Water Sector Overview

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I. INTRODUCTION

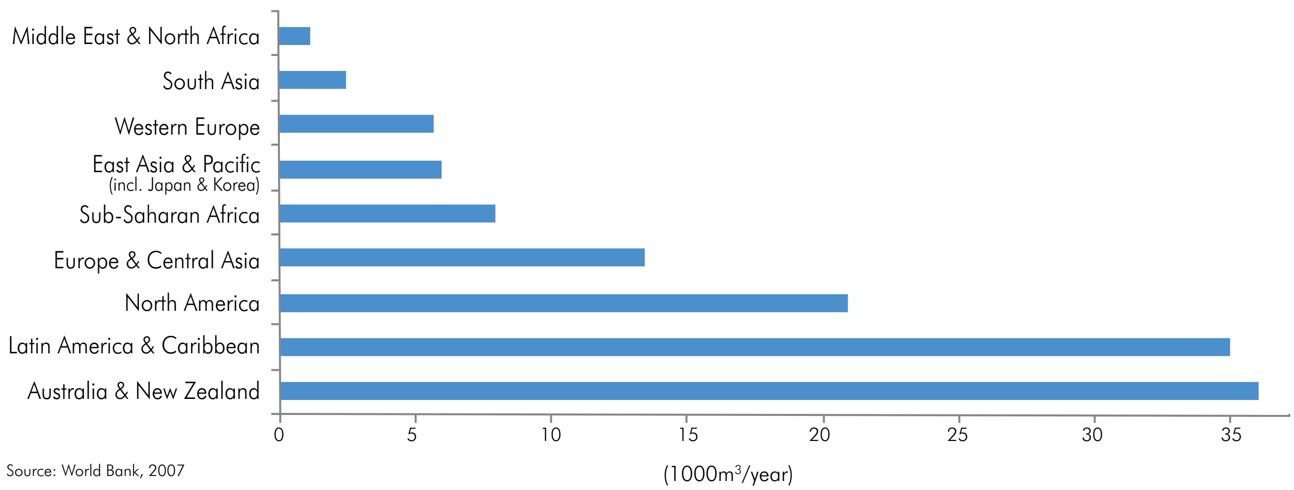
The water sector in the Arab countries is facing several challenges. This sector is receiving increasing attention among policy makers and development agencies in the region. For example, the World Bank devoted its regional development report of the Middle East in 2007 to the water sector (World Bank, 2007). The Islamic Development Bank (IDB) commissioned a special report on water in the member countries to mark its 30th anniversary (IDB, 2005). The United Nations Development Program (UNDP) Arab Human Development Report for 2009 devoted a special chapter to issues related to water and environmental security in the region (UNDP, 2009). This chapter draws substantially on issues and data presented in these three reports.

Available renewable water resources per capita in the Arab world are among the lowest in the world. Expanding economic growth and burgeoning populations in the region will intensify the effects of water scarcity. To meet increasing demands for domestic, agricultural, and industrial water uses, underground water aquifers are being pumped at rates exceeding their replenishment limits. This raises serious questions about the future viability and integrity of these renewable water systems. Compounding these issues, millions in the Arab world still lack access to clean water and safe sanitation. The severity of water shortages is forcing many countries in the region to augment conventional surface and sub-surface water resources by investing in more expensive, less favorable water systems and non-conventional water sources. These sources include seawater desalination, wastewater treatment for reuse, and tapping non-renewable water supplies from deep aquifers.

Water policies and strategies promoted by government programs as well as by international and bilateral development agencies have focused on the following issues: options for comprehensive management of water as an integrated ecological resource; policies, rules, and regulations to address the public good dimension of water particularly as resources are declining in both quantity and quality; the institutional framework for efficient implementation and monitoring of these policies and regulations; the economic role of water in increasing agricultural productivity and food security; impact on the poor; management of water supplies, demands, and allocation among various users within an integrated and participatory approach; water pricing and financing; sustainable management of water utilities; water rights; river basin planning; and international cooperation.

This chapter will address a selection of these issues and their implications on the performance of the water sector in the Arab world. Furthermore, the chapter will discuss the multi-dimensional role of water in economic development, protecting the environment, driving social development, and safeguarding health and hygiene. The chapter will also highlight factors affecting the provision of water services to millions of households, especially the poor, to improve their quality of life.

FIGURE 1 ACTUAL RENEWABLE FRESHWATER RESOURCES PER CAPITA, BY REGION



Source: World Bank, 2007

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

	Annual Availability						Annual Water Usage		% Use by Sector		
Country	Natural Renewable Resource Bm³/year	Desalinated End Water Bm³/year	Wastewater Reuse Bm³/ year	Per Capita Renewable Availability m³ (2006)*	2015** (AFED) m³	2025** (AFED) m³	Bm³	As a % of Total Water Resources	Domestic	Industry	Agriculture
Algeria	11.50	0.07	Neg.	350	297	261	4.59	40	25	15	60
Bahrain	0.11	0.14	Neg.	157	125	106	0.25	170	26	3	71
Djibouti	0.02	0.00	Neg.	367	306	260	0.02	113	88	0	12
Egypt	61.90	0.06	5.90	773	641	552	73.10	108	6	8	86
Iraq	80.00	0.03	n.a.	2652	1989	1551	42.80	48	3	5	92
Jordan	0.87	0.00	0.07	164	114	98	0.98	104	26	7	68
Kuwait	0.11	0.65	0.12	7	5	4	0.76	87	37	2	60
Lebanon	3.20	0.00	n.a.	1110	999	919	1.29	40	28	4	68
Libya	0.80	0.03	n.a.	99	80	67	3.89	469	9	4	87
Morocco	20.00	0.02	0.07	940	620	558	16.84	84	5	-	95
Oman	1.60	0.12	0.02	550	440	365	1.22	74	9	1	93
Qatar	0.05	0.12	n.a.	71	50	40	0.28	n.a.	23	3	74
Saudi Arabia	2.50	2.28	0.15	96	77	64	17.00	506	15	1	84
Sudan	24.00	0.00	0.00	1711	1369	1122	19.00	5	6	5	89
Syria	18.70	0.00	0.26	865	650	550	14.70	78	9	1	87
Tunisia	3.35	0.00	0.14	450	405	373	2.53	72	12	4	84
UAE	0.20	0.95	0.14	35	26	20	1.60	180	24	10	67
West Bank & Gaza	0.76	0.00	0.01	215	160	120	0.44	57	51	49	58
Yemen	2.50	0.02	0.03	97	70	50	3.20	126	5	2	93

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

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

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

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

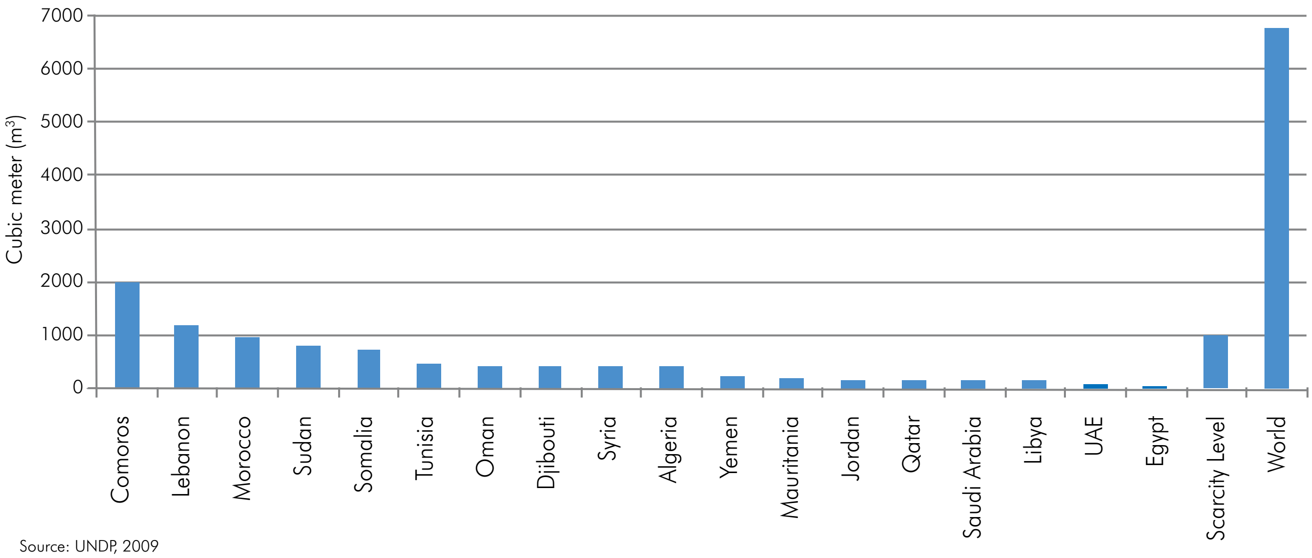
The figures are mainly indicative trends because of the different methods and tools used to calculate the aggregate main source of water. The projections take the lower side of population growth in the region, and do not take into account the impact of increase in GDP and other variables which push the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

II. WATER RESOURCES IN THE ARAB WORLD ARE SCARCE AND NEW SOURCES ARE EXPENSIVE

All Arab countries are short of water. A World Bank (2007) report ranks the Arab countries last in renewable freshwater availability per capita compared to other regions of the world, as shown in Figure 1. High rates of economic growth, rapidly growing populations, and climate change are expected to worsen water shortages in the region.

Table 1 summarizes country data for water

FIGURE 2 ARAB INTERNAL FRESHWATER RESOURCES ARE OFTEN BELOW SCARCITY LEVELS AND THE WORLD AVERAGE, 2005 (CUBIC METERS PER CAPITA)



Source: UNDP, 2009

availability by source and water usage by sector (domestic, industry, agriculture). In some countries, total water withdrawals exceed available renewable water resources. In fact, per capita internal renewable freshwater resources in most Arab countries are already below the water scarcity level, as illustrated in Figure 2.

Because most countries in the region have limited renewable water resources and their populations are growing fast, water conditions will be particularly severe. Table 2 indicates that water withdrawal in several Arab countries has increased between the year 1985 and 2000 by about 50 percent. In the same period, the population of these countries increased by 40 percent. This trend is likely to be observed in most Arab countries in the years ahead. The challenges facing these countries are likely to intensify as economic growth continues to increase and water demand rises in crowded urban centers.

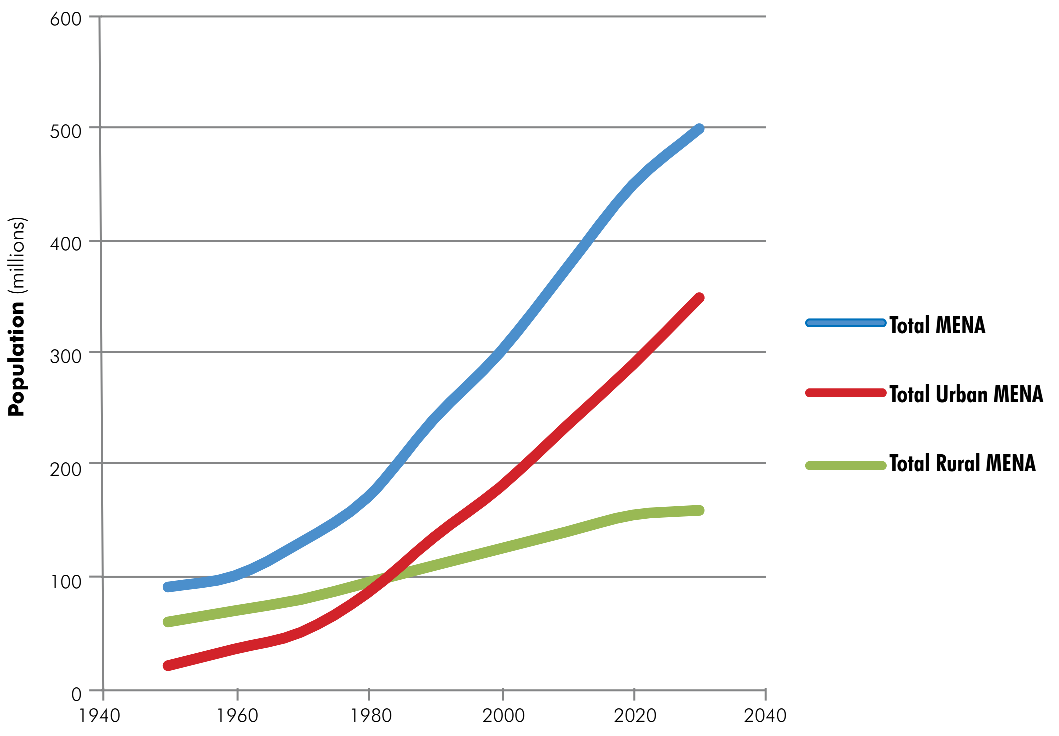
Public agencies are being pressured to improve

TABLE 2 INCREASE IN WATER DEMAND IN SELECTED ARAB COUNTRIES

Country	Population 1985 (million)	Population 2000 (million)	Total Water Withdrawals 1985 (10^9 m^3)	Total Water Withdrawals 2000 (10^9 m^3)
Tunisia	7.10	9.56	2.48	2.70
Algeria	21.86	30.46	3.50	6.07
Libya	3.60	5.31	2.83	4.27
Morocco	22.10	27.84	11.00	12.61
Egypt	46.70	67.29	52.90	68.30
Syria	10.48	16.81	7.01	19.90
Lebanon	2.67	3.40	0.85	1.40
Total	114.51	160.67	77.57	115.88
% Change	40% increase in population			51% increase in water consumption

Source: Plan Bleu/UNEP Database, 2005

FIGURE 3 MORE PEOPLE WILL LIVE IN URBAN AREAS



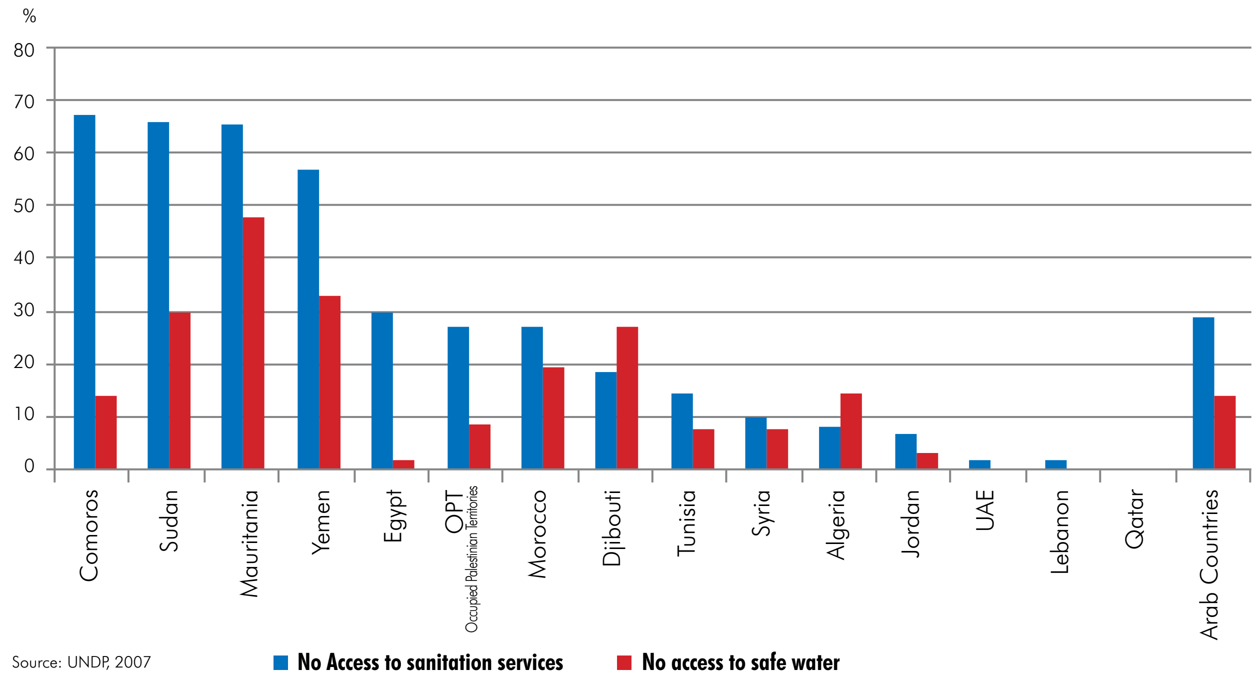
Source: World Bank, 2007

the delivery of safe and clean water to the burgeoning rural and urban populations. The growth in population in the coming two decades, 90 percent of which will occur in urban areas, will increase the political pressure to meet these demands especially for domestic and industrial use. As Figure 3 indicates, by 2030 more people in the Arab world will live in cities. The total population of the Arab world will exceed that of Europe with only a fraction of the water resources available to the population of Europe.

Several countries in the region have allocated substantial resources for the development and management of water supplies, clean sanitation, and irrigation contributing to significant levels of economic growth and poverty reduction. The economic benefits of expanding irrigation have been shared by millions of small and poor farmers in most Arab countries.

However, more than 45 million people in the Arab world still lack access to clean water or safe sanitation (UNDP, 2009), as Figure 4 indicates. Moreover, in most Arab countries, a large portion of the water supply is not accounted for. Many cities in several Arab countries are 'leaking buckets'. The poor bear the disproportionate share of the impact of inefficient water and sanitation services. Fewer poor people are connected to piped water supply. When they do have access, the installation has to be shared among many more people. The poor in most

FIGURE 4 PERCENTAGE OF POPULATION WITHOUT ACCESS TO SAFE WATER AND SANITATION SERVICES, 15 ARAB COUNTRIES, 2007



Source: UNDP, 2007

Arab cities pay high prices for water supply, generally more than those paid by more affluent households connected to the piped system (World Bank, 2007).[1]

The task of achieving universal coverage of water supply and sanitation is becoming more challenging because several Arab countries are experiencing tight financial control over public budgets (World Bank, 2007). The service institutions are extended beyond available technical and financial resources. They can hardly sustain efficient services to the current populations, which are growing at 2-3% annually. Most of this growth is adding pressure on already crowded and inadequately serviced cities and towns.

Several Arab countries are trying different approaches to addressing failing water and sanitation services to poor communities. Some undertake to improve services overall, on the premise that making services work for all is necessary for making them work for the poor (IDB, 2005). Some governments, especially in North Africa and the GCC countries, are inviting the private sector to assist in this effort. The results are not always successful. Governments worldwide deem it their responsibility to provide, finance, regulate, and build water infrastructure. They do it for two good reasons, namely, market failures and equity concern (World Bank, 1993). Several countries in the region are advancing the decentralization of water services to local governments, town councils, and communities. This process is in its early stages, and more is needed to strengthen ownership and accountability of services, especially to poor communities.

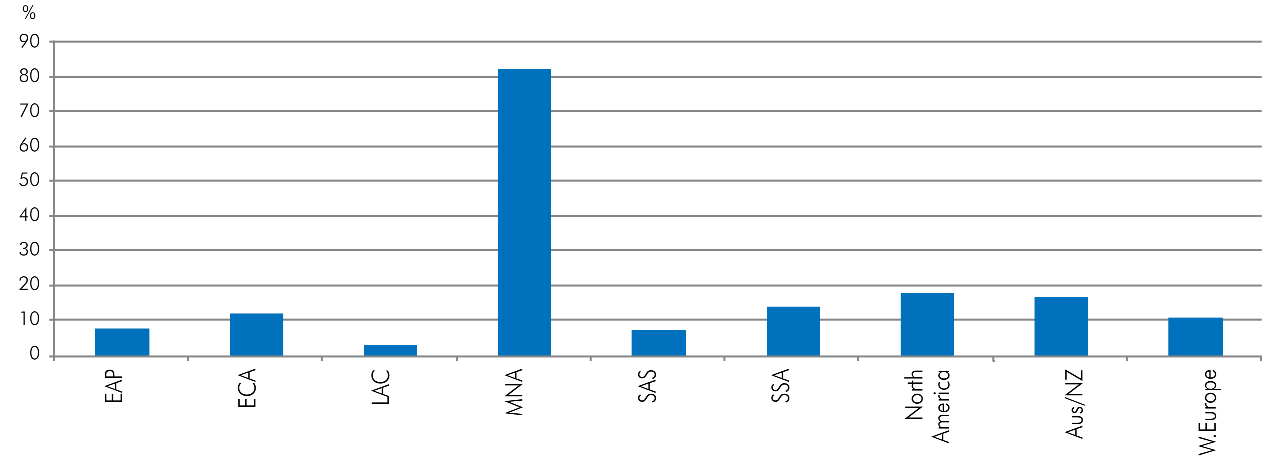
Governments tend to address this problem through an incremental project approach narrowly focused but simple to design and implement. Such procedure may allow for urgent terms of engagement for the implementing agencies, and immediate rewards for the benefiting communities. But the long term reliability and sustainability may suffer if such investment is carried out without an integrated development strategy for the water sector.

That is why the economic and financial health of the water sector in these countries is at risk. Much of the investment has been financed through public expenditure and national budgets.[2] The allocation to this sector has been stagnant or declining (World Bank, 2004a). Allocations of public funds vary by country. Egypt allocates about 10% of it annual budget to the sector and to maintaining its infrastructure, especially the public irrigation systems (World Bank, 2007). It allows for an additional 5% for expansion and development.[3] Kuwait spends about 15% of its annual budget on water subsidies (World Bank, 2004b). A recent study indicates that the United Arab Emirates spends about US$3.4 billion annually on the water sector (to cover operations and maintenance and investment in new water plants) (World Bank, 2004b). Other member countries of the GCC allocate significant resources to the water sector as they increase investment in desalination and non-conventional sources of water. Yemen and Jordan spend about 9% of their annual budgets on operating and maintaining the services in the irrigation sector (World Bank, 2004b). Data on water supply and sanitation are not available because budget allocations are largely distributed among local governorates and city councils. The figures from other countries are not available because little has been done to review and assess public expenditure especially as related to delivering services to the poor.[4]

The increasing financial burden can be addressed through realistic institutional reform that can improve the efficiency of services and strengthen partnerships with water users. The search for alternative sources of funding should include contribution by water users, the empowerment of the beneficiaries, and carefully debated partnership options with the private sector. Another dimension relates to the growing concern for better management of shared international water ways. The bulk of water resources, both surface and groundwater, are shared among different riparian countries. Equitable sharing has become a major concern to reduce possible conflicts over disputed water rights, prompting calls for efficient cooperative utilization and joint investment throughout the river basin. The financial requirements needed to achieve this goal are beyond the available resources in many countries in the region (World Bank, 1999).

Current and future water scarcity problems in fourteen Arab countries[5] are so serious that immediate action is needed on multiple fronts: addressing the growing water needs of burgeoning populations, increasing investment in water infrastructure, articulating policy options for equitable and efficient water allocation among various users, investing in new technologies to improve water efficiency in agriculture, and augmenting existing water resources from non-conventional sources. Non-conventional sources include the expansion of seawater desalination as well as utilizing properly treated wastewater and low quality water in agriculture. Many Arab countries are using saline water for irrigation and investing in the recycling and reuse of drainage water for agriculture. These non-conventional sources are likely to play an increasingly larger

FIGURE 5 **PROPORTION OF REGIONAL FRESHWATER RESOURCES STORED IN RESERVOIRS [6]**



EAP: East Asia & Pacific, ECA: Europe & Central Asia, LAC: Latin America & Caribbean, MNA: Middle East & North Africa, SAS: South Asia, SSA: Sub-Saharan Africa.

Source: World Bank, 2007

role in balancing water demand and supply in the years ahead.

III. INCREASING COST OF DEVELOPING NEW WATER RESOURCES

For all Arab countries, new water resources are expensive to exploit. Most available water resources have been developed (World Bank, 2007). As Figure 5 indicates, more than 80 percent of all surface water resources in the Arab world have been stored in reservoirs (World Bank, 2007).

Most suitable and accessible fresh water sources have already been developed and the cost of building new dams and storage reservoirs continues to increase rapidly. The mounting opposition from environmentalists and non-government organizations has negatively influenced the support of international development agencies for financing new dams or reservoirs. The rising cost of new dams combined with increased deterioration and sedimentation of existing reservoirs mean net water storage is stagnant or declining in many countries (World Bank, 2004a). Governments do not have the resources to invest in building new water storage facilities. Over-drafting of groundwater resources has intensified in most Arab countries. The declining water tables make the extraction cost too high.

This situation confirms that there are limited and expensive opportunities to utilize additional water resources in the region. Instead, governments have allowed for expanded exploitation of groundwater resources to meet the growing demands for water, at high pumping and transport cost, especially in the burgeoning urban centers and in crowded cities in the region. Some countries are expanding investment in desalination of seawater and in wastewater treatment and reuse.

As a result, the pressure to reallocate water among different users is likely to intensify in the next decade. Since irrigated agriculture is the main user of these scarce resources, pressure is mounting in several countries in the region to adjust water allocation to agriculture. The justification is to meet the growing demands of the increasing population, satisfy the expanding urban centers, and supply new industries with water (UNDP, 2009). In addition, more water would have to be allocated to ecosystems restoration to maintain their ability to provide environmental services sustainably.

In both urban and rural communities, serious political, economic, and social dimensions are shaping the debate on water allocation. The pressure to satisfy immediate demands may result in hurried reallocation decisions with little attention to the long-term implications on society in both social and economic terms. The debate is intense in Jordan, Yemen, and the GCC countries regarding the justification for allocating significant quantities of water to the agricultural sector despite the fact that the contribution of this sector to national economic growth is diminishing (UNDP, 2009).

According to a World Bank (2007) report, urbanization and industrialization will also increase the demand for energy and hydropower. These developments pose great challenges for governments in their effort to better manage water resources without increasing carbon emissions. The challenges for water supply and sanitation will also need to meet the backlog of demands while meeting the needs of growing populations with rising incomes. There are now increasing demands for expanding sanitation and additional treatment of wastewater. But the existing systems of urban water supply and sanitation in many countries already fail to provide adequate services, and the problems posed by urban pollution are likely to grow (World Bank, 2007). To adequately address these challenges, these countries need to articulate new water policies, invest more in managing the water sector, and develop new approaches and efficient institutional frameworks for better water management and allocation.

A recent study estimated the average tariff charged by water utilities in many cities in the region will increase. In Amman, Jordan, for example, the average incremental cost of water rose from $0.41 per cubic meter during the 1980s to $1.33 per cubic meter in the 1990s, as a result of groundwater shortages (Rosegrant et al., 2002a). Similar trends have been reported about the cost of new irrigation systems in

SALT TOLERANT CROPS

Shoaib Ismail

Salinity has been critical in affecting agricultural productivity over the past decade. Salinity affects plant growth, particularly in irrigated land where one third of the world's food is produced. Because it contains dissolved salts, irrigation water accelerates and exacerbates soil salinization significantly.

Soil salinization is likely to get worse because of the anticipated reduction in water availability and deterioration in water quality. UN estimates show that globally every minute three hectares of arable land are lost due to salinity. Salinization is caused primarily by the mis-management of irrigation systems. Irrational water use to obtain higher productivity has led to the accumulation of salts, rise in groundwater, and compaction of soil. Open or flood irrigation systems practiced generally for all crops without proper management has resulted in land degradation.

Many crops developed early on for their higher productivity fail to respond under changing salinity conditions. Attempts have been made to develop new crops that are more tolerant to salinity and/or to identify crops that can be adapted to more severe salinity conditions. The latter requires alterations in agronomic practices to optimize production. Technologies to develop new crops range from classical breeding programs to biotechnology methods and gene transfers. However, for many crops (glycophytes) the extent to which the limits of salt tolerance can be extended has reached its maximum limit. Major breakthroughs will only take place by means of a significant change in the genetic make-up of existing crops or through natural selection for new highly salt-tolerant crops/plants (and halophytes). However, not only do crops have to be improved, but the integrated management of resources (soil and water) also has to be adopted for a more sustainable form of agriculture. Use of modern irrigation methods like drip and sprinkler needs to be compatible with the type of production system(s) in order to ensure better water use, availability of water in the rhizosphere, and the prevention of salt built-up in the soil.

During the last few years many salt tolerant crops and vegetables have been developed for cultivation in saline (soil and water) conditions. In addition, significant work has been done on different production systems, e.g., forage, fuel, horticulture, and landscaping, that are tolerant to irrigation with moderate to highly saline water

(total dissolved solids of 7,000-17,000 ppm). The list of plant species/cultivars accessions is extensive and many are related to specific site(s), climate, soil, and water conditions. Many new production systems have been introduced and adapted from the Central Asia and Caucuses region to the Middle East and North Africa region that have been adapted for scaling-up.

There also exists potential to develop crops adapted to the highest salinity levels (sea water salinity) as well where few production systems can be sustainable. Mangroves have been known not only to protect coastal areas, but to provide an ecosystem for marine production. High quality oil can be extracted from Salicornia spp., which also has a high commercial value as a vegetable. Distichlis spp., which has grain, forage, and landscaping value, can be grown in seawater.

In addition to improved crop yields of these alternative production systems, there are environmental benefits to be gained because many of these adapted agricultural systems can significantly improve the micro- and macro-environment, leading to better soil and water conditions

In summary, the need for improved tolerance to salinity will increase in coming years due to limited land and water resources. Therefore, improved crop varieties and other salt tolerant plants have to be introduced into production systems, whether through natural selection or modern technologies. The search for improved crops and adapted production systems need to be continuous and evolving as will be demanded by changes in soil, water, and climate conditions.

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several Arab countries. The real cost of irrigation have been rising over the past 3 decades, resulting in "low rates of economic return for new irrigation construction" (Rosegrant et al., 2002a). The high costs have been caused by storage construction needed to regulate river flows, severe climate variability requiring high irrigation duties, expensive flood control schemes, construction in remote locations requiring high transportation costs, and basic infrastructure (World Bank, 2006).

Despite the rising cost of developing new water resources, many governments still prefer expanding water supplies, which has led to investment in infrastructure that could have been avoided or postponed. Water users in the Arab world often pay little for their publicly supplied irrigation water (World Bank, 2007). They have few incentives to refrain from growing water-intensive crops or to conserve water. In some arid areas, water prices are so low that it is attractive to grow low value crops. Similarly, many towns and cities charge fees that provide no incentive to conserve water. A recent review by the World Bank (2007) of municipal water supply projects found that the price charged for water covers only about 35 percent of the average cost of supply, and charges in many irrigation systems are much less (World Bank, 2006). The benefits of this cheap water go largely to the middle class and the rich. The poor usually depend on water vendors, and may pay many times more for water than the well-off who usually enjoy piped water. It is therefore believed that cross-subsidies whereby higher-income customers cover part of the cost of serving the poor can be achieved by incorporating a 'progressive tariff schedule', but in practice subsidies are often poorly targeted (Rosegrant et al., 2002b).

IV. DEEP GROUNDWATER ABSTRACTION HAS EXHAUSTED STRATEGIC WATER RESERVES

With the spread of energized pumping in many Arab countries, deep groundwater extraction has increased exponentially to irrigate land and to provide drinking water for the millions of rural communities which are not connected to national water carriers. The expansion of pumping technology has often resulted in dramatic declines in the water table in areas of low or zero recharge (World Bank, 1999). Great improvements have been made in the methods of drilling in recent years, thanks largely to technology developed by the petroleum industry. Powerful pumps enable users to draw large volumes of water via deep boreholes, thus affecting the water table beyond the confines of their property and depleting distant wells formerly considered to lie safely beyond the drilled zone (World Bank, 1999).

Many countries have recognized this problem and introduced regulations for exploiting groundwater. But the implementation of these regulations is lacking as groundwater, like surface water, is a fluid that recognizes no national boundaries. Conflict is common over groundwater use among both private owners and among nations sharing water aquifers. Criteria for establishing rights and equity in sharing groundwater resources are not adequately well defined in many countries or among countries (World Bank, 1999). Where groundwater flows naturally from one state to another, cooperation is needed in areas such as the exchange of information and data required to better monitor and manage both water quality and quantity. Especially important is the sharing of information on water recharge, and other changes in water tables in order to coordinate and adjust withdrawal rates among the riparian owners or states (Grey and Sadoff, 2003).

Yemen, for example, has expanded abstraction of groundwater with the widespread adoption of tube well technology to better deliver groundwater for agriculture and household use. The groundwater is being pumped at a rate approximately four times more than that of natural recharge (World Bank, 2007). As a result, some productive valleys are experiencing drastic shortage of water and are consequently being abandoned. Conflict over groundwater sharing and allocation is spreading among competing users. Overexploitation of underground water resources is the result of a decentralized process of drilling wells without adherence to a national water plan. Such a plan would have required careful monitoring, data gathering, and regulations to control drilling and define priorities for water use and allocation. Yemen is now preparing, with the assistance of several donors, a comprehensive water resources management plan, which would provide some guidelines to regulate the process of groundwater use and allocation.

A large percentage of the overall water supply in the GCC countries comes from groundwater resources, mostly non-renewable in nature. Only in Oman does renewable groundwater represent a significant portion of the water supplies used for domestic and industrial purposes. The water is derived from deep aquifers located in Saudi Arabia and Oman. The fossil water in these aquifers was deposited in these formations millions of years ago. Although the GCC countries continue to use modeling tools extensively, the volume of water stored in these aquifers is largely undetermined. These reserves contain large but unknown volumes of brackish water, and the depth of usable water exceeds 500 meters. There are no tariffs on groundwater abstraction in GCC countries, which has led to the cultivation of low value crops such as grains, and high water consuming crops such as alfalfa and green forage for livestock and dairy production.

The over-extraction of groundwater beyond safe yield levels has resulted in the pollution of existing groundwater aquifers, due to intrusion of saline seawater and the up-coming of brackish and saline water supplies from lower aquifers. This is particularly serious in Libya, Jordan, Yemen, Oman, Bahrain, the UAE, and Qatar where deterioration of groundwater quality has been observed and measured over the last few years (World Bank, 2007). Recovery of the aquifers, even with the introduction of appropriate measures, may take generations. The responsibility of the public water agencies is to ensure that these resources are better protected and sustainably managed for future generations. But available technical skills are limited, and the enabling policy environment is largely restricted. The expansion in, and unrestricted use of, non-renewable groundwater supplies in many countries demonstrate the impact of inadequate policies and misguided investment in this sector. The absence of a strategic national water framework to protect non-renewable water supplies is driving many Arab countries to waste precious water resources on activities, such as cultivating low value crops, which have not received adequate economic or environmental assessment and evaluation.

This situation could be addressed through carefully developed and articulated integrated water management approaches specifically designed to change the way groundwater is being abstracted and used. This requires an appreciation that groundwater is part of the integrated water cycle in the country including both surface river basins and below ground water flow networks. This recognition is essential to harmonize water use for high priority social and economic objectives, within a framework that also considers the water needs of future generations. Efficient management of groundwater resources recognizes that some of the tapped aquifers are connected with the national hydrological network, and that they may also be recharged by the irrigation networks distributing surface water to the fields. As such, managing groundwater becomes an integral part of a national water plan.

In Jordan, for example, the public water agency has recognized the important fact that aquifers systems and sub systems are intimately connected with portions of the overall hydrological system in the country, and that the patterns of groundwater use are usually interconnected and often sequential. The government has consequently introduced a new policy framework to regulate and manage the groundwater subsector. The average annual abstraction from groundwater in all sub basins in Jordan is about 160% of the annual renewable average of recharge (World Bank, 2007). The recently enacted national water policy is being supported with tough regulations. It prevents the issuing of new licenses for new wells or the renewal of existing licenses, imposes full control on water drilling throughout the country, and permits only hospitals and educational institutions to renew their license to abstract groundwater. About 90 percent of all wells are equipped with meters to enforce new volumetric water pricing on abstracted groundwater. Also included in the new framework is a new mechanism designed to regularly monitor the status of groundwater resource through observation wells, and to identify and enforce actions required for water resource protection and quality control (World Bank, 2007).

The new procedures clearly define the development priorities for each sub basin, set guidelines for water allocation, introduce specific policy tools to install and measure abstraction, and enforce targeted rules to prevent illegal drilling. The policy also provides support for long term research on water quality, on managing shared water aquifers, and on communication and education to the public.

V. DESALINATION TO PROVIDE DRINKING WATER FOR MILLIONS OF HOUSEHOLDS

The Arabian Peninsula and the GCC countries in particular have historically been faced with extreme shortages of reliable water supplies. The Gulf region is underlain by large deep aquifers which contain non-renewable supplies of fossil water. This source has provided agricultural development in some parts of the Gulf, but has a finite life and quality limitations. Because of these limitations, all of the GCC countries have resorted to desalination of both seawater and brackish water to provide high quality and reliable water supplies to their citizens. Seawater desalination in the Arabian Peninsula has been employed since the 1950s. The process initially used was based on distillation. The scale of operations was usually small. Reverse Osmosis (RO) came on stream in the 1970s, but the technology became commercially well-established in the 1980s.

There are unusual demands on water management in the GCC countries because of the pressure to maintain food security and having to rely on scarce water resource to allocate to agriculture. At the same time these countries are facing rapidly expanding demands for high quality water to support expanding populations and growing industries. Governments have provided subsidies to expand irrigated agriculture. Water resources management in the UAE, Saudi Arabia, and Oman is being reviewed within a well-defined process to modernize water institutions, reform water policies, and improve water technologies (GCC, 2008).

GCC member countries continue to invest in mega seawater desalination plants to provide water supplies for millions of households. Table 3 illustrates the expansion in desalinated water capacity in the GCC countries. Recent reports predict that annual investments to produce, manage, and operate seawater desalination plants in the Arab world is likely to be between $15 to $20 billion in the next decade (GWI, 2010). The bulk of this water is allocated to cities and towns, while groundwater is allocated to agriculture.

According to the Water in the GCC Statistics Book (2008), the total use of desalinated water in the region is estimated to reach four billion cubic meters in 2011. At an average cost of one US dollar per cubic meter of desalinated water, the region spends more than US$ four billion annually on obtaining water from these sources (GCC, 2008). Three countries, Saudi Arabia, the United Arab Emirates, and Kuwait, are by far the largest users of desalinated water with 77% of total regional capacity, with Saudi Arabia alone accounting for 41% (World Bank, 2004c).

Until the 1960s, desalination plants were expensive and difficult to run. The Multi-Stage Flash (MSF) distillation process has been the workhorse desalination technology in all GCC states. It is the method most widely used on a large scale, but there is still room for improvement by making better use of computer modeling, making use of low grade heat, and extending the plant's life (Rogers and Lyndon, 1994). Because it can utilize low-grade heat, MSF is usually installed as part of a dual-purpose plant, along with a power generation function. MSF has an advantage over reverse osmosis (RO) because it requires less specialized technical expertise and is much more robust. MSF is more suitable for desalinating seawater containing large concentrations (greater than 35,000 parts per million) of total dissolved solids, while RO is more suitable for desalination of brackish water containing between 5,000 and 10,000 ppm of dissolved solids. However, more recently RO systems are increasingly being installed and operated to desalinate seawater on a commercial basis.

The economic analysis for desalination revolves around production cost, price, and affordability of drinking water. The cost can be subdivided into capital cost and production cost. Capital cost is related to capital investment, whereas production cost is composed of the variable items that make possible the running of the desalination plant. The greatest single cost of water desalination is energy, followed closely by capital cost (Rogers and Lyndon, 1994). Often a 20-year lifespan is assumed for capital, but some MSF plants have been operating satisfactorily in Kuwait for as long as 26 years, because of efficient operations and maintenance.

The private sector has been playing an important role in water desalination in the GCC countries at an annual current investment of about $3-4 billion annually (GCC, 2008). Many governments in GCC countries see private sector participation as the way forward for managing and operating desalination facilities. The key drivers for private sector participation are increased access to private capital, increased managerial and technological capabilities, increased operational efficiency, and reduced need for subsidies. The criteria for determining the right option for private sector participation in the provision of desalination services are whether capital investment is required, whether assets are to remain publicly owned, to what extent governments want to keep control over operations, and which risks governments want to transfer to the private sector. A set of rules and regulations defining the roles and responsibilities is needed and a transparent process for awarding contracts to service providers needs to be adopted. Where privatization is introduced, it should be managed by a regulatory authority which could be an independent body or a government agency.

VI. WATER QUALITY AND POLLUTION

The Arab Human Development Report states that "water pollution is now a serious challenge in the region" (UNDP, 2009). The report attributes water pollution to high chemical input use in agriculture as well as to increasing inflows of domestic and industrial wastewater into the water cycle (UNDP, 2009). The lack of clean sanitation to large segments of the population contributes to water pollution by raw sewage. Table 4 shows that the main agricultural countries in the region (Egypt, Algeria, Tunisia, Morocco, and Iraq) are also the main water polluters as indicated by data on the daily emissions of organic water pollutants (UNDP, 2009). Also causing environmental pollution is the increased utilization of seawater desalination.

Water pollution problems are caused by the large volume of desalination plant effluents generated in the Gulf countries and elsewhere. According to a World Bank report (2007), "discharge of hot brine, residual chlorine, trace metals, volatile hydrocarbons, and anti foaming and anti-scaling agents are having an impact on the near-shore marine environment in the Gulf." The brine produced from seawater desalination process is highly saline. In the UAE, the concentration of total dissolved solids (TDS) in brine can reach 65,000 mg/l (EAD, 2009). This high salinity brine can harm marine life and biodiversity in coastal zones. What magnifies these negative effects is the large number of desalination plants located on the coastal areas of the Gulf into which countries dispose of their brine, causing increased seawater salinity. The Gulf countries flush about 24 tons of chlorine, 65 tons of pipe-cleaning anti-scaling agents, and about 300 kg of copper into the Gulf daily (Alshaaer, 2009). The Gulf can be considered as a closed sea where water renewal takes years to replace polluted seawater.

VII. WATER AND FOOD SECURITY

The dilemma in debating policies related to food self sufficiency involves the conflicting requirements to better conserve water, especially in countries where water scarcity is at the warning level, and at the same time, meet the growing demands for basic food

TABLE 3 DESALINATION CAPACITY OF GCC COUNTRIES (MILLION M³/YEAR)

Country	1990	2000	2008
Bahrain	75	104	371
Kuwait	318	522	1,662
Oman	55	60	294
Qatar	112	178	941
Saudi Arabia	950	1,278	3,341
UAE	502	1,081	4,878
Total	2,012	3,223	11,487

Source: GCC, 2008 and World Bank, 2005

commodities, especially grains. Food policies require fundamental assessment because of the increasing globalization in agricultural trade associated with the removal of trade barriers and improved access to competitive markets for importing grains (Barghouti et al., 2004). The allocation of substantial and precious amounts of water to produce agricultural commodities that can be imported from water rich or highly subsidized regions should be carefully analyzed. The concept of food security and food self-sufficiency in the current global market needs urgent assessment, because of the implications on the water sector (Lipton, 2004). The trade-offs between achieving food self-sufficiency and sustaining water security in several Arab countries is an important issue which requires careful policy analysis and objective assessment of national priorities. Some governments may treat the importation of grains as acquiring virtual water. Each ton of grain (wheat or barley) would require 2000-3000 cubic meters of water-based on the efficiency of irrigation methods used (Barker and Molle, 2004). In his analysis of grain production, Khan (2003) presents data which indicate that self sufficiency in cereal production is less than 50 percent in several countries in West Asia and North Africa. Table 5 illustrates the significant volume of virtual water embedded in imported cereals in the Arab countries. The annual grain import in West Asia and North Africa was about 59 million tons in 2000-2001.

The virtual water embedded in imported grain is the equivalent of the annual flow of the Nile and double of the annual flow of the Euphrates (IDB, 2005). More virtual water is imported through other food commodities such as meat. The food gap is likely to increase because of population growth and increased income, which would allow for increased and diversified consumption of agricultural products including high quality small grains and livestock products. Therefore, policy-makers should assess the benefits of various policy options regarding the advantages of importing

TABLE 4 **WATER POLLUTION LEVELS FROM ORGANIC POLLUTANTS IN 15 ARAB COUNTRIES AND 2 INDUSTRIALIZED COUNTRIES, 1990-2003 (IN DESCENDING ORDER BASED ON 1990 POLLUTION LEVELS)**

COUNTRY	Emission of organic water pollutants (metric tons daily) in 1990	Emission of organic water pollutants (metric tons daily) in 2003	Emission of organic water pollutants (kilograms per worker daily) in 1990	Emission of organic water pollutants (kilograms per worker daily) in 2003
Egypt	211.5	186.1	0.20	0.20
Algeria	107.0	-	0.25	-
Tunisia	44.6	55.8	0.18	0.14
Morocco	41.7	72.1	0.14	0.16
Iraq	26.7	-	0.19	-
Syria	21.7	15.1	0.22	0.20
Saudi Arabia	18.5	-	0.15	-
Kuwait	9.1	11.9	0.16	0.17
Jordan	8.3	23.5	0.19	0.18
Yemen	6.9	15.4	0.27	0.23
UAE	5.6	-	0.14	-
Oman	0.4	5.8	0.11	0.17
Sudan	-	38.6	-	0.29
Lebanon	-	14.9	-	0.19
Libya	-	-	-	-
United States	2562.2	1805.2	0.15	0.13
Russian Federation	1991.3	1388.1	0.13	0.18

Source: World Bank, 2007

food grains. To enhance long-term food security, it is key to develop proper management of grain stocks and storage facilities, rather than invest in developing expensive and scarce water resources to increase food production. It is well-established that the Arab countries are major importers of basic food commodities and only export small quantities of high value crops such as fruit and vegetables. Therefore, there is a need to better study the balance in virtual water between the import and export of agricultural commodities in the Arab countries in order to select efficient production systems, which could assure reasonable return on the investment in valuable and scarce water resources for irrigation.

TABLE 5 VIRTUAL WATER IN CEREAL IMPORT IN THE ARAB WORLD, 2000/2001

Region	Cereal imported (000 Metric Ton)	Equivalent in virtual water (billion m³)
West Asia	32,368	64,736
North Africa	26,687	53,374

Source: Khan, 2003 and IDB, 2005

VIII. REFORM IN THE WATER SECTOR: BEYOND MANAGING WATER INFRASTRUCTURE AND SERVICES TO MANAGING THE SECTOR

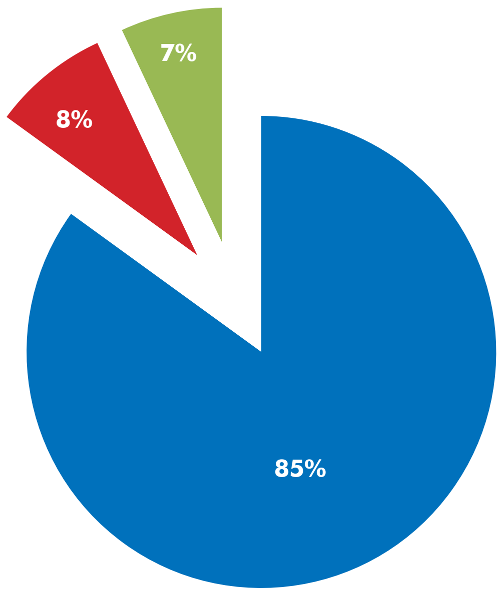
Several Arab countries have, over the last few years, prepared water action plans that highlight the importance of water in equitable economic growth and sustained environmental management. Water resources assessment and the reform of water policies and institutions have been or are underway in Yemen, Jordan, Tunisia, Saudi Arabia, Egypt, and the United Arab Emirates. The main elements endorsed by these new policies include managing national water resources as an integrated system of hydrology and development, introducing decentralization as the basis of managing services, and articulating rules, regulations, and incentives to increase the participation of stakeholders, the private sector, and local communities in water management (World Bank, 2007). Several countries have encouraged local communities to assume more responsibility, authority, and control over improvements and operations of water services and to develop local water resources to meet local needs. Rural communities have also been empowered to address evolving community demands. This partnership would ensure equitable management of water for irrigation and water supply through community action in cooperation with water users and public service institutions.

Most countries are shifting their concern from heavy focus on water infrastructure to better management of water resources. The results of this shift are mixed, because intervention in the water sector is a complex process. Some countries face difficulties in articulating clear water policies due to the lack of clear development objectives of the water sector. As mentioned earlier, the water sector can serve several development goals, and they need to be carefully articulated, prioritized, and accompanied by realistic action plans to achieve them. Not all of these objectives are equal. Many countries face difficulties in setting priorities among these objectives. Prioritization should also be supported by reliable performance indicators to measure the results of new policy frameworks. Many countries have been engaged in sector reform, but have not yet articulated field-tested indicators needed to assess the impact of newly recommended policies on the performance of the water sector within national and local settings.

Water issues usually attract the concern of political leaders, both at the national and local levels, especially in times of crises, which are frequent due to repeated droughts and associated water shortages and scarcity in the region. High level public officials in the water sector are frequently engaged in water crises management, thus leaving little time to concentrate on long term strategic planning in partnership with other players from affected sectors. It would be desirable to establish specialized multidisciplinary teams of experts to handle problem solving and crisis management, and devolve responsibilities to the local levels, guided by national strategic goals. Doing so would free public agencies to be strategically focused on policy planning, monitoring, and implementation, especially as related to rules and regulations designed to improve and protect water resources.

Most investment programs and associated

FIGURE 6 WATER CONSUMPTION (%) BY SECTOR IN ARAB COUNTRIES, 1999-2006*



- Agricultural water withdrawal (% of total freshwater withdrawal)
- Domestic water withdrawal (% of total freshwater withdrawal)
- Industrial water withdrawal (% of total freshwater withdrawal)

*Latest values for all 22 Arab countries

Source: UNDP, 2009

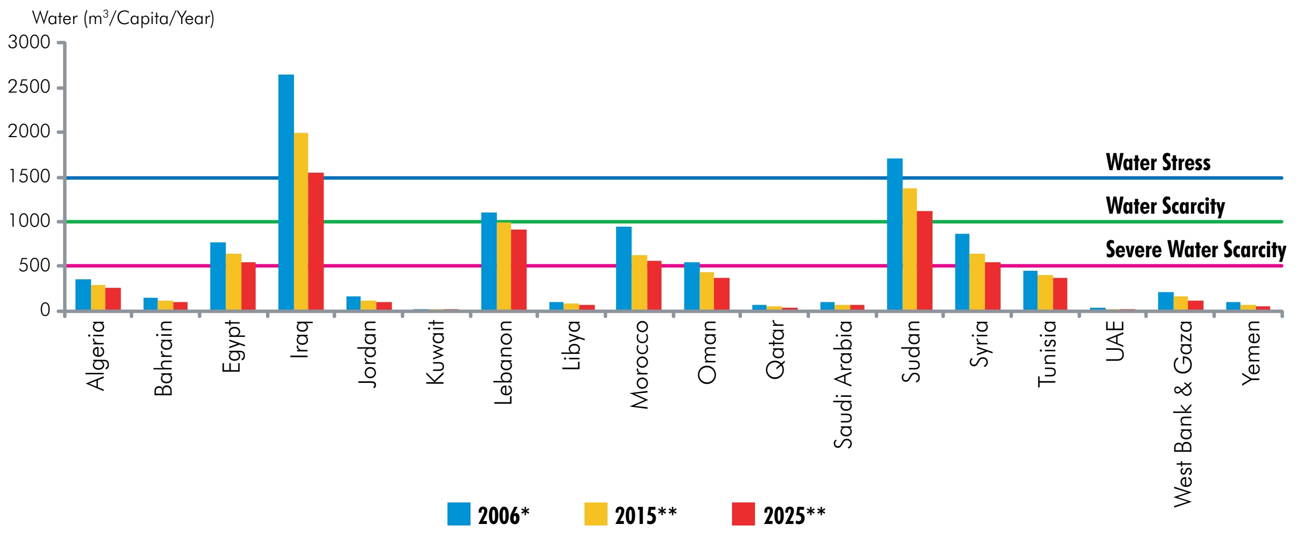
reform packages provide support for institution building and capacity enhancement. The main challenge to overcome is to articulate a comprehensive framework to manage the water sector and to engage major stakeholders, including the private sector and consumers, in the decision-making processes needed to better sustain service provision. Other elements of this approach include a shift in planning from only engineering and construction of new facilities to a more comprehensive planning of the economic, financial, and social needs of the water sector. This shift should be supported by increased reliance on decentralized services and a management system at the local level. The decentralization process should be supported by a clear legal framework. Because most countries do not have centralized national water carriers with branches to reach scattered communities, decentralization of water service provision will allow for efficient responses to local needs and for designing realistic structures suitable to meeting local conditions.

The integrated framework should also articulate policies to guide water and power pricing and cost recovery. Power is increasingly used for pumping water from deep aquifers and for desalination. Energy price subsidies add more distortion to the national effort to better manage water resources. In addition, reform in water policies cannot be carried out in isolation from reforms in the agricultural sector, especially in commodity pricing and trade. Governments tend to justify subsidies to irrigation on the grounds that farmers are required to sell portions of their production to government agencies at pre-determined prices. Pricing policies in water supply and agriculture in many Arab countries tend to favor subsidies and to promote inefficient, inequitable, and environmentally non-sustainable allocation of scarce land and water resources (Barghouti, 1999).

An important area for reform in the water sector is to improve the efficient use of water for irrigation. As indicated in Figure 6, agriculture continues to consume more than 80 percent of all water resources in the region (UNDP, 2009). This is a serious challenge because the return on water investment in many irrigation schemes in most Arab countries is low by international standards (World Bank, 2006). Cropping intensities (which are the ratio between irrigated crop areas where double or triple cropping areas are counted twice or three times, respectively, and the physical areas equipped for irrigation) in most Arab countries vary from less than 0.8 to 2.2. Figures available for some countries show a cropping intensity of 1.66 for Egypt, 1.19 for Syria, 1.15 for Oman, and 1.07 for Jordan (FAO AQUASTAT). In Saudi Arabia, Bahrain, and Kuwait the cropping intensity is reported to be less than 1.00, probably because no cropping is possible in the hot season. Analysis of much farm budget data for irrigated projects shows that cropping intensity less than 1.00 is not always economically viable (Barghouti et al., 2004). Low cropping intensity is hardly profitable for small farmers.[7]

Areas with low cropping intensity usually suffer from low water availability, sustain only low productive agriculture, and produce a low economic rate of return on irrigated farming (FAO, 2001).

FIGURE 7 **PROJECTIONS OF FRESHWATER AVAILABILITY IN ARAB COUNTRIES**



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

Policy guidelines and appropriate incentives would be needed to encourage farmers in these areas to invest in water saving technology for irrigation, or compensate them as an incentive for exiting irrigated farming altogether. These changes may cause more efficient use of water in other sectors. In most Arab countries, the issue of rehabilitation and modernization of irrigation systems is becoming increasingly important because of the shortage of suitable arable land and water scarcity (IDB, 2005). Moreover, the increasing competition among sectors using water is affecting the quality and quantity of water being allocated to agriculture. Controlling allocation to irrigation and pricing policies are essential to reducing waste and damage to the resource base. Egypt, Syria, Iraq, Lebanon, and Tunisia do not face immediate water shortages. The main challenges in these countries are to improve the performance of existing investment in the water sector, especially in irrigation, achieve universal coverage in water supply and sanitation, and address emerging issues in water quality and risks to the environment (IDB, 2005).

Tunisia, Morocco, Algeria, Jordan, Yemen, and to some extent Egypt, Saudi Arabia and Syria, have been encouraging farmers to adopt modern irrigation technology systems (IDB, 2005). Such systems can enhance agricultural production, increase water use efficiency, and reduce field level water losses. Traditional irrigation technologies (furrow, border, and flood irrigation), which involve water delivery to plants through gravitation and have usually resulted in substantial water losses and limited uniformity in water distribution (Hillel, 2008), have been replaced only in some areas by modern irrigation technologies, particularly sprinkler and drip irrigation to increase water use efficiency.

Egypt has demonstrated the successful use of modern irrigation system on newly developed land in the Western Delta and other areas covering more than 13 percent of the irrigated land in the country (World Bank, 2007). Improved production and irrigation technology, including the latest in crop breeding, plastic culture, protected greenhouses, fustigation, and pressurized irrigation delivery systems of low volume but high frequency have permitted rapid change in the newly developed areas.[8] But these technologies are being adopted only slowly in other agricultural regions, which constitute more than 87% of the country's total irrigated areas. The success of modern technology in Egypt may pave the way for wider adoption throughout the country, thus converting Egypt's irrigated land to become among the most modern and productive

TABLE 6 **CLIMATE CHANGE FUTURE SCENARIOS: WATER AND AGRICULTURE**

Scenario	Type of change	Effects on human security	Affected area
WATER	2°C rise in Earth temperature	1 to 1.6 billion people affected by water shortages	Africa, the Middle East, Southern Europe, parts of South and Central America
	3°C rise in Earth temperature	Increased water stress for additional 155 to 600 million people	North Africa
	Climate Change	Repeated risk of drought known in recent years, with economic and political effects	Mauritania, Sudan and Somalia
	Climate Change	Reduced average rainfall	Egypt, Jordan, Lebanon and OPT
	Rising sea levels	Risk of flooding and threats to coastal cities	Gulf coast of Arabian peninsula
	Climate Change	50% decline in renewable water availability	Syria
	1.2°C rise in earth temperature	Decreased water availability by 15%	Lebanon
	1°C rise in earth temperature	Reduced water runoff in Ouergha watershed by 10%	Morocco
	Climate Change	Greater water shortages	Yemen
	Climate Change	Reduced water flow by 40-60%	Nile River
	3°C rise in Earth temperature	Increased risks of coastal surges and flooding	Cairo
AGRICULTURE	2-3°C temperature rise in tropical regions	A drop by 25-35% in crop production (with weak carbon enrichmen) and by 15-20% (with strong carbon enrichment)	Africa and West Africa (Arab countries included)
	3°C rise in Earth temperature	Reduced agricultural productivity and unsustainable crops	North Africa
	1.5°C rise in Earth temperature	70% drop in yields of Sorghum	Sudan (Northern Kordofan)
	Climate Change	Flooding of 4,500 km^2 of farmland and displacement of 6 million people	Lower Egypt

Source: UNDP, 2009

in the world. This possibility could also allow for substantial conservation in water resources. The challenge is likely to be in mobilizing large financial resources needed for this desirable development prospect, and would require significant changes in water pricing regimes and the construction of modern water delivery and metering systems.

Barghouti (1999) has argued that these new irrigation systems "have opened greater opportunities to cultivate soils with low water-holding capacity (sandy and rock soils) and to farm low quality lands and steep slopes". This technology has also enabled farmers in regions facing limited water supplies to diversify their production systems, and shift from low-value crops with high water requirements, such as grain crops, to high-value crops with lower water requirements such as fruits, vegetables, and oil seeds. It has also allowed the use of low-quality water (e.g., high saline and treated wastewater) in regions with high temperatures and high evaporation rates (Barghouti, 1999).

Even with measures to contain and better manage water demand and improve the efficiency of existing systems, new water supplies will be needed for agriculture and urban areas. As mentioned earlier, the lowest cost and most reliable sources of water have already been developed in many countries. The new sources of supply currently being considered have higher financial and environmental costs than those developed earlier. The costs of municipal water supply and irrigation will increase even further when adequate drainage and sanitation facilities are included as essential parts of these investments. For most cities in the region the cost of a cubic meter of water provided by "the next project" can be two to three times the cost of current supplies, even before environmental costs are factored in (IDB, 2005). In this context of intensifying competition for finite or dwindling resources, the principal challenge for policy makers is to determine the optimal allocation of water resources for irrigation, while minimizing the negative environment impact of water use.

Expansion of irrigation in the GCC countries, which is totally dependent on modern irrigation technology, has created attractive opportunities to successfully cultivate food crops under harsh conditions. This success was achieved through generous subsidies, and at a very high cost of water abstraction from non-renewable groundwater aquifers (Word Bank, 2004c). The use of water under these conditions requires careful assessment, particularly in light of the fact that the contribution of agriculture to gross domestic product (GDP) in these countries is almost insignificant, except in Saudi Arabia. While investments in irrigation can provide employment opportunities for the large number of landless and poor rural labor in many Arab countries, irrigation in the GCC and some countries largely employs an expatriate labor force and contributes little to improving rural employment (World Bank, 2004c).

In their review of water in the Arabian Peninsula, Al Alawi and Abdulrazzak (1994) argue that the countries of the Peninsula, especially Saudi Arabia, which are motivated by achieving food self-sufficiency, have encouraged investment in irrigated agriculture and that "successful subsidy and incentive programs have resulted in a large scale expansion of farming activities using substantial water requirements". The authors reported in their essay that over a ten-year period (1980-1990), the demand for water jumped from 6 to 22.5 billion cubic meters per year. Farming activities consumed substantial quantities of water provided mainly from deep aquifers. The authors (1994) present data to indicate that deep aquifer water levels are declining, pumping costs are increasing, and saltwater intrusion is contaminating the aquifers and causing disturbance of the dynamic equilibrium among aquifers. These factors have led to the abandonment of farm land, a decline in agricultural productivity, and an increase in migration away from rural areas (Al Alawi and Abdulrazzak, 1994).[9]

The role of agriculture in the national economy varies from less than 3 percent in the GCC countries to 29 percent in Yemen, but employs a relatively large segment of the labor force (World Bank, 2004b). As water scarcity intensifies, irrigated agriculture and associated reliable food production systems will be at risk, unless serious effort and investment is made to modernize irrigation and diversify agriculture. The prevailing irrigated production system in the Arab world would have to undergo a serious adjustment process, because most of these countries would be forced to make adjustments in the agricultural sector to cope with globalization and trade liberalization in agricultural commodities (Barghouti, 1999; Molden and et al., 2007). This adjustment process needs to be carefully planned and implemented within a comprehensive water policy, which also recognizes the importance of incentives in guiding a smooth transition in agriculture, and related adjustment in traditional water rights and allocation.

The issues facing the reallocation of water away from agriculture in the region are mainly political, economic, and social. Most farmers have acquired the rights to the water they use to irrigate their lands over several generations. Political leaders in some countries would like to emphasize the need for achieving high rate of food self-sufficiency. Achieving this goal may be unrealistic.

Efforts are underway in several Arab countries to treat wastewater and allocate it for irrigation in exchange for fresh water diverted from agriculture to meet the growing demands for urban and rural water supply. The process is complex and some countries have rushed into this exchange with little attention to possible high risks related to environmental and health hazards associated with the use of wastewater (Qadir, 2007).

IX. INVESTMENT IN WATER RESEARCH

The complexity of water management and allocation requires an aggressive approach to long term planning based on a systemic process of scientific discovery and relevant research for developing, delivering, and managing water resources. There is an important role for research in the modeling of supply and demand as well as other societal trends such as demographic changes. Several academic and research institutions have developed useful models to study water requirements under alternative options of water planning, population growth, changes in water use and quality, and other economic and social trends likely to have an impact over the long term. Field research and modeling have also been adapted to study the future water capabilities of river basins to meet growing needs under alternative scenarios of growth and development. Research models are also needed to study on a regular basis salt balance in water courses and drainage network, and to assess modern technology for desalination and disposal of salt residues in many Arab countries. Such tools are essential to better understand the technical, economic, and environmental issues affecting the water sector, and to devise proper plans to adequately manage and utilize the mix of different water resources.

The future water needs of growing populations in the Arab countries will not be solved through construction of new water projects alone. The importance of management should not be underrated. However, management of water resources can be sound and credible only if it has access to updated empirical research data and information about water issues and is willing and able to adopt technological innovations. Arab countries could do more to support investment in public research on water.

The water sector is facing complex challenges in the years ahead, and policy makers should develop scientific frameworks to guide national water plans to address these challenges. Only a few countries, such as Egypt and Kuwait, have invested in this type of research. More research is needed considering that many small countries cannot afford investment in research due to lack of resources, a short supply of qualified experts, and limited capacity to build specialized research facilities in these fields.

The Consultative Group for International Agricultural Research (CGIAR) comprises 15 international research centers, which are supported by more than 60 countries. CGIAR is dedicated to the search for technologies and scientific solutions to meet the growing demands for food and sustainable natural resources management. However, the success of CGIAR can only be possible if it is supported by capable institutions at the national level that could test and adapt new technologies to local needs.

Arab countries should invest more in their national research systems to further develop and strengthen their capabilities in water science and management, and to acquire expertise to address future vulnerabilities and challenges caused by climate change. Several countries have increased their investment in research to assess the impact of climate change on water and agriculture. Arab countries are located in one of the most vulnerable regions where climate change is likely to have serious implications as stated in several UN reports. Table 6 is a summary of some of the anticipated implications.

While the risk of climate change to their already scarce water resources is extremely serious, Arab countries have demonstrated lack of interest in studying the impact of these changes on current and future economic activities. It is unfortunate to report that Arab countries have committed the least amount of public funds to invest in and support their research and technology institutions that are needed to address the growing challenges of climate change (UNDP, 2009).

To address these needs, it is desirable to establish a regional water research center to serve countries of the region. This institution could expand the limited but important research work currently being conducted by the International Center for Biosaline Agriculture (ICBA). Located in Dubai, ICBA has established a strong reputation among international centers of excellence in the use of saline water for agricultural production. Additional support can target and build on the foundation already established by ICBA. Such an approach would allow ICBA to expand its mandate, go beyond the concern for biosaline agriculture to cover broader issues in water sector management, and establish strong partnerships with national research institutes, such the Water Research Center in Egypt and the Kuwait Institute for Scientific Research (KISR).

It is also important to build partnerships with private sector research programs. These partnerships are needed to catalyze innovations in wastewater treatment and reuse, in improving water quality, in groundwater management and monitoring, and in the desalination of seawater and brackish water. Such partnerships would also assist guide investments in rehabilitating and modernizing existing water facilities including irrigation technology and water supply and sanitation.

X. CONCLUSION

The water sector in all Arab countries will have to contend with a complex set of challenges over the coming decades. Shortages in clean water and sanitation aggravated by unsustainable policies, lack of institutional capacity, and vulnerabilities to climate change top the list. This paper has presented an overview of the strained condition of the water sector in Arab countries, while emphasizing the urgent need for introducing reforms that ensure efficient, equitable, cost-effective, and environmentally sustainable management of water resources.

Water policies in Arab countries have allowed for unrestricted use of scarce water resources. Low water tariffs and high subsidies have compromised the financial health and physical condition of urban and rural water supply networks. Combined with weak demand management policies, the resulting budgetary burden is making it difficult to raise financial resources needed to meet the growing demand. Another key motive for water reform is the intensifying competition among domestic, agricultural, industrial, and environmental uses. These concerns are worthy of careful examination by Arab decision-makers, who should articulate appropriate policy frameworks to guide a strident water reform process. A business-as-usual scenario threatens to lead to more waste in water allocation and delay the necessary reforms urgently needed to ensure availability of clean water and sanitation to millions in the Arab world who have been deprived because of poorly targeted investments in the water sector.

Arab countries should support the formulation and implementation of policies enforcing water demand management. While the importance of the supply side cannot be overstated, the effectiveness of demand management is now universally accepted, particularly where water is scarce and unnecessarily wasted. Ensuring the efficient use of available supply may yield significant benefits and may often prove to be more cost-effective than traditional supply management measures. Efficient demand management is often less capital-intensive and, therefore, more cost effective, but it is also better adapted for addressing ‘emergency’ situations. Better demand management reduces waste and unaccounted for water, improves leakage control, and enhances the quality and reliability of water services. Key measures for promoting demand management include regulations and more efficient technology for water delivery and agricultural production systems. Additional investment may be needed to ensure that benefits can be obtained from increasing water use efficiency. Such investment is needed to modernize existing irrigation production and delivery systems. The effects of raising public awareness and inducing behavioral changes through financial incentives along with the use of metering and volumetric water pricing cannot be underestimated.

One of the most critical demand management issues is water re-allocation. This requires that effective policy guidelines be developed to improve the performance of the farming sector, by far the largest consumer of water. Arab governments should increase investments to upgrade traditional irrigation systems through the adoption of modern water delivery technology. Such a technology will improve productivity of water (drop per drop or cash return per unit of water delivered), and could increase diversification and commercialization of agriculture. This shift should be gradual, should involve the beneficiaries, and should be selective in converting traditional systems into high performing delivery networks.

A more aggressive water allocation policy, based on the concept of integrated water resources management (IWRM), could be coordinated with land use policies to regulate unwanted growth in already crowded urban centers. Incentives in water allocation can be used to encourage local industries and housing projects to target poor regions, where they can create jobs and economic opportunities. This is much preferable to investing in large water conveyance projects designed to transport water over long distances to growing cities.

The stressed condition of the water sector in many Arab countries requires a new breed of managers, better able to address a different host of challenges from season to season, such as better management of drought and scarce seasonal supplies. A new class of water managers should also be able to address flooding threats, natural disasters, deterioration in water quality, as well as questions pertaining to shared water resources. National strategic goals for the water sector should be articulated including making shifts in water allocation among sectors, introducing new pricing policies, drafting new rules and regulations to address groundwater abstraction, and designing plans to clean public water ways from industrial waste and pollution. Therefore, visionary management is crucial for articulating these policy and investment plans for sustaining the resource base as well as for managing the long-term implementation of these plans adaptively. These functions are complex and interrelated and require regular upgrading of staff skills and the recruitment of new types of expertise. The organizational structure of many public water agencies has traditionally been heavily dominated by experts in water infrastructure, who believe that most water problems can be solved by building yet more infrastructure water projects. It is difficult to expect that public water agencies that adhere to traditional approaches in staffing and water management to be able to lead this sector as it faces mounting challenges that are multi-dimensional and multi-disciplinary in nature. Therefore, public water agencies in Arab countries should attract a balanced mix of experts who can design, implement, and monitor strategic water plans.

Water governance in Arab countries should be strengthened by building partnerships with beneficiaries and the private sector. Governments should encourage joint investment by the private sector and the community of beneficiaries in modern, timely-controlled, and well-monitored and metered water delivery services. Increased decentralization and empowering water user associations should be promoted in order to devolve responsibilities to manage and operate local services to user communities. In addition, Arab countries should recognize the important goal of reaching the poor and expanding water services to all communities, particularly in rural areas. Priority should be given to expanding water services to vulnerable communities and encouraging local initiatives in building and managing such services.

In the face of such extensive challenges, drastic changes in institutional structures and outcomes subjected to well-defined monitoring indicators are needed. These indicators can be measured at the policy and institutional level. Legal indicators include actions, rules, and regulations approved and enacted as well as measures taken to enhance the capacity of institutions. Other indicators relate to the social impact on affected people including improved delivery of drinking water and associated improvements in quality of life, health, and hygiene. These indicators measure the extent to which water services have been extended to all segments of the population, especially the poor. Other social indicators could be used to measure the extent of ownership and participation among water users. For large water infrastructure projects, it is suggested to include indicators related to the impact on those directly affected by the construction of new facilities such as dams and canals, and the adequacy of compensation for resettlements and relocation of affected communities.

The performance of the water sector could also be measured by employing economic and financial indicators to assess revenue received from costumers for water use, cost recovery, agricultural water productivity, and private sector investments. Other indicators may also be designed to assess the impact of new policies on environmental protection, pollution reduction, and natural habitat and biodiversity restoration in areas affected by the construction of water projects.

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NOTES

1. The 2004 World Development Report “Making Services Work for the Poor” provides detailed analysis as to the reasons behind inadequate services to the poor. It argues that the providers of services are generally more accountable to the policy makers than the clients. Poor clients have no political voice and often have no choice among service providers.
2. Data on public expenditure was not available in a time series for this study. Assessment of expenditure on the water sector is difficult to collect because of the fragmentation of expenditure among various agencies. Also expenditure by farmers and communities is not always updated.
3. A rough methodology has been informally developed by experts in irrigation, and is based on reviewing the cost of O&M of irrigation systems in several developing countries assuming that the cost rehabilitation of irrigation infrastructure is about $150-180 per hectare, and the O&M is $50-60 per hectare. With three million hectares under irrigation, Egypt allocates about $1 billion annually for

O&M and for major rehabilitation works. Data on expenditure on water supply and sanitation is not included in this calculation.

4. The World Development Report for 2004 "Making Services Work for the Poor" devotes a special chapter to drinking water and sanitation.

5. The six GCC countries (United Arab Emirates, Oman, Saudi Arabia, Kuwait, Bahrain, Qatar), Jordan, Libya, Yemen, Algeria, Morocco, Mauritania, Somalia, and the West Bank and Gaza.

6. World Bank regional classification: EAP – East Asia & Pacific (China, Indonesia, Lao PDR, Philippines, Thailand, Vietnam), ECA – Europe & Central Asia (Bosnia and Herzegovina, Kazakhstan, Kyrgyz Republic, Russian Federation, Tajikistan, Turkey, Turkmenistan, Uzbekistan), LAC – Latin America & Caribbean (Bolivia, Brazil, Guatemala, Mexico), MNA – Middle East & North Africa (Arab Republic of Egypt, Islamic Republic of Iran, Morocco, Republic of Yemen), SAS - South Asia (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka), and SSA – Sub-Saharan Africa.

7. Data on cropping intensity are available in the FAO statistics database, (www.fao.org/ag/aquastat). Unfortunately the data are not updated regularly. Cropping intensity in many countries has declined because of water shortages in many irrigation schemes.

8. Different irrigation methods and water delivery systems prevail in the Arab courtiers. The advent of small scale irrigation, especially tube wells and small water pumps, has facilitated the adoption of water saving methods and improved control on water delivery in several countries.

9. The authors provide detailed discussion on the status of water in the Peninsula, and the emerging challenge between current water supplies and the growing demand for water in the countries of the region.