

Water Resources Management Issues and Challenges in the Gulf Cooperation Council Countries: Four Scenarios

Prof. Waleed K Al-Zubari

*Water Resources Management, Vice-Dean, College of Graduate Studies, Arabian Gulf University,
PO Box 26671, Manama, Bahrain, Email: waleed@agu.edu.bh*

Summary

Water is the most valuable resource on Earth. It is an important vector in the socio-economic development and for supporting the ecosystem. In the arid to extremely arid Arabian Peninsula, home of the GCC countries, the importance and value of water is even more pronounced. The GCC countries of United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, and Kuwait, are facing the most severe water shortages in the world. Rainfall scarcity and variability coupled with high evaporation rates have characterized this part of the world with a limited availability of renewable water. However, the scarcity of renewable water resources is not the only distinctive characteristic of the region, inadequate levels of management and the continuous deterioration of its natural water resources have become during the past few decades equally distinguishing features as well.

In the last three decades, rapid population growth and accelerated socio-economic development in the GCC countries were associated with a substantial increase in water demands, which have escalated from less than 5 Billion cubic meter (Bcm) in 1970 to about 30 Bcm in 2000. These demands have been driven mainly by agricultural consumptions (consumes 85% of total water used), and by rapid urban expansion (14%).

To meet rising demands, water authorities have focused their efforts mainly on the development and supply augmentation aspects of water resources management. Demands are being satisfied by the development of groundwater (91%), extensive installation of desalination plants (7%), expansion in wastewater treatment and reuse (2%), in addition to dams construction to collect, store, and utilize runoff. Currently, groundwater resources are being over-exploited to meet mainly agricultural water demands, with continuous deterioration in quantity and quality. In most of the countries, unplanned groundwater mining continues without a clear "exit" strategy. To meet domestic water supply requirement, GCC countries have turned to desalination and have become collectively the world leaders in desalination, with more than 50% of the world capacity. However, desalination remains an important technology, capital intensive and costly, and with negative environmental impacts. In terms of wastewater recycling, available treated wastewaters are still not being reused to their potential; planning for full utilization of treated effluent are in the early stages.

The supply-driven approach for water management has demonstrated its inability to deliver substantial degree of water sustainability or security to the water-stressed GCC countries; despite the strenuous efforts made by these countries, they still face serious water deficits due to the continuously increasing water demands beyond the limits of their available water resources. Indeed, it is questionable if adequate supplies can be sustained in the future without expensive socio-economic and environmental impacts. In fact, the supply augmentation approach coupled with inadequate attention to improving and maximizing the efficiency of water allocation and water use have led to the emergence of a number of unsustainable water uses in these countries, such as low water use efficiency, growing of both water demands and per capita water use, increasing cost of water production and distribution, and deterioration of water quality as well as land productivity. The situation was further aggravated by the lack of comprehensive long-term water policies and strategies that are based on supply-demand considerations, and was further compounded by the institutional weaknesses, multiplication and overlap of water agencies, and inadequate institutional capacity development and enabled participating society.

Fortunately, all the GCC countries have realized that efficient development and management of water resources requires water policy reforms, with emphasis on supply and demand management measures and improvement of the legal and institutional provisions. In essence, appropriate water sector policy

reform need to address the key issues of reliable assessment of water supply and demand, water quality deterioration and protection, water use efficiency and allocation, role of the private sector, pricing policies and cost recovery, groundwater mining, stakeholder participation, improved institutional support, food security and the increasing problem of water scarcity. Water policy reform needs to address these key issues, taking into consideration the specific requirements and the prevailing social, economic, and cultural conditions of the GCC countries.

Furthermore, addressing the immense challenges associated with water resources management in the GCC countries requires daring reforms to existing institutions and policies governing water resources. Far reaching and multi-sectoral approaches will be critical if we are to overcome inefficient use of water resources and make their use sustainable.

However, the most important choices affecting water resources, as well as the environment, in the future are not necessarily water/environment sector choices; achieving water/environmental sustainability relies on a multitude of potential interventions and developments, such as changing governance approach, the education system, the implementation of technological innovations, changing the behavior of people, in addition to many other socio-economic policies. Moreover, water and environmental policies should not be compartmentalized, and they should be integrated and mainstreamed into the national socio-economic development plans.

Four scenarios - termed Markets First, Policy First, Security First, and Sustainability First – are presented in a narrative storyline to the year 2050, and are used to represent the wide spectrum of different policy approaches and societal choices that could be taken by the GCC countries. These scenarios are used to explore how current social, economic and environmental trends may unfold along the divergent development paths in the future and what might this mean for the water/environment, as well as for development and human wellbeing. The most important policy lesson of these scenarios is that investment in human resources development, governance improvement, Investment in R&D to solve societal problems and meeting its needs, GCC countries integration, and GCC cooperation with the Arab countries are key issues in the long, intricate path to sustainability.

Introduction

The GCC¹ countries, situated in an extremely arid zone², have an extremely poor endowment of water resources, and are considered one of the most water stressed countries in the world. These countries' water requirements are met mainly by groundwater (91%) and desalination (7.2%), and to a lesser extent by treated wastewater (Al-Zubari, 2008). The water scarcity in these countries is being aggravated by the high population growth rates, averaging more than 3% per annum³, and considered highest in the world, with its associated water requirements to satisfy the population domestic water needs as well as their food production needs.

Reflecting the rapid population growth witnessed by these countries since the discovery and exploitation of vast oil reserves, the overall per capita freshwater availability fell from about 680 m³ in 1970 to about 180 m³ in 2000⁴. These figures are much lower than the approximate figure of 1,100 m³ for the entire MENA⁵ region (WB, 2003), and much below the general water poverty line⁶ of 1000 m³. Even worse,

¹ The Gulf Cooperation Council countries are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates.

² The region is mostly desert with the exception of narrow coastal areas and mountain ranges; average annual rainfall ranges from 70 to 130 mm except in the coastal zone along the Red Sea in south-western Saudi Arabia and along the Gulf of Oman on the eastern shore (rainfall reaches more than 500 mm). On the other hand, the total annual evaporation rate ranges from 2,500 to more than 4,500 mm (Al-Alawi and Abdulrazzak 1994), making it impossible for a perennial surface system water to exist.

³ Bahrain= 2.0, Kuwait=3.2, Oman=2.4, Qatar=2.7, Saudi Arabia=2.7, and United Arab Emirates=5.5%/annum.

⁴ Bahrain=164, Kuwait=73, Oman=373, Qatar=85, Saudi Arabia=186, and United Arab Emirates=59 m³/y/capita; per capita water share of total traditional and non-traditional (desalination and wastewater) is 284 m³/y/capita, representing these countries efforts in augmenting their water supply by non-traditional water resources.

⁵ MENA = Middle East and North Africa.

based on the projected population increase to about 56 million in 2030, per capita freshwater availability of these countries could fall by nearly one-half to about 94 m³ (AGFUND/WB, 2005).

In the last four decades, the GCC countries have experienced an accelerated development growth due to the sudden increase in these countries oil revenues, which have led to a fast increase in their economic base and rapid improvement in the standard of living⁷. The total population has increased from about 8 million in 1970 to about 30 million in 2000 (AGFUND/WB, 2005). In addition to the marked improvement in the standard of living and health, the large increase in the population was also due to the influx of a large number of expatriates in order to meet the fast-growing development demand for manpower; latest figures on expatriate population in the GCC countries range from 25% (Oman) to 90% (UAE).

The rapid increase in population, along with social, agricultural, and industrial development, was associated with substantial increase in water demands, placing great pressures on the region's limited water resources. GCC total annual water demands have increased from 6 Billion cubic meters (Bcm) in 1980 (Al-Alawi and Abdulrazzak, 1994) to about 28 Bcm in 2000 (AGFUND/WB, 2005).

To meet rising demands, water authorities have focused their efforts mainly on the development and supply augmentation aspects of water resources management, represented by development of groundwater, extensive installation of desalination plants, and expansion in wastewater treatment and reuse. However, this approach, i.e., supply-driven, for water management has demonstrated its inability to deliver substantial degree of water sustainability or security to these water-stressed countries; despite the strenuous efforts made by these countries, they still face serious water deficits due to the continuously increasing water demands beyond the limits of their available water resources. Indeed, it is questionable if adequate supplies can be sustained in the future without expensive socio-economic and environmental impacts. If current population growth rates and water use practices and patterns continue, water will become an increasingly scarce commodity, and would become a limiting factor for further social, agricultural and industrial development in the GCC countries, unless major review and shifts in the current policies of population and adopted food self-sufficiency are made, and an appropriate and drastic measures in water conservation are implemented.

Water Resources and Water Uses

The GCC dramatic increase in water demands is attributed to two sectors, the agricultural sector (85% of total water demands) and the municipal sector (13%) (Al-Zubari, 2003). In the past three decades, the need felt for food security, or food self-sufficiency in certain items, for the fast growing population have prompted decision-makers in these countries to encourage agriculture. Food security/self-sufficiency became a major economic goal and it is used to justify the expansion of certain grains and crops characterized as water-intensive. In most of the countries, this was made through subsidy and incentive programs⁸, and has resulted in a large-scale expansion of farming activities with substantial water requirements, satisfied mainly by the utilization of non-renewable groundwater resources. Furthermore, unregulated pumping along with lack of enforcement of rules against unlawful drilling, poor irrigation practices (irrigation efficiency 30-50%), and absence of agricultural water tariffs have resulted in substantially excessive agricultural consumption (Al-Zubari, 2003).

⁶ Water Stress Indicator: Water availability of more than 1,700m³/capita/year is defined as the threshold above which water shortage occurs only irregularly or locally. Below this level, water scarcity arises in different levels of severity. Below 1,700m³/capita/year water stress appears regularly, below 1,000m³/capita/year water scarcity is a limitation to economic development and human health and well-being, and below 500m³/capita/year water availability is a main constraint to life (Falkenmark, 1989).

⁷ Life expectancy increased by about 10 years to 74 years during 1980-2000 and literacy rates increased from 20% to about 80% over the same period. Average per capita income of the GCC countries was estimated at about US\$ 12,000 in 2002 with their combined nominal GDP reaching close to US\$ 340 billion (AGFUND/WB, 2005).

⁸ Subsidized prices of gasoline and electricity, subsidized credit for buying water pumps and irrigation equipment, exemptions of tariffs on imported fertilizers and equipment, subsidized prices of certain agricultural products, protection against foreign competition in the domestic markets, are all examples of the tools used to implement these agricultural-based economic policies. It is obvious that none of these policies have been subject to serious assessment in terms of their impact on the sustainability of groundwater resources (Al-Zubari, 2003).

Groundwater resources in the GCC countries are divided into types, renewable shallow and non-renewable deep aquifers. Shallow aquifers are developed in the alluvial deposits along the main wadi channels and the flood plains of drainage basins, and represent the only renewable water source in the GCC countries, with an estimated annual recharge of about 3.5 Bcm (Al-Alawi and Abdulrazzak 1994). The GCC countries possess limited large deep aquifers, which contain non-renewable supplies of fossil water, but have a finite life and quality limitations. Only Saudi Arabia possesses substantial amounts of non-renewable groundwater in deep aquifers amounting to about 430 Bcm (WB, 2003). However, these are being mined extensively to meet mainly the increasing agricultural demands and are rapidly depleting; it is estimated that about 35% of non-renewable groundwater resources in Saudi Arabia were already depleted by 1995 (Al-Turbak, 2003).

Over-exploitation of groundwater resources, both shallow and deep, has resulted in continuous and sharp decline in groundwater levels and severe quality deterioration in all the countries⁹ due to seawater intrusion and connate waters encroachment (UNESCWA 1999; FAO 1997). In addition to their over-exploitation and quality deterioration, groundwater resources in the region are being threatened and polluted by numerous point and non-point sources of pollution generated from anthropogenic (agricultural, industrial, and domestic) activities (Al-Zubari, 2002).

Although agriculture is the largest user of water in the region, rapid urbanization and improved quality of life in terms of health, sanitation and social services have resulted in a sharp increase in water demand for municipal purposes. A significant portion of oil revenues has been used to modernize infrastructure and improve the living standards of the population¹⁰, with water supply and sanitation services have been made accessible to a large percentage of the population; percentage of population with access to safe drinking water supply reaches almost 100%, while the percentage of population with access to improved sanitation is between 75% to almost 100% in the GCC countries (ESCWA, 2007). However, municipal/domestic water demands have been escalating at rates that the allocated available water resources (represented mainly by desalination) cannot keep pace with. These needs are exaggerated by the lack of effective conservation programs, inadequate tariffs and charges for water use, and excessive leakage from municipal supply networks, leading to high per capita water consumption rates in the domestic sector.

Desalination technology was introduced in the region in the mid-fifties and has developed very rapidly to counteract the shortage and quality deterioration in groundwater resources and to meet quality requirements for drinking/domestic water standards. At present, municipal water supplies in the GCC countries rely mainly on desalination plants produced water, which are used either directly or blended with groundwater. The current and under-construction total capacity of desalination plants in the region is more than 3.4 Bcm/y, with a share¹¹ of more than 56% of drinking water supply (AGFUND/WB, 2005).

Multi-Stage-Flash (MSF) technology used for seawater desalination dominates the desalination industry in the GCC countries with a market share of about 78%, followed by reverse osmosis (RO) technology used for brackish water at a share of 16% (IDA 2000). MSF technology has been the most economically and financially viable. MSF plants are usually operated as co-generation units in conjunction with power plants. Recently, the Reverse Osmosis (RO) process has also been considered as cost reduction, improvements in reliability and membrane technologies and advancement in the energy recovery made it strongly competitive. The region has witnessed a sharp rate of increase in the RO seawater desalination capacity.

⁹ Al-Mahmood, 1987; Al-Zubari, 1999; Sayid and Al-Ruwaih, 1995; Al-Murad, 1994; Rizk *et al.*, 1997; Al-Asam and Wagner, 1997; Macumber *et al.*, 1997; Abdulrahman, 2000.

¹⁰ In the GCC countries, oil revenues account for about a third of total GDP and three-fourths of annual government revenues and exports. Given that oil revenues flow entirely to national treasuries, government services in all GCC countries are provided free or at highly subsidized prices to the national population. Moreover, given the high oil revenues, government revenue from direct and indirect taxes is negligible. Public and utility services, including energy and water, account for more than 20 percent of national expenditure (AGFUND/WB, 2005).

¹¹ Bahrain=66%, Kuwait=90%, Oman=33%, Qatar=100%, Saudi Arabia=41%, UAE=81%.

Treated municipal wastewater treatment in the GCC countries constitutes an increasing water source driven by escalating water consumption in urban areas. These waters have become available in the early eighties in most of the GCC countries due to the completion of sewage water treatment facilities and urban sewage networks in most of the large cities. Almost all of the countries are operating modern treatment facilities with tertiary and advanced treatment capabilities. In 2000, the treated wastewater in the GCC represented about 20%¹² of the total municipal water volumes (845 Mcm of a total of 4.2 Bcm; AGFUND/WB, 2005), posing the problem of wastewater discharge and its associated health hazards caused by the pollution of shallow aquifer, coastlines, and the marine environment, in addition to its contribution to the problem of water table rise in urban areas, e.g., Riyadh, Doha, and Kuwait Cities (UNEP, 2003). Furthermore, reused treated wastewater do not exceed 12% of the available domestic water supply volumes, and about 60% of treated wastewater. Treated wastewater are used mainly for urban uses (irrigating gardens, parks, and road ornamentals), fodder crops irrigation, and highway landscaping (Al-Zubari 1997), which does not give these waters their economical value under the present water shortage conditions in the region. The remainder is dumped at wadis to infiltrate the shallow aquifers or to the sea. However, all of the GCC countries have ambitious plans for the expansion in the utilization of reclaimed wastewater as a strategically alternative source to meet their future demands of irrigation water and to reduce groundwater abstraction for agricultural purposes (Al-Zubari 1997).

Main Issues and Challenges in Water Resource Management

Currently, the GCC countries are suffering from a huge deficit in their water resources reaching more than 19 Bcm¹³, being met mainly by an intensive over-drafting of renewable and non-renewable groundwater resources for the agricultural sector, and by the extensive installation of highly expensive desalination plants for the municipal sector, and by reusing a small percentage of treated wastewater in the agricultural and municipal sector. Furthermore, Conflict between the agricultural and domestic sectors on the limited water resources in the region are rising, and as a result, groundwater over-exploitation and mining is expected to continue in order to meet growing demand in these two sectors.

If current population growth rates, water management approach, water use practices and patterns continue, annual water demand may reach more than 50 Bcm by the year 2030 (Al-Zubari, 2003). With the anticipated future limited desalination capacity and wastewater reuse, this demand will have to be met mainly by further mining of groundwater reserves, with its negative impacts of fast depletion and loss of aquifer reserves and the deterioration of water quality and salinization of agricultural lands, of which these resources usefulness is questionable with the expected deterioration of their quality. Under these circumstances, water will become an increasingly scarce commodity, and would become a limiting factor for further social, agricultural and industrial development, unless major review and shifts in the current policies of population and adopted food self-sufficiency are made, and an appropriate and drastic measures in water conservation are implemented.

A diagnosis of the water sector in the GCC countries (Al-Zubari, 2003) indicated that the main problems and critical issues in these countries are: 1) limitation of water resources and increasing water scarcity with time due to prevailing aridity, fast population growth, and agricultural policies; 2) inefficient water use in the agriculture (traditional irrigation practices), and municipal/domestic sectors (high per capita water use, high rates of unaccounted-for-water); 3) rising internal water allocation conflicts between the agricultural and municipal sector; 4) rapid depletion and groundwater quality deterioration due to their over-exploitation, with multiple impacts on agricultural productivity and ecosystems; 5) inferior quality of water services in large cities due to fast pace of urbanization; and 6) weak water institutions due to fragmentation of water authorities and lack of coordination and inadequate capacity development.

Currently, there are two main challenges of water resources management in the GCC countries. These are the unsustainable use of groundwater resources with its ramification on these countries socio-economic development, and the escalating urban water demands and its heavy burden on their national budget and negative impacts on the environment.

¹² Bahrain=21%, Kuwait=56%, Oman=7%, Qatar=33%, Saudi Arabia=10%, UAE=32%.

¹³ Bahrain=85, Kuwait=335, Oman=340, Qatar=220, Saudi Arabia=15,830, UAE=2,483 Mcm.

As the quality of groundwater deteriorates, either by over-exploitation or direct pollution, its uses diminishes, thereby reducing groundwater supplies, increasing water shortages, and intensifying the problem of water scarcity in these countries. It is expected that the loss of groundwater resources will have dire consequences on the countries' socio-economic development, increases health risks, and damages their environment and fragile ecosystem regimes. Moreover, the development of many GCC countries is relying heavily on non-renewable fossil groundwater, and the issue of "sustainability" of non-renewable resources is problematic, and requires clear definition. Sustainability of these resources need to be interpreted in a socio-economic rather than a physical context, implying that full considerations must be given not only to the immediate benefits and gains, but also to the "negative impacts" of development and to the question of "what comes after?" An "exit strategies" need to be identified, developed, and implemented by the time that the aquifer is seriously depleted. An exit strategy scenario must include balanced socio-economic choices on the use of aquifer storage reserves and on the transition to a subsequent less water-dependent economy, and the replacement water resource.

Despite their relatively enormous cost and heavy burden on the national budget¹⁴, limited operational life (15-25 years), their dependence on depleting fossil fuel, and their negative environmental impacts on the surrounding air and marine environment¹⁵, the GCC countries are going ahead with desalination plant construction and expansion in order to meet the spiralling domestic water demands - a function of population and urbanization growth. The rapid increase in urban water demands in the GCC can be explained by two factors, rapid population growth and the rise in per capita consumption; per capita average daily consumption in the domestic sector ranges between 300-750 liters, which ranks the highest in the world. This is due mainly to the reliance on the supply side of management with little attention given to the demand management and the non-existence of price-signaling mechanism¹⁶ to consumers. Furthermore, despite the lack of hard data on the unaccounted-for-water in most of the countries, estimates of leakage levels from water distribution networks in some countries are considered high, ranging between 20-40 percent, which is at odds with the high cost incurred in producing desalinated water which varies between US\$ 1.0-2.0 per cubic meter (AGFUND/WB, 2005).

The other strategic issue is that, despite the current and anticipated future dependence of the GCC countries on desalination to meet its domestic/drinking water supply, desalination remains an imported technology for the GCC countries with limited directed R&D towards these technology. Furthermore, desalination industry have limited added value to the GCC countries economies (e.g., localizing O&M, plant refurbishment, fabrication, manufacturing of Key Spare Parts, qualifying local labor to work in desalination industry, etc..).

Future Scenarios

While policies and management interventions undertaken by the water authorities in the GCC countries have a role in alleviating the water situation, the most important choices affecting the water sector in the future are not necessarily water sector choices; achieving water sustainability relies on the adopted development paradigm, and a multitude of potential interventions and developments, such as changing governance approach, the education system, the implementation of technological innovations, changing the behavior of people, in addition to many other socio-economic policies. Moreover, water policies should

¹⁴ While the financial cost of desalinated seawater from recently completed large plants has been decreasing to around US\$ 0.70 per cubic meter (without distribution costs and depending mainly on plant size, duration of amortization and energy costs) in the US and other places, the average water production costs in GCC countries remain somewhere between US\$ 1-2 per cubic meter (AGFUND/WB, 2005). More importantly, the investment needs for constructing new desalination plants to supply water for rapidly growing population and high per capita consumption are enormous. It is estimated that the total cost of desalination plants installed in the GCC up to the year 2003 is US\$ 21 billion (IDA, 2000).

¹⁵ All desalination plants have some negative impacts on the surrounding environment. These include air pollution by emitted oxides and seawater and marine life pollution by rejected brines, which have elevated temperatures, increased salt concentration and may contain residual treatment chemicals and trace element picked up within the desalination plant (Abderrahman and Hussain, 2006).

¹⁶ Water tariffs are generally quite low, representing on the average no more than 10 percent of cost, which implies that no incentives exist under current policies for consumers to save water.

not be compartmentalized, and they should be integrated and mainstreamed into the national socio-economic development plans.

Four scenarios, termed **Markets First, Policy First, Security First, and Sustainability First**¹⁷, are presented in a narrative storyline to the year 2050, and are used to represent the wide spectrum of different policy approaches and societal choices that could be taken by the GCC countries. These scenarios are used to explore how current social, economic and environmental trends may unfold along the divergent development paths in the future and what might this mean for the water/environment sector, as well as for development and human wellbeing. It should be noted that these developed scenarios are not predictions, nor should they be taken as the most likely of possible futures. At most, they portray pictures of limited number of plausible futures based upon a certain set of assumptions about driving forces, critical uncertainties, and system relationships. These include governance, demography, human development, economic development, science and technology, culture, and regional integration. Their rationale is not to indicate what will, but rather what might, happen if certain choices are made. Their purpose is to assist in thinking more carefully about how it might be possible to encourage or counteract particular events and trends.

The fundamental assumptions defining the scenarios focus on who is making the key decisions, i.e., the dominant actors; how these decisions are made, i.e. the dominant approaches to governance; and why certain decisions are made, i.e. the dominant priorities. The assumptions about these in each of the scenarios are summarized in brief in Annex A, while Annex B gives a general brief description of the nature and assumptions of the four scenarios in GEO-4 (UNEP, 2007).

The scenarios presented here are used to try to answer the following main question: Under the current fast pace of socio-economic development and prevailing water scarcity, could the GCC countries achieve sustainable water resources development, where socio-economic development and water environmental protection are balanced; **If yes, how? and if not, why?** Other more specific questions these scenarios are trying to address and explore are: Under the current socio-economic development policies, what are the impacts on human wellbeing and environmental/water consequences? Under these conditions, is it possible to avoid environmental negative impacts or mitigate them? What are the compromises/tradeoffs involved? Can water and other natural and environmental resources continue to be exploited to increase economic development and human welfare without victimizing these resources? what are the environmental, economic, and social costs that would result from this exploitation on the long term?

Market First Scenario

Under this scenario, development in the GCC countries is dominated by market forces and market mechanisms (demand and supply for goods and services); "economic growth/development at any cost" dominates. Exploitation of natural resources, provision of inexpensive labor, mass production and manufacturing efficiency are seen as the formula for lowering price and competition in the regional and global markets. Economic development through better technology and management is prioritized, while social problems and environmental stresses are left to the self-correcting logic of competitive markets. In the field of human development, the assumption that economic growth will naturally lead to improvement in social conditions prevails, meaning that investment in education, capacity development, and health must compete against other possibilities that might offer more immediate returns. GCC society adopts and gradually converges to the values and expectations prevailing today in industrialized societies (materialism, individualism, and consumerism). Private sector investment and marketing initiatives play the main role in moving the wheel of the economy, while government officials and legislators are increasingly put under pressure to minimize intervening in free market mechanism and so facilitate self-regulation (e.g., oil & gas sector self-regulation). The economic base will be expanded with less dependence on oil revenues and diversification in industrialization and services sector. While these countries witness positive socio-economic trends, natural and environmental resources depletion, environmental degradation, and health risks increase.

¹⁷ The framework of these scenarios is based mainly on UNEP's Global Environmental Outlook process, namely GEO-4 (UNEP, 2007). They represent four archetypical visions of the future and trace their roots back to GEO-3 and earlier global scenario exercises (UNEP/RIVM, 2004; Raskin *et al.*, 2002).

The scenario assumes fast transformation of the state role from a service provider to service enabler and regulator. Privatization is perceived to be the solution to lower government economic burden, eradicate corruption, attract investments, increase services efficiency, and enhance cost recovery. Privatization will accelerate and will include vital sectors such as water (i.e., desalination & wastewater) and energy sectors. In general, this will have a positive impact on resources use efficiency and the overall performance of water services. However, the regulatory capacity of the governments would not cope with these rapid developments (inadequate monitoring and regulatory capacity); to attract investments, environmental aspects receive low priority and are relaxed to investors with minimal interventions from governments.

Water stress in the GCC countries will continue to increase due to the rapid population growth rates¹⁸ and the limitation of renewable water resources and non-conventional water resources. Per capita available water share will continue to decrease and will remain under the absolute water scarcity line, as water demand rates will by far exceed the anticipated water resources development rates (desalination and reuse of treated wastewater). Water demands, particularly by the agricultural sector will continue to exceed available groundwater replenishment rates. Over-exploitation and intensive use of agrochemicals will lead to degradation of groundwater quality, exacerbating water scarcity, increasing land degradation, reducing food production and increasing water-related health problems. Sectoral competition, mainly between the agricultural and domestic/industrial sectors (due to rapid urbanization and industrialization) increases, with more water diverted to the latter sectors. As water scarcity increases, water will become increasingly an expensive commodity; the use of non-conventional water resources (desalination & treated wastewater) will increase to meet the escalating demands. R&D in desalination and water treatment will advance with time, driven mainly by the multinational private sector, leading to reduction in the unit cost of desalination and treatment (as current trends indicate). However, despite GCC almost complete dependence on these technologies in providing their domestic water supply, and their ownership of more than 45% of the world desalination capacity, they will continue to be an importer of these technologies and will not be able to acquire and localize them, due to their low investment in these technologies¹⁹.

Desalination (dual production of water and electricity) will continue to depend on fossil fuel²⁰, and with the increase of desalinated water production to meet escalating domestic demands, it will continue to be associated with environmental problems such as air and marine pollution²¹. However, it is anticipated that many steps will be taken to control pollution from these plants to alleviate air pollution (e.g., NOx burners) and to reduce thermal, brine, and chemical pollution to the coastal and marine environment. Furthermore, rapid population and economic growth will lead to rapid, unplanned/planned urbanization, and fast increases in domestic water demands as well as large amounts of wastewater. Despite GCC efforts in increasing their desalination capacity, the rate of increase in water demands will bypass these efforts. Moreover, sanitation services will be lagging far behind water supply services, leading to raw wastewater discharge to shallow aquifers and the marine environment.

As oil continues to dominate the world energy, as well as the region energy sector, GCC exports of oil are expected to increase²², higher risks of oil spills from offshore extraction and transportation, hydrocarbon

¹⁸ Due to failure of government population policies and substitution programs to control foreign labor force to meet rapid economic growth requirements.

¹⁹ This is a regional problem and has the dimension of regional cooperation in R&D in the field of desalination; GCC countries efforts to coordinate research in desalination has failed and these ambitions are currently stopped.

²⁰ however, currently there is a complete shift towards the relatively cleaner gas.

²¹ use of clean renewable energies, such as solar and wind, abundant in the region, will be very limited and their share in the region energy sector will continue to be marginal.

²² The GCC countries hold together about 45% of the world's proven oil reserves, 25% of crude oil exports and at least 17% of liquefied natural gas. Thus oil and gas exports are expected to increase with time as other producers will go out of the market; region reserves are estimated from 50-100 years.

concentrations in the Arabian Gulf²³, which is expected to impact desalinated water production and posing human health risk.

As food demand increases (due to population growth as well as change in consumption patterns), it will lead to further water resources over-exploitation and salinization, land over-cultivation and rangeland over-grazing. Over-cultivation under the conditions of deteriorating irrigation water quality and soil salinization will lead to land degradation and loss, and eventually more desertification. As a consequence, there will be an intensive use of agrochemicals (fertilizers, pesticides, etc.) as well as over-irrigation (to wash soils from salts) to increase productivity, leading to more groundwater pollution and quality deterioration and water logging and soil salinization (typical farmers vicious cycle). Under these deteriorating conditions and the lack of 'regional' strategic food production and management, policies of food security/self-sufficiency in some basic food items will fail. Market forces will lead to the gradual expansion of non-traditional agriculture (e.g., protected and soil-less agriculture), as well as the importation of genetically modified crops (GMOs; drought and salt tolerant crops), which is expected to increase agricultural productivity. However, their introduction will be made with little concern for minimizing its potential health and environmental impacts.

In general, this represents a depressing scenario for the water/environment in the GCC countries. The countries will be facing considerable water and environmental problems, and the situation will deteriorate. This is mainly due to the concentration on economic development while giving little attention to environmental aspects, where investment policies over-ride environmental policies (weak environmental governance and institutions, particularly weak enabling environment: institutions, policies, and legislation/enforcement). Water/environment will have least priority and will be overridden by investment and maximum economic development policies.

Policy First Scenario

Strong actions are undertaken by the GCC countries' governments in an attempt to reach specific social and environmental goals. The countries place strong policy constraints on market forces in order to minimize their undesirable effects on human and environment. Environmental and social costs are factored into policy measures, regulatory frameworks and planning processes. Required laws and legislation for the protection of the human health and the environment, and the enhancement of resources sustainability are formulated and implemented. The private sector is brought on board to contribute in investment and economic development by PPP and a set of incentives, and with strong regulatory body and regulations. This scenario envisages that constitutional democratization, public representation and voting, auditing and transparency, etc., will be gradually institutionalized in the GCC countries. Civil society empowerment will gradually advance and public participation will have "some" impact upon major decision making²⁴. Health and environmental issues gradually become one of the main concerns of the civil society, enhancing and strengthening the role of environmental authorities/institutions in the decision making process at the national level (i.e., an alliance is gradually formed between environmental authorities and environmental NGOs, and other related associations). At the regional level, there will be greater regional harmony and cooperation at the level of ministerial forums and organizations (e.g., GCC Secretariat, ROPME, CAMRE, ...). Furthermore, there will be more integration in the GCC block (in infrastructures of transportation, energy, water, and human resources, etc.). This will result in the emergence of a strong diversified economic block that takes into account each member country comparative advantage, at the end of this scenario.

Population growth will be slowed down compared to that at the turn of the century (less than the Market First scenario, but still high!). This will occur due to many factors²⁵, but mainly due to effective national population policies that aim at controlling and reducing foreign migration and their planned substitution by

²³ The Arabian Gulf is the oil tankers highway, 60% of total oil exports to the world navigate through the straight of Hormuz annually, it is estimated by ROPME that about 1.2 million barrel of oil is spilled in the Arabian Gulf from ballast water only!

²⁴ As compared to participation in the decision making process in sustainability scenario

²⁵ General increase in the education level, women education and entry into employment market.

nationals²⁶. Substitution programs are made possible by heavy investment in nationals training and capacity development programs.

The reduction of the population growth rate, in addition to the adoption of strategic water resources management to increase water use efficiency and resources protection will further alleviate the water stress in the region. Water moves gradually to the top of the national agenda priority list, and a policy shift from supply augmentation towards demand management and conservation is made. GCC countries implement different instruments and programs that include water pricing with targeted subsidies, awareness and education campaigns, legislation enforcement, management of marginal water, and efficient water resources allocations among the competing economic sectors.

However, water demands will continue to exceed available water resources, and depletion and degradation of groundwater quality continue (but at lesser rates than the Market First scenario), with its negative impacts on land and food production. The need for non-conventional water resources (desalination and treatment) will continue to increase to meet increasing water demands. Treated wastewater reuse will be increasing significantly. In this scenario, there will be more regionally coordinated and directed research on non-conventional water technologies aiming at their localizing in the region. The unit cost of desalination and treatment will continue to decrease with time, as a general global trend. The hope is that this coordinated regional research will eventually make major breakthrough in freshwater production, increase freshwater resources, and significantly modify per capita freshwater share in the domestic sector in the region. The use of clean renewable energies, particularly solar and wind, will be increasing. However, their share in the region energy sector will continue to be marginal. Thus there are concerns that this achievement will be associated with environmental problems such as air and marine pollution, as fossil fuel will continue to be the dominant form of energy.

Urbanization trends in GCC countries continue to increase, but they will be at lesser rates than the market first scenario due to the reduction in population growth rate and the adoption of integrated urban planning methodologies. However water supply and wastewater services and capacity continue to lag behind urbanization rate, and environmental problems persist.

Food demand increases at slower rates than in the Market First scenario, and GCC countries adopt strategic food demand management that takes into account the available resources capacity and their sustainability. Food demand management addresses increases in food needs taking into account water and land use and eliminating over-exploitation of resources. In addition, heavy national/regional investments in research and development in improved farming practices and soil management are made. These efforts help reduce or stabilize environmental degradation, increase the levels of food security/self-sufficiency. Import of genetically modified crops continues as in Market First scenario, but with better consideration of the potential negative impacts, and the effective implementation of "Cartgena Protocol of Biosafety". Furthermore, economic integration and regional cooperation among the GCC countries as well as between the Arab countries help modify agricultural policies of maximum food production/food security in the region and reduce water consumption by the agriculture sector.

This scenario envisions an improvement of human well-being and decrease of environmental degradation due to assigning higher priority to human resources development, health and environment protection than the market forces scenario. However, great pressures will continue to be exerted on the environment by investment and economic development policies. Furthermore, the governance approach in this scenario, in addition to its top-down approach, suffers from being a reactive rather than proactive and is slow to respond to change.

Security First Scenario

Under this scenario, the current instability in the region is intensified²⁷, contributing to stalling of human and economic developments and crippling any progress towards regional economic integration. Political conflicts and tensions, occupation, superpowers interventions, sanctions, lack of economic and political

²⁶ The assumption is that these programs are already going on now and they will be accelerated.

²⁷ i.e., Israeli-Palestinian conflict, US occupation of Iraq, Israel/US-Iran tension

reforms, and social inequity prevails in the region. A world full of contradictions and security obsessions, dominated by social inequality and conflicts at the national and regional level prevails in the region. Social and economic ethics, and moral values deteriorates, and represents a minority of elites living in protected enclaves and safeguarding their privileges by controlling the majority and managing critical natural resources. Constitutional democratization, transparency, accountability, and public participation are absent, with the military and security establishments controlling the state. The GCC governments appropriate large amounts of their budgets to armaments/security on the expense of social, economical development and environmental protection. Under these conditions, the level of corruption increases, leading along with instability to the outward movement of national and foreign investments, resulting in the increase of unemployment levels, the decline of human development indices to their lowest levels, and widening the division between the poor and the rich. As a result, societal groups cluster around tribal/ethnic/religious lines instead of the state, leading to the disintegration of the social fabric in the GCC countries.

The region witnesses high levels of internal instability. Foreign pressure and interest in the strategic resources of the region sets the ground for further destabilization, plunging the region into deep economic-social disparities and political turmoil, leading to authoritarian solutions of a minority of affluent. The fragmented economies of the GCC countries are merged into the major economic blocks and superpower domains of the world, resulting in external hegemony, domination, and subordination of the region. The GCC countries are continuously pulled into regional conflicts leading to an escalating increase in the share of their military/security expenditures, adversely affecting the economy and human resources development. Natural resources and the environment receive the lowest priority in the national agenda, and continuously victimized to meet security needs.

This scenario assumes high population growth rates in the GCC countries (greater than the Market First scenario), leading to increasing water stress. The situation is further exacerbated by the lack of proactive strategic water resources planning and management, leading to significant deterioration of water quality, increasing competition and conflicts between sectors, accelerating land deterioration and desertification, and reducing food production and water-related health problems. Water scarcity reaches its highest levels; groundwater resources are depleted and unfit for direct use. Wastewater reuse is stepped up to compensate for agricultural water demands, but without adherence to treatment standards, leading to major outbreaks of water-related diseases. R&D in non-conventional water resources is negligible. Desalination is intensified to meet domestic water demand, and continued to depend on fossil fuel with little concern of its environmental impacts. The management of water resources and services are "auctioned" to multinational companies, particularly those having business ties with the military establishment and ruling elites. As higher taxation is required to finance governments' budget deficits and security and military needs, subsidies are removed, leading to inequitable access to water resources and basic services.

Unplanned random urbanization will occur due to rapid population growth, with concentrated urban centers surrounded by mushrooming insalubrious slums and low living standards. There will be uneven distribution of public services between the rich and poor areas. Water supply and sanitation services will be at their highest levels in elites and affluent urban sections, while these services will be at their lowest levels in other urban sections causing major environmental and health consequences in these sections. Furthermore, in these sections, insufficient basic health care and sanitation, deteriorating infrastructure facilities, increasing unemployment pressures and crime rate will become the source of social unrest.

Food self-sufficiency is high on the political agenda in the GCC countries as one form of security. Subsidies are offered to encourage local agricultural production leading to immense stresses on water resources and arable lands. Intensive agricultural production under deteriorating irrigation water quality and soil salinization lead eventually to land impoverishment and loss. After a peak in agricultural production, food self-sufficiency starts to decline as land and water resources are mined beyond their sustainable limits.

This scenario, considered as an extreme case of the Market First Scenario, envisions at the end a complete decadence and breakdown of the GCC society along with the Arab world, with humans and

environment victimized to meet security needs. However, after breakdown and complete collapse of the state in most countries, a new generation of young and motivated people will emerge and lead their societies to rebuild and get grasp of its future!

Sustainability First Scenario

This scenario pictures an emergence of a new development paradigm in response to the challenges of sustainability, supported by new, more equitable values and institutions. The notion of human development, rather than material acquisition, is advanced as a form of cultural and social evolution (investment in human capital). A more visionary state of affairs prevails, where proactive solutions to the challenges of sustainability are provided (sustained link between social, economic and environmental policies). This is achieved by the adaptation of long-term integrated strategic planning, with the objective of achieving superior quality of life and healthy environment, and accomplished in the long-term by strong emphasis and heavy investment on human development through educational, training and capacity development programs. The aim is to create a productive knowledge-based society that will allow the removal of traditional government welfare support system that exists now in most of these countries, as well as fulfilling the needs of the GCC countries' economic development. Environmental sustainability is pursued through changing education system and human behavior and attitude towards his surrounding environment and natural resources for long-term viability and success. Furthermore, scientific R&D to solve the society's social, economical and environmental problems is encouraged greatly with significant funds allocations in national budgets. GCC society is gradually transformed into a scientific, information/knowledge-based society. In this scenario, environmental policies aiming at protecting the environment and the sustainable use of resources will decide investment policies, leading eventually to massive use of green technologies. Eco-taxes and polluter pay charges proliferate.

GCC society will adopt the positive features of cultural globalization and industrial societies. Materialism and consumerism, associated with western life style/industrial societies, will be rejected, while professionalism, productivity, awareness, public participation, and commitment towards the environment (environmental citizenship) will be adopted and will infiltrate society to replace some of the existing widespread negative cultural habits and attitudes (e.g., non-compliance, petition system, and wastage). Furthermore, National/regional identity and positive indigenous societal values, such as family/society unity and Islamic spiritual/moral values will be maintained and enhanced.

Under this scenario, GCC society will be a completely democratic society, and civil society empowerment will reach its highest levels, leading to active public participation with major participation in the decision making process on the national and regional levels (balanced relationship and power between government, private sector, and civil society). The present situation of centralization and lack of participation in the governance system (top-down governance as opposed to the grass-roots, bottom-up approach) will be gradually reversed, having a positive impact on the decision-making process, development, and public involvement and participation. Health, environment, and resources sustainability issues will become the main concern of the civil society. As a result, government water/environmental authorities will have stronger impact on the decision-making process at the national and regional levels, leading to favoring environmental policies on economic policies in case of their conflict.

On the regional level, integration between the GCC countries reaches its highest levels, leading to one (Con-)Federal State (replacing Gulf Cooperation Council, say, United States of Arabia!), has the required elements for survival and facing external challenges and threats. This marks the emergence of a strong diversified economic block in the region, with strong economic ties with the Arab world at large (revival of the Arab Free Trade Zone). The regional ministerial forums/organizations will be enhanced and strengthened by this development. Regional environmental policies will be formulated at the regional level by these organizations with full cooperation of the member states and implementation at the national level. The region will be an active partner in setting the global environmental policies.

Under these developments, water stress in the GCC countries has been significantly reduced by the implementation of effective population policies leading to a slowing down/stabilization of population growth, achieving high level of environmental awareness at all level of society, and enhanced by the adoption of IWRM strategies (economic efficiency and environmental sustainability), with strong

emphasize on demand management and conservation. This was made possible by establishing an enabling environment for water resource management through institutional, policy, and legislation reforms. Water now is a national priority.

Strong cooperation between the GCC member countries in non-conventional water technologies is made, where the countries decide to own and localize water desalination and treatment technologies in a specific period of time (say, 15 years), and allocate considerable funds to achieve this goal. These major investments in R&D in these technologies are paralleled with the same in alternative cleaner renewable energies (solar and wind) leading to major breakthrough in desalination and treatment technology without major environmental problems²⁸. The unit cost of desalination may not be reduced significantly (as in Market First scenario), but environmental pollution by desalination plants (represented by air, coastal and marine pollution) is reduced considerably.

Water stress has also been substantially reduced by the abandonment of the old agricultural policies of maximum food production (national food security) due to regional integration and cooperation among the GCC and Arab countries, as well as by the high investment in non-traditional hi-tech agriculture (e.g., soilless culture) to overcome the problem of water and land scarcity. As a result, degradation in the quality of available groundwater resources has been significantly lowered. Furthermore, there will be limited and rational application of biotechnology in the field of food production, with careful and safe handling of genetically modified crops. These efforts, aided by population growth slowing down/stabilization, will lead to a significant modification in water stress, and per capita water share of available water resources is stabilized.

Green cities will be widely spread in the GCC countries, and negative environmental and health impacts associated with urbanization are mitigated through better integrated planning and management, enhanced by population slowing down/stabilization and environmental awareness of the population. The GCC countries ratify and jointly implement relevant MEAs, particularly MARPOL73/78 protocol, establish oil wastes reception facilities, and declare the ROPME Sea Area as a Special Area, resulting in the reduction of marine oil pollution significantly. The global program of action for the protection of the marine environment from land-based activities is also strictly implemented to control sewage releases into the marine environment (polluters pay), significantly reducing sewage releases into the marine environment. This will lead to a considerable reduction of hydrocarbon and other industrial pollution into the marine environment, and minimizing significantly their threat to desalinated water production.

Under this scenario, a balance will be struck between natural and human managed ecosystems in the long-term. These practices will lead to conservation and efficient use of natural resources and sound management of the environment, providing ideal conditions for human well being. Although economic growth will be moderate and less than the market forces and policy reforms scenarios (a trade-off), there will be a considerable improvement in health and environmental welfare, and the cost of pollution on GCC countries' GDP is reduced considerably.

Scenarios Policy Lessons

The most important policy lessons that these scenarios offer to the GCC countries is that investment in human resources development, governance improvement, Investment in R&D to solve societal problems and to meet its needs, GCC countries integration, and cooperation with the Arab countries are key issues in the long, intricate path to sustainability. In the latter, cooperation in the fields of food production and R&D in desalination and water treatment technology would help alleviate the problem of water scarcity in the region.

Relying on the Market alone is unlikely to achieve key environmental and human well-being goals. Although it stimulates needed improvements in resource efficiency and developments of some new technologies, the extreme emphasis on markets and economic growth and technological fixes in the

²⁸ This is made despite the abundance of fossil energy in the region, and its continued dominant share in the world energy market, in fact this will lead to prolonging the life of the fossil fuel reserves in the region, while making a considerable income for the countries of the region.

“Markets First scenario” results in significant increases in environmental pressures and only slow down advances in achieving social targets. Alternatively, the increased levels of investments in human resources development, along with increased integration among the GCC countries in “Policy First” and “Sustainability First” make for significantly faster progress without sacrificing economic development in the region. In “*Sustainability First*”, the improvement of governance and a sustained link between social, economic, and environmental policies provides a solution to the sustainability challenge in the region. Integration, cooperation, and dialogue at the national, regional, and inter-regional levels replace tensions and armed conflicts. In “Security First scenario”, an extreme case of “Markets First”, the prolongation of regional political tensions and conflicts would create a state of security obsession that would lead to sacrificing human well-being, the environment, and natural resources to meet security demands, and would impact negatively the overall development of the region.

References

- Abderrahman, W, and Hussain, T, 2006, Pollution Impacts of Desalination on Ecosystems in the Arabian Peninsula. In: Policy Perspectives for Ecosystem and Water Management in the Arabian Peninsula, Amer, *et al.* (Eds.). UNESCO/UNU-INWEH.
- Abdulrahman, W, 2000, Groundwater Pollution by Irrigated Agriculture: A Case Study. A paper submitted to the EGM on Implications of Groundwater Rehabilitation for Water Resources Protection and Conservation (Beirut, 14-17 November 2000) (E/ESCWA/ENR/2000/WG.3/13).
- AGFUND/World Bank, 2005, A Water Sector Assessment Report on the Countries of the Cooperation Council of the Arab States of the Gulf. World Bank Report No. 32539-MNA, March 31, 2005.
- Al-Alawi, J, and Abdulrazzak, M, 1994, Water in the Arabian Peninsula: problems and perspectives. In Water in the Arab World, Perspectives and Prognoses, Rogers, P, and Lydon, P (eds.), Division of Applied Sciences, Harvard University.
- Al-Asam, M S, and Wagner, W, 1979, Investigations for development of groundwater management strategies in the Eastern Coastal Plain of the United Arab Emirates. The WSTA Third Gulf Water Conference: Towards Efficient Utilization of Water Resources in the Gulf, 8-13 March, 1997, Sultanate of Oman, vol. 1, pp. 329-339.
- Al-Mahmood, M J, 1987, Hydrogeology of Al-Hassa Oasis. MSc Thesis, Geology Department, College of Graduate Studies, KFUPM, Saudi Arabia.
- Al-Murad, M A, 1994, Evaluation of the Kuwait aquifer system and assessment of future wellfields abstraction using a numerical 3D flow model. MSc Thesis, Desert and Arid Zones Sciences Program, School of Graduate Studies, Arabian Gulf university, Bahrain.
- Al-Turbak, A, 2003, Water in the Kingdom of Saudi Arabia: Policies and Challenges, paper presented at the Future Vision of the Saudi Economy symposium organized by the Ministry of Planning.
- Al-Zubari, W K, 1997, Towards the establishment of a total water cycle management and re-use program in the GCC Countries. In Water in the Arabian Peninsula, Problems and Policies, Mahdi K A (ed.), Ithaca Press, pp. 255-273.
- Al-Zubari, W K, 1999, Impacts of groundwater over-exploitation on desertification of soils in Bahrain –A case study (1956-1992), Proceedings of International Conference on “Regional Aquifer Systems in Arid Zones –Managing non-renewable resources”, Tripoli, Libya, 20–24 November 1999, General Water Authority of the Libyan Arab Jamahiriya, IHP-V Technical Documents in Hydrology No. 42, UNESCO, Paris, 2001.
- Al-Zubari, W K, 2000, Guidelines for groundwater protection and pollution control in the GCC countries. UNESCWA EGM on Implication of Groundwater Rehabilitation for Water Resources Protection and Conservation, Beirut, 14-17 November, 2000.
- Al-Zubari, W K, 2003, Alternative Water Policies for the Gulf Cooperation Council Countries. In: Water Resources Perspectives: Evaluation, Management, and Policy, Ed., A.S. Al-Sharhan and W.W. Wood, 2003, pp. 155-167. Elsevier Science, Amsterdam, The Netherlands.
- Al-Zubari, W K, 2008, Integrated Groundwater Resources Management in the GCC Countries- A Review. Proceedings of the WSTA 8th Gulf Water Conference, Bahrain, 2-6 March, 2008. Water Science and Technology Association, Bahrain.
- ESCWA, 1999, Groundwater Quality Control and Conservation in the ESCWA Region. Report No. E/ESCWA/ENR/1999/1, ESCWA, Beirut.
- ESCWA, 2007, ESCWA Water Development Report 2: State of Water Resources in the ESCWA Region. Report E/ESCWA/SDPD/2007/6, ESCWA, Beirut.
- Falkenmark, M, 1989. The massive water scarcity now threatening Africa – Why isn't it being addressed. *Ambio* 18, 112-118.
- FAO, 1997, Irrigation in the Near East in Figures. Water Report No.9, Rome.
- IDA (International Desalination Association), 2000, IDA Worldwide Desalting Plants Inventory CD-PAM2000. Wangnick Consulting.
- Macumber, P G, Niwas, J M, Al-Abadi, A, and Seneviratne, R, 1997, A new isotopic water line for Northern Oman. The WSTA Third Gulf Water Conference: Towards Efficient Utilization of Water Resources in the Gulf, 8-13 March, 1997, Sultanate of Oman, vol. 1, pp. 141-1161.
- Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A., Kates, R. and Swart, R., 2002, Great Transition: The Promise and Lure of the Times Ahead, Boston, Stockholm Environment Institute.

Rizk, Z S, Alsharhan, A S, and Shindu S, 1997, Evaluation of groundwater resources of United Arab Emirates. The WSTA Third Gulf Water Conference: Towards Efficient Utilization of Water Resources in the Gulf, 8-13 March, 1997, Sultanate of Oman, vol. 1, pp. 95-122.

Sayid, S A S, and Al-Ruwaih F, 1995, Relationship among hydraulic characteristics of the Dammam Aquifer and wells in Kuwait. Hydrogeology Journal, vol. 3, pp. 57-70.

UNEP, 2003, Groundwater and its Susceptibility to Degradation, a Global Assessment of the Problems and Options for Management. Report # UNEP/DEWA/RS.03-3.

UNEP, 2007, Global Environmental Outlook (GEO-4). UNEP, Nairobi, Kenya.

UNEP/RIVM, 2004, The GEO-3 Scenarios 2002-2032: Quantification and Analysis of Environmental Impacts. UNEP/DEWA/RS.03-4 and RIVM 402001022.

WB (World Bank), 2003, Kingdom of Saudi Arabia: Assessment of the Current Water Resources Management Situation, Phase I, Vol. I, December 2003.

WB (World Bank), 2003, World Bank Middle East and North Africa (MENA) Regional Water Initiative, Middle East and Mediterranean Regional Day: Moving from Scarcity to Security through Policy Reform, Summary Report, Kyoto, Japan, March 2003.

Annex A

Overview of Drivers, Uncertainties, and Assumptions across the Four Scenarios

Driver and Sub-Driver	Market Forces	Policy Reform	Security	Sustainability
GOVERNANCE				
<i>Dominant actor and power balance</i>	Private sector with strong government support; power more to the private	Government with civil society support; power more to the government	Government and private sector, civil society marginalized	Balanced civil society, government, and private sector, power more to the civil society
<i>Governance approach</i>	Top-down (with emphasis on hierarchical structures)	Top-down (with stakeholders consultation)	authoritarian	Balanced Bottom-up and top-down approaches
<i>Level of public participation priority</i>	Low public participation Maximum economic growth, with presumption that social and environmental concerns will naturally be dealt with	Medium public participation Social development and environmental management and economic development	Zero public participation Security and maintaining privileges of the elite	High public participation Social and environmental welfare with economic sufficiency
<i>Mainstreaming of social & environmental policies</i>	low	medium	Lowest if none	high
ECONOMIC DEVELOPMENT				
<i>Economic growth diversification privatization</i>	Highest High towards services Highest, no control	high High towards services High, with control	lowest Military oriented highest	medium High towards services Medium with control (if government agencies are allowed to operate and work as corporates can achieve the same efficiency as the private sector)
DEMOGRAPHY				
<i>Population growth rate</i>	highest	high	high	Medium/low
<i>Urbanization</i>	High due to population growth rate, random	Medium, more controlled but still exerting pressures on environment	Slums and shanty towns	Well planned, lower or Stabilized in proportion to resources
HUMAN DEVELOPMENT				
<i>Level of investment in education and health</i>	medium	High	Lowest (only in the elite and military circles)	highest
<i>Capacity building and training programs</i>	Medium, left to market demands	High, government are leading the efforts	Lowest as above	Highest, well planned by leading government efforts
<i>Traditional government support system</i>	Medium (decreasing trends)	medium	low	low (population is highly educated and entrepreneurial, do not need help from government)
<i>Environmental awareness</i>	medium	high	lowest	highest
SCIENCE AND TECHNOLOGY				
<i>Level and type of investment</i>	High, but market driven by the private sector, for its own needs and problems, emphasis on profit	High, government and private sector, to solve societal needs and problems as well as making profit	High in the military field	High, government and private sector, to solve mainly societal needs and problems (e.g., desalination technology)
<i>General level of</i>	low	high	lowest	Highest,

technological
progress and
Science
infiltration into
society

CULTURE

<i>Global culture homogenisation</i>	highest	high	low	Wise! Diverse and accepting community
<i>Individualism vs. community focus</i>	individual	More community	More individual	
<i>Indigenous culture and Heritage retention</i>	Eroded with conflicts (religious retreat)	Retained with less conflict	Resentment by young population	Retained with least conflict

REGIONAL INTEGRATION & COOPERATION

<i>Type, level, and rate</i>	Market driven (trade focus), medium, slow rate	Policy driven, high, medium rate	Lowest level of integration, disintegration of state along religious and ethnic lines	Policy driven, Highest towards or approaching integration, fast rate
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HEALTH & ENVIRONMENT

<i>General Status</i>	medium	better	worst	Best
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Annex B General Scenarios Description

The emphasis in **Markets First** is on ensuring the smooth functioning of markets. Strong efforts are made toward the development of international institutions encouraging and supporting the open exchange of resources, finances and products. Faith is placed in the hypothesis that the surest path to the improvement of social and environmental welfare is through rapid economic growth. In **Policy First**, national governments are assumed to play a greater role and greater coordination is also expected in the evolution of international governance. There is more direct effort to define economic, social and environmental goals, as well as manage and direct society toward the achievement of these. **Security First** assumes the dominance of governments and larger private sector actors, e.g. multi-national corporations, in exerting authority, but there is not always agreement among these groups. There is less emphasis on pursuit of the goal of the greatest good for the greatest number; nor is it assumed that the world can really agree on a common future. This is reflected in the general assumption that groups, primarily but not exclusively bounded geographically, establish systems of governance that emphasize their own security and welfare. Finally, **Sustainability First** assumes a significant shift in the attitudes and behaviour of many key actors. A balance is established between the government, private and civic sectors with respect to governance. There is a strong emphasis on environmental and social progress, with economic growth seen as a means to an end, and not an end in itself. Greater emphasis is placed on accountability, transparency and legitimacy, not only with respect to governments, but also private sector actors and other societal institutions including science. Strong efforts are taken to ensure that participation in governance is widespread and goes beyond mere dissemination of information (UNEP, 2007).