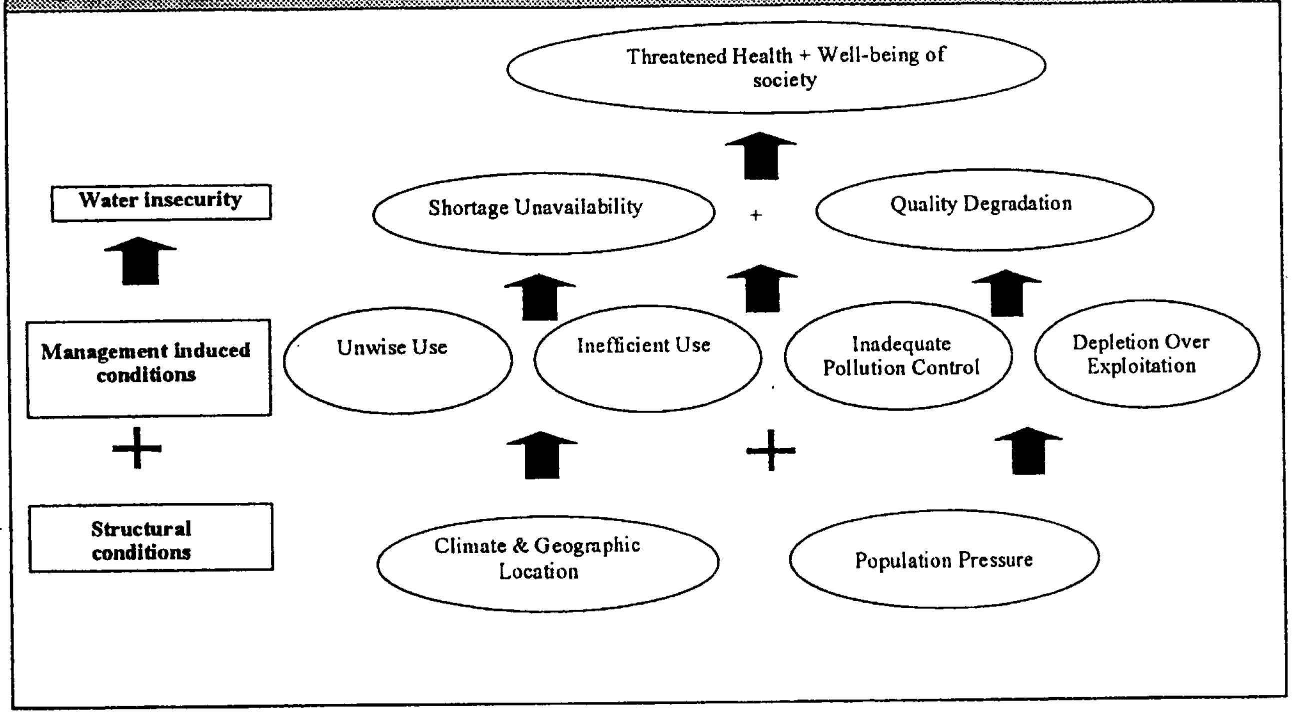
The Middle East and North Africa region is the driest in the world where freshwater availability has declined rapidly to a crisis level. In many countries, cities are running thirsty and communities are unable to obtain safe water supplies. In the absence of irrigation water, farmers resorted to untreated or partially treated wastewater for food production with significant public health implications. There is no other region in the world where the need is so acute for a serious shift in the water resources policies and management practices from the supply management to demand and efficiency management. The supply management approach continues to largely prevail.

THE WATER SHORTAGES IN MENA

MENA's water resources have been the subject of numerous studies, reports, and conferences both at national, sub-regional, and regional level. Various information sources suggest that limited water resources are one of the main constraints to social and economic development and even a source of insecurity. The water shortages in the region are a result of two categories of conditions:

1. Structural conditions related to geographic location, climatic characteristics and the population growth. Water policies and management practices can do little to influence these conditions.
2. Management-induced conditions brought about by existing water policies and management practices. These conditions can be averted and their impact reduced through improved water management policies and practices.

Figure 2: Causes and impact of water shortages in MENA



Structural conditions causing water shortages

Water scarcity

MENA, home to 5% of the world's population, has the lowest water availability in the world with less than 1% of the world's freshwater resources (Tables 1). MENA comprises some of the driest countries in the world and water shortages are largely natural. The region's climate is arid and semi arid characterized by low and erratic rainfall. Eight of MENA countries receive less than 100 mm per year and only 4 countries receive more than 300 mm per year (FAO, 1997).

Table 1 Distribution of Net Renewable Water Resources by Region (Total and Per Capita), 1995 estimates

	Total Availability (billion m^3/year)	Population (millions)	Per Capita Availability (m^3/year)
Oceania	769	21	36619
Latin America	10766	466	23103
North America	5379	287	18742
Eastern Europe and Central Asia	7256	495	14659
Africa	4184	559	7485
Western Europe	1985	383	5183
Asia	9985	3041	3283
MENA	355	284	1250

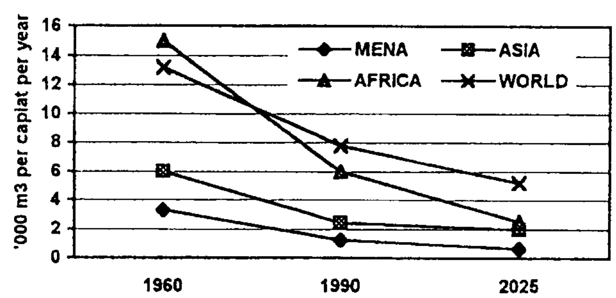
Source: World Bank (1996)

The demand is rising and the availability is declining

The demand on water is growing rapidly due to rapid population growth, urbanization and socioeconomic development. The population doubled in the past 30 years and is predicted to double in the next 30 years. Urban areas are home to about 60% of the region's population and cities are growing at an annual rate of 4 percent (World Bank 1996). As the population continues to grow against finite freshwater resources, the water availability for each individual continues to fall. The regional average annual per capita renewable water in MENA dropped from 3300 cubic meter in 1960 to about 1250 cubic meter in 1995 and is expected to drop to 650 cubic meter in 2025 (figure 3).

The regional average hides significant variations in the availability of water amongst countries of the region. By 2000, the internal renewable water resources in many MENA countries, especially Yemen and Jordan, were much below the projected regional average for 2025 (Table 2).

Figure 3. Projected Renewable Water Resources in Selected Regions



Source: World Bank, 1996

Management induced conditions causing water shortage

The water resources management policies and practices in MENA further worsen the water shortages in the region. Historically, water policies focused on supplying more water to meet the perceived demand with little or no attention to challenging the demand on water or increasing the efficiency of water use, allocating water among user groups, or environmental protection.

Water is unwisely, inefficiently and often wastefully used by all user sectors

The sectoral withdrawals of water in MENA countries are shown in Table 2. Irrigated agriculture is the biggest water user in the region with share ranging from less than 70% in Algeria, Bahrain, Cyprus, Kuwait and Lebanon to over 90% in Iran, Iraq, Morocco, Oman, Saudi Arabia, Sudan, and Syria. The domestic share of water varies from over 20% in Algeria, Bahrain, Cyprus, Jordan, Kuwait, Libya and Qatar to 5% or less in Oman, Morocco, Iraq, Sudan and Syria. The industrial share of water is generally less than 5% except in Algeria and Djibouti.

Water utilization by all water user groups is characterized by great inefficiencies in the water delivery systems and during utilization. Losses from municipal water delivery and supply systems reach as high as 60% (figure 4) exceeding the quantity of water reaching the consumers. In agriculture, as much as 50% of the produced water is lost during production, storage, and conveyance.

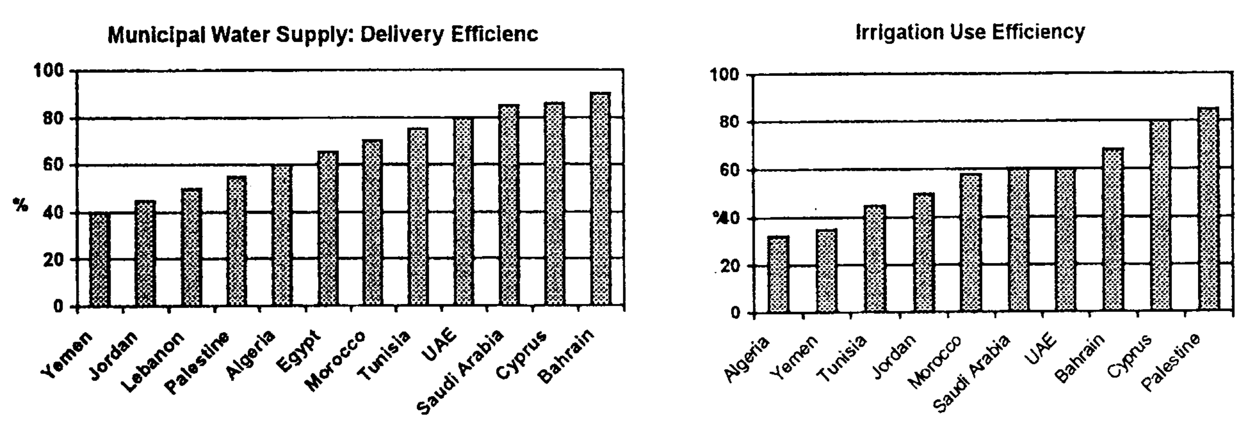
Domestic and agricultural supplies are subsidized and the cost to the consumer is far below the real cost of water. Low pricing encourages wasteful consumption of water and offers no incentives to conserving and investing in water efficiency solutions. Best quality water is used in ornamental gardening. Inefficient and water wasting fixtures are widely used and public building are water wasters.

Table 2. Annaul Internal Renewable Freshwater Resources and Withdrawals							
Country	Annual availability (m3 per capita)	Annual Withdrawals			Sectoral Withdrawals (percent)		
		Year	% of available resources	Per Capita (m3)	Domestic	Industrial	Agriculture
Algeria	442	1990	32	180	25	15	60
Bahrain *	7	1991	5980	465	39	4	56
Cyprus *	1213	1993	23	331	24	2	74
Egypt	26	1993	3,061	920	6	8	86
Iran	1,898	1993	55	1,165	6	2	92
Iraq	1,523	1990	122	2,368	3	5	92
Jordan	102	1993	145	187	22	3	75
Kuwait	...	1994	...	307	37	2	60
Lebanon	1,463	1994	27	444	28	4	68
Libya	143	1995	486	783	9	4	87
Morocco	1,058	1992	37	446	5	3	92
Oman	388	1991	124	658	5	2	94
Palestine	...	...	...	...	...	...	...
Qatar *	93	1994	559	528	23	3	74
Saudi Arabia	111	1992	708	1,002	9	1	90
Sudan	1,187	1995	51	669	5	1	94
Syria	434	1993	206	1,069	4	2	94
Tunisia	367	1996	76	295	14	3	83
UAE	61	1995	1,405	954	24	10	67
Yemen	226	1990	72	253	7	1	92

Source: World Resources Institute (2000) * Source: FAO (1997).

In agriculture, water is often used on land and crops with low productivity and low added value on using water. Irrigation method are inefficient. Flood irrigation efficiency is barely 30%. Water is used for producing export crops even in those countries with the lowest water availability. Exporting crops is effectively exporting the water needed to produce them.

Figure 4: Water use efficiency can be enhanced.



Source: Macoun, 2000

While the big consumers use water inefficiently and wastefully, the small consumers struggle to obtain the basic needs. Municipal and industrial demands are on the rise and there is not enough water available to them. Cities are running dry and their water supplies are increasingly becoming insecure.

Water withdrawals exceed renewable availability and water resources are being depleted

To meet the rising demand on water, eight MENA countries have tapped their existing resources beyond their renewable availability (table 2). Jordan, entirely dependant on its internal water resources, withdraws 45 percent from its internal renewable resources than is being replenished.

Groundwater and surface water resources in some of these countries are shrinking to crisis situation and their quality is degrading. Gaza aquifers are being mined at a very fast rate with the water tables dropping at the rate of 10-20 cm per year (UNEP 1999). In Sana'a the water table also dropped seriously as a result of over exploitation (Environmental Protection Council, 1995). Sea water intrusion in the Batinah coast of Oman caused complete loss of land (UNEP/UNESCWA 1992). Some countries are mining their non-renewable fossil groundwater. Saudi Arabia, UAE, and Libya are the largest users of fossil water (FAO, 1997). Fossil groundwater in Libya accounts for 95% of the country's freshwater withdrawals (UNEP, 1999). Excessive exploitation of non-renewable is not sustainable.

Pollution eats away at scarce water resources

Pollution is a freshwater consumer and a serious threat to health. An increasing proportion of the region's scarce surface and ground water resources is lost to pollution caused by:

- Unsafe management and domestic wastewater: disposal of untreated or poorly treated wastewater, seepage from poorly constructed and maintained onsite sanitation systems
- Uncontrolled disposal of industrial waste into sewers, land and water bodies
- Leaching from unsanitary solid waste landfills
- Seepage from agrochemicals (excessive use of fertilizers and pesticides)

The Sebou river in Morocco, Sidi Salem reservoir in Tunisia, and Mitidja and Saida aquifers in Algeria's are threatened by pollution from cities, industrial effluents and agricultural runoffs . The Nile, Al-Assi and Barada rivers in Syria are severely polluted from uncontrolled industrial, domestic and agricultural discharges. Shallow aquifers in Sana'a, Batinah cost in Oman, and Cyprus are contaminated (UNEP 1999). Nitrate levels in Gaza reached 40 ppm, 4 times higher than WHO guidelines (World Bank 1996).

Non-conventional water sources are being used

To cope with water scarcity, several MENA countries supplement their fresh water with treated wastewater and desalinated water (Table 3). Desalinated water and recycled wastewater account for 20-50% of the total water withdrawals in Bahrain, UAE, Qatar and Kuwait.

Table 3: Use of Non-Conventional Water in MENA Countries

Country	Reused treated wastewater			Desalination Water			Recycled & Desalinated
	Million m^3/yr	% of agriculture withdrawals	% of total withdrawals	Million m^3/yr	% of domestic and industrial withdrawals	% of total withdrawals	% of total withdrawals
Kuwait	52	16	9.7	231	107.9	42.937	52.602
Qatar	25.2	12	8.8	98.6	132.7	34.609	43.454
UAE	108	7.7	5.1	385	55	18.264	23.387
Bahrain	8.03	5.9	3.4	44.1	42.3	18.436	21.793
Saudi Arabia	217	1.4	1.3	714	41.8	4.196	5.471
Jordan	50.3	6.8	5.1	2	0.8	0.203	5.315
Cyprus	11	7.1	5.2	...	...	...	5.213
Oman	26	2.3	2.1	34	45.3	2.780	4.906
Libya	100	2.5	2.2	70	11.7	1.522	3.696
Syria	370	2.7	2.6	...	...	...	2.568
Algeria	...	...	...	64	3.6	1.422	1.422
Tunisia	20	0.7	0.7	8.3	2.4	0.270	0.92
Egypt	200	0.4	0.4	25	0.3	0.045	0.408

Source: FAO, 1997

Wastewater is widely recognized as a potential and reliable water source of growing availability. Jordan's and Tunisia's water policies count recycled wastewater in the national budget (Ministry of Water and Irrigation-Jordan, 1998 & Bahri, 1996)). In Syria, Lebanon, Jordan, Iraq, and West Bank and Gaza, 200 million cubic meters of wastewater are used annually for irrigation (UNEP1999). In GCC countries, about 400 million cubic meter of the annual 918 million cubic meter of treated wastewater are tertiary treated and reused for irrigating non-edible and fodder crops and urban landscaping. About 60% of the partially treated sewage is discharged to the sea (UNEP 1999).

Supported by their substantial energy and financial resources, the extremely water short countries of the GCC turned to desalination of sea water to meet the increasing demand on water. The power hungry and extremely costly desalination technologies remain beyond the reach of the majority of the region's countries. The cost of desalinated water is still high compared to the tariff charged.

Other water scarce countries, such as Jordan, explored cross-border water transfers especially from Turkey but the transfers never materialized for political reasons and concerns over security of the new supplies. Small scale water transfers from Syria to Jordan help alleviate the summer water shortages. Huge water bags from Turkey are transported to Northern Cyprus. Other transfer schemes from Iran to the Gulf countries are also being explored.

Municipal water supplies are insecure and their quality is degrading

Many cities in the region are running dry with severe water shortages especially in the summer season. Intermittent water supplies, accompanied by severe water quality deterioration, are common. Water supplies are interrupted routinely and rotated. Water availability and consumption in those cities are low. For example, the average daily per capita water consumption in Jordan is 70 litres (Ministry of Water and Irrigation-Jordan, 1998) which is modestly higher than the minimum basic needs of 50 litres per capita per day (Gleik, 1996).

Scarcity of water is the most significant constraint to the extension of safe water supply services to needy communities. In the West Bank, for example, providing a water supply system to villages is a question of finding a water source, not the funding for the system construction. Many new water supply schemes remain without running water for extended periods of time.

Over exploitation and pollution increase the cost of water supplies presenting another constraint to expansion of safe water supply services. Limited availability of groundwater and the declining groundwater tables makes development of sources and withdrawals more costly. Deeper boreholes have to be drilled and the pumping costs may rise to practically uneconomical levels. Once contaminated, water requires costly treatment before it can be used for community water supply. Where adequate treatment cannot be afforded, communities rely on insufficiently treated water for their water supply with considerable risk to health.

FUTURE CHOICES: The demand management approach

The supply driven approach has effectively demonstrated its inability to deliver water security to the region. The natural water shortages have been made even worse by historical supply driven water policies and management practices. Accessible water sources are tapped beyond their virtual capacity. Securing additional water sources from across national borders, while achievable, remains costly and carries a great deal of security risks. Turning to the sea for additional water sources is also achievable, but remains costly and within the near future, it will not be affordable to most MENA countries.

Before embarking on development of new costly water sources, a new approach to water resources management in the region is needed. The new approach focuses on manipulating the demands in a serious attempt to match them with the available water resources. Each nation's water resources must be protected, conserved, developed, managed, used, and controlled in ways which ensure efficient, sustainable and beneficial use of water in the public interest.

In the water stressed countries of MENA, every drop of water including wastewater, must count. The water resources and wastewater management policies must come together in addressing the water cycle in a holistic manner within the umbrella of integrated water resources management processes. Water must be used efficiently to reduce the consumptive use of water and wastewater flows. Wastewater flows must be managed effectively to safeguard public health, and protect the freshwaters from pollution. They must be reintegrated safely in the water cycle and accounted for in the water budget of the household, community, industry, and agriculture.

The recommended approach stipulates that new water sources and additional supply facilities will be developed only after exhausting all available possibilities for reducing the demand on water to match the existing supplies. The water deficits can be reduced with a large-scale shift from the supply driven approach to the demand management approach placing the following three groups of functions at the heart of water management policies and practices:

1. Efficient allocation of water amongst the competing groups of users to ensure that water supplies are used wisely, efficiently, in a sustainable manner for the public interest
2. Increasing the efficiency of water use to reduce the consumptive use of water while maintaining the social benefits of water
3. Strengthening environmental protection policies and pollution control to safeguard the quality of the scarce freshwater and safely reintegrate wastewater into the water cycle as a component of the water budget of households, communities, industries, and agriculture.

Water allocation for serving the public interest

The severe competition between the various water user groups (domestic, commercial, industrial, and agricultural) will only get worse. As the population continues to grow, the municipal and domestic

demand on water will continue to rise. Industrial and commercial water demands will also grow due to the changing nature of the region economies from large dependence on agriculture to increasing dependence on the industry, tourism and services. As the water resources are subjected to increasing pressure, all effort must be made to ensure that every drop of water is used wisely and optimally in a socially beneficial manner in the public interest. Water allocation amongst the competing water user groups is the main tool available for ensuring that water is used optimally in the public interest.

Public health protection is the most socially beneficial use of water which serves the public interest. To protect the public health and meet the basic human water needs, the domestic and municipal water demand must be first met and the highest quality water must always be reserved for the domestic municipal water requirements. In times of water crises such as droughts, the domestic water demand is first met at the cost of the other competing demands mainly the agriculture demand.

The industrial and commercial water user groups are viable economic entities capable of adding high economic and social returns (employment for example) on utilizing water. If the water is treated as a commodity and is left to the market forces and subsidies on water are removed, the industrial and commercial water users might afford the real cost of water.

The agriculture, the largest user group, appear to be the user group which has to yield part of its share of the water resources as the pressure mounts. Agriculture is the largest water user with the least water productivity (value added by using water), the contribution to GDP is lowest, and the employment generated from using water is lowest (World Bank, 1996 & Macoun 2000).

THE EFFICIENCY SOLUTION

Using water more efficiently in all applications is the tool to reducing the consumptive water use without reducing the social benefits of water. The enabling solutions for more efficient water use include:

1. Increasing the efficiency of the municipal, agricultural, industrial and commercial water supply and delivery systems
2. Increasing the efficiency of water utilization by all water user groups
3. Eliminating wasteful consumption of water by all water user groups
4. Allocating water to the more productive applications within each water user group,.
5. Matching the water quality with the intended water application and ensuring that water is used at least twice before it is discharged.

Efficient municipal water use

There are many misconceptions surrounding efforts to increase municipal water use efficiency. Water use efficiency exercises are often fragmented and crisis driven. Water utilities often perceive the water efficiency measures as sporadic and low profile public awareness exercises often targeted at the wrong audience.

The demand management approach calls for institutionalizing comprehensive, sustained and long-term water efficiency measures within the management practices of the water suppliers. The demand management approach calls on the water suppliers to play a proactive role and invest not only in improving the efficiency of the water supply systems but also in ensuring that consumers of water are using water efficiently. Investment in municipal water efficiency is of paramount importance in

order to save the best quality and scariest water from wastage and also to spare the millions of dollars necessary to produce it. In Tunisia and Bahrain, significant water savings were realized through the execution of municipal water demand management programmes which combined: increasing supply system efficiency through leakage control and better management; universal metering and pricing; improved customer services; and public education for creating a water conservation culture (Box 1).

The first priority water efficiency measure is reducing water losses in municipal water supply schemes through efficient management of the production, conveyance, storage, and distribution facilities. The system efficiency can be increased to over 80% as the case in Bahrain, Cyprus, UAE and recently in Tunisia (Figure 4). Reducing the water losses in municipal systems defers and may eliminate urgent investment in additional water sources and expansion of the water supply system in addition to safeguarding the water quality in the municipal systems. Improved efficiency of municipal supply systems enhances the public's confidence in their water supply systems and encourages positive behavioral change towards conserving water. In Tunisia sustained leakage control efforts over 4 years period reduced water losses in the system from 24.1% to 14.5% (Box 1). Bahrain's leakage control measures and improved customer services allowed significant manipulation of water demand as also demonstrated in Box 1.

Domestic water metering and pricing are the tools to reduce wasteful water consumption. Water metering increases people's awareness of their water consumption and encourages consciousness. The rising block tariff structures have been used widely and have proven their effectiveness as water conservation tools. While developing water pricing tools, planners must maintain the supply of the basic human needs at an affordable cost to the low income groups within the society and must ensure that water efficiency measures should never harm public health. Water must always be available for meeting the basic human needs at a reasonable and affordable cost.

Indoor and outdoor water efficiency brings direct benefits to the consumers whose spending on water can be reduced. Consumers with limited supplies can stretch their share of water to last for longer duration in order to avoid having to buy transported additional supplies at very high costs. Indoor water use efficiency can be boosted significantly through the use of improved water saving fixtures and appliances such as low volume flush toilets, dual flush toilets, high performance shower heads, showers and facet aerators, and front loading washing machines without inconveniencing the water users. New air-displacement flush toilets, using 1.6 litre per flush, are under development (Moore 2000). The enabling water saving technologies are proven and available and must be made widely reachable. Water utilities must encourage and invest in wider application of these enabling technologies through retrofitting programmes or financial incentives. Legislation, revised building codes, import and manufacturing restrictions, tax incentives are all necessary measures for encouraging availability and wider use of water efficient domestic solutions.

Private and public landscaping and vegetable gardens are the biggest outdoor water users in the region. Solutions for water efficient landscaping are also available. Xeriscaping utilizes native and drought tolerant plants and water efficient designs to create beautiful surroundings with as little water as possible.

Box 1: Water Demand Management in Tunisia and Bahrain

TUNISIA saves 66 million cubic meter of water in 4 years through leak detection alone[1].

Like most EMR countries Tunisia has a very limited water supply and a constantly rising water demand. To cope with water supply shortages crisis, Tunisia began to implement a comprehensive and sustained water demand management programme since 1991. Tunisia water conservation strategy combines the following: Increasing water supply system efficiency and controlling leakage; Universal water metering and pricing for conservation (rising-block-tariff); Public awareness and education to create a water conservation culture.

By 1999, major water saving were made:

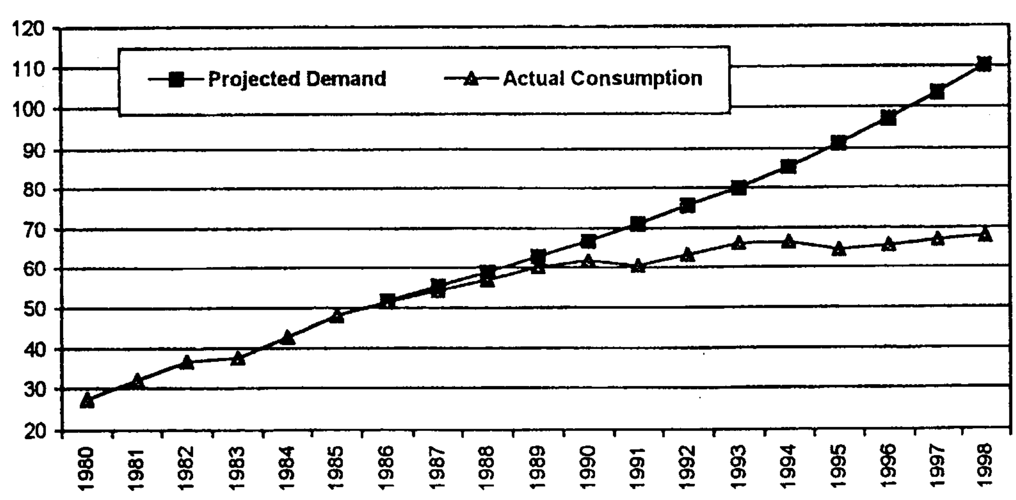
- Water losses in the distribution system dropped from 24.1% to 14.5%. The resulting water savings from 1996 to 1999 were 66 million cubic meters equivalent to 20 % of the annual drinking water consumption and the capacity of a medium size dam.
- 37% reduction in institutional and public water consumption which dropped from 1248 to 784 m3/year/connection
- 18% reduction in tourism consumption which dropped from 576 to 472 liters/day/bed
- 5% reduction in the average domestic consumption which dropped from 137 to 130 m^3/year/connection in 1991.

BAHRAIN defers a major expansion of its water supply system by conserving water[1].

In 1985, the State of Bahrain predicted that by 1998, the demand on water would rise to 110.28 from 48.16 million gallons per day (mgd) in 1985. The additional 62.12 mgd would have had to be met through building an additional desalination plant. Bahrain embarked on a comprehensive water conservation programme in 1986 and further expanded it in 1992. Bahrain water conservation strategy combined the following: leak control through system rehabilitation and replacement; universal water metering and water pricing for conservation; improved consumer services compounded with public awareness and education

By 1998, the actual water consumption was 42.4 mgd less than predicted. By effectively controlling the demand on water, Bahrain eliminated the need to build a new desalination plant.

The Impact of Water Demand Management Policies in Bahrain



Source: Limam (2000), Tunis, and Ministry of Electricity and Water – Bahrain (1999)

Enabling technologies are also available for using low quality water for non-potable water applications such as toilet flushing and landscaping to free up the most expensive, scarcest best quality water. Separation and recovery of graywater for toilet flushing or landscaping can readily be done. Brackish or lower quality water aquifers contaminated from onsite sanitation systems can be used for landscaping and toilet flushing. Small wastewater recycling systems at the scale of the household, residential building or neighborhood offer a cost effective and robust means of closing the water loop. The water authorities in Cyprus provide financial incentives and equipment to those households that wish to install graywater systems or drill a borehole for utilizing the low quality shallow aquifers for landscaping and toilet flushing (Kambanellas, 1997 &1999). In Saudi Arabia, a residential development company reports water savings of 40% in residential buildings equipped with small wastewater recycling systems - closed water loop system (Badruddin, 2000).

The enabling technologies and the water pricing tools must be compounded with behavioral change and a water conscious culture which is influenced partly by people's knowledge of how much water they consume, for what purpose, at what cost and what consequences. The Bahrain customer information services notify the customer of their past consumptions. The pioneering Greater Hermanus water conservation project in South Africa provides the consumers with lots of information on their water consumption pattern and offers them prepaid water option as a tool to change their behavior towards water.

Public education and awareness is of paramount importance. However there are a lot of misconceptions. Water utilities often target the wrong audience with their across the board public awareness exercises and water education campaigns. In many cities in the region the average water consumption of 70 lpcd is common and a significant proportion of the population barely gets the basic water needs while the big consumers continue to wastefully use water. Water efficiency campaigns must be targeted at the right audience and must be closely coordinated with other demand management measures in order to ensure long-term behavioral change..

Water efficiency in agriculture

Agriculture water use efficiency can be improved to grow more with the same water or grow the same amount with less water. Huge volumes of water can be freed up for meeting rising and priority domestic and industrial demands. Losses from the water storage, conveyance and distribution facilities can be reduced by lining water canals, replacing open canals with pipes, lining and covering on farm storage facilities. The irrigation efficiency can be improved significantly by departing from the inefficient flood irrigation methods to drip irrigation. Irrigation management services should be established to guide farmers on when, how, and how much to irrigate. To boost the irrigation efficiency in agriculture, Oman offered incentives and subsidies to encourage farmers to use drip irrigation. The productivity and efficiency of water use in agriculture can be improved by only allowing irrigation of crop and on lands with optimum crop yield per cubic meter of water. Better pricing of irrigation water can provide rational incentives to reduce wasteful irrigation and shift to more productive agriculture practices.

Countries may have to offer import incentives in order to encourage importation of water intensive crops and to discourage their local production. Bans might have to be placed on certain farm lands known for their low yields for every cubic meter of water. It might be necessary for countries with severe water shortages to stop farming of export crops. Exporting one ton of oranges is effectively exporting the 400 cubic meters of water that is needed to grow it. Likewise, importing one ton of bananas is effectively importing the 900 cubic meters of water necessary to produce it.

Crops require varying quality water. Crops which require a very high quality water might have to be replaced with salt tolerant and drought tolerant crops to make use of the brackish water, which in many counties is plentiful. Recycled wastewater is widely used in agriculture. Increasing use of recycled wastewater will become even more necessary in the future as the better quality irrigation water is shifted to municipal and industrial applications.

Water efficiency in the industry

The total amount of water use in the industry is determined by the mix of products produced, the intensity of water requirements in the production process, and the efficiency of the production processes. To produce more with the available quantity of water, it necessary to examine the mix of products and shift to products requiring less water to produce. Water intensive products can be avoided. Water intensive processes can be replaced with more efficient and less water dependant processes. Industrial wastewater must be recycled and as much as possible and used, together with treated domestic wastewater and other low quality waters, in appropriate applications within the production processes.

The industrial sector is considered a viable economic entity capable of competing for the scarce water supplies in the open market. Industrial water pricing to reflect the real cost of water will encourage conservation and investment in water saving solutions.

Environmental Protection, Pollution Control, and Recovery of Water

As we use water in our homes, buildings, industry, and agriculture, we generate wastewater. The generated wastewater will either end up consuming the scarce freshwater resources if poorly managed or can be brought back into the water budget as a non-conventional water source thus closing the water loop. Pollution control through effective wastewater management is the tool available to water resource managers to protect the scarce water resources and recover water. To maximize wastewater recovery and beneficial use, wastewater management services must be extended at an accelerated rate to the unserved urban and small communities. Robust, efficient, cost effective, affordable and environmentally responsible wastewater management solutions must be identified and employed.

Necessity, investment and promotional efforts over the past two decades led to wide recognition of the importance of wastewater as a potential water source in the region. Yet this potential water source is not fully utilized and it continues to pollute the scarce water resources. The problem lies in the way wastewater is managed and recycling is perceived. For a long time, centralized wastewater systems were the preferred choice of planners and decision makers and the ultimate solution. The standard large, water and capital intensive sewer networks are built to transport domestic wastewater to central treatment. The high cost of centralized systems renders them unaffordable and and their dependence on water as a transportation medium renders them inappropriate in MENA especially for small communities. Experience with centralized systems in MENA is far less than desirable. Sewer networks are overloaded and often suffer from siltation and blockages due to the low water consumption where water supplies are intermittent. Treatment plants, often added years after the

construction of the sewer networks, are overloaded and poorly maintained. Their outputs fall short of the expectations for the intended pollution control and recovery of water.

The centralized management of wastewater concentrates wastewater reuse in agriculture often far away from the generating communities overlooking the ample wastewater reuse opportunities within the generating communities where the best quality and most expensive water is used. Reuse within the generating communities in domestic and public landscaping, other non potable domestic application such as toilet flushing, in addition to market gardening will free up large volumes of drinking water.

For reasons of the economy of scale, the large systems were promoted. There is growing evidence however that while large sewerage treatment plants gain some economies of scale the entire wastewater management system gains bigger diseconomies because of the cost of the sewers networks to collect waste from greater areas. The centralized systems place lesser investment in the treatment plants and greater investment in the non value adding sewer networks which account for about 90% of the entire wastewater management systems. A study in Adelaide, Australia, found that the conventional centralized design was at least ten fold, and even thousand fold larger than an economic optimum (Clark and Tomlinson, 1995).

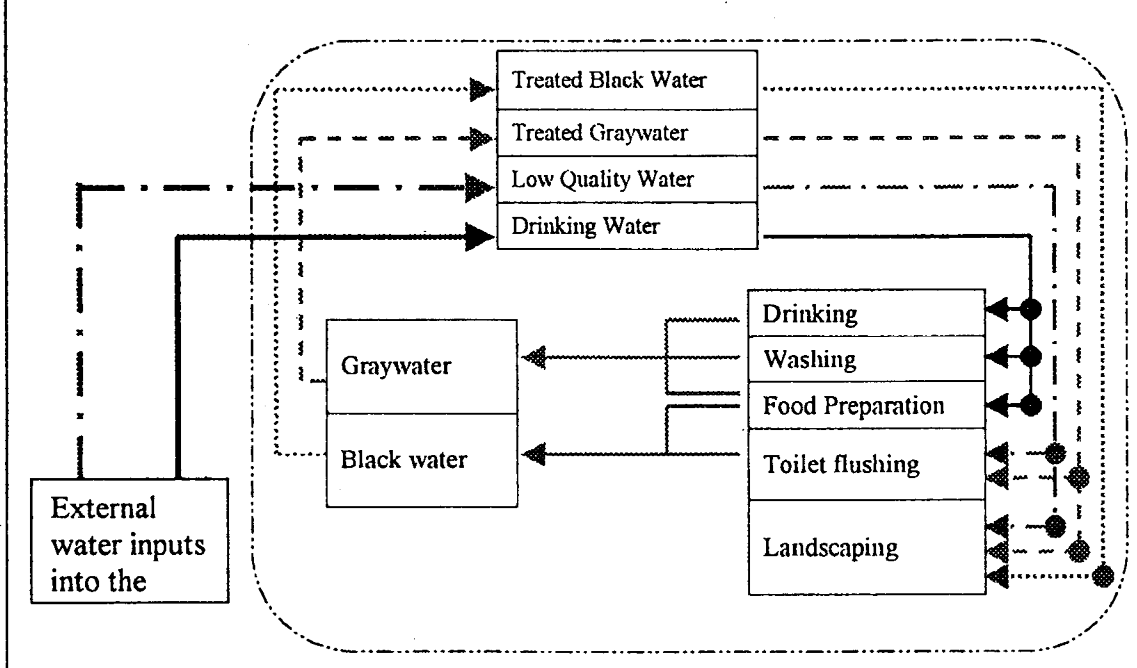
There is a growing evidence that small decentralized wastewater systems at the scale of a household, or neighborhood can efficiently deliver at much lower cost the intended benefits of wastewater management which are: the protection of public health; stopping pollution of the community environment; stopping pollution of the scarce water resources; and maximizing the recovery for water for beneficial use. Small decentralized systems facilitate accelerated and environmentally responsible extension of wastewater services which are robust and efficient. The necessary domestic water conservation efforts can be accommodated and the water inputs in wastewater transportation can be reduced, eliminating the unnecessary demand on freshwater. Investment in pollution control can be made more efficient and modular, site tailored and capital efficient wastewater systems are added when necessary. By managing wastewater closer to the source, they place greater investment in reliable treatment works than in non value adding sewer networks. The environmental risks associated with large schemes are reduced by isolating the problem rather than centralizing it. Wastewater reuse opportunities can be increased within and closer to the source in the household, neighborhood and community where the value of water is highest. The community needs can also be met for better surrounding environment, habitat, trees, and economic productivity.

The enabling tools and technologies are well developed and tested. Wastewater management starts with reduced wastewater generation as a result of water conservation efforts. Onsite wastewater management systems can be improved to stop pollution and recover water. Greywater can be separated and immediately reused for meeting the household needs of non potable application. If total onsite management is not possible due to prevailing site conditions, modular wastewater systems can be built using the lower cost and less water intensive settled sewers to collect the partially treated wastewater effluent from septic tanks to a simplified neighborhood or community treatment facility after which the effluent is brought back for beneficial reuse (WHO-CEHA, 2000).

The closed water loop concept

The closed water loop concept, graphically illustrated in (Figure 5), emerges from the water demand management approach as a management tool. At the scale of the household, neighborhood, community, industry, or institution water can be managed as a closed loop. Water inputs, of various qualities, can be brought into the closed water loop for the various water applications where the water quality is matched with the intended application quality requirements. Every drop of water can be used at least twice before it is sent out of the loop. After water is used, the generated wastewater is segregated according to the level and type of contaminations it contains. The wastewater streams are treated and the recycled water is kept in the loop and used in the appropriate applications.

Figure 5: A closed water loop for a residential building



At the scale of the household and residential buildings, the highest quality water is reserved for drinking and food preparation and hygiene requirements. Water abstracted from contaminated shallow aquifers can be used for landscaping or toilet flushing. Brackish water for example can be used for toilet flushing. Greywater is separated, treated, and kept in the household water loop for landscaping or toilet flushing. Wastewater from the toilets and kitchens can be treated in a septic tank followed by a sub-surface wetlands. The sub-surface wetland can be built within the household landscape and used to grow ornamental plants and others to aid the treatment process. The treated effluent can be applied though sub-surface irrigation network to irrigate trees and to create a pleasant environment and a habitat for birds.

Implementation

Implementation of the demand management approach requires in the first place recognition and understanding of the non-structural or management induced conditions causing the water shortages.

The supply management approach will further worsen the water shortages crisis. We cannot continue to do the same thing and expect a different result.

Water management policies must recognize the need to shift from the business as usual supplying more to meet the demand to demand management approach to manipulate the demand to match the supplies. Rational planning processes and management practices must be developed and adopted to translate recognition to action. The planning processes entail:

1. An assessment of the available water resources (current and potential) and the past, current and future water demands by all water user groups to provide answers to the following questions:
   i. Does the water use pattern support the public interest and the overall socioeconomic objectives of the society?
   ii. Does the quantity and quality of water use match those of the available resources?
   iii. Is water used efficiently by all water users groups? Is the actual water use reasonable, in terms of both quantity and quality, and as judged by accepted standards?

2. Allocating water, in quantity and quality, amongst the competing water using groups to ensure meeting the public interest as defined by the national socioeconomic objectives
3. Establishing water efficiency targets for each water users group
4. Identifying water efficiency performance indicators to monitor the performance of each water using group
5. Establishing an incentive or disincentive system to enforce the demand management approach
6. Designing and executing sustained water efficiency programmes integrated within the operation of each water using group
7. Monitoring the performance of the water efficiency programmes of each user group and undertaking the necessary adjustments.

Water management institutions must also recognize that investment in water demand management is an effective investment in the country's water resources which can lead to better returns than investment in new water supplies. Water suppliers must play a proactive role not only investing in improving their efficiency in producing, delivering and distributing water, but also investing in ensuring that their customers use water efficiently.

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