NOMINATION OF

Ministry of Water & Electricity

Kingdom of Saudi Arabia

Supporting Documents

For

King Hassan II Great World Water Prize 2012

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PART 1: BACKGROUND INFORMATION

1.1 Location and Geography

Saudi Arabia is situated at the furthermost part of the southwestern Asia, and it occupies about four-fifth of the Arab Peninsula, with a total area about 2 million square kilometers of which about 40% are desert lands. It lies within Latitudes 16^{o} and 32 ^{o} 12' N, and longitudes 34 ^{o} 36'E. Saudi Arabia is bounded by seven countries and three bodies of water. Saudi Arabia is bounded on the west by the Gulf of Aqaba and the Red Sea; on the east by the Arabian Gulf, Qatar, and the United Arab Emirates; on the south by Yemen and Oman; and on the north by Jordan, Iraq, and Kuwait (Figure 1). The total land boundaries is about 4,415 km (Iraq 814 km, Jordan 728 km, Kuwait 222 km, Oman 676 km, Qatar 60 km, UAE 457 km, and Yemen 1,458 km). The coastline is about 2,640 km (1,800 on the Gulf of Aqaba and Red Sea and about 864 km on the Arabian Gulf).

Figure 1: Location map of Saudi Arabia.

Saudi Arabia's geography is varied. From the western coastal region (Tihamah), the land rises from sea level to a peninsula-long mountain range (Jabal Al-Hejaz) beyond which lies the plateau of Nejd in the center. The southwestern 'Asir region has mountains as high as 3,000 m and is known for having the greenest and freshest climate in all of the

country. The east is primarily rocky or sandy lowland continuing to the shores of the Arabian Gulf. The geographically hostile Rub' al Khali ("Empty Quarter") desert along the country's imprecisely defined southern borders contains almost no life.
In general Saudi Arabia can be divided into five main physiographic units:

- The Western Mountains, called the Arabian Shield, with a peak at 2,000 meters (m) above sea level and crossed by deep valleys;
- The Central Hills, called the Nejd, which run close to the western mountains and lie in the center of the country. Their elevation ranges between 900 and 1,800 meters above sea level;
- The sand deserts of Dahana and Nafud;
- The Rub al-Khali Desert, which is the largest sand desert in world.
- The Coastal Regions, which include the coastal strip along the Red Sea with a width of 16 to 65 km. The important part is the Tihamah Plain in the south. The plain on the eastern side overlooks the Arabian Gulf is generally wide and includes the region of oases.

Much of the nation's landmass consists of desert and semi-arid regions, with a dwindling traditional Bedouin population. The total arable lands of the Kingdom are 52.68 million hectares (ha) or 23.4% of total area of the Kingdom. About 850,000 ha or 1.6% of the arable lands are cultivated.

1.2 Climate

Saudi Arabia falls in the tropical and subtropical desert region. The winds reaching the country are generally dry, and almost all the area is arid. Because of the aridity, and hence the relatively cloudless skies, there are great extremes of temperature, but there are also wide variations between the seasons and regions. In the central region, the summer (May to October) is overwhelmingly hot and dry, with maximum temperatures of over 50°C, while the winter is dry and cool with night-time temperatures close to freezing. There can be severe frost generally and even weeks of snow in the mountains. The western and eastern regions are hot and humid in the summer months, with maximum temperatures around 42°C, while the winters are warm.

The rainfall distribution in Saudi Arabia is shown in Figure 2. In the central, annual rainfall varies between 100 and 200 millimeters (mm). Further in the south, except near the coast, annual rainfall drops below 100 mm. The higher parts of the west and south do, however, experience appreciable rainfalls and over some small areas 500 mm/year is not uncommon . Total precipitation has been estimated at 126.8 km^3/year, which is equal to 59 mm/year over the whole country.

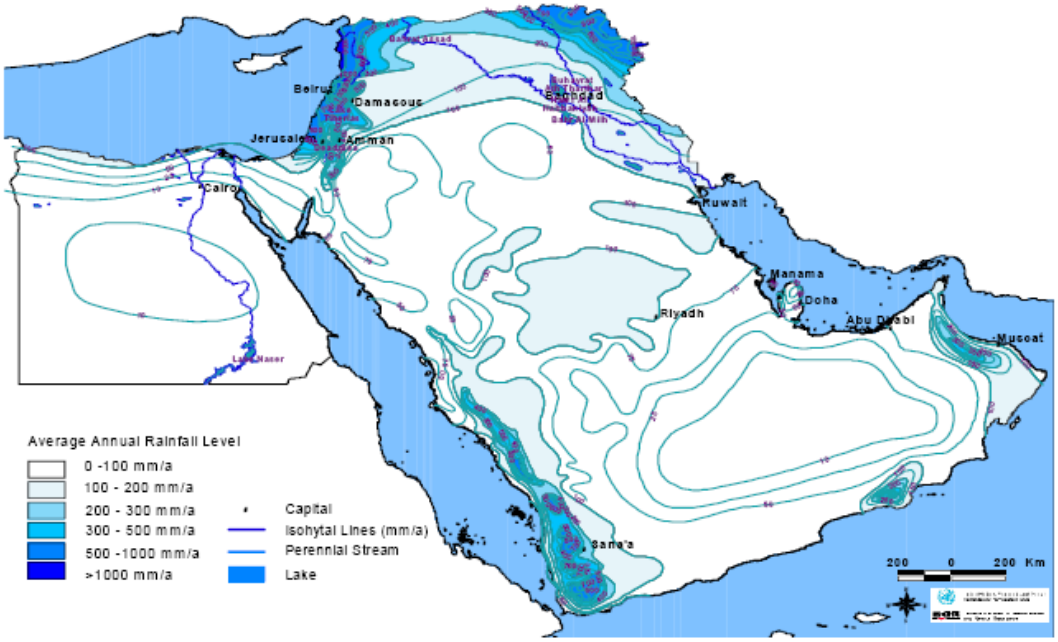


Figure 2: Rainfall distribution in Saudi Arabia.

1.3 Population

In Saudi Arabia, the population of the Kingdom has increased from about 4.07 and 7.7 million in 1960 and 1970 respectively, to about 10.7, 15 and 23.9 million in 1980, 1990 and 2007 respectively, and expected to reach at growth rate of 2% to about 31.5 and 69.7 million by 2020 and 2060 respectively (Figure 3). The population has increased by 2.8 times between 1970 and 2000, and expected to double during the coming 25 years. The rapid population increase is due to high growth rate which is about 2.8% especially after 1975. The country witnessed, in 1975, a major threshold increase in its oil revenues by about twenty to forty times. The annual government revenues (mainly oil) have increased after 1974 from less than Saudi Riyals (SR) 5 billion to about SR 100 - SR 220 billion.

This high growth rate is due to major improvements in public health services in urban and rural areas coupled with better standard of living after 1975.

1.4 Urbanization

Domestic water consumption in urban areas is usually considerably higher than in rural areas because of the increased need of affluent populations living in cities. Urbanization is therefore a significant factor in increasing water demand and, hence, in exerting pressure on the available water supply sources. With increasing urbanization, that pressure eventually may extend to the peripheral zones of major towns and cities, and lead to potential conflict between urban-rural populations competing over the same water sources.

The urban population has increased from about 3.74 million or 50% of the total population in 1970 to about 6.4 (60%), 10.5 (76.6%) and 15.6 (79.8%) million in 1980, 1990 and 2000 respectively (Figure 4). The urban population is expected to reach about 30.7 million in 2030 or about 80% of the total population of the country. Consequently, it is observed that the domestic water ratio has increased from about 6.0% of the total national water use in 1990 to about 10% in 2000, and it is expected to rise to about 30% in 2030.

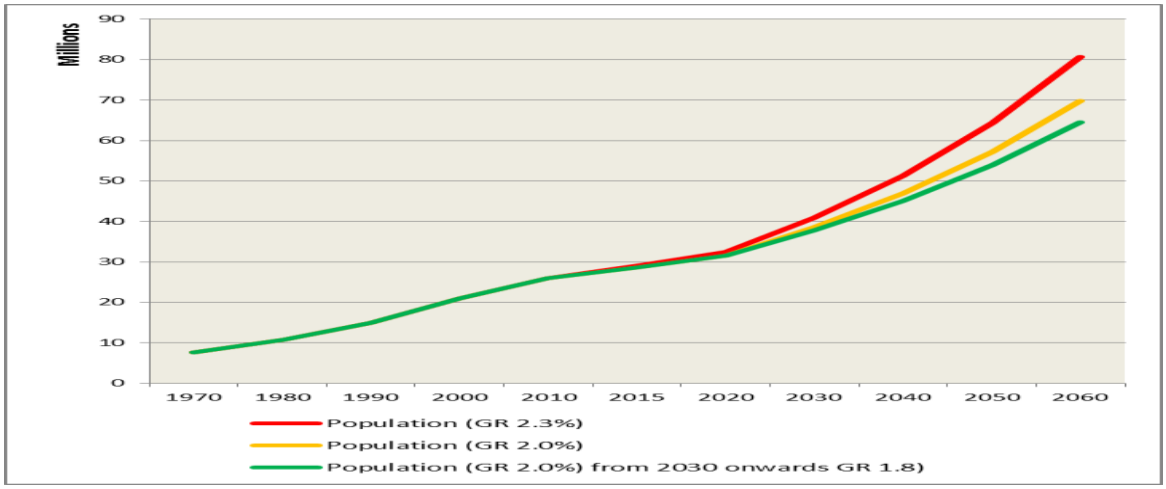


Figure 3: Population Growth in Saudi Arabia.

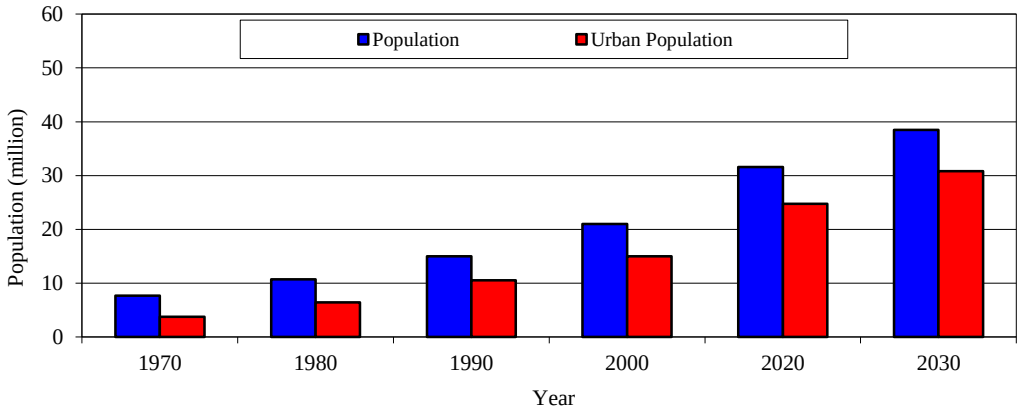


Figure 4: Urbanization in Saudi Arabia.

PART 2: WATER RESOURCES IN THE KINGDOM

Water resources in Saudi Arabia are generally scarce due to the low average annual rainfall and high evaporation.Water is obtained from four distinct sources:

- Surface water;
- Groundwater (renewable and non-renewable)
- Desalinated water, and
- Treated wastewater

Assessments of available water resources were started in 1965. The country was divided into eleven hydrological regions and comprehensive investigations were carried out on regional and national levels between 1965 and 1985 (MAW 1984). The results of these studies revealed that the surface water is limited, while non-renewable groundwater represents most of conventional water resources in the country. Groundwater is encountered in shallow and deep aquifers with various potentialities. Desalination plants are established to substitute for water deficiency. Reuse of treated wastewater is practiced at a limited scale. Ongoing resource assessments are expected to provide reliable estimates of the volume of water left in storage in each aquifer, and estimates of the portion of that volume that can be extracted on a sustainable basis.

2.1 Surface water

Perennial rivers and lakes do not exist in Saudi Arabia. Surface water resources are scarce to absent with the exception of the mountainous areas in southwestern part of Saudi Arabia. Run-off occurs mainly in the form of intermittent flash floods, and is governed by rainfall patterns and topographic features over the Saudi Arabia. The low rainfall quantities in most of the Kingdom resulted in limited surface runoff. The average precipitation is around 59 mm/year. On the other hand, the evaporation rate in Saudi Arabia varies between 2.5 mm/day in December and January to about 17 mm/day in July and August. The annual evaporation varies between 2500 mm/yr in the coastal areas to about 4500 mm in the central parts of the desert of Saudi Arabia. The average annual volume of rainwater in Saudi Arabia is estimated at 158.47 billion m^3.

Because of the flat nature of most of the lands of Saudi Arabia along with the high evaporation rate, it is difficult to directly harvest and utilize the surface water runoff. Limited amounts of this water recharge the groundwater resources. The quantities of the annual runoff are estimated as 5,000 million cubic meters (MCM) of which 780 MCM are produced in the Arabian shelf and the rest are in western coastal parts of the Kingdom.

The storage capacity of 215 constructed dams of different shapes and sizes is 832 MCM. These dams were constructed for groundwater recharge and flood control purposes. In addition, there are four major dams under construction with a capacity of 753 MCM.

2.2 Groundwater

Geologically, the country is divided into the Arabian Shield and the Arabian Shelf. The Arabian Shield is essentially composed of Precambrian-Cambrian elevated lands of igneous and metamorphic complexes in some areas with volcanic flows (Harrats) of Tertiary-Quaternary/Recent ages. The shield, which covers one-third of the peninsula, consists of an outcrop of hard rock that begins in the western part of Saudi Arabia and extends from the Gulf of Aqaba in the north to the Gulf of Aden in the south. The shield has limited groundwater stores in the alluvial deposits of wadi channels, and weathered joints and fracture zones.

The Shelf is mainly formed of a sedimentary sequence lying unconformably on the shield rocks and dipping away towards the Arabian Gulf. The sedimentary sequence starts with detrital deposits of the Cambro-Ordovician Saq Formation, and ends with the Quaternary-Recent deposits of the Gulf. The dependable groundwater reserves are those stored in the thick extensive sequences of sedimentary formations of the Arabian Shelf, underlying two-thirds of the Arabian Peninsula.

Most of the groundwater resources in Saudi Arabia exist in two main sources: deep nonrenewable groundwater in aquifers located mostly in the sedimentary cover engulfing the Arabian Shelf, and renewable groundwater in fractured Precambrian basement and shallow alluvial aquifers located mostly in the western and southwestern parts of the country.

2.2.1 Shallow Alluvial Aquifers

Shallow alluvial aquifers, restricted mainly to major wadis (a wadi is a dry river bed with seasonal runoff) are the major source for water in western Saudi Arabia. Water from these aquifers is used for irrigation and domestic purposes, and for most of the rural areas, for drinking. Though limited in quantity, groundwater in the shallow alluvial aquifers can be replenished more frequently and more rapidly than the deep sedimentary, mostly confined aquifers. However, these aquifers are sensitive to human activities because of the shallow water table coupled with frequent runoff, and proximity of the aquifers to major cities and towns with large population densities.

These aquifers store about 84 BCM with an average annual recharge of 1,196 MCM. These assessments need to be updated with the ongoing studies such as BRGM and GTZ studies, because they were mostly based on investigations carried out before more than fifteen years.

2.2.2 Fossil Groundwater Aquifers

The main source of water for Saudi Arabia is the non-renewable fossil groundwater stored in the sedimentary deep aquifers. The sandstone and limestone geological formations of the Arabian Shelf, shown in Figure 5 store significant amounts of groundwater that are thousands of years old. The sedimentary aquifers have been classified as either primary or secondary, based on their areal extent, groundwater volume, water quality, and development potential. The principal aquifers are: Saq, Wajid, Tabuk, Minjur, Dhruma, Biyadh, Wasia, Dammam, Umm Er Radhuma and Neogene. The secondary aquifers are: Al-Jauf, Al-Khuff, Al-Jilh, the upper Jurassic, Sakaka, the lower Cretaceous, Aruma, Basalts and Wadi Sediments. Apart from the last two, the groundwater resources stored in these aquifers are non-renewable. . These aquifers crop out in the western parts of the Shelf and extend towards the eastern parts. The total thickness varies between few hundred to more than 5,000 meters. The groundwater quality varies between sites and among aquifers. The salinity of the water as indicated by total dissolved solids (TDS) varies between 300 to more than 10,000 parts per million (ppm). The isotopic analyses showed that the fossil groundwater in the above aquifers is 10,000-32,000 years old. Large volumes of groundwater are stored in the sedimentary aquifers. Table 1 lists the reserves in the main and secondary deep aquifers, their annual

recharge and water quality.. The estimated groundwater reserves to a depth of 300 meters below ground surface is about 2,185 billion cubic meters (BCM) with a total annual recharge of 2,762 MCM.

Table 1: Groundwater reserves in the deep aquifers, estimated annual recharge and total dissolved solids

Aquifer	**Reserve** (MCM)	**Recharge** (MCM**)**	**Water quality** ppm
Saq	290,000	310	300-3,000
Tabuk	210,000	455	250-2,500
Wajid	220,000	104	500-1,200
Minjur-Dhruma	180,000	80	1,100-20,000
Wasia-Biyadh	590,000	480	900-10,000
Umm Er Radhuma	190,000	406	2,000-5,000
Dammam	45,000	200	2,600-6,000
Khuff & Tuwal	30,000	132	3,800-6,000
Aruma	85,000	80	1,600-3,000
Jauf & Sakaka	100,000	95	400-5,000
Jilh	115,000	60	3,800-5,000
Neogene	130,000	360	2,400-4,000
Total	2,185,000	2,762	

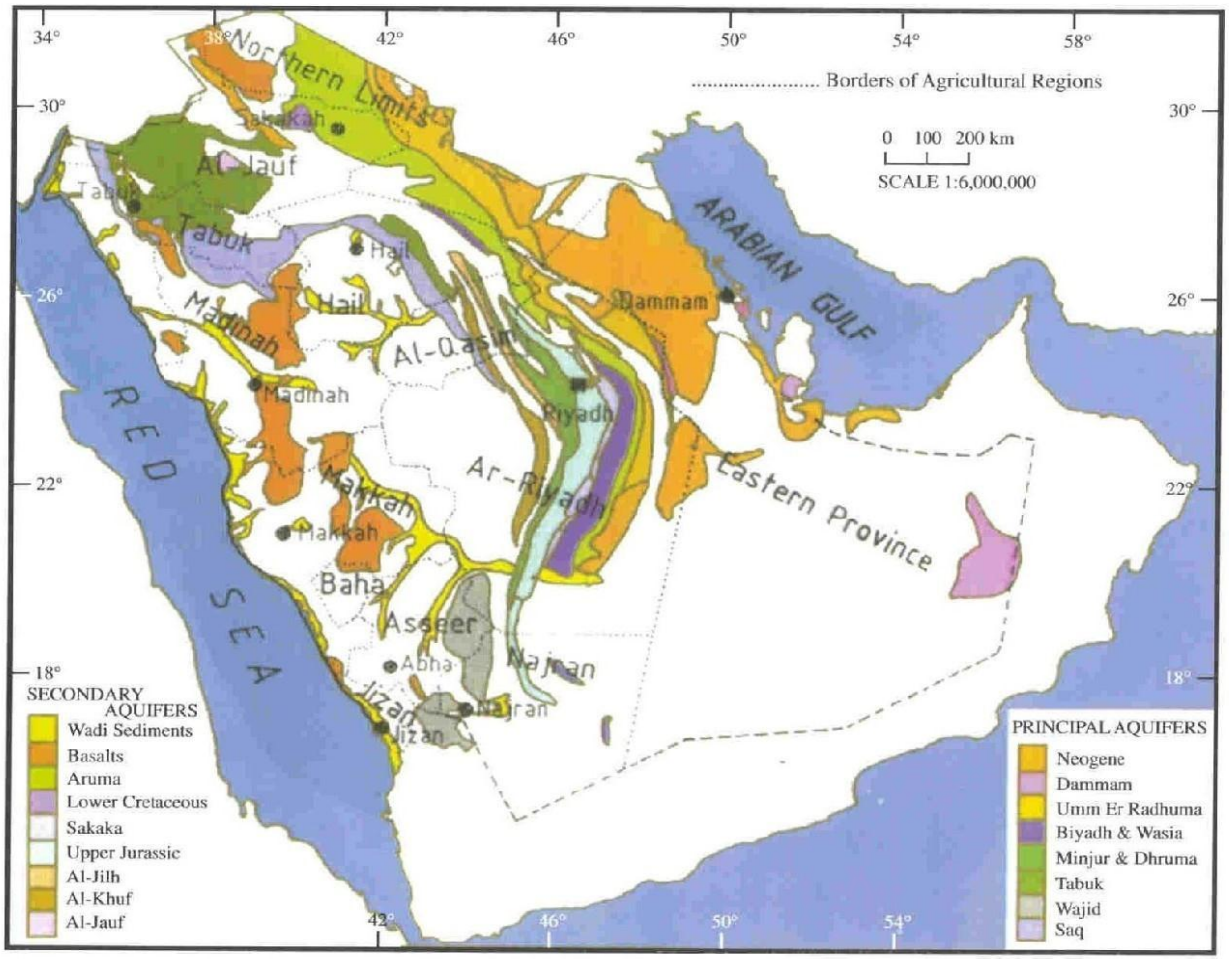


Figure 5: The extension of the outcrop areas of principle and secondary aquifers in Saudi Arabia.

2.3 Treated Wastewater

In 2002, the wastewater facilities are available to 22 cities out of 106 cities which are classified as directorates and municipalities, and the numbers of sewage collections connections are 577,000 with total length of 9,700 Km. While, the number of domestic water supply connections are 925,000 with a total length of 32,000Km. The sewage coverage is about 45%. In 2005, the present wastewater treatment plants capacity is around 778 MCM/year. It is estimated that about 1,460 MCM of wastewater are generated in the country. The volumes of collected and treated wastewater are about 671 MCM, which represent about 46% of the total generated wastewater, and 34% of the total portable water supply. The Water Authorities are responsible for management of wastewater facilities.

The shortage in wastewater infrastructures in some cities, and the use of lined and unlined septic tanks and shallow wells for discharging the wastewater at house levels has resulted in negative impacts on the environment such as shallow water Table rise and possible pollution to groundwater. This is in addition to the hazards of shallow water Table on foundations and engineering facilities. It is estimated that the values of the damages and negative impacts on health and environment are about SR 5,000 billion annually.

The government has encouraged the reuse of treated wastewater for irrigation purposes. The WHO (UN) has been the reference for the reuse of treated wastewater for irrigation. About 9,000 ha near Riyadh cultivated with date palm and forage crops are irrigated using about 146 MCM of wastewater effluents. Wastewater is reused for irrigating landscape plants, trees and grass in municipal parks in several cities such as: Riyadh, Taif, Jeddah, Dhahran and Jubail. Presently, about 240 MCM of the treated wastewater are reused annually for landscape and crop irrigation purposes. This presents about 38% of the treated wastewater and about 12% of the portable water supply. The treated wastewater for reuse in the Kingdom is expected to reach about 2,430 MCM which represent about 65% of the total domestic water use in 2025

2.4 Desalination Water

Large seawater desalination plants were constructed on the Gulf and Red Sea coasts to produce the suitable drinking water. Water transportation pipelines were implemented to

convey the desalinated seawater from the coasts to coastal and inland cities and towns such as Riyadh, Makkah, Medina and Taif. In 1997, about 88% of the desalination capacity in Saudi Arabia used multi-stage flash systems (MSF), while the remaining plants used reverse osmosis (RO).

Saline Water Conversion Corporation (SWCC) is providing potable water through 30 plants situated on the Western and Eastern Coast of the Kingdom, of which 24 plants are on the Red Sea coast and six plants on the Arabian Gulf coast. The desalination plants capacity range from less than 1,000 to 815,185 cubic meters per day. In 2006, the quantity of exported water from SWCC plants was about 1,033 million cubic meters. The Eastern coast plants exported 517.9 MCM (50.14%) whereas the western coast plants exported 515 million cubic meter 49.86%). Eastern coast plants could export additional quantities of water due to the increase of production of some units, whereas the production in some western coast plants decreases as a result of maintenance and rehabilitation programs which required shut down of some production units.

Saudi Arabia became the largest desalinated water producer in the world. The total water production from desalination plants increased from about 200 MCM in 1980 to 540 MCM, 785 MCM and 1050 in 1990, 1997 and 2010 respectively. The desalinated water production is expected to reach about 1921 MCM in 2015 and more than 2144 MCM in 2030. The present production represents about 50% of the total domestic and industrial demands, and the rest is from limited surface water and mostly from groundwater resources in shallow and deep aquifers. In 1990 and 2010, the desalination water production was about 33% and 54% of the total domestic and industrial demands respectively.

2.5 Water Demand

The rapid and comprehensive developments in all sectors coupled with high standard of living have resulted in major and fast rise in water demands for domestic, agricultural and industrial. This has put immense pressure on water agencies to supply the required water quantities and qualities within limited period of time.

2.5.1 Domestic Water Demands

The rapid and high population growth especially urban population and development of mega cities in the Kingdom, coupled with high standard of living have resulted in major jump in domestic water demands especially after 1974. These demands have increased from about 200 MCM in 1970 to 446, 1,800 and 2063 MCM in 1980, 2000 and 2010 respectively, and expected to reach about 2,880, 3,510 and 6,360 MCM in 2020, 2030 and 2060 respectively (Table 2). The domestic water use ratio has increased from less than 4% in 1970 to about 6.0%and 10% of the total national water use in 1990 and 2000 receptively, and it is expected to rise to about 17% and 30% in 2010 and 2020.

About 54% of the domestic water demands are satisfied from desalination plants and the rest are from groundwater resources. The ratio of desalinated water varies among cities. For example, it constitutes about 92%, in Makkah, 80% in Madenah, 66% in Riyadh, 93% in Jeddah, 100% in Jubail, 100% in Khafji, and 36% in Khobar and Dhahran.

Table 2: Growth of Domestic Water demands in the Kingdom of Saudi Arabia in MCM/year

YEAR	Water Demands
1970	200
1980	446
1990	1,508
1997	1,563
2000	1,800
2010	2,063
2015	2,609
2020	2,881
2030	3,512
2040	4,281
2050	5,219
2060	6,361

2.5.2 Industrial Water Demand

The industrial water demands in Saudi Arabia have grown rapidly during the last two decades due to significant industrial developments. The industrial sector consists mostly of petrochemicals, cement, steel, fertilizers, mining, basic metals, textiles, food and beverage production. In Saudi Arabia, the industrial demands has increased from 56 MCM in 1980 to 190 MCM in 1990, and to 800 MCM in 2010, and it is expected to increase to 1,024, 1,311 and 2,375 MCM in 2020, 2030 and 2060 respectively (Table 4). The growing industrial water demands are mainly satisfied from desalination plants (about 50% of the total demands) and from the non-renewable groundwater resources.

Table 4: Growth in industrial water demands in Saudi Arabia in MCM/year.

YEAR	Water Demands
1970	20
1980	56
1990	190
2000	450
2010	800
2015	905
2020	1,024
2030	1,311
2040	1,598
2050	1,948
2060	2,375

2.5.3 Agricultural Water Demand

The agricultural sector has received major support from the government as an effective tool to improve the standard of living of rural communities and to protect the social

structure in remote areas including the nomads. Between 1974 and 2006, the cultivated areas have increased by three times. New agricultural infrastructure including wells, pumps, sprinkler irrigation and drip systems were introduced in these remote areas, and hundreds of thousands of hectares of desert lands were reclaimed. More than 100,000 wells were drilled in different regions of the country for agricultural purposes. The new irrigated areas were spread over the rural areas in different regions especially with the availability of groundwater in local aquifers. The cultivated areas have expanded from less than 400 000 ha in 1971 to 1.62 million ha in 1992, and started to decrease in 1993 until it reached about 1.10 million ha in 2005 and 0.85 million ha in 2009. The reduction was mainly in wheat areas as the new policy will phase out wheat by the year 2015. The total irrigation water use has increased from about 6,108 MCM in 1970 to about 9,470 MCM, 18,000 MCM, 18,500, 15,050 MCM in 1980, 1990, 2000, 2005, and 2009 respectively. The major threshold increase in irrigation water use has occurred after 1980, with the major rise in irrigated areas. The irrigation water is satisfied mainly form non-renewable groundwater resources (8,300 MCM) and reset from surface and renewable water resources (6,750 MCM). In order to maintain the non-renewable water resources, the agriculture water demand will not be more than 13,500 MCM.

Table 5: Growth in agriculture water demands in Saudi Arabia in MCM/year.

YEAR	Water Demands
1970	6,108
1980	9,470
1990	18,000
2000	18,500
2010	15,040
2015	13,473
2020	13,473
2030	13,473
2040	13,473
2050	13,473
2060	13,473

2.6 Water Supply

Table 7 shows the different water supplies to satisfy different water demands. The desalination plants supplied about 1050 MCM or 5.8% of the water use in 2010. Groundwater supplied the rest of domestic and industrial purposes. The treated wastewater supplied about 400 MCM or 2.2% in 201000. Most of the volumes of recycled effluents are still very limited. The nonrenewable groundwater resources consumption has grown from 2,662 MCM or 26 % of the national water use in 1980 to about 15,623 MCM or 67% in 1992, and decreased to about 10,471 MCM or 58.4% in 2010 . This is due to change in cultivated areas and mainly due to change in support policy to cereals especially wheat.

Table 7: Water supply

Year	Desalinated water	Surface Water and Recharge	wastewater	non-renewable groundwater	Total Water Supply
2,010	1,082	6,000	400	10,421	17,903
2,015	1,921	6,000	509	8,558	16,987
2,020	2,070	6,000	749	7,983	16,802
2,030	2,144	6,000	1,644	7,806	17,593
2,040	2,144	6,000	2,004	8,348	18,496
2,050	2,144	6,000	2,442	9,009	19,596
2,060	2,144	6,000	2,977	9,815	20,936

2.7 Average Water Share

Several countries, that have few renewable water resources, overlie important non-renewable (fossil) groundwater basins, partly shared with neighboring countries. In Saudi Arabia by far the largest part of the total water withdrawn is fossil water, as seen in the next section. However, although groundwater reservoirs may allow storage of huge quantities of water accumulated during the pluvial periods of Quaternary, its development cannot be considered sustainable in the long term, as the lack of present recharge would result in the slow depletion of the aquifers. Moreover, the water level decline and the resulting increase of the cost of pumping, as well as the deterioration of the water quality in some areas may also make the abstraction of fossil water less attractive with time.

The total volumes of available renewable water resources from surface water and groundwater recharge are about 6,000 MCM. The average water availability from renewable resources is about 231 cubic meters per person per year in 2010. A country is said to experience *water stress* when annual water supplies drop below 1,700 cubic meters per person. At levels between 1,700 and 1,000 cubic meters per person, periodic or limited water shortages can be expected. When annual water supplies drop below 1,000 cubic meters per person, the country faces water scarcity. Once a country experiences *water scarcity*, it can expect chronic shortages of freshwater that threaten food production, hinder economic development, and damage ecosystems. According to the scarcity index of UNESCO, the country is under extreme water shortages. Saudi Arabia falls below the "water scarcity" line of 1,000 cubic meters per person per year. However, significant volumes of freshwater are produced from non-conventional sources (desalinated water and treated wastewater). The average water availability from non-conventional sources is about 65 cubic meters per person per year in 2010. The total per person annual share from available water resources in Saudi Arabia becomes about 296 cubic meters per person per year. Yet, water poverty conditions persist even when the currently produced supplementary water from non-conventional sources is considered, since the per capita share in the country still remains below 1,000 cubic meters per person per year.

PART 3: CHALLENGES AND ACHIEVEMENTS OF WATER SECURITY BEFOR MOWE ERA

3.1 Pending Challenges of water security in KSA

1. Increasing water demands as a result of rapid increase in population, and Excessive use of water for irrigation, high levels in Uncounted for Water (20-40%).
2. Water Resources:
   - Costly desalination processes, and decline in renewable water resources, and Significant Gap between demands & supplies.
   - More improvement for surface and groundwater resources monitoring systems is required.
   - Optimal water allocation among Sectors on the base of economic, social and environmental factors.
   - Large variations in per capita water consumption among different cities.
   - The centralized water policies should be modified to accommodate the local water, social and environmental conditions.
3. More development of Brackish and fresh groundwater treatment, development, and transportation for domestic use for inland cities. Private sector can be an effective by PPP tools to execute such large projects.
4. Human Resources: More skilled human resources are needed in addition to more training and specialized educational programs
5. Institutional and Legal frameworks: There is still needs for more improvement in organizational and institutional frameworks, including national legal act for water
6. Wastewater Coverage, treatment and reuse: coverage of Wastewater collection networks by 45% is still low, and the treatment and reuse needs to be enhanced
7. More Private Sector Involvement: Private sector still requires more encouragement and support to expand its participation in water production and treatment, wastewater treatment and reuse, and other services through BOO, BOT, DBO, etc.
8. Financing: Huge investment required for water and Wastewater utilities
9. More financial support for research, education and technology transfer and localization
10. Higher and fair water Tariffs to reflect the value of water services, enhance the awareness, and reduction of water demands

11. The implementation of Aquifer Storage Recovery (ASR) approach is essential for securing and storing huge quantity of water in the aquifer systems to satisfy large cities such as Riyadh, Jeddah, Mekkah, Medina and Dammam in case of lengthy crisis. This is a strategic issue which has to be given urgent priority in the Kingdom
12. Lack for regulating agency for the water sector
13. Climate change impacts: effective adaptation and mitigation measures should be planned and implemented for minimizing the climate change impacts on water resources
14. More support for use of renewable energy for water production

3.2 The impact of pending challenges

The above challenges resulted in:

- The water and sanitation are now recognized as insufficient to large portion of the population (40-50%) in urban and rural areas in the kingdom.
- Negative impacts on groundwater productivity and quality and its sustainability due to intensive use of non-renewable groundwater especially in Arabian shelf.
- Possible deterioration in groundwater conditions represents threat to the sustainability of agriculture, food security, and for long-term water supplies for domestic and industrial purposes.
- Possible deterioration in groundwater conditions will have negative impacts on socio-economic and national development of the kingdom.
- Negative impacts on environmental resources .
- Serious shallow water table problems in urban areas.
- Un-equitable water allocation.
- Unpredicted water supply under emergency conditions.

3.3 Achievements before Mowe Era

3.3.1 Institutional and Legislations

Understanding its duties, the government of Saudi Arabia, which follows the principles of Islamic law, or *sharia*, in all aspects of life, founded specialized water agencies for production, distribution, and treatment of water in the kingdom in the post–World War II decades. The Water and Waste-water Authority (WWA) is an independent agency under

the Ministry of Rural and Municipal Affairs to distribute drinking water and to collect and treat wastewater in different cities and towns of the kingdom.

The Ministry of Agriculture and Water (MAW) was established in 1953, and was assigned the responsibility for water production to satisfy the required water demand in terms of quantities and qualities.

The Saline Water Conversion Corporation (SWCC) was established as a ministerial agency under the MAW in 1965, and then as an independent corporation within the MAW in 1974, to be responsible for construction, operation, and maintenance of desalination plants for drinking water production.

More recently, the government has modified the past approach of increasing supplies to meet rising demand. To protect the community of interest that constitutes the traditional basis of Islamic customary water law, the government has taken several measures to protect the sustainability of aquifer systems and groundwater resources. Laws, regulations, and *fatwa* were developed, in accordance with Islamic law, to deal with water management issues, including measures to reduce national water demand and augment available water resources. This section describes Saudi Arabia's available water resources, and how demand is managed for different purposes according to Islamic law.

3.3.2 Demand Management

3.3.2.1 Domestic Water Demand Management

As discussed in the previous section the domestic water demand has increased from about 446 MCM in 1980 to about 1,563 MCM in 1997, and is expected to reach 2,88 1MCM in 2020. Hence large-scale desalination plants were constructed, which at present supply 54 per cent of domestic demand.

Additionally, water conservation was also emphasized during the early times of Islam, and to reduce the domestic water demand in Saudi Arabia, several water control and conservation measures have been introduced. These include the following.

- In 1994, water tariffs were introduced to enhance the people's awareness of the value of water production. The tariff per cubic metre of potable water is US$0.04 (SR 0.15) for the first one hundred cubic metres, US$0.27 (SR 1.0) for the second one hundred cubic metres, US$0.53 (SR 2.0) for the third one hundred cubic metres, and US$1.07 (SR 4.0) for the fourth one hundred cubic metres. The water charges for a medium-sized middle-class family (six persons) living in a small house with garden (assuming water consumption of about 200 cubic metres a

month), and with an average income of SR 4,000 a month, are less than SR 200 a month (US$55 a month). However, the charge for water is only a small fraction of the actual cost of water production and transportation, which ranges between about SR 1,120 and SR 1,320.

- Leakage control measures have been implemented to minimize water losses from water supply networks.
- Treated wastewater recycling has been implemented; for example, ablution water is recycled for toilet flushing at the two Holy Mosques at Makka and Al-Medina Al-Monawwarah.
- Highly saline water from Wadi Malakan near Makka is used instead of desalination water for toilet flushing at the Holy Mosque at Makka.

3.3.2.2 Irrigation water demand management

The cultivated area in the kingdom has increased from less than 0.4 million ha in 1971 to 1.62 million ha in 1992, and total consumption of irrigation water has increased from about 1,850 MCM in 1980 to 29,826 MCM in 1992. The threshold increase in the agricultural area started after 1979. Because of its responsibility for making water available to the people for different uses, including irrigation as the third priority, the government gave financial support to farmers for well drilling and the introduction of modern and efficient irrigation systems. Extension services were also introduced to help farmers in proper scheduling of irrigation water to avoid excessive use.

The non-renewable groundwater from shallow and deep aquifers supplied about 28,576 MCM in 1992 for irrigation use. This represented about 94 per cent of the total irrigation water use and 90 per cent of the total national water use in Saudi Arabia. The total number of drilled wells increased from about 26,000 in 1982 to about 52,500 in 1990, and hundreds or even thousands of production wells were thickly clustered in some agricultural areas. In several agricultural regions, excessive water pumping has resulted in negative effects on groundwater levels and on quality. Consequently, improvement of groundwater management and reduction in irrigation water consumption, especially for wheat cultivation, became essential for maintaining the long-term productivity and quality of the aquifers. Understanding this serious issue, the government, after consultation with leading Islamic scholars and with specialists in agriculture, economics,

and water, took several measures and developed regulations to improve the management of water demand and to protect and conserve water resources.

Regulation of well drilling

Following the Islamic trend, a royal decree was issued in 1980 to regulate well drilling and to protect aquifers from exploitation and pollution. Special permits must be issued in advance by MAW to drill or deepen any well, and drilling and deepening must follow approved designs and be carried out and under supervision of MAW. Well owners and the drilling companies face penalties for not observing this decree.

Reduction in wheat price supports

Saudi Arabia's largest crop is wheat, with a total of 907,309 ha or 56 per cent of the total cultivated area in 1992, while fodder crops, vegetables, and fruits accounted for 18, 7, and 6 per cent of the total agricultural area respectively. The wheat production of 4.25 million tons in 1992 far exceeded the predicted national demand of 1.22 million tons (MOP 1990), which hindered diversification of agricultural production and resulted in unnecessary consumption of large volumes of groundwater: in 1992, irrigation demand of wheat was 9,895 MCM or 33 per cent of the total national irrigation water consumption.

In 1993, the government reduced the area of wheat cultivation eligible for price support to 25 per cent of its previous size. This was to reduce wheat production to the level of the annual consumption, encourage farmers to diversify crop production, and reduce irrigation water consumption. The reduction in water use was projected to amount to about 7,400 MCM per year or 25 per cent (assuming a 75 per cent reduction in wheat area). In actual fact, the area under wheat dropped by about 325,000 ha between 1992 and 1994, and as shown in table 2, although the water supply from other sources remained constant from 1992 to 1997, the reduction in wheat production subsidies resulted in a drop from 28,576 MCM to 15,376 MCM in water pumped from non-renewable aquifers. This reduction positively affected groundwater levels and quality in different wheat areas in the kingdom. Field measurements of groundwater levels in deep observation wells in a large irrigation scheme in the Eastern Province have shown a recovery after reduction of the area under wheat of about 20–30 per cent from the drawdown recorded in previous years. Recently, the MAW announced similar positive effects on groundwater levels in other regions of the kingdom as a result of reductions in wheat cultivation.

Reuse of wastewater effluents for irrigation

After lengthy and deep investigations and discussions with scientists and specialists, a special fatwa on the matter was issued by the Council of Leading Islamic Scholars (CLIS) of Saudi Arabia in 1978. The fatwa postulated that

Impure waste water can be considered as pure water and similar to the original pure water, if its treatment using advanced technical procedures is capable of removing its impurities with regard to taste, colour and smell, as witnessed by honest, specialized and knowledgeable experts. Then it can be used to remove body impurities and for purifying, even for drinking. If there are negative impacts from its direct use on the human health, then it is better to avoid its use, not because it is impure but to avoid harming the human beings. The CLIS prefers to avoid using it for drinking (as possible) to protect health and not to contradict with human habits.

At present, about nine thousand hectare of date palms and forage crops near Riyadh are irrigated using about 146 MCM of wastewater effluents. Wastewater is also reused for irrigating landscape plants, trees, and grass in municipal parks in several cities, such as Dhahran, Jeddah, Jubail, Riyadh, and Taif.

Other water demand reduction measures

The MAW has considered the introduction of water meters on farm pumps to help in minimizing overpumping and water losses. There is also the possibility of shifting of some fodder and cereal cultivation from zones of high irrigation water consumption to areas of lower consumption, thus saving considerable quantities of irrigation water. The MAW is active in improving public knowledge of the value of water conservation in the news media and in educational institutions.

3.3.2.3 Industrial Water Demand Management

The growing demand is satisfied mainly by costly desalination in some industries, especially food, although groundwater satisfies other types of industries. Industrial demand varies among regions of the kingdom. In some industrial plants, part of the effluent is recycled. However, uncontrolled disposal of wastewater has had negative effects on the environment and groundwater.

The following legislation and measures have been taken to improve industrial water demand management.

- To minimize industrial water demand, to maximize wastewater recycling, and to protect the environment, the government has established large industrial cities in different parts of the kingdom. Each city contains tens or hundreds of factories. Industrial wastewater is collected, treated, and recycled within each city at the plant level for industrial and landscape purposes. The industrial cities have specifications for the quality of the wastewater collected from factories.
- Closed water cycles have been introduced in industrial plants to minimize wastewater disposal, reduce groundwater pumping, and protect the environment. In this approach, wastewater is converted into good quality condensate by evaporation at low temperature under vacuum. This technology was introduced to large industrial plants in 1995.

3.3.3 Major Projects and Studies

3.3.3.1 Preliminary Studies on Water Possibilities

The late King Abdulaziz, the founding father of modern Saudi Arabia, realized that water is the most challenging factor for comprehensive development, and that it is the foundation for any social progress and stable life in a country dependent on limited water resources such as a few springs and traditional wells. He was aware of the difficulty of depending on local experts lacking knowledge of modern agricultural and hydrological sciences. As a result, he invited distinguished specialists from abroad to conduct several studies as follows:

1. **Studies conducted by Karl Twitchell**: In late 1349AH (1930) King Abdulaziz invited the American businessman, Mr. Charles Crane, to visit him in Jeddah. The King expressed to Mr. Crane his desire to have a study of the water situation in the Kingdom, and especially investigating the possibility of finding groundwater in the western and central parts of the country, as they are the areas that have the greatest water shortages. The King also invited Mr. Twitchell, (an American Geologist) to explore the sources of water especially along the Hajj (annual pilgrimage) routes. Mr. Twitchell toured the region and submitted a report indicating little chance of finding groundwater in the areas he surveyed.
2. **The American Agricultural Mission**: At the request of the Kingdom in 1942 (1362AH), the US Government sent a technical agricultural mission consisting of

Karl Twitchell, A. L. Wane, and J. Hamilton. This mission toured most of the Kingdom's territory and identified the climatic, soil, and water conditions in the various regions.

3. **The American Engineering Team**: In 1366AH (1946) a team of three engineers was recruited from the US. The team studied a number of water resources in the Kingdom and submitted a report on dams that could be constructed. The team also proposed repairing and renovating some old dams to store larger quantities of water and deepening some shallow wells.
4. **The Arabian American Oil Company (ARAMCO) Studies**: ARAMCO conducted geological and engineering studies in the eastern region and other areas within its concession area, in search for water sources. The Company produced reports and geological maps for many regions. The water wells drilled by the Company as well as those drilled by the Saudi Government indicated that there were indeed geological formations bearing water. The Company also implemented water projects in various areas.
5. **The American Geological Survey Mission**: In 1368AH (1948) a mission from the American Geological Survey, headed by Mr. Glenn Prawell, arrived in the Kingdom. The mission conducted geographic and geological surveys in several parts of the Kingdom. Its work included aerial photography of some sites in order to identify water reservoirs. The mission investigated the water situation in Alkharj and Riyadh and submitted a proposal for constructing a number of dams to increase surface water supply.
6. **Other Technical Missions**: The Kingdom's efforts to study water resources were not limited to the studies cited above. From the early years endeavors were made to benefit from Arab and foreign technical expertise, the most important of which were the following:
    - Royal Decree No. 24/7/2 issued on 27/12/1354AH (1934) granting a license to a French company to explore for water in the City of Jeddah. The company concluded that there were no sources of water in the area except for Wadi Fatima (Fatima Valley). Accordingly, it recommended expansion of water desalination activities.
    - In 1367AH (1947) King Abdulaziz decreed the establishment of a Directorate of Agriculture.
    - Also in 1367AH (1947) the Gelately-Hanky Co. Ltd., in cooperation with Saudi, British, and Egyptian companies, built a project to supply Jeddah with water from

Wadi Fatima. On Tuesday 5/1/1367AH (20/11/1947) water from the Wadi Fatima springs reached the city of Jeddah.

- At the end of 1369AH (1949) the American firm, Mitchell Cotts looked into installation of a number of pumps for lifting water from the wells in Riyadh, Alkharj, Aflaj and Alahsa. The company installed the pumps over the two-year period 1370 – 1371AH (1950 – 1951).
- In 1370AH (1950) the American Company, Bechtel, conducted a study through which it concluded that it is possible to construct a number of dams in parts of the Kingdom to bolster water resources.
- In 1371AH (1952) King Abdulaziz decreed that water should be supplied to Riyadh from the Albatin and Al-Suwaidi valleys.
- In 1374AH (1954) a Pakistani mission came to the Kingdom to study the water conditions in Riyadh City. It recommended that dams be constructed to enhance the water resources of the city.
- Technical missions from Arab countries such as Egypt, Syria and Iraq were invited to the Kingdom to look into the water resources issue and improvement of irrigation methods.

3.3.3.2 Preliminary Studies for Water Sources

In 1383AH (1963) hydro geological surveys made a quantum leap. The Kingdom was divided into eight hydro geologic areas, based on their topographical conditions and relations between geological formations. The objective of this division was to facilitate investigation of the different aquifers in order to identify the hydraulic characteristics of each aquifer, its storage capacity, quality of its water and its suitability for drinking, domestic purposes, or industrial and agricultural purposes. In order to gain a more complete picture of the country's hydrogeology, the Kingdom engaged the services of international experts and consulting offices to conduct water surveys and preliminary studies covering most regions of the Kingdom over a five-year period. At a later stage, researchers in Saudi universities and research centers became active in research work in the water and wastewater fields and produced significant applied studies.

3.3.3.3 Surface Water Projects

Due to the nature of the environment and geography of the Kingdom it was important to resort to construction of dams as one of the sources for water. Some 258 dams of various

sizes and types such as earth, gravel, concrete, and underground dams have been constructed, with a total storage capacity of 910 million cubic meters and at a total cost of 3.5 billion Saudi Riyals. These dams were constructed to diversify and strengthen the Kingdom's portfolio of water resources.

With regard to utilizing dams to supply potable water, the Kingdom has carried out many successful projects such as:

- Turba underground dam that for three decades now has been supplying 17,000 cubic meters of potable water daily to the Taif and Alhada regions.
- Bisha Supply Project that provides 15,000 cubic meters daily from a well field, an underground dam, and a water treatment plant. The water from these facilities is transported to Bisha through a forty kilometer pipeline.
- The City of Albaha depends largely on Alaqiq Dam which provides about 15,000 cubic meters daily.

3.3.3.4 Groundwater Projects

Groundwater resources are found in aquifers that range in age from Paleocene to Cenozoic. Water in these aquifers was stored during the last wet age in the Arabian Peninsula some 20,000 years ago. From the results of the preliminary and detailed water studies mentioned earlier in this paper, it was possible to classify the aquifers into principal and secondary aquifers based on the geological extent of the aquifer, its thickness, and the quantity of its stored water. The hydraulic parameters of such aquifers have been determined. The suitable depth of drilling was also identified as well as the type of water in each layer. Currently the daily consumption of drinking water from groundwater sources is about three million cubic meters.

Groundwater projects have been classified as follows:

A) Groundwater Projects for Main Cities

Groundwater Project for Riyadh; the capital is supplied from several fields and water aquifers such as the Alhinni Field that provides about 350,000 cubic meters daily, the Um Er Rudhumah aquifer; the Alwasie Well Field that provides about 200,000 cubic meters daily, the Alwasie aquifer; and about 280,000 cubic meters daily provided by Almanjour aquifer from various sites.

The Groundwater Projects for the Cities of Buraidah, Unaiyzah, Alrass, Hail and Alkharj are in the form of groups of groundwater wells. Water from these wells is treated to eliminate salts and bring water quality to international standards.

B) Comprehensive Regional Groundwater Projects

These projects are implemented to provide potable water to a number of towns and villages within a defined area. The project services include drilling wells, connecting wells with pipelines, building holding tanks, pumping stations, and pipelines to connect the towns and villages with these facilities. This approach to implementation of this type of project was considered a pioneering experience to upgrade the level of services at minimum cost. The approach has many advantages in consolidating the number of small projects and purification plants that need to be built, increasing production efficiency, maximizing the number of scattered settlements that are provided with the services, and achieving a great deal of savings in the costs of operation and maintenance.

The most important comprehensive regional groundwater projects implemented in the Kingdom are the following:

- Engineering study and design for the use of treated wastewater in the Kingdom. The project includes field surveys of 213 cities, counties and towns to collect data on water resources, water supply systems, collection and treatment of wastewater; and proposing suitable alternatives for reuse of treated effluent water. The project is currently under execution by Italconsult.
- Sudair Water Project to supply water to 26 towns and villages. The cost of this project is SR462 million.
- Dawadimi and Afif Water Project to supply water to 75 towns and villages at a cost of SR500 million.
- Alwasham Water Project to supply water to Shaqra, Murat, Tharmada, Othytha, Algraen, Oshaigir, Qusoor Murat, Qusoor Shaqra and Alfaraah from a well field located sixty kilometers west of Shaqra. This field consists of 16 wells that produce about 34,000 cubic meters of water daily. The cost of the project is SR260 million.

C) Medium Size Groundwater Projects in Smaller Cities

The Kingdom has implemented groundwater projects in smaller cities such as Abha, Alkharj, Hail and Buraidah. These were integrated projects built to high standards and included drilling wells, building pipelines to transport water to the cities, underground and elevated water reservoirs, and water distribution networks.

D) Potable Water Supply for Villages and Small Settlements from Groundwater Sources

When suitable and good quality water sources are available, the government provides potable water to residents of villages and hamlets by implementing micro water projects consisting of a well, an elevated water tank, a small spout for filling small containers, a water transportation network, and a large spout to fill tankers. About 1380 water projects of this type were implemented. Where there are no aquifers or where the type of water is not suitable for drinking, water is supplied by water tankers to the area residents by *Sugia* Providers (contractors hired and paid by the government).

3.3.3.5 Water Desalination

3.3.3.5.1 Phases of Development of Desalination

The first step in establishing the desalination industry in the Kingdom may be traced to the era of the late King Abdulaziz when he realized the extent of suffering of the residents of the City of Jeddah as a result of shortage of potable water, which was becoming increasingly acute during the Hajj (pilgrimage) season. Accordingly he issued a directive to import two condensers for desalination of seawater (locally called *Kindasah* at that time). They were installed and operated on 6/1/1345AH. The daily production capacity for each condenser was 135 tons of water. In the same year a condenser that was already installed in the port town of Yanbu was repaired. In the year 1363AH a condenser was installed in the port town of Jazan. As the number of towns using condensers increased a Desalination Directorate was established by a resolution of the Shoura Council on 24/1/1359H which was endorsed by the Vice-Roy for Hijaz (Prince Faisal Ibn Abdelaziz, later King Faisal) on 28/5/1359H. The objective of the directorate was to regulate the work of condensers in accordance with the approved regulations. The Statute of the Condensers Department consisted of twenty one articles. It included within the authority granted to the Department the right to supply distilled water, sell it, collect payments, and install special meters to measure the quantity of water desalinated and stored in dedicated tank storage. Installation of the condensers drew attention to the

possibility of using desalination as a significant source to provide the populace with credible means to meet their increasing need for potable water. Later this possibility materialized as critical needs for potable water necessitated the search for sources of water to supply a number of main cities in the Kingdom such as Makkah, Madinah, Jeddah, Taif, Riyadh, Dammam, Alkhobar, Jubail, and Abha.

The initial step on the road to modern day desalination was issuance of Royal Decree No. 360 on 4/7/1385AH (1965) charging the Minister of Agriculture and Water to take steps to look into construction of a desalination plant in the Eastern Province and a similar plant in the City of Jeddah. In addition, Royal Decree No. 210 was issued on 4/7/1385AH (1965) approving the agreement between the Kingdom of Saudi Arabia and the United States of America on seawater desalination.

The first body responsible for desalination affairs was established as part of the office of the Minister of Agriculture and Water in 1386AH (1966) under the name of Desalination Office. On 9/8/1388AH (1971) the Office of Desalination was elevated to the status of General Directorate of Saline Water Conversion. On 26/8/1391H (1971) the status of the Directorate was, in turn, upgraded to the level of Deputy Minister under the name of Deputy Ministry for Saline Water Conversion.

From the beginning, attention was focused on the use of advanced technologies to treat saline water and convert it to fresh potable water as a means of finding new sources of water in this desert country and enhancing natural water resources to meet the predicted increasing demands. Technical studies indicated the feasibility of constructing two small plants at Alwajh and Dhuba on the Red Sea coast with a total capacity of 60 thousand gallons of water daily for each plant. The two plants became operational in 1389AH (1969). Operation of these two plants proved the feasibility of investing in the desalination industry. Studies also had shown that economically for large plants, it is more beneficial to build them as cogeneration plants to produce electricity along with the main product of desalinated water.

This was followed by the construction of the first cogeneration plant in Jeddah in 1390AH with a total capacity of five million gallons per day and 50 megawatts of power. In 1393AH (1973) the first phase of the Alkhobar desalination plant was opened, as the first plant on the shores of the Arab Gulf, with a total capacity of over ten million gallons per day. Water from the plant was used to supply the cities of Alkhobar, Dhahran, Dammam and Qatif after mixing it with groundwater produced from wells.

3.3.3.5.2 Establishment of the Saline Water Conversion Corporation (SWCC)

Following the success of the first phases of the desalination process as the main supplement to natural water resources, expansion in the construction, operation and maintenance of desalination plants has become a strategic option for the Kingdom. The success was crowned with issuance of Royal Decree No. R/49 on 20/8/1394 (1974) – mandating creation of "The Saline Water Conversion Corporation" (SWCC) as an independent public body. A governor was appointed for the Corporation and the Minister of Agriculture & Water was made chair of its Board of Directors. The Charter of the Corporation states its objectives are to construct more desalination plants whether single-purpose plants producing only desalinated water or cogeneration plants producing water and electric power. The Corporation's efforts to carry out its charges under the charter continued. In two decades, production of desalinated water increased more than a hundred fold, while electricity generation increased more than eighty fold. The Corporation produces more than 1,000 million cubic meters of desalinated water annually making the Kingdom the biggest producer of desalinated water in the world.

It should be noted that the cogeneration plants operate by multi-stage flash evaporation, using part of the electric power generated to operate the production plant facilities and exporting the remaining electricity production to the Saudi Electricity Company.

The phenomenal success of the Kingdom as the leading producer of desalinated water internationally, has enabled the Corporation to continue developing this industry in order to insure its growth and reduce its costs. Furthermore, in order to keep pace with the scientific developments of the desalination industry, the Corporation established a research and development center in Jubail in 1417AH (1997). The main objectives of this center are to conduct research and perform studies aimed at improving performance of the operating plants, find appropriate solutions for their operational problems, and extend the operational life of plants for as long as possible. By the grace of Allah, the Corporation has many scientific achievements, such as development of membrane nano-technology, for which it obtained an international patent.

The Corporation is still continuing its efforts to expand the infrastructure of the production and supply systems. In this regard, it has undertaken a process to re-plan the desalination sector (after thirty years of operation since the establishment of the Corporation) in order to align it with future needs and requirements. Thus, the

Corporation currently is considering privatization of its entire organizational structure and operations taking into consideration the variable and new economic conditions. It has accelerated its movement in this direction, and has signed contracts with a number of international consultants to achieve this objective.

3.3.3.6 Treated Wastewater

The government attaches special importance to the wastewater sector particularly in view of the possibility of using the treated effluent to supplement water resources in the various cities and regions of the Kingdom, and its use to meet the needs of key sectors such as agriculture and industry. Many secondary wastewater treatment plants have been constructed and some of them have later been upgraded to tertiary treatment plants.

3.4 National development plan and water use in Saudi Arabia

To maintain effectiveness in achieving the goals of national development, Saudi Arabia has adopted the five years development plan approach since 1970 until now. The common objectives of these plans are: to improve the standard of living, to protect the country's progress, security, and economic stability Each plan followed different policies to achieve above common goals such as: human resources development, increase in the national gross domestic product (GDP), diversification of production sectors. The major rise in oil revenues in 1974 has contributed significantly in expanding the magnitude and objectives of these plans. Since 1974, the country has experienced comprehensive and rapid developments in social, construction, education, health, transportation, industrial, and agricultural sectors. The Kingdom managed to move within limited number of years from typical third world country to advanced and developed country with modern and effective facilities such as roads and highways, airports, hospitals, schools, universities, water and wastewater networks, modern irrigated farms, and large industrial cities. This is in addition to providing higher and school education to millions of Saudis during the last twenty seven years. Mega-cities with population of more than three millions have been developed such as Riyadh and Jeddah.

The rapid and comprehensive developments in all sectors coupled with high standard of living have resulted in major and fast rise in water demands for domestic, agricultural and industrial. This has put immense pressure on water agencies to supply the required water quantities and qualities within limited period of time. The government has completed the

implementation of the six plans in 2000. The water and agricultural development has been given great attention because the agriculture has become one of the production pillars of the Kingdom especially for its major role in supporting the socio-economic development in rural areas. The limited water resources in the Kingdom need to be managed efficiently to satisfy the growing national demands in the country. The main objectives of the Seventh Development Plan for 2000-2005 are to be realized through the adoption of the following water and agricultural policies:

Water:

- To review the existing policies of the agriculture and water sectors and to regulate water consumption priorities;
- to reconsider the administrative organization of the water sector and consolidate all agencies responsible for management of this sector into a single autonomous agency;
- to support a computerized central database covering all aspects of water affairs;
- to expand and upgrade the hydrological and hydrogeological monitoring network;
- to expand application of advanced methods and technologies for conservation of water and improvement of utilization efficiency, in cooperation with the Saudi research centers;
- to develop and support renewable surface and groundwater by utilizing precipitation (rain) and runoff water, and supporting the dams construction program;
- to update the detailed hydrogeological studies and to issue the national water plan in cooperation with universities, KACST and related government agencies;
- to improve the system of collecting water fees;
- to develop non-conventional water resources, including construction of desalination plants and appropriate facilities in order to support other sources of water, as well as implementation of projects for re-use of reclaimed wastewater and agricultural drainage water;
- to develop Saudi manpower in the water sector.

Agriculture:

- Provide some agricultural inputs and support services to farmers and ensure an adequate climate for the private sector to continue producing and processing agricultural products, and adopt modern technology to reduce the costs of production;

- increase local production of fruits and vegetables in greenhouses and encourage adoption of modern cultivation and irrigation techniques;
- raise the efficiency of research, technical and agricultural extension institutions, and enhance coordination with implementing agencies;
- upgrade the efficiency of producing projects through supporting technical studies and research, as well as the application of modern technologies;
- improve the marketing of vegetables and fruits, particularly for small producers;
- enforce the conditions and criteria related to the use of reclaimed wastewater and agricultural drainage water for agricultural purposes;
- develop and upgrade Saudi manpower in the agricultural sector;
- provide adequate storage capacities of silos and warehouses for various types of grain in line with domestic consumption needs;
- increase the production capacity of flour mills in line with the expected increase of demand of flour products;
- provide agricultural loans in line with agricultural policy and the need to balance disbursements with loan repayments;
- contribute to realization of ecological equilibrium through the conservation of natural resources, control of desertification, conservation and development of forests, provision of adequate protection conducive to reproduction of animal and plant species, in addition to protection of the marine environment and the conservation and development of fish resources;
- prepare the agricultural sector to deal in a flexible and efficient manner with local, regional, and international developments.

The above policies are important to be implemented, especially after the establishment of the Ministry of Water for sustainability of water resources and agriculture. The following sections describe the growth in different sectors in the Kingdom and its relations with water, food security and agricultural policies.

PART 4: NEW ERA: SUSTAINABLE WATER SECURITY AFTER ESTABLISHMENT OF MOWE

In July 2001, The Ministry of Water and Electricity was announced to be responsible for all related issues of water in the Kingdom. All water agencies and authorities became under the Ministry after the appointment of the Minister of Water in September 2002. This is to secure effective water management and national planning, and to achieve the sustainability of water resources and continuity of the development and progress of the country.

4.1 Objectives Related to Water

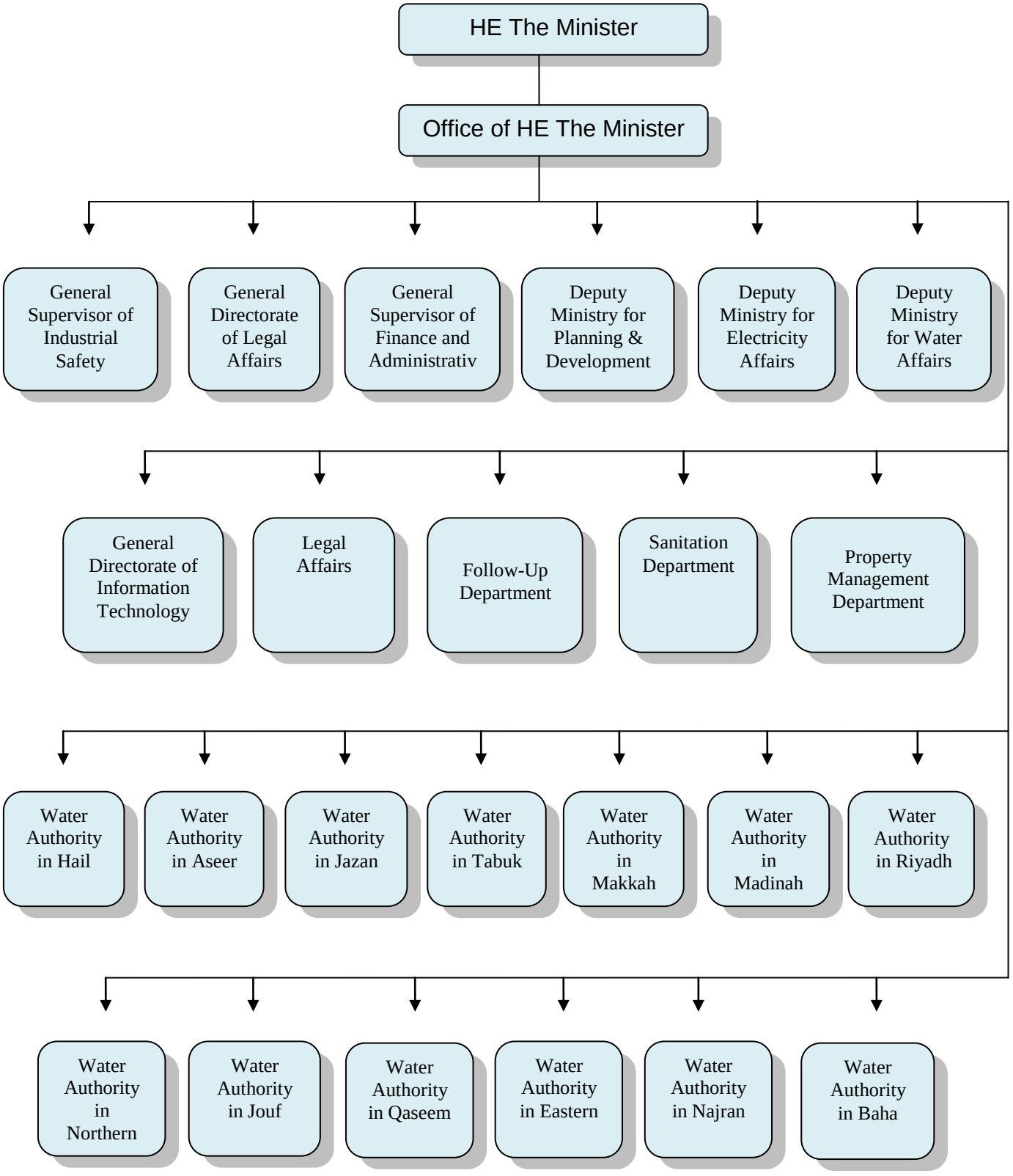
The specific objectives of the new Ministry as stated in the Royal Decree No 125 on 25/4/1422 (16 July 2001) are:

- To supervise the water sector and its facilities, and the management, monitoring and organization of this sector.
- To carry out all related studies to water in order to assess it resources, storage and available volumes.
- To prepare a comprehensive water plan defining the policies related to water, development of its resources, and water resources protection and conservation for different purposes.
- To prepare a national program to expand the drinking water and wastewater networks in all cities of the Kingdom and its Directorates and Centers.
- To develop water policies and to suggest the required organizations for protection of water resources and to define the best procedures to benefit from water resources.
- To restudy the water tariffs for all sectors of water users.
- To develop a mechanism to improve the performance of water collection system.
- To develop mechanisms, frameworks and suitable actions for private sector investment in water sector financially, execution, operation and maintenance.

The government has developed several regulations for the proper utilization of water resources and to protect groundwater resources. These include: consideration of factors related to regional water needs and its population and economic conditions, and the

availability of water supply source; the need for special permits from the Ministry for well drilling including site, aquifer, depth, design, development and production; supervision of well drilling and development by the Ministry, control on the purpose of water use by the Ministry, and pan on well drilling in over pumped areas or in aquifers which suffer from water level declines and quality change. The Ministry has also the right to claim water protected zones for special uses such as domestic purpose.

4.2 Organization Structure of the MoWE



4.3 Achievements of MoWE

4.3.1 Restructuring of MoWE

4.3.1.1 National Water Company

Formation of the Company: Royal Decree No. M/1 dated 3/1/1429H and the Council of Ministers Resolution No. 5 dated 12/1/1429H were issued approving the establishment of the National Water Company and its charter, with a capital of SR22,000,000,000 (twenty two billion Saudi Riyals). The main points of this resolution are as follows:

- Based on phases determined by the Government, the company shall perform and provide, on a commercial basis, all the services of the groundwater sector, the potable water distribution sector, and the wastewater collection and treatment sector (currently under the purview of the Ministry of Water and Electricity). The company shall receive all its fees, including charges for its services on their due dates and regularly from all subscribers without any exception. The company shall also be liable for all its debts.
- All government rights and properties related to the sectors as listed above shall be transferred to the company according to the phases determined by the Ministry of Water & Electricity.
- All financial and contractual commitments of the State that are related to those sectors shall be transferred to the company in accordance with the phases determined by the Ministry of Water & Electricity.
- The Ministry of Water & Electricity will supervise performance of the company in rendering services to these sectors as per its charter and relevant laws and regulations.
- The Ministry of Water & Electricity shall study the costs of producing water, connecting it to the distribution networks of the company, the company's purchase price of water in view of the authorized tariff to be collected by the company, and the company's performance costs for its commitments under its charter. Until this study is completed the government undertakes to provide the company with its needs of potable water.

The Council of Ministers shall consider offering the company's shares for sale to the public based on recommendations that shall be submitted by the Ministry of Water &

Electricity, in coordination with the Ministry of Finance and other competent authorities, whenever the Ministry of Water & Electricity deems right.

Objectives of the Company: The Company is trying to make radical changes in the performance level of the water sector through increasing operational efficiency to the highest international standards, providing high quality services to customers, reducing network losses, and providing an infrastructure capable of fulfilling the increasing needs and demands of the country's residents. All development operations will be carried out in the context of the concepts of sustainable development that supports improvements and innovation without jeopardizing the environment or the natural resources of the country, and having full regard for the development needs of future generations.

In order to achieve these goals, the company will adopt the best international practices and experiences, as well as use the latest advanced IT systems. The company will also do its utmost to transfer knowledge to its Saudi manpower through training, and enhancing their qualifications so that they can take charge of development of this sector. These efforts will be undertaken by the Company in fulfillment of its national role to support its community through support to education, and social and economic development.

Scope of Work of the Company: The responsibilities of the company may be summarized as follows:

- providing services for groundwater production, its purification, treatment, and distribution
- collection of wastewater, and its treatment, including all other related work, such as construction, management and operation, and building of water and sewage networks and treatment plants
- developing, operating and maintaining sewage treatment plants
- supply of water to subscribers as well as its distribution and sale
- preparing plans and conducting studies required for developing and providing water and sewage services in the Kingdom
- purchasing water from other sources that the Company deem suitable
- investing its assets and increasing its revenues
- purchasing real estate and movable assets, including acquisition and rental
- making commercial representation for businesses related to the activity of the company

- contributing to training of the Saudi human resources
- employing a Saudi workforce
- undertaking research and development
- transferring technology and adapting it to local environment
- taking over all the functions and responsibilities of the General Directorates for Water in the respective cities.

The company has the right to delegate to others any of its obligations and commitments related to performance of its services and undertake all activities required in this regard, whether related to its real estate or movables assets. The Ministry of Water and Electricity will perform a supervisory role to monitor the performance of the company.

4.3.1.2 Saline Water Conversion Corporation

The Saline Water Conversion Corporation (SWCC) is a Saudi government corporation responsible for desalinating sea water, in order to augment the supply of potable water to coastal and inland cities in the Kingdom. SWCC is also the second largest electric power producer in the Kingdom. SWCC, an entity under the authority of the Ministry, is in charge of operating the country's 30 publicly-owned desalination plants and operating a network of pumping stations, reservoirs and 2,300 miles (3,700 km) of pipes to transport the water in bulk from the plants to the major consumption centers, some of them located far inland such as Riyadh. SWCC is not an independent company run on commercial principles, but rather a branch of the government. Its water is provided for free to the branches of MOWE and to NWC. SWCC has a research department and a training center. In 2008 the government announced plans to "privatize" SWCC by transforming it in a holding company. The holding company would initially supervise affiliated production firms that would run the desalination plants. Subsequently it would sell off the include the private sector in a way similar to what has been done with the Independent Water and Power Projects (see below

4.3.1.3 Saudi Electricity Company

Establishment and Merger: On 05/04/2000, Saudi Electricity Company was established as a Saudi joint stock company with a paid-up capital of SR 33,758,632,650 (Thirty three billion seven hundred fifty eight million six hundred thirty two thousand six hundred and fifty Saudi Riyals). This amount was divided into 675,172,653 shares (Six hundred

seventy five million, one hundred seventy two thousand six hundred and fifty three shares). This was achieved by virtue of the Cabinet Order No. 169 Dated 11/08/1419H which stipulated the merger of all Saudi electricity companies in the Central, Eastern, Western and Southern Regions in addition to the ten small companies operating in the north of the Kingdom as well as all other electricity operations managed by The General Electricity Corporation, into a single joint stock company which is now known as Saudi Electricity Company.

Vision, Values, Mission and Strategic Goals

Vision: To help and improve the standards of living and enhance the economic competitiveness of the Kingdom of Saudi Arabia in all domains.

Values: Our values stand as the foundation and the reference on which the Company's decisions and work philosophy are based. These values make up the starting point from which we set on towards realizing our common vision and what we wish to achieve in view of the imminent change trends expected to occur in the Kingdom's electricity industry, as well as achieving our strategic goals.

We are also keen on making our values clear and accessible to all employees:

- Excellence in Service- All customers are worthy of attention and are entitled to excellent and timely service that will meet their expectations and more
- Promotion of Added Value for Shareholders - Giving due considerations to shareholders and achieving best yields for them.
- Staff Development - Employees represent our most important component; hence the Company is keen on upgrading their standards, developing their skills through training, empowering them to the performance of their work, as well as spreading the teamwork spirit and enriching interaction and understanding among them.
- Optimum Utilization of Resources - Reducing costs and constantly working on boosting the yields level.
- .Synergy - Constant improvement of all activities by effective use of flexible business processes that are based on teamwork..
- Innovation - Innovative ideas come from employees and receive our encouragement, support, and rewards.
- Saudization - Constant keenness on job Saudization.
- Safety and the Environment - Giving the top priorities to safety and protecting the environment.t
- Conduct - Respect to prevailing social traditions and values.
- Customs- Commitment to the best level of reliability, righteousness, transparency, and respect towards shareholders, customers, the community, and all company stakeholders.

- Communication Showing constant interest in opinions, suggestions, and remarks presented inside and outside the Kingdom.

Mission: We are committed to provide our customers with safe & reliable electric services, to meet the expectations of our shareholders, caring for our employees, and ensuring optimum utilization of available resources.

Strategic Goals: Our strategic goals are focused on the following:

1. Achieving high levels of satisfaction for various customers by meeting their expectations, actively communicating with them, and providing them with value-added services and products.
2. Upgrading the level of electric services delivery to various customer segments.
3. Preparing and adopting the programs and approaches necessary for implementing the employee training and development plans.
4. Performing in a reliable businesslike manner to establish interconnected electric grids throughout the Kingdom to provide electricity services.
5. Participating in the electric power generation, transmission, and distribution projects within the Kingdom and abroad on a business basis.
6. Interacting and contributing actively to the community service and charitable projects.
7. Conducting and supporting research studies aimed at improving the performance in all activities and conserving the environment.

4.3.1.4 Water & Electricity Company

In a bold step, the Government initiated a privatization program for the water projects with the aim of improving the service level. The launching point was establishment of the Water & Electricity Company that can oversee the private sector building of cogeneration plants (producing desalinated water and generating electricity simultaneously). The company will buy the water and electricity output of these plants. It then supplies water to SWCC and electricity to the Saudi Electricity Company.

To develop a very transparent and well defined process and project structure that yields optimized plant's capital cost, performance and efficiency in order to procure water and electricity reliably, securely, and cost-effectively through IWPPs in the kingdom of Saudi Arabia .

To remain at the forefront as a distinct and an outstanding offtaker in attracting competitive and lowest tariff bids for both water and power through Independent Water & Power Projects (IWPPs) and maintain sustainable development in water & power sectors in the kingdom of Saudi Arabia .

Water and Electricity LLC

Pursuant to supreme economic council resolution (5/23) WEC was established as a limited liability company (LLC) in 2003. WEC's corporate purpose is the sale and purchase of water and electricity and all required ancillary activities. WEC will be the counterparty under the PWPA and will buy the Project's water and electricity. WEC will in turn sell this water and electricity on to SWCC and SEC respectively .

WEC was formed with an authorized share capital of SAR 30,000,000 divided into 600,000 shares of SAR 50 each. SWCC and SEC each own a 50% shareholding in WEC. The term of WEC is 50 years. WEC's Articles of Association are based on the standard form of LLC Articles, as provided by the Ministry of Commerce and Industry (MoCI).

The desalination plant at Shuaibah (Shuaibah 3) is the first desalination plant being constructed by the private sector and has a total production capacity of one million cubic meters per day. This output will significantly increase the water supply to Jeddah, Makkah, Taif and Albaha. Commercial operation of this plant is expected to start in the very near future. At the same time, Phase II of the Shuqaiq Desalination Plant is being constructed by the private sector to enhance water supplies for Asir and Jazan with a total production capacity of 212,000 cubic meters per day. Currently preparations are being made to award the contract for construction of the third plant at Ras Alzor that will supply Riyadh with one million cubic meters of desalinated water per day

4.3.1.5 Electricity &Co-Generation Regulatory Authority (ECRA)

The Electricity &Co-Generation Regulatory Authority (ECRA) is a financially and administratively independent Saudi organization , which regulates the electricity and water desalination industry in Saudi Arabia to insure provision of adequate ,high quality, and reliable services at reasonable prices , its mission is to develop and pursue a regulatory framework ,in accordance with government laws, regulations , policies, and standards, as well as international best practices, in order to guarantee the provision of safe, reliable , reasonably priced and efficient electric power and desalinated water to the consumers of Saudi Arabia.

Mission: To insure that supplies of electricity and desalinated water products provided to consumers in the Kingdom are :

- Adequate
- Reliable
- Of high quality
- Fairly priced

Goals and Objective: The Authority's goal is to become an efficient, technically competent Regulator for the electricity and co-generation industry as it evolves from the current state of a vertically integrated monopoly, through a careful and gradual process of unbundling and restructuring to a competitive market with multiple suppliers, service providers and buyers. ECRA has a duty to protect the public interest as well as the right of consumers to receive high quality, safe and reliable electricity services at economically sound prices. At the same time the Authority must protect the interests of service providers and investor's rights to realize reasonable economic returns on prudent investments; promote the creation of a favorable environment that encourages legitimate and fair competition among providers and suppliers of electricity services, and promote consumer's right of choice among competing suppliers.

ECRA’s mandate covers the regulation of the electricity and water desalination industry in order to guarantee that the services of the industry are adequately provided to the country at the lowest prices consistent with high quality and reliability. Specifically, the main goals of the Authority are:

- Protection of the public interest and rights of consumers to receive high quality, safe, and reliable electricity, desalinated water, and cogeneration services at economically sound prices.
- Promotion of consumer oriented electricity, water desalination, and cogeneration services that protect the consumer's right of choice among competing service providers.
- Encouragement of private sector investors to participate and invest in the development of the Saudi electricity and water desalination industry, protecting their interests, and enabling them to realize fair economic returns on their investments.
- Formation of a clear, transparent, stable, and non-discriminatory regulatory framework for the electricity and water desalination industry.
- Creation of a favorable environment that encourages legitimate and fair competition among providers and suppliers of electricity, water desalination, and cogeneration desalination services.

4.3.2 National Water Strategy

The current use of the Kingdom's water resources is unsustainable and unless corrective measures are taken soon the long-term viability of the resource will be jeopardized. The unsustainable character of the current use of water shows up in two fronts: the unrestricted and uneconomical use of irrigation water and the fiscal burden generated by the water supply and sanitation . These factors motivated the Ministry of Water and Electricity (MOWE) to restructure the water sector and to prepare a National Water Strategy (NWS) to guide the process.

The overall challenge is to stop the degradation of the base resource while helping materialize the national vision that demands *"...the sustainable development and management of the Kingdom's water resources"*. *Sustainability* is the first element to ensure: the recommendations embedded in the proposed NWS seek to treat non-renewable groundwater as a strategic resource such that today's use of water is not in detriment of future generations. *Efficiency* is the second element to guarantee. This is done by promoting the usage of water to generate maximum economic benefits along with other resources (oil, land, labor and capital).

International experience indicates that when urban consumers pay a small fraction of the cost of delivering piped water and farmer's benefits do not reflect the true cost of water extraction due to large input subsidies for the production of low value crops, managing the consumption of water becomes an intractable problem. Thus, the particular challenge is to make sure that the policy options and instruments provided by the NWS reach inside and outside the water sector, so as to integrate water resources management with all water consuming sectors of the country. Resolution No.335[1], passed recently by the Council of Ministers, is a rational step that sets the scene for a more orderly use of the Kingdom's water resources. Most notably, it removes the incentives for wheat and fodder production and establishes mechanisms for better control and protection of the base resource.

Main Issues, Policy Options and Immediate Actions

Depletion of Aquifers: The current levels of groundwater extractions (mostly water used for irrigation) far exceed the level of natural recharge of the aquifers, causing severe

[1] Resolution No.335 entitled "*Rules and Procedures to Rationalize the Use of Water and Manage its Use in Agriculture for all the Kingdom of Saudi Arabia*", approved by the Council of Ministers on November, 2007.

groundwater depletions. This implies exploitation of the sources well beyond their sustainable yield. A fundamental reason for the over-exploitation of the aquifers by farmers results from two mutually reinforcing forces. One is the high level of agricultural support (energy subsidies and subsidized loans) which induced a sudden increase in the cultivated area and discourages water savings. The second one is the unrestricted and free access to groundwater. This makes farmers to treat groundwater as a free good, a behavior that is encouraged by the lack of government control and regulation of the irrigation activity.

Policy: Consider removing all incentives leading to excessive extraction of groundwater. A policy of reducing drastically the domestic production of crops (wheat, fodder, feed grains) can be complemented with a well designed imports policy with long term contracts and the holding of an appropriate level of working stocks so as to provide an acceptable degree of food availability while avoiding further depletion of the groundwater.

Immediate Actions:

- Phase-out GSFMO[2] purchases of wheat over a period of time and consider the need to establish a decoupled compensation package for wheat farmers genuinely affected by this measure
- Implement a strategic policy for food security relying on both domestic and international markets to substitute crops with high water consumption levels (cereals, fodder, feed grains)
- Establish aquifer protection areas in zones with highly impacted groundwater levels

- **Water Conservation**: The current level and tariff structure for urban water paid by consumers provides no incentive to conserve water, inciting per capita consumption levels inconsistent with the water scarcity condition in the Kingdom. Moreover, the low pricing of water is also a disincentive for utility companies to diminish water losses along the pipe networks. Another evidence of the lack of incentives to conserve water is the imbalance between the treated wastewater supply and its minimum reuse, disregarding an important supply of water that can be reused for irrigation, in industry and even in urban areas. But the sector where conservation efforts are most needed is irrigated agriculture, being the largest water consumer and the sector with the lowest water efficiency.

Policy: *Any effort in building new infrastructure to meet the increasing urban water demand needs to be accompanied with proper incentives to bring down*

[2] GSFMO (Grain Silos and Flower Mill Organization) is a government held agency that owns and operates all the silos and mills in the Kingdom

household consumption levels and to reduce water losses occurring along the distribution networks (the least expensive water to reclaim). Since acceptability of wastewater reuse does not seem to be a problem, it is critical to speed up the construction of infrastructure and the approval of the new regulatory framework in order to make use of such indispensable resource. Besides the need to drastically reduce the current level of cultivated area in the Arabian Shelf, there is also a need to improve irrigation practices and irrigation efficiencies for all crops that show good economic prospects.

Immediate Actions:

- Strengthen current water conservation programs aimed at curtailing domestic demand, including: water pricing, full metering, installation of water saving devices, public awareness campaigns
- Put in place a national plan for improving irrigation practices and on-farm irrigation efficiency for crops with good economic prospects (MOA-MOWE working jointly)
- Identify opportunities and conditions for reusing treated wastewater in irrigation, industry and urban areas; while promoting the participation of the private sector in the effort (working under inter-institutional arrangements)

- **Water Services**: Urban water supply faces a grand challenge having to serve nearly 25 million people under severe water quantity and quality problems and a decaying infrastructure. The challenge will be even greater in 2035 when near 46 millions inhabitants will have to be served. Aside from just a few cities that have relatively good service and two large cities which recently have come under management contracts, the quality of water supply and sanitation (WSS) services in general remains below internationally acceptable standards. An increasing portion of the population remains dependent on supply through water tankers, forcing non-served citizens to pay many times what connected households pay. The extremely low cost recovery level also hinders the capacity of the public utilities to extend sewerage services to more areas and build new treatment facilities.

Policy: *Partnership between the public and the private sector in the provision of WSS services will improve substantially the present management practices and may even add capital needed to extend coverage and improve service. At the same time, government may promote the "corporatization" and commercialization of government run utilities, operating as autonomous entities with private sector incentives. As the private sector takes over the day-to-day management of the largest water utilities, the National Water Company should evolve into a regulator*

overseeing the performance of the contracted as well as the public utilities, regulating water services, benchmarking performance and promoting inter-regional schemes and policy making.

Immediate Actions:

- Extend the provision of water supply and sanitation services to achieve the established coverage targets
- Continue putting in place "performance-based management contracts" for the largest cities, with the proper incentives to reduce unaccounted-for-water, to reduce operating costs and to improve service levels in general
- Speed-up the corporatization and commercialization of government run utilities, operating as autonomous corporations with private sector incentives.

- **Financial Burden**: Water related activities impose a fiscal burden on the government budget. The cost derives from two fronts: the lack of cost recovery in urban water supply; and the large portion of the urban water demand supplied by desalinated water. Agriculture and trade policies aggravated the fiscal picture by encouraging farmers to select low, rather than high, value crops. This creates a substantial gap between the production cost to farmers (private cost) and the true cost of agriculture to the Saudi economy as a whole (social cost). Crops such as wheat, fodder and feed grains are detrimental to the Saudi economy as revealed by their negative social returns. Irrigated agriculture also competes with urban use for water supply making the latter more dependent on expensive desalinated sea water. This occurs despite the fact that most urban areas are close to or lay directly above sufficient groundwater reserves to meet their domestic needs at a lower cost.

Policy: *Consider redirecting credit subsidies aimed at significantly reducing wheat, fodder and feed grains acreage while inducing farmers to produce high value products (fruits, vegetables, seeds, etc). Most consumers are able to pay higher prices for water services than those currently charged. This should be done in parallel with well designed targeted subsidies for poor consumers. Furthermore, the large increase in population expected for the coming years makes it imperative to reverse the present tendency where desalinated water supplies a constantly increasing percentage of the urban water demand. The supply of desalinated water should be restricted to cases with proven economic feasibility, always looking for alternative less expensive sources, including brackish groundwater.*

Immediate Actions:

- Gradually increase tariffs for water supply and sanitation services to cover full

operation and maintenance costs while putting in place safety net provisions to assist the poor

- Reallocate part of the groundwater saved in irrigation to urban/industrial use so as to minimize the need for desalinated water, delaying new desalination investments

- **Water Governance**: Past administrations dedicated their best efforts to build the Kingdom's major water infrastructure, paying little attention to base resource management (resource assessment, monitoring, planning, allocation, protection and enforcing). This created many of the problems that the water sector faces today, even threatening the very existence of the resource. The weakness in water governance is exacerbated by deficiencies in the legal and regulatory frameworks, poor management arrangements and an inadequate recruitment policy.

Policy: *Government needs to reconcile the public character of water with the individual right to use the water. The prospects for better management of the Kingdom's water resources require a number of reforms that include: new enabling legislation, restructuring the management organization, developing management instruments, establishing mechanisms for policy coordination, building and recruiting new capacities, reformulating the staff retribution regimes; and last but not least, strong political will to bring all the reforms to realization.*

Immediate Actions:

- Adopt a modern water law (a law of principles), leaving all operational aspects as part of the regulatory and administrative framework
- Create national water registries (for wells, water rights and effluent disposal) to protect the legitimate development, use and disposal of water
- Enhance MOWE's operational capabilities by creating a new organization around basic IWRM functions, including regional water authorities

- **Policy Coordination**: Although the Kingdom's water related strategies (agriculture, environment, urban development, petroleum and minerals, etc) recognize the scarcity of water as a constraint for development, the action plans accompanying the strategies come up short in incorporating the environmental dimension of the water problem. Nowadays, with proper knowledge of recharge rates and the availability of "exploitable" groundwater, the Kingdom is in a position to harmonize all sectoral strategies and action plans that directly or indirectly impact the country's water resources. Strategies should be updated to reflect the water scarcity condition of the Kingdom,

demanding an urgent shift in government policy: from "food self-sufficiency" to "water security" and from "supply management" to "demand management".

Policy: Consider the harmonization of all strategies by creating horizontal linkages across government agencies to find the best possible solution to the water allocation problem. Conflicting interests can be reconciled by establishing technical and political coordination so that a coordinated approach to development can be implemented. Coordination is achieved by setting up an integrated water planning process; the instance when all water related agencies gather (at the technical level) to bring into line water demands with water availability, yielding as output unambiguous instructions for bulk water allocation.

Immediate Action:

Put in place an "Integrated Water Resources Planning" procedure such that a coordinated approach to development can be implemented for an orderly utilization of the Kingdom's aquifer reserves

4.3.3 National Comprehensive Water Act

Recently, the government of Saudi Arabia formulated a comprehensive **National Comprehensive Water Act** to establish integrated and multidimensional regulatory (legislative) framework for rational water use, water rights and allocations, protection, and sustainable management of Water Resources of the Kingdom. The water act will help in formulation and implementation of institutional, operational and financial reforms in water sector of the Kingdom.

Ministry of Water & Electricity (MOWE) has a mandate to work as regulator of water sector of the Kingdom and is responsible to formulate, implement and enforce the National Water Act and implementation regulations to all water affairs of the Kingdom.

Major objectives and components of the NCWA are

- To provide reliable access of safe and clean water as basic human right of all citizens and to preserve and sustain water resources for present and future generations;
- To regulate and control water rights and uses to ensure fair and rational use of water irrespective of economic perspective and promote water as a basic life element and an economic value-added substance.

- To ensure fair distribution of water and to rationalize its use for comprehensive and sustainable development through equitable supply and demand management and protection for future generations.
- To protect quality of water and infrastructure against the impact of environmental pollution due to different water uses and to safeguard public health and the environment.
- To establish and define the responsibilities of a new Water Services, Regulatory and Licensing Agency (WSRLA) to enforce and implement Water Act on all water affairs including water resource development, treatment, transportation, storage and distribution.
- To formulate regulatory, administrative, financial, technical and operational framework for establishment of **Water Data Center** to build a comprehensive database of water resources and their uses.
- To develop transparent, impartial and integrated procedures and mechanism for private sector participation in water sector of the Kingdom.
- The National Water Act comprises (11) sections which covers all aspects of the water affairs including ownership of Water Resources and Infrastructure, Protection and Sustainability of Water Resources, Priorities and Allocation of Water, management of Water Demand, Rationalization of use and water feasibility water conservation.
- The Water Act provides framework of Water Tariff system and Regulations on Water Use, licenses of water services and Fines and Penalties of violations.
- The Water Act provides guidelines for water quality and pollution control with the help of Water quality standards and water services quality norms.

4.3.4 Privatization of the Water and Wastewater Sector

4.3.4.1 The Kingdom's Vision of Privatization

The Government has adopted an ambitious vision to upgrade the performance level of the water and wastewater sector in the Kingdom within five years. It is aimed to bring the sector up to international standards through privatization commencing with partnership contracts (Public-Private Partnership, or PPP as they are known).

4.3.4.2 Objectives of Privatization

The main objectives of developing and increasing efficiency of the water and sewage sector in the Kingdom are as follows:

- To provide all consumers with high quality potable water.
- To provide water and sewage services at a suitable price conducive to conservation and recovery of costs.
- To connect all residential units with the water and sewage networks.
- To preserve the country's natural water resources and protect the environment.
- To make beneficial use of treated wastewater.
- To provide high quality services to customers.
- To develop Saudi manpower and train them in accordance with the most modern international training standards.
- To run operations on a commercial basis and move gradually towards privatization.

Currently, an integrated team from the projects department and work units in the cities is working on privatization of the sewage water treatment plants in Riyadh and Jeddah by National Water Company. The existing treatment plants being targeted for privatization include Alkharj Plant 1, Alkharj Plant 2, and Alhaer Plant 1. Alkharj Plant 3 and Alhaer Plant 2 will be privatized through the build, operate, and own (BOO) system. This will be followed by privatizing the Jeddah wastewater treatment plants and the treatment plants of the other remaining targeted cities in turn.

In the meantime, work is being done with the private sector to determine the strategic direction for use of the treated wastewater by establishing an independent company under the umbrella of the National Water Company. The proposed new company will manage, sell, and market wastewater to users. The objectives of this endeavor are the following:

- To enhance management of water demand by directing the treated wastewater to other uses, such as industry, agriculture, etc.
- To assist in protecting the environment by reducing damage and violations caused by inappropriate disposal of wastewater; and also by the possibility of re-injecting the treated sewage effluent underground.
- To gain economic benefits through sale of the treated wastewater to users in various fields, that will provide income for the National Water Company.

4.3.4.3 The Strategic Plan for Privatizing the Sector

As the water and wastewater sector is vitally important for the lives of all inhabitants of the Kingdom, it was important to make radical and fast changes/improvements in the sector. Before any changes were adopted, a review was undertaken of experiences of other nations in this field. The government decided to adopt various types of partnership projects with private industry in order to improve the performance of the water sector, increase its efficiency, reduce its dependence on government finances, and increase private investments. Accordingly, a strategic transformation plan was implemented to move gradually towards privatization of the water and wastewater sector. The plan focuses on the following:

- Making reforms throughout the Kingdom in the water and wastewater sector to improve management of water demand.
- Making internal changes in the water and sewage sector such as restructuring procedures, establishing advanced customer service centers, and developing organizational structures.
- Making changes outside the water and sewage sector such as educating the public about the importance of water conservation and regulating consumption, and attracting international and local investors.

4.3.4.4 Implementation of the Privatization Plan

(1) The National Water Company

Initiation and implementation of PPP plans of the organization including procurement of Management / Concession contractors for managing water networks, wastewater networks and treatment plants in the urban centers of the kingdom through international consultancy services. It also involves exploring opportunities to promote re-use of treated wastewater through establishment of special purpose companies as joint ventures with potential investors

Management Contract

NWC's Management Contracts with international water operators for Riyadh and Jeddah are performance based agreements in which payments, incentives and compensations are related to achievement of Key Performance Indicators (KPIs) identified in the contract. The contract is structured to achieve both output performance, knowledge transfer and capacity building thus providing a sustainable platform for the business units to attain NWC's strategic objectives.

PPP (Public Private Partnership)

The Public Private Partnership is an arrangement involving the management of public utilities in which the governmental agencies combine with private sector operators by entering into short, medium and long term agreements. Under the agreement, payments for services are linked to pre-identified performance targets with the outcome guaranteed by the private partners.

There are five basic models in PPP with several variants to suit the situation and the existing status. Starting with Management Contracts and O&M Contracts (ranging in terms from 3 to 5 years), and other models such as Lease, Build-Operate-Transfer (BOT), Build-Own-Operate (BOO) and Concession the term of agreement can go up to 25-30 years.

Apart from improving efficiency and better customer services through adoption of international best practices, the PPPs with different models are expected to provide the following benefits with particular reference to water sector:

- Expert Consultancy Services in areas like O&M, reduction of leakages and Non-Revenue Water (NRW) and Improvement in revenue collection
- Assumption of full responsibility for operation and maintenance of existing assets and water services
- Bring in investment to rehabilitate and improve existing assets
- Develop and operate new assets
- Bring in investment for addition of new assets

(2) The Saline Water Conversion Corporation (SWCC)

Privatization of SWCC is a particularly sensitive issue due to the vital role of water in people's daily life. SWCC's steps in this direction have been well planned and deliberate. Within the framework of the government's policy on privatization, several resolutions were issued by the Council of Ministers, the Supreme Economic Council, and the Shoura Council urging the SWCC to expedite submittal of the study of its restructuring,

amending its charter, and encouraging private sector investment in building and operating desalination plants.

Phases of Implementation of SWCC Privatization: In compliance with these directives and resolutions issued during the last few years, SWCC completed important steps in the privatization and restructuring program. Execution of the implementation program for SWCC's privatization and restructuring consists of four major phases as follows:

Phase I Preliminary Steps and Detailed Studies: This phase was started in 1425AH (2004). A planning team studied the procedures required for SWCC's privatization and restructuring and produced a work plan and timetable for transforming the Corporation from a government-owned entity to a commercial entity running its business on a commercial basis. In order to carry out this task, international and local consulting firms were invited to take part.

Privatization Options: A privatization and restructuring team consisting of four committees (strategic, technical, financial and legal) was established. It was charged with the responsibility of completing internal preparations for the required studies phase. The studies included more than twenty models of which three were considered to be viable options for implementation. The three options are:

First Option: Transform SWCC into a joint stock company with participation of the private sector through partial sale of the company in a public offering of the company's stock and soliciting a financial strategic partner to add his expertise to SWCC's technical and administrative competencies.

Second Option: Transforming SWCC into a holding company and establishing subsidiary companies for production. Private sector participation in the holding company and in the production companies will be made at a later stage through a public offering of the companies stocks in a manner similar to the model of the independent water and power project companies (IWPP's).

Third Option: Transforming SWCC into a holding company and establishing subsidiary regional companies. Participation of the private sector in the regional companies will be through concession contracts.

Phase II Securing Approvals: This phase entailed obtaining approvals from the competent authorities for proceeding toward implementation of the outcomes and recommendations of the studies (Phase III - implementing restructuring and preparing requests for bids for privatization). Royal letter No. (2/29) by the Servitor of the Two Holy Sanctuaries, King Abdullah Ibn Abdulaziz, Chairman of the Supreme Economic

Council, was issued on 29/6/1429 AH granting royal approval of the implementation program for privatizing SWCC according to the option of transforming the Corporation to a holding joint stock company (second option). The percentage of the private sector's participation in each of the production companies owned by the holding company shall be as dictated by the attractiveness of the investment and the situation of each plant – provided that percentage shall not be less than 60% of the ownership in any of the subsidiary production companies.

Phase III Implementing Privatization and Restructuring of SWCC: Following granting of the royal approval for implementation the pre-qualified consultants were authorized to proceed with the program to privatize and restructure the Corporation and transform the plants to be privatized into production companies. Documents will be prepared to request proposals for privatizing these producing companies.

Phase IV Privatizing the Holding Company: In the short and medium term (up to about five years) the private sector will participate in the holding company through management contracts. In the long term the possibility of making a public offering of the shares of the holding company will be considered. The private sector may then participate as a strategic partner. In the long run a public offering/subscription will be floated.

The table below shows the production companies proposed to be offered for private sector participation.

Production Companies	Plants
Yanbu Small Plants – 1	Yanbu 1, 2, 3 and Reverse Osmosis Dhuba -3, Umloj -3, Wajh – 3, and Wajh 4
Small Plants – 2 Alkhafji Shaibah Shaqiq Alkhobar Juabil	Leith-1, AlQunfudhah-1, Farasan-2 and Rabigh -2 Alkhafji-2 and 3 Shuaibah 1, 2, 3 Shuqaiq -1 and 3 Alkhobar – 3, 4 Jubail-4 and Reverse Osmosis

4.3.5 Water Supply and Demand

4.3.5.1 Water Supply

1 Assessment of water resources: detailed studies on certain aquifers were conducted such as:

- studies of the water, agriculture, and soil of the "Sag" aquifer and overlaying formations
- study of the Umm Er Radhumah aquifer
- hydro geologic studies on five wadis: Yaba, Habona, Tubalah, Lia and Leith
- studies of the water resources to supply cities and towns in the regions of Baha, Riyadh and Makkah.

2 Water Supply Augmentation:

- **Independent Water and Power Projects:** Since the early 2000s, Saudi Arabia has invited the private sector not only to build, but also to finance and operate new desalination plants. An example is the Shoaiba III Independent Water and Power Prdoducer (IWPP), which is the country's largest desalination plant with a production capacity of 150 million cubic meters per year, built at a cost of US$ 1.06 billion and completed in 2005.[11] It is located on the Red Sea and provides water to Jiddah, Mecca and Taif. A Water and Energy Corporation (WEC) has been established as an off-taker that would buy the water from the IWPP. The government fully guarantees the payments due from WEC to IWPP. This follows the example of the Persian Gulf countries, which had introduced IWPPs several years earlier.

  Saudi Arabia plans to launch ten IWPPs by 2016 at a total investment of $16 billion. The first phase of this plan, to be completed by 2009 at an approximate cost of US$7.3 billion, will consist of three IWPPs:

  - Shuqaiq, Phase II - a US$2.5 billion project to produce 850 MW of electricity and 212 million cubic meters of desalinated water per day. Shuqaiq II will be modeled after the Shoaiba III IWPP project, with similar guarantees and a 20-year power and water purchase agreement (PWPA).
  - Ras Azzour - a US$2.4 billion project to produce 2,500 MW of power and 176 million gallons of desalinated water per day.

- Jubail, Phase III – The project will produce 1,100 MW of electricity and 25,000 gallons of desalinated water per day.

- **Dams:** Currently about 150 dams are under construction at a total cost of three billion Saudi Riyals and a total capacity of 1,900 million cubic meters as indicated in Figures 6 and 7 The dams are constructed for a multiplicity of purposes such as providing potable and irrigation water, recharging the groundwater aquifers of the valleys which feed wells, or controlling floods to limit natural disasters and safeguard lives and property.
- **Rain harvesting**
- **Wastewater Treatment plants:** New wastewater treatment plants and sewer networks have been constructed. For example in 2008, six wastewater treatment plants and sewer networks with total length of 648 km were constructed.
- **Groundwater project:** New wells, transmission line, pumping stations, water treatment plants, and reservoirs were developed and constructed since the establishment of MOWE. For example in 2008, two water treatment plants with capacity 155,000 m3/day were built. Furthermore 401 wells were developed in different parts of the Kingdom to satisfy domestic demand. Water distribution network with a total length of 4,854 km and a transmission line with a total length of 12 km were constructed in the year 2008.

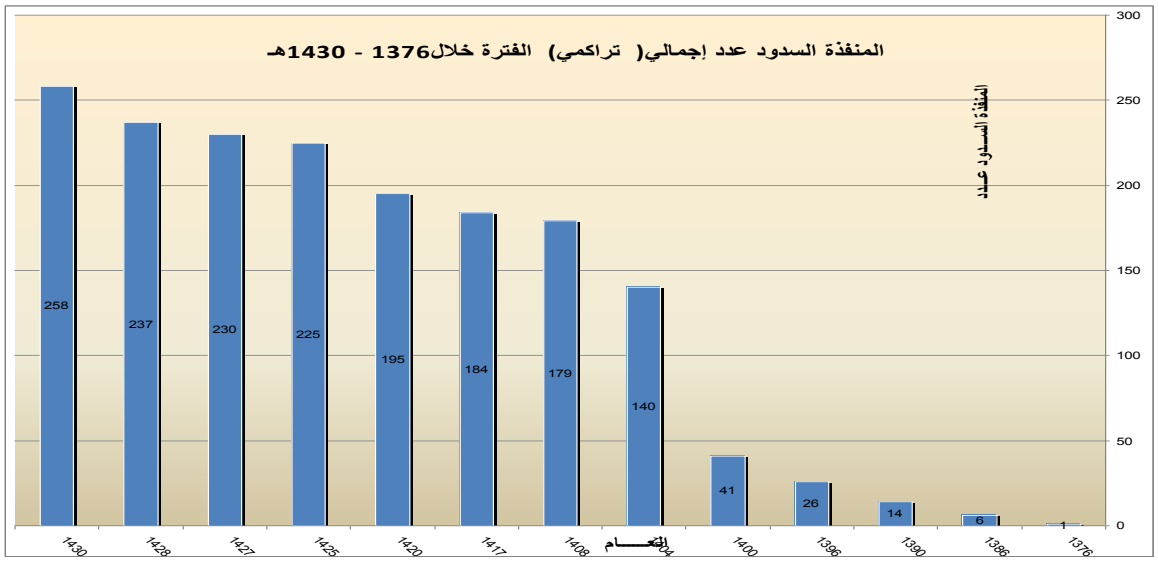


Figure 6 Cumulative total number of dams constructed during the period 1376 – 1430AH (1950-2009)

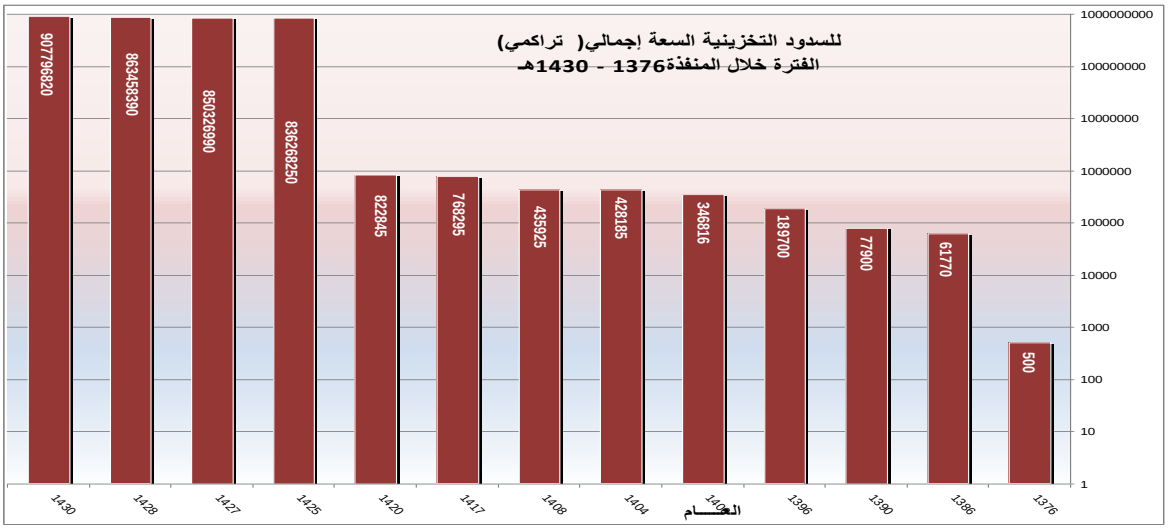


Figure 7: Cumulative total capacity of dams constructed during the period 1376 – 1430AH (1950-2009)

4.3.5.2 Water Demand

- Leakage control measures have been practiced to minimize water losses from water supply networks.
- Enhancement of treated wastewater recycling such as recycling of ablution water in the high rise building of in Makkah Company for Construction.
- The adoption of flushing boxes with capacity of 6 liters to minimize the excessive water use for toilet flushing.
- Guide for the use of gray water
- Guide to save water and electricity in the home
- Guide to design sewage treatment plantsIntensive awareness program for the public in the media with the values and procedures of water conservation for different purposes.
- Organization of conferences and workshops about water conservation procedures and benefits.
- Announcement of a water week every year during which the water conservation activities are intensified.
- Celebration of the International Water Day on 22 March every year in which the water conservation activities are celebrated by all sectors of the country.

4.3.6 Water Conservation

With the directive and patronage of the Servitor of the Two Holy Sanctuaries, King Abdullah Ibn Abdulaziz, the government mounted a national campaign for residential water conservation. The campaign involved distribution free of charge of conservation tools to houses, schools, mosques, hospitals, government buildings, and commercial buildings; these tools were also installed free of charge. The program had a noticeable effect on conservation where actual measurements indicated achievement of savings of as much as 35%.

4.3.6.1 Objectives of the National Water Conservation Campaign

The national water conservation campaign was undertaken to achieve the following objectives:

- Identifying the current and future water situation and emphasizing the importance of conservation for sustainability
- Taking practical measures and adopting a clear and direct approach to inform and educate the public about conservation and addressing all components of society.
- Highlighting the Kingdom's high per capita consumption, and the low tariff paid by consumers for water compared to other nations.
- Acquainting the public with the conservation tools, and encouraging them to use them.

4.3.6.2 Programs of the National Water Conservation Campaign

Media Campaign: The Government mounted a widespread media campaign to advise the public about the importance of water conservation. State and private sector organizations contributed in this campaign. Conservation competitions were held in which more than 43,000 male and female participants took part. Many awards were given out and about 530,000 conservation gift bags were distributed in shopping malls, showrooms, festivals and public events. These activities had good effect in strengthening links with local communities. A number of specialized seminars and lectures on the subject of water conservation were also held.

Establishment of the Women's Permanent Exhibition for Water Conservation: The exhibition was opened on 20/10/1426AH under the patronage of Her Royal Highness Princess Adlah Bint Abdullah Ibn Abdulaziz. The aim of the exhibition is to convey the message of water conservation to the women's community in the Kingdom. The exhibition receives female student visitors from schools, and universities as well as housewives. The exhibits aim to instill in the minds of the visitors the concept of conservation. Documentary films on water conservation are shown and practical demonstrations of the conservation tools are held.

Further arising from a strong belief in the important role that women can play in support of water conservation, the exhibition also organizes a program of informational visits directed towards women in schools, colleges, and the community at large. During these visits, conservation gifts are distributed and conservation tools shown.

Exhibits were held in various women's activities such as the Janadiryah Festival, the Back to School Festival held at Prince Salman Social Center, and the March of a Nation Festival held at Al-Hukair Land.

A women's symposium on water conservation was organized under the patronage of Her Royal Highness Princess Adlah Bint Abdullah Ibn Abdulaziz on 27/5/1426AH. The symposium received considerable media coverage and a good deal of public recognition.

Outlets for Sale of Conservation Tools: Showerheads were targeted to highlight the advantages of conservation as shower water consumption represents 15% of home water consumption. Regular showerheads, consume 5 to 7 gallons of water per minute while those suitably adapted to save water consume 1.5 to 2.5 gallons per minute. The Ministry of Water & Electricity opened the first outlet to sell the water saving showerheads to the public in its headquarters building in Riyadh (as a first stage) at a nominal price to encourage consumers to use the conserving design. The Ministry is planning to expand opening of these outlets throughout the Riyadh and other regions of the Kingdom.

The Program of Free Distribution of Water Conservation Tools to Residences: (First stage of the campaign): His Excellency the Minister of Water & Electricity inaugurated the initial stage of the campaign and the first conservation tools bag was handed out on 18/8/1425AH. Thereafter, the Ministry started distributing the conservation tools to housing units with the aim of strengthening the concept of optimum use of water and avoiding wastage. More than 34 million conservation tools were distributed to 18 million people (citizens and residents) in the Kingdom. The average saving was about 30% of home consumption. This program achieved remarkable results as the percentage of houses which installed the tools has reached 80%. This campaign is considered to be the largest water conservation campaign of its kind in the world in terms of quantity and quality. The expected water saving due to installation of the conservation tools in the houses is estimated to be 524,000 cubic meters per day, equivalent to the output of desalination plants Jeddah 4, Yanbu 2 and Assir combined. The expected annual financial saving resulting from installation of these tools is estimated at about SR900 million.

Program for Distribution of Conservation Tools to the Government/Public Sectors (Second stage of the campaign): His Excellency the Minister of Water & Electricity inaugurated this stage on 5/2/1426AH which is aimed at public sector facilities such as government buildings, schools, mosques, parks and airports. About 2.1 million conservation tools have been distributed and installed.

Program for Distribution to the Private Sector (Third stage of the campaign): His Excellency the Minister of Water & Electricity inaugurated this stage on 17/8/1426AH which is aimed at private sector facilities such as hotels, furnished flats, and residential compounds. More than 2.5 million conservation tools have been distributed and installed.

Program for Distribution of Water Saving Showerheads at Nominal Prices (fourth stage of the campaign): At this fourth stage, the Ministry targeted private sector facilities such as hotels, furnished flats and residential compounds. A number of sale points were opened for distributing the water saving showerheads at a nominal price to encourage use by the public. The heads are available in different sizes and colors, can easily be installed, and are attractively designed. More than 592,000 water saving showerheads have been distributed and installed. The water saving achieved ranges from 25% to 45%. The government has implemented a national program to reduce leakage of water from the public water networks and renewal of old networks to reduce the loss to less than 5%. The tables below show the percentage saving of water due to the program.

Examples of water saving achieved at some government premises due to installation of conservation tools

Department	Consumed water (M^3 per day)		Saved water (M^3 per day)	Percentage of saved water
	Before installing conservation tools	After installing conservation tools		
Geological Survey Board	361	239	123	34
Ministry of Petroleum and Mineral Resources (Riyadh)	15	10	5	33
Ministry of the Interior (Riyadh)	387	252	135	34
King Abdulaziz	299	220	79	26

Hospital in Riyadh				
Armed Forces Medical Complex	1,268	900	368	29