Potential for Water Savings & Reuse in the Arab Region

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Abstract

Water resources scarcity, accessibility, and environmental degradation are the major challenges facing most of the Arab countries.

The current population of about 284 million in the Arab Region is expected to reach 472 million people by year 2025. This poses great stresses on satisfying water demand for irrigation, domestic, and industrial uses. In the Arab Region, the average annual per capita water share of renewable water resources is expected to decrease 65% by year 2025.

Currently, in the Arab region, there are about 54 million people with no access to safe drinking water, and about 79 million people with no access to proper sanitation. To achieve the Millennium Development Goals on water in the Arab region by year 2015, it is required to provide safe drinking access to about 83 million people and to provide proper sanitation to about 96 million people, which will need investments of about 17.5 billion Euros.

Realizing the scarcity of water and the inaccessibility to water services in many parts of the Arab region, in addition to the large amount of investments needed in the water sector, water savings and reuse will play a very important role in development in the Arab region. This paper presents water savings methods in the different water sectors. The paper estimates the current annual potential for water savings in the Arab region at 20 Billion Cubic Meters (BCM) per year in the irrigation, domestic, and industrial sectors. The paper also estimates the potential for wastewater reuse and recycling of domestic and industrial water in the Arab region at 12 BCM/year, which is considered an alternative non-conventional water resource that will indirectly contribute to water savings.

The paper also gives assessments of expected future water savings that could be realized if water savings measures are put in place, and it gives estimates of the associated costs for implementing most of these water savings measures.

Introduction

The Arab region belongs to the most arid regions of the world characterized by water resources scarcity and unevenly distributed water resources. The renewable water resources as of year 2000 varies from less than 100 m^3/capita/year as in Jordan, Kuwait, and Qatar to about 2500 m^3/capita/year in Sudan, Iraq and Mauritania.

Moreover, even if enough water is available, in most cases there is an accessibility problem to irrigation and drinking water supply due to lack of funds for investment in the water sector in most of the Arab countries.

Since availability and accessibility to water resources play considerable roles in the socio-economic development, it is of utmost importance to the Arab region to put sound savings

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plans and measures.

Water Savings programmes are implemented in many countries not only because water may be scarce in these countries but also to meet the increasing demand on food and water and the escalating need for the environmental protection of natural ecosystems. To do more with less water is one of the essential steps towards development in all sectors, such as agricultural, industrial, and municipal. In countries where renewable water resources are limited and almost all available renewable water resources are used every year, a shift in water use practices is required, in order to meet the need for development, meeting the increasing water demand, and protecting the environment. The shift in water uses has been reflected in developing water savings programmes which started to be implemented in many countries of the Arab region.

Some of these water savings programmes include irrigation improvement projects to increase water use efficiency in the irrigation sector. Public awareness programmes are implemented for saving on potable water use. Recycling of industrial wastewater is also starting to draw considerable attention in many countries. Many countries are also constructing dams on their rivers to save water from being lost to the sea and to store it for a more controlled use and sustainable development. Reuse of agricultural drainage water is being practiced to save freshwater for other uses. Artificial recharge to groundwater also saves freshwater from being lost and stores it in the ground for future use. The use of modern irrigation techniques such as drip and sprinkler irrigation also saves on agriculture water. Reuse of different levels of treated municipal wastewater in growing trees and some non-edible and edible plants saves as well on the use of freshwater. The use of fossil groundwater contributes for a period of time to the saving of renewable freshwater resources. Although desalination of sea water is considered as one of the only freshwater resources for some countries, in other countries it contributes to freshwater savings for more uses.

In general, water savings methods and alternatives may be categorized under two main categories:

- Water savings by reducing the use of conventional water resources
- Water savings by increasing the use of non-conventional water resources

In many cases, water savings techniques under both categories are inter-linked and affect one another, not only quantity wise but quality wise as well. Each water savings technique has its positive and negative environmental impacts. Not only that, but sometimes what is commonly being viewed as water saving by a certain water user may be considered as a water loss by another water user. A perfect example is that of groundwater users depending on their groundwater recharge from canals that will be lined under a water savings programme. The term water loss need to be evaluated on a case by case basis, and on the use of this lost water and its destination. Guidelines and limitations on water savings programmes and policies are needed. Different alternatives for water savings need to be compared.

For real water savings on conventional water use, either water has to be saved from being unnecessarily lost out of a specified boundary system, or water has to be saved from being unnecessarily transformed into a deteriorated-quality form of water, or unnecessary extra energy has to be saved from being wasted to supply excess water, even if it will be reused later on (Abu-Zeid, K., 1996).

Water Uses in the Arab Region

The table below shows the annual water uses in the Arab countries for year 2000 as being 162 Billion Cubic Meters (BCM) in the irrigation sector, 12 BCM in the domestic sector, and 9 BCM in the industrial sector. This assessment is based on a population in the Arab region of about 284 million people. If current water use patterns remain the same, water demand by year 2025 is expected to increase by about 66% to meet the needs of the expected population of 472 million. Knowing the water scarcity situation in most of the Arab region, water savings programs will be essential to meet this increasing water demand.

	Population (thousands)		Irrigation Water Use	Domestic Water Use	Industrial Water Use
	2000	2025	(Million m^3/year)	(Million m^3/year)	(Million m^3/year)
ALGERIA	30291.34	47322.000	2700.000	1125.000	675.000
BAHRAIN	639.75	959.630	133.840	93.210	9.560
Comoros	705.93	1058.894	0.000	0.000	0.000
DJIBOUTI	632.10	948.144	6.960	1.040	0.000
EGYPT	67884.48	95766.000	47730.000	3330.000	4440.000
IRAQ	22946.25	41600.000	39376.000	1284.000	2140.000
JORDAN	4913.12	11894.000	738.000	216.480	29.520
KUWAIT	1914.40	2904.000	322.800	199.060	10.760
LEBANON	3496.49	4424.000	879.240	362.040	51.720
LIBYA	5289.73	12885.000	4002.000	506.000	92.000
MAURITANIA	2664.53	4443.000	1499.600	97.800	32.600
MOROCCO	29878.40	39925.000	10161.400	552.250	331.350
OMAN	2538.16	6538.000	1149.620	61.150	24.460
Palestine	2484.00	5200.000			
QATAR	565.44	848.159	210.900	65.550	8.550
SAUDI ARABIA	20346.23	42363.000	15316.200	1531.620	170.180
SOMALIA	8777.88	23669.000	785.700	24.300	16.200
SUDAN	31095.16	46850.000	16732.000	712.000	178.000
SYRIA	16188.76	26303.000	13545.400	576.400	288.200
TUNISIA	9458.66	13524.000	2706.176	276.768	92.256
U.A.E.	2605.96	3297.000	1412.360	505.920	189.720
YEMEN	18348.75	39589.000	2697.440	205.240	29.320
Total	**283,666**	**472,311**	**162,106**	**11,726**	**8,809**

Source: WRI 2000-2001, FAO 1997,GEO3

Note: No data is available on Palestine and Comoros

Water Challenges in the Arab Region

The key water challenges in the Arab region may be stated as the following:

- Water scarcity, population growth, and the growing supply/demand gap
- Coordination between different water sectors and stakeholders
- Problems of transboundary waters
- Limited information on water resources
- Overlap of responsibilities
- Water quality degradation and water pollution
- Limited awareness of water issues
- Lack of funds for water development
- Capacity building and institutional development

Examples of Irrigation Water Savings Methods

One of the reasons why farmers use water inefficiently is due to irrigation system constraints, use of traditional irrigation systems, lack of funds for maintenance, and unaccountability for amounts of water being used in irrigation. If cost recovery of operation and maintenance services are properly implemented, increased awareness is realized, and low water-consumption irrigation systems are used, water use efficiency will, undoubtedly, increase.

The Egypt Water Use Project (EWUP) has concluded that irrigation water use efficiency could be increased by adopting certain irrigation management measures which include proper irrigation scheduling, precision land leveling, use of modern on-farm irrigation systems (sprinkler & drip irrigation), and other on-farm irrigation management measures such as cleaning and maintaining furrows, canal lining, use of dikes to prevent undesirable surface drainage, and improved crop management and use of low water consumption crop varieties.

Irrigation application efficiencies in the Egypt Irrigation Improvement Project increased from 60% to 75% because of land leveling interventions. According to Abu-Zeid, M. (1992) the average expected water savings from irrigation improvement projects has been estimated at 10-15 % with an increase in agricultural productivity of 30%.

Examples of Domestic Water Savings Methods

Since the dominant fact over the next few decades is the imbalance between the increasing demand on water resources to meet the growing development and the limited available supply, it is essential to look into all means of water savings. Although the domestic water use is much less compared to the irrigation water use, still some substantial water savings could be achieved in this sector. Water savings could be achieved by improving on the maintenance of water supply networks and also by using new water savings devices. Losses in the water distribution systems in major cities of the Mediterranean ranges from 20% to 50% (GWP-Med, 2000)

Examples of domestic water saving methods include:

- Use of household water-saving devices
- Metering
- Use of high-efficiency washing machines
- Use of landscape water conservation devices

Household water-saving devices include low-flow showerheads, toilet displacement devices or ultra low flush toilets, and faucet aerators.

Low flow showerheads are designed to provide water at lower rates of water flow at less than 2.5 gallons per minute at high pressure levels up to 80 pounds per square inch. The estimate of water savings by using low flow showerheads is about 5 gallon per day /low-flow showerhead. Toilet displacement devices come in a variety of designs that all displace some water volume in the toilet tank. Since less water is needed to fill the tank, less water is used per flush. The estimated water savings attained by the installation of toilet displacement devices amounts to 4.2 gallon per day /device. A similar result could be achieved by using ultra low flush toilets which use water tanks that are especially designed to provide the same water pressure but with low water use as compared to traditional toilet water tanks. Installing faucet aerators can attain water savings that amounts to 1.5 gallon per day /device.

Water savings from using the above mentioned household water savings devices are estimated at an average of 15% of the total domestic water use (CUWCC, 2000). In addition, detection of any residential water leaks and efficient maintenance could avoid the continuous loss of water. Household leaks are very common problems which are attributed to inadequate maintenance of pipelines and water connections.

Metering for water conservation requires installing meters in existing housings that are not equipped with metering devices. It also requires that new housings be equipped with water meters. Meters can be added to individual units in buildings, where the so called sub-metering allows separate household–level water usage measurement in buildings where there are only a master meter. Metered water consumption would lead to water savings of about 25 -40% of water use. (CUWCC, 2000)

High efficiency washing machines are those designed to save energy and water. The savings perceived by the use of high efficiency washing machines is about 37%. Studies have reported that high efficiency washing machines consumption is about 24 gallons per load /machine (CUWCC, 2000).

Landscape water conservation programs target outdoor water use. Sometimes landscapes are metered separately from non-landscape water consumption. Large landscape programs can take on many forms and involve site visits, training, device adjustment, upgrading, or water budgets. Devices and activities include centralized computer control, moisture sensors, rain shut-off switches, and other technologies to improve the efficiency of landscape water use. Several landscape water savings programs in California resulted in water savings of up to 50% (Ash, T., 1998). A conservative figure for savings in water use by implementing landscape water conservation programs are in the order of 20% (CUWCC, 2000).

Other domestic water savings may be achieved indirectly by the recycling and reuse of domestic wastewater.

Examples of Industrial and Commercial Water Savings Methods

Examples of industrial and commercial water saving methods include:

- Use of self –closing faucets
- Use of Ultra-low flow flush toilets
- Use of low-flow urinals

Self-Closing faucets are based on one of two technologies. The first involves a spring loaded faucet lever that closes the faucet in a prescribed period of time after it is opened. The second technology involves an infrared sensor which turns on the water when it detects hands under the faucet. Both faucets save water compared to conventional low flow faucets by reducing the average length of time the faucet is opened. These types of faucets may be used in industrial and commercial areas including factories, airports, schools, theaters, restaurants, and also offices.

CUWCC (2000) determines that self-closing faucets reduce water consumption by up to 50% compared to conventional low flow faucets. A conservative estimate of 25% may be used for water savings using self closing faucets.

Ultra Low Flush (ULF) Toilets are low-water-using toilets. ULF toilets use less than 1.6 gallons per flush.

There are also water-saving urinals which are equipped with low-flow valves that utilize less water than conventional valves. The savings accomplished by the installation and use of these urinals is around 33% of the water used per flush (CUWCC, 2000).

Other industrial and commercial water savings may be achieved indirectly by the recycling and reuse of industrial and commercial wastewater.

Current Potential for Water Savings in the Arab Region

Based on the previous studies mentioned above, the following conservative assumptions were derived and used in estimating the potential for water savings in the Arab countries.

For the irrigation water use, potential water savings was assumed to be at 10% of the total irrigation water use.

For the domestic water use, it was assumed that 70% of the total domestic water use could pass through household water savings devices and that potential water savings using household water-saving devices was estimated at 15% of the 70% of the total domestic water use. Assuming that some of the existing housings are already equipped with water meters, potential water savings due to metering was assumed to be at 20% of the total domestic water use. It was assumed that each washing machine can serve 10 persons. The consumption of a normal washing machine was assumed 0.25 m^3/load at an average of 4 loads per month. The potential water savings using high-efficiency washing machines is 37% of the normal washing machines consumption. Landscape irrigation water use was estimated at 5% of the total domestic water use, and the potential water savings was assumed to be 20% of the landscape water use. In California, 5% of the total water use goes to landscape irrigation (CUWCC, 2000).

For the industrial water use, it was assumed that it includes the commercial water use, and that 5% of the industrial and commercial water use could flow into self-closing faucets, low-flow flush toilets and low flow urinals. It was assumed that potential water savings in industrial and commercial water use was 25% of that 5%.

For the indirect potential water savings that could be contributed by using treated wastewater, it was assumed that 80% of the domestic and industrial water use, after deducting their freshwater savings, could be collected, treated, and reused.

Potential Domestic Water Savings

The table below shows the total potential annual water savings in the domestic sector as being 3.8 Billion Cubic Meters (BCM), 1.2 BCM obtained by using water saving household devices, 2.3 BCM obtained by using metering devices, 0.12 BCM obtained by using high efficiency washing machines and 0.1 BCM obtained by implementing landscape water conservation programs.

Country	Using Water	Using	Using High	Using Landscape	Total Potential

	Saving Household Devices M m³/year	Metering Devices M m³/year	Efficiency Washing Machines M m³/year	Water Conservation Programs M m³/year	Domestic Water Savings M m³/year
ALGERIA	118.13	225.00	13.45	11.25	367.82
BAHRAIN	9.79	18.64	0.28	0.93	29.65
DJIBOUTI	0.11	0.21	0.28	0.01	0.61
EGYPT	349.65	666.00	30.14	33.30	1079.09
IRAQ	134.82	256.80	10.19	12.84	414.65
JORDAN	22.73	43.30	2.18	2.16	70.37
KUWAIT	20.90	39.81	0.85	1.99	63.55
LEBANON	38.01	72.41	1.55	3.62	115.60
LIBYA	53.13	101.20	2.35	5.06	161.74
MAURITANIA	10.27	19.56	1.18	0.98	31.99
MOROCCO	57.99	110.45	13.27	5.52	187.22
OMAN	6.42	12.23	1.13	0.61	20.39
QATAR	6.88	13.11	0.25	0.66	20.90
SAUDI ARABIA	160.82	306.32	9.03	15.32	491.49
SOMALIA	2.55	4.86	3.90	0.24	11.55
SUDAN	74.76	142.40	13.81	7.12	238.09
SYRIA	60.52	115.28	7.19	5.76	188.75
TUNISIA	29.06	55.35	4.20	2.77	91.38
U.A.E.	53.12	101.18	1.16	5.06	160.52
YEMEN	21.55	41.05	8.15	2.05	72.80
Total	1,231	2,345	125	117.26	3818.48

Potential Savings by Using Treated Wastewater

Sewage treatment facilities have tended to lag behind water provision. There are direct human health risk of discharges of untreated sewage to surface and ground water. There is also a threat of discharges of untreated sewage to the oceans, seas and on marine ecosystems and wetlands. Wastewater treatment provides opportunities to increase the use of wastewater in agriculture (GWP-Med, 2000).

The percentage of population served with water supply and sanitation varies from one country to another. As more water supply and sanitation coverage is provided, the potential for reuse of treated wastewater increases. It has to be noted that domestic wastewater can reach up to 80% of domestic use if efficiently collected and countries are fully covered with sewage treatment facilities (Abu-Zeid, K., 1998).

The table below shows the annual water use in the domestic and the industrial sectors after savings as being 17 BCM. Assuming 80% of wastewater will be collected and treated, the annual collected wastewater could reach 13 BCM. The existing wastewater reuse is estimated at 1.2 BCM in the Arab countries (FAO, 1997). The potential for treated wastewater reuse can therefore be estimated at 12 BCM/year in the Arab countries.

Country	Domestic + Industrial Water After Savings M m³/year	Collected Wastewater based on 80% of Use M m³/year	Current Reused Treated Wastewater M m³/year	Potential Treated Wastewater For Reuse M m³/year
ALGERIA	1424	1139		1139
BAHRAIN	73	58	8	50
DJIBOUTI	0	0		0
EGYPT	6635	5308	200	5108
IRAQ	2983	2386		2386
JORDAN	175	140	50	90
KUWAIT	146	117	52	65
LEBANON	298	238	2	236
LIBYA	435	348	100	248
MAURITANIA	98	78		78
MOROCCO	692	554		554
OMAN	65	52	26	26
QATAR	53	42	25	17
SAUDI ARABIA	1208	967	217	750
SOMALIA	29	23		23
SUDAN	650	520		520

SYRIA	672	538	370	168
TUNISIA	276	221	20	201
U.A.E.	533	426	108	318
YEMEN	161	129		129
Total	16606.63	13285.30	1178.53	12106.77

Total Potential Water Savings

The table below shows the potential annual water savings in the Arab countries as being 16 Billion Cubic Meters (BCM) in the irrigation sector, 3.8 BCM in the domestic sector, 0.1 BCM in the industrial and commercial sectors, and 12 BCM in potential treated wastewater for reuse. Hence, the total potential water savings can reach up to 32 BCM/year.

Country	Potential Total Irrigation Savings M m^3/year	Potential Total Domestic Savings M m^3/year	Potential Total Industrial/Commercial Savings M m^3/year	Potential Treated Wastewater For Reuse M m^3/year	Total Potential Water Savings M m^3/year
ALGERIA	270	367.82	8.44	1139	1,785
BAHRAIN	13	29.65	0.12	50	94
DJIBOUTI	0.70	0.61	0.00	0	2
EGYPT	4,773	1079.09	55.50	5108	11,016
IRAQ	3,937	414.65	26.75	2386	6,765
JORDAN	74	70.37	0.37	90	234
KUWAIT	32	63.55	0.13	65	161
LEBANON	88	115.60	0.65	236	440
LIBYA	400	161.74	1.15	248	811
MAURITANIA	150	31.99	0.41	78	261
MOROCCO	1,016	187.22	4.14	554	1,761
OMAN	115	20.39	0.31	26	162
QATAR	21	20.90	0.11	17	59
SAUDI ARABIA	1,531	491.49	2.13	750	2,775
SOMALIA	79	11.55	0.20	23	113
SUDAN	1,673	238.09	2.23	520	2,433
SYRIA	1,355	188.75	3.60	168	1,715
TUNISIA	271	91.38	1.15	201	564
U.A.E.	141	160.52	2.37	318	622
YEMEN	270	72.80	0.37	129	472
Total	16,211	3818.48	110.12	12107	32245.93

Future Potential for Water Savings in the Arab Countries

Based on the water demand of year 2025, and assuming that this water demand could be satisfied by available water resources, the following savings could be achieved as shown in the table below. 27 BCM/year could be achieved in the irrigation sector, 6 BCM/year in the domestic sector, 0.2 BCM/year in the industrial and commercial sectors, and 20 BCM/year in potential treated wastewater for reuse. Hence, the total potential water savings can reach up to 53 BCM/year.

Country	Potential Irrigation Savings M m^3/year	Potential Domestic Savings M m^3/year	Potential Industrial / Commercial Savings M m^3/year	Potential Treated Wastewater For Reuse M m^3/year	Potential Total Water Savings M m^3/year
ALGERIA	422	567.06	13.18	1785	2,787
BAHRAIN	20	44.33	0.18	80	144
DJIBOUTI	1	0.77	0.00	1	2
EGYPT	6733	1509.92	78.29	7298	15,620
IRAQ	7139	743.45	48.50	4332	12,263
JORDAN	179	167.26	0.89	292	638
KUWAIT	49	95.97	0.20	126	271
LEBANON	111	145.85	0.82	299	557
LIBYA	975	390.60	2.80	751	2,119
MAURITANIA	250	52.55	0.68	131	435
MOROCCO	1358	245.72	5.53	744	2,353
OMAN	296	50.74	0.79	109	457
QATAR	32	31.22	0.16	39	102
SAUDI ARABIA	3189	1013.57	4.43	1803	6,010
SOMALIA	212	24.54	0.55	67	304

SUDAN	2521	351.72	3.35	789	3,665
SYRIA	2201	302.19	5.85	507	3,016
TUNISIA	387	128.85	1.65	298	815
U.A.E.	179	202.78	3.00	431	816
YEMEN	582	147.64	0.79	286	1,017
Total	26,834	6,217	172	20,168	53,392

Cost Estimates of Water Savings in the Arab Region

The total irrigated land in the Arab region is estimated at 60 million acres. The average cost of implementing irrigation improvement programs is estimated at 700 Euros per acre. Therefore an investment cost estimate for achieving the current above-mentioned 16 BCM/year of water savings in the irrigation sector in the Arab region may be estimated at 42 billion Euros.

As for the domestic sector in the Arab region, the total estimated investment cost for achieving the 3.8 BCM/year of water savings may be estimated at 18 billion Euros. This is based on the following costs and assumptions. The cost of a low flow showerhead, toilet displacement device and faucet aerators per household is around 25 Euros. Total cost in the region is estimated at 1.8 billion Euros (assuming each household is composed of 4 people). The purchase and installation of each visual reading metering system costs 75 Euros. The estimated cost in the region is 5.3 billion Euros (assuming 4 people per household). The high efficiency washing machines are assumed to cost 400 Euros each. The estimated cost for replacement is 11.3 billion euros in the Arab region (assuming one washing machine for each 10 persons). The cost of implementing landscape water conservation programs is 150 Euros per site which results in a total estimated cost of about 0.4 billion euros assuming 4 million sites (one site per 100 people).

As for the industrial and commercial sectors, the total estimated cost for achieving a 0.1 BCM/year water savings in the Arab region is 0.28 billion euros. This figure is based on the cost of water saving devices in industrial and commercial facilities (i.e. self closing faucets, Ultra Low Flush Toilets, etc.) as being 200 euros per 200 people.

As for the potential treated wastewater it is estimated that an investment of about 12 billion euros is needed to fill the gap in water supply and sanitation coverage (assuming 150 Euros/person for providing water supply services for 54 people without access to safe drinking water, and 50 Euros/person for supplying sanitation services for 79 million people without access to sanitation). An additional investment of about 9 billion euros may be needed to achieve the 12 BCM/year of treated wastewater (assuming 0.75 Euros/m^3).

Conclusions & Recommendations

It is concluded that the potential water savings in the Arab region based on current uses could be around 32 BCM/year. Of these savings, 12% domestic, 0.3% industrial, 50.2% irrigation, and 37.5% could be obtained from recycling and treated wastewater reuse.

The average investment cost is estimated at 2.6 Euro/m^3 for achieving water savings in irrigation water, 4.9 Euro/m^3 savings in domestic water use, 2.8 Euro/m^3 for savings in industrial and commercial water use, and 1.75 Euro/m^3 for recycled and treated wastewater reuse (mainly due to the required investment in filling the accessibility to water supply and sanitation gap).

To translate the potential water savings of 32 BCM in the Arab countries into food security figures, it could be estimated that this water savings alone can contribute to satisfying the annual wheat grain demand of a 34% of the Arab region population. This estimate is based on wheat water requirements of about 2000 m^3/acre/year, an acre of land cultivated with wheat producing 2180 kg of flour, and a person consumption of 365 kg of flour per year (Abu-Zeid, K. 1998). This will result in satisfying the annual wheat demand of 96 million people by cultivating 16 million acres of wheat.

As for the future potential savings based on the water demand and use of 2025, the estimated total potential water savings is about 53 BCM/year in Arab region. It has to be noted that this is greatly attributed to the great potential of water savings in the irrigation sector and reuse of treated wastewater reuse.

Several actions should be incorporated in an integrated policy for water savings in the Arab region. Irrigation water savings plans should be prepared by irrigation sectors and irrigation improvement projects should be designed and implemented widely. Urban water conservation plans should be prepared by cities including provisions for changing building codes if necessary. Industrial water conservation plans should be prepared as well and be part of approval for licenses for new business and industries.

Public awareness is very important, as water is generally taken for granted by the public. The ignorance of the water scarcity problem leads to misuse of water. This awareness can be enhanced through school education systems in the region.

In addition, wastewater reuse in landscape irrigation and other quality-appropriate uses should be widely implemented and promoted as a common practice for the sake of freshwater saving. Collection of wastewater and its treatment should expand to cover wide areas in the region. Furthermore, metering and accounting for water use through appropriate socio-sensitive cost recovery mechanisms would change the water use customs and attitudes of consumption.

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