Household water and sanitation services in Saudi Arabia: an analysis of economic, political and ecological issues

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Occasional Paper 56
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May 2004

This study evaluates Saudi Arabia's investment in household water and sanitation services (WSS) over the past three decades or so. It finds that over one half of Saudi householders still have no municipal water connections and two thirds are without sanitation connections. Saudi cities have no rainwater drainage systems to deal with the brief and occasional, but severe deluges of winters. Desalinated water is transmitted across hundreds of kilometers of desert terrain to two major urban centers (Riyadh and Qaseem) that are rich in groundwater reserves while their local water is used in irrigation.

The study addresses the subject in six sections: 1) the inadequate coverage of WSS facilities in a country that received US$1,034 billions from crude oil exports between 1972 and 2001 (Saudi Arabian Monetary Agency (SAMA), Annual Report, 2002: p.388). 2) Possible causes behind this poor state of affairs. 3) The sources of Saudi household water. 4) Comparisons among the economic cost of water production and pipeline transmission of the various sources of domestic water: a) groundwater, b) modern desalination plants and, c) Saudi Arabia's existing 30 desalination plants. An opportunity cost of capital will be included in the computations. 5) Availability, or lack of availability, of sufficient groundwater reserves near main Saudi urban centers. 6) Policy implications of sections (4) and (5). The data are from government and other official sources.

1. Inadequate level of household water and sanitation service

Saudi government efforts during the past three decades to provide household water and sanitation services have been significant. However, municipal water connections benefit about one half of the population only. The other half receives their water through water trucks, wells and water containers. The following table shows the methods of domestic water delivery in the region of the capital city Riyadh and the country as a whole as of the end of Islamic Hijra year 1421, corresponding to March 26, 2001 (the Islamic Hijra year 1421 started on April 6, 2000).

Table 1 Channels of delivering household water to the population of the Riyadh region and Saudi Arabia as of March 2001 (figures are in millions of persons)

	Population	Number of people receiving household water through				
		Public networks	Water trucks	Wells	Water containers	Others
Riyadh region	4.73	3.081	0.703	0.038	0.9	0.008
Saudi Arabia	20.847	9.902	6.515	0.694	3.608	0.128

Source: Saudi Statistical Yearbook (SSY), 2001: p.69.

The above table shows that for the whole country, 47% of the total population had municipal water connections (9.902 millions/ 20.847 millions). The remaining 10.945 millions (20.847 millions– 9.902 million), or some 53% of the total population, had no such connections (10.945 millions/ 20.874 millions). For Riyadh Region 65% of the 4.73 million in population had connections to the municipal water network (3.081 millions/ 4.73 millions). The remaining 35% received domestic water through trucks, wells and containers. In Riyadh City, the number of connected households in March 2002 was

280,000 and the network's length was 9,640 kilometers, according to the Annual Report of the Riyadh Region Water and Sewage Authority (RRWSA, 2002: p.21).

Regarding sanitation services in Riyadh City, sewage disposal connections to the municipal network in March 2002 covered 48% of the surface of the City (RRWSA, 2002: p.50). It served 159,000 households, out of total domestic water connections of 280,000 households, or 57% of the households that have water connections (159,000 sewage connections/ 280,000 water connections), or 37% of the population [57%* (3.081 millions/ 4.73 millions, Table 1)]. Wastewater treatment facilities processed 154 million m3 out of 406 million m3 of the domestic water supplied by RRWSA, or 38% (154 million m3/ 406 million m3). 56 million m3 of the treated wastewater were reused for agricultural and industrial purposes. The Riyadh sewage network measured 2,322 kilometers. Table 2 summarizes.

Table 2 Riyadh city's potable water and sewage networks as of March 2002

	No. of connections	Volume (000 m3)	Network's length (km)
Household water supply (a)	280,000	406	9,640
Sewage collection (b)	159,000	154	2,322
(b) / (a)	57%	38%	24%

Source: RRWSA, 2002: pp.21& 50.

As for wastewater treatment in the country, it is estimated that 1.3 million m3 per day, or 475 million m3 per annum (1.3 million m3* 365 days) of wastewater is treated. This represents 25% of overall water use [(475 million m3/ 1.9 billion m3 (Section 3). One third of the treated water is treated to the third degree, or 158 million m3 per annum (475 million m3/ 3). The treated wastewater is re-used in irrigation (Altukhais, 2002: p.4). In the whole of Saudi Arabia, "only a third of all Saudi households are hooked up to sewage treatment plants. Sewage from the rest is pumped into lagoons, where it is left to evaporate or leach into the ground. As a result, the ground water below several of the country's biggest cities is polluted. The New York Times (January 26, 2003)."

Additionally, the country's main cities, including the capital Riyadh, have no drainage systems. A heavy rainfall makes some major roads un-passable and turns many road intersections into small lakes for days.

2. Why was there insufficient investment in water and sanitation services in Saudi Arabia?

The inadequacy of Saudi Arabia's water and sanitation coverage is rather surprising, especially in view of the huge revenues that the country earned during the past three decades from crude oil exports. Between 1974 and 2001, Saudi oil revenues totaled SR3,710 billions, or US$1,034 billions (SAMA, 2002: p.388). The majority- at least 63%- however, was spent on the military, on desert irrigation and maintenance of the ruling family. This left insufficient resources for water and sanitation services.

Defense and security budgets between 1981 and 2002 totaled US$390 billions, or an average of 33.5% of total government budgets for the period (SAMA, 2002: pp.385-387). Furthermore, according to the Saudi Minister of the Interior (Arab News Newspaper, Riyadh, September 27, 2002), the 1991 Gulf War had cost Saudi Arabia US$80 billion. Between 1981 and 2002, defense and security spending totaled US$470 billions (US$390 billions + US$80 billions). This excludes military spending between 1974 and 1981 for unavailability of data. Saudi government's desert irrigation schemes started in earnest in the early 1980s. The venture has been a classic case of unsustainable development. Its cost has been staggering in financial and water terms. Between 1984 and 2000, the former may be estimated at US$84 billions,[1] the later at 300 billion m3, mostly from non-renewable aquifers, equivalent to about 6 years of the Nile River's flow into Egypt. Finally, the cost of sustaining the ruling family over the past three decades or so, could add up to US$100 billions, possibly more.

[1] This excludes: a) energy subsidies, b) the value of concessionary loan terms on US$8.7 billions, c) the value of government land given away under the 1968 Regulation for Fallow Land distribution and d) the cost of abandoning 476,000 hectares, or 30% of the country's irrigated surface since 1994 due to government's change in policy on subsidies.

The total of these three items would be US$654 billions, or 63% of the country's oil revenues between 1974 and 2001 (US$654 billions/ US$1,034 billions). The amount becomes greater when other cost elements were accounted for, such as the "US$50 billions… that corrupt Saudis may have siphoned off from the US$ 400 billion spent on development."[2] Consequently, the remainder of government revenues was insufficient to provide all residents with comprehensive water and sanitation facilities. These had to compete with allocations to education, health, roads, harbors, telecommunications, etc…

High population growth rates quickly increased the demand for WSS facilities. Rapid urbanization exacerbated the limited coverage of the services. Between 1974 and 2001, while the population increased by 304% (21 millions in 2001/ 6.9 millions in 1974, FAO Statistical Database), the urban population increased by 462% (18 millions in 2001/ 3.9 millions in 1974). In 1974, the ratio of urban dwellers to the total population was 56.6% (3.9 millions/ 6.9 millions). In 2000, it jumped to 86% (18 millions/ 21 millions). In 1974, Riyadh had some 250,000 people. By 2001, it became over 2 millions.[3]

3. Domestic water supply sources

The Vice Minister of the Ministry of Agriculture and Water (MAW) put the daily per capita domestic water use at 250 liters (Altukhais, 2002: p.13), or 91 m3 per annum, or about 1.9 billion m3 for the country (91 m3* 21 millions in population in 2000). A. Bushnak (2001: p.257) put the estimate at 1.8 billion m3. The two estimates appear to be rather on the high side. It may be argued that the volume is closer to 1.5 billion m3 per annum.[4] Nonetheless, MAW's figure will be followed in this study.

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[2] Stated by the Saudi Ambassador to the USA to Business Week Magazine (October 29, 2001, p.34).

[3] Until the mid 1970s, Riyadh was the political capital. Jeddah was the diplomatic and commercial center, where the Ministry of Foreign Affairs, foreign embassies, SAMA and the head offices of Saudi banks were located. By the early 1980s, they moved to Riyadh (except the head office of National Commercial Bank).

[4] Given that the volume of water supplied from municipal sources during the 2000 fiscal year was 982 million m3 (SSY, 2001: p.356), then the 10.945-million population [20,847 millions – 9.902 millions (Table 1)] that had no municipal connections would have received 918 million m3 (1.9 billion m3 per MAW's estimate – 982 million m3), or a per capita of 84 m3 (918 million m3/ 10.945 million residents). Such level is rather excessive for non-connected users relative to the 99 m3 (982 million m3/ 9.902 million residents) for those with municipal connections. The inconvenience and high expense of water from non-municipal connections, plus the fact that such recipients would typically be among the less affluent

In 2002, there were 24 desalination plants on the Red Sea Coast with a total daily rated capacity of 1.4 million m3. Also, there were 6 plants on the Gulf Coast with a total daily rated capacity of 1.5 million m3. The aggregate daily rated capacity of the 30 plants at present is 2.9 million m3 (Altukhais, 2002: table 1), or 1.06 billion m3 per annum. During 2001, 814 million m3 of desalinated water were produced [Saudi Statistical Yearbook (SSY), 2001: p.355].[5] The remainder, about 1.1 billion m3 (1.9 billions– 814 millions) were supplied mainly from groundwater sources. Of the 30 plants, 12 are of the dual-purpose multi-stage flash distillation type. In 2002, their generating capacity was 3,426 MW (Balghunaim, 2000). They contribute about 20% of the total national electricity production (Abdrrahman, 2001: p.247).

A network of pipelines 4,160 kilometers long and storage reservoirs with capacity of 9.1 million m3 distribute the water from desalination plants to major inland urban centers (Balghunaim, 2000). Riyadh City and the Qaseem Region, both in the Najd plateau, receive their water from the Jubail desalination plant on the Gulf Coast (Table 4). Two pipelines, with total capacity of 830,000 m3 per day (303 million m3 per annum), cross the rising terrain of the desert Southeast from Jubail to Riyadh, 450 kilometers away. The Najd Plateau gradually rises to 800 meters above sea level as it moves westward from the Gulf Coast to the Qaseem Region. From Riyadh another pipeline transmits the water Northwest to Buraida, some 350 kilometres away, with subsidiary pipelines connecting local towns and villages of the Najd Plateau.

Medina is supplied from the Yanbu plant on the Red Sea, about 150 kilometers away. A pipeline from another plant on the Red Sea, Shuaiba supplies Mecca, about 100 kilometer away and then the mountainous Taif (88 kilometers from Mecca). Abha and Khamis Mushait are supplied from the Shuqaiq plant on the Red Sea. Coastal cities on the Gulf (Alkhobar, Dammam, Dhahran and Khafji) and cities and towns on the Red Sea

suggests that the difference between the two groups ought to be greater than the 14% suggested by MAW (85 m3/ 99 m3). At a more reasonable 50 m3, Saudi domestic water use ought to be around 1.5 billion m3 (982 million m3 + (10.945 million residents* 50 m3)].

(Jeddah and small towns like Haql, Duba, Alwajh, Umlajj, Rabigh, Azizia, Albirk, and Farasan Island) are supplied from local desalination plants.

According to data from the Saudi Statistical Yearbook (2001: pp.355, 356), the contribution of desalinated water to total domestic water used by subscribers connected to municipal water networks in Saudi Arabia's 10 largest urban centers[6] remained almost constant between 1990 and 2000. During this period, the ratio moved from 85% in 1990 (653 million m3 in desalinated water/ 771 million m3 in total household water use) to 83% in 2000 (814 million m3 in desalinated water/ 982 million m3 in total domestic water use). During the same period, however, the per-subscriber water use in the same cities dropped from 1,694 m3 in 1990 (771 billion m3/ 455,455 subscribers) to 1,391 m3 in 2000 (982 million m3/ 706,069 subscribers), or a drop of about 18% [(1,391 m3/ 1,694 m3) – 1]. This may be due to conservation efforts and/or to the growth rate in subscribers being greater than the growth rate in water use.

Measured in terms of Saudi total population, per capita desalinated water production declined from 42.4 m3 in 1990 (653 million m3/ 15.4 millions in total population), to 38.8 m3 in 2000 (814 million m3/ 21 millions in total population). The drop was 8.5% [(38.8 m3/ 42.4 m3) – 1]. Said differently, while the population increased by 36% (21 millions/ 15.4 millions), desalinated water production increased by 25% (814 million m3/ 653 million m3).

In some cities like Jeddah, Mecca, Medina, Abha and Taif desalinated water provides about 90% of domestic water needs (Altukhais, 2002: p.4). In 2001/2002, Riyadh's total water use was 406 million m3. Of this volume, 261 million m3, or about 65%, was supplied from the Jubail desalination plant. The remaining 145 million m3, or 35%, were supplied from 141 wells in 4 fields in the capital city (of which 118 wells are deep), processed through 7 water stations (RRWSA, 2002: P.20).

[5] During 2002, the production capacity of three plants was increased by 709,891 m3 per day (390,909 m3 at Shuaiba II + 78,182 m3 at Jubail II + 240,800 m3 at Alkhobar III), or 259 million m3 per annum.

4. Cost comparison between desalinated water and groundwater

The Saudi newspaper Arab News, reported on July 8, 2001 the signing of a contract to boost water supply in Riyadh. The contract, over a period of 3 years provides for the installation of pumps in 65 tube wells north of Riyadh along with a water tank of 50,000 m3 capacity, a main pumping station, three substations and a pipeline. The production capacity of the wells is planned at 300,000 m3 per day, or about 110 million m3 per annum. The cost was SR744 millions, or US$198 millions (SR744/ R3.75).

In order to evaluate the financial competitiveness of the New Riyadh Project, its economic cost of water production should be estimated. This cost will then be compared with: 1) the economic cost of producing a cubic meter of desalinated water from building a new plant instead of the new wells scheme, plus the economic cost of transmitting the water via pipeline to Riyadh from the Gulf Coast and, 2) the average economic cost of production of one cubic meter of desalinated water from the Saudi 30 existing plants.

4.A. The economic cost of water supplied from the New Riyadh Project

The accounting cost of one cubic meter of domestic water from the New Riyadh wells Project may be estimated at some US$0.36. This assumes an annual depreciation rate of 5% and operating expenses of 15% of capital investment.[7] When an assumed 10%

[6] Riyadh, Jeddah, Medina, Yanbu, Mecca, Taif, Dammam, Al Khobar, Aseer and Qaseem.

[7] US$198 millions* 5% in depreciation charges (assuming 20 years blended useful life and straight line depreciation policy)= US$10 millions. US$198 million* 15% of capital investment in guesstimated annual operating expenses= US$ 30 millions. The annual total becomes US$40 millions and the cubic meter cost US$0.36 (US$40 millions/ 110 million m3.

per annum opportunity cost of capital, or US$0.18,[8] is added the economic cost of the new water becomes about US$ 0.54 per m3.[9]

The costing is sensitive to changes in rate assumptions. At an annual depreciation rate of, for example, 4% (instead of 5%) and operating expenses of 12% (instead of 15%), the accounting cost becomes US$0.29 per m3 (instead of US$0.36).[10] Similarly, an opportunity cost of capital of 8% (instead of 10%) would add US$0.15 per m3 (instead of US$0.18),[11] for a total water cost of US$0.44 per m3 (instead of US$0.54 per m3).

4.B. The economic cost of water produced in recently built desalination plants

Recently constructed desalination plants are more efficient than those built in the late 1970s/early 1980s. In September 2001, the United Arab Emirates (Fujairah Emirate) contracted to pay 100 million Euros, or about US$100 millions at the US$/Euro exchange rate then prevailing (US$87 millions at the end of May 2003 exchange rate of US$1.15 to Euro1) for the world's largest reverse osmosis seawater desalination plant. The capacity of the new plant is 170,000 m3 per day, or 62 million m3 annually (Ondeo press release dated September 11, 2001). The accounting cost of producing one cubic meter of

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[8] (US$198* 10% in assumed opportunity cost of capital = US$20 millions)/ 110 million m3 = US$0.18 per m3 + US$0.36 per m3 in depreciation, operating and maintenance charges= US$0.54.

[9] The annual rates applied to opportunity cost of capital, depreciation charges and operating expenses are intended for illustrative purpose only. Actual depreciation rates of the Riyadh new facility after completion could very well be different from those assumed here. Other identical plants to this facility might apply different depreciation rates. This is because accounting evaluations are often subjective. Such differences should not compromise the integrity of our analysis, however. The objective here is merely to create an appreciation of the relative magnitudes of the costing or pricing issues involved. For example, the overall blended depreciation rate of an industrial plant is a function of the different types of assets that comprise the plant. In the absence of a detailed breakdown of the types of machinery, equipment and other items in the Riyadh project, assumptions are made to guesstimate a blended rate for annual depreciation charges. While pipelines might have a useful life of say, 30-40 years, storage tanks 40-50 years, pumps 10-15 years, computers have useful life of 1-3 years. The Riyadh project is assumed here to have a blended useful life of 20 years applied on a straight-line basis, or 5% of the investment annually.

[10] [(US$198 millions* 4%= about US$8 millions) + (US$198 millions* 12% = about US$24 millions) for a total of US$32 millions (US$8 millions + US$24 millions), or US$0.29 per m3 (US$32 millions/ 110 million m3)].

[11] [(US$198 millions* 8%= US$16 millions)/ 110 million m3= US$0.15 per m3]. The total becomes US$0.44 per m3 (US$0.29 + US$0.15).

desalinated water from such a plant could be estimated at about US$0.35 per m3.[12] To this, the opportunity cost of capital should be added. It is estimated at some US$10 millions per annum (US$100 millions* 10% in assumed annual opportunity cost of capital), or about US$0.17 per m3 (US$10 millions/ 62 million m3). The economic cost of desalinated water could then be estimated at about US$0.52 per m3 (US$0.35 + US$0.17).

Like the cost estimate of the new Riyadh water project, the cost of desalinated water from the Fujairah Plant is sensitive to changes in rate assumptions. At a 20-year useful life (instead of 15 years), 20% operating expenses (instead of 15%) and 12% opportunity cost of capital (instead of 10%) the estimated cost of desalinated water becomes US$0.6 per m3 (instead of US$0.52).[13]

To this, the cost of pipeline transmission of the desalinated water from the Gulf Coast to Riyadh, 450 kilometers away, needs to be added. It may be assumed here that this cost is generally equivalent to the US$1.32 per m3 in average water transmission cost throughout the 4,160-kilometer of the Saudi water pipeline network, to be discussed in Section (4.C.2). As such, the all-in cost of a new desalination option as delivered to the gates of Riyadh would be about US$1.84 per m3 (US$1.32 + US$0.52).

4.C. The economic cost of desalinated water from the 30 existing Saudi plants

F. A. Balghunaim (2000), Governor, Saline Water Conversion Corporation of Saudi Arabia stated that in 1998, the cubic meter cost of desalinated water produced by Saudi small sea desalination plants ranged between US$2.83 and US$5.89. The weighted average cost of production from these plants was US$3.82 per m3. The weighted average

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[12] Depreciation charges of about US$7 millions per annum, assuming 15 years in blended useful life, a somewhat shorter period than that of the life of the equipment involved in the Riyadh scheme, given the more extensive mechanical parts in a desalination plant (US$100millions/ 15 years= US$6.66 millions)+ US$15 millions in annual operating and maintenance expenses, assuming 15% of the capital invested (US$100 millions* 15%)= US$22 millions, or US$0.35 per m3 (US$22 millions/ 62 million m3).

[13] [(US$100 millions/ 20 years= US$5 millions)+ (US$100 millions* 20%= US$20 millions)+ (US$100* 12% = US$12 millions). The total becomes US$37 millions, or US$0.6 per m3 (US$37 millions/ 62 million m3)].

cost of the large plants in the same year was US$0.63 per m3. The weighted average cost of all Saudi desalinated water was US$0.67 per m3.

Table 3 Desalinated water production cost in 1998 (US$ per 1 m3)*

	Minimum	Maximum	Weighted average
Small plants	2.83	5.89	3.82
Medium and large plants**	0.42	1.68	0.63
Overall average			0.67

Source: Balghunaim, F. A. (2000).
* Cost figures cover operations, maintenance, administrative and depreciation charges.
** The small plants account for 1.15% of total water export capacity. They were built in the late 1970s and mid 1980s to supply domestic water to mainly small towns of the Red Sea on the West Coast.

The data in Table 3 reflect accounting cost estimates, not economic costs. They excludes two cost elements: 1) opportunity cost of the capital involved in the 30 desalination plants. 2) Cost of pipeline transmission. In order to make a proper comparison, these two cost factors need to be quantified and added to the cost of production of existing desalination plants.

4.C.1. An estimate of the amount of opportunity cost of the capital invested in Saudi Arabia's 30 desalination plants

In 1998, the accounting cost of production of desalinated water in Saudi Arabia may be estimated at US$508 millions [US$0.67 per m3 (Table 3)* 758 million m3 in desalinated water produced (SSY, 2001: p.355)]. Of this amount, according to Balghunaim (2000), 37.3%, or about US$190 millions, represented capital cost; i.e. depreciation. The remaining 62.7%, or US$318 millions represented, labor (22.1%), maintenance (6%), chemicals (2.1%) and, energy costs (32.5%).[14] Assuming: 1) a 15-year blended useful life for the various types of equipment in the plants and, 2) a straight-line depreciation policy, capital investment in the country's 30 desalination plants would be about US$2.9 billions (US$190 millions* 15 years). At 10% per annum, the 1998 opportunity cost of capital would be about US$290 millions, or US$0.38 per m3 (US$290 millions/ 758 million m3). When added to the accounting cost of desalinated water produced the economic cost becomes US$1.05 per m3 [US$0.67 in production cost (Table 5.3) + US$0.38 in opportunity cost of capital].

4.C.2. A cost estimate of pipeline transmission to urban centres

The figures in Table 3 represent the cost of desalinated water production at the plant level. They do not include the cost of pipeline transmission. The Saudi pipeline network measures about 4,160 kilometres. It includes 9.1 million m3 of storage reservoirs. Assuming an average investment of US$1 million per kilometre for the pipeline, reservoirs and the pumping stations, the investment could add up to about US$4 billions. The annual operations and maintenance cost of such an investment may be estimated at about US$ 960 millions per annum.[15] Any change in the assumptions that make up this estimate (such as the cost of pipeline construction) will change the annual cost of operating the pipeline network correspondingly.

From the above, the aggregate of the three cost elements- opportunity cost of capital plus depreciation charges and operating expenses- as a percentage of capital investment, ranges from 24% for pipeline networks (US$960 millions/ US$4 billions) to 30% for the Riyadh new water project (US$60 millions/ US$198 millions) and to 32%

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[14] T. Dabbagh (2001: p.7) states that, "the cost of energy represents nearly 70% of the total cost of the desalinated water when the oil prices are in the region of US$24 per barrel and above. This ratio drops to 30-35% when the price of oil drops to about US$10 per barrel."

[15] US$4 billions* 10% in assumed opportunity cost of capital= US$400 millions+ US$160 millions in depreciation, assuming 25 years blended useful life of the pipeline, pumping stations and other equipment (US$4 billions/ 25 years)+ US$400 millions in operating and maintenance expenses at an assumed 10% of the invested capital (US$4 billions* 10%)= US$960 millions.

(US$32 millions/ US$100 millions) for the Fujairah desalination plant. They are sensitive to the rate assumptions.

To estimate the cubic meter cost of pipeline transmission the volume of water delivered through the pipeline network needs to be determined. As outlined in section 3 above, the majority of the 4,160 kilometres of the Saudi inter-city water pipelines network was built to deliver desalinated water to Riyadh city and the towns of the Qaseem region.[16] Cities and towns not too far from the Red Sea like Medina, Mecca, Taif, Abha and Khamis Mushait utilize the Saudi pipeline network less extensively. Urban centres on or near the Gulf Coast and the Red Sea utilize no part of the network. The following table shows an estimate of the volume of water that could be transmitted through the water pipeline network to inland cities and towns.

Table 4 Estimate of the volume of desalinated water transmitted through the Saudi water pipeline network to inland urban centres

City	Plant	Daily capacity (M3)	Annual capacity (million M3)*
Riyadh / Qaseem	Jubail – Phase I	118,447	43.23
	Phase II	815,185	297.54
	Jubail R/O	78,182	28.54
	Total Jubail plants	1,011,814	369.31
Medina	Yanbu – Phase I	94,625	34.54
	Phase II	120,096	43.84
	Yanbu R/O	106,904	39.02
	Total Yanbu plants	321,625	117.4
Mecca / Taif	Shuaiba – Phase I	191,780	70
	Phase II	390,909	142.68
	Total Shuaiba plant	582,689	212.68
Abha / Khais Mushait	Shuqaiq plant	83,432	30.45
Inland cities	Total 9 plants	1,999,560	729.84

Source: Balghunaim, F. A. (2000).
* Daily capacity* 365 days.

The cost of pipeline transmission may be estimated at about US$1.32 per m3 (US$960 million/ 729.84 million m3). The estimate represents the minimum cost involved because the annual actual water production is typically less than the rated capacity of the plants. The grand total of desalinated water cost becomes US$2.37 per m3 (US$1.05 in production and opportunity costs + US$1.32 in pipeline transmission cost), or SR8.89 per m3 (US$2.37* SR3.75).

To arrive at a correct approach to estimating the cost of water production from Saudi Arabia's 30 existing desalination plants, the imputed value of the electricity produced in the 12 multi-stage flash distillation plants (MSF) needs to be deducted. These plants have a total electricity export capacity of 3,426 MW. Total electricity generated during 2000/2001 was 28 million MWh (SSY, 2001: p.354). This represents about 25% of the 113 million MWh (SSY, 2001: P.352) in electricity consumption throughout the country during the same year (28 million MWh/ 113 million MWh). Due to the unavailability of data this factor will not be quantified here.

The table below summarizes the accounting and economic costs of water production under the three above mentioned alternative sources.

Table 5 Costs comparison among three water alternative sources (all in US$ per m3)

	Accounting cost	Opportunity cost of capital	Economic cost	Pipeline transmission cost	Grand total
Riyadh's New wells Project	0.36	0.18	0.54	Included in accounting cost	0.54
Sharjah's new desalination plant	0.35	0.17	0.52	1.32	1.84
Average 30 desalination plants (1998)	0.67	0.38	1.05	1.32	2.37 less the value of electricity generated

Table 5 suggests that the present cost of desalinated water from the most recent plants on the Gulf Coast is rather competitive at the plant level with the cost of water from wells north of Riyadh (inclusive of the cost of pipelines for water harvesting and

[16] Such as Shagra, Alghat, Buraida, Zulfi, Majmaah, Hotat sidair, Alhisi etc…

transmission). However, the cost of pipeline delivery renders the desalination alternative too expensive for Riyadh and Qaseem, as well as for other inland cities and towns. At US$1.32 per m3, the overall average of pipeline transmission cost is about 126% the average production cost of the country's all desalinated water (US$1.32/ US$1.05).

This analysis suggests that, to be efficient, Saudi domestic water requirements ought to be sourced from locations that would minimize the length of pipeline transmission. This, however, is dependant on the availability of sufficient high quality groundwater reserves in the general vicinity of inland population centers.

5. Is there sufficient groundwater near major Saudi urban centers?

The answer in many cases is yes. Many Saudi urban centers are surrounded by farmlands at present. They are irrigated from groundwater sources, mainly non-renewable. The great majority of Saudi Arabia receives irregular and scant rainwater, save for low to modest rainfall over a relatively small hilly region in the Southwest close to the Red Sea.

Considering that: 1) the average volume of water used in irrigation during 1999 in Saudi Arabia was 14,930 m3 per hectare,[17] and that, 2) the average Saudi domestic water consumption is 91 m3 per annum (MAW estimate), then the water used to irrigate one hectare of agricultural land could satisfy the annual domestic water needs of about 164 persons (14,930 m3/ 91 m3). As such, 1,000 hectares could supply the domestic water needs of a town of 164,000 people and 10,000 hectares could satisfy a city of 1.64 million inhabitants. If a portion of the water used for irrigation were diverted to supply Saudi cities, the need for expensive desalinated water, at least for inland urban centers that have local water sources, would correspondingly be reduced. Table 6 shows Saudi

[17] The volume of Groundwater extracted for irrigation during 1999 was estimated at 18.303 billion m3 (preliminary estimate of Ministry of Agriculture and Water (MAW), as presented by A. S. Altukhais, Vice Minister, 2002: tables 4, 5 and 6). Total cultivated land in 1999 was 1.226 million hectares (SSY, 2001: p.511). The average per hectare water use in 1999 may thus be estimated at 14,930 m3 per hectare (18.303 billion m3/ 1.226 million hectares).

domestic water requirements of major urban centers in comparison with agricultural water use in the same areas.

Table 6 Comparison between estimates of household water needs and agricultural water use in Saudi Arabia in 2000, assuming uniform per capita water needs and per hectare water use throughout the country

Administrative area	Population (millions)*	Estimated household water needs (million m3) (a)	Irrigated land* (000 hectares)	Estimated agricultural water use (million m3) (b)	Column(a) / column(b)
Riyadh**	4.7	428	256	3,822	11.2%
Mecca/Jeddah**	5.5	501	53	791	63.3
Jazan	1.1	100	157	2,344	4.3
Eastern area**	3	273	96	1,433	19.1
Asir	1.6	146	38	567	25.7
Qaseem**	1	91	229	3,418	2.66
Hail	0.5	46	117	1,747	2.63
Medina**	1.4	128	28	418	30.6
Baha	0.5	46	6	90	50.5
Northern area	0.25	23	-	-	-
Tabuk	0.6	55	55	821	6.7
Najran	0.4	37	15	224	16.5
Aljowf	0.4	37	69	1,030	3.6
Total	21	1,911	1,119	16,706	11.4

Source: * Saudi Statistical Yearbook, 2001: p.66 (population) and p.511 (irrigated land).
** Supplied with desalinated water.
(a) Assuming 91 m3 per capita water needs annually, according to MAW data.
(b) Assuming a per hectare water use of 14,930 m3.

The above table shows that while Saudi agricultural water consumption was 16.7 billion m3 in 2001, domestic water use was estimated at 1.9 billion m3, or 11.4% of the water used in irrigation (1.9 million m3/ 16.7 million m3).

Except for the sparsely populated Northern Region,[18] most Saudi areas have sufficient groundwater to meet their domestic needs. The sufficiency ratio, however, varies. In the Riyadh Region, the domestic water requirement of its 4.7-million inhabitants is only 11.2% of the water used in irrigation. In the Qaseem Region, the ratio is even less, only 2.66%. Nonetheless, in spite of groundwater abundance in the two areas, expensive desalinated water supplies the bulk of their household needs. 35% of the Saudi desalinated water capacity is dedicated to these two areas [369.31 million m3 in 2002 (table 5.4)/ 1,060 million m3 in total production capacity (section 3)]. In the Medina area, 30.6% of the water used in irrigation could satisfy its 1.4 million inhabitants. In the Mecca/Jeddah region, farming is modest. Almost two thirds of the irrigation water is needed to satisfy their 5.5 million in residents.

6. Saudi water politics

Investment in desert agriculture is unsustainable. Between the early 1980s and 2000, the water cost of Saudi desert irrigation was 300 billion m3 of water, mostly from non-renewable groundwater sources [Ministry of agriculture and Water data as presented by its Vice Minister, A.S. Altukhais (2002: table 6)]. In terms of financial cost, it produced foodstuffs that could have been imported for less than one half of cost of production. That this policy was pursued in order to achieve food security is a good national slogan, but unrealistic. Reliance on desalination plants for drinking and household water exposes Saudi security to a much greater risk; namely, spare parts boycott by the countries that manufacture the plants.

Given the inefficiency of agricultural production in desert environments, it is anomalous to deplete mainly non-renewable groundwater reserves in the Riyadh and Qaseem Regions so that farms in the forbiddingly arid and hot Najd plateau are irrigated, while desalinated water for household use is piped from hundreds of kilometers away. 65% of the new irrigated land developed under the country's wheat security drive is

[18] Composed of nomadic and small Bedouin villages and hamlets scattered over a large arid area. Their water supply is basically from oasis and wells.

located in the Riyadh and Qaseem Region.[19] 35% of the Saudi desalination capacity and the major part of the pipeline network are dedicated to this groundwater-rich area. How and why did this situation evolve?

The process allocating resources and investment in relation to water in Saudi Arabia is similar to the process of national decision-making as a whole. Saudi Arabia's governance is absolute monarchy. It is basically non-representative and non-participatory. Groupings of major trading families, religious and tribal leaders and the military support the status quo in return for benefits. Foreign manufacturers of desalination plants, irrigation systems, pumps, pipelines, earth-moving equipment etc… associate closely with the power elites. Non-economic and environmentally unsound schemes like food self-sufficiency are packaged attractively with slogans that evoke national sentiment. In the absence of a free press, environmental groups and other ethicist egalitarian non-governmental organizations find it difficult to introduce into water policy a balancing economic or environmental perspective. Consequently, there has been no effective voice saying that desert agriculture was a seriously negative economic and environmental option. Once the high-water-using irrigation schemes were in place, domestic water supply requirements had to be addressed via desalination and pipeline technologies. This outcome benefited not only the new farming entrepreneurs but also the desalination equipment and pipeline suppliers along with their local sponsors. [20]

It was the narrowness of the decision-makers coalition, the absence of an environmental voice and the absence of scientific economic evaluation that made it possible to evolve the unsustainable water policies of the 1980s and 1990s. The Saudi experience is an extreme case of politically determined ecological policies- namely

[19] Between 1973 and 2000 the cultivated area increased from 373,000 hectares (FAO Statistical Database) to 1.12 million hectares (SSY, 2001: p.511), or by 747,000 hectares. In 2000, the cultivated area in the Riyadh and Qaseem region, all irrigated from groundwater sources, was 485,242 hectares, or 65% of the new irrigated area since Saudi Arabia embarked on its food independence scheme.

[20] "Corrupt Saudis may have siphoned off…US$50 billions from the US$ 400 billion spent on development," stated the Saudi Ambassador to the USA to Business Week Magazine (October 29, 2001: p. 34).

groundwater use in an oil economy. The oil economy and the nature of the Saudi political system provided the decision-making context. All the negative tendencies of a poorly informed elite enjoying rentier economic circumstances are in evidence- denial (Allan, 2003), the pursuit of fantasy projects (Allan, 1983).

At the risk of being prescriptive, future growth in Saudi cities' demand for household water ought to be sourced from the water currently used to grow alfalfa, fruits, meat and wheat, of which a proportion of which is even exported to neighboring states.[21] These commodities are water intensive, especially in desert environment. They are virtual water. Importing them from the international market is much less expensive than growing them at home.

Since the cost of pipeline water delivery represents the major component of Saudi water cost, three population centers in; namely, Riyadh, the towns of the Qaseem Region and to a lesser extent, Medina (Table 5) ought to source their future growth in household water requirements from nearby groundwater reserves. This assumes that new desalinated water transmission would require the construction of a new pipeline.

Future decisions to divert water from irrigation to domestic use depend on two factors. The first is the cost of harvesting and transporting the water from the groundwater locations to the specific urban center. The second factor is the compensation that would be paid to farm owners in return for giving up their wells and farms. This assumes that access to groundwater will be made through existing wells on established farms. The government, however, might choose to establish new wells on public land at no acquisition cost. Such action might infringe on the available water to existing farms. If the total of the two factors makes the cost of the diverted water less than the cost of production and delivery of desalinated water, then the diversion would be preferable. As the New Riyadh Project shows, the cost of harvesting and transporting the water to the

[21] It may be shown that between 1997 and 2001 Saudi exports of animals and animal products plus agricultural products consumed about 2.5 billion m3 of water annually, or some 12.5 billion m3 for the period. If the water embedded in alfalfa exports, until it was stopped in 2000, were added the water lost to agricultural exports could possibly double.

gates of inland population centers represents a small proportion of the cost of the desalination alternative plus pipeline transmission from the Gulf Coast.

In the aftermath of Saudi Arabia's sudden policy reversal on cereal production starting in 1993,[22] hundreds of water wells have been abandoned throughout the country. These may be used to supply water to the towns and villages nearby. Given the efficiency of modern desalination plants, coastal cities and towns, where no pipelines and associated equipment is needed, could be supplied competitively from desalination plants.

Sourcing household water from aquifers in the Riyadh and Qaseem areas, instead of transmitting desalinated water from the Jubail plant could have saved the Saudi government considerable amounts of money since 1982, when the Jubail plant was commissioned, in terms of pipeline investment and transmission expenses.[23]

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[22] In 1992, Saudi wheat production reached an all time high of 4.1 million tonnes. In 1993, it dropped to 3.4 million tonnes, in 1994 to 2.6 million tonnes and in 1995 to 1.6 million tonnes. In 2000, it stood at 1.8 million tonnes. Barley production reached an all time high of 2 million tonnes in 1994. It dropped to 0.8 million tonnes one year later. In 2000, it stood at 0.1 million tonnes (data from FAO Statistical Database, Saudi Ministry of Planning (2003), Saudi Statistical Yearbook (2002) and Saudi Ministry of Agriculture and Water as outlined by its Vice Minister, A. S. Altukhais (2002).

[23] For the 20 years since 1982, this may be estimated at US$2.4 billions for every one million in the average number of inhabitants in the areas involved in pipeline water deliveries during the period (US$1.32 transmission cost per m3* 91 m3 per person per annum* 1 million persons * 20 years).

References

Allan, Tony, 2003, *Water in the environment/socio-economic development discourse: sustainability, changing management paradigms and policy responses in a global context.* Paper given at a conference on Resource Politics and Security in a Global Age at the Political Economy Research Centre, University of Sheffield, 26-27, June 2003.

--------------, 1983, *Natural Resources as National Fantasies,* Geoforum. PP 243 – 247.

Altakhis, Ali bin Saad, Vice Minister, Ministry of Agriculture and Water affairs of Saudi Arabia. *The future of Water Resources in the Kingdom of Saudi Arabia,"* a paper presented at a conference organized by the Ministry of Planning in Riyadh (October 19 – October 23, 2002) entitled "Future Vision for the Saudi Economy 2020."

Abdrrahman, W, "Energy and Water in Arid developing countries, Saudi Arabia, a case study" in *Water Resources Development,* Vol. 17, No. 2, 2001.

Arab News Newspaper, July 8, 2001. *SR744 millions Contract Signed to Boost Riyadh Water Supply.*

Balghunaim, F. A., Governor, Saline Water Conversion Corporation, Saudi Arabia. Slide presentation at a conference entitled *Meeting the Water Demands for the Kingdom of Saudi Arabia. Major Investment Opportunities in the 21st Century,* November 13-15, 2000.

Bushnak, A. “Investment Needs and Privatisation of Water Services in Saudi Arabia” in *Water Resources Development*, Vol. 17, No. 2, 2001.

Dabbagh, T. Presentation of a paper entitled *Assessing Future Potable Water Demand and Cost in Saudi Arabia* at a conference on investing in Saudi Arabia organized by MEED Magazine, London, 6th to 7th November 2001.

Ministry of Planning, Kingdom of Saudi Arabia, *Statistical Yearbook,* Thirty Seventh Issue, 2001.

______________________________________, *Achievement of the Development Plans, Facts and Figures*. Nineteenth Issue 1970 – 2001, Published in 2003.

Riyadh Region Water and Sewage Authority, Annual Report, 2001/2002.

Saudi Arabian Monetary Agency, Annual Reports, Riyadh, Saudi Arabia.

The New York Times, January 26, 2003. *Saudis Worry as They Waste Their Scarce Water,* by Graig Smith.

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