6

Future Water Supply and Demand in the Gulf States

Nadim Farajalla

Water is vital to life, and access to water is considered by the United Nations to be a basic human right. The services derived from it represent the cornerstone around which development is shaped. Water is essential in agricultural and industrial production, and is critical for human health as well as the health of ecosystems. If water is limited, then development becomes restricted and the health of both humans and the environment is strained. Changes in climate, land use, and increasing demand have put major stress on freshwater resources.[1] According to recent studies, worldwide demand for water in 2030 will be 40 percent greater than that of today.[2] This increasing demand will be fueled mostly by population growth. World population has reached the seven billion mark and if the current growth rate is maintained as much as 60 percent of the global population may suffer water scarcity by 2025.[3] This situation will become worse as population increases, with the most water scarce countries dipping to below 100 m^3 per person per day (as shown in Table 6.1). This is well below the severe water scarcity level of 500 m^3/p/d defined by the UNESCO–IHE Institute for Water Education, at which water availability is considered a primary constraint to life.[4]

According to Bouwer, most of the population growth will be in third world countries, and more specifically in cities resulting from internal migration from rural areas and immigration across boundaries from one country to another.[5] This population-driven increase in demand for water is to satisfy:

- an increase in demand for food;
- increased energy consumption;
- human consumption; and
- industrial uses, due to increasing economic activity

Postel estimates that renewable water supply of a minimum of 2,000 m^3 per person per year are required to maintain living standards similar to those of western and industrialized nations.[6] However, many nations do not have the freshwater supplies to attain that volume.

Table 6.1

Water Availability in the Most Water-scarce Areas of the World in 2035

Country	Population 2010 (thousands)	Projected population 2035 (thousands)	Per capita water availability 2035 (m^3/person/yr)
Kuwait	2,737	4,328	4.6
United Arab Emirates	7,512	11,042	13.6
Qatar	1,759	2,451	21.6
The Bahamas	343	426	46.9
Saudi Arabia	27,448	40,444	59.3
Bahrain	1,262	1,711	67.8
Libya	6,355	8,081	74.3
Maldives	316	392	76.6
Yemen	24,053	46,196	88.8
Singapore	5,086	6,098	98.4

Source: Food and Agriculture Organization of the United Nations (FAO), "Information System on Water and Agriculture," Rome, 2011; and United Nations Population Division (UNPD), "World Population Prospects: The 2010 Revision." UN Population Division, 2011.

Worldwide, 70 percent of water withdrawals are for agriculture while 11 percent are for municipal (including domestic), and 19 percent for industrial uses.[7] The two main sources of water are surface and groundwater. Groundwater represents 90 percent of readily available water resources, with nearly one billion rural households in Africa and Asia directly dependent on it for their livelihood, while large parts of the global population relies on it for drinking water.[8] Water quantity is

affected by water quality. Thus, if water is at hand but not suitable for use owing to some form of contamination, that water will not be available and might as well not be present. Thus threats to this resource are represented mainly by:

- discharges of domestic wastewater (treated and untreated);
- discharges of industrial effluent (treated and untreated);
- salinization of groundwater due to over-extraction and/or leaching of agrochemicals;
- over-pumping or over extraction; and
- climate change.

With the added demand for water and the increasing scarcity of this resource as a result of the problems described above, the dilemma then becomes how to ensure adequate quality water supply for a growing population—keeping in mind the need to ensure that water supply for economic activities is consumed in a sustainable manner.

The countries making up the Gulf Cooperation Council (GCC) reflect and even magnify the issues described. The following sections will detail the issues confronting these countries in relation to current and future supply and demand.

Water Resources in the GCC Countries

The Gulf Cooperation Council (GCC) is made up of six countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The geographical area covered by these six nations is characterized as arid, with very high temperatures during summer and very mild winters. The annual average temperature regionally varies from 21°C during the period from October to March, and 33°C from April through September.[9] This combined with other climatic factors has resulted in a very high evapo-transpiration, reaching more than 2,200 mm/yr.[10] According to the UN Food and Agriculture Organization the average annual precipitation in the region is 90 mm, divided per country as shown in Table 6.2.[11] These facts have lead to the region being described as one of the most water scarce in the world.

Table 6.2
Average Annual Precipitation in the GCC Countries

Country	Precipitation (mm/yr)
Bahrain	83.0
Kuwait	121.0
Oman	125.0
Qatar	74.0
Saudi Arabia	59.0
United Arab Emirates	78.0

Source: Food and Agriculture Organization of the United Nations (FAO), "FAO AQUASTAT, 2012" (http://www.fao.org/nr/water/aquastat/main/index.stm).

Water Demand

The demand for water in the GCC countries follows the global trend, in that the major portion of the supply is allocated to agriculture, followed by municipal (including domestic) use, and last to industry. According to various reports over the past two decades, the average allocation of water in the GCC countries per sector was 60 percent to agriculture, 35 percent to municipal use and five percent to industry;[12] noting that Kuwait is the only country of the group to allocate more water to domestic use than agriculture.

Demand for water in the GCC countries in the decade from 1990 to 2000 showed an increase of nearly 140 percent.[13] While Qatar was to come close, Kuwait was the only country in which municipal water demand ever exceeded – as a percentage – agricultural demand. This distribution of water allocation is not expected to change significantly in the future in most countries of the region. The share of the agricultural sector is expected to drop from 63 percent in 1995 to 48 percent in 2025—but will still be the dominant recipient of this limited and scarce resource. Meanwhile, the share of available water supply allocated to domestic use is projected to rise from an average of 34 percent of total water demand in 1995, to 40 percent in 2025. Even though industrial water demand will rise most steeply, it will remain a low user. Data compiled by the FAO for the period 1995 to 2000 and projected to 2025, corroborates the trend observed by the World Bank in its 2005 report.[14] Table 6.3 summarizes these variations of demand on water per sector per cluster of years.

Table 6.3

Water Demand by Sector, 1995, 2000 and 2025 (%)

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE	Average
Domestic							
1995	38.6	77.0	6.1	39.2	9.3	34.4	34.1
2000	43.8	63.6	10.0	48.7	13.2	34.4	35.6
2025	27.8	78.6	25.4	47.4	26.7	34.4	40.0
Agriculture							
1995	53.8	20.9	93.5	56.2	89.6	63.8	63.0
2000	46.4	18.6	84.3	47.4	84.4	64.2	57.6
2025	44.5	10.0	60.5	42.3	67.4	64.1	48.1
Industrial							
1995	7.6	2.1	0.4	4.6	1.2	1.8	3.0
2000	9.7	17.8	5.6	3.8	2.3	1.4	6.8
2025	27.8	11.4	14.1	10.3	6.0	1.6	11.9

Source: FAO, 2012, op. cit.

Water Sources

According to data collected and compiled from the FAO, the main freshwater source in Bahrain, Kuwait, Qatar and Saudi Arabia is groundwater, with the former three almost totally dependent on groundwater as their only source of freshwater. Surface water is dominant in Oman and the United Arab Emirates. Table 6.4 summarizes the renewable water resources for each of the GCC countries for the year 2002.

However, the withdrawals from groundwater far exceed available renewable amounts. For example, Saudi Arabia utilizes 14,430 million cubic meters (mcm), which is nearly three and half times its renewable groundwater sources. The situation is the same in all other countries, with the withdrawal ratio being about 3:1, while the UAE far exceeds this ratio.[15] This mining of fossil groundwater sources is not sustainable, and will continue to deplete these nonrenewable sources, rendering future generations even more vulnerable to water scarcity.

Table 6.4

Annual Renewable Water Resources in the GCC Countries

	Renewable Water Resources				
	Surface (MCM/yr)	**Ground (MCM/yr)**	**Total (MCM/yr)**	**Surface % of Total**	**Ground % of Total**
Bahrain	0.2	100.0	100.2	0.2	99.8
Kuwait	0.1	160.0	160.1	0.1	99.9
Oman	918.0	550.0	1468.0	62.5	37.5
Qatar	1.4	85.0	86.4	1.6	98.4
Saudi Arabia	2230.0	3850.0	6080.0	36.7	63.3
United Arab Emirates	185.0	130.0	315.0	58.7	41.3

Source: FAO, 2012, op. cit.

When available fresh water amounts are compared to the demand by each country, it is evident that the volume of water is not sufficient to meet the demands of the various sectors. Table 6.5 shows a comparison of available fresh water to total water demand for each country. Oman is the only nation which can currently meet its demand through available resources; however, this should not be considered a comfort, as the values that are typically presented in databases are for average years. If available fresh water is diminished via reduced rainfall (droughts, etc.), the demand will not be met.

Table 6.5

Comparison of Available Freshwater to Water Demand

Country	Total Demand (mcm)	Available Freshwater (mcm)
Bahrain	443	100
Kuwait	436	160
Oman	1,407	1,468
Qatar	298	86
Saudi Arabia	22,352	6,080
United Arab Emirates	3,988	315

Source: FAO, 2012, op. cit.

In summary, the majority of the GCC countries suffer from water deficit ranging from a maximum of nearly 660 m^3/person/year in the UAE to no a slight surplus of about 50 m^3/person/year in Oman. This deficit has forced the GCC countries to look for alternative sources of water to augment available fresh water supplies in order to meet the demands of their various sectors. As such, all (by varying degrees) have turned to seawater desalination. Use of treated wastewater has grown in recent years; while very limited use of has been made of return irrigation flows.

Table 6.6

Water Deficit by Country

Country	Water deficit (m^3/person/year)
Bahrain	-296.60
Kuwait	-106.40
Oman	49.70
Qatar	-113.40
Saudi Arabia	-522.40
UAE	-659.00

Source: FAO, 2012, op. cit.; and World Bank, "World Bank Development Indicator Database," 2012 (http://data.worldbank.org/indicator).

Table 6.7

Non-conventional Sources of Water in the GCC Countries

	Total Non-conventional	Desalinated		Treated Wastewater		Agricultural Drainage	
	(mcm/yr)	Total (mcm/yr)	%	Total (mcm/yr)	%	Total (mcm/yr)	%
Bahrain	134.2	119	88.7	15	11.2	0.2	0.1
Kuwait	397	345	86.9	52	13.1	-	-
Oman	109	86	78.9	23	21.1	-	-
Qatar	159	131	82.4	-	-	-	-
Saudi Arabia	1,450	1,050	72.4	360	24.8	40	2.8
UAE	1,242	1,008	81.1	234.5	18.9	0	0

Source: FAO, 2012, op. cit.; and World Bank, 2012, op. cit.

Desalination thus plays a prominent role in augmenting freshwater sources to meet the water demand of various sectors. The GCC countries account for nearly 60 percent of the world's desalination capacity,[16] with Saudi Arabia and the United Arab Emirates accounting for half of that. Production has increased, as has the share of the total water supply that is generated by desalination. Table 6.8 presents data for the years 1990 and 2000. It may be observed that the smallest increase in production occurred in Oman (about six percent) – the country that is closest to being totally supplied by renewable freshwater – and the largest in Saudi Arabia, at nearly 105 percent—the country with the largest area and largest population. The United Arab Emirates also nearly doubled its output. What is noteworthy, however, is that the percentage of total supply from desalination has not varied much in this ten-year period—amounting to an increase of around six percent in total and with Saudi Arabia and Oman actually experiencing a reduction. This indicates that the water supply mix for these two countries has shifted in the period 1990 and 2000 to include other sources of water—both conventional and non-conventional.

Table 6.8

GCC Desalination Production and Percentage of Total Water Supply

	1990		2000	
	Production (mcm/yr)	**% of Total Supply**	**Production (mcm/yr)**	**% of Total Supply**
Bahrain	56	54	76	66
Kuwait	240	79	418	90
Oman	52	37	55	33
Qatar	83	98	132	100
Saudi Arabia	495	47	1022	41
United Arab Emirates	342	63	674	81

Source: World Bank, "A Water Sector Assessment Report on the Countries of the Cooperation Council of the Arab States of the Gulf." Washington, DC, 2005 (http://siteresources.worldbank.org/INTMNAREGTOPWATRES/Overview/20577193/GCCWaterSectorReport--Englishversion.pdf).

The Problem

As stated earlier, water resources in the GCC countries are being subjected to increasing stress, mostly owing to escalating demand, but also as a result of environmental threats. The major stressors observed are: population growth, economic growth (leading to heightened living standards) and climate change.

Population Growth

The most apparent stressor is population growth. The economic boom experienced by all GCC countries has encouraged local population growth and attracted migrant workers of all professions—both blue and white collar workers. This population increase has been very rapid and explosive. Between 2002 and 2010, GCC countries' GDP grew by an average of about seven percent.[17] The fastest growth in that period was in Qatar, with an annual growth rate of 13 percent, followed by the UAE at 10.5 percent, and Bahrain at 8.5 percent. The overall population increased from slightly over 30 million in 2002 to more than 43 million in 2010.[18] Table 6.8 summarizes the population growth of the six GCC nations. This rapid expansion was reflected in the growth of urban centers, mostly owing to people (both locals and migrants) moving into them. According to Mirkin, currently nearly 85 percent of the all the residents of the GCC may be found in urban centers.[19] Kuwait and Qatar have the highest percentages of urban dwellers, at 98 and 96 percent respectively, and Oman the lowest at 72 percent (see Table 6.9).

Table 6.9
Population of the GCC Countries in 1,000s (2002–2010)

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Bahrain	642	647	672	725	811	926	1,052	1,170	1,262
Kuwait	2,070	2,127	2,189	2,264	2,351	2,448	2,548	2,646	2,737
Oman	2,303	2,336	2,378	2,430	2,491	2,561	2,637	2,712	2,782
Qatar	624	654	715	821	978	1,178	1,396	1,598	1,759
Saudi Arabia	21,463	22,334	23,214	24,041	24,799	25,504	26,167	26,809	27,448
UAE	3,255	3,401	3,658	4,069	4,663	5,406	6,207	6,939	7,512
Total	30,357	31,499	32,827	34,350	36,094	38,023	40,007	41,874	43,500

Source: FAO, 2012, op. cit.; and World Bank, 2012, op. cit.

This growth in population has increased the demand on a scarce resource, and this is clearly shown in the average increase in demand for domestic of 53 percent over a 20-year period from 2005 to 2025,[20] the largest of which is observed in the UAE and Kuwait (see Table 6.11).

Table 6.10
Percentage of Population living in Urban Areas: Past, Present and Projected

	1975	2010	2050
Bahrain	84	89	93
Kuwait	86	98	99
Oman	30	72	82
Qatar	88	96	98
Saudi Arabia	49	82	90
United Arab Emirates	78	78	87

Source: Barry Mirkin, "Population Levels, Trends and Policies in the Arab Region: Challenges and Opportunities," Arab Human Development Report, Paper 01, 2010.

Table 6.11
Total Domestic GCC Water Demand in 2005 and 2025 (mcm)

	2005	2025 (projected)	% Increase
Bahrain	139.1	204.4	47
Kuwait	405.5	642.3	58
Oman	205	302.8	48
Qatar	80	123.6	55
Saudi Arabia	2100	3178.3	51
United Arab Emirates	943	1500.2	59

Source: United Nations Economic and Social Commission for Western Asia (ESCWA), "ESCWA Water Development Report 2: State of Water Resources in the ESCWA Region," E/ESCWA/SDPD/2007/6, New York, 2007.

The increase in demand has reduced the amount of freshwater available to the residents of the GCC countries by an average of 75 percent for the period 1970–2000, with the UAE experiencing a 93 percent reduction (see Table 6.12).

Table 6.12
Annual Renewable Water per Capita (mcm/yr)

	1970	1980	1990	2000
Bahrain	524	329	219	164
Kuwait	215	116	75	73
Oman	1,245	817	553	373
Qatar	450	218	103	85
Saudi Arabia	670	411	244	186
United Arab Emirates	864	182	107	59

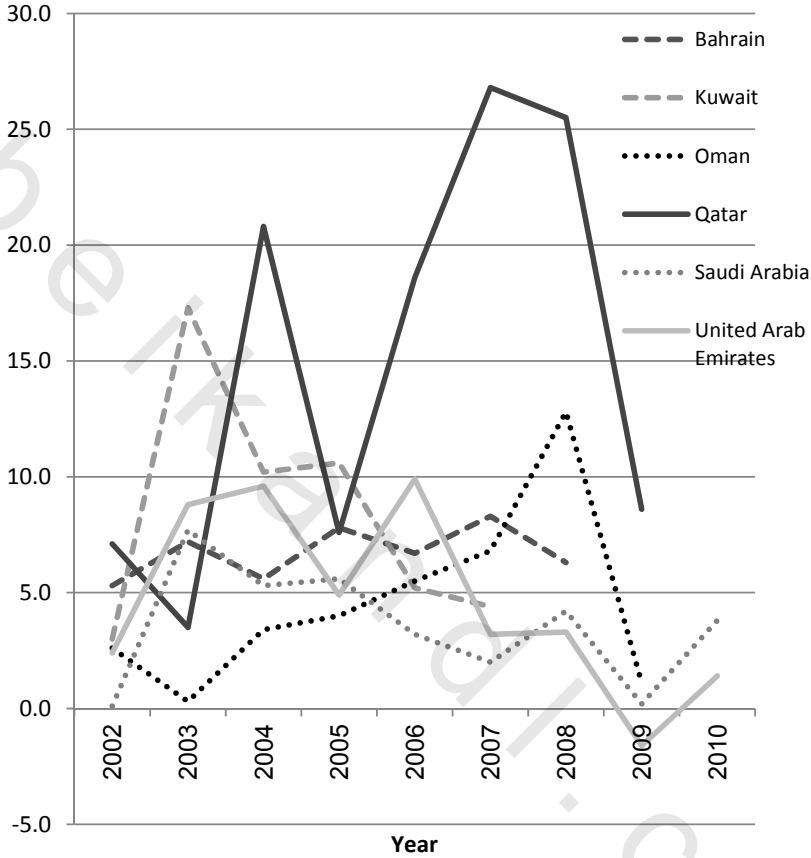
Source: World Bank, 2005, op cit.

Growing Economy

The growth in the economies of the GCC countries over the last three decades has transformed these countries in many ways. Infrastructure has been modernized, enabling most residents to have access to water supply and sanitation. In addition, life expectancy increased by nearly 10 years, reaching 74 in 2000.[21] Per capita income rose for all six countries, as did their GDP, which averaged seven percent growth in the period 2002–2010 (noting that the global economy crashed in 2009). The largest growth was witnessed by Qatar, reaching an average of 15 percent for the same period. Figure 6.1 shows the variation in GDP growth for all six countries. This GDP growth, however, was partially to blame for a 17 percent increase in water use for the same period.

The improvement in the economy also brought about an increase in the standard of living, and along with it an increase in the consumption of water that ranges (with the exception of Oman) from 300 to nearly 750 liters per person per day, which is considered amongst the highest in the world.[22] For example, daily per capita consumption of water in Kuwait rose from 208 liters in 1980 to more than 500 liters in 2000 – a 140 percent increase – while Oman's increase in consumption rose by 170 percent. These rates can be compared to 300 liters per person per day in Japan and around 400 liters in Australia.[23]

Figure 6.1
GDP Growth in the Six GCC Countries (%)



Sources: Adapted from: World Bank, 2012, op. cit.

Climate Change

The changing climate will have a major impact on the availability of fresh water in the GCC countries. According to Elasha,[24] the region will suffer from rising temperatures along with a change in the pattern of rainfall. Some parts of the region, such as parts of Saudi Arabia, may observe a trend of precipitation increase. However, the added rainfall will likely come in as short bursts resulting in higher risks of flash flooding.

Overall though, Kundzewicz, et al. indicate that the region as a whole will experience a reduction in precipitation, which coupled with rising temperatures and sea levels will have negative impacts on freshwater resources.[25] El-Quasy estimates that rainfall over the Arabian Peninsula could be diminished by 15–20 percent.[26] It is expected that if current trends endure, available freshwater would fall to 50 percent of present amounts by the year 2030.[27] Recharge of groundwater will decrease considerably, as will surface water; extreme events, such as droughts and floods, will be more common and more devastating; desalination plants will be vulnerable to rising sea levels as well as increases in sea salinity, making the desalination process more expensive;[28] infrastructure will also be vulnerable to the variable climate, with pipelines and water or wastewater treatment facilities particularly sensitive; coastal regions will be vulnerable to sea level rises, particularly in view of the extensive number of people living in coastal areas in the GCC; and water quality problems could arise, stemming from microbial and pathogen content.[29]

Rising temperatures will lead to greater consumption of water by people, animals and plants, further adding stress to a depleted and vulnerable resource. Furthermore, low flows in rivers will accentuate the problems by increasing the pollutants in rivers, streams, lakes and groundwater, thereby leading to higher treatment costs or – at times, if the pollution is too high – rendering the source unavailable for consumption. In addition, more energy will be consumed in the treatment of water with increasingly higher concentrations of contaminants. Finally, more water will be consumed for cooling people, animals, plants and equipment as a result of the rising temperatures.

Other issues

There are several other issues that add to the stress on water resources, which mainly stem from economic, financial and administrative approaches (regulations, policies, etc.) that have not been addressed in the previous sections. The following comprises a brief listing of these stresses.

Water Management Plans and Strategies and Infrastructure Development

Most water-related strategies in the GCC countries have focused on the supply side rather than the demand side. The Abu Dhabi Declaration (at the 31st meeting of the GCC leadership) seems to have been a turning point, in that it called for a comprehensive long-term water strategy that takes into consideration all relevant issues that might impact water resources and their utilization, including:[30]

- the possible impact of climate change on water resources;
- management of water consumption in different development sectors;
- interaction between the agricultural and water sectors; and
- the potential effects of desalination operations and activities on the quality of sea water, living creatures and climate change.

The sanitary network in the GCC countries lags behind that of the water supply network, reaching a high of 60 percent coverage in Kuwait versus an average of 20–40 percent in the other countries of the Council.[31] Of the nearly 1,100 mcm of treated wastewater produced annually, only 769 mcm are reused. Bahrain, Qatar and Kuwait reuse nearly all their treated sewage, while Saudi Arabia only uses 47 percent.[32]

Dawoud and the World Bank indicate that leakage from water and sewage networks are causing water tables to rise, flooding the basements of buildings.[33] Moreover, sewage leakage is contaminating groundwater resources.

Groundwater management in most GCC countries is poor—no country, with the exception of Oman, has a clear, effective groundwater management policy. Regulation and prioritization of access to groundwater are haphazard, with no proper well licensing in place and no pricing mechanism. The uncontrolled pumping of groundwater, especially for agricultural production, has led to seawater intrusion and to up-coning of brackish water in areas more remote from the sea and ocean;[34] this is especially the case in Oman, Bahrain and Qatar.

Financial Perspective: Tariffs, Subsidies, Costs, etc.

Water supply and demand and the infrastructure involved require significant capital investment to set up, and equally significant budgets for maintenance and operation. According to the World Bank, the major financial drawbacks to most operating and maintaining this infrastructure are:[35]

- Heavy subsidization of the water sector: if current trends endure, nearly 10 percent of oil revenues across the region will be taken up by 2025.
- There is sufficient data on the production/supply side, but very little on consumption, unaccounted for water (which in some areas is up to 40 percent), cost recovery, etc.
- Tariffs are very low, barely covering 10 percent of costs (and in Saudi Arabia less than one percent).
- Tariffs target residents differently; nationals in Kuwait, Qatar and the UAE get their water practically for free, while expatriates pay tariffs which in some instances are very steep.
- Leakage from water supply networks is fast becoming a serious financial drain. For example, in the leakage and loss from the water supply network in the UAE is in the range of 20–40 percent. When this is coupled with cost of desalination of $1–2 per cubic meter the amount becomes alarming.

Desalination

As stated earlier, this process is crucial and its product accounts for a significant portion of the water consumed within the GCC countries; however, there are issues of concern within this sector as reported by Alterman and Dziuban, the World Bank, and Handley, amongst others:[36]

- The cost of desalination is still high, especially for multistage flash plants. Current estimates put the range at $1–2 per m^3. Considerable improvements have been made with reverse osmosis, and the costs of this process are reportedly nearing $0.5/$m^3$. Some costs reported by

Dawoud and Abderrahman range between $0.48 and $2.20 per cubic meter in Saudi Arabia; from $1 to $1.45 in the UAE; $1.14 to $1.64 in Qatar and $0.56 in Bahrain.[37] These reduced costs are also due to the fuel subsidy in each of these countries.

- The disproportional nature of the costs are exemplified by Saudi Arabia, which uses 1.5 million barrels of oil per day (mbpd) to desalinate 24 mcm of water per day.[38]
- Desalination plants are working at near capacity, but many plants were commissioned in the 1970s and 1980s and now require extensive rehabilitation, for which significant investments must be made. Some would need to be scrapped and replaced by newer plants.
- Desalinated water is appropriated to irrigating landscaped areas and for agricultural products. In Abu Dhabi only 25 percent of desalinated water is used for drinking.
- Domestic oil use is mostly taken up by desalination. For example, 65 percent of domestic oil use in Saudi Arabia is for desalination.
- Arabian Gulf salinity is increasing owing to the return of brine to the sea from desalination plants in many locations. This will increase the cost of desalination, especially in terms of operation and maintenance.

Agriculture

Most of the GCC countries subsidize agricultural production as a means to achieve some kind of self-sufficiency, particularly in crops, and also as a way of redistributing accumulated oil wealth.[39] These subsidies are typically focused on wells, fuel, trade protection, price support programs, etc. This has led to the production of poor quality crops with poor returns, making agriculture production profitable only because of the subsidies and incentives that governments have put in place. This approach has led to wasteful use and depletion of groundwater. In some areas of the region, the water table has dropped by 200 m in a 20-year period. Furthermore, in Saudi Arabia, for example, irrigation water use over a period of 20 years rose from 7.4 billion cubic meters (bcm) in 1980 to 18.3 bcm in 1999, having reached a mid-period peak of 20.3 bcm.

According to the World Bank, net irrigated areas in GCC countries have increased by 100–300 percent,[40] but agriculture contributes on average only around two percent to their GDP, with the highest contribution being around five percent in Saudi Arabia and the smallest in Qatar and Kuwait.[41] Agriculture is the largest user of water in half of the GCC countries; the allocation is as follows: 84 percent in Saudi Arabia and Oman; 64 percent in the UAE; 47 percent in Bahrain and Qatar and < 20 percent in Kuwait.[42] Nearly 85 percent of the water used in agriculture comes from groundwater sources, with nearly 80 percent from fossil – i.e. non-renewable – sources.[43] Losses of water in agriculture are high, often as a result of the traditional irrigation methods employed (flood and furrow) and also due to improper irrigation application and scheduling practices. These losses may reach 50 percent of pumped water. Less than two percent of treated wastewater is used for agricultural production—most is either used in landscape irrigation or simply discharged into *wadi* beds where they percolate into the soil or simply evaporate.

Summary and Recommendations

Water resources in the GCC countries are very scarce and are under increasing pressure from growing populations and their associated activities, as well as from climate change. No integrated water resource management plans have been effectively implemented either nationally or regionally. Groundwater is the main source of water for most GCC countries, yet no country (with the exception of Oman) seems to have developed a proper groundwater management strategy with proper access controls, prioritization, and pricing mechanisms. The focus is placed on making up the deficit through desalination. Even though the cost of desalination has come down and new technologies such as remote sensing are helping to achieve further cost reductions, most plants were commissioned in the 1970s and 1980s and now require major investment for their rehabilitation or replacement. A significant amount of water goes to the agricultural sector, with heavy subsidies encouraging poor quality produce and inefficient use of a scarce resource. Treated wastewater reuse is very limited and misdirected – most of it going to landscape irrigation and nonproductive uses. Tariffs

are minimal, and do not cover the cost of production, treatment, conveyance, etc.

The most sustainable approach to overcome the region's water scarcity (which would handicap development) is to start by controlling demand and establishing the institutional framework to implement this approach. Such an approach is best implemented using integrated water resources management (IWRM), the focus of which would be primarily on demand management and then on the enhancement of supply. The following approaches include those that could be taken by the GCC countries individually or collectively.

Establishing an enabling environment in which all management plans would be implemented is crucial. Most GCC countries have reasonably well operating institutions and agencies that manage various aspects of their water resources; however, these institutions have conflicting jurisdictions and mandates, and often each handles one aspect of the resource to the exception of others, i.e., one agency for groundwater and another for desalination with little or no coordination as to production, conveyance, use, etc. As such, there is a need for an institution or agency that governs all aspects of water resources, starting with supply, passing through the demand aspect and ending with wastewater treatment and encompassing all the sources within—similar to water boards in many states in the USA. This agency would develop the overall water strategy for the country and would supervise and coordinate the plans and operations of sub-agencies who could handle the separate components. This would ensure that there is no duality in resource development or allocation of water, and that all activities related to the water sector are coordinated and not abortive. Furthermore, such an agency would also coordinate strategic water resource plans and their implementation with other agencies of the various countries of the GCC.

Alongside institutional changes, legal and regulatory reforms should take place to modernize laws and mainstream regulations, thereby reducing bureaucracy and improving the potential for implementation. Another key component to this aspect is the incorporation of financial

incentives to promote water conservation and deter waste. A fair tariff scheme – the basic aim of which is to recover the cost of ensuring the supply of safe water – is the cornerstone around which other financial schemes may be cultivated. These include, but are not restricted to:

- Charges for water extraction.
- Incremental block rates to ensure equity.
- Variable charges at different times during the day/season.
- Provision of conservation subsidies.
- Waver of customs fees on water saving technologies.
- Tax and financial incentives to incorporate water saving technologies in developments and rehabilitation.

In addition to the above, a two pronged approach should be taken to preserve and conserve available sources. The first is to control demand and the second to enhance supply. In enhancing the supply of water the aim would be to acquire as much of the available resource as possible at the most reasonable cost. Several steps may be taken in the following areas:

Source Control

- Groundwater
- Control access to groundwater.
- Institute and/or improve aquifer recharge.
- Phase out and remove subsidies for well drillings, pumps and all other equipment and activities related to groundwater exploitation.
- Meter all existing and new wells.
- Desalination
- Improve efficiency by using modern technologies such as reverse osmosis, nano-filtration, etc.
- Reduce cost through development of co-generation plants.

- Target brackish water for desalination as a primary effort to reduce desalination costs and environmental degradation.
- Wastewater
- Diversify the use of wastewater as a source for usage in other than landscape irrigation to include industrial use, irrigation of certain corps.
- Stormwater
- Integrate rainwater collection/harvesting schemes at various scales. For example, impose the incorporation of rainwater collection and storage infrastructure in all new and retrofitted buildings; incorporate collection and storage of stormwater in existing and new roads and in open spaces in rural and urban areas.
- Bulk Imports of Water from Regions Enjoying Water Surpluses

Distribution and Conveyance

- Network Extent
- Expand the sewage network to ensure full coverage to decrease and even prevent discharge into groundwater thereby reducing pollution and uncontrolled water rise.
- Unaccounted-for-water
- Reduce leakage through rigorous water supply network maintenance programs.
- Use modern technology in tracking water distribution – i.e. supervisory control and data acquisition systems (SCADAs).
- Prevent breaking into distribution networks and illegal siphoning of water by vigilant inspections and levying of heavy fines.

On the demand control and management side, several actions may be taken that would allow the limited resource to last longer. The following are general areas in which improvements would have significant effect, and that are applicable across the GCC countries:

Agriculture

Since this sector is the greatest user of water, any improvement in efficiency and reduction in waste will have positive repercussions for the water sector in general.

- Introduce new crops and plants suited to the dry and hot environment and to saline water.
- Focus agricultural production on cash crops revenue from which would be able to cover the cost of water supply.
- Enforce the use of efficient irrigation techniques such as drip/ trickle and subsurface irrigation.
- Turn to conservation agriculture.
- Use soil-less agriculture including hydroponics.
- Remove subsidies on all aspects of agriculture except those that promote water conservation.
- Educate farmers on modern cultural practices to reduce wastage of water and other resources.
- Incorporate virtual water principle in assessing agricultural production costs.
- Rely on local scientific research for the development of all the above especially the International Center for Biosaline Agriculture in the UAE and International Center for Agricultural Research in Dry Areas (ICARDA), amongst others.
- Consider moving away from agriculture in certain areas and train farmers in professions other than agriculture.

Water Saving Measures

- Require the fitting of water saving devises in all new constructions and the retro-fitting of existing buildings undergoing renovation and rehabilitation.
- Impose metering throughout the distribution network.

Community Outreach and Public Involvement

- Development of water users' associations.
- Involve communities in planning for water resource development and allocation.
- Educate communities on conservation techniques and involve members in disseminating the information and training.

Policies and Regulations

- Cost recovery and tariffs are at the core of sustainable management of water resources. Therefore structure tariffs to attain full cost recovery—introduce incremental block rates to ensure equity.
- Encourage the participation of the private sector with the aim of building up the capacity of the public sector and streamlining operations.
- Integrate water resource management into the national and regional development plans so that water availability controls development and not the other way round.