Water Resources

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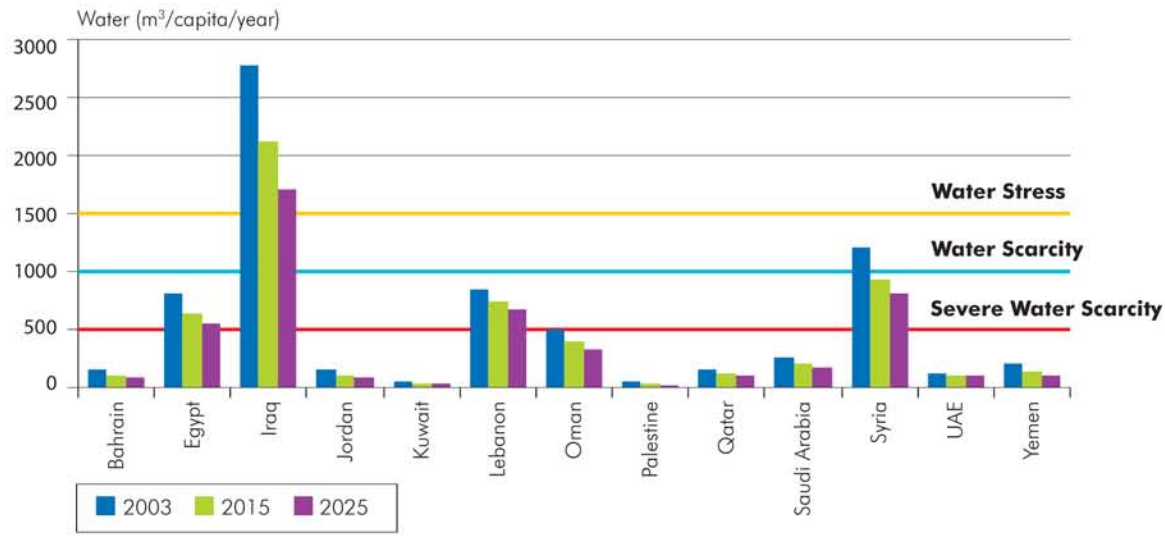
I. INTRODUCTION

At present worldwide freshwater resources are on the decline, with demand far exceeding the available supply. Although the global water supply may be adequate to combat this problem for the time being, it is quickly dwindling, as more and more consumption increases are becoming unsustainable; it is projected that 90% of all available freshwater could be consumed by the year 2025 (Salem, 2003). The potentially adverse impact of climate change on water resources is particularly worrisome for the Arab, Middle East and North African regions since the already meagre water resources of countries in these regions are being stretched thin by rising water demand driven by population growth and rising living standards. Water is considered the single most constraining factor of growth in the Arab countries.

Water resources are unevenly distributed among and within countries, with some presently facing severe drought and water scarcity, especially in the Arab region. In the 2001 benchmark report entitled *The Future of Environmental Action in the Arab World*, M.K. Tolba et al estimated that the average annual available water per capita in the Arab countries was 977 cubic meters in 2001, and that this figure will decrease to 460 cubic meters in the year 2023. The United Nations definition of a nation under water stress is when its available annual water per capita is less than 1,500 cubic meters, under water scarcity if the annual available water is less than 1000 cubic meters, and severe water stress if the available annual water is less than 500 cubic meters; in the year 2025 Iraq will be above the water stress line, Lebanon, Syria and Egypt will be above the severe water stress line, and the rest will be under the severe water stress line. M.E. Osman compiled in 2004 water stress data in some Arab countries, outlining the occurrence of water scarcity in the years 2003, 2015 and 2025 as presented in Figure 1.

The United Nations estimates that globally some 1.1 billion people lack access to clean water and 2.4 billion lack access to proper sanitation (most of these being in developing countries). In addition, a third of the world's population has serious water shortage problems (this number could grow to two thirds by the year 2025 if corrective measures are not taken) (McCarthy, 2003). Exacerbating these problems are accelerated population growth, especially in third world countries, coupled with the concomitant expansion of the agriculture and industrial sectors which increase pollution (higher water usage and untreated wastewater); along with climate changes, these factors combined produce drastic declines in the global water supply (Rosegrant,

FIGURE 1 **WATER STRESS, WATER SCARCITY, AND SEVERE WATER SCARCITY IN THE ARAB COUNTRIES IN THE YEARS 2003, 2015, AND 2025**



Source: Proceedings of the Symposium on challenges facing water resources management in arid and Semi-arid regions. American University of Beirut, Oct 7-9, 2004. (CD Publication).

TABLE 1 **FRESH WATER AVAILABILITY PER CAPITA PER YEAR IN DIFFERENT ARAB COUNTRIES FROM 1955-2050**

	Water availability m^3 / capita / year							
Country	**1955[b]**	**1990[b]**	**2000[a]**	**2003[c]**	**2010[a]**	**2015[c]**	**2025[a]**	**2050[d]**
Algeria	1,770	689					332	300
Bahrain	672	179	170	153	139	120	89	
Egypt	2,561	1,123	800	770	750	600	550	510
Iraq	18,441	6,029	3,100	2,800	2,400	2,100	1,700	
Jordan	906	327	<500	150	<500	130	121	100
Kuwait				<100	<100	<100	<100	
Lebanon	3,088	1,818	900	900	800	800	867	800
Libya	4,105	1,017					359	250
Morocco	2,763	1,117					590	600
Oman	4,240	1,266	500	500	450	450	410	
Qatar	1,427	117	<100	<100	<100	<100	68	
Saudi Arabia	1,266	306	<500	400	320	250	113	
Syria	6,500	2,087	1,250	1,250	900	850	732	600
Tunisia	1,127	540					324	400
United Arab Emirates	6,195	308	<500	<400	<300	<200	176	
West Bank and Gaza	1,229	461	<500		<500		264	
Yemen	1,098	445	<500	300	250	200	152	

Sources:
a- Policies and institutions for coping with environmental aspects of water scarcity in western Asia, by Hosni Khordagui Ph.D., Lebanon http://www.unwater.org/downloads/wwwKhordagui.pdf
b- ITT industries guidebook to global water issues http://itt.com/waterbook/per_cap_country.asp
c- Economic and Social commision for Western Asia, UN, 2003 - http://www.escwa.org.lb/information/publications/edit/upload/sdpd-03-13.pdf
d- Water demand management in the Mediterranean, Hamdy A., http://www.idrc.org.sg/en/ev-42818-201-1-DO_TOPIC.html

1995). Although wide and concrete evidence of this crisis exists there is little or slow progress in bringing about sufficient national, regional and international political commitment and implementation to try and reverse this process.

This situation is very pertinent to the countries of the Arab region: the region accounts for 3% of the world's population, 10% of its land, but only 1.2% of the world's renewable water reserves. Many of the countries in this region are fragile developing countries, struggling with the dual demographic and economic strains of increasing populations and high demand for policies of economic expansion (via industrial and agricultural development), which together lead to even more acute pressure on their already scarce water resources.

II. PRESENT FRESH WATER AVAILABILITY AND USE PER SECTOR IN THE ARAB WORLD

The Arab region is characterized by very low rainfall that is not equally distributed in time and space and is not predictable from year to year. The actual water situation in the region can easily be described as precarious. Within one lifetime, annual average per capita renewable supplies excluding so-called "fossil" aquifers will have fallen by about 80%, from 3,430 cubic meters per capita (in 1960) to 667 cubic meters (in 2025) (World Bank 1994). These levels are far below the levels of other major regions in the world. In several, if not most, Arab countries, renewable water will barely cover the sustainable human needs as defined by the United Nations (as mentioned above). Moreover, more than 10 rivers flowing from outside the region supplying around 35 percent of these renewable water supplies are vulnerable to extraction by upstream riparian countries (Tolba et al., 2001). Table 1 shows the renewable fresh water resources for some Arab counties in annual cubic meters per capita for the years 1955, 1990, 2000, 2010, 2015, 2025, and 2050.

As the above figure makes alarmingly clear, renewable freshwater availability is projected to decrease on per capita basis by a factor of thirty-five in the UAE, a factor of ten in Oman and Iraq, and five in Algeria between the years 1955 and 2025. Only Iraq will remain above the water scarcity line (1,000 cubic meters) by the year 2025.

TABLE 2 **GOVERNMENT EXPENDITURE ON WATER AS PERCENT OF THE GNP IN SOME ARAB COUNTRIES**

	Public expenditure on water as a share of GDP (%)***				Ground water depletion as % of GNP
Country	**2001**	**2002**	**2003**	**2004**	
Algeria	1.3	1.7	1.7	1.5	-
Egypt	-	3.6	3.3	2.4	1.3
Morocco	3.6	3.6	3.6	30.6	0
Saudi Arabia	-	1.7	-	-	-
Tunisia	1.7a	-	-	-	1.2
Yemen	-	-	3.5	-	1.4
Jordan					2.1

a- Average 1997-2001
*** World Bank 2004b, 2005b, 2006g; AWC 2006.

The vital importance of water can hardly be overstated. In arid regions, where most of the Arab counties are located, it largely determines the pattern of settlement and plays a crucial role in human culture and life-style. Health and nutrition depend on the availability of water of acceptable quality, and it is an essential input for most economic activities, especially in rural areas. On the other hand, throughout history the Arab countries have depended on irrigated agriculture, and governments have given irrigation projects priority to feed the growing population. Examples are Egypt, Jordan, Morocco, Saudi Arabia, Tunisia and others. Investment in the water sector has been significant in these countries, typically accounting for 10-20 percent of total public sector investment, and equivalent to perhaps 2 to 4 percent of the GNP as shown in table 2.

By far most of the available water supplies are used for irrigation, accounting for more than 80 percent of total water use in most Arab countries (Table 3). However, with the projected increasing scarcity of fresh water availability, the priority will increasingly be placed on human consumption to meet basic needs. This future shift from irrigation to domestic water use requires careful analysis of the various factors affecting the improvement and development of the water sector – resource management – and the efficient utilization of the water balance – demand management.

Lamentably, as shown in table 3, water use efficiency barely exceeds 40 percent in most of the countries in the Arab world. Strategic planning should therefore stress on water productivity – production of any commodity per unit of water – and focus especially on the agriculture sector, in order to attempt to achieve more value per unit of water.

Annual renewable water supplies in the Arab countries average about 219 BCM (billion cubic metres) as compared to 4,184 BCM in Africa, 10,485 BCM in Asia and 40,673 in the world (World Resources Institute 1992). Of this figure, about 120 BCM are from flowing from outside the region (table 4): 84 BCM by the Nile, 28 BCM by the Euphrates, and 38 BCM by the Tigris and its tributaries. In such situations, countries are more sensitive to exogenous shocks as they do not themselves control the river source. Besides renewable surface water and groundwater, there are substantial non-renewable groundwater resources, and countries in the Arab region have varying access to brackish water and unlimited seawater for future development.

Table 4 compares renewable fresh water resources per capita in the countries with estimates for other regions of the world.

Many Arab countries have been intensively mining their groundwater; this is especially the case in the Gulf States as well as Algeria, Jordan, Lebanon, Palestine and Yemen. Egypt is also mining water from the Nubian Sandstone aquifer. Mining the accessible groundwater resources is often risky since interactions with river flows may affect surface supplies, and the lowering of the water tables can cause no water flow in the river during the summer season and result in saline intrusion from brackish water and/or seawater on the coastal area.

Non-conventional water sources are becoming increasingly important. The region in general, especially the Gulf states, produces more than 60% of the desalinized water in the world. Due

TABLE 3 **RENEWABLE FRESH WATER RESOURCES AND TOTAL WITHDRAWAL AND USE PER SECTOR IN SOME ARAB COUNTRIES IN BILLION CUBIC METERS (BCM)**

Countries	Renewable resources per capita			Total withdrawal		
	1960	1990	2025	BCM	% of Total	% of Total
Algeria	1,704	737	354	3	16	27
Bahrain	na	na	na	0.2	na	
Egypt	2,251	1,112	645	56.4	97	93
Iraq	14,706	5,285	2,000	42.8	43	52
Jordan	529	224	91	0.8	87	77
Lebanon	2,000	1,407	809	0.8	16	24
Libya	538	154	55	2.8	404	854
Morocco	2,560	1,185	651	11	37	35
Oman	4,000	1,333	421	0.4	22	
Qatar	na	na	na	na	174	
Saudi Arabia	537	156	49	2.3	106	643
Syria	1,196	439	161	3.3	61	73
Tunisia	1,036	532	319	2.3	53	54
UAE	3,000	189	113	0.4	140	
Yemen	481	214	72	3.4	136	151
MENA	3,430	1,436	667	177.2	51	
Africa	14,884	6,516	2,620	144	3	
Asia	6,290	3,368	2,134	1,531	15	
World	13,471	7,685	4,783	3,240	8	

Countries	Per sector % of total					
	Domestic	Industry	Agriculture	BCM agric.need	BCM agric. actual	water use efficiency
Algeria	22	4	74	1.45	3.94	37
Bahrain	60	36	4			
Egypt	7	5	88	28.51	54	53
Iraq	3	5	92	11.2	39.38	28
Jordan	29	6	65	0.29	0.68	43
Lebanon	11	4	85	0.42	1.06	40
Libya	15	10	75	2.56	5.13	50
Morocco	6	3	91	4.24	10.18	42
Oman	3	3	94			
Qatar	36	26	38			
Saudi Arabia	45	51	4	6.68	15.42	43
Syria	7	10	83	8.53	18.96	45
Tunisia	13	7	80	1.21	2.43	50
UAE	11	9	80			
Yemen	5	2	93	2.48	6.19	40
MENA	6	7	87			
Africa	7	5	88			
Asia	6	8	86			
World	8	23	69			

Sources: A strategy for Managing water in the MENA 1993
AQUASTAT FAO's information System on Water and Agriculture 2001. www.fao.org/ag/agl/aglw/aquastat/water_res/waterres_tab.htm

to its physical constraints and the relatively high cost of desalinization, this source of water is still confined to industrial and domestic water use.

Water availability depends mainly on seasonal and inter-annual variability; 65 percent of renewable fresh water depends on precipitation, and in

the semi-arid and arid climate prevalent in much of the Arab region precipitation varies from year to year, and from place to place. In many areas rainfall occurs at the wrong time and in the wrong place with the wrong intensity and is confined to a very short period of the year. In the case of Lebanon, there are a maximum of 80 days of rainfall a year, and this is mostly confined to the coastal areas. Annual precipitation varies from negligible amounts in desert areas to about 1,500 mm in mountainous areas with most rain falling in the winter season. Stream flows vary considerably during the year in response to rainfall patterns. Water availability therefore fluctuates markedly about the average in table 4. For example, low flows on the Tigris and Euphrates have been recorded at less than one third of the average annual flows, on the Jordan at less than half, and at the Litani at less than one tenth.

This water supply variability implies three important constraints in water management. First, expensive storage capacity is required to utilize the variability of flows in space and time, subjecting the stored water to evaporation losses. Fourteen percent of the Nile flow at Aswan is lost in evaporation from the reservoir and deep percolation losses. Groundwater recharge and storage can play an important role in minimizing these losses, but this requires expensive geophysical studies to define the underground storage aquifers and their boundaries. Second, it introduces an element of risk, which makes estimation of water's true opportunity cost – its value in the next best economics use – quite difficult. This is relevant, since the cross sectional comparison of water's opportunity cost becomes increasingly important as scarcity increases. And third, this variability requires systematic contingency planning.

The minimum amount of water required to sustain human life is 25 litres per day (about 10 cubic meters per year); a reasonable supply to maintain health may be 100-200 litres per day per capita, although in developed/industrial countries domestic use can exceed 300-400 litres

TABLE 4 **TOTAL ANNUAL INTERNAL RENEWABLE WATER, ANNUAL RIVER FLOWS, AND NET ANNUAL RENEWABLE RESOURCES IN THE ARAB COUNTRIES**

Countries	Total renewable BCM	Total available/ year BCM	Annual river flows From other countries	Annual river flows To other countries	Net annual renewable resources BCM
Algeria	15	11.30	0.2	0.7	18.4
Bahrain	na		na	na	na
Egypt	58	16.00	56.5	**	58.3
Iraq	75		66	na	100
Jordan	1	**	0.16	**	0.86
Lebanon	4	3.90	na	0.86	3.94
Libya	1	-3.00	na	na	0.7
Morocco	29	20.50	na	0.3	29.7
Oman			na	**	2
Qatar			na	**	0
Saudi Arabia	2		na	**	2.2
Syria	26	24.50	27.9	30	5.5
Tunisia	4	1.50	0.6	na	4.35
UAE			na	na	0.3
Yemen	4		na	**	2.5
Arab Countries	219				
Africa	4,184				
Asia	10,485				
World	40,673				

Sources: A strategy for Managing water in the MENA 1993
AQUASTAT FAO's information System on Water and Agriculture 2001
www.fao.org/ag/agl/aglw/aquastat/water_res/waterres_tab.htm
Margat, J., Domitille, V., 1999. Mediterranean Vision on Water, Population and the Environment for the XXIst century.
Contribution to the world water council and the global water partnership prepared by the Blue Plan in the framework of the MEDTAC/GWP.

per day. In some Arab countries, the renewable water supply exceeds basic human requirements, but still remains far less than the minimum amount of water required to sustain good livelihood – food and daily use – which is estimated to be 1,000 cubic meters per year, as defined by the United Nations. Tables 5 and 6 below, abstracted from different sources summarize the withdrawal of water for various sectors, i.e. domestic, industrials and agricultural use.

Water demand is expanding most rapidly in urban areas. Most countries in the region are classified as middle income and the percentage of the urban population that has access to safe drinking water is approaching 100 percent. In contrast, rural areas are much less well served with accessibility to drinking water, with only about 66 percent having safe access. Population growth rates are expected to slow down in the region, reaching around 2.5 percent between 2000 and 2025, which is still high by world standards; the region's population is expected to increase to 466 million in 2025. The urban share of population is also expected to increase from 60 percent to 75 percent, leading to a dramatic increase in domestic water use, which must be met by increasing the efficiency of water used in agriculture so that the saving can be reallocated to different sectors.

Water withdrawal, or use, in most of the Arab countries already exceeds renewable supplies; this is the case in Libya, Saudi Arabia, the Gulf states, and Yemen. Only Iraq and Lebanon have renewable water resources that are adequate and well distributed relative to population. Nonetheless, even for these two countries water conservation projects are necessary.

Reliably modelling a demand-supply strategy is difficult and uncertain, because the data on supply and demand are variable. Each sector can predict its own water demand with a certain degree of accuracy and reasonably estimate the investments needed for meeting these demands, but if investments are faced with financial and/or phys-

TABLE 5 **WATER RESOURCES IN SOME ARAB COUNTRIES FROM CONVENTIONAL RENEWABLE AND NON-CONVENTIONAL WATER RESOURCES, INCLUDING DESALINIZED AND TREATED WASTE WATER (IN MILLION CUBIC METERS (MCM)**

	Conventional water resource (MCM)			Non-conventional water resources (MCM)	
Country	Surface water	Groundwater recharge	Groundwater use	Desalination	Wastewater and drainage reuse
Lebanon	2,500	600	240		2
Oman	918	550	1,644	51	23
West bank and Gaza	30	185	200	0.5	2
Yemen	2,250	1,400	2,200	9	52
Jordan	350	277	486	2.5	61
Bahrain	0.2	100	258	75	17.7 (3)
Saudi Arabia	2,230	3,850	14,430	795	131 (24)
Qatar	1.4	85	185	131	28
United Arab Emirates	185	130	900	455	108
Iraq	70,370	2,000	513	7.4	1,500
Syria	16,375	5,100	3,500	2	1,447
Egypt	55,500	4,100	4,850	6.6	3,800
Kuwait	0.1	160	405	388	30

(values in brackets are drainage water reuse)

'Shared groundwater resources in the ESCWA region: the need, potential benefits and requirements for enhanced cooperation,' paper presented at the Expert Group Meeting on Legal Aspects of the Management of Shared Water Resources, Sharm El-Sheikh, Egypt, 8–11 June 2007 – cited in "Sectoral Water Allocation Policies in Selected ESCWA Countries", Economic and Social Commission for Western Asia of the United Nations. November 2003. 5

ical constraints, then a deficit in demand will occur. Ultimately and with good planning and management supply and demand should balance. The question is at what cost?

Besides its role as a basic need and an economic input into production sectors, water is also one of the three prime natural resources besides land and air. Comprehensive data on water quality is not fully available in most countries. No data is available on the availability and use of saline water. Some data is available on treated waste water and its recycling for use in landscape as presented before. But recent World Bank studies suggest that deteriorating water quality, which adds to fresh water scarcity, is becoming a serious issue in many countries. The principle sources of water pollution include the following:

1. Seepage and runoff of agrochemicals such as nitrogen, and pesticides;
2. Seepage from landfills due to the dumping of the solid wastes;
3. Untreated municipal waste water;
4. Untreated industrial wastes, either discharging in municipal sewer systems or directly in watercourses.

This decline in water quality is adding another dimension to the scarcity thereof, which in the long run will affect the human health, the productivity of water, and the quality of life. Declining water quality, besides being hazardous, increases the purification cost to downstream users and may not be suitable to be used for particular purposes.

VIRTUAL WATER

The concept of virtual water refers to the amount of water *embedded* in certain goods; that is, the amount of water that is required to produce the good. For example, with crops this refers to the amount of water needed to grow a certain quantity of the crop. The implications of the concept of virtual water – a concept developed by Professor John Anthony Allan of King's College London and the School of Oriental and African Studies – for water-scarce countries such as those in the arid regions of the Arab world, are that an awareness of the content of virtual water, when taken into account in the production of goods, can aid a country in using its scarce water resources in a more sustainable manner. Using trade theory, then, it would make sense for water-scarce countries to import goods for whose production water is intensively used, thereby saving the domestically available water supply for other uses.

TABLE 6 **SECTORAL WATER DEMANDS IN SOME ARAB COUNTRIES FOR THE YEARS 2010 AND 2025**

Countries	Sectoral water demand projection									
	Domestic		Agriculture		Industry		Energy		Total	
	2010	2025	2010	2025	2010	2025	2010	2025	2010	2025
Algeria	0.83	0.80	1.90	1.90	0.2	0.3			2.93	3
Bahrain										
Egypt	5.00	6.00	75.00	95.00	10	14			90	115
Jordan	0.43	0.57	1.75	2.40	0.13	0.2			2.31	3.17
Lebanon	0.40	0.52	0.92	1.10	0.1	0.14			1.42	1.76
Libya	1.00	1.76	9.00	11.90	0.24	0.57			10.2	14.2
Morocco	2.80	3.70	1.10	1.40	6	8	10	12	19.9	25.1
Syria	2.10	3.00	17.60	25.20	0.3	0.37	0.1	0.1	20.1	28.7
Tunisia	0.42	0.53	3.37	4.23	0.16	0.26			3.95	5.02

Countries	Sectoral water demand sustainable									
	Domestic		Agriculture		Industry		Energy		Total	
	2010	2025	2010	2025	2010	2025	2010	2025	2010	2025
Algeria	0.50	0.60	1.00	1.30	0.15	0.20	0	0	1.65	2.10
Bahrain										
Egypt	4.00	5.00	60.00	65.00	8.60	11.4	0	0	72.60	81.40
Jordan	0.34	0.50	1.30	2.00	0.12	0.20	0	0	1.76	2.70
Lebanon	0.40	0.48	0.78	0.82	0.10	0.14	0	0	1.28	1.44
Libya	0.90	1.50	5.85	8.70	0.20	0.50	0	0	6.95	10.70
Morocco	1.20	1.80	0.80	0.80	5.00	5.00	8	8	15.00	15.30
Syria	1.00	1.26	17.20	20.70	0.30	0.47	0	0	18.50	22.40
Tunisia	0.40	0.50	2.50	2.05	0.12	0.17	0	0	3.02	2.72

III. CONCLUSIONS AND RECOMMENDATIONS

The water scarcity problem described so far requires an integrated multi-disciplinary and multi-dimensional approach in order to be resolved. The problem no longer requires the sole expertise of water technicians and specialists to be resolved; it should be integrated within national social and economic planning. Economists, policy makers, legislative and executive branches of the government, industrialists, agronomic specialists, public health officials, as well as public administrators need to pool resources and energy together to come out with a plausible and acceptable solution to this water crisis.

Management of the supply side is inadequate without a concomitant management of the demand side; both these areas should be approached in concert (that is, one cannot be dealt with without the other). This is especially true in the Arab region where most of the renewable water resources have already been exploited and new conventional sources of water are scarce. Therefore, the management of the supply side with a broad and comprehensive policy alone is insufficient. The demand side needs also to be strictly managed and accounted for.

On the demand side, the most basic needed step is a long-term plan that is multi-dimensional and incorporates all sides of the equation (both demand and supply sources). To this extent a number of issues should be considered:

Water losses should be reduced. These losses could be due to leakages in closed conduits or seepages from open watercourses. It has been shown that low water costs encourage and lead to increased consumption and waste. Therefore, dealing with water as an economic commodity and placing a price tag to account for the externalities or increasing the water charge would create an environment of conservation and self-management and hence reduce water loss. This has been proven effective in many European nations where water utilization is charged just like electricity; studies have revealed a

TABLE 7 **TOTAL VIRTUAL WATER AND TOTAL AVAILABLE NON-CONVENTIONAL WATER AVAILABLE IN THE REGION IN PERCENTAGE AND MILLION CUBIC METERS (MCM).**

Countries	Virtual water			Treated wastewater	
	Eq. 1,000m^3 of net import	% Pop access to drink	% Pop access to sanit	%Agric.	%Total
Algeria	12.4	94	73		
Bahrain	680			5.9	3.4
Egypt	18.17	95	94	0.4	0.4
Iraq	2.18	85	79		
Jordan	3.467	96	99	6.8	5.1
Lebanon		100	99		
Libya	3.237	72	97	2.5	2.2
Morocco	2.419	82	75		
Oman		39	92	2.3	2.1
Qatar				12	8.8
Saudi Arabia	13.86			1.4	1.3
Syria	1.014	80	90	2.7	2.6
Tunisia				0.7	0.7
UAE	3.362			7.7	5.1
Yemen	3.375	69	45		

Countries	Desalinised water		Non-conventional	Total consumption			
	%Agric.	%Total	Total MCM	Drinking	Agric	Industry	Total
Algeria	3.6	1.422	474.6	2,181	2,543	680	5,404
Bahrain	42.3	18.264	111	107	161	19	287
Egypt	0.3	0.045	4,432	2,700	54,500	5,900	63,100
Iraq			77	1,179	47,584	344	49,107
Jordan	0.8	0.203	61	245	1,088	50	1,383
Lebanon			61	415	750	60	1,225
Libya	11.7	1.522	320	408	4,275	74	4,757
Morocco			3,55.6	543	10,180	322	11,045
Oman	45.3	2.78	60	85	1,150	6	1,241
Qatar	132.7	34.609	229	85	337	17	439
Saudi Arabia	41.8	4.196	1,321	2,387	18,575	193	21,155
Syria			1,643	773	13,618	175	14,566
Tunisia	2.4	0.27	108.7	313	2,518	69	2,900
UAE	55	18.436	489	600	1,539	73	2,212
Yemen			29	470	3,280	69	3,819

Sources:
J.A. Allan, 1999. *"Virtual Water": An essential Element in Stabilizing the Political Economies of the Middle East*. School of oriental & African studies, University of London.
World Health Organization and United Nations Children's Fund, 2000. *Global Water Supply and Sanitation Assessment*. 2000 Report. www.un.org/Depts/unsd/social/watsan.htm
WHO publications
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decrease in water waste and consumption after the implementation of these water taxes or price tags, as well as an improvement of the efficiency and equity among users. This can and should be applied to all sectors. In the industrial sector, industries should be made to implement water usage quality standards; this would force the manufacturing managers to re-circulate their water processes substantially decreasing water demand. Furthermore, water saving technologies should be introduced to the industry and replace the older more water demanding mechanization processes; although more costly in the short term, its return in both water conservation and resource preservation will even out in the long term. Moreover, if environmental laws were also applied, pollution would decline, increasing the availability of freshwater supply and the sustain-

ability of present resources. In the agricultural arena, water losses can be reused via drainage systems or channelled to recharge the underground water, thereby increasing overall basin efficiency. Moreover, farmers should be encouraged to use more effective methods of irrigation like levelling their field for higher yield surface irrigation or using more efficient technologies like sprinkler and trickle irrigation. In the domestic sector, water should be treated like electricity and elevated charges applied, which in turn will induce people to become more thrifty and conscious of water wasting and preservation, hence declining the demand within the domestic sector. This is especially important when we realize that paradoxically per capita consumption for domestic use in some water-poor Arabian Gulf countries, depending entirely on desalinated sea water, exceeds average global levels!

In order to achieve the needed sustainability of the Arab region's scarce water resources a holistic and comprehensive approach should be adopted. The above-mentioned solutions are meaningless without simultaneous capacity building, public and technical education, and increased public awareness.

To sum up, the Arab region countries are faced with many challenges related to the water scarcity problem. In order to alleviate the pressure and develop socio-economically in an adequate and sustainable fashion, they should adopt the following recommendations for long-term strategy planning:

1. Optimization of water allocation among the three domains (agricultural, industrial, domestic).
2. Implementation of an optimal water productivity strategy that leads to the import of water through virtual water.
3. Holistic and integrated approach to water resources supply and demand planning and management.
4. Capacity building and technical upgrading of all stakeholders.
5. Awareness raising at levels, from end users to decision makers.
6. Issuing and implementing of sustainable water policies based on the above points, current and prospective water data and research.

7. Development of water resources management models that will be able to unfold many solution scenarios to select the optimal approach.

Whereas the topic of virtual water may be new to the region many nations worldwide have successfully invested in its development and invested in it to help reduce water shortages and wastes. Therefore it could be of value for water-scarce nations to invest and shift their resources to import water-rich products instead of growing them domestically and loosing the rare available water resources (this shift would create more water for use in other needed sectors). Based on international trade theories, nations should import products in which they have a comparative disadvantage in production (i.e. water-intensive products for water-poor nations) and export those products in which they have a comparable economic advantage.

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