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A Water Sector Assessment Report on the Countries of the Cooperation Council of the Arab States of the Gulf

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EXCHANGE RATES AND CONVERSION MEASURES

EXCHANGE RATES

GCC Exchange Rates
In US$
IMF Website, April 9, 2004

Country	Currency Symbol	Exchange rate
Bahraini Dinar	BD	BD 0.376/US$
Kuwaiti Dinar	KD	KD 0.295/US$
Omani Riyal	OR	OR 0.3845/US$
Qatari Riyal	QR	QR 3.64/US$
SA Riyal	SR	SR 3.75/US$
UAE Dirham	AED	AED 3.6725/US$

CONVERSION MEASURES

1 m^3	= 220 Imperial Gallons (IG)
1 IG	= 0.0045 m^3
1 m^3	= 264 Gallons (G)
1 G	= 0.0038 m^3
1 IG	= 1.2 G
1 Ha	= 2.47 Acres
1 Acre	= 0.405 Ha
1 Liter	= 0.264 Gallons
1 G	= 3.785 Liters
1 IG	= 4.54 Liters

ABBREVIATIONS AND ACRONYMS

ADWEA	Abu Dhabi Water and Electricity Authority
AED	Arab Emirates Dirham
AGFUND	Arab Gulf Programme for United Nations Organizations
BD	Bahraini Dinar
Bm^3	Billion Cubic Meters
BOT	Build-Own-Operate
DEWA	Dubai Electricity and Water Authority
DRC	Domestic Resource Cost
ED	Electrodialysis
ERP	Effective rate of Protection
FEA	Federal Environmental Agency
ERWDA	Environmental Research and Wildlife Development Agency
FEWA	Federal Electricity and Water Authority
G	Gallon
GCC	Gulf Cooperation Council
GD	Gallon per Day
GDP	Gross Domestic Product
GIS	Geographic Information System
GSFMO	Grain Silos and Flour Mills Organization
Ha	Hectare
HIS	Hydro-meteorological Information System
ICBA	International Center for Biosaline Agriculture
IG	Imperial Gallon
IGD	Imperial Gallon per Day
IWRM	Integrated Water Resource Management
KAHRAMA	Qatar General Electricity and Water Corporation
KD	Kuwaiti Dinar
l/c/d	Liters per Capita per Day
KISR	Kuwait Institute for Scientific Research
LRMC	Long Run Marginal Cost
m^3	Cubic Meter
MA	Ministry of Agriculture
MAF	Ministry of Agriculture and Fisheries
MED	Multiple Effect Distillation
MENA	Middle East and North Africa (Region of the World Bank)
MEW	Ministry of Electricity and Water
MG	Million Gallons
MHEW	Ministry of Housing, Electricity, and Water
MIG	Million Imperial Gallons
MIGD	Million Imperial Gallons per Day
MMAA	Ministry of Municipal Affairs and Agriculture
Mm^3	Million Cubic Meters
MNE	Ministry of National Economy
MPW	Ministry of Public Works
MSF	Multi Stage Flash
MRMEWR	Ministry of Regional Municipalities, Environment, and Water Resources
MWE	Ministry of Water and Electricity
MWH	Ministry of Works and Housing

OECD	Organization for Economic Cooperation and Development
O&M	Operation and Maintenance
OR	Omani Riyal
OWSC	Oman Water and Sanitation Corporation
PSP	Private Sector Participation
QEWC	Qatar Electricity and Water Corporation
QR	Qatari Riyal
OWSC	Oman Wastewater Services Company
RO	Reverse Osmosis
RSB	Regulation and Supervision Bureau
RWI	Regional Water Initiative
SAAB	Saudi Arabian Agricultural Bank
SEWA	Sharjah Electricity and Water Authority
SWCC	Saline Water Conversion Corporation
TDS	Total Dissolved Solids
UAE	United Arab Emirates
UFW	Unaccounted for Water
US$	United States Dollar
WAJ	Water Authority of Jordan
WSTA	Water Science and Technology Association
WTO	World Trade Organization

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FOREWORD

The Arab Gulf Programme for United Nations Development Organizations (AGFUND) is a regional developmental institution established in 1980 upon my initiative and with the support of the Leaders of the Arab Gulf States that constitute its membership and contribute to its budget. The institution also has at its forefront, a mission to support United Nations programs.

It is my firm conviction that AGFUND, along with its affiliated institutions and organizations, can continue to play a vital role in helping tackle the issue of water scarcity. Many developing countries have been faced with significant water shortages. This is mainly the result of growing water demand due to rapid population growth, urbanization and irrigation expansion. Among the key solutions to the water problem are improving water resource management, strengthening the capabilities of water related institution and promoting legislation that encourages water conservation to the maximum. In the developing world, there is an urgent need to shrink the gap between water supply and rising demand in order to meet the requirements of economic and social development.

In this regard, in 2002, AGFUND expressed to the World Bank its desire to look into the challenges of water resources management of the Gulf countries, discuss the issues with a broad range of stakeholders and obtain policy recommendations on water reforms. In December 2002, a Memorandum of Understanding was signed between me and Mr. James Wolfensohn, President of the World Bank, to conduct a comprehensive review of the water sector in the countries of the Cooperation Council for the Arab States of the Gulf (GCC). The objectives of the study are to assess the overall water situation in the Gulf region ranging from irrigation to urban water supply and sanitation. The study also aims to formulate policy recommendations for sustainable and efficient water resources management in terms of water demand management, water supply, institutional and legal reforms, public-private partnerships and development of new non-conventional sources of water.

The GCC Water Sector Report is the culmination of this successful partnership between AGFUND and the World Bank. It has been prepared in anticipation that the critical nature of the numerous water issues facing Gulf countries will be brought to the forefront. It is hoped that the Report will generate intensive dialogue among the GCC countries and, through its recommendations and conclusions, will encourage Governments to adopt policies and laws that will conserve this precious resource for future generations. I thus look forward to hearing the views and concerns of the Gulf countries and hope that the GCC Water Symposium will usher in a new era of closer cooperation between governments and institutions in the water sector. Both the AGFUND and the World Bank, in coordination with the GCC, shall continue to provide support for recommended actions in this regard.

His Royal Highness Prince Talal Bin Abdul Aziz Al Saud

President

Arab Gulf Programme for United Nations Organizations

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The team is also very grateful for the water institutions and their senior staff in each Arab Gulf country that provided valuable information and offered their time to discuss the issue at hand. Also, the support of the Islamic Development Bank and its role in facilitating some of the contacts in the region are gratefully acknowledged.

The team comprises Messrs. Satoru Ueda, (Task Team Leader, Sr. Water Resources Specialist, MNSRE, World Bank), Joseph Fuleihan (Agriculture Economist, Consultant), Mohammed Lahouel (Economist and Urban Water Specialist, Consultant), Larry Simpson (Water Resources Specialist, Consultant), Gaurav Raina-Thapan (Operations Analyst, Consultant, MNSRE), Nathalie Abu-Ata (Water Sector Consultant, MNSRE), Ahmed Shawky (Water Resources Engineer, MNSRE), and Josephine Onwuemene (Program Assistant, MNSRE). Mr. Vijay Jagannathan (Sector Manager, Water and Environment, MNSRE) provided overall guidance for the team. The team was assisted in collecting data and logistical aspects by three local consultants: Messrs. Mohamed Abdel Hamyd Dawoud, Water Resources Specialist (UAE); Osman Al Nawawy, Water Resources Specialist (Qatar); and Mott MacDonald and Company (Oman). The assistance and guidance provided by AGFUND to facilitate contacts with various Ministries and institutions of the Gulf countries during the repeated missions of the World Bank was remarkable.

The team would like to thank Mr. Mustapha Nabli (Chief Economist, MNA region, World Bank) for providing comments on the final draft and express its appreciation to Ms. Claudia Sadoff (Lead Economist, ARD, World Bank) and Mr. Pier Mantovani (Senior Water and Sanitation Specialist, MNSIF, World Bank) for reviewing the report and providing helpful comments. Messrs. Khairy Al-Jamal (Sr. Operations Specialist, MNSIF), Rory O'Sullivan, Shawki Barghouti, and Gustavo Diaz (Consultants) also provided valuable comments.

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EXECUTIVE SUMMARY

Partnership Objective and Motivation

1. The main objective of the Water Sector Review in the member countries the Cooperation Council of the Arab States of the Gulf (GCC) is to (i) conduct a diagnosis of the current situation of the water sector, identify issues in the GCC region, evaluate the GCC governments' current water policies, and propose recommendations for improved Integrated Water Resources Management (IWRM) in Phase I of the study; (ii) present key findings and recommendations at the GCC Water Conference in Bahrain, September 19-20, 2005, where Government officials, academic specialists and technical experts from the region would provide inputs to this study; and (iii) if amenable to the GCC governments, conduct Phase II of the study to develop specific policies and action plans for more sustainable water resources management in individual GCC states.

Background

The Oil Factor in the GCC Economies

2. Over the past three decades, the GCC countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, have witnessed an unprecedented economic and social transformation. A significant share of oil revenues has been used to modernize infrastructure and improve the living standards of the population. Water supply and sanitation services have been made accessible to a large percentage of the population. Life expectancy increased by about 10 years during the period 1980-2000, and reached 74 years by 2000, which is among the highest in the world. Literacy rates rose from 20 percent to about 80 percent over the same period. Average per capita income stood at about US$ 12,000 in 2002 while total GDP was close to US$ 340 billion in the same year, accounting for more than one half of the GDP of all MNA countries.

3. As it is well known, oil plays a major role in the economies of these countries, accounting for about a third of total GDP and three-fourths of government revenues and exports. Together, these countries hold about 45 percent of the world's proven oil reserves, 25 percent of crude oil exports and at least 17 percent of liquefied natural gas. Given that oil revenues flow entirely to government treasuries, governments tend to use part of them to provide services to the national population free of charge or at highly subsidized prices Moreover, due to high oil revenues, direct and indirect taxes have played a marginal role as sources of government revenues.

4. During 2003-2004, reflecting favorable developments in the oil market, the GCC countries' macroeconomic performance has been on the rise again. However, while numerous elements are involved in forecasting the future performance of the oil market, it is important to stress the volatile nature of oil prices. Heavy dependence of these economies on oil revenues has rendered them vulnerable to market fluctuations. Steadily increasing expenditures, especially for utility services, have also diminished fiscal policy flexibility. In the past, oil market instability led to major swings in economic activity, export earnings and government expenditures. As governments are well aware, it is important to smooth out public spending in the face of these exogenous fluctuations in order to foster sustained economic growth and secure a prosperous future for upcoming generations.

Climate and Water Resources

5. Climatic conditions in the GCC countries are among the harshest in the world. Surface water resources are quite limited in the coastal zone along the Red Sea in Saudi Arabia and along the Gulf of

Oman on the eastern shore. No perennial rivers exist except in the littoral zone of Oman. They are also handicapped by the scarcity of renewable aquifer endowments. Thus, available annual freshwater resources per capita range from around 60 to 370 cubic meters, making these countries the least endowed in these resources in the world. Per capita freshwater resources could fall by nearly one-half to about 94 cubic meters as early as 2030 based on a projected population increase to around 56 million. Only Saudi Arabia possesses substantial amounts (around 430 billion m^3) of non-renewable groundwater in deep aquifers, which are, however, rapidly depleting. It is evident that the GCC countries are faced with a colossal responsibility in managing the scarce water resources in as efficient a manner as possible.

The Increasing Prominence of Desalination Technologies

6. Due to increasing shortages in non-renewable water resources, all GCC countries have supplied the bulk of municipal and industrial water from desalination of sea water for the past 20-30 years and will increase their reliance on this mode of water supply as the population grows. The desalination process primarily used is Multi-Stage-Flash (MSF) distillation, which until recently 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.

7. 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 to 2 per cubic meter. More importantly, the investment needs for constructing new desalination plants to supply water for rapidly growing population and high per capita consumption are enormous. The population in GCC countries almost quadrupled during 1970 – 2000, increasing from 7.8 million to around 29.8 million over this period. It should also be noted that GCC countries are highly dependent on a large expatriate labor force, which now accounts for about three-fourths of the total workforce. Immigration policy is bound to have implications for future water strategies.

8. Given the specific economic, social and climatic conditions, the GCC countries face water challenges and possible solutions that are quite unique in comparison to the rest of the world. While they are generally well endowed with substantial financial and human resources, their water challenges are far more pressing than what other regions may have encountered. These challenges require important actions in order to stimulate investment and enhance efficiency in the water sector so as to avoid future crises. This report identifies the key issues and challenges in water resource management and provides recommendations for the future, keeping in mind the unique circumstances in this part of the world.

Key Water Management Issues

Rapid Increase in Urban Water Demand

9. Two factors explain the current alarming increase in urban water demand. The first is the rapid population growth and the second is the rise in per capita consumption. Average population growth in the GCC countries over the last two decades is indeed among the highest in the world (around 3.5 to 6.0 % per annum). More strikingly, the average daily water consumption per capita ranges between 300 – 750 liters, which ranks the highest in the world. This volume has dramatically increased over the last three decades. In Kuwait, for example, water consumption per capita was only around 200 liters in the 1980s

and has now increased to around 500 liters. Nowhere else in the world has per capita water consumption risen so rapidly over such a time period.

10. The fundamental issues at stake are the absence of proper demand management and an almost non-existent price-signaling mechanism. Government policies have primarily focused on the supply side of producing water from either aquifers or desalination plants while demand management has been by and large neglected. While there is a substantial amount of data on water production in most GCC countries, information on Unaccounted-For-Water (UFW), actual water consumption, and cost recovery is quite limited. This lack of data in itself highlights the gravity of the issue. In spite of the lack of hard data the leakage level from water distribution networks is considered rather high, in the range of 20-40 percent, which is at odds with the high cost incurred in producing desalinated water which varies between US$ 1.0 to 2.0 per cubic meter.

11. 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. Furthermore, water metering and billing are only loosely applied to nationals. In some countries such as Kuwait, water is made available to nationals almost free of charge with the exception of a small nominal flat monthly fee that is charged irrespective of the amount of water used. Hence, there exists a substantial difference in water consumption in Abu Dhabi resulting from pricing differentiation between metered and non-metered water use, the former estimated at around 260 liters against 1400 liters per capita per day for the latter. This illustrates the fact that the lack of metering and price signaling constitutes the fundamental cause of wasteful water use.

The Heavy Fiscal Burden of Water Subsidies

12. Current Government policies of heavily subsidizing the water sector could become counterproductive in the future. Heavy reliance on subsidies will not only exacerbate rapidly rising water demand, but will also place an intolerable burden on national budgets. A substantial amount of water will have to be supplied by costly desalination plants. Even though newer and more cost efficient desalination technologies have become available, water subsidies alone could take away up to 10 percent of oil revenues in some GCC countries by 2025. Given recent trends in the growth of water demand, the fiscal burden is likely to be very heavy, particularly in Kuwait and Saudi Arabia.

13. While it is possible that high oil prices could persist and result in significant revenues over a sustained period in the future, a major question remains as to whether it is wise to proceed with expenditures on excessive water use against the alternative of allocating the resources involved to the development of the non-oil sector and the creation of employment opportunities for newcomers in the job market. The reduction of subsidies for water services and the reallocation of the resources saved towards non-oil activities would go a long way in reducing wasteful use, strengthening fiscal discipline, insulating the economy from trade shocks, creating jobs and ensuring inter-generational equity in the distribution of the wealth derived from oil.

14. It should be noted that the investment needed for rehabilitating existing desalination plants and constructing much needed wastewater treatment facilities is not included in the cost and subsidy estimates done in this report. Most of the existing desalination plants were built during the 1970s and 1980s and have been operating at almost their maximum capacity. It is reported that some of the plants have faced interruptions in operations, resulting in intermittent water supply during repair periods. Furthermore, the increasing level of salt concentration in the Gulf region due to large amounts of highly saline brines discharged from desalination plants could render the operation of desalination plants more costly and challenging in the future. These challenges could be further exacerbated by potential disruptions resulting from oil spills, plant malfunctions and subsequent rehabilitation costs.

Lagging Wastewater Treatment and Reuse

15. While the coverage rate of basic sanitation services seems to be quite high in all GCC countries, a fairly large portion of the area seems to be covered by on-site sanitation facilities such as septic tanks and cesspits which may not provide adequate water pollution control measures in high population areas. On the basis of the amount of treated wastewater compared to the total produced urban water, the coverage rate of sewerage collection and treatment system seems to be in the range of 20 to 40 percent, except for Kuwait (around 60 percent), lagging far behind water supply service. The result has been that shallow aquifers are polluted from concentrated use of septic systems in some areas giving rise to high levels of nitrates in the shallow groundwater reserves.

16. In most of the GCC countries, the primary use of treated wastewater is for municipal landscaping while a significant volume is lost to the sea or adjoining wadis even after it is treated to the secondary level. The treated wastewater is also used on a pilot basis for groundwater recharge and is expected to play an increasingly vital role in securing valuable aquifer reserves. The reuse of treated wastewater for irrigating tree and fodder crops is also being piloted with careful consideration to the potential negative impacts on groundwater quality, hygiene and health. Kuwait and the UAE are undertaking or considering new irrigation agriculture projects which include tertiary wastewater treatment plants and piped water transfer systems, particularly for enclosed production of high-value vegetable crops. While these initiatives are technically well advanced, careful consideration should be given to the opportunity cost of this reclaimed water treated to the tertiary level.

Weak Urban Water Management

17. In order to meet the challenges outlined above, the performance, incentive structure, and service / demand orientation of urban water management have to be changed. The private sector can play a significant role in facilitating these changes: its involvement entails a change in business culture and salary levels and provides much needed managerial and technical expertise. GCC countries have been opening up water and energy utilities to private investors. Several international consortiums have been awarded contracts for building desalination and wastewater treatment plants in the UAE, Kuwait, Oman, and other GCC countries. The UAE is leading the region in terms of partial privatization of the water and energy sectors. The Abu Dhabi Emirate, in particular, is aiming to complete partial privatization of the two sectors by 2007. The required regulations and laws have been formulated and legislated in terms of foreign ownership, permissions and taxation in order to facilitate foreign direct investment. The experience of Abu Dhabi has introduced more transparency in cost monitoring and improving the accountability of the companies involved in providing water services even if the participation of the private sector remains limited.

18. Despite recent improvements in the business climate for foreign investment in the water sector and the prospects that these changes hold for more efficient services, particularly in the UAE, the operation and maintenance of water distribution networks require further attention. The leakage and loss rate of 20-40 percent may not be alarming. However, given the fact that desalinated water production costs are between US$ 1.0 and 2.0 per cubic meter, major improvements in the distribution systems would appear to be the least expensive way to meet rising water demand in the expanding urban areas.

19. Not surprisingly given the high level of UFW and the deficient sewage collection system, groundwater tables in urban cities, such as Muscat, Kuwait City and Doha, have been rising and causing basement flooding as well as other structural problems for buildings and foundations. Furthermore, there is evidence based on sample testing of biological contamination. The latter is due to leakages from water

mains and sewerage collection networks and is a stark reminder of the poor conditions of water distribution and sewerage networks. Sound integrated water resources management is clearly needed.

20. This issue is related to the broader problems concerning incentives and the overall management structure of water services in the GCC countries. The private sector has been involved in areas ranging from smaller management assistance, such as regular maintenance, to participation in major international consortium businesses including Build-Operate-Transfer (BOT) schemes for desalination plants. While some sound arrangements have been made for stand-alone desalination plants, daily operations of water distribution systems have been neglected. Some management and service contracts do not seem to provide incentives for operators to improve operational efficiency and save costs.

Rapid Aquifer Depletion and Agriculture Policy

21. In all GCC countries, since the amount of groundwater abstraction is far greater than the amount of recharge, aquifer levels have been rapidly depleting and the groundwater has been increasing in salinity. Although reliable estimates are not available, one source estimates that 35 percent of non-renewable groundwater resources in Saudi Arabia were depleted by 1995. The UAE's Environmental Research and Wildlife Development Agency (ERWDA) has estimated that out of the remaining groundwater supplies around 7-8 percent is fresh water while the rest is brackish water. The over-extraction of groundwater beyond safe yield levels has also resulted in the pollution of the existing groundwater aquifers due to the intrusion of saline seawater and the up-coning of brackish and saline water supplies from lower aquifers. This is particularly serious in Oman, Bahrain and Qatar, and recovery may take generations.

22. While agriculture consumes around 60 to 90 percent of water, it accounts for only 2 to 7 percent of GDP in Saudi Arabia, the UAE, and Oman. The agriculture sector is much more insignificant in Bahrain and Qatar with less than 1 percent of GDP while still using around 50 to 60 percent of water. Irrigation water is generally used in a wasteful manner, mainly through usage of traditional flooding and furrow irrigation techniques and for cultivating low value, high water-consumptive crops, without considering its economic opportunity cost for potable and urban/industrial purposes. In this predominately desert region, losses can exceed 50 percent of pumped groundwater.

23. In spite of the low economic contribution of the agriculture sector, the majority of GCC countries provide generous subsidies to the agriculture sector in an effort to increase self-sufficiency levels in certain commodities, and as a means of redistributing oil revenues. Agricultural subsidies for wells, fuel, and other inputs, price support programs and trade protection in some countries along with lack of controls on groundwater extraction or charges increased the irrigated areas drastically and are contributing to the depletion of aquifers. Over the last decades, the net irrigated areas increased in all GCC countries by 100 to 300 percent. It is worth noting that in Saudi Arabia, the rapid expansion of irrigation areas due to generous subsidies led to nearly tripling the volume of water from around 7.4 BCM in 1980 to 20.3 BCM in 1994, before falling to 18.3 BCM in 1999. Unsustainable development of groundwater for irrigation is shown by the continuous decline of water table levels, which in some aquifers dropped more than 200m during the last two decades. Many springs and shallow aquifers have dried up.

24. Generous subsidies for agriculture have enabled farmers to produce crops which have low returns to water, such as forage crops, alfalfa, and low value-added vegetables grown in open fields. These subsidies distort costs and revenues, and many of the agricultural activities in the GCC countries are financially profitable only because of Government subsidies and incentives, notwithstanding the high opportunity cost of water. Even with such generous support from the government, the agriculture sector performance is generally poor and the quality of local agriculture produces cannot compete with imported

products due to lack of modern irrigation technology, adequate quality control, post-harvesting techniques and marketing.

Lack of Groundwater Management and Regulation

25. All GCC countries possess significant technical expertise in their ability to carry out hydro-geological surveys, studies, laboratory testing, and numerical modeling. However, government agencies seem to be weak on areas related to groundwater management planning, monitoring and enforcement of regulations for drilling rigs control, inventory and permits, not to mention pumping volume measurements and charging. In most cases, either the Ministry of Agriculture or of Water and Electricity is nominally in charge of groundwater management, which has often brought about conflicts of interests between their primary objective of meeting water demand and their secondary mandate of water resource conservation.

26. With the exception of Oman, the lack of an effective groundwater management policy and unclear and conflicting responsibilities among ministries or regional governments in the regulation of groundwater use and conservation has exacerbated this issue. Currently, there are no proper well-licensing procedures and pricing mechanisms to prioritize and regulate access to groundwater. In some countries, there are ordinances for banning well drilling and efforts for withholding the issuance of licenses to drilling companies and for penalizing violators. In reality however, most of the countries do not enforce those regulations and do not possess the institutional capacity to do so. Furthermore, such items are not a priority on the reform agenda and there exists an absence of strong political support.

Policy Recommendations

27. For the last few decades, all GCC countries have focused their strategies solely on increasing water supplies through costly seawater desalination for municipal and industrial water use while exploiting renewable and non-renewable groundwater for agriculture. It is commendable that they have provided water supply and sanitation (to a lesser extent) services for the rapidly increasing population under the harsh climate conditions and sustained economic growth.

28. However, even for oil-rich Gulf countries, a major paradigm shift is needed for putting more emphasis on water demand management in order to catch up with ever-increasing water demand and provide water in a more efficient and sustainable manner. Integrated water resources management is a key in reforming water sector policies including better planning, inter-sectoral coordination, water conservation, regulation, and pricing.

Strengthened Municipal Water Tariff System

29. International and regional experiences have demonstrated significant reductions in per capita water consumption after major demand control measures from pricing, incentives, and other regulatory programs were introduced. Bahrain has also witnessed significant reductions in water consumption when it introduced water metering and tariffs. In the UAE, differences in water consumption between metered and non-metered users clearly bring out the importance of volumetric water charges and metering.

30. In order to further enhance demand control measures and users' responsiveness, municipal water tariff schemes should be the subject of an intensive study and evaluation with a focus on the optimality of the tariff structure and full cost recovery. The increase in tariff rates on the basis of metered consumption for the entire population is essential for water conservation and financial sustainability. Consideration must be given to an incremental block tariff so that customers receive clear price signals to conserve water. Targeted subsidies can be maintained for a particular segment of the population below a certain income threshold in order to avoid excessive financial burdens on the poor.

31. The GCC countries should also tighten water saving measures and reduce UFW. Currently, UFW which exceeds 30 percent in Qatar and Saudi Arabia should be reduced to about 15-20 percent or less given the high costs of desalinated water. Water meters should be maintained on a regular basis in order to provide accurate and reliable water use measurement. More frequent leakage inspections and an advanced pressure control system for water distribution networks should significantly reduce leakages and a program of monitoring the different segments of the distribution systems and rehabilitation or repair of the systems, when necessary, should be implemented.

Management Efficiency Improvement and Private Sector Participation

32. In order to meet the rapidly increasing water demand and improve operational efficiency, GCC countries also need to undertake fundamental changes in the performance, incentive structure, and service orientation of urban water and sanitation utilities. The private sector can play a significant role in facilitating those fundamental changes which include improving technical and managerial expertise, increasing operational efficiency, constructing and managing large scale projects, reducing public expenditures for subsides and making the water sector more responsive to its users and demands.

33. Various options are available for promoting private sector participation and careful evaluation of other models such as BOT, concession, divestiture, and other experiences for the development of water resources infrastructure. The BOT may be an ideal instrument if the government provides necessary guarantees and, in particular, take-or-pay guarantees, eliminating a significant portion of commercial risk for the private sector. Furthermore, governments should carefully examine future water demand and patterns as well as financial obligations based on long term development plans.

34. The experience of Abu Dhabi in the partial privatization of desalinated water production could be useful for other countries considering further privatization of the water sector. However, most of the GCC countries still pursue the direct public management model which has proved elsewhere to be inefficient. These countries should strongly consider the use of public or semi-private corporations to manage their water services with strong representation from user sectors in order to participate in shaping the direction of these organizations. While it is possible that the provision of water and wastewater services will remain under government authority, every effort should be made to make this sector as independent as possible from the bureaucratic governmental institutional structure. Qatar has taken important steps in that direction.

35. It must be noted that these initiatives require the provision of a clear and transparent legal and regulatory framework along with the improvement of ownership rights for international firms. Equally, the role of the government is vital in assuring that water resources are allocated and managed in an efficient and equitable manner. The legal separation of service provision from policy-making as well as from regulation and supervision is important for greater transparency and accountability of service providers.

Sustainable Aquifer Management and Agricultural Policy

36. Some of the GCC countries are not convinced that groundwater resources can represent a viable component of future water supplies and are not paying enough attention to the depletion and pollution of the aquifers, thinking that that the destruction of aquifers and the full reliance on desalinated water for meeting all water demand is inevitable. This attitude may or may not be justified depending on how the state of oil reserves in the near future is perceived and what stand is taken on its inter-generational allocation.

37. However, the GCC countries should view aquifers as a strategic resource to sustain various water uses, conserve ecosystems and provide emergency reserves in the case of disruption of desalinated water supply due to large-scale oil spills. More importantly reliance on desalinated water alone could be a risky policy considering the volatile nature of oil prices and revenues. The sustainable use of groundwater resources should be a consideration in the overall integrated water resource management policy of each country.

38. While some countries such as Oman, and to a lesser extent Saudi Arabia, appear to be taking bold steps in moving toward sustainable groundwater management, much still needs to be done. Strong measures need to be adopted in order to recover existing aquifers, reduce extractions to a point below sustainable, or to less unsustainable levels and curtail the further development of wells until sufficient studies are carried out and the necessary control regulatory mechanisms can be put in place and enforced.

39. Strengthened groundwater management measures should be adopted including: (i) establishing a comprehensive groundwater regulatory, monitoring, and pricing mechanism; (ii) improving irrigation efficiency, i.e. increasing agriculture value-added per drop of water; (iii) allowing water transfer through a system of tradable water rights along the lines of the current Aflaj system in Oman; and (iv) carrying out an extensive education, public awareness and media campaign for groundwater conservation.

40. Given the large amount of groundwater used for irrigation, the emphasis should be put on improving irrigation efficiency through: (i) expanding the use of modern pressurized irrigation systems, micro-irrigation and automated irrigation scheduling systems to increase water productivity; (ii) shifting from low value vegetables grown in open fields to high value vegetables grown in greenhouses; and (iii) reducing the area of high water consuming crops such as fodder and alfalfa.

41. GCC countries should also phase out subsidies for well drillings, pumps, seeds, fertilizers, etc. as well as price support programs to reduce non-profitable and water-wasting agriculture. Instead, targeted subsidies should be provided for the introduction of water saving techniques and increased monitoring of pumping and water use. Within the context of trade liberalization and integration of the Gulf countries in the World Trade Organization (WTO), agricultural reforms should encourage the promotion of a market-oriented policy through the cultivation of crops with high water productivity and low-water content. The "virtual water" approach can be used to measure the potential water saving through food imports and to assess water security in comparison with food security. Oman estimated that "virtual water" imports in 1998 were approximately 3,860 million m^3, which represents about three times the total replenishment of the natural water resources of the country.

Necessity of Integrated Water Resources Management (IWRM)

42. The IWRM concept articulated at the 3rd World Water Forum in Kyoto 2003 is being transformed into action on the ground through development and implementation of sound water management policies and practices, which focuses, in particular, on: (i) a broad-based water demand management policy; (ii) a comprehensive program for reducing groundwater extractions and achieving a more sustainable aquifer management; (iii) a comprehensive program for non-conventional water resources including desalinated water, reclaimed wastewater, and brackish water; (iv) institutional arrangements and coordination for water resources management; and (v) an increased role for the private sector in water resource management.

43. In general, however, none of the GCC countries has adopted a fully integrated approach in the planning, development, and management of their water resources. This has resulted in concentrated use of desalination water for potable and industrial supplies, and the relegation of valuable and, in most instances, non-renewable groundwater for wasteful irrigation of low-value and high water consuming

crops. The use of brackish groundwater as a lower cost feed for desalination than seawater has not been considered sufficiently. Furthermore, while the present use of treated wastewater is exemplary in some areas, it has not been sufficiently taken advantage of in many countries. This resource does not seem to be duly valued as an economic good that could be used to supplant the unsustainable extraction of groundwater, even though it may have to take an increasing role in meeting water demand in urban, industrial, agricultural, and possibly some household uses as well.

44. The water sector needs to be integrated into an over-all plan, encompassing groundwater, desalinated water and treated wastewater in order to optimize the use of each resource for the highest economic and social benefit of each country. While it can be concluded that, with the exception of Oman, a significant proportion of future water supplies for both potable and industrial water will be derived from the desalination of both brackish and sea water, an IWRM program covering demand management, institutional and legal aspects, a greater role for the private sector, and new sources of supply, is needed to ensure that water resources are utilized most efficiently and sustainably.

45. Furthermore, a consolidated and accessible water database is an absolute necessity for ensuring adequate integrated management of water resources and utilities. In some GCC countries, important data gaps exist, most notably pertaining to the volume of extractable groundwater resources as well as benchmarking data for indicating utilities management efficiency. This effort is fragmented and data are not readily available in a transparent and usable manner. Countries should endeavor to establish a reliable information network and database which could be readily accessible by both the private and public sectors.

Next Steps

46. The main findings of the report will be presented at the GCC Water Symposium to be held in Bahrain in September 2005, organized by the AGFUND and the World Bank under the auspices of the GCC and the UAE Government. The main objectives of the Symposium would be: (i) encouraging knowledge sharing among GCC countries and identification of strengths and weaknesses in water resources management; (ii) conducting a broad-based dialogue with key stakeholders to provide inputs to this report; and (iii) proposing a broad framework for the development and implementation of a regional water strategy based on the IWRM approach.

47. Following the Symposium, it is recommended that the GCC countries form a high-level committee within the existing GCC structure composed of technical experts, Government officials, and user representatives. The purpose of such a committee would be to address the main issues, constraints, and recommendations identified by the study at the Symposium. The high-level committee would present its findings and conclusions to the political leadership in the GCC countries. Furthermore, enhancing GCC coordination for supporting countries' efforts in terms of policy formulation and regional water strategies should also be considered.

48. Following such a presentation, it is recommended that an action plan be prepared by this committee that will translate conclusions and recommendations into actions. The committee will decide if there is a need for a follow up Phase II of the study, where key water sector development and management options for individual GCC countries can be developed. It will take into account the issues, strategies and policies analyzed in Phase I and discussed at the Symposium. The World Bank will be ready to continue supporting this effort if requested by the AGFUND, the GCC or any of the individual countries.

WATER SECTOR REVIEW IN THE GULF COOPERATION COUNCIL COUNTRIES

I. BACKGROUND

1.1 In the water-scarce Middle East, and particularly in the Gulf Cooperation Council (GCC) countries, there is a clear and urgent need for a review and analysis of the water resources sector, with a view to providing an enabling environment (policy and planning, institutional, legal, and financial/economic) for implementation of integrated and sustainable water resources management policies and programs. The Arab Gulf Programme for United Nations Development Organizations[1] (AGFUND) made available a grant to finance a review and analysis of the water resources situation in the GCC countries as part of its partnership agreement with the World Bank.

1.2 The partnership program is carried out under the umbrella of the World Bank's Middle East and North Africa Region (MENA) Regional Water Initiative (RWI). The overall objective of the RWI is to provide a regional forum for promoting water policy reform and further enhancing cooperation among the MENA countries. The program strives to achieve this objective by facilitating dialogue, knowledge and information sharing, dissemination of best practices, lessons learned from the region and around the world. It aims to raise awareness among decision makers to promote sustainable management of the water sector. This process would help identify useful policy, institutional and technical solutions that are applicable in the MENA region with a special focus on the Gulf countries.

1.3 This report presents its objective and methodology in Section II, an overview of the current water resources and use situations in Section III, main issues identified and requiring further discussion in Section IV, key recommendations for future water resources management in Section V, and the next steps to be taken, in Section VI.

[1]The AGFUND is a regional Arab organization established in 1980 on the initiative of HRH Prince Talal Bin Abdul Aziz of Saudi Arabia with the support of the leaders of Saudi Arabia, Kuwait, the United Arab Emirates (UAE), Qatar, Oman, and Bahrain, which constitute its membership and contribute to its budget. AGFUND supports sustainable development initiatives targeting the neediest groups in developing countries through supporting United Nations (UN) and other organizations which are active in this field.

II. OBJECTIVES AND METHODOLOGY

2.1 The main objective of the World Bank-AGFUND partnership on the Water Sector Review in GCC Countries is to:

- Carry out a study and prepare a report that provides an overview and diagnosis of the current situation and main issues in the water sector in the GCC region as well as a comparison with relevant experiences from the rest of the world; present and evaluate the governments' current water policies; review the institutional, legal, financial and economic framework, and the role of the private sector in water resource management; and propose recommendations for improved and Integrated Water Resources Management (IWRM) for the GCC courtiers in Phase I of the study.
- Organize a regional consultation conference/workshop where Government officials and experts from the region would be invited to comment on and provide inputs to this study. The GCC Water Sector Report will be shared with all participants, concerned government agencies and regional and international organizations.
- If found agreeable by GCC countries, conduct Phase II of the study, develop specific policies and action plans for more sustainable water resources management in each of the GCC states.

2.2 The main findings and conclusions of the report will be presented during the GCC Water Conference in Bahrain, in September 2005. Key issues, policy options, and recommendations for action will also be discussed during the Conference. The regional conference will involve a variety of stakeholders. These shall include governments and regional and international organizations working to improve the water situation in the Gulf region. It will seek to delineate broad elements of a regional strategy based on the IWRM approach as well as an action-plan for the short, medium, and long-term.

2.3 In view of the complexity and multi-disciplinary nature of water resource management, the assessment of water resources covers both (vertical) strategic sector modules, and (horizontal) cross-cutting themes:

- Strategic Sector Modules: Groundwater and surface water resources (if any) management, desalination, municipal, and industrial water resources management, irrigated agriculture, reuse of treated wastewater and water importation.
- Cross-Cutting Themes: Policies and incentives, institutions, legal and regulatory framework, tariffs and cost recovery, efficiency improvements, private sector and stakeholder participation, public awareness and environmental aspects.

2.4 The assessment work in Phase I of the study focused on cross-country thematic issues, rather than on in-depth assessments of water resources and institutional aspects of individual countries in order to maximize the synergies of the assessment and facilitate subsequent regional dialogue. Nonetheless, the team tried to collect as much data as possible, analyze and present it in the most clear and concise manner possible for the reader even though data gaps continue to exist in several areas and conflicting information. The team is ready to further update the report if it receives further information and feedback from the countries. However, the team believes that the overall assessment of the situation, main water management issues, and recommendations are valid.

III. OVERVIEW OF WATER RESOURCES AND USES IN THE GCC COUNTRIES

This section presents the overall water resources situation in the GCC countries as well as the constraints and future prospects of all water sources from groundwater and desalination to treated wastewater.

A. Water Resources Availability and Usage in the GCC Countries

The GCC Countries have the lowest per capita renewable fresh water resources in the world that continue decline rapidly.

3.1 The GCC countries are situated in extremely arid zones. The region is mostly a desert with the exception of narrow coastal areas and mountain ranges. The 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, where orographic rainfall reaches more than 500 mm. The total annual evaporation rate ranges from 2,500 mm in the coastal areas to more than 4,500 mm inland. The amount of renewable aquifer volume is very limited and shallow alluvial aquifers provide some renewable groundwater only in those limited coastal strips. Large deep aquifers are present in the region, 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. However, even these are rapidly depleting.

3.2 With this harsh climatic and hydrological condition, the GCC countries have an extremely poor endowment of water resources. Per capita freshwater availability fell from about 680 m^3 in 1970 to about 180 m^3 in 2000 ranging from 60 m3 to 370 m3. These figures are much lower than the approximate figure 1,100 m3 for the entire Middle East and North Africa Region. Even worse, the per capita freshwater availability of the GCC countries could fall by nearly one-half to about 94 m^3 as early as 2030 based on a projected population increase to around 56 million.[2] Table 1 below provides a glimpse into the water resource endowments for the GCC region.

Table 1: Water Resources Endowment

Country	Area (km2)	Average annual rainfall (mm)	Groundwater recharge (MCM/year)	Non Renewable Reserve (MCM)
Bahrain	652	30-140	110	negligible
Kuwait	17,818	30-140	160	n/a
Oman	212,460	80-400	900	102,000
Qatar	11,610	20-150	50	negligible
Saudi Arabia	2,149,690	30-550	3,850	428,400
UAE	83,600	80-160	190	n/a

Source: United Nations University 1997 modified with country reports.
Note: 1. Oman recharge is based on its country data (1300 MCM is rechargeable and 900 MCM is recoverable).
2. UAE from the Bank report (other source indicates 125)

[2] World Development Indicators 2004, The World Bank.

Table 2: Changes of Annual Renewable Water Per Capita between 1970 and 2000

Country	Renewable Groundwater (MCM/Year)	Population (millions)				Annual Renewable Water Per Capita (MCM/Year/Capita)			
		1970	1980	1990	2000	1970	1980	1990	2000
Bahrain	110	0.2	0.3	0.5	0.7	524	329	219	164
Kuwait	160	0.7	1.4	2.1	2.2	215	116	75	73
Oman	900	0.7	1.1	1.6	2.4	1,245	817	553	373
Qatar	50	0.1	0.2	0.5	0.6	450	218	103	85
Saudi Arabia	3,850	5.7	9.4	15.8	20.7	670	411	244	186
UAE	190	0.2	1.0	1.8	3.2	864	182	107	59
Total	5,260	7.8	13.5	22.3	29.8	678	391	236	176

Note: The annual renewable water per capital counts only natural water resources endowment without considering artificial water supply augmentation through seawater desalination and treated wastewater reuse.

Table 3: Population Growth of GCC Countries (millions)

Country	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
Bahrain	0.2	0.3	0.5	0.7	0.8	0.9	1.0
Kuwait	0.7	1.4	2.1	2.2	2.8	3.2	3.5
Oman	0.7	1.1	1.6	2.4	3.0	3.7	4.2
Qatar	0.1	0.2	0.5	0.6	0.7	0.8	0.8
Saudi Arabia	5.7	9.4	15.8	20.7	27.4	35.5	42.5
UAE	0.2	1.0	1.8	3.2	3.5	3.9	4.2
Total	7.8	13.5	22.3	29.8	38.1	47.9	56.2

Source: The World Bank (2004)

Economic and social conditions have markedly improved in the GCC countries since the discovery and exploitation of vast oil reserves.

3.3 The local population of the GCC countries adapted their lifestyles to the highly dry and arid climatic conditions that characterize this region. The population was small and was restricted to oases and upland areas endowed with higher rainfalls which would support cattle and crops. However, due to rapid population growth and the discovery and exploitation of oil resources starting from the 1960s, economic and social situations have drastically improved while imposing tremendous pressure on limited water resources. Table 4 below provides a general idea on the changing economic and population indicators in the GCC countries.

3.4 Over the past three decades, the GCC countries have witnessed an unprecedented economic and social transformation. A significant portion of oil revenues has been used to modernize infrastructure and improve the living standards of the population. Water supply and sanitation services have been made accessible to a large percentage of the population. Life expectancy increased by about 10 years to 74 years during 1980-2000 and literacy rates increased from 20 percent to about 80 percent 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 (more than half of all MNA countries).[3]

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[3] IMF (2002)

3.5 In the GCC countries, oil revenues account for about a third of total GDP and three-fourths of annual government revenues and exports. Together, these countries account for about 45 percent of the world's proven oil reserves, 25 percent of crude oil exports and at least 17 percent of liquefied natural gas reserves. 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.[4]

Table 4: Economic and Population Indicators in GCC Countries (2000)

Country	Nominal GDP (millions of US$)	Nominal GDP Per Capita (US$)	Population (millions)	Population Growth rate (%/annum)
Bahrain	8,506	11,619	0.7	2.0
Kuwait	33,215	15,098	2.2	3.2
Oman	20,290	7,515	2.4	2.4
Qatar	17,321	28,362	0.6	2.7
Saudi Arabia	188,960	8,567	20.7	2.7
UAE	71,187	19,613	3.2	5.5

Source: GDP estimates by the IMF in 2002 and population estimates by the World Bank in 2004

The GCC countries have increased water use in all sectors at an unprecedented rate and could face a water crisis despite their economic and social development.

3.6 During this period, total water demand in all GCC countries has increased dramatically as a result of high population growth, improvements in the standard of living, industrial development in major urban centers and efforts to increase food self-sufficiency. The total water use for all sectors in the region increased by about four-and-a- half times from around 6 billion m3 to 27 billion m3 while the population more than doubled from around 14 million to 30 million during 1980-2000 (Table 5). The deficit has been and will be continuously met mainly by seawater desalination and mining of renewable and non-renewable groundwater resources.

Table 5: Water Demand Increase of GCC Countries (MCM)

Country	1980	1990	2000
Bahrain	138	223	269
Kuwait	186	383	993
Oman	665	1,236	1,303
Qatar	110	194	433
Saudi Arabia	2,362	16,300	20,800
UAE	789	1,490	3,506
TOTAL	6,230	19,826	27,304

Source: Al-Alawi and Abdulrazzak 1994 (Hydrology of An Arid Region, 2002)
Countries data and team's analysis for 2000

3.7 Irrigated Agriculture is the primary water consumer with a regional average of around 80 percent of total water use. This is particularly the case in Saudi Arabia and Oman (around 85 – 90 percent), and to

[4] Ibid

a lesser extent, the UAE, Bahrain and Qatar (50 – 60 percent). The average irrigation water use in the region has increased from around 18 billion m3/year to 22 billion m3 /year just over ten years between 1990 and 2000. Irrigation water is mainly supplied by groundwater and rapid expansion of irrigated areas has resulted in substantial increases in groundwater abstraction volumes. In all GCC countries, this volume far exceeded the renewable amounts of groundwater and depleted aquifers in many areas. In Saudi Arabia, rapid expansion of irrigated areas (although the area has started to decline since 2000 due to government policy changes) has led to extensive mining of deep non-renewable aquifers. These countries would have to mine groundwater resources further and may face the destruction of aquifer resources in some areas if current practices continue.

3.8 Domestic water demand increases can also be attributed to a lack of conservation measures and price signaling mechanism to consumers. Domestic water use in all GCC countries increased from around 2.8 billion m3 to 5.1 billion m3 during 1990-2000. Drinking water use alone is expected to reach around 8.5 billion m3 in the year 2025 if the current trend continues and no policy changes are made. All GCC countries will have to allocate significant amounts of financial resources for the construction of new seawater desalination plants in order to meet ever-increasing water demands as well as wastewater treatment plants for handing the resulting wastewater discharge. The huge investment needs may constrain the fiscal conditions of the GCC countries even while their substantial oil revenues are sustained. Tables 6.1 and 6.2 below provides data on sectoral water use changes during 1990-2000.

Table 6.1: Sectoral Water Use Changes between 1990 and 2000
Unit: MCM/Year

Country	1990			2000			Growth Rate (%)		
	Municipal Water	Agriculture Water	Total Water	Municipal Water	Agriculture Water	Total Water	Municipal Water	Agriculture Water	Total Water
Bahrain	103	120	223	132	137	269	128%	114%	121%
Kuwait	303	80	383	772	221	993	255%	276%	259%
Oman	86	1,150	1,236	179	1,124	1,303	208%	98%	105%
Qatar	85	109	194	163	270	433	192%	248%	223%
Saudi Arabia	1,700	14,600	16,300	2,500	18,300	20,800	147%	125%	128%
UAE	540	950	1,490	1,344	2,162	3,506	249%	228%	235%
TOTAL	2,817	17,009	19,826	5,090	22,214	27,304	181%	131%	138%

Source: Country data and team's analysis

Table 6.2: Sectoral Shares of Total Water Resources

Country	1990		2000	
	Municipal Water	Agriculture Water	Municipal Water	Agriculture Water
Bahrain	46%	54%	49%	51%
Kuwait	79%	21%	78%	22%
Oman	7%	93%	14%	86%
Qatar	44%	56%	38%	62%
Saudi Arabia	10%	90%	12%	88%
UAE	36%	64%	38%	62%
TOTAL	14%	86%	19%	81%

Source: Country data and team's analysis

GCC countries have done well in providing water for their citizens, but may need to consider its economic implications toward the future.

3.9 Despite the rapid increase in water demands, GCC countries have done well in providing water for municipal, industrial, and commercial uses through the construction and expansion of desalination plants. They also have provided water sanitation services and prepared ambitious future plans to expand capacity to meet rising demand as a result of the high rates of population increase and a rising standard of living.

3.10 However, the GCC countries are at a critical juncture with regard to managing water and financial resources in a sustainable manner and securing the balanced development of economic, social and environmental conditions for their citizens and future generations. It is time to squarely face the critical problems plaguing the water sector and come up with suitable solutions to balance the major challenges ahead, mainly on how to sustain vulnerable aquifer resources, meet rapidly increasing water demands in all sectors, and make the best use of oil revenues.

3.11 During 2003-2004, reflecting favorable developments in the oil market as well as higher oil production and prices, the GCC countries' macroeconomic performance has been on the rise again. However, while numerous elements are involved in forecasting the future performance of the oil market, there is a need to be aware of the volatile nature of oil prices. The mere dependence by these economies on oil revenues has rendered them vulnerable to market fluctuations. Rising expenditures, especially for utility services, have also diminished fiscal policy flexibility. In the past, oil market instability led to major swings in economic activity, export earnings and government expenditures. As governments are well aware, it is important to prudently manage public spending in the face of these exogenous fluctuations in order to foster sustained economic growth and guarantee a prosperous future for upcoming generations.

B. <u>Overview of Water Supply Sources</u>

This section provides the overview of the current situations of water supply sources including groundwater, seawater and brackish water desalination as well as wastewater treatment and reuse.

B1. Groundwater

3.12 Renewable and non-renewable groundwater represents a large percentage of the overall water supply for the GCC countries and constitutes the majority of the water resources utilized for agricultural production. Only in Oman does renewable groundwater represent a significant portion of the water supplies used for domestic and industrial uses. Non-renewable groundwater is principally derived from deep aquifers that arise in Saudi Arabia and in Oman. The water in these aquifers is principally fossil water which was deposited in the formations millions of years ago. Recharge of these aquifers is virtually non-existent. The use of these non-renewable supplies should be considered as a mining operation with a finite usable reserve. The volume of water stored in these aquifers has not been ascertained, although considerable modeling has been done in this regard and additional work is planned for the future. These reserves contain large but unknown volumes of brackish water, and in some locations the depth of usable groundwater exceeds 500 m. The usable quantity of extractable groundwater from these aquifers represents a major concern for all of the countries as their economies and populations continue to expand. Table 7 presents the features of major aquifers in the GCC countries.

Table 7: Most Important Aquifers in the GCC Countries

Aquifer	Thickness (m)	Total Dissolved Solids (mg/l)	Depth from ground surface (m)	Country
Wajid	300-400	500-1,000	15-1,110	Saudi Arabia
Saq	500-600	500-1,500	100-1,500	Saudi Arabia
Tabuk	1,000	500-3,500	10-1,400	Saudi Arabia
Minjur	360	400-1,600	1,400	Saudi Arabia
Wasia	200-230	1,000-3,000	230-1,200	Saudi Arabia
Umm er Radhuma	500	300-1,000	250-600	UAE, Bahrain, Oman
Dammmam	200	1,000-6,000	100-500	Bahrain, Qatar, Kuwait
Meogene	30-100	100-4,000	10-150	UAE, Bahrain, Oman

Source: Al-Mogren 1995, Dabbagh and Abderrahman 1997 (Elsevier 2001)

3.13 The deep non-renewable groundwater aquifers are largely located in Saudi Arabia with the exception of the Dammam aquifer, which dips to the east from Saudi Arabia into the other Gulf countries. The aquifer provides the principle underground water resources for Kuwait, Bahrain and Qatar. While these resources are non-renewable fossil water supplies due to their eastern and lower position with regard to the aquifer in Saudi Arabia, groundwater supplies are continually renewed through underflow from there. Consequently, to the degree that groundwater in the Dammam aquifer is not over-exploited within Saudi Arabia, this underflow represents a finite and limited renewable supply for Kuwait, Bahrain and Qatar. The amounts of these underflows have been estimated through modeling and, if extractions are managed within sustainable limits in those countries, this underflow could represent a strategic reserve of usable water for the foreseeable future. To the degree possible, a regional allocation policy and integrated management of the Dammam aquifer should be jointly explored through the GCC so that all countries which have access to this aquifer can receive a proportional allocation of the benefits from this resource.

3.14 To a certain extent, recharge in the northwestern regions of Oman is also considered to flow into deep aquifers and could represent a renewable supply of fresh to brackish water for agricultural and limited potable supplies within the interior of Oman. It has been speculated that the underflow from these aquifers could also represent a potential resource for the regions of Saudi Arabia and the UAE that have frontiers with Oman. No technical evidence was observed to confirm this speculation.

3.15 **Bahrain:** The primary underground water supply within Bahrain is from fossil water within the Dammam aquifer. This water is renewed on a relatively long term basis through underflow from this aquifer that originates in Saudi Arabia. This underflow from the Arabian Peninsula represented, historically, a supply to freshwater springs both on the island and offshore, that provided a freshwater supply to populations. Bahrain was renowned for its rich springs and greenery. However, the over-exploitation of this underground resource at a level far beyond the estimated 120 Mm^3 per year of sustainable yield has resulted in the cessation of flows from these springs and the loss of an environmentally and culturally significant resource to Bahrain. It has also resulted in the pollution of the water in the aquifer through the up-coning of more saline groundwater from aquifers lower in the geologic sequence.

3.16 The economic value of this restoration of surface springs fed by the Dammam aquifer should be evaluated as its tourism and cultural value could outweigh the relatively insignificant agricultural value of the use of this water. This over-exploitation supports the inefficient irrigation of primarily low-value crops. The management of groundwater extraction to recuperate the aquifer and to maintain future extractions within sustainable levels could restore the flows to the springs with significant value to the country in terms of the environment, culture, and tourism. Furthermore, this relatively renewable underground resource could represent a significant strategic reserve of freshwater to support the developed commercial/industrial economy of the country in the event of interruption of the present and future desalination systems due to pollution of the feed supply and technical glitches (or political reasons). The value of the resource for this purpose alone is possibly far more significant than its present over-exploitation to support low-value agriculture.

3.17 **Kuwait:** Within Kuwait, the principle groundwater resource is contained within the Dammam aquifer, a non-renewable resource, which is recharged through underflow from Saudi Arabia and Iraq. Given its location at the lower end of the aquifer, this resource is relatively saline and not suitable for potable use, but can be used for agricultural purposes. The examination of iso-chloride and iso-salinity maps indicates regions where the salinity of this underground water would be amenable to agricultural development. Some of these regions are presently being exploited principally near the southwestern and northeastern borders of the country. However, there is an area in the north-central region that could produce underground water of sufficient quality to support agricultural use or, more importantly, to be used as a reserve supply to the desalination systems of the country, in the event that the present supply from the Gulf is interrupted. This needs to be examined from both a water resources and an economic perspective to determine the highest and best use for this underground water supply. There also appears to be an opportunity to develop a system of groundwater recharge and well field harvesting in urban areas where water demand is highest to recharge treated sewage effluent in a controlled manner and develop a groundwater reserve. However, this needs to be developed using recharge techniques that are economical and that possibly do not require desalination of the treated effluent. This option is worthy of additional study and pilot analysis, as the value of such a reserve could be significant to the reliability of the water supplies of the country.

3.18 **Oman:** Renewable groundwater represents a significant part of the water resources of Oman. This resource has historically represented the base upon which the Aflaj culture and economy of the Sultanate has evolved. The coastal aquifers along the Gulf of Oman are recharged from orographic precipitation that occurs within the coastal mountain ranges along the central southwest to the northeast axis of the country. It is estimated that 1,300 Mm^3 of water is recharged to the groundwater aquifers in Oman, with an estimated 900 Mm^3 of water recoverable from this volume. However, present groundwater extraction within Oman is estimated to exceed the recoverable average annual recharge by 25 percent. Locally, this over-extraction is even greater, creating a major problem within the coastal region near Muscat and the developing urban area to the northeast of the capital. The result of this over-extraction, along with a five-year drought, has caused the dry-up or diminution of available supplies to the historic Aflaj, upon which the rural agrarian population depends. This has also caused significant saline intrusion into freshwater aquifers resulting in degradation of the water supplies.

3.19 The Government of Oman has developed a long range National Water Resources Master Plan which includes strong measures, including restriction of the irrigated area, to reduce groundwater extraction to sustainable levels. The Plan also calls for the development of surface water storage and groundwater recharge systems to enhance usable groundwater supplies. In the interior of Oman, it is estimated that a significant quantity of nonrenewable groundwater exists in aquifers that slope into both the UAE and Saudi Arabia. Studies have been carried out with regard to this resource, and it is estimated that 100 billion m3 of brackish water could be developed for irrigation of relatively salt tolerant crops. Moreover, it has been estimated that over 2 billion m^3 of freshwater could be made available from these aquifers for potable use. These estimates need considerable verification prior to the development of a dependence on these supplies to support an agrarian economy in this region.

3.20 **Qatar:** The situation in Qatar is similar to that of Bahrain in that the principal underground water resource comes through underflow from Saudi Arabia through the Dammam aquifer. While the estimated 50 million m^3 per year of underflow available to Qatar is somewhat less than that of Bahrain, this relatively long term sustainable supply still represents an important alternative strategic reserve for the desalination systems of the country in the event of mechanical problems or oil spills. The present over-extraction of this groundwater resource estimated to exceed 270 Mm^3 per year to support largely uneconomical irrigation of low-value crops is both unsustainable and a waste from a strategic and economic viewpoint. Desalinated water used to be blended with groundwater (around 30 percent). However, this has no longer been the case since 2001.

3.21 **Saudi Arabia** has six large sandstone and limestone aquifers. Sandstones predominate in the lower middle parts of the succession and limestone in the upper or younger aquifers. Each aquifer is very extensive. Several of them extend from the northern boundary southwards into the Rub-al-Khali, and eastwards from the central area to the Gulf. In most regions of the country, several aquifers occur one above the other.[5]

3.22 Within Saudi Arabia, a significant supply of fresh and brackish water is available from the deep aquifers that underlie the north and central-eastern portions of the country. These aquifers are presently being exploited in a rather uncontrolled manner, primarily for agricultural production. While numerous studies have been conducted, there is presently no agreement on the quantity of exploitable water available from these non-renewable aquifers or any firm policy with regard to the planned life of these sources of water at the present rate of extraction. The aquifers, according to unconfirmed estimates, store about 924 billion m^3 of water, of which 428 billion m^3 are available for extraction (Table 1). Tentative estimates indicate that annual water use in Saudi Arabia was about 20 billion m^3 in 1999, of which 16 billion m^3 (or 80 percent) comes from non-renewable groundwater resources, and around 4 billion m^3 from renewable resources (surface and groundwater, desalinated water, and treated wastewater[6]). One source estimates that about 35 percent of non-renewable groundwater resources were already depleted by 1995.[7] The government has begun to monitor groundwater extraction, reduce subsidies and adopt policies that discourage non-sustainable extraction practices. However, a firm and enforced governmental policy with regard to limitation on extractions is urgently needed.

3.23 Along the western coast of the country, there are significant renewable supplies of water within alluvial aquifers that are recharged from annual orographic rainfall in the coastal mountain range. This

[5] World Bank, Kingdom of Saudi Arabia, Assessment of the Current Water Resources Management Situation, Phase I – Volume 1, Main Report, April 2004.
[6] Ibid.
[7] Al-Turbak, A., 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, 2003.

region includes the Tihama along the Red Sea covering Jizan, Asir and Madinah regions. Over 60 percent of the estimated annual runoff of around 2 billion m^3 occurs in this region. In order to capture the surface runoff, the Government has built about 200 dams with a total storage capacity of around 800 million m^3, of which the Jizan and Ajran dams are the most important with 86 and 56 million m^3 capacity respectively. The capacity of the Jizan dam was reduced by about 70 million m^3 on account of siltation and needs occasional dredging. The dam, like others in Saudi Arabia, is exposed to a high evaporation rate and ex-post water balance and economic analyses should be carried out. This renewable resource in the region is presently exploited in a largely unregulated manner, principally for agricultural use. The optimization of this resource, through careful analysis and the development of managed recharge and extraction programs, represents a renewable resource that could be managed to support the high value agriculture now developing within this coastal region. Coupled with the implementation of strict demand management measures, this renewable underground water resource has the potential to maintain a viable agricultural economy in a sustainable manner.

3.24 **United Arab Emirates:** The groundwater aquifers of the UAE are recharged from limited surface flows which are derived from the central mountain range that lies in the southeast region of the country. Moreover, alluvial aquifers in the Emirate of Fujairah are recharged from relatively significant orographic precipitation in the coastal range along the Persian Gulf. The renewable amount is estimated at around 190 million m^3.[8] Brackish non-renewable groundwater also exists in the northwestern part of Abu Dhabi. This resource is primarily derived from the Dammam aquifer which underlies this area. The Environmental Research and Wildlife Development Agency (ERWDA) of Abu Dhabi estimates that the UAE has about 235 billion m3 of mainly non-renewable groundwater reserves, about 80 percent of which consists of brackish water. Groundwater in the UAE is used primarily for irrigation purposes with little attempt being made in the past to regulate or monitor the extraction, which far exceeds the estimated safe yield of the various aquifers and has resulted in saline intrusion, abandonment of wells, and other adverse effects of this exploitation. There is evidence that the aquifers are susceptible to recovery during wet periods provided that extraction could be limited to a safe average yield level. The regulatory and management policies for groundwater vary significantly from one Emirate to the other. If properly managed with extraction limited to the safe yield of the aquifers, the groundwater resources of the country could represent a significant strategic reserve.

B2. Desalination

3.25 All Gulf countries have an established policy of providing the principal municipal/industrial supply of water from desalination of water diverted from the sea. A significantly large share of drinking water is supplied by desalination plants in all GCC countries. In particular, Qatar and Kuwait almost entirely rely on desalination plants for drinking water supply. The UAE has rapidly increased its share by building several large-scale desalination plants to meet ever-increasing urban water demands. Saudi Arabia is by far the largest desalination water supplier for its citizens. The amount of desalination production water is around 1 billion m3 equivalent to about 40 percent of the total urban water demand. However, this ratio in 2000 is lower than that of 1990, which means that Saudi Arabia is increasingly relying on groundwater for urban water supply despite efforts for increasing desalination water production capacity (Table 8).

[8] The UAE Irrigation Sector Note, World Bank (2001)

Table 8: Desalination Water Supply Share in 1990 and 2000

Country	1990			2000		
	Municipal Water (MCM/Year)	Desalination Water Production (MCM/Year)	Desalination Share (%)	Drinking Water (MCM/Year)	Desalination Water Production (MCM/Year)	Desalination Share (%)
Bahrain	103	56	54%	115	76	66%
Kuwait	303	240	79%	465	418	90%
Oman	86	32	37%	169	55	33%
Qatar	85	83	98%	132	132	100%
Saudi Arabia	1,700	795	47%	2500	1,022	41%
UAE	540	342	63%	831	674	81%
TOTAL	2,817	1,548	55%	4,212	2,377	56%

Source: United Nations University 1997 modified with country reports.
Note:
1. No distinction is made between municipal water and industrial water.
2. Municipal water in 1990 may include general municipal use such as landscape irrigation as opposed to in 2000.
3. Blended groundwater is considered for Bahrain and Kuwait as opposed to Qatar (no information was available).

3.26 The desalination process primarily used in the GCC countries is Multi-Stage-Flash (MSF) distillation. This is an established technology and is combined with co-generation of electricity which greatly improves the economics of desalination.[9] It also exhibits significant economies of scale which are critical for large scale production. An alternative technology is Multiple Effect Distillation (MED) which is more energy efficient even for smaller desalination plants than MSF. MSF is the most widely used technology in GCC countries, which has a useful life of about 25 years that can be nearly doubled through proper maintenance and refurbishing of plants[10]. In recent years, the MED process combined with thermal vapor compression has been increasing.

3.27 While the GCC countries continue to rely on large-scale distillation plans, such as MSF, for bulk water supply in the foreseeable future, Reverse Osmosis (RO) technologies have been gradually adopted with some very large plants now in operation. RO plants had operational problems during earlier periods due to higher salinity and temperature and more abundant marine life in the Gulf. Hence, the technology was not as well received by the GCC countries as by other regions in which it was dominating the market. However, as the industry obtains a much better understanding of scaling problems and more experience with design and operation of the pre-treatment systems, which are crucial to successful plant operation, RO technology has been increasingly perceived and accepted as a cost-effective and competitive option.

3.28 The primary fuels used for desalination are petroleum and natural gas, which are primarily produced within each country. However, in Kuwait, the older plants are being considered for replacement with plants using natural gas imported from Qatar. Although this would provide significant savings in the cost of desalinated water that are estimated to exceed US$ 700 million annually and improve the reliability of supply, such imports would move through pipelines constructed across Saudi Arabia, and the

[9] The MSF plants are coupled with power plants which can supply "low grade" steam. This is often referred to as waste heat. This is a misnomer. The steam used by MSF plants could be used to generate more electrical power but at low efficiency. By tapping this steam at a higher temperature than necessary, the power output of the power station is slightly reduced (WB desalination report in 2004).

[10] Richard Morris and Associates, Kingdom of Saudi Arabia, Water Sector Strategy and Action Plan, World Bank Two-Year Cooperative Program (2003-2005), (report prepared for the World Bank), July 2003.

negotiations for rights of way that have not been completed. The use of natural gas as a fuel for desalination promises to be more efficient, less costly and more environmentally neutral than petroleum.

3.29 Table 9 shows the presently installed desalination capacity and production for each country as reported by GCC officials or official statistics.[8] Saudi Arabia has the largest installed capacity, followed by the UAE, while Bahrain and Oman have the smallest installed capacity. Kuwait plans to increase desalination capacity from the current 522 to 606 million m^3 by 2005. Oman plans to increase its annual desalination capacity from 60 to 69 million m3 while Qatar plans to increase its annual capacity from 178 to 275 million m3. Bahrain and the UAE have also taken on major desalination projects.

Table 9: Desalination Capacity of GCC Countries

(unit: MCM/Year)

Country	1990	2000
Bahrain	75	104
Kuwait	318	522
Oman	55	60
Qatar	112	178
Saudi Arabia	950	1,278
UAE	502	1,081
Total	2,012	3,223

Source: United Nations University 1997 modified with country reports.
Data for the year 2000 was provided by individual countries
Note: The capacity data was provided in terms of m3/day, but was later converted to millions of m3/year for the sake of easy comparison with other water supply and demand data.

3.30 The cost of desalinated water is high and varies with the technology used, scale, and age of plants. Studies show that capital costs exhibit economies of scale or a lower cost as plant size increases. For smaller desalination plants producing 10,000 m^3/day or less, the capital cost per cubic meter produced is around US$ 1.4-2.0/m^3, which falls to around US$ 0.7-1.3/m^3 for larger desalination plants having a capacity of 20,000 m^3/ day and greater. Recent cost estimates for a desalination plant of 30,000 - 32,000 m3/day indicated that the total water costs are in the range of US$ 1.04 -1.25/m^3 for MSF, US$ 0.75 – 0.95/m^3 for MED, and US$ 0.68 – 0.82/m^3 for RO.[11]

3.31 The cost of producing desalinated water, including both capital and operating costs, has fallen appreciably during the last decade. The water purchase price of a new MSF plant of the capacity of 4 x 57,500 m3/d in Taweelah (Abu Dhabi, the UAE) is reported to be around US$ 0.84 /m3. The most efficient RO plants in Tampa, Florida (95,000 m3/d) and Ashkelon, Israel (274,000 m3/d) are reported to have production costs of around US$ 0.50/m^3. It should be noted that the salinity level of the feed water for the RO plant in Tampa Bay is around 26,000 mg/l, which is much lower than the approximate figure of 45,000 mg/l in the Gulf (Table 10). Moreover, the RO plant in Ashkelon is still under construction and the definite figures on energy consumption has not been available. The energy costs may be subsidized in both cases.[12] In the RO membrane process, energy consumption is directly related to the salinity of the

[11] N.Wade, 2001 for 32,000 m3/d and IWACO, 2000 for 30,000 m3/d: from the World Bank study below noted.
[12] However, recent advancements in energy recovery devices utilizing pressure and work exchangers with the RO plants resulted in reducing specific energy consumption from 5 to 2 kwh/m3.

feed water whereas in the distillation process, the salinity of the feed water has little impact on the overall energy consumption.[13]

3.32 The brackish groundwater desalination is being used near major urban centers due to relatively lower costs. Numerous RO plants have been built mainly in Saudi Arabia and Oman for providing potable water with people living in outlying populated areas that have no other source but brackish groundwater. The unit production cost is much less than that of seawater desalination due to lower salinity ranges from around US$ 0.3/m^3 to US$ 0.6/m^3. The costs of water production depend on some other factors, such as plant size and the concentration of salinity, heavy metals and organic materials.

Table 10 : Salinity Level of Seawater and Brackish Groundwater

Unit: Total Dissolvied Solids (TDS mg/l)

Water	TDS (mg/l)
Gulf	45,000
Red Sea	41,000
Closed seas: Mediterranean Sea	38,000
Open seas (oceans)	35,000
Baltic Sea	7,000
High salinity brackish water	5,000-15,000
Low salinity brackish water	1,000-5,000
Potable water	<1,000

Source: World Bank Desalination Study 2004

3.33 While most of the environmental negative impacts can be mitigated by technologies, there is a significant concern about the disposal of brine (a concentrated salt solution that may be hot and may contain various chemicals) which could harm coastal and marine ecosystems or in the case of inland brackish water desalination, pollute aquifers, wadi flows and soils. Any chemicals added to the desalination process for scale prevention, corrosion reduction and corrosion products may be discharged to those water bodies together. The increased amount of brine discharge to the Gulf could also lead to a building up of salt concentrations given the enclosed nature of the sea. Likewise, inland brackish water desalination plants can also face major challenges in disposing brine discharges in a safe manner and incur heavy treatment costs.

B3. Wastewater Treatment and Reuse

Lagging Wastewater Treatment and Water Pollution

3.34 The GCC countries have made substantial progress in providing basic water and sanitation services for most of their citizens, which was a commendable effort given the rapidly increasing population in urban areas. Where population densities are low, on-site sewage disposal systems, such as septic tanks and cesspits, are acceptable as long as proper design, construction and maintenance works are provided on the basis of sound technical standards. However, as the number of population and water supply volume in urban areas has increased very rapidly, there are bigger chances that the incidence of overflowing tanks and malfunction would cause significant environment and health hazard.

[13] DHV Water BV (Netherlands) and BRL Ingenerie (France) Seawater and Brackish Water Desalination in the Middle East, North Africa, and Central Asia, December 2004 (report prepared for the World Bank).

3.35 As witnessed in some major urban centers, such as Muscat, Kuwait City, and Doha, water tables are rising, leading to basement flooding and other structural problems due to leakage from water distribution networks and wastewater systems. This phenomenon increases the chance of spreading contaminants in larger areas and polluting aquifers. There is some evidence that inadequate septic tanks and other on-site waste disposal facilities caused increases in nitrate concentrations. Even worse, in some areas, wastewater is discharged directly to aquifers, wadis and costal lines without proper treatments, causing severe environment and health problems locally.

3.36 Despite countries' efforts in providing basic services to their citizens, innovations in wastewater collection and treatment systems continues to lag far behind urban development. Table 11 illustrates the quantity of treated wastewater produced and reused wastewater in GCC countries. On the basis of the amount of treated wastewater compared to the total produced drinking water, the coverage rate of sewerage collection and treatment system seems to be in the range of 20-40 percent[14], lagging far behind water supply services (about 80-90 percent). Kuwait is an exception with the high rate of 60 percent as in the table. In the UAE, wastewater collection and treatment is highly developed in the major metropolitan areas, such as Dubai, Abu Dhabi, Sharjah and Ajman, which collectively treat 623,000 m^3/day (227 million m^3/year).[15] It should be noted that the actual coverage rate varies within countries. It was reported that the western part of Saudi Arabia, such as Jeddah, is lagging in wastewater treatment in comparison with higher coverage rate in its eastern part.

3.37 In order to meet the rapid expansion of urban areas and increasing population growth, GCC countries have embarked on major wastewater treatment construction projects from sewage collection, proper treatment (increasingly to tertiary level), and possible increases in treated wastewater reuse. They have prepared ambitious investment programs for rapidly expanding the coverage of sewerage treatment systems. Kuwait plans to increase its capacity from 260 MCM to 340 MCM by 2020, Bahrain plans to increase from 24 MCM to 78 MCM by 2010, and Qatar will increase from 44 MCM to 73 MCM over the next three years. The UAE plans to significantly increase its treatment capacity and Saudi Arabia plans to expand the sewerage network coverage over 90 percent of major metropolitan areas. While these ambitious plans will certainly improve environmental and hygiene conditions, the treated wastewater amount will certainly constitute a substantial portion of water supply in the near future and strategic reuse planning is indispensable.[16]

[14] The treatment rate would be lower if we take the total urban water use instead of desalinated water as the denominator.
[15] The total volume of treated wastewater in the country is estimated at 265 million m^3 per year.
[16] Other sources indicated that the treated wastewater volume in Saudi Arabia is around 1.3 million 3/d (475 MCM), of which 30-40 % is treated to the tertiary level. The figure of 475 MCM seems to include on-site treatment.

Table 11: Treated Wastewater and Reuse in 2000

Country	Desalination Water Production (MCM/Year)	Treated Wastewater (MCM/Year)	Reused Wastewater (MCM/Year)	Wastewater Treatment Rate (%)	Treated Wastewater Reuse Rate (%)
Bahrain	76	24	17	32%	71%
Kuwait	418	260	182	62%	70%
Oman	55	12	8	22%	67%
Qatar	132	44	31	33%	70%
Saudi Arabia	1,022	240	98	23%	41%
UAE	674	265	159	39%	60%
TOTAL	2,377	845	495	36%	59%

Note:
1. The wastewater treatment rate is based on its volumetric share of the total desalination water production volume without considering the amount of treated wastewater by on-site sanitation equipment.
2. The treated wastewater reuse rate is based on its volumetric share of the total treated wastewater volume. No concrete inforamtion was available to indicate the actual reuse rate due to lack of monitoring.
3. Desalination water production volume of 76 MCM in Bahrain includes 19 MCM of brackish water desalination using reverse osmosis process.

Limited Wastewater Reuse

3.38 In all GCC countries, the full utilization of treated wastewater remains in the early stages of development and in some areas, much of the treated wastewater even to the tertiary level is discharged unused to the sea. The volume of reuse of treated wastewater is still far less than the volume of treated wastewater discharged.

3.39 The primary use for treated wastewater is for municipal landscaping. This usage is accepted from a social and aesthetic standpoint and provides a means for beautifying the municipal environment in this arid region. In the UAE, more than 50 percent of the tertiary-treated wastewater is utilized in this fashion with the remainder being discharged to the sea.

3.40 Treated wastewater is also used for the irrigation of crops not consumed by humans such as fodder crops and for landscaping. However, due to the long distance between treatment plants and the point in use for irrigation, the irrigation use is rather limited except for some specialized development schemes.

3.41 In Kuwait, the government recently negotiated a contract for a large-scale Build-Operate-Transfer (BOT) scheme to install a quaternary level wastewater treatment plant using RO technology along with the pipeline distribution system to farming areas. The objective is to purify the wastewater to an extent that it could be used for agriculture in greenhouses. The purification of treated wastewater to such a level has significant economic implications. It also has envisaged plans for using treated wastewater for aquifer recharge in order to create a reserve for potable water in the event that there is a disruption in the desalination systems.

3.42 In Qatar, the potential exists for using treated wastewater to recharge the groundwater aquifers through karstic depressions that exist in the interior. While it is desirable to use treated wastewater to support irrigated agriculture and to diminish unsustainable groundwater extraction, the economic cost of the use of such water should be carefully analyzed, particularly if treatment is to exceed the normal treatment cost and where costly transportation is required. Another factor to be considered is the impact of the treated wastewater on groundwater quality and potential hygiene and health risks. Careful risk control measures are required.

3.43 In Saudi Arabia, treated wastewater in Riyadh has been utilized systematically by the National Irrigation Authority (NIA) from pumping, storing, conveying over 40 km and 60 m elevation higher, and distributing it to farming areas. The NIA supplies a maximum of 300,000 m3/day of treated wastewater (average reused volume is around 50 million m3 /year for the last ten years) to farms for around 15,000 ha. The irrigated crops include wheat, fodder, orchards and palm trees.

IV. MAIN CHALLENGES IN WATER RESOURCE MANAGEMENT

This section highlights the key water management issues facing the GCC countries, principally being; (A) unsustainable use of groundwater resources; (B) lack of urban water demand management; (C) institutional and legal constraints; and (D) limited private sector participation based on the water resources data and assessment in the previous chapter.

A. <u>Unsustainable Use of Groundwater Resources</u>

Some GCC countries are depleting non-renewable groundwater and water quality is deteriorating at rapid rates

A1. Rapid Aquifer Depletion Due to Inefficient Irrigation Expansion

4.1 Without exception, all of the GCC countries are extracting groundwater resources in an unsustainable manner. In Oman, Bahrain, Kuwait, Qatar, and the UAE, this represents a level of extraction in excess of the natural recharge of the aquifers. In the case of Saudi Arabia, this represents the accelerated extraction of non-renewable resources without adequate knowledge of the finite life of water supplies within the aquifers.

4.2 In particular, groundwater abstraction has been rapidly accelerating in Kuwait, Qatar and the UAE, whose over-pumping rates against the safe yield[17] are around 250 – 1400 percent (Table 12). As a result of the uncontrolled groundwater extraction, the remaining groundwater resources in the UAE are mostly brackish. The UAE government seems to be relinquishing aquifer conservation policy in exchange for promoting expanded irrigated agriculture within the backdrop of its enormous financial capability and vast land on the assumption that they may have to abandon some wells but may be able to find other aquifer sources in other areas.

4.3 Saudi Arabia, has heavily tapped into large reserves of non-renewable aquifers and around one-third of its non-renewable groundwater resources are estimated to have been depleted[18]. The potential reserve of the aquifers and their level of use are still being debated and await more detailed survey and modeling. The country has embarked on a major reform program including the establishment of a new Ministry of Water and Electricity. However, the sheer size of the country poses a tough question on how to balance groundwater conservation and the rural economy, mainly supported by irrigated agriculture.

[17] The 'safe yield' was based on the governments' estimates of annual rechargeable groundwater. The concept of the safe yield in such arid climatic conditions warrants careful consideration. In this report, these estimates of safe yield were used to compare with the amount of groundwater extraction.
[18] Al-Turbak, A., op. cit.

Table 12: Increasing Groundwater Abstraction and Mining

Country	Non Renewable Reserve (MCM)	Renewable Volume (MCM/Year)	Abstraction Volume (MCM/Year)		Pumping as a Percent of Renewable Water	
			1990	2000	1990	2000
Bahrain	negligible	110	167	195	152%	177%
Kuwait	n/a	160	143	393	89%	246%
Oman	102,000	900	1,204	1,240	134%	138%
Qatar	negligible	50	111	270	222%	540%
Saudi Arabia	428,400	3,850	15,505	19,680	403%	511%
UAE	n/a	190	1,148	2,673	604%	1407%
TOTAL		5,260	18,278	24,451	347%	465%

Source: Data provided by countries, Alsharan et.al, Hydrogeology of an Arid Region, Elsevier, 2001and team's analysis

Note: The groundwater abstraction volume and renewable recharge volume was based on the county reports, other reports and team's analysis as stated in the note of table 1.

4.4 The over-extraction of groundwater beyond safe yield levels has resulted in the pollution of the existing groundwater aquifers due to intrusion of saline seawater and the up-coning of brackish and saline water supplies from lower aquifers. This is particularly problematic in Oman, Bahrain and Qatar where major deterioration of groundwater quality can be observed through examination of iso-chloride and iso-salinity maps over time. Furthermore, the excessive use of fertilizers and pesticides, which may be subsidized, has contributed to the pollution of aquifers through seepage.

4.5 However, it seems feasible that aquifers conditions could improve if strong measures are adopted to reduce groundwater abstraction to sustainable levels although, this would take generations to accomplish. Oman seems to have started controlling aggravation of groundwater mining although they still have to reduce the abstraction volume to sustainable levels. It has also adopted a comprehensive set of measures for sustainable groundwater management by establishing strong monitoring and regulatory programs as well as conservation of the traditional Aflaj system.

4.6 The use of groundwater for irrigation of low-value agricultural crops in GCC countries had resulted in the wastage of both non-renewable and renewable resources which would be better reserved for present or future high value uses. Only limited attempts have been made for controlling groundwater demand through the use of water charges, restrictions on groundwater pumping, limitations on groundwater development, and the introduction of advanced irrigation systems.

4.7 Notwithstanding the fact that 85 percent of the area equipped for irrigation in the UAE and 53 percent in Saudi Arabia is equipped with modern irrigation techniques, low irrigation techniques, such as flood and furrow irrigation, are still being used. In Saudi Arabia, large areas are irrigated by center pivot sprinklers for cultivating wheat and alfalfa. These irrigation technologies result in heavy water losses for evaporation and percolation to levels below the root zones of the crops. The total losses combined with transmission losses through the use of open and unlined canals, can exceed 50 percent of abstracted groundwater.

4.8 In comparison with a large share of groundwater use for irrigation, the contribution of the agriculture sector to Gross Domestic Product (GDP) in GCC countries is small. Agriculture consumes around 60-90 percent of total groundwater use, but accounts for 2-6 percent of GDP in Saudi Arabia, the UAE, and Oman. The agriculture sector is much more insignificant in Bahrain and Kuwait, constituting less than 1 percent of GDP while still using around 55-70 percent of total available water resources. In Qatar, groundwater use is primarily for irrigation purposes despite its minuscule contribution to the economy. Table 13 below presents data on groundwater use in irrigation in the GCC countries.

Table 13: Groundwater Irrigation and Agriculture

Country	1990		2000			1990 - 2000	2000
	Irrigation Water (MCM/Year)	Total Groundwater Abstraction (MCM/Year)	Irrigation Water (MCM/Year)	Total Groundwater Abstraction (MCM/Year)	Irrigation Water Share of Total Groundwater Abstraction (%)	Groundwater Irrigation Volume Increase (%)	Agriculture GDP share (%)
Bahrain	120	167	137	195	70%	14%	<1%
Kuwait	80	143	221	393	56%	176%	<1%
Oman	1,150	1,204	1,124	1,240	91%	-2%	2.1%
Qatar	109	111	270	270	100%	148%	<1%
Saudi Arabia	14,600	15,505	18,300	19,680	93%	25%	6.4%
UAE	950	1,148	2,162	2,673	81%	128%	3.6%
Total	17,009	18,278	22,214	24,451	91%	31%	

Source: Country data and team's analysis

A2. Distorted Agriculture Subsides and Support Program

4.9 One of the primary reasons for the unsustainable exploitation of groundwater resources has been the provision of direct and indirect subsidies to well excavation, pumps, fuel and other inputs as well as price support programs and trade protection in some GCC countries. This has resulted in distorted costs and revenues as well as misallocation of resources by artificially attracting investment to the sector that have obscured the high opportunity cost of groundwater for municipal and industrial uses, and have created a disincentive for the rational use of this resource. While the governments intend to redistribute oil revenues for citizens, given that most of the employment in the agriculture sector is provided by expatriates, employment generation is not an objective of agricultural policy in GCC countries.

4.10 In Saudi Arabia, lavish agricultural input, output, and credit subsidies had been provided to private farmers who irrigate around 1.2 million ha of land.[19] An important instrument of agricultural policy in Saudi Arabia was the producer price support program for wheat, which in 2000 was 3.75 times the import parity price. The import of wheat and flour was subject to a 100 percent duty and the imports of fresh fruits and vegetables were subject to an agricultural calendar during which a 25 percent duty is applicable. As a result, the high rate of growth in the agriculture sector led to nearly a quadrupling of the cropped area and a tripling of the volume of irrigation water used from around 7.4 billion m^3 in 1980 to 20.2 billion m^3 in 1994. When only the economic cost of water is considered, value added in wheat production is negative, and there is little economic justification for wheat production in Saudi Arabia[20].

4.11 Since 2000, the Saudi government has taken bold and commendable steps such as stopping land distribution and reducing input subsidies in order to reduce groundwater depletion, encourage efficient irrigation water use and reduce fiscal burdens. It has also provided incentives for the use of water-saving technologies such as drip irrigation and soil moisture sensing equipment. Wheat production fell from 4 million tons in 1992 to 1.8 million tons in 2000. The estimated irrigation water demands fell from 20.2 billion m^3 in 1994 to 18.3 billion m^3 in 2000.

[19] Irrigation engines and pumps, 50%; agricultural machinery, 45%; and poultry and dairy equipment, 30% (20% with a loan). SAAB finances 100% of interest free loans up to SR200,000, 75% up to SR 3 million, and 50% for loans over SR 3 million.
[20] World Bank (draft report), Kingdom of Saudi Arabia, Divestiture of Grain Silos and Flour Mills, 2000

4.12 Over the last decades, the net irrigated areas increased in all GCC countries by around 100-300 percent[21]. In the case of the UAE, Kuwait, Qatar and Bahrain, new irrigation projects have been initiated by the governments with the provision of various forms of subsidies. Advanced irrigation systems, including dripper and greenhouses, have been built to cultivate high value cash crops. In addition to fresh groundwater, brackish groundwater, reclaimed and desalinated water use will be increased under a tightly controlled system. However, those countries have been facing with rapid aquifer depletion and salinization. Some of the farming areas ended up being abandoned.

4.13 In the *UAE*, the government of Abu Dhabi reclaims land to make it cultivable before ceding it to farmers. As a result of these types of incentives, farming land in the UAE increased from 73,000 ha to 242,000 ha over the 1995-2000 period. The state subsidizes 50 percent of the cost of modern irrigation equipment, greenhouses and selected inputs. Abu Dhabi also has a price support program for some crops. The UAE has significantly increased the production of vegetables, fruits, fodder crops as well as dairy products with the support of various subsidies. It is now exporting flowers to Europe. However, this trend has caused aquifer depletion and salinization in many places and some farm areas have been abandoned.

4.14 In *Kuwait*, agricultural production, particularly for the production of higher-value vegetables and fruits, is highly subsidized in the form of production payments and energy subsidies. As a result, the irrigated area in Kuwait increased by 40 percent from 6,265 ha in 1996 to 8,822 ha in 2000.

4.15 In *Qatar*, there is a moderate program to encourage the use of advanced irrigation techniques through subsidies, in addition to a program to supplant groundwater use with treated sewage effluent at no charge to farmers. The Government also provides some free services to farmers in the form of fruit and windbreak seedlings, pesticides, and the use of agricultural machinery. As a result, Qatar currently produces 83 percent of its consumption of dates, 54 percent of milk and dairy products, and 40 percent of vegetables.[22]

4.16 In *Bahrain*, the Government provides the free use of agricultural machinery for farmers and sells vegetable seeds at subsidized prices to them. In Bahrain, the irrigated area increased by about 70 percent to 4070 ha between 1999 and 2001 as a result of establishing new farms and increased usage of treated wastewater for irrigation.

4.17 In *Oman*, temporary financial contributions were provided to Aflaj systems to alleviate the impact of a five-year drought. Agricultural support programs also provide 65 percent of the purchase price subsidies and installation of advanced irrigation systems in villages for demonstration purposes.

B. <u>Lack of Urban Water Demand Management</u>

Throughout the GCC, there has been a primary concentration on the development of water supplies and addressing all water resources problems from the supply side. There are few, if any, efforts to improve demand management of urban water supplies through metering, pricing and other efficiency improvement measures.

B1. High Per Capita Water Consumption Due to Inadequate Demand Measures

4.18 Unaccounted-for-Water (UFW) seems to be rather high in GCC countries, such as Saudi Arabia and Qatar (around 30-40 percent), while the situation is better in Bahrain, Oman and the UAE due to a relatively reliable metering system. Considering that about half of the municipal water supply in Saudi

[21] FAO Statistics
[22] Ministry of Municipal Affairs and Agriculture, 2000 Agricultural Census, Doha, Qatar.

Arabia, and almost all of potable water in Qatar, come from desalination plants, it is apparent that such high losses lead to significant financial losses. It was rather difficult to accurately estimate the actual quantities of fresh water consumed and number of water users covered by networks due to serious deficiencies in water metering and billing as well as assessing physical losses in the distribution network.

4.19 A striking common characteristic of GCC countries, with the exception of Oman, is the very high level of water consumption per capita. Qatar and the UAE are the largest users, producing respectively 744 l/c/d and 631 l/c/d (liters per capita per day) in 2002. Bahrain and Kuwait have a gross consumption equal to around 500 l/c/d while estimates for Saudi Arabia indicate an average of 300 l/c/d (Table 14). Oman is the only country in the region where consumption is relatively low, at about 200 l/c/d in 2002.

4.20 Even if we assume the UFW rate as 30 percent, net consumption reaches 520 l/c/d in Qatar and 460 l/c/d in the UAE. These volumes are too high by international standards. With the exception of Oman, all GCC countries consume far more water than the member countries in the Organization for Economic Cooperation and Development (OECD) in which per capita consumption ranges around 150 – 300 l/c/d.

4.21 Most of the GCC countries have not addressed the tariff, metering and billing as major policy issues, which led to the excessive use and its rapid increase of municipal water. The lower cost recovery has also created problems of heavy reliance on government subsidies and inadequate operation and maintenance budget, leading to the occurrence of deferred maintenance of desalination systems with a concomitant decrease in service over time, in Saudi Arabia, Kuwait and others.

Table 14: Trends in Per Capita Fresh Water Production in GCC Countries (1980-2002)

Category	**l/c/d**			**Growth in production (% annual)(1)**					
	1980	**1990**	**2002**	**1980s**		**1990s**		**1980s&1990s**	
				Total	**Per capita**	**Total**	**Per capita**	**Total**	**Per capita**
GCC Countries									
Bahrain	415	579	511	8.9	3.9	2.6	-1.0	5.4	1.1
Kuwait	208	368(2)	503	8.2	3.5	7.0	2.0	7.6	2.8
Oman(3)	75	186	203	16.5	12.6	4.5	0.8	10.0	5.9
Qatar	-	557	744	-	-	7.0	3.6	-	-
Saudi Arabia(4)	-	-	300	-	-	-	-	4.2(5)	-
UAE	-	590(6)	631						

(1) The period over which the average annual percentage change is calculated varies from one country to another according to data availability.
(2) For the year 1992 given the country conditions of 1990-91
(3) In Oman it is estimated that MEW water supply accounts for only 55% of fresh water produced. Given volumes produced and assuming that this supply accounted for a lower proportion of total water in earlier years we get estimates for total production and for per capita production for the whole country.
(4) Based on KSA Assessment of the Current Resource in Water Situation (Draft Report, WB, 2003)
(5) Average annual growth over the period 1985-95

Sources: Estimates based on data provided by national ministries or water companies

Table 15: Per capita Consumption of Freshwater in Selected Countries(1)

Country	L/c/d
Tunisia (2002)	106
Western Australia (2003)	411
Ontario, Canada (2003)	215
England (1997)	141
Israel (1998)	250
Germany (1997)	129
Fukuoka, Japan (2000)	307

The figures for the OECD countries are the closest to residential water consumption although they may include use by small businesses in some cases.

Sources: For Tunisia, SONEDE (Société Nationale d'Exploitation et de Distribution des Eaux); for OECD countries: Working Party on Economic and Environmental Integration, "Household Water Pricing in OECD Countries", OECD, 1999
Great Lakes Commission, Canada, 2004

4.22 Bahrain, Oman, and Saudi Arabia have adopted progressive block tariff systems, whereas Kuwait, the UAE, and Qatar have retained flat rate systems. Qatar and the UAE effectively exempt their national citizens from municipal water charges. As a result, the actual cost recovery rates are lower than normal tariff rates.

4.23 The lower per capita consumption rate of Oman has indicated the modest increase from 186 l/c/d to 203 l/c/d between 1990 and 2002. The current water use per capita is by far the lowest among the GCC countries. Oman has adopted a tariff policy that is more conducive to water-saving than other countries. It sets much higher tariffs than other GCC countries. It also applies an increasing block tariff system for residential and government use comprising two consumption brackets with a threshold of 23 m^3 of water consumption per month. The corresponding tariffs are 1.14 and 2.11 US$/$m^3$. These tariffs are by far the highest among the GCC countries except for Dubai, where tariffs are applied only to expatriates. The relatively lower coverage of municipal water supply network may also contribute to this lower figure since tanker water users must use water more carefully.

4.24 In Kuwait, the per capita water consumption rose nearly 2.5 times from 208 l/c/d to over 503 l/c/d between 1980 and 2002. This rapid increase may attribute to the huge decline in the relative price of water. Leakages, which have not been well assessed, may also have contributed to this high water use. It was reported that Kuwait City has been faced with a rising water table due to the increased leakage from water distribution and wastewater collection networks. Most households are connected to the water supply network.[23] The extended use of fresh water for home garden irrigation may account for as much as half of total domestic use in some areas[24]. It was also reported that dual water distribution systems which used to supply brackish water for garden irrigation significantly reduced it due to the increased salinity of groundwater.

[23] Unconnected areas obtain their supplies by tankers through filling stations, which account for about 12 percent of total water sales, according to estimates of the Ministry of Energy and Water (MEW).

[24] A. Mukhopadhyay, A. Akber and E. Al-Awadi, "Analysis of Freshwater Consumption Patterns in the Private Residences of Kuwait" in Urban Water, 3, Elsevier, 2001. The sample on which the study is based may however not be very representative since it involves 48 households only. The controlled experiment by installing a separate meter for outdoor water use is based on an even smaller number of households.

4.25 In Bahrain, the per capita water consumption decreased from 579 l/c/d to 511 l/c/d during 1990 and 2002 after having witnessed an annual increase rate of around 4 percent in 1980s. Contributing factors may be the generalization of metering since 1986 and the stricter enforcement of billing. Although it has employed a progressive tariff system since 1990, the rate itself is very low: the first block below 60 m3/month is US$ 0.07/m3, which translates to around US$ 4 per month for a household of five members. The reduction of the UFW from around 36 percent to 21 percent between 1993 and 2002 was also an important factor. This case highlights a very important lesson that the introduction and enforcement of metering and billing is very effective even if the tariff rate is very modest compared to water supply costs. Educational programs also helped raise public awareness for water conservation.

4.26 Qatar indicated the highest per capita consumption rate of 744 l/c/d and a sharp increase from 560 l/c/d in 1990. While the rapid increase of the average income and lifestyle may have partly contributed to this increase, inadequate pricing policies must have played a significant role in bringing about this sharp increase. Although it sets a relatively high tariff of US$ 1.21/m3 for non-nationals, nationals do not pay for water in their primary residences. Deficiencies in metering and water leakages from distribution networks seem to be important factors. Doha has faced rising water tables due to increased leakage from water distribution and wastewater collection networks.

4.27 In Saudi Arabia, the per capita consumption in 2002 is estimated at around 300 l/c/d, which is smaller than other GCC countries except Oman. However, it is still higher than that in the OECD countries. Although the country has adopted a progressive tariff system, the rate for the first two categories (0-50 m3/month and 50-100 m3/month) are extremely low, which are US$ 0.03/m3 and US$ 0.04/m3 respectively. High UFW rates (30-40 percent) and inadequate metering should also be addressed for reducing the per capita consumption rate. This is quite important for the country given its much higher number of current population and the predicted growth rate over the next decades.

4.28 In the UAE, per capita water consumption increased from 590 l/c/d to 630 l/c/d between 1995 and 2002. Water tariffs in the UAE vary from one Emirate to another, but the metering and pricing policies effectively exempt nationals from water tariffs. No water distribution companies have introduced progressive block tariff systems.

Table 16: Water Tariffs in GCC Countries, US$/m^3

Category	Residential			Government	Commercial	Industrial
	Piped	Tanker	Un-metered			
Bahrain (2004)						
Domestic blended						
1-60 m3	0.07			0.07		
61-100 m3	0.21			0.21		
101 and +	0.53			0.53		
Commercial and industrial blended						
1-450 m3					0.80	0.80
451 and +					1.06	1.06
Kuwait (2004)						
US$/m3	0.57	0.22		0.57	0.57	0.18
Oman (2004)						
1-23 m3/month	1.14	1.16 – 1.38		1.69	1.69	1.69
above 23 m3/month	2.11	1.16 – 1.38		2.11	2.11	2.11
Qatar						
Consumption (other than for first residence of Qataris)	1.21					
Saudi Arabia (Riyadh 2003)						
0-50 m3/month	0.03			0.03	0.03	0.03
51-100 m3	0.04			0.04	0.04	0.04
101-200 m3	0.53			0.53	0.53	0.53
201-300 m3	1.07			1.07	1.07	1.07
301 and +	1.60			1.60	1.60	1.60
UAE						
Abu Dhabi (ADWEA)	0.60	0.30	13.75/month	0.60	0.60	0.60
Dubai (DEWA)	2.10			2.10	2.10	2.10
SEWA	1.6			1.8	1.8	1.8
FEWA	1.2			1.2	1.2	1.2

Sources: Official ministries or authorities in charge of the water sector.

4.29 Most importantly, the per capita consumption rate greatly differs between metered and un-metered groups within the residents covered by the Abu Dhabi Water and Electricity Authority (ADWEA). While non-nationals are charged with a flat rate of US$ 0.60/m3 based on metering and billing, non-metered nationals are charged with a flat monthly fee of US$ 13.75/month. Based on the information provided by the Abu Dhabi Regulation and Supervision Board (RSB), it is estimated that non-metered customers consumed about 1400 l/c/d, while metered customers used only about 260 l/c/d. The average price paid by non-metered customers is estimated at about US$ 0.04/m^3, as opposed to US$0.60/m^3 paid by metered customers. Non-metered users (nationals), for instance, use desalinated water to maintain their lawns and gardens. Other factors, such as differences in life styles and type of houses may contribute to the huge difference in per capita water consumption between the two categories.

However, there is no doubt that the very low flat monthly charge without metering contributes to wasteful water use. Table 16 below indicates various types of water tariffs currently in existence in the GCC countries and Table 17 presents water prices in some OECD countries for comparative purposes.

Table 17: Water Prices in selected OECD coutnries
Unit: US$/m3

Countries	Unit Cost
Australia	1.7
Austria	1
France	3.1
Netherlands	3.2
Portugal	1
Spain	1.1
United Kingdom	2.2
USA	1.3

Source: Environmental Indicators Volume 3, OECD 2001 and "The Price of Water", 2001

B2. Heavy Water Subsides and Fiscal Burden

The tariff policies of the GCC countries are not conducive to water conservation as seen in the previous section. Given the low cost recovery and rapidly increasing population, water subsidies would become a very heavy burden on GCC economies if current tariff policy and water use patterns continue.

4.30 In the GCC countries, production costs range between US$ 1.1/m3 and US$ 2.0/m3, except for the lower costs in Bahrain (US$ 0.65/m3) where much cheaper groundwater is blended with desalinated water around one-third and two-thirds respectively, for drinking use.[25] More importantly, the gap between production costs (including production, transmission, and distribution) and revenues is quite large in all GCC countries, resulting in large subsidies portion ranging between around US$ 0.5/m3 and US$ 1.8/m3[26] (Table 18).

4.31 Water sales revenue is very low in Saudi Arabia, averaging US$ 0.08/m^3, which covers barely 6 percent of cost, while in Kuwait; sales revenue covers less than 10 percent of costs. In Abu-Dhabi, the average charged price is lower than nominal tariff rate because usage by a large proportion of the population is non-metered. Users pay only US$0.13/$m^3$ on average, while the cost is estimated at US$1.2/$m^3$.[27] Oman's water tariffs are relatively high even for the lower consumption bracket, whose average revenue is about US$0.84/$m^3$, while the average price is estimated at around US$ 1.34/m3.[28] In

[25] Furthermore, in countries like Bahrain, desalination capacity is being increased in order to reduce dependence on depleting groundwater resources. The proportion of groundwater used for drinking fell from 93 percent in 1980 to 34 percent in 2002. It is anticipated to fall further as the Ministry of Electricity and Water (MEW) plans to rely increasingly on desalinated water in the near future.

[26] Cost figures are based on audited accounts, such as in the case of Bahrain and UAE (Abu Dhabi), and in some other cases on estimated averages for different desalination plants and proportions between desalinated water and pumped groundwater.

[27] Because of data limitation, the average costs and revenue figures of the Abu Dhabi was used for all drinking supply in the UAE in the latter paragraphs.

[28] The average revenue is estimated for Oman on the basis of the tariff schedule. Metering is strictly enforced but no data are available concerning the revenues actually collected.

Qatar, , the average revenue is estimated at around US$ 0.42, which is much lower than the average production cost of US$ 1.31/m3. The subsidy portion of Bahrain's tariff is relatively smaller thanks to the lower production cost despite of its lower tariff rate (US$ 0.17/m3).

4.32 As Table 18 indicates, the total amount of water subsidies is quite high for all GCC countries both in terms of budgetary amounts and as a share of oil export revenue. In Saudi Arabia, estimated subsidies reached US$ 3.2 billion in 2000, which represents 1.7 percent of GDP and 7.0 percent of oil export revenue. In Kuwait, estimates based on the cost of water supply and the actual revenue from water sales show a total subsidy of almost US$ 830 million in 2000, about 2.4 percent of GDP and 5.9 percent of oil export revenue[29]. In the UAE, freshwater subsidies account for around 1.2 percent of GDP, while Oman and Bahrain spend respectively 0.4 and 0.7 percent of their GDP on water subsidies.

Table 18 : Estimates of Current Costs and Subsidies for Freshwater in the GCC Countries

Country	Total Production in 2000 (in Mm3)	Cost (US$/m3)	Average revenue (US$/m3)	Subsidies		
				In US$ million	% of GDP	% of Oil Export revenue
Bahrain[(1)]	115	0.65	0.17	55	0.7%	1.4%
Kuwait[(2)]	465	1.98	0.19	832	2.4%	5.9%
Oman[(3)]	169	1.34	0.84	85	0.4%	1.1%
Qatar[(4)]	132	1.31	0.42	117	0.7%	1.3
Saudi Arabia[(5)]	2500	1.35	0.08	3175	1.7%	7.0%
UAE Abu Dhabi[(6)]	831	1.16	0.13	856	1.2%	2.1%

Notes:

1. Bahrain: The cost and the average revenue are given by MEW for 1999.
2. Kuwait: Estimates are for the year 2002. The cost figure is taken from KISR, the average revenue from water sales is calculated on the basis of figures of total revenue and volume of water produced given in MOW Statistical Yearbook (2003). Subsidies are estimated on the basis of average revenue from water sales.
3. Oman: The cost is estimated using weighted average of desalinated water (US$ 1.89/m3, 55MCM/year) and groundwater (US$ 0.55/m3, 114MCM/year) plus distribution costs (US$0.35/m3). Average revenue of water sales is estimated on the basis of the tariff structure and the composition of consumption.
4. Qatar: 132 MCM is indicated by Planning Council. Estimates of QEWC, Statistical Abstract, 2003 indicated 158MCM/year. The cost is computed as an average cost of production and distribution (data QEWC).
5. Saudi Arabia: Estimates of consumption, cost and average revenue from World Bank draft report, Kingdom of Saudi Arabia: Assessment of the Current Water Resources Management Situation, Phase I, Vol. I, December 2003.
6. UAE: Estimates based on cost figures in " 2002 Price Controls Review, Final Proposals for PC2", Regulation & Supervision Bureau, Water and Electricity Sector. MEW estimates ADWEA production at 473 Mm^3.

C. Institutional and Legal Constraints[30]

[29] A more indirect estimation approach has given a lower but still significant subsidy on water, 159.6 KD (about US million 541), Source: KISR (draft report), Evaluating the Impact of Subsidy Reform Policies in the State of Kuwait: The Case of Consumption and Production Subsidies, Phase I: Identification and Quantification of Subsidies Impact Analysis of Changing the Price of Electricity, December 2003.

[30] For details, refer to Appendix 1.

4.36 In some GCC countries, the responsibility for the administration, regulation, and development of water supplies is rather fragmented between many government entities while Oman and recently Saudi Arabia have embarked on institutional reforms for integrated water resources management. Fragmented arrangements frequently result in conflicting policies, political competition between agencies, and lack of a comprehensive and coordinated policy for the allocation, management and use of water supplies.

4.37 While all GCC countries possess significant technical expertise in their ability to carry out hydrogeological surveys, studies, laboratory testing, and numerical modeling, government agencies are relatively weak on areas related to groundwater management planning, monitoring and enforcement of regulations for drilling rigs control, inventory and permits, not to mention pumping volume measurements and charging. In most cases, either a Ministry of Agriculture or a Ministry of Water and Electricity is nominally in charge of groundwater management, which has brought about conflicts of interests between their primary and secondary mandates of supplying water and conserving water resources, respectively.

4.38 In most GCC countries, except Oman, the lack of effective groundwater management policy and unclear responsibilities among ministries or regional governments to regulate groundwater use and conservation has exacerbated this issue. Currently, there exists a dearth of well licensing procedures and pricing mechanisms to prioritize access to groundwater. In some countries, there are ordinances for banning well drilling and efforts for withholding the issuance of licenses to drilling companies and penalizing violators. In reality, however, most of the countries cannot enforce those regulations and neither possess the capacity to do so.

D. <u>Limited Private Sector Role</u>

4.39 Most of the GCC countries, except the UAE, still seem to pursue the direct public management model for water and sanitation purposes. These models have in general proven to perform poorly and GCC countries should gradually move away from this approach in the provision of water and wastewater services. A significant step towards attaining this objective in most GCC countries would be to establish state-owned water and wastewater enterprises which will operate under company or corporate law.

4.40 The privatization or "corporatization" of water production, transmission and distribution in Qatar is a first step. In Qatar, the private sector owns part of the RAF (B) desalination plant that is operated by the Qatar Electricity and Water Company (QEWC), and a consultant is studying the privatization of KAHRAMAA, the state-owned utility in charge of transmission and distribution of desalinated water supplies.

4.41 In Oman, the Government's long term policy in the urban water sector aims at the partial or full privatization of the production of desalinated water and wastewater treatment. For instance, the proposed Barka desalination project will be owned by the private sector. Moreover, the Oman Water and Sanitation Corporation (OWSC) operates on a corporate basis in preparation for its eventual privatization.

4.42 Service contracts have been employed in Saudi Arabia. However, traditional management contracts have resulted in the maintenance of the status quo with respect to expansion and prices. This is in part due to the fact that operators were not required to make any investments and partly because they saw no direct gain from adding customers. Since the operator saw no benefit from reduced costs, it was difficult to improve efficiency and thus reduce prices.

4.43 The experience of Abu Dhabi Emirate of the UAE in the partial privatization of desalinated water production has made substantial progress and could serve as a model for other countries considering further privatization of the water sector. The Abu Dhabi Emirate has embarked on an ambitious privatization plan with the formation of 11 companies (four independent power and water producing companies with a 60 percent shareholding from the Abu Dhabi Water and Electricity Authority (ADWEA) and 40 percent by international private investors; and seven ADWEA owned subsidiary companies for water and power distribution and other related functions of the ADWEA that are supervised by the Regulation and Supervision Bureau (RSB) for Water and Electricity. The RSB will act as an independent agency with the responsibility of regulating and auditing electricity and desalinization water sectors

4.44 However, the transmission and distribution of electricity and water are still under full control by the Emirate. Fuel for the generation of desalinized water is provided to the production system, but data was not available as to whether this price is subsidized or not. The experience of Abu Dhabi in the partial privatization of the production of desalinated water has progressed quite well and should be examined carefully and can be emulated by other GCC countries as a viable option.

4.45 The recently negotiated Build-Operate-Transfer (BOT) scheme for an integrated water reuse project including tertiary treatment of wastewater, reclaimed water transmission, and reuse in Kuwait could provide useful insight for the new paradigm of private sector partnership spanning over existing government ministerial boundaries.

V. POLICY RECOMMENDATIONS

On the basis of the discussions concerning the critical water management issues facing the GCC countries in the previous sections, this section provides the following policy recommendations on the following issues: (A) adopting integrated water resources management; (B) enhancing urban water demand management; (C) achieving sustainable aquifer management through irrigation water demand control; (D) conducting institutional reform for sustainable water resources management; (E) enhancing public-private partnership; (F) accelerating water supply management; and (G) expanding the GCC's coordination as a means for improving water resources management.

A. Adopting Integrated Water Resources Management

5.1 The Integrated Water Resources Management (IWRM) concept, declared in the 1990s and again articulated at the 3rd World Water Forum in Kyoto 2003, is being transformed into action on the ground through development and implementation of sound water management policies and practices which focus in particular on:

- A broad-based water demand management policy.
- A comprehensive program for reducing groundwater extractions and achieving a more sustainable aquifer management.
- A comprehensive program for non-conventional water resources including desalinated water, reclaimed wastewater, brackish water, and water importation.
- Institutional arrangements and coordination.
- An increased role for the private sector.

5.2 In general, however, none of the GCC countries has adopted a fully integrated approach to the planning, development, and management of their water resources. This has resulted in the relegation of valuable and, in most instances, non-renewable groundwater for the wasteful irrigation of low-value and high water consuming crops and concentrated use of desalination water for potable and industrial supplies. It has also resulted in the limited use of valuable treated wastewater, without consideration of its value as a replacement for non-sustainable groundwater extraction, use for industrial purposes, and the potential for recharge of aquifers in combination with well fields for use as both a potable and industrial supply. The countries should develop integrated water resource management policies that consider all the water resources in a rational and coordinated manner.

5.3 Based on the IWRM policies, the GCC countries should then develop national and regional water master plans covering water demands of all sectors and all sources including conventional and non-conventional sources in participation of all relevant agencies and stakeholders. The planning process can help diagnose the inefficient areas of water management and identify others for realizing higher water use efficiency and economic and environmental benefits through the combined management of different sources of water and usage including treated wastewater, urban discharge, brackish groundwater and desalinated water.

5.4 Furthermore, the countries should develop mid-long term investment plans as well as their operational plans for each region including water supply, sanitation and reuse networks based on a comprehensive review of future water supply sources and demands projections. The economic and financial analysis of the water management system is crucial to help manage and allocate water in a most efficient way depending on seasonal and yearly conditions as well as the required energy sources and costs for water treatment, pumping and transfer. It should be noted that Oman has been preparing a national water master plan including the water supply and demand assessments, which is commendable.

5.5 The inter-connection of different water supply systems may create huge synergies given the expected large variations in seasonal water demands and the volume of treated wastewater and comprehensive water saving and recycling systems should be included in the plans. Dual water distribution systems using reclaimed water for toilet flushing or landscape irrigation may represent a feasible option. This approach could produce significant benefits in metropolitan areas in which large volumes of treated wastewater can be handled with no major transportation costs and small seasonal fluctuations.

5.6 The GCC countries should also ensure that the current stand-alone desalination schemes led by private sector should be commensurate with water saving potentials in the future. They could be locked in inflexible and stand-alone water production plants along with the governments' take-or-pay obligations if they do not consider this level of comprehensive water planning. This concern cannot be over-emphasized if one thinks of current poor demand management including the high leakage rates of distribution networks and extremely high per capita water consumption. Potentially, water demand could be significantly reduced through the promotion of pricing and awareness raising programs and in that case, the government could end up assuming huge financial liabilities irrespective of actual water demands. Integrated water development and management plans at the national and regional level need to be urgently prepared in consultation with all stakeholders and users urgently prior to embarking on large scale infrastructure programs.

5.7 The GCC countries should also conserve aquifer resources as strategic reserves for emergency uses and future generations, rather than depleting them for wasteful irrigation practices. Artificial recharge using treated wastewater could enhance the level of potential groundwater reserves. Moreover, the use of brackish groundwater for desalination feed and salt-tolerant crops could release valuable fresh groundwater resources for other purposes.

B. Enhancing Urban Water Demand Management

The next phase of urban water sector management in GCC countries should focus on water demand management through pricing signals and efficiency improvement measures.

5.8 All GCC countries should put more emphasis on urban water demand management. Demand management should include a combination of tariffs, financial incentives, regulations, and improved efficiency in irrigation and municipal water use, to achieve conservation of scarce water resources and minimize wasteful water use. There is a clear need in all of the countries to review national water tariff structures to establish a system that transparently recuperates the full costs of providing water supply and wastewater treatment from all water sectors and that incorporates economic incentives for water conservation.

5.9 The GCC countries need to take urgent measures to control increasing water demands, which include, but are not limited to, the following:

- The revision of tariff structures to provide reasonable price signals to consumers including national citizens.
- Mandatory metering for all households including national citizens with periodic inspection and certification of meter accuracy.
- Enhanced collection of water bill payments.

- A strong program of leakage inspection of water distribution systems, regular maintenance / rehabilitation and the introduction of advanced automatic pressure adjustment systems.
- A subsidized program of retrofitting household water use systems and appliances with water efficient technologies.
- A formal education and public information program regarding the scarcity and value of water resources and the actual cost to society for wastage.

B-1 Water Pricing and Metering

5.10 Reform in demand management of municipal water through the introduction or increase in tariff rates is essential for water conservation and achieving financial sustainability in water resource management. The municipal water tariff structure of each GCC country should be subject to rigorous review and structural reform. It is recommended to raise water tariffs with a progressive block tariff structure in order to reduce the subsidy level. It is also recommended to increase sewerage service fees in a phased manner in order to promote efficient water use. It should be noted that part of the reduced subsidies can be used to provide targeted subsidies for the poor below a certain threshold in income.

5.11 The tariff systems should be made transparent so that any subsidies established by government policy are clearly identified and funded. The model used by Abu Dhabi for the regulation of desalinated water should be examined by all GCC countries as a workable standard for the assessment of the real cost of water at different stages. The tariff system of ADWEA is a binomial tariff system in which the capital cost of the system is assessed on an actual cost basis, and the operating and variable costs are charged on a volumetric delivery basis. The production component of the tariff is calculated based on the optimized cost of operation of the various desalination plants to meet the varied demand patterns. A bulk water tariff is also calculated based on the binomial components for the bulk transmission facilities and a distribution component is calculated at the distribution level, similarly based upon capacity demand and volumetric deliveries. While the cost of fuel in that model introduces a non-transparent subsidy, the concept of the recuperation of costs based upon each module of production, transmission and distribution could well be emulated within the GCC states.

5.12 In order to implement water pricing and billing on the actual volume used, it is critical to ensure that all households be installed with accurate meters and accordingly charged on the metered volume. No exemptions should be made for national citizens. This would be able to gradually give price signals to the use of high-cost desalinated water for landscaping and aesthetic purposes. The metering and billing based on the volume used will induce a significant reduction in water consumption and, therefore, in the water resource deficit. It would also reduce water subsidies in significant proportions, as simulations under alternative scenarios have shown, and save financial resources that could be put to better uses. Given the huge gap between the current tariff rates and cost of water, the impact of metering and billing would be huge.

B-2 Water Use Efficiency Improvement Measures

5.13 The leakage rate from water distribution systems seems to be much higher than generally thought, although it is difficult to obtain data due to lack of metering. The UFW of Saudi Arabia and Qatar is reported to be in the range of 30 to 40 percent. Most urban water agencies do not have incentives to deliver water efficiently and are unable to accurately determine the efficiency of their service delivery given that metering is not comprehensive and is limited to main cities. Furthermore, those agencies do not carry out regular analysis of water flows nor provide periodic detection of leaks.

5.14 The reduction of leakages should be prioritized by rigorous leakage inspection and replacement of old pipes, given the very expensive water costs. As Dubai (succeeded in reducing the leakage from 40 to 15 percent in 1990s) and Abu Dhabi have attained low network losses, leak detection and other measures are essential to reduce UFW from the current high levels in Saudi Arabia and other areas. It is noteworthy that as a result of intensive and systematic leakage inspection, an automatic pressure controlled system for the entire distribution network in Fukuoka City, Japan, drastically reduced the leakage rate to almost 5 percent (Box 2). The necessitated level of the UFW should be carefully evaluated based on the economic analysis weighing required maintenance costs in comparison with lost revenues and opportunity costs.

5.15 Building and plumbing codes should also be modified or adopted that stipulate the use of only high water-efficient appliances, such as low pressure shower heads, small capacity flushing toilets and water saving washing machines, along with certification of appliances. Financial incentives and subsidy programs should be provided that encourage retrofitting of existing appliances and the adoption of water saving types. Given the high water consumption levels especially with regard to domestic irrigation for gardens, the introduction of efficient garden irrigation systems should be emphasized. In-house leak inspection should also be conducted that create an impetus for retrofitting the existing appliances for more efficient use. Intensive water saving campaigns and incentive programs in Australia succeeded in reducing the water consumption per capita by around 20 percent (See Box 2).

Box 1: Leak Prevention and Detection Successes in Fukuoka City, Japan

Fukuoka city with an estimated service population of 1.3 million (2000) and daily per capita water use of approximately 307 liters. It has implemented greater water conservation measures in an effort to balance water supply and demand with comprehensive measures of leak prevention and detection to reduce water loss. Water leakage can occur in areas where it is not easily detected, such as under roads where an increase in traffic volume may be responsible for damage to the pipes, or where certain soil types cause excess pipe corrosion. At 5 percent leakage, Fukuoka city has achieved the lowest leakage rate in Japan. Fukuoka has worked to manage its potential leakage by using its resources for leak prevention surveys, distribution pipe maintenance, and water distribution regulation. As a result of these surveys, approximately 800 leaks are discovered and repaired every year. The city has also created an innovative water distribution system to regulate pressure and flow in distribution pipes to promote the effective use of water. This system uses pressure gauges and flow meters that have been installed throughout the city to monitor conditions within the pipes on a 24-hour basis from the Water Distribution Control Center via telephone lines. As part of the water distribution regulation system, 110 pressure gauges, 65 flow meters and 151 motor valves have been installed city-wide. Based on the information obtained from the gauges and meters, the motorized valves can be opened and closed remotely to regulate the water pressure and flow. This helps to reduce excess pressure which, in turn, helps to reduce the occurrence of leaks within the system. This level of the intensive O&M program was necessitated due to shortage of water supply and rapidly increasing water supply costs.

Source: Shinoda, et al., Japan (2000)

5.16 A strong public awareness program should be implemented in order to create a water conservation consciousness within the user public to use water efficiently, particularly with the national populations. In particular, calling for irrigation water saving for home gardens, such as the prohibition of irrigation during daytime and setting limits would be effective. These programs should be designed in such a manner as to include the educational systems at all levels, the political leadership, the media and the public in general. Such programs should focus on making the user public aware of the true cost of water, its scarcity, and the need for water demand management based on a rational tariff system and regulations to discourage wasteful and excessive uses in all sectors.

Box 2: Waterwise Rebate Program (WRP), Western Australia, Australia

The Waterwise Rebate Program was introduced by the state government in February 2003 to encourage water use efficiency in residents' homes and gardens. The estimated service population in 2003 was 1.5 million and the combined effect of these initiatives has been to reduce water use from 507 l/c/d in 2000-2001 to 411 l/c/d in 2003-2004. Beginning in 1995, US$ 2.4 million was invested in one of the first large-scale water efficiency retrofit programs in Australia to help reduce the high costs associated with high-efficiency water equipment, including replacing of existing plumbing fixtures with efficient toilets, washing machines and showerheads for indoor use, as well as certified tap flow regulators and timers.

It was also the first state in Australia to implement watering limits for conservation. Existing drought response measures involve the restriction of watering gardens to two days per week with no watering between 9:00 AM and 6:00 PM when evaporation rates are the highest. Existing state by-laws require US$ 70 infringement penalties for individuals that do not observe these watering restrictions.

Source: Water Corporation, Western Australia State (2003)

B-3 Accelerating Wastewater Treatment and Reuse

5.17 In most GCC countries, the sanitation coverage itself seems to be rather high in the range of 80-90 percent although supporting data is not adequate. What is clear is that some urban areas and most of rural areas are covered mainly by on-site sanitation facilities, such as septic tanks and cesspits, which may not provide adequate treatment for preventing water pollution discharge to aquifers, wadis and coastlines. In some cases, wastewater effluent is not treated, leading to the pollution of local water bodies, even to the extent of causing hygiene programs among local population.

5.18 The proportion of desalinated water supply that is collected and renovated through sewerage treatment systems is only around 20–40 percent of the desalinated water supply (para 3.35 Table 11). This should be raised to the international average of around 60-70 percent in an accelerated manner. Since the GCC countries are technically advanced, treating collected water to more than a secondary level using international standard technologies, the treatment network coverage would significantly improve the situation. This would also provide numerous opportunities to reuse treated wastewater at such a high quality.

5.19 Treated wastewater can be used for landscape irrigation, amenity purposes, irrigation of non-contact agricultural crops, and aquifer recharge. A water recycling and reuse master plan on a regional scale should be prepared based on the availability of treated wastewater in time and space and the identification of its potential uses. Treated wastewater can be used more efficiently as a precious water resource.

5.20 Under the recycling and reuse plan, the degree of treatment and associated monitoring requirements should be defined based on the specific purpose of treated wastewater reuse as well as the required safety level and acceptable health risks. The use of modern treatment technologies should be considered in order to attain high health standard security for more extended use of the treated wastewater resources, considering both the environmental / health risks, economic benefits and costs.

5.21 A common misunderstanding in planning for treated wastewater reuse is that the reclaimed water represents a low-cost new water supply. This assumption is generally true only when water reuse facilities are conveniently located near large agriculture or industrial users and when no additional treatment is required beyond the existing water treatment. The conveyance and distribution systems for reclaimed water represent the principal cost of most water reuse projects. The recent experience in California indicated that around US$ 4 million in capital costs are required for each 1 million m3 / year of reclaimed water for reuse, which translated to an average unit cost of around US$ 0.5/m3. [31]

5.22 This would create a major impediment for treated wastewater reuse with regard to irrigation. Only highly advanced irrigation agriculture could economically justify the use of such expensive water. A recently contracted major wastewater renovation project in Kuwait, including the treatment of effluents to quaternary level and pumping over 30 km to farming areas for enclosed type irrigation of high-value crops, would be an important test to examine the optimal use of treated wastewater. While the cost of wastewater treatment and collection should be logically assessed, treatment beyond the level necessary to preserve water quality and prevent pollution should be assessed against the users of this treated wastewater resource. This should include the costs for quaternary treatment, transmission of the water to its point of use and distribution, and overall management. While such tariffs may be temporarily waived in order to establish the usage of this water as a substitute for groundwater, eventually these costs should be passed on to the users. Otherwise, this valuable resource would not be used in a most efficient manner.

5.23 Considering such cost implications, it seems reasonable to use this resource locally near areas where wastewater is generated for urban, industrial and environmental (amenity) uses without incurring transportation costs. These uses can afford to pay for or justify higher water prices in general. Newly created parks, urban complexes including toilet flushing use, and amenities and landscape irrigation would be suitable options for consideration. [32]

5.24 Municipal landscape irrigation may continue to be the biggest consumer of reclaimed water and suitable for amenity enhancement of cities. The environment and health risks are also relatively low. However, there seems to be room for improving landscape irrigation efficiency with automated irrigation control equipment and the introduction of desert plants.

5.25 Furthermore, treated wastewater recharge programs should be piloted more extensively along with rigorous risk control measures for the environment and health. Aquifer Storage Recovery (ASR) using treated wastewater as well as desalinated water in winter has been piloted for establishing strategic groundwater reserves and maximizing its use in Kuwait and other countries. There are several successful cases in Arizona, California, Australia, Germany, etc. Likewise, where geologic opportunities exist, as in Qatar, consideration should be given to combining the recharge of tertiary-treated wastewater into alluvial aquifers, in combination with the development of downstream well production fields, in order to produce water supplies that have been purified through the natural processes of the aquifer for use in urban and industrial supplies.

C Achieving Sustainable Aquifer Management through Irrigation Water Demand Control

The sustainability of most aquifers could be attainable if strong measures are undertaken for controlling irrigation water demand and conserving groundwater use.

C-1 Strategic Value of Aquifer Resources and Sustainable Aquifer Management

5.26 Some of the GCC countries appear to have made a policy decision that groundwater resources do not represent a viable component of future water supplies of the country and are allowing the depletion

[31] The amortized cost of this reclaimed water was estimated based on the assumption of a facility life of 20 years and 9 percent interest rate. Asano, T. Water from (Waste) Water – The Dependable Water Resource, University of California Davis, 2001 Stockholm Water Prize Laureate Lecture. The required water quality levels and associated treatment costs will differ depending on the natural and social conditions.

[32] Ibid.

and pollution of the aquifers with an attitude that the eventual destruction of aquifers and the full reliance on desalinated water for meeting all water demands is inevitable. This may or may not be justified depending on how the state of oil reserves in the near future is perceived and their inter-generational allocation.

5.27 However, the GCC countries should view aquifers as a strategic resource to sustain various water uses, conserve ecosystems and provide emergency reserves in the case of disruption of desalinated water supply due to large-scale oil spills. More importantly, reliance on desalinated water alone could be a risky policy considering the volatile nature of oil prices and revenues. The sustainable use of groundwater resources should be a consideration in the overall integrated water resource management policy of each country.

5.28 While some countries such as Oman and to some extent Saudi Arabia appear to be taking bold steps to move toward sustainable groundwater management, much still needs to be done. In order to recover these aquifers and to continue their use in a sustainable manner, strong measures need to be taken to reduce extractions to a point below sustainable, or to less unsustainable, levels and to curtail the further development of wells until sufficient studies are carried out and the necessary control regulatory mechanisms can be put in place and enforced.

5.29 In order to conserve the strategic aquifer water reserves and reduce unsustainable groundwater extraction to levels below the sustainable inflow to the aquifer, or at least to less unsustainable levels, the GCC countries should adopt the following measures, taking into consideration the local conditions in each country:

- Establishing a comprehensive groundwater regulatory (well permits, drilling rigs control, etc.) and monitoring and pricing mechanism;
- Registering all wells and installation of flow meters in all large farms;
- Imposing volumetric metering and charges (ideally on a progressive scale) to send price signals for all groundwater users;
- Accelerating the installment of efficient irrigation systems and growing more water efficient and high value added crops,
- Facilitating possible water transfer through tradable water rights along similar lines as in the Aflaj system in Oman; and
- Conducting extensive education and public awareness programs at the school and local levels, and an extensive media campaign that emphasizes the scarcity and economic value of water resources and the need for their conservation and economical use.

C-2 Institutional Reform of Groundwater Management

5.30 Volumetric water metering and pricing could be a powerful too for encouraging farmers to improve irrigation water use efficiency and enhance agriculture production per drop of water. It could also give right price signals for the appropriate allocation of water resources and hence contribute to the sustainability of ecosystems, the protection of water quality, and conservation of groundwater resources for emergency situations.

5.31 The introduction of volumetric charge systems, however, requires an effective administration and enforcement mechanism and there is little if any experience in the MNA region regarding aquifer management, except in Jordan, which is implementing a successful program of groundwater management including wells licensing, metering and volumetric water charges even for farmers irrigation wells (Box 3), and in Tunisia, which follows the participatory approach and charges a binomial water tariff for groundwater extraction.

Box 3: Improving Groundwater Management through Government Action in Jordan

In Jordan, the Ministry of Water and Irrigation (MWI) is responsible for water resources management. It regulates the use of water, prevents its waste, preserves consumption, levies and collects tariffs and gives water extraction permits. The law states that water is public property and under control of the government. In the early 1990s, the MWI established a by-law prohibiting the drilling of new wells in most parts of the country where aquifers were afflicted by depletion and quality degradation. Only new wells for governmental municipal water supply, universities, hospitals and military camps were exempted from this by-law. Furthermore, repairs of existing wells were allowed only if the same specifications of the original wells were used. All drilling companies were notified of the fines against those who violated the regulation under the by-law. If a drilling rig was found at an unlicensed well, the rig would be confiscated and the drilling team would be arrested. They would be released only after paying an appropriate fine and a bail. The regulation has been strictly enforced with very few exceptions.

The MWI went to great lengths to control the wells. It took around ten years to accomplish a full inventory. Fieldwork was carried out all over the country to register wells, measure coordinates and obtain information on depth, water level, year of drilling and water use. As a result, the MWI has files for nearly all wells in the country whether they are licensed or illegal. The total number of wells in 2000 was 2,449, of which 1,830 were used for irrigation, 450 for municipal supply and 169 for mainly industrial uses. In general, water levels are deep, 100-200m below ground surface.

In 1998, a new regulation was issued, charging a price for all extracted groundwater for municipal, industrial and commercial uses, excluding irrigation. The charge was a flat rate of US$ 0.15 per cubic meter. All wells were metered on a regular basis by the MWI, which collected fees based on the abstraction volume. In 1999, the charge was raised to $0.37 per cubic meter. Despite strong protests from consumers, the MWI did not give in and advised industrial users to install water saving and recycling devices. It turned out that those industrial plants succeeded in saving around 10 percent of water use and found the devices worth the investment.

The MWI also took an important step to install meters on all wells including those used for irrigation. The first objective was to measure the abstracted volume of water from all wells. The second objective was to remind farmers that they are allowed to abstract only the amounts of water stated on their drilling licenses. Farmers fiercely resisted the installation of meters and some meters were even destroyed in the beginning. To address this issue, the MWI announced that it would close any wells in which the owner hindered or destroyed the installation of the meter. Now, the MWI is proud of the fact that the enforcement rate is about 95 percent. Farmers were also asked to pay for the amount of water exceeding the limits in the licenses. As a result, farmers gradually stopped selling water to others. Prior to this, they would frequently abstract water not included in the licenses for trade.

In 2002, the Cabinet of Ministers approved a new pricing policy on irrigation water – even on amounts already granted in existing licenses – with a block tariff system, where charges increase in relation to the amounts of water extracted. The MWI instituted this new policy after conducting intensive and difficult negotiations with farmers' representatives. The new pricing system will go into effect in three years. Details of the block tariff are: abstractions from one single well of less than 150,000 cubic meters remain free of charge; abstraction of 150,000 to 200,000 cubic meters will be charged at the rate of US$ 0.036 per cubic meter; and abstractions over 200,000 cubic meters will be charged at US$ 0.09 per cubic meter.

The introduction of this new pricing policy of irrigation water is expected to reduce greatly the amount of pumping water used for irrigation. This case may only be partially replicable to other MNA countries due to the following reasons: (i) the Jordanian government has strong capacity to enforce monitoring and regulations; (ii) water scarcity in Jordan is more severe than most other MNA countries; and (iii) the number of well is relatively small – around 2,500 nationwide (including illegal ones) and they are located in flat terrain easily accessible by government offices.
Source: Salame, Ueda, et al: Groundwater Case Study for Barcelona Workshop, MNA Regional Water Initiative, World Bank 2002.

5.32 A Spain case illustrates that an integrated irrigation water management systems including water pricing and temporary transfer mechanism can work successfully in arid climatic conditions. Such systems could possibly include all alternative water sources in the area from fresh and brackish groundwater, desalinated water and treated wastewater as in the GCC countries.

Box 4: Case Study of Mula (Murcia), Spain – Modernization of a Traditional Irrigation District by a Water Users Association

Mula County has a precipitation of around 200-300 mm per year is situated in a semi-arid region. Until a few years ago, the traditional basin irrigation was characterized by old and deteriorated irrigation networks causing high water losses. It was on the brink of land abandonment and desertification. However, with the support of the Murcia Regional Government and international and regional institutions, the local farmers groups introduced modern micro-irrigation networks with computerized automatic monitoring and operation systems, which allows all different sources of water - wells, small reservoirs and pumping stations – to operate most efficiently depending on their availability in different seasons on a community basis. The irrigation system covers a hilly area of about 2,000 hectares and divided into seven main plots.

The design choices and operational practices, consistent with the local crop requirements and farmers' capacities, were decided by the irrigation users, and now, the irrigation network is owned by the Water User Association (WUA). Sixty-eight percent of farmers are small holders owning farms of less than one hectare. This participatory approach with IWRM accomplished: (i) sustainable exploitation of the aquifer; (ii) maintenance of water quality; (iii) equitable distribution of irrigation water; (iv) ecosystem conservation; and (v) improved living quality for irrigators.

One of the prominent features of water management is a computerized water allocation and charge system. Each farmer has a "water account" similar to a bank account in which all water allocation and transactions (withdrawals) are indicated. Each user has its own "water book" where all his water and fertilizer transactions are registered. Water users are charged automatically and financial fees as well as the amount of available water with each allocation are subtracted from their personal accounts. Water rights can be sold on a yearly basis to those who need quantities of water above a standard threshold.

Another interesting innovation is the "water teller machine" which is similar to a banking teller and cash dispensing machine located outside of the WUA's headquarters office. Farmers can program the irrigation opening/closing and verify water withdrawal volume by these machines. The WUA also has a distribution plan of irrigation water and fertilizer at the same time. Water carries the dissolved fertilizers that each kind of irrigation crop requires and according to the requests of farmers. It was reported that water loss was reduced from 1.2 to 0.14 million cubic meters by the introduction of the system, in addition to other benefits, such as energy cost savings, savings in fertilizer used and agricultural production increases.

Source: Maetsu, Ueda, et al. Groundwater Case Study for the Barcelona Workshop, MNA Regional Water Initiative, World Bank 2002.

5.33 An alternative approach, possibly during a transitional period, is to levy a two-tier charge used in several countries such as Cyprus and Brazil: a fixed charge based on area (hectare), and a variable charge based on crops grown and frequency of irrigation or length of season, which serves as a proxy for volumetric charges (Box 5).

5.34 Oman is the only GCC country that has a relatively strong program for regulating groundwater abstraction. New wells that have been drilled after 1991 without license have been closed at the cost of the owner, and a fine has been levied. It has completed the national well inventory and collected data of well depths and other technical specifications for well licenses. However, the enforcement is sometimes difficult because deep wells have been drilled at locations of old unused shallow wells from which owners had a license. Abstractions from existing wells remain largely unchecked and metering is not practiced [33]

5.35 It is noteworthy that Oman also has maintained a market-based transfer system of water use rights within the historic Aflaj system. Since permanent water rights are principally transferred through inheritance or land sale, the transfer system is primarily limited to annual rental basis. Despite some shortcomings, the system has worked well and provides the flexibility for the transfer of water rights to adjust supply to meet the highest value demands, based upon the value of the water within the market. The system of market-based transactions operates through individual negotiations or through auctions. This market-based transfer could be expanded to other groundwater entitlements within Oman or other GCC countries.

5.36 Natural and social conditions differ among GCC countries and those policies should be carefully examined to see if they are relevant and effective. In the case of Oman and Saudi Arabia, more participatory approaches would be effective given the larger size of rural farmers, many of whom are still using irrigation water in a wasteful manner. Furthermore, in some costal areas, such as Tihama in Saudi Arabia and along the Gulf of Oman, aquifer balance could be sustained given their relatively higher precipitation and natural recharge volumes. A successful groundwater management through the establishment of Water User Association in the case of Barcelona City, Spain, may be relevant (Box 6).

Box 5: Water Pricing in Cyprus

Cyprus is an example of a country experiencing a high degree of water shortage and has a long history of charging for water. Irrigation water pricing, though more advanced than in many other countries in the region, aims at discouraging wastage rather than achieving economic efficiency. On the other hand, charges are differentiated by dependability and mode of service. The EU Water Framework Directive is expected to increase irrigation water charges in the Mediterranean states to disproportionately high levels relative to those in other member states, because of the high level of water scarcity they face and the extra infrastructure cost they bear to overcome it.

Water charges include the interest on capital, amortization of capital cost over the life of the project, insurance cost of works, operations and maintenance covering energy and management costs for the project. Charges are based on the weighted average unit cost of water, which is either calculated based on annual costs or quantities or on costs and quantities expressed in present worth terms. The rate of interest generally applied is 8% and the economic life of the projects is assumed to be 40 years from start of operations. The weighted average cost per cubic meter of water is the sum of annual costs from all existing projects divided by total water delivered from these projects.

Alternatively, a unit cost of water is calculated for each project by aggregating the unit capital cost for the project and the annual cost of operations and maintenance per unit of water. Here, the annual cost for each project consists of operations and maintenance, energy, materials, equipment, wages, salaries and administration costs of the Water Development Department staff. In general, water charges to the beneficiaries are required to be at least 38% of the weighted average cost of irrigation water per cubic meter and, though they are expected to be less than 40% of such costs, the charge may go up to 65% of the weighted average cost if capital costs are very high. The water meters are read every two months and the consumer is expected to pay within 90 days of the date of the bill. Unpaid amounts bear an interest of 8% per annum and further delays could lead up to a $US 1,000 in fines or have their water supply cut off.

Source: Tsiourtis, in Shetty, S., World Bank draft report, Kingdom of Saudi Arabia: Future Vision of the Saudi Economy: Agriculture and water Resource Management: Issues and Options2003

Box 6: Barcelona: Management of the Baix-Llobregat Aquifer

[33] MNA RWI Groundwater Management Workshop Proceeding, 2000

The Baix Llobregat aquifer supplied water to Barcelona city (Water Supply Company of Barcelona - AGBAR), towns, industries, and irrigation area in conjunctive use of surface water. The irrigated agriculture has been marginalized by the expansion of the urbanized area. Faced with rapid aquifer depletion and salinization, an extensive public awareness campaign was conducted since 1970s. The Baix Llobregat Delta User Association (CUADLL) was established in 1976 in response to the alarming situation, but faced difficulties due to lack of regulatory framework. The 1985 Revised Water Law put groundwater under public domain and enabled the basin management authority to declare over-exploitation and intervene in these aquifers. The Law also provided all water users with the rights of constituting user associations and participating in basin authorities. Today, the CUADLL is composed of a General Assembly, Governing Board, Arbitrator, Technical Commission, Water Police, etc. to protect the common interests and acquired water rights and to establish appropriate aquifer management norm. It has an independent legal status allowing it to enforce the decisions of the Board in association with the Catalan River Basin Authority. These efforts have greatly contributed to turning around aquifer depletion

Source: Maetsu, J., Ueda, et al. Case Study for the Barcelona Workshop, MNA Regional Water Initiative, World Bank 2002.

C-3 Agriculture Policy Reform

Many agricultural activities in GCC countries are profitable in financial terms only because of the various incentives that some Governments provide.

5.37 In all GCC countries, current agricultural policies have ended up encouraging overuse of precious groundwater for inefficient low-value crop irrigation despite the agriculture sector's insignificant proportion of GDP (para 4.4) through various kinds of subsidy and price-support programs. These policies have distorted rational water allocation, shifting from higher value-added water use for other purposes to unsustainable and unprofitable irrigation agriculture. In most cases, the value added of water in agriculture is lower than municipal and industrial uses. Agriculture policies have erroneously encouraged the production of low value added crops such as open-field tomatoes for domestic markets.

5.38 In all GCC countries, governments should revisit the agriculture policies with the dual objectives of improving irrigation water use efficiency and competitiveness in the agricultural sector to meeting the challenges of integration within the global economy and water conservation to sustainable, or less unsustainable, levels. The government should adopt the policies which lead to: (i) expanding the use of modern pressurized irrigation systems, micro-irrigation and automated irrigation scheduling systems to increase water productivity; (ii) shifting from low value vegetables grown in open fields to high value vegetables grown in greenhouses; and (iii) reducing the area of high water consuming crops such as fodder and alfalfa; and (iv) liberalization of agricultural trade and reduction of subsidies.

Phase Out and Better Targeting of Agriculture Subsidies

5.39 The ultimate objective of agricultural policy reform in GCC countries needs to move towards market driven growth and groundwater demand management through the adoption of the following measures: (i) phasing out direct and indirect subsidies on well drillings, irrigation pumps, engines, seeds, seedlings, fertilizers, pesticides as well as price support programs to reduce non-profitable and wasteful irrigation (in Saudi Arabia and the UAE), (ii) introduction or enhancement of targeted subsidies on technologies which promote water conservation such as micro irrigation technologies and moisture sensing equipment as well as water use monitoring; and (iii) discouraging or prohibiting the production of high water consuming low-value crops, such as alfalfa and other fodder crops while considering brackish water use for salt tolerant crops[34].

5.40 In order to accelerate the transition to more efficient and competitive agriculture, governments should also strengthen agriculture research, extension and training programs to support this transition. It is recommended to (i) intensify research programs on crop water requirements, salinity tolerance and the potential use of brackish water, (ii) enhance research to develop better quality, higher yielding and disease resistant varieties of date palms; (iii) promote on farm water management; and (iv) expand advisory support programs to improve post harvest technology and market competitiveness.

5.41 In the GCC countries, the impact on agricultural employment is generally not significant given that foreign labor constitutes the large majority of the labor force in the sector. However, some cases may need cautious approaches. In order to alleviate the potential threat of poverty for small farmers, mainly in Saudi Arabia and Oman, it may be prudent for Governments to: (a) phase out subsidies slowly for those farmers; (b) accelerate training programs to provide needed skills; (c) use "blue box" measures to compensate these farmers for reducing their production if deemed necessary (see below). This is important for long-standing traditional agriculture using qanats, shallow aquifers and springs in the rural areas, which is not only important for sustaining the livelihoods of the poor, but also vulnerable to the changes of the environment such as rapid aquifer depletion.

Increased Integration within Global Markets

5.42 The UAE, Kuwait, Oman, Qatar, and Bahrain are members of the World Trade Organization (WTO) and have liberal agricultural trade regimes with minor exceptions. Saudi Arabia is currently negotiating to gain entry into this world body. Membership entails further liberalization of agricultural trade in Saudi Arabia, which imposes a 100 percent duty on the import of wheat and wheat flour[35], and increase access to its market, although some exceptions are allowed under "green box" and "blue box"[36] measures. With trade liberalization, Saudi agriculture would undergo structural adjustment and the production mix would shift in favor of higher value added crops, while inefficient producers, particularly wheat farms that depend on deep groundwater aquifers would exit the sector. Agriculture would survive and very likely thrive in areas with renewable water resources along the western coast of the country, which has many small to medium farms. Furthermore, Oman would need to remove the remaining calendar-based restrictions on the import of fresh fruits and vegetables by 2005 as mandated by the terms of its WTO membership.

5.43 Trade liberalization and integration with global markets have an indirect but important role in rationalizing the use of irrigation water in agriculture. Increasing access to markets would help movement toward a market-driven sector, where farmers have to rely less on government subsidies and more on improving productivity and irrigation efficiency, maximizing the returns to water, and production of higher value added crops, including increased production of horticultural crops in greenhouses. In lieu of

[34] In most GCC countries, the largest irrigated areas are planted with crops which have high water demand but are tolerant to salinity, such as date palms, alfalfa and other fodder crops. Although the use of fresh groundwater for date palms is not economic, there is little scope for reducing its areas because of its ability to tolerate higher levels of salinity and suitability for harsh climate conditions.

[35] It has been reported that as part of the customs union agreement among GCC countries, import duties on wheat and flour have been repealed. However, Saudi Arabia has asked the GCC to approve a 50% import duty on these commodities during a transitional period.

[36] In TWO terminology, "green box" measures are those "which meet general and specific criteria so as to have no, or at most minimal, trade-distorting or production related effects". "Blue box" measures are those "which cover certain direct payments under production-limiting programs".

output price support and input subsidies, countries need to encourage the emergence of a competitive agriculture sector, and explore ways to make its support to farmers. Within the context of agricultural trade liberalization and integration of the GCC countries in the WTO, agricultural reforms should encourage the promotion of a market oriented policy through the cultivation of crops with high water productivity and low water content.

Economic Indicators and "Virtual Water"

5.44 The concept of "virtual water" is useful for water-scarce countries in assessing how much water can be saved through the import of certain food items (particularly those that consume high amounts of water such as fodder or alfalfa for dairy production), and other products such as wheat. According to the World Water Council, "Virtual water is the amount of water that is embedded in food or other products needed for its production. Trade in virtual water allows water scarce countries to import high water consuming products while exporting low water consuming products and in this way making water available for other purposes." Thus, countries exporting high water consuming products indirectly augment the water resources of the importing countries. Analysis of "virtual water" should be included in development plans as a means to relieving pressure on the scarce water resources of GCC states.

5.45 Oman estimated that "virtual water" imports into the country in 1998 was approximately 3,860 million m^3, which represents about three times the total annual replenishment of the natural water resources of the country[37]. This provides strong insights as to how much water could be saved by importing food and possibly shifting the saved water for other higher economic purposes or future generations. It is strongly recommended that other GCC countries also evaluate this virtual water as an important reference for formulating their future water and agriculture policies. Other useful indicators including Effective Rate of Protection (ERP) and Domestic Resource Cost (DRC) should also be used for agricultural policy analysis to evaluate the competitiveness of agricultural activities[38].

5.46 Notwithstanding the fact that agriculture has brought about numerous positive externalities such as landscaping and certain protective measures for villages and towns against sunshine, wind and dust, it is crucial to consider the high opportunity costs of water when implementing such types of projects which might be beneficial to society overall but nonetheless increase the strain on already scarce water resources. It could be more profitable to import agriculture produces or invest the same amount of money overseas for securing the same amount of agriculture produce, from which significant water content can be imported indirectly.

D. <u>Conducting Institutional Reforms for Sustainable Water Resources Management</u>

5.47 There are some successful cases of water reforms in the Gulf region such as the partial privatization of the production of desalinated water in Abu Dhabi, the creation of the integrated Ministry of Water and Electricity in Saudi Arabia, the privatization or "corporatization" of water production and distribution in Qatar, the monitoring and enforcement of groundwater abstraction in Oman, or the establishment of a high water council in Bahrain to increase coordination among various water-related

[37] The annual recharge amount is estimated at around 1,300 MCM/year while the recoverable recharge amount is around 900 MCM/year (70%).

[38] The ERP shows the level of distortion in value added in production due to protection and subsidies (by expressing the difference between value added of an activity at international and domestic prices of inputs and outputs, as a proportion of value added at international prices). The DRC is a static concept used to asses the competitiveness of a country in the production of an agricultural activity. In brief, it can be defined as the ratio of the cost of domestic resources (and non-traded inputs) to the value added in production of an activity, both valued at border or economic prices. A country is competitive in an activity if the DRC<1.

Ministries. The Kuwait Government has established a strong research center, the Kuwait Institute for Scientific Research (KISR) to undertake research on numerous issues including water resources management. However, there is still room for improvement along the lines described below. In order to achieve efficient and sustainable water resources management, the following recommendations are put forth:

D-1 Water Laws and Regulations

5.48 Water laws and the regulatory framework should be examined to determine what modifications should be made to discourage the waste of water and to improve the efficient use of this resource. For instance, water laws should mandate the registration and regulation of all wells within each country, the monitoring of groundwater extractions, and the issuance of water use rights that allow authorities to limit extractions within safe yields. These laws should establish a strong regulatory body with power to regulate the extraction of water and to establish water use rights. These laws should also establish a legal framework for the adoption of regulations on all matters regarding the use of water, including well excavation criteria, water appliance efficiency, water transport, water tariffs and collections, water quality, wastewater collection, treatment and discharge or reuse, water user participation, etc. Much of this type of framework is in existence but is not adequately administered or has not been adequately developed into workable regulatory form.

5.49 It is recommended that all of the GCC countries undertake a comprehensive re-examination of their laws and regulations for integrated water resources management including conventional and non-conventional sources. In some countries such as Oman, a groundwater management program has been implemented despite its enforcement challenges. In others, the legal and regulatory systems are rather fragmented and are, in some instances conflicting between water use sectors. Each country should carry out a comprehensive review of its water legal and regulatory framework with the aim of developing an integrated water resources management program that considers water as a scarce resource and enhances inter-sectoral coordination. An ongoing World Bank study compares more than 20 national water laws that could also provide background information to assess the existing water related legislation.

D-2 Institutional Reform towards IWRM

5.50 The overall planning function for the development and management of the integrated water resources of the country should be consolidated in one agency that is not an operating entity in any water sector. The agency must be able to view the water resources of the country on a macro scale with a view toward the integration of the water planning and management into the over-all economic and developmental planning of the country. In this manner, the critical water resources needed to support the over-all national development can be integrated into the planning and development effort. This is being addressed in some countries such as Bahrain and Oman through the development of a High Council on water to coordinate actions between agencies, and in Saudi Arabia with the formation of the Ministry of Water and Electricity.

5.51 The water resources authority should also assume responsibility for establishing a regulatory and a water resources allocation framework on all water user sectors independent from the operational agencies in order to prevent conflicts between the regulation and operational needs of each sector. It is further recommended that such an authority be governed by an independent council that is not directly connected to the operating entities. Furthermore, an advisory body to the governing council should be formed, consisting of members from each water sector agency and an appropriate number of actual users from each sector. This body would provide input and reaction to the regulatory processes pursued by the regulatory body and assist in the dissemination of information regarding regulations, water tariffs, and enforcement provision.

5.52 The specific changes needed for such integrated water resources management vary within each country, which needs to undertake a comprehensive review of the present policies and institutional framework in order to develop a long-term sustainable management program for water resources that will support long range economic development plans. The model presently being pursued in Oman could represent an option to be examined by other countries. Under this model, most water management functions except for desalination water production, has been integrated under the Ministry of Regional Municipalities, Environment and Water Resources. Furthermore, Bahrain has been actively trying to create a high council on water to coordinate actions between agencies.

5.53 Saudi Arabia presents a striking case through its attempt to initiate a comprehensive water sector reform program. The Ministry of Water and Electricity (MOWE) recently completed a comprehensive stocktaking of the water sector. This included relevant discussions on the policy, regulatory and institutional framework, economic viability, tariffs and cost recovery, private sector participation and environmental sustainability. Phase I of the final report lists the strategic choices for integrated water resources management and has been validated through an active consultative process with stakeholders and government officials. A Phase II Work Plan is now under preparation and will focus on the identification of policy options and recommendations on key water sub-sectors. Furthermore, a completed World Bank desalination study provided insights about the linkage between the latest technological advancements, water resources management policy and institutional development.

5.54 Furthermore, each GCC country should discuss and formulate capacity building and continuous performance review programs. It is critical to establish clear and realistic management targets and reform time-frame as well as monitoring and oversight procedures for the water resources authority and operational agencies. Regular supervision by independent advisory bodies will help in evaluating the institutional reform process and performance of service providers and regulators in meeting policy goals. Measuring progress toward these regional and national goals, as well as benchmarking progress against other countries, will be important in evaluating the impact of reform strategies towards IWRM. Internal incentives should be reinforced by external pressures, including the comparison of utility performance against sensible benchmarks and the public disclosure of these results. Staff training programs should be provided based on capacity building needs of those managing entities.

D-3 IWRM Supporting Tool - Water Management Information System

5.55 In order to develop water master plans based on accurate and reliable data, a consolidated and accessible water information system is an absolute necessity. In some GCC countries, important data gaps exist, most notably the volume of extractable groundwater resources and benchmarking data for indicating utilities management efficiency. In many of the countries, this effort is fragmented and data are not readily available in a transparent and usable manner to those that need this information. Countries should endeavor to establish a reliable network of data collection. They must subsequently integrate and archive this information with data collected from the private sector, regional and international organizations and other sources. The data must be readily accessible by both the private and public sectors as needed and be compatible with its use in electronic modeling. It must be ensured that that the provision of data with regard to quality, coverage, periodicity, timeliness, consistency, inter-agency coordination and staff training be clearly defined, programmed and funded. One such integrated structure could be the building of an Integrated Water Resources Information System by linking water information layers with those prepared by other Government agencies (Agriculture, Industry, Petroleum, etc.) that affect, or are affected by decisions taken by the appropriate water authorities.

5.56 A reliable set of water demand and supply data is also critical to enable all stakeholders and users to understand and appreciate water value and encourage them to have their views reflected in future water strategies, planning and management. This is an important step for all stakeholders in participating in the IWRM planning and implementation process. Once they understand the opportunity costs of water and policy options, conservation measures can be introduced that will preserve water for future generations and enable oil revenues to be invested in developing other sectors of the economy rather than utilizing them in the form of regular expenses that bring no returns.

E. <u>Strengthening Public-Private Partnership</u>

E-1. Private Investment in Water Resources Development

5.57 The private sector can play an important role as a partner of the public sector in improving the operational efficiency of utilities management, providing technical and management expertise, and funds for major investment water infrastructure building. The provision of new technologies and operational strategies should be considered as one of the key elements for the development of comprehensive water supply and distribution as well as wastewater collection, treatment and reuse programs. The present model in Abu Dhabi presents a workable concept that should be considered by the other GCC countries.

5.58 Until recently, the provision of water and sanitation services in Abu Dhabi has remained in the hands of Government companies at all stages of supply, production, transmission and distribution. Reforms introduced in 1998 consisted of separating the three activities among four different companies (for water and electricity) under a single authority, ADWEA. The purpose of this reform is to introduce more transparency and accountability in the costing of these operations, and to reduce cost at different stages of the supply chain. In addition to the privatization initiative of water and electricity services, the new system has established a regulatory agency, the Regulation and Supervision Board (RSB), which was created with the objective of regulating and monitoring the provision of services and pricing. Price setting is based on the principle of Maximum Allowed Revenues (MARs), which are based on costs, with built-in incentives to increase efficiency of service provision. Price controls are based on the principle of "CPI-X", which allows an increase in the overall revenue of each company at the rate of increase in the consumer price index, minus an efficiency improvement factor. While the RSB deals with all stages of production and distribution of water and electricity, price setting is the responsibility of ADWEA, subject to Government approval. This new system, which has built-in incentives to reduce cost and improve quality, seems to have already produced positive results, notably a reduction in cost. It has been working for already almost four years and lessons should be drawn for use in the other GCC countries.

5.59 Careful evaluation of other models and experiences in the involvement of private investment in the water resources infrastructure throughout the world should also be made with regard to the possible applicability of some or all of these concepts within the GCC countries. However, private sector partnerships should not be viewed as a manner in which the governmental role in water resources regulation and integrated management can be avoided or passed on to the private sector. While the introduction of the private sector into the water resources management and production area can improve efficiency, it does not eliminate the oversight role of the government in assuring that this resource is allocated and managed in a manner that is efficient and equitable to all water user sectors, and that social and environmental concerns are adequately considered.

5.60 The experience of Abu Dhabi has introduced more transparency in cost monitoring and in improving the accountability of the companies involved in providing water services, even if the participation of the private sector remains limited. The first step to be taken throughout the region, where applicable, is to establish water and wastewater companies separate from their respective ministries. Bahrain, Kuwait, Oman and Saudi Arabia have pursued the direct public management model which has proven elsewhere to be inefficient. Instead of direct management, service providers should be corporatized even if they remain under government authority. Performance indicators should be set with respect to key technical or financial variables such as the ratio of UFW, the financial working ratio, bill collection and labor productivity. As tariffs are gradually adjusted to reflect cost, subsidies should become transparent and shown in companies' books.

5.61 The main rationale for Private Sector Participation (PSP) in the water sector, in addition to attracting very large private investments needed for desalination and wastewater treatment infrastructure, is to improve operational efficiency, lower costs through the introduction of better technology and managerial capacity, and improved customer service. However, PSP involves, among others, certain credit risks and the lack of a track record for PSP performance in some countries, and possibly an inadequate legal and regulatory framework. Models of private sector participation in investment in water sector infrastructure include[39]: (i) Build-Own-Transfer (BOT), where a government agency enters into a contractual agreement with a qualified firm to design, build, and operate the desalination or wastewater treatment facility. The BOT approach usually involves one part of the water management network, such as desalination or wastewater treatment plants. Here, the capital investment and commercial risk are assumed by the private firm. This model is most commonly used in water desalination where capital investments are quite high. It is used in Cyprus, Israel, and Australia. Furthermore, variations of the BOT are used on a limited scale in Jordan and Tunisia for wastewater treatment plants. Typically, the contract is for 20-30 years, after which ownership reverts to Government; (ii) *concession*, which is similar to the BOT model but varies in two main respects: assets may be owned jointly by the private and public sectors, and the private firm operates the entire system (production, transmission, and distribution), which is used in such countries as South Africa, Argentina, the Philippines, and Morocco; and (iii) *divestiture*, or full privatization, whereby the private sector assumes full ownership and operation of the entire system for an indefinite period, as in England and Wales, and the Czech republic. In all cases, Government retains an oversight and regulatory role over private firms to guard against the development of private monopolies, regulate tariffs, and monitor the quality of service. The various models are summarized in Table 20 below.

E-2. Participation in Operation and Management

5.62 International experience has shown that the involvement of users and user organizations has greatly improved the management of water resources. This is particularly true with regard to the management, regulation, operation and maintenance of irrigation systems and irrigation programs. For instance, the participation of water users in conjunctive water management systems through the system administration, water allocation, and monitoring of water management parameters has been very successful in other countries (Boxes 4, 5 and 6). The use of water user councils, water user associations, and the involvement of the users in the management of the irrigation water supplies should be considered where relevant in each of the GCC countries. Active participation in the management of water at the local level has, historically, been utilized in the governance, operation, and maintenance of the Aflaj systems in Oman in a successful manner (para 5.25). This concept of management by user entities should be considered and expanded where applicable.

5.63 Several models can be used for private sector participation in the O&M of municipal water and wastewater treatment networks. These include: (i) a *service contract* procured on a competitive basis usually for 1-2 years, for bill collections, leak detection, etc. which is used in Jeddah and Dammam in Saudi Arabia, and in Chile, India, and Mexico. The service contract does not include any incentives to

[39] Draft reports: (i) Seawater and Brackish Water Desalination in the Middle East, North Africa, and Central Asia (by DHV Water, Netherlands, and BRL Ingenerie, France), prepared for the World Bank, October, 2003; (ii) World Bank, Kingdom of Saudi Arabia, Assessment of the Current Water Resources Management Situation, op. cit., and (iii) Al-Bastaki, N., 'Comparison of Privatization Schemes for New Water Desalination Projects', paper presented at the Challenges on New Horizon Symposium held in Bahrain, January 2004.

improve service, or to reduce network losses or cost; (ii) a competitively procured *management contract*, on the other hand, is based on performance benchmarks or indicators that are designed to improve efficiency and service, and reduce cost. Its duration is usually 3-5 years, and is used in Gaza, Bethlehem, and Trinidad/Tobago; and (iii) a *lease* which usually runs for 10-15 years to operate the whole system is based on competitive bidding, where commercial risk is shared by the public and private sectors, as in Guinea, Senegal, and Poland.

5.64 Management contracts or leases can also bring in significant private sector expertise and enhance operational efficiency. However, traditional management contracts have resulted in the maintenance of the status quo with respect to expansion and prices. This is in part due to the fact that operators were not required to make any investments and partly because they saw no direct gain from adding customers. Since the operator saw no benefit from reduced costs, it was difficult to improve efficiency and thus reduce prices. More recently, performance-based management contracts have been implemented in many places, which address these issues and improve the nature of incentives for the operator. Concession-type contracts in which the operator has a high level of autonomy and an incentive to add new consumers, if profitable in the long run, may be more relevant for managing the entire system.

Table 20: Models of Private Sector Participation in the Water Sector

Option	Asset Ownership	Oper. & Maint.	Capital Invest.	Commer. Risk	Contract Scope	Duration	Examples
Service Contract	Public	Public & Private	Public	Public	Public	1-2 years	Chile India Mexico
Management Contract	Public	Private	Public	Public	Full System	3-5 ears	Gaza Aman Bethlehem Trinidad/ Tobago
Lease	Public	Private	Public	Shared	Full System	8-15 years	Guinea Senegal Poland
BOT	Private	Private	Private	Private	Bulk supply, wastewater treatment plants	20-30 years	Malayia Jordan Australia
Concession	Public/ Private	Private	Private	Private	Full system	25-30 years	Argentina Ivory Coast Philippines Morocco
Divestiture	Private	Private	Private	Private	Full system	Indefinite	England Wales

Source: World Bank, Urban Water and Sanitation in the Middle East and North Africa Region, The Way Forward (January 2000), op. cit.

F. Enhancing Water Supply Management

The GCC countries have made substantial progress in water supply augmentations. Their efforts in this regard need t o be sustained and accelerated in order to secure more water resources in supplement to water demand management. This section describes key supply management options that should be explored and expanded to increase water supply for the future.

Better Assessment of Groundwater Resources

5.65 In some of the GCC countries, particularly Saudi Arabia and Oman, there is still a lack of knowledge with respect to the quantity of water available for extraction within the non-renewable aquifer systems, and the manner in which this finite resource should be allocated between present and future uses.[40] In order to establish strong policies for regulating and allocating the use of these resources, better knowledge of the parameters needs to be determined through groundwater modeling and aquifer testing. Without question, these water resources have a finite life and it is much more important to consider the use of these resources as non-renewable, and to adopt strong policies and regulatory processes that prohibit their wasteful use for uneconomic purposes in a manner that will eventually restrict the options of future generations.

5.66 Assessment should be made of each aquifer so that long-range extraction policies and allocations can be made and enforced. The assessment of these aquifers should be a continuing and dynamic process as more information becomes available to evaluate the adequacy of the allocations of extraction rights on the future life of the aquifer. A comprehensive system of monitoring wells, combined with a strong and enforced program of reporting annual extractions from each production well, should be implemented. This information should be collated in an interactive water resources database that can be accessed for computer modeling and evaluation on an ongoing basis. This dynamic assessment process should make use of existing or developed groundwater models so that decisions regarding the impact of extractions and the need for limitation or expansion can be made on an informed basis.

Aquifer Recharge

5.67 Groundwater recharge to renewable aquifers within Oman, UAE and Saudi Arabia from natural runoff and precipitation represents a significant resource for those countries. They have been making efforts for enhancing this recharge through the construction of recharge dams in order to retard surface flows in order to allow them to infiltrate into the aquifers. This program should be carefully evaluated and expanded where possible, to allow the maximum utilization of these surface flows for recharge. It is useful to carry out ex post analysis of existing recharge structures to determine net incremental recharge and cost effectiveness to provide guidelines for designing future recharge dams.

Use of Brackish Water in Agriculture

5.68 Significant quantities of brackish groundwater exist in the non-renewable aquifers within the GCC countries (para 3.8). This water is presently being used for irrigation to a limited extent. However, the use of this water for the irrigation of salt tolerant crops could represent a significant expansion of the usable quantity of water for the agricultural sector. Significant research is being conducted on the development of salt tolerant crops in many parts of the world including the GCC countries, and particularly at the International Center for Bio-saline Agriculture (ICBA) in Dubai. This research should be supported and expanded with the objective of developing a sustainable agricultural sector using this brackish water resource in order to alleviate the over-exploitation of fresh groundwater. Research on soil-

[40] However, at present, there is an on-going effort by Saudi Arabia in assessing its groundwater resources.

less agriculture is in its early stages in Bahrain but early results are promising. Ongoing research in this field also needs to be supported and encouraged.

Desalination Technologies

5.69 Desalination technology continues to evolve, and since desalination is the primary method for the production of potable and industrial water, the evolution of cheaper and more efficient technologies should be closely monitored as to their adaptability in the GCC countries. The adaptation of such technologies to the present co-generation programs of the countries should be evaluated, as well as other challenges such as economies of scale in the case of multi-effect distillation and vapor compression technology, quality of feed source and disposal of brine in the case of reverse osmosis, and such other challenges presented by new technology. A hybrid scheme combining distillation plants and RO plants should also be considered in order to adapt to the seasonal variation in both energy and water demands more efficiently. Objective evaluation should be made with the goal of developing the most efficient, reliable, and economic desalination systems possible for these countries.

5.70 Strong consideration should be given to the use of the brackish water as feed water for desalination plants such as Reverse Osmosis (RO) and electrodialysis (ED) plants which should reduce the average cost of desalinated water. Saudi Arabia and Oman have built some inland plants that could be expanded depending on further technological advancement of the RO membranes and other elements. As the salinity of the brackish water is considerably below that of the Gulf water, the average cost in terms of non-renewable energy could be considerably reduced. In remote rural areas which have access to brackish groundwater, consideration should be given to small RO plants that are powered by solar or wind energy to provide water to small rural populations. This option for pure water supply to small rural populations has proven to be effective in other regions of the world, such as Brazil and the Canary Islands.

Expand Use of Treated Wastewater

5.71 The treated wastewater will be an integral part of water resources in the near future given the rapid expansion of wastewater treatment networks. The treatment level and methods compatible with environment, hygiene and health standards should be carefully studied based on the latest technologies while due consideration should be given to the economic and financial aspects. This resource can be used, after adequate treatment, for the irrigation of landscaping and esthetic purposes, the irrigation of non-contact agricultural crops, and for the recharge of aquifers, but its scope could be further expanded with the support of associated infrastructure development, such as dual water supply system (grey water use for office cooling, toilet flushing, etc.), and advanced treatment and risk control measures. The use of more advanced treatment technologies such carbon absorption, advanced oxidation, and reverse osmosis should be considered in order to attain high health standard security for the more extended use of the treated wastewater resources with due consideration for the economic aspects. Furthermore, consideration should be given to combining the recharge of tertiary-treated wastewater into alluvial aquifers, in combination with the development of downstream well production fields, in order to produce water supplies that have been purified through the natural processes of the aquifer for use in industrial and urban supplies and secure strategic reserves for emergency uses.

Water Importation and Regional Water Grid and Emergency Water Reserves

5.72 While water importation requires prohibitively expensive investments in pipelines and other infrastructure as well as high operation and maintenance costs for any one country alone, it is worth exploring if a joint venture among some GCC countries would make it economically viable when investment and operation and maintenance costs are shared. Water importation can serve as a supplemental source of municipal water supply for use in daily consumption, and for supplementing storage capacity to meet unexpected emergencies, where careful economic and technical evaluations are warranted for any options.

5.73 The water grid that links or will soon link population centers in the UAE can play a crucial role in emergencies and balancing water supplies. The trans-basin diversion of supplies from one Emirate to another is presently in operation in the UAE, such as a major transfer of desalinized water from Fujairah and Abu Dhabi city to supply the Al Ain area. Other transfers and connections are under consideration such as the integration of transmission networks between Dubai and Abu Dhabi. This integration is being considered with the goal of balancing the supplies within the UAE and of providing a redundancy in the potable water supply system to decrease vulnerability to extraordinary events such as oil spills in the adjacent gulf, major plant failures, or other interruptions of supply due to any individual population center. It is also important to prepare emergency contingent plans while also taking into account the increase of emergency water reserves. The current reserve volume provides water only for a few days in most countries.

5.74 The construction of a water grid linking some GCC countries can relieve major population centers in case of emergencies of very short duration, but its usefulness during a protracted water shortage is very doubtful, and the cost may be prohibitive. The economic viability of such a grid needs to be seriously considered since GCC countries do not have much excess production capacity beyond their immediate needs, and they have limited storage capacity which provides about two- or three-days' supply. A study for GCC Water Grid has been commissioned by the GCC Council to a consulting firm (SOGREA) and is expected to provide its technical and economic feasibilities.

G. Expanding GCC Coordination for Improving Water Resources Management

5.75 The GCC issued regional guidelines for the conservation of water resources in member states. This publication, No. 0188-091/K/H/98 of the General Secretary, GCC, outlines proposed water conservation rules, executive procedures and extensive groundwater registration, inventory and regulation procedures for consideration by its members. The GCC appears to provide a principal vehicle for the coordination of joint efforts to develop model integrated water resources management policies, procedures and regulations that are adaptable to the Gulf Region. The Council can strengthen its role in harmonizing water legislation and policies among GCC countries and adopt a common strategy and policies in the water sector to reduce excessive depletion of fresh groundwater, especially in aquifers shared by the GCC countries, and in water tariffs and cost recovery.

5.76 The GCC can also initiate joint feasibility studies, and subsequent implementation and financing studies establish their viability. These could include: (a) water importation from Iran or Turkey; (b) supporting research on more efficient desalination technology and the use of brackish water in agriculture; and (c) establishing a regional hyrdo-meteorological information system for water resources.

5.77 The GCC's ministerial-level water resources and agriculture committee meets once a year. The ministerial committee is supported by five staff, which make up the GCC's water resources and agriculture department. Due to the pressing issues in the water sector, it is recommended to strengthen the staff of the water and agriculture department for the technical, economic/financial, and institutional fields of water resource management. The expanded water and agriculture department can serve as the technical secretariat of the water resources and agriculture ministerial committee. It may also be prudent to explore the possibility of separating the water resources department (to become in charge of policy and planning), from the agriculture (water user) department.

VI. NEXT STEPS

6.1 The main findings of the report will be presented at the GCC Water Symposium to be held in Dubai during June, 2005 organized by the AGFUND and the World Bank under the auspices of the GCC and the UAE Government. The main objectives of the Symposium would be: (i) encouraging knowledge sharing among GCC countries and identification of strengths and weaknesses in water resources management; (ii) conducting a broad-based dialogue with key stakeholders to provide inputs to this report; and (iii) proposing a broad framework for the development and implementation of a regional water strategy based on the IWRM approach. The enhancement of the GCC's coordination role for supporting countries' efforts in this respect should also be considered.

6.2 Following the Symposium, it is recommended that the GCC countries form a high-level committee within the existing GCC structure composed of technical experts, Government officials and user representatives. The purpose of such a committee would be to address the main issues, constraints, and recommendations identified by the study and at the Symposium. The high-level committee would present its findings and conclusions to the political leadership in the GCC countries.

6.3 Following such a presentation, it is recommended that an action plan be prepared by this committee that will translate conclusions and recommendations into actions. The committee will decide if there is a need for a follow up Phase II of the study, where key water sector development and management options for individual GCC countries can be developed. It will take into account the issues, strategies and policies analyzed in Phase I and discussed at the Symposium. The World Bank will be ready to continue supporting this effort if requested by the AGFUND, the GCC or any of the individual countries.

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ANNEX 1
BAHRAIN

Table 1.1: Water Production in Bahrain, MG

Year	Groundwater	RO	Desalina Ted	Total	Daily Average	% Ground Water	% RO	% Desalination
1980	9023.55	0	721.57	9745.12	26.63	93	0	7
1985	8174.64	3384.33	6054.47	17613.44	48.26	46	19	34
1990	10603.25	3219.30	8698.00	22520.55	61.70	47	14	39
1995	12022.07	3909.85	7641.69	23573.61	64.59	51	17	32
2000	10049.37	4981.50	12899.22	27930.09	76.31	36	18	46
2001	9941.51	5028.80	14794.06	29764.37	81.55	33	17	50
2002	10279.48	5004.72	15103..05	30387.25	83.03	34	16	50

Table 1.2. Desalinated Water Cost in Bahrain, fils/m ^{3}, 1998-99

	Production Cost		Transmission Cost		Distribution Cost		Total Water Cost		Average	
	1999	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**	**1998**	**1999**	**1998**
Fuel	15	16	-	-	-	-			8	8
Electricity	30	33	3	4	-	-			19	22
Operations	25	26	1	2	-	-			15	15
Maint Repairs	17	20	13	18	13	15			34	43
Works	87	95	17	24	13	15			76	88
Overhead	8	9	3	3	6	7			13	15
Depreciation	104	122	29	28	43	44			126	137
Adm Finance	20	18	3	3	14	13			28	25
Total fils/m ^{3}	219	244	52	58	76	79	347	381	243	265
Total \$/m ^{3}	0.58	0.65	0.14	0.15	0.20	0.21	0.92	1.01	0.64	0.70
Water Prod. Mm ^{3}	116.7	114.7	1999= 38.4 MSF 22.9 RO 55.4 Groundwater 1998= 38.7 21.5 54.5							

Source: MEW 1 BD = 1000 fils ; 1 BD = 2.653 US$ as of 3/13/04

Table 1.3. Investment in Desalination Projects in Bahrain, BD Million

Year	Projects Under Construction				Projects in the Planning Phase			
	Production		Transmission		Production		Transmission	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost
1997	1	121.90	19	12.95	1	12.00	5	37.00
1998	1	9.26	15	17.00			9	26.30
1999			4	13.10			4	12.00
2000	1	1.80	2	0.52				
2001					4	24.7	4	35.40
Total	3	132.96	40	43.57	5	36.70	22	110.70
Future Projects								
2002	1	7.5	2	15.42				

Source: Ministry of Electricity and Water, 2001 Statistical Yearbook

ANNEX 2
KUWAIT

Table 2.1: Installed and Planned Capacity of Desalination Plants in Kuwait

Year	Installed Capacity MIGD	Mm^3/D	Gross Production Desal. Water MIG	Mm^3	Gross Production of Fresh Water MIG	Mm^3
1980	100	0.45	21298	96.8	23480	106.7
1985	215	0.98	34398	156.4	37241	169.3
1990	252	1.15	44454	202.1	47548	216.1
1995	252	1.15	57367	260.8	61546	279.8
2000	286.8	1.30	82455	374.8	88475	402.2
2001	315.6	1.43	84815	385.5	91535	416.1
2002	315.6	1.43	90668	412.1	97640	443.8
2003	315.6	1.43				
2004	315.6	1.43				
2005	365.6	1.66				
2006	365.6	1.66				

Source: Ministry of Energy Statistical Yearbook, Water 2003. $1\ m^3$ = 220 Imp. Gallons

Table 2.2: Per Capita Consumption of Fresh Water in Kuwait

Year	IGD	LCD
1980	45.7	208
1985	57.4	261
1990	n.a.	n.a.
1995	98	445
2000	108.3	492
2001	108.6	493
2002	110.7	503

Source: Ministry of Energy Statistical Yearbook, Water 2003 1 Imp. Gallon = 4.54 liters

Table 2.3: Capacity and Expansion of Major Wastewater Treatment Plants, $1000m^3$/day

Plant	2003 Capacity $1000m^3$/day	2005	2010	2015	2020
Aridiya/Sulaybiya	399*	425	445	470	500
Rikka	126*	146	177	202	220
Jahra'a	95*	105	113	123	125
Um al Hayman	87	87**	87**	87**	87**
Total	707	763	822	882	932

Source: Ministry of Public Works, 2004 *Extrapolated **Assumed.

Table 2.4: Water Storage Capacity in Kuwait

Year	Fresh Water		Brackish water		Total	
	MIG	Mm^3	MIG	Mm^3	MIG	Mm^3
1980	236	1.1	142	0.6	378	1.7
1985	1274	5.8	219	1.0	1493	6.8
1990	1914	8.7	302	1.4	2216	10.1
1995	1897	8.6	459	2.1	2356	10.7
2000	2183	9.9	508	2.3	2691	12.2
2001	2183	9.9	508	2.3	2691	12.2
2002	2183	9.9	508	2.3	2691	12.2

Source: Ministry of Energy Statistical Yearbook, Water 2003 $1\ m^3$ = 220 Imp. Galons

Table 2.5: Estimated Subsidies in Kuwait in 2003, KD Million

Subsidy	Consumption Subsidies			Production Subsidies	Total Subsidies	% of Grand Total
	Kuwaitis	Expatriates	Total			
Electricity	157.6	127.8	285.4	139.6	425.0	23.8
Water	71.7	48.5	120.2	39.4	159.6	8.9
Fuel	0.3	0.2	0.5	4.4	4.9	0.3
Housing Loans	126.9	-	126.9	-	126.9	7.1
Renovation Loans	7.4	-	7.4	-	7.4	0.4
Marriage Loans	8.7	-	8.7	-	8.7	0.5
Industrial Loans	-	-	-	4.1	4.1	0.2
Gov. Housing	67.5	-	67.5	-	67.5	3.8
Gov. Plots	49.7	-	49.7	271.2	320.9	18.0
Health care	70.2	91.8	162	-	162.0	9.1
Education	246.2	70.5	316.7	-	316.7	17.7
Transportation	0.4	6.7	7.0	-	7.0	0.4
Communications	8.6	4.6	13.2	4.4	17.6	1.0
Direct Gov. Aid	34.5	-	34.5	-	34.5	1.9
Basic Food Items	5.2	-	5.2	-	5.2	0.3
Cleaning & Maintenance	54.7	35.9	90.6	26.2	116.8	6.5
Grand Total	909.6	386.0	1295.6	489.3	1784.9	100.0
Ratio of Subsidy to (%):						
- Gov. Revenues	17.4	7.4	24.7	9.3	34.1	-
-Gov. Expend.	22.7	9.6	32.3	12.2	44.5	-
-GDP	10.2	4.3	14.6	5.5	20.1	-

Source: KISR (Draft Report), Evaluating the Impact of Subsidy Reform Policies in the State of Kuwait: The Case of Consumption and Production Subsidies, Phase I: Identification and Quantification of Subsidies Impact Analysis of Changing the Price of Electricity, December 2003.

Table 2.6: Fresh Water Demand Projections for Kuwait (2002-2025)
(Total consumption in Mm3 and per capita consumption in l/c/d)

Year	Scenario I		Scenario II		Scenario III		Scenario IV				
							Tariff increase				
								Price elas. =-1.1		Price elas .= -0.5	
	Total Mm3	Per capita (l/c/d)	Total Mm3	Per capita (l/c/d)	Total Mm3	Per capita (l/c/d)		Total Mm3	Per capita (l/c/d)	Total Mm3	Per capita (l/c/d)
2002	444	503	444	503	444	503	0.57	444	503	444	503
2005	544	542	526	525	517	528	0.62	500	498	508	507
2010	761	595	753	589	673	608	0.72	550	430	610	477
2015	1066	652	1078	660	877	700	0.84	605	370	733	449
2020	1492	715	1544	740	1142	806	0.97	666	319	880	449
2025	2088	785	2208	830	1488	928	1.12	732	275	1058	397
Average growth in (2005-2025)	7.0%	1.9%	7.4%	2.3%	5.4%	2.9%	3%	1,9%	-2,9%	3,7%	-1,2%

Consultants' projections
Estimated elasticities:
Population: 0.8
Price: -1.2
Per capita GDP: 0.2
Length of network: 0.4

Scenario I: Historical trend (Growth of total consumption of the period 1993-2002 which is equal to …)

Scenario II (based on the equation coefficients): No change in tariff as in the past, since 1966, which implies a decline in the real price at the rate of about 2% per annum; population growth: 5% per annum which is the average rate in the period 1992-2002; growth in per capita income: 1% per annum in real terms; extension of the network in terms of length at 2.6% per year which is the rate of expansion in recent years (1998-2002)

Scenario III: Population growth declines from 5% to 3% per year

Scenario IV: The price policy scenario: Tariffs are raised by 5% each year (3% in real terms). All other variables change as in scenario II

Table 2.7: Projections of Freshwater Subsidies in Kuwait (2002-2025)

	2002	2005	2010	2015	2020	2025
Scenario I						
Amount in US$ million	796	921	1310	1860	2638	3735
Ratio to GDP (%)	2.3	2.4	2.8	3.4	4.1	4.8
Ratio to 2002 oil export revenues (%)	5.2	6.0	8.5	12.1	17.1	24.2
Scenario II						
Amount in US$ million	796	893.9	1299.7	1886.4	2733.8	3956.6
Ratio to GDP (%)	2.3	2.1	2.3	2.5	2.7	3.0
Ratio to 2002 oil export revenues (%)	5.2	5.8	8.4	12.2	17.7	25.7
Scenario III						
Amount in US$ million	796	931	1224	1609	2112	2770
Ratio to GDP (%)	2.3	2.4	2.7	2.9	3.2	3.6
Ratio to 2002 oil export revenues (%)	5.2	6.0	7.9	10.4	13.7	18.0
Scenario IV						
Amount in US$ million	796	825	880	931	978	1017
Ratio to GDP (%)	2.3	2.0	1.6	1.2	1.0	0.8
Ratio to 2002 oil export revenues (%)	5.2	5.4	5.7	6.0	6.3	6.6

ANNEX 3
OMAN

Table 3.1: Areas of Major Crops in Oman - Acres

Crop	2000	2001	2002	2003
Vegetables	15694	16248	15976	16170
Field Crops	14719	15184	15003	14890
Fodder Crops	42559	43269	42914	42532
Fruits	100345	101423	100886	100009
Total	173317	176124	174779	173601

Source: Ministry of Agriculture and Fisheries

Table 3.2 (a): Water Production in Oman, MG

Category	2000	2001	2002
Muscat - Wells - Desalination	13,761 -2,561 -11,200	13,722 -2,474 -11,248	14,615 -1,850 -12,765*
Total	20,791	21,538	22,724

Source: Ministry of National Economy Statistical Yearbook 2003
* Equivalent to 48Mm^3. Other official estimates give desalination capacity of 104 Mm^3.

Table 3.2 (b): Water Production and Distribution in Oman

Category	20000	2001	2002
Production MG	20,791	21,538	22,724
Distribution MG	20,692	21,529	22,855
Connections (000)	116	128	134

Source: Ministry of National Economy Statistical Yearbook 2003

Table 3.3: Wastewater Treatment in Muscat, 2002

Network length kms	Installed capacity m^3/day	Aver. Vol. Treated m^3/day	% Treated
132	27,662	26,385	91%

Source: Data provided by the Ministry of Agriculture and Fisheries

Table 3.4: Population of Oman (000)

	1993	1995	2000	2001	2002
Total	2000	2131	2402	2478	2538
Omani	1465	1557	1778	1826	1870
Expatriate	535	574	624	652	668

Source: Ministry of National Economy: Statistical Yearbook 2003

Table 3.5: Relative Shares of GDP

Economic Activity	2000	2001	2002
Petroleum	48.7	42.6	41.7
Agriculture & Fishing	2.0	2.1	2.1
Industry	8.6	11.7	11.0
Services	42.9	45.6	47.3
Total	**100.0**	**100.0**	**100.0**

Source: Ministry of National Economy: Statistical Yearbook 2003

ANNEX 4
QATAR

Table 4.1: Water Production in Qatar (MG)

Year	Desalinated Water	Well Fields	Total MG	Total Mm^3
1997	24008	600	24608	93.2
1998	28895	614	29509	111.8
1999	29053	379	29432	111.5
2000	31930	372	32302	122.4
2001	33492	0	33492	126.9
2002	34843	0	34843	132.0*

Source: The Planning Council, Annual Statistical Abstract, September 2003 1 m^3 = 264G
***** Other official sources estimate production at 158 Mm^3.

Table 4.2: Land Utilization in Qatar Ha

Year	Cultivated land	(Forages)	Not Cultivated	Total
1996	9555	(2355)	55445	65000
1997	11510	(2812)	53490	65000
1998	10117	(3011)	54883	65000
1999	10039	(2886)	54961	65000
2000	9762	(2967)	55238	65000
2001	6071	(1562)	58929	65000

Source: The Planning Council, Annual Statistical Abstract, September 2003.

Table 4.3: GDP at Current Prices 1999-2003, QR Million

Sector	1999	2000	2001	2002	2003
Agriculture and Fishing	263	241	240	255	260
GDP	45111	64646	64579	65088	70828
Percent	0.6	0.4	0.4	0.4	0.4

Source: The Planning Council, Annual Statistical Abstract, September 2003.

Table 4.4: COST OF PRODUCTION OF DESALINATION WATER -2003

	Station 1 RAF B Year 2003 ACTUAL	Station 2 RAF B1 Year 2003 ACTUAL	Station 4 RAF A Year 2003 ACTUAL	Satellites	Station 8 DUKHAN Year 2003 ACTUAL
OPERATING EXPENSES					
Man Power					
	20,894	2,805	34,296	7,144	2,383
Gas	98,509	71,606	191,653	70,747	2,661
Spare parts & Consumables	18,309	174	11,744	8,978	1,024
General Expenses	16,491	2,108	1,787	413	925
Depreciation	209,760	28,441	29,757	12,236	2,683
Finance Costs	140,818	8,035	-	-	-
Liquidated Damages				15,913	
H O Cost	29,836	8,592	14,779	5,078	603
				-	
TOTAL OPERATING EXPENSES	534,617	121,761	284,016	120,509	10,279
Allocation to products-QR '000					
Power	329,998	121,761	180,051	120,509	
Water	204,619		103,965		10,279
Production					
Power- mwh	4,472,266	1,845,506	2,297,289	1,753,100	
Water-Cubic meter	54,108,569		97,218,093		1,823,000
Unit cost (QR)					
Power- mwh	73.7877	65.9770	78.3754	68.7405	-
Water-Cubic meter	3.7816		1.0694		5.6385

Allocation of Common Costs:
Gas Allocated 80/20
Head office cost 50/50
Other cost 65/35

Source: Data provided by QEWC

ANNEX 5
SAUDI ARABIA

Table 5.1: Employment in Agriculture

Category	1982 Number Percent	1999 Number Percent	Change Number Percent
Total Workers in Agric.	457,338 100.0	563,170 100.0	105,832 +23.1
Saudi	356,194 77.9	268,537 47.7	87,657 -24.6
Non-Saudi	101,144 22.1	294,633 52.3	193,489 +191.3

Source: MOA, 1982 and 1999 Agriculture Census

Table 5.2: Number and Area of Agricultural Holdings, 1999

Traditional Irrigation		Modern Irrigation		Not Irrigated		Total	
No.	**Area (ha)**	**No.**	**Area(ha)**	**No.**	**Area (ha)**	**No.**	**Area (ha)**
147,325	1,749,113	22,502	2,164,738	35,222	136,639	205,049	4,050,490

Source: MOA, Agriculture Census 1999.

Table 5.3. Cropped Area and Production

	1971		1992		2000	
Item	**Area (ha)**	**Production (tons)**	**Area (ha)**	**Production (tons)**	**Area (ha)**	**Production (tons)**
Total	418,907		1,570,818		1,119,769	
Cereals	300,758	180,000	1,124,600	4,704,838	618,720	2,170,794
(Wheat)	30,156	41,908	924,409	4,123,656	419,220	1,787,542
Vegetables	34,340	683,000	124,222	2,073,546	94,034	1,927,013
Fruits	42,709	361,973	102,574	899,169	193,350	1,188,460
Forages	41,100	493,000	219,423	2,425,561	213,665	3,262,545
Red Meat		22,000		140,000		160,000
Poultry Meat		7,000		288,000		483,000

MOA, Time Series of Agricultural Statistics in Saudi Arabia During Three Decades (1971-2000), 2003.

Table 5.4: Evolution of Irrigation Water Use in Saudi Arabia

Year	Irrigated Area (ha)	Water Used for Irrigation MCM: Non-Renewable Groundwater	Renewable Water	Total
1980	437,177	3,199	4,273	7,472
1985	946,359	8,503	3,104	11,607
1990	1,379,154	11,230	5,283	16,513
1994	1,595,546	14,224	5,941	20,165
1995	1,302,363	12,539	6,549	19,088
1999				18,303*

* Preliminary estimate.

Source: Al-Tokhais, Dr. Ali, Future of Water Resources and Development Requirements in the Kingdom of Saudi Arabia, 2003 (Arabic), paper presented at the Future Vision of the Saudi Economy Symposium, organized by the Ministry of Planning, 2003.

Table 5.5. Summary of Groundwater in Storage and Available Groundwater

Aquifer	Volume of Groundwater in Storage* (MCM)	Available Groundwater (MCM)
Saq	258,400	103,360
Tabuk	237,500	95,000
Jawf-Sakakah	109,800	43,920
Minjur-Dhraum	74,000	38,480
Wasia-Bidyadh	171,300	111,340
Umm er Rhaduma	66,600	33,300
Dammam	6,000	3,000
Total	923,600	428,400

Source: World Bank, Kingdom of Saudi Arabia: Assessment of the Current Water Resources Management Situation, Phase I, Vol. I, December 2003
*To a depth of 300 m, and estimated for the early-1980s

Table 5.6: Water Tariffs in Saudi Arabia, 1998

Cubic Meters per Month	SR/cubic meter
0-50	0.10
50-100	0.15
100-200	2.00
200-300	4.00
300+	6.00

Source: World Bank, Municipal Water and Sewerage Sector in Saudi Arabia

PSP and Selected Issues, April 21, 1998, in Shetty, S. op. cit

Table 5.7: Renewable Water Resources in Saudi Arabia, Mm^3

Source	Annual Availability 1999	Potential*
Reclaimed Wastewater	180**	2000
Desalinated Water	1060	2000
Surface Water	800	1600
Renewable Groundwater	2000	2000
Total	4040	7600

Source: World Bank, Assessment of the Current water Resources Management Situation, op. cit.
* Based on several assumptions ** Other sources (Al-Tokhais) give a figure of 475 in 2002 (Table 3.4).

ANNEX 6
UNITED ARAB EMIRATES

Table 6.1 (a): Cultivable and Cropped Area in the UAE (ha)

Category	1998	1999	2000	2001	2002
No. Farms	25212	28369	35584	37550	38209
Cultivable Area	111356	235948	273332	269059	270941
Cropped Area	93333	214422	244613	241423	242422

Source: MOAF, Agriculture in Numbers, 2003

Table 6.1 (b): UAE Self Sufficiency Ratios

Category	2001	2002
Vegetables	58	90
Dates	100	100
Fruits	8	8
Red Meat	31	26
Poultry Meat	17	24
Fresh Milk	83	81
Eggs	39	36
Fresh Fish	100	100

Source: MOAF, Agriculture in Numbers, 2003

Table 6.2: Water Consumption in the UAE (million gallons/year)

Year	FEWA	ADWEA	DEWA	SEWA	Total
1997	13695	48170	28670	7364	
1998	14747	54809	32446	8083	
1999	14638	58169	35834	8867	
2000	16032	63642	38442	9740	
2001	17212	72897	41343	10830	
2002	18074	88670	44429	11812	

Source: UAE MEW

Table 6.3: Per Capita Water Consumption in the UAE

Year	Water Production (million gallons/day)	Population (million)	Per Capita Consumption (gallons)
1997	338	2.684	126
1998	376	2.759	136
1999	412	2.938	140
2000	441	3.103	142
2001	478	3.277	146
2002	547	3.487	157

Source: UAE MEW

Table 6.4: Wastewater Treatment in the UAE, 2003

Source	Effluent m^3/day	Treated Water m^3/day	% Treated
Abu Dhabi Municipality	291,000	268,000	92.1
Dubai Municipality	266,817	260,000	97.4
Sharjah Municipality	105,000	95,000	90.5
Total	662,817	623,000	94.0

Source: Ministry of Electricity and Water

Table 6.5. Water Resources and Use in the UAE 1995 and 2002

Water renewable resources	**1995**		**2002**		**Average annual growth rate (1995-2002)**
	Mm3	**Share (%)**	**Mm3**	**% Share**	
Surface runoffs	150	13.8	150	8.0	
Recharge	125	11.5	125	6.7	
Desalination	704	64.8	720	71.1	
Treated wastewater	108	9.9	227	14.1	
Total	**1087**	100.0	**1222**	100.0	
Water use (Mm3)					
Municipa:l	600				7.7%
(Domestic)	520	23.5	830.7	23.7	6.9%
(Landscaping)	80	3.6	179.6	5.1	12.2%
Industrial	73	3.3	332.9	9.5	24.2%
Agriculture	1539	69.6	2161	61.7	5.0%
Total	**2212**	100.0	**3504.2**	100.0	**6.8%**
Water resource balance					
Overall balance In Mm3 In % of total use	-1125 -51%		-2282.2 -65.1%		
Surface and groundwater balance (in M3)	-1264		-1886		

Sources: For 1995: Al Zubari (2003); for 2002: Consultant's notes

Table 6.6. Projections of Water Supply and Demand in the UAE

	Projections of Water Supply and Demand in the UAE, Mm3					
Water Source	**2002**	**2005**	**2010**	**2015**	**2020**	**2025**
Surface runoff	150	150	150	150	150	150
Recharge	125	125	125	125	125	125
Desalination	720	945	1488	2342	3688	5806
Treated Wastewater	227	273	387	540	754	1053
Total	1222	1493	2150	3157	4717	7134
Water Use						
Municipal:						
Domestic	830.7	1045.5	1571.9	2363.2	3274.6	4923.2
Landscaping	179.6	254	452.6	806.4	1280.1	2281
Industrial	332.9	381	477.1	597.3	715.1	895.4
Agricultural	2161	2499	3185.2	4059.1	4927	6280
Total	3504.2	4179.5	5686.8	7826	10196.8	14379.6
Water Resource balance						
- Mm3	-2282.2	-2686.5	-3536.8	-4669	-5479.8	-7245.6
-% of Total Use	0.6512756	0.6427802	0.6219315	0.5966011	0.5374039	0.5038805
Cost of Desalination (US$ Million, 2003 Prices)	885.6	1162.35	1830.24	2880.66	4536.24	7141.38

Assumptions Resources: Conventional resources: no growth
Desalination: annual growth in supply equal to 9.5%, which is the rate of growth in desalinated water during the period 1995-2002Treated wastewater: increase at the same rate as domestic water use (6.9% per annum which is equal to the average growth rate during the period 1995-2002)
Use: same growth rates as in table… except for industrial use which is assumed to increase at the same rate as manufacturing value-added during the years 1999-2002 (4.6% per year)

Table 6.7: Water Tariffs by Type of Use in the UAE (AED/TIG*, 2004)

TYPE OF USE	ADWEA	DEWA	SEWA	FEWA
Metered:				
Commercial	10	35	30	20
Industrial	10	35	30	20
Federal ministries	10	35	30	20
Local Government	10	35	30	20
Residential national	0	15	15	20
Residential expatriate	10	15 35?	15 25?	20
Tankers	5	n.a.	n.a.	n.a.
Un-metered (AED per month)	50	n.a.	n.a.	n.a.

Sources: Ministry of Electricity and Water and Regulation and Supervision Bureau, Emirate of Abu Dhabi * 1000 IG: one thousand imperial gallons, which is equal to 4.56 m3 (one m3=220 IG

Annex 7
Water Statistics in GCC Countries

Table 7.1. Water Resource Availability in GCC Countries 1995

Country	Annual Rainfall mm	Annual Evaporation mm	Conventional Sources Mm3: Surface Runoff (1)	Conventional Sources Mm3: Groundwater Recharge(2)	Conventional Sources Mm3: Groundwater Used	Non-Conventional Water Sources Mm3: Desalination Capacity	Non-Conventional Water Sources Mm3: Desalination Production	Non-Conventional Water Sources Mm3: Treated Wastewater Capacity	Non-Conventional Water Sources Mm3: Treated Wastewater Production (3)	Non-Conventional Water Sources Mm3: Agricultural Drainage
Bahrain	80	1650-2050		-2	239	75	56	58.4	55.2	
Kuwait	110	1900-3500		-2	405	475	402	193	95	
Oman	20-300	1900-3000	1450	955	1223	51	34	>30	26	
Qatar	75	2000-2700		50	286	185	126	>105	103	
Saudi Arabia	70-500	3500-4500	3210	3850	17000	>875	795	>667	526	30
UAE	89	3900-4050	150	125	1615	704	385	>108	102	
Total			4810	4980	20768	2365	1798	>1161	907	30

Source: Al-Zubari, W., "Alternative Water Policies for the Gulf Cooperation Council Countries", in Alsdhahran A.S, and W.W. Wood (eds)
Water Resources Perspectives: Evaluation, Management, and Policy
(1) Most are seasonal flows of wadi systems. (2) Aquifer recharge occurs by underflow from equivalent aquifers in Saudi
Arabia, Bahrain (90-110 Mm3/year), and Kuwait (58-117 Mm3/year). (3) Reused treated wastewater volume is only 392 Mm3 used mainly in irrigation .
the balance is used either for recharge or disposed of in the sea.

Table 7.2. Water Use in Gulf Cooperation Council (1995)

Country	Municipal	Industry	Agriculture	Total
	Mm3	Mm3	Mm3	Mm3
Bahrain	107	19	161	287
Kuwait	297	13	323	633
Oman	85	6	1150	1241
Qatar	85	17	337	439
Saudi Arabia	2387	193	18575	21155
UAE	600	73	1539	2212
Total	3561	321	22085	25967
l/c/d	383	34.5	2367	2793
% of Water Use	13.7	1.3	85	100

Source: Al-Zubari, W., "Alternative Water Policies for the Gulf Cooperation Council Countries", in Alsdhahran A.S, and W.W. Wood (eds) Water Resources Perspectives: Evaluation, Management, and Policy

Table 7.3. Water Balance in GCC Countries Using Alternative water Policies, Bm3

Scenario I	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
Business as Usual							
Available water Resources	13.57	13.57	13.57	13.57	13.57	13.57	13.57
Total Water Demand	26	29.22	32.52	36.19	40.24	44.86	49.38
Water balance	-12.43	-15.65	-18.95	-22.62	-26.67	-31.29	-35.81
% Balance/Demand	-47.81	-53.56	-58.27	-62.50	-66.28	-69.75	-72.52
Scenario II							
Supply Augmentation							
Available water Resources	13.57	14.68	15.85	17.1	18.44	19.87	21.36
Total Water Demand	26	29.22	32.52	36.19	40.24	44.86	49.38
Water balance	-12.43	-14.54	-16.67	-19.09	-21.8	-24.99	-28.02
% Balance/Demand	-47.81	-49.76	-51.26	-52.75	-54.17	-55.71	-56.74
Scenario III							
Supply Augmentation and Policy Remedies							
Available water Resources	13.57	14.68	15.85	17.1	18.44	19.87	21.36
Total Water Demand	26	27.51	29.02	30.81	32.88	35.44	37.81
Water balance	-12.43	-12.83	-13.17	-13.71	-14.44	-15.57	-16.45
% Balance/Demand	-47.81	-46.64	-45.38	-44.50	-43.92	-43.93	-43.51

Source: Al-Zubari, W., "Alternative Water Policies for the Gulf Cooperation Council Countries", in Alsdhahran A.S, and W.W. Wood (eds) Water Resources Perspectives: Evaluation, Management, and Policy

APPENDIX 1

AN INSTITUTIONAL AND LEGAL FRAMEWORK FOR WATER RESOURCE MANAGEMENT IN GCC COUNTRIES

This Appendix provides only preliminary assessment and recommendations on water policies, legal and institutional frameworks for each country based on the information provided during the mission travels in March 2004. Further detailed analysis would be required through visits to relevant institutions and intensive discussions with decision-makers and operational staff in charge before making final recommendations.

Bahrain Policy, Legal, and Institutional Framework

The control of the water resources of Bahrain is divided between several ministries and several departments within those ministries.

The control of groundwater resources has been moved through a number of ministries over the past several years. This has resulted in a fragmented and unclear policy with regard to the use, control and allocation of groundwater and the adequate enforcement of existing laws and regulations. The present location of the Water Resources Directorate, the principal entity for the control of groundwater, is within the Ministry of Municipal Affairs and Agriculture (MMAA), a ministry basically concerned with agriculture. As this sector is the primary user of groundwater, this creates a conflict as the user is managing the regulator.

The control of desalination and potable/industrial water is within the Ministry of Electricity and Water. This ministry is also a user of groundwater for the purpose of blending but is primarily concerned with the production, transmission and distribution of desalinized water.

The control of the collection, treatment, transmission and distribution of sewage effluent is within the Sewerage and Drainage Department of the Ministry of Works and Housing. This Department is also responsible for the transmission and distribution of treated wastewater to the users. This places the burden of transmission and distribution of treated effluent on an agency that is under tremendous stress just to maintain adequate planning, expansion and operation and maintenance of the sewerage collection and treatment system.

A very recent effort has been made to create a coordination council between the various ministries involved in water resources. This may be a significant step forward in the planning for integrated management of the water resources of the country. However, the planning and regulation of water for the entire country is still fragmented and not addressed on an integrated basis.

A strong water law requiring the mandatory registration and allocation of pumping rights should be adopted and implemented. This should have as its main objective, the limitation of all groundwater extractions to a level below the sustainable inflow to the Dammam aquifer within Bahrain. This could result in the dry-up and abandonment of some farms and may require compensation for the dried up farms. A program of voluntary dry-up combined with a compensation package, could be offered in an attempt to reduce operating wells to a sustainable level. Mandatory dry-up and compensation should be considered if voluntary dry-up is insufficient to accomplish the desired result of sustainability.

Such a program would necessitate a strong public awareness program, participative meetings with users and strong support from the highest levels of government, in order to convince farmers that it is in the best interest of the entire country to restore this vital reserve and to return agriculture extractions to a long-term sustainable level when combined with the use of treated sewage effluent.

Strong regulations adopting modern water tariffs for potable water, groundwater and treated sewage effluent should be adopted and enforced.

Regulations should be considered for the adoption of water use standards for household appliances, sanitary appliances and facilities and the restriction of the use of desalinated water for landscaping over a certain limit. These regulations should consider the use of financial incentives for the retrofitting of water-using appliances to install efficient systems. The cost of such incentives should be offset by the deferral of the need to increase capacity in both the desalination system and the sewage effluent collection and treatment system.

Regulations should be adopted and enforced to penalize the wastage of water through inefficient or inappropriate use.

A Water Resources Ministry should be considered that would be independent of any operational water resources user agency. This would minimize the probability of conflict of interest in the regulation and allocation of groundwater and the limitation of groundwater pumping. This Ministry should incorporate the present Water Resources Directorate. This Ministry should have the responsibility for integrated water resources planning and management as well as coordination between agencies within the sector. This Ministry should also be responsible for the regulation and enforcement of a system of water use rights for underground water use and the development of a comprehensive system of water resources tariffs for Bahrain. This Ministry should chair and be guided by a water resources council that includes representative from the relevant water resources operations agencies and selected representatives from the water user sector such as environmental, agriculture, commercial and industrial users.

Consideration should be given to the establishment of an over-all integrated water resources management planning department within the Water Resources Ministry. This entity would develop a long- range water resources strategy for Bahrain in close coordination with the operating sectors such as sewage collection and treatment, desalination and irrigated agriculture. The concept would be to separate planning and regulation from the operating departments to maintain objectivity and remove potential conflicts.

Within such an entity, consideration should be given to the establishment of a country-wide and sector-wide hydro-meteorological information system (HIS), with a centralized data base that is transparent and accessible to all planning, regulating and operating entities, and to the public.

Kuwait Policy, Legal, and Institutional Framework:

Within Kuwait, the water sector is divided between the Ministry of Energy and Water (MEW) regarding underground water and desalinated water and the Ministry of Public Works (MPW) with regard to the collection, treatment and distribution of wastewater. Within the MEW the Assistant Undersecretary for Water Projects has jurisdiction over all water projects, including groundwater development and management. The jurisdiction over groundwater however, appears to be limited to governmental groundwater projects and wells. There does not appear to be an effective program of regulation for either the construction of wells or extraction from those wells within the private sector. There is no central water resources authority in Kuwait and the coordination between the desalination systems, the groundwater use and the collection, treatment and distribution of treated wastewater appears to be informal. The Higher Committee for Economic Development and Reform is a relatively independent agency that provides oversight of the economic development planning of the country, including the water resources sector. The Kuwait Institute for Scientific Research (KISR) is a technical resource widely used by government entities for research and study of the natural and economic resources of the country. With the exception of private wells, the private sector plays little role in water resource management in Kuwait. However, it is reported that the Sulaybiya wastewater treatment facility will be tendered on a BOT (Build-Operate-Transfer) basis.

The adoption and enforcement of stronger laws and regulations regarding the collection of water tariffs accompanied by a strict policy of curtailing service for non-payment would enhance collections and instill a conservation ethic in the users.

The adoption of escalating block tariffs with a lifeline tariff set at a low level for an initial sustenance amount of water would curtail the use of high-value desalinated water for the purpose of landscaping within residential areas and other uneconomical uses of the scarce potable water supply.

A law requiring the inventory, registration and regulation of all wells would enhance the ability of both the users and the relevant agencies to better manage underground water.

The formation of a State Water Coordination Commission with participation from both the user community and the relevant agencies would create an integrated perspective on the development, operation and maintenance of the water resources infrastructure of the country. This would also provide the government with a "sounding board" for proposed regulatory changes, water tariff adjustments and would serve to initiate water sector reform within the country.

The Ministry of Energy and Water should have jurisdiction over all uses of water, including the administration and management of treated wastewater after it is collected and treated by the Ministry of Public Works. This would allow the optimization of the use of this water within the most beneficial sectors.

It is recommended that the private sector be given a bigger role in the management of water resources in Kuwait, through participation in investment and operation of desalination facilities similar to the approach followed by Abu Dhabi and in the transmission and distribution of treated wastewater as well as the construction and operation of wastewater treatment plants.

Oman Policy, Legal and Institutional, Framework

1. Legal framework:

Oman has enacted a series of water resources related legislation and laws which culminated in a comprehensive water law that was promulgated in 2000. This law formed a Ministry of Water Resources (MWR) that was recently combined with environment under the Ministry of Regional Municipalities, Environment, and Water Resources (MRMEWR). This law consolidated the responsibility for all water resources with the exception of desalinated water within one ministry. This law also established authority to issue water use permits, established well field protection zones and Aflaj protection zones.

Under this water law, regulations have been established that mandate the registration of existing wells, require any new well or modification of existing wells to obtain a permit before construction or modification. This same regulation requires the registration of all well construction contractors.

The regulations give the Department of Environment and Water Resources (DEWR) within the MRMEWR the right to define, control or curtail the abstraction of water from any well.

The regulations also give the DEWR the right to control the extension or maintenance of a falaj.

These regulations establish criteria for maintenance and repair of aflaj, the drilling of aflaj support wells and the use or installation of desalination units on wells, primarily to control the disposition of brine and to prevent contamination of the soil or aquifers from this brine.

The Environmental Department of MRMEWR has established regulations to prevent the discharge of any wastewater or pollutants into wadis.

The MRMEWR has also established a series of concentric zones around well fields that are based upon underground flow travel times that regulate the discharge of wastewater in these zones to prevent pollution of the well fields.
Each municipality or town has an environmental committee that assists in the review and regulation of environmental protection of the groundwater resources within their respective areas.

2. Institutional Framework:

The policy of Oman is to sustain the ancient historical aflaj rights and to restore these rights to their original levels. This includes the development of wells upstream of the aflaj to augment flows in the aflaj to historic flows. This decision to sustain this cultural water resources in Oman is principally under the jurisdiction of the MRMEWR, Department of Environment and Water Resources. This entity has jurisdiction over all groundwater, surface water, aflaj and the construction and operation of all large water resources infrastructure including flood control within Oman.

With the exception of desalinated water and wastewater treatment, the MRMEWR has responsibilities for all water resources planning within Oman in close coordination with the Financial Affairs and Energy Resources Council and the Ministry of National Economy (MNE).

The MRMEWR has the collection of data and maintenance of the data base for a Hydro-meteorological Information System (HIS).

The development, operation and maintenance, and transmission of potable and desalinated water supplies are under the jurisdiction of the Ministry of Housing, Electricity and Water (MHEW).

The distribution of potable water is under the jurisdiction of the MHEW, with the exception of Muscat where it is under the jurisdiction of the Governorate of Muscat.

The responsibility for the assessment and collection of tariffs for potable water supplies lies with the MHEW.

The collection and treatment of sewage is under the jurisdiction of the MHEW with the exception of the Governorate of Muscat where it is under the jurisdiction of the Oman Wastewater Services Company (OWSC).

The Ministry of Agriculture and Fisheries has responsibility for the provision of extension services and irrigation technology capacity building within Oman.

3. Water Resources Policy:

Oman has adopted a policy of curtailment of any additional well construction in addition to a prohibition of expansion of any irrigated agricultural areas in order to control and eventually reduce groundwater to a sustainable level.

All water resources planning and infrastructure development is controlled by the MNE through the capital allocation process which coordinates all planning and development within Oman. Water resources planning is set out in a 20-year National Water Resources Master Plan which is being implemented in 5-year stages under the jurisdiction of the MRMEWR and the MNE.

Oman also has a policy of evaluating the production of foodstuffs and consumer items within Oman on the basis of the concept of "virtual water" to emphasize the importation of goods that require high water consumption for production. It has been estimated that this program has provided for the importation of approximately 1,700 m^3 of virtual water per capita per year.[41]

Irrigation policy in Oman includes the financing and modernization of up to 100 farms per year as demonstration farms for improved water use technology. These demonstration farms are distributed throughout the agricultural regions of Oman.[42] This policy is administered by the Ministry of Agriculture and Fisheries.

4. Legal and Institutional Changes

Water Laws and Regulations: No changes to water laws or regulations are recommended for Oman. The present legal and institutional framework is functioning well and no obvious changes were observed to be necessary. Stronger emphasis could be placed on demand management and improved efficiency, but this is best addressed through extension programs, tariffs and public awareness.

Associated Water Sector Laws and Regulations: Additional protective legislation and regulations could strengthen the protection of environmentally valuable areas and protection of the historic cultural uses of water may need stronger support to prevent inadvertent destruction because of over-extraction of groundwater.

Institutional and Management Options: There appears to be a need for stronger coordination between the Ministries responsible for the administration of groundwater and desalinated water, and for the over-all planning for future development, to provide a more balanced consideration of future options and integration and optimization of these resources.

Qatar Policy, Legal and Institutional Framework

1. Legal and Institutional framework

The water sector in Qatar is divided between two Ministries. The Ministry of Municipal Affairs and Agriculture (MMAA) contains the Department of Drainage, the Department of Agriculture, and the Department of Environment. The Ministry of Electricity and Water, has jurisdiction over desalinated water supplies. This jurisdiction includes the relatively independent, KAHRAMAA, which has responsibility for water networks affairs and the distribution of water supplies to industrial and municipal uses. KAHRAMAA is governed by a Board of Directors appointed by the Government and operates as

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[41] Interviews with Water Resources Development Dept., MRM. 2004

[42] Interviews with the Ministry of Agriculture and Fisheries, Planning and Investment Dept. 3/2004

an independent public corporation. This Ministry also has jurisdiction over another independent public corporation, the Qatar Electricity and Water Company (QEWC). This Company has responsibility for the actual operation of the desalination plants. A recently formed High Water Council, which consists of representation from Ministries, the associated Departments and the public corporations will have responsibility for coordinating the activities within the water sector in Qatar. The Qatar Supreme Council for Planning has the over-all planning responsibility for the water sector in Qatar. There is lack of an Integrated Water Resource Management (IWRM) in Qatar. Aside from wells used in agriculture, the private sector plays a very limited if any role in water resource management in Qatar. The partial or full privatization of KAHRAMA and QWEC is under consideration by government.

2. Legal and Institutional Changes

Water Laws and Regulations: There is a need to develop, adopt and enforce laws and regulations to restrict the extraction of groundwater to a sustainable or lower level, in order to restore the quality of the groundwater within the Dammam aquifer. These laws and regulations should curtail further construction of wells and should control the well constructors to assure compliance. If such steps are not taken, the aquifer and the safe yield of 50.3 Mm^3 could be degraded to the point where the groundwater resources of the country become unusable and the emergency reserve that this water source could represent would not be available to the country in the foreseeable future. The development of new wells along the coast should be immediately curtailed to stop expansion of saline water intrusion and consideration should be given to an enforced reduction of pumping in this zone in order to begin to alleviate this water pollution problem.

Institutional and management options:

The present trend to decentralize the desalinated water production is an excellent move and could provide a path towards the privatization or partial privatization of the production infrastructure of this water source in the future, should the country desire.

There is a need to strongly support the present effort of the High Water Council in order to effectively integrate the management of water resources from the supply to the final disposition.

Management of the groundwater resources should be placed in a Department within the present Ministry that is less susceptible to conflicts with regard to the use of this water resource for irrigation. Groundwater policy should be driven by the need to reduce the use of this resource to a sustainable level, not from the agricultural user standpoint.

All agricultural policies should consider the concept of the use of virtual water by importing those agricultural products that require high consumption of water. Also, agricultural policy should be guided be efficiency indicators such as Domestic Resource Cost (DRC), Effective Rates of Protection (ERP) of agricultural production activities, and estimation of virtual water.

A similar consideration should be adopted when evaluating the potential relocation of industries to Qatar that require high water consumption and that produce products that might best be imported, from a water availability standpoint, unless this is justified by the high value added of such industries.

In addition, the participation of the private sector in investment or operation and maintenance of desalination and wastewater treatment infrastructure should be encouraged.

Saudi Arabia Policy, Legal, and Institutional Framework

1. Current Situation. The present legal, regulatory and institutional framework for water cannot adequately address some of the major problems with regard to the efficient utilization of the scarce water resources of the Kingdom or the non-renewability of a large percentage of these resources. Its high fragmentation and inconsistencies will undoubtedly result in conflicts, redundancy of efforts among agencies and confusion among water users with regard to the conflicting authorities and responsibilities for implementation and enforcement of water resource management policies. The Government of Saudi Arabia has taken an important step towards consolidating and integrating water resource management through the Ministry of Water and Electricity (MOWE).

Yet, there exist gray areas of overlapping responsibilities and authorities that should be clarified, although it will still require extensive cooperation between ministries and other governmental entities. These include the apparent overlap of responsibilities between MOWE and the Ministry of Agriculture (MOA) in the area of agriculture irrigation and the control and implementation of water reuse for irrigation. Conflicts can also be expected with local governments for the provision of urban water. Possible overlapping roles between the National Geologic Survey and MOWE should be carefully examined and modified as necessary, to facilitate cooperation and avoid duplication of effort in information collection and archiving.

Clarifications are also needed to prevent conflicts between the various agencies and public corporations that are now part of MOWE. For instance, the role of the Water Resources Department in the control of bulk water supplies and the control and enforcement of well extractions by the WASAs and the internal relationships between these entities. The new institutional arrangement should make this coordination effort more straightforward and simple, with less political interference.

2. Recommendations. The various laws now available in the water sector should be revised and/or reformulated to assure institutional compatibility with the new institutional structure and should be incorporated under a general umbrella water law —a law of principles— that clearly spells out the water resources policies of the KSA and sets the framework for more detailed laws and regulations within each separate area of responsibility.

Based upon the general policies set out within MOWE's water law, additional specific laws should be drafted for each of the water related sectors as necessary. These laws should be specifically related to each water sector and should spell out the policy and legal framework for that sector. Existing laws such as the Urban Sanitation Law and the Rural Sanitation Law are examples of these types of more specific laws.

In all instances, detailed legal directives and mandates should be addressed at the regulatory level. The laws should lay out the legal framework for each sector and the details should be clearly dealt with in implementing regulations. This provides the flexibility for changes in the regulatory framework to adjust to changing conditions, modifications due to experience or for other reasons, without having to make major changes in the water laws themselves. Each agency or entity within MOWE should be guided by the MOWE Water Law and such specific laws as are deemed necessary. However, the operational aspects, implementation aspects and more detailed mandates for each entity should be dealt with in the regulations promulgated by that entity within its sector.

A water entitlement system needs to be developed within the KSA and strongly enforced. This should be carefully founded in the water laws (i.e., the main Water Law plus all the specific water laws) and should be guided by clear and defined regulations. This system may start incorporating the rudimentary water rights and entitlement system as it may exist today. After a reasonable grace period, all water uses should be encompassed within the system. The water entitlement system must have provisions for the small users, hereditary or traditional rights, and other rights that may be necessitated by history or cultural reasons and for the grandfathering of existing uses with some criteria of reasonability of use. This water entitlement system must be maintained in an up-to-date manner and should be administratively efficient so that long delays in issuing entitlements, modifying entitlements or resolving deputes regarding entitlements are avoided.

A water tariff should be implemented for several reasons. First, to recover at least a portion of the costs of implementing the water resources management system through a bulk water tariff. Second, to recover the costs of providing end-user water such as treated potable water, industrial water and irrigation water at the farm gate. Third, to recognize that the use of water has a cost and that must be supported by those that consume water. These tariffs should be designed to reflect the ability of the users to pay, the essential nature of potable water to all people, the cross-subsidy of the poor by those users more capable of payment etc.

Consideration should be given by MOWE to appoint a legal, institutional and regulatory advisory committee (LIRAC) to cooperate with the Ministry with regard to the design of a new legal and institutional framework. This committee should have representatives of academia, the Chamber of Commence, representatives from relevant ministries and agencies and significant water users sectors. These advisory committees should provide suggestions, innovations as well as cultural and traditional considerations.

United Arab Emirates Policy, Legal, and Institutional Framework

1. Federal Institutional Framework

The role of the Federal Government varies by sector, and in the water sector, the Federal government role in the larger emirates of Dubai, Abu Dhabi and Sharjah is minimal compared to the role of the emirate governments. In the smaller emirates of Ajman, Fujairah, Umm Al Qaiwin and Ras Al Khaimah, the Federal government plays a key role in both the potable water and irrigation sectors. There is a clear lack of an Integrated Water Resources Management (IWRM) perspective in the UAE.

In all instances, both between the Federal Government and internally within the emirates, there is a great deal of duplication of effort, redundancy and fragmentation of effort in the water sector. This will be discussed in terms of functions and in terms of the situation observed within the Federal Government and the two larger emirates of Dubai and Abu Dhabi;

Within the Federal government the following institutions are involved in the water sector to varying degrees:

The Ministry of Electricity and Water (MEW) is involved in coordination of activities within the sector. It monitors the sector and is involved in the collection and archiving of data regarding water and electrical resources. From an operational standpoint, its associated agency, the Federal Water and Electricity Authority (FEWA) actually supplies water and energy to the four smaller emirates through the operation of desalination, and electrical co-generation systems combined with the blending of brackish groundwater.

The Federal Ministry of Agriculture has responsibilities for the irrigation and, at least, implied responsibility for the use of groundwater for irrigation. This authority is blurred with regard to the larger emirates, which have organic departments of agriculture and strong municipalities but is clearer with regard to the smaller emirates. While there appears to be implied authority to control groundwater use and the development of wells, it does not appear that any control is being exercised.

The Federal Environmental Agency (FEA) is responsible for the implementation of the Federal Environmental Law and the activities outlined therein. In this regard it is developing the National Environmental Action Plan for Water Resources. This action plan includes a proposed water resources data bank, assessment and monitoring of groundwater resources, the surveying and inventorying of all water resources areas, aquifers, the numbering and recording of all groundwater abstractions and an evaluation of water resources including groundwater recharge potential, and the use of treated wastewater. The action plan also includes rationalization and more efficient use of water in the agricultural sector, water resources inventory and evaluation, domestic and industrial water demand management, including institutional frameworks to implement demand management and the assessment of long-term sustainability for desalination as a water supply. This far-reaching action plan is, obviously, inclusive of the responsibilities and authorities of other agencies and authorities with similar charges, both at the Federal level and at the emirate level. The manner in which it will be achieved in a participative, cooperative and coordinated effort remains to be seen.

The Department for Water Resources Studies, under the office of the President of the UAE, is presently in the process of establishing a Hydro-meteorological Information System (HIS) for the UAE. Its role to date appears to be concentrated in the meteorological area and in the analysis of the potential for rainfall augmentation through artificial nucleation. However, discussion with this center revealed plans for the eventual incorporation of water resources information into the database, including an inventory of all wells, the physical parameters of the wells and abstraction capacities and historical abstraction volumes. This effort does not appear to be closely coordinated with other efforts in the HIS area such as the aspirations of the FEA and the stated objectives and activities of the EWRDA as discussed below.

Dubai Emirate. The Dubai Water and Electrical Authority (DWEA) is responsible for the production and distribution of electrical energy and desalinated water for potable and industrial use within the emirate. It also uses groundwater from well fields for blending with desalinated water. It is governed by a Board appointed by the Emirate Government and is managed by a professional manager and staff. The tariffs are set by the government and all electrical and water infrastructure are owned by the Authority.

The Municipality of Dubai is responsible for the collection and treatment of wastewater within the emirate and for the distribution of the treated wastewater for use in landscape irrigation and for some industrial use.

The Dubai Agriculture Department is responsible for irrigation within the emirate and for the control of groundwater use.

Abu Dhabi Emirate. Abu Dhabi, represents over 80% of the geographic area (and 42% of the population) of the UAE The Abu Dhabi Water and Electrical Authority (ADWEA) is responsible for the administration of the production of electrical energy and water derived from desalination. As opposed to the Dubai desalination system, which is totally governmentally owned, the production of electricity and desalinized water in Abu Dhabi involves the private sector, with 4 of the 7 facilities being privatized at a level of 40 % private sector, 60 % public sector. The transmission of electricity and water is still totally held by the emirate, as well as the distribution. Fuel for the generation of electrical energy and desalinized water is provided to the production system but data was not available as to whether this price is subsidized or not.

The Abu Dhabi Electrical and Water Regulation and Supervision Bureau (RSB) is an independent agency of the emirate with the responsibility of regulating and auditing the electrical and desalinized water sectors. It maintains an independent surveillance of the financial aspects of the system.

The Abu Dhabi Municipality is responsible for the collection, treatment and distribution of wastewater within the emirate.

The Terrestrial Environmental Research Center (ERWDA) is an agency of Abu Dhabi. It has, as its objective, management of the overall water resources of the Emirate of Abu Dhabi in a sustainable, economically viable and environmentally sound way that will allow the long-term socio-economic development of the Emirate of Abu Dhabi. Towards that end, ERWDA is developing a Water Resources Management Strategy that includes the establishment of a Water Resources, GIS-enabled Database for the entire emirate. The first phase is anticipated to include the inventory and registration of all wells. It would also include a complete inventory of all water production, demands and uses from all sources including desalination, groundwater, treated wastewater and other sources. The baseline information would include a comprehensive water balance by Water Assessment Units and for the Emirate as a whole, along with projected demands and balances for the future. A review of the present water resources monitoring network and proposals for improvement and expansion would be made. The second phase would be the development of strategy options and scenarios and the 3rd, 4th and 5th phases would involve the adoption of a water resources management strategy and the commencement of the implementation of that strategy at the end of the 5 year period involved in this ambitious plan. Many of the objectives of this effort appear to duplicate efforts of other entities, both at the Federal level and within the Emirate of Abu Dhabi. Coordination between responsible entities will be required if this program is to be successful.

The Agriculture Department in the Abu Dhabi Municipality is responsible for the administration of a governmental farm program and other agricultural programs including land subsidies, agricultural input subsidies and the purchase of agricultural products from the farmers within the Emirate. The Municipality provides up to 2 ha of land to farmers at no cost, provides all agricultural inputs such as fertilizer and then buys certain crops from the farmers. This agency appears to have some control over the use of groundwater for irrigation, at least on Emirate-owned farms. The complete function of this department was unclear and its role in the water sector was difficult to define. Undoubtedly, any agricultural subsidies that contribute to groundwater use for uneconomic agricultural activities further exacerbate the major problem of groundwater over-exploitation within the Emirate of Abu Dhabi.

Within the Sharjah Emirate, direct contact with the emirate was not possible so the following information is not based upon direct interviews or analysis. The Sharjah Electrical and Water Authority, (SEWA) is responsible for the production of electrical energy and desalinized water for the Emirate. However, information on other agencies within the Emirate and their role or impact on the water sector was not made available.

2. Legal and Institutional Changes

There is no comprehensive system of water law that applies to the UAE. There is a fragmentation of laws and regulations that are applicable to each emirate and a body of Federal Regulations that are ineffective in dealing with the over-all problem because of the division of responsibilities and authorities between the many different agencies of the Federal government and the major Emirates.

There is no enforced regulation that deals with the registration of wells, water rights for wells, the allocation of volumetric extraction rights, the measurement of extractions, measurement of groundwater quality, well construction or the enforcement of well extraction entitlements. Some regulations exist within the emirates for the requirement of permits for the construction of wells but appear to be ignored.

There are no regulations that deal with water tariffs on groundwater extraction or any other economic attempt to limit extraction to a sustainable level.

The Federal Environmental Agency appears to have been given the power to establish rules and regulations over the over-extraction and pollution of groundwater, but this does not appear to be under implementation.

The present institutional system for the water resources sector is highly fragmented and responsibility is scattered within many agencies, at both the Federal and Emirate level. In the groundwater area, this has led to differing standards and regulations from one region to the other and to the apparent abandonment of the responsibility of regulating or managing this highly controversial area by any agency. At present, there is no system of registration of groundwater use, wells or limitation on extractions. Such is the case despite the fact that almost all aquifers are suffering from gross over-extraction beyond safe yield. There is a problem of groundwater quality deterioration, saline intrusion and unrestricted expansion of wells and extractions that works to the detriment of both the physical aquifer and the economies that are dependent upon the groundwater resource.

In order to begin to deal with the pervasive problem of over-exploitation of the groundwater resources of the UAE and the degradation and deterioration of the quality of that resource, strong actions need to be taken at the highest levels of government. These will need to be actions and decisions that deal decisively with the problem, regardless of vested interests, political pressures and economic pressures. Unless such measures are taken, the majority of the groundwater resources and aquifers within the UAE are destined to become unusable from both a quantity and quality standpoint and the segment of the economy dependent on this resource, namely the majority of agriculture, will be destined to extinction within the country.

To more adequately coordinate the management of the entire water resources sector within the UAE, it is recommended that all agencies and governments participate in a cooperative integrated water resources management process. To that end, it is imperative that open communications, data bases and resource integration be coordinated and that competent water resources personnel work together to assure the optimum use of the varied water resources within the country.

It is recommended that a Federal Water Regulatory Authority be established that is independent of any user sector such as potable water supply, agriculture or wastewater production. This authority should have the clear authority to set minimum standards and regulations regarding water conservation, groundwater use and management within the UAE. This Authority should work with and through the individual Emirates to the extent possible to implement these standards and regulations. The authority should be provided with trained water resources management and enforcement personnel including personnel assigned to each emirate and to the outlying regions within the UAE to provide guidance, assistance in the registration, and licensing process and to implement the follow-on regulation and enforcement process.

This Authority should be provided sufficient power and independence to be able to implement controversial regulations, withstand pressures from vested interests and to operate in an objective and goal-oriented manner for the furtherance of the well-being of the country and its citizens. For this reason, it should have both the support of and access to the highest levels of government and decision-making.

Consideration should be given to the formation of user commissions to assist the Regulatory Authority in the administration, management and enforcement of allocations and extractions within each aquifer. This peer level management should be accompanied by a strong education and training program within the user community so that the realization of the importance of preserving the long term integrity of the water supply and the aquifer is clearly understood by all users. Also, in this manner, the users will participate in the determination that all users are operating within the allocation limits and that none are being given favoritism or taking unfair advantage of the system.

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