UNITED NATIONS

E

Distr.:
LIMITED:
E/ESCWA/ENR/1999/WG.2/12
22 September 1999
ORIGINAL: ENGLISH

Economic and Social Commission for Western Asia

Expert Group Meeting on Harmonization of Environmental Standards
in the Water Sector of ESCWA Member States

Eighth Biennial Meeting of the Arab National Committees
of the International Hydrological Programme of UNESCO

Beirut, 28 September – 1 October 1999

Water Vision for the Arab Countries of Western Asia: Alternative Water Policies

99-0861

WATER VISION FOR THE ARAB COUNTRIES OF WEST ASIA ALTERNATIVE WATER POLICIES

Arabian Gulf University
PO Box 26671, Bahrain

1. Introduction

The 4 million km^2 West Asia region can be divided geographically and ecologically into two sub-regions: the Mashreq (or East Mediterranean), with a 1995 population of 45.1 million, includes Lebanon, Syria, Jordan, Iraq and the territories of the National Palestinian Authority (NPA); and the Arabian Peninsula, with a 1995 population of 40.5 million, includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates (UAE), and Yemen.

The Arabian Peninsula is characterised by extremely arid climate and, with the exception of the coastal strips and mountain ranges, it is largely desert, and are generally devoid of reliable surface water supplies. The countries of the Peninsula depend entirely on groundwater and desalination to meet their water requirements. The Mashreq countries are characterised by semi-arid climate, with small high altitude areas enjoying Mediterranean climate. The Mashreq climate is a transition zone between the arid south (Arabian Peninsula) and the sub-humid north (East Turkey), with high variation of precipitation with time, in which some years may resemble peninsular drought and other years a more northerly situation. However, by contrast, the Mashreq sub-region is richer in surface water resources, having two shared rivers (Tigris and Euphrates) originating from outside the region, and a number of short seasonal and perennial rivers and a series of sizeable springs.

During the past five decades, the total population in West Asia has increased fourfold from about 19.9 million in 1950 to 86.7 million in 1996 (UNSPD, 1997). The average population growth rate during 1980-1995 averaged 3.8% annually, which is higher than other regions across the world. The population of West Asia is young, where the working population (age group 15-65) constitutes only about 55% of the total (WB, 1997). Furthermore, migration from rural to urban areas has been observed to increase with time, which places great pressures on cities; urban population increased from 66.7% in 1980 to 75.4% of the total population in 1995.

The rapid increase in population, along with social, agricultural, and industrial development, was associated with substantial increase in water demands, placing great pressures on the two sub-regions' limited water resources. In the Arabian Peninsula, the total annual water demands have increased from 6 billion cubic meter (Bcm) in 1980 to 29.7 Bcm in 1995, with the agricultural sector being the main water consumer at 85%, in an attempt to achieve maximum food self-sufficiency by the countries, of the peninsula. Spiralling water demands are met mainly by intensive over-drafting of groundwater resources, leading to their depletion and accelerated degradation of their water quality.

Furthermore, during the past two decades, the First and Second Gulf Wars have seriously affected the economy of West Asia, where socio-economic developments have to be reviewed. Water development schemes have been cut back and delayed. Water resources in Syria, Iraq, and the West Bank and Gaza Strip were reduced by conflicts over allocations from rivers and aquifers shared with neighbouring countries. This has led to the postponement of 30-40% of planned agricultural schemes.

At present, a clear imbalance between available water resources and water demands exists in most of the countries of West Asia, with the remaining countries approaching critical conditions between the two. This imbalance is expected to continue in the future. In the 21st century, West Asia will experience a series of major environmental problems resulting from:

- Escalating conflicts over shared water surface and groundwater resources if agreements are not reached on equitable allocations; and
- Escalating water demands and lack of conservation measures;
- Slow rate of water resources augmentation;

continuous decline in groundwater levels and a deterioration in water quality caused by the encroachment of seawater in coastal alluvial aquifers and up-flow of connate waters in inland aquifers. A comparison between the Arabian Peninsula annual groundwater recharge (7.2 Bcm) and groundwater abstraction rates (23.6 Bcm) in 1995, indicates that mining of groundwater reserves in the Arabian Peninsula is about 16 Bcm; groundwater depletion rates in Mcm in: Bahrain 100, Kuwait 200, Oman 240, Qatar 140, Saudi Arabia 13,558, UAE 1,495, and Yemen 700 (FAO, 1997).

In the Mashreq, there is a growing evidence of groundwater depletion in many countries, such as Syria, where groundwater use has increased by 0.5% annually during 1976-85 and by 7% per year during 1989-93, largely because of a decrease in surface water availability (MSE/UNDP, 1997). It is estimated that water levels in the Gaza Strip aquifer are dropping at a rate of 10-20 cm/yr. In Jordan average groundwater depletion was estimated at over 150 Mcm/yr, resulting in degradation of water quality and reduced exploitable quantities, resulting in the abandonment of many municipal and irrigation water wellfields (FAO, 1997). In addition, over-irrigation and surface dumping of partially treated wastewater has generated large volumes of contaminated waters that increase the pollution levels of shallow aquifers.

Similarly in the Mashreq sub-region, the discharge of raw and partially treated wastewater from agriculture, industry and municipalities into water courses has caused deep concern over health impacts, and has subjected agricultural land and water resources to severe pollution, and causing shallow aquifers contamination. It is reported that nitrate concentration in some domestic wells in the Gaza Strip reached 40 mg/L (Zarzour et al., 1994), four times the limit set by WHO. River basins in this sub-region have shown similar symptoms (Hamad et al., 1996; MSE/UNDP, 1997).

Non-Conventional Water Resources

Desalination technology was introduced in the Arabian Peninsula, particularly the GCC countries, in the mid fifties and has developed very rapidly to counteract the shortage in conventional water sources and to meet the qualitative requirements for drinking water standards. The present (1995) and under-construction total capacity of desalination plants in the region is more than 2,316 Mcm/yr, about 41% of global capacity (Bushnak, 1995), with a total produced water of about 1,645 Mcm in 1995 (Al-Zubari, 1997). In the Mashreq sub-region, desalination plants are few in number and of small capacity, and are located in Jordan, Lebanon, and Syria with a total of 7 Mcm annual production.

In order to meet domestic water demands, which is a function of population and urbanization growth, the countries of the Peninsula are going ahead with desalination plants construction, despite their relatively enormous costs, which ranges between 1-1.5 US$/m^3 (Bushnak, 1995). It is expected that the total desalination capacity of the region will be more than 3,000 Mcm by the year 2020 (Ismail, 1995; Alalawi and Abdulrazzak, 1993). In addition to their high cost, all desalination plants have some negative impacts on the surrounding environment. These include air pollution by emitted oxides and seawater and marine life pollution by rejected brines, which have elevated temperatures, increased salt concentration and may contain residual treatment chemicals and trace element picked up within the desalination plant (Alalawi and Abdulrazzak, 1993).

Wastewater treatment in the Arabian Peninsula constitutes an increasing water source driven by escalating water consumption in urban areas. These waters have become available in the early eighties in most of the Arabian Peninsula countries due to the completion of sewage water treatment facilities and urban sewage network in most of the large cities. Almost all of the countries are operating modern treatment facilities with tertiary and advanced treatment capabilities. The total designed capacity of the major facilities is more than 1,120 Mcm/yr. This volume represents no more than 30% of the domestic water volumes, posing the problem of wastewater discharge and its associated pollution of shallow aquifer and the coastlines, and the rise of urban water table. At present, the total treated wastewater volume is about 940 Mcm/yr. However, the reused treated wastewater does not exceed some 392 Mcm per year (43% of total treated), and is used mainly for

The total water used for all purposes in the West Asia region in 1995 amounted to 96,286 Mcm of which 29,786 Mcm was accounted for in the Arabian Peninsula and 66,500 Mcm in the Mashreq (Table 3). Currently the agricultural sector takes 85% of available water resources in the Arabian Peninsula and 95% in the Mashreq, followed by domestic water use, at 13.5% and 4%, respectively, with industry in both sub-regions accounting for less than 2%.

The high growth rate of population, and its associated need for food production, today constitutes the core problem in the development of water resources in West Asia, where water demand rates by far exceed the anticipated water resources development rates. In fact, the deficit in food production is growing and is aggravated by the scarcity of resources (land and water), that are already over-exploited. Consequently, the annual per capita share of water resources is decreasing, and at an increasing rate; according to the Global Water Assessment, the share per individual in the Arab world has decreased during the last two decades from 2,200 m^3/yr to 1,100 m^3/yr.

In the Arabian Peninsula, except for Oman, all countries have per capita water share of less than 1000 m^3/yr, the benchmark established to identify chronic water scarcity (WRI/UNEP/UNDP/WB, 1996), with an average of about 393 m^3/yr (Table 4). These countries even have per capita water share of equal or less than half of the benchmark. On the other hand, the per capita water use in these countries averaged 735 m^3/yr in 1995 (Table 3), causing a deficit of about 340 m^3 per capita which is provided by mining groundwater reserves. In the Mashreq, the per capita available water resources seems apparently better, except for Jordan and the territories of the National Palestinian Authority. However, all countries of this sub-region have critical conflicts concerning shared water resources issues, which are still pending reconciliation with the neighbouring countries. In Iraq, Lebanon and Syria it is above the benchmark of 1,000 m^3/yr, but the above mentioned conflicts remain to be resolved.

The water stress experienced by the countries of West Asia in 1995 (Table 4) is expressed as the percentage of available water resources actually used. The index reaches values of over 100% in five of the seven countries in the Arabian Peninsula, and critical values in the remaining two. This indicates that these countries have already exhausted their renewable water resources and are now exploiting non-renewable reserves. It is worth mentioning that the groundwater reserves in the Peninsula have been over-drafted by about 16 Bcm in 1995.

In the Mashreq, the water stress index looks relatively better except for Jordan where it is over 100%. However, all countries of this sub-region have critical conflicts concerning shared water resources, which remain to be reconciled. The overall value of the water stress index for West Asia is 84.4 percent, which is considered very critical.

Despite the natural supply limitations and over-consumption, comprehensive water policies and plans to assess, develop, and manage water resources are still lacking in most of the countries of West Asia. The present policies, if exist, are fragmented and stress development in one economic sector without regard to effects on the other sectors. e.g. in the Arabian Peninsula, agriculture was greatly expanded to establish food self-sufficiency for the fast growing population, without regard to the limited availability of water and its consequences on water resources. Furthermore, water supplies were developed without concurrent conservation program. This was compounded by the institutional weakness of land and water management authorities, multiplication and overlap of water agencies and lack of coordination among them, as well as with the agricultural agencies, inadequate technical and financial resources, and lack of public participation.

4. Future Water Demand

Clearly, there is a need for an urgent policy review of the development and rational utilisation of water resources throughout the region. Projections of the total sectoral water demand in West Asia over the period 1995-2025 (Table 5) are based on the criteria explained in Appendix A. The increase in water demand across all sectors in West Asia will be 75,650 Mcm by 2025 and it is evident that agriculture will continue to dominate (87%) all other uses. Furthermore, from the available water

regions. However, the intense of their environmental impact varies according to the geopolitical and socio-economic status of each country.

5. Alternative Policies towards Sustainable Development

Three scenarios are used to investigate and study the water balance required to ensure sustainable development in West Asia for the period 1995-2025. Assumptions for these scenarios were as follows:

Baseline Scenario 1 (Business as Usual)

- 1997 UN population projections.
- No further development of water resources.
- Total water demand estimated on the criteria given in Appendix A.
- Secure domestic and industrial water uses as first priority.
- Maximum food self sufficiency policies.
- Improving agricultural productivity per unit of water to achieve 20% saving in agricultural water demand by 2025.
- Settlement of shared water resources disputes.

Scenario 2 - Supply Augmentation

- Increase surface and groundwater resources for both the Arabian Peninsula and the Mashreq sub-region by 100 Mcm/yr to give a total increase of 3,000 Mcm in 2025 for each sub region.
- Increase desalination capacity to reach 3,260 Mcm/yr in the Arabian Peninsula by 2025, unchanged in Mashreq.
- Increase recycled wastewater to 5,090 Mcm/yr in the Arabian Peninsula and to 3,000 Mcm in the Mashreq by 2025.
- Increase irrigation water reuse to 1,620 Mcm in Mashreq in 2025, unchanged in the Arabian Peninsula.
- Other assumptions for population, water consumption rates, priority for domestic and industrial water use, and policies of maximum food self-sufficiency, improvement in agricultural production research, settlement of shared water resources disputes, as in Scenario 1.

Scenario 3 - Supply Augmentation and Policy Remedies

- Further gradual, rational decrease of the consumption patterns outlined in Scenario 1 and 2 is achieved by increasing the efficiency of irrigation, reviewing the price of water, and improving wastewater management; resulting in a decrease in total water demand of the Mashreq and Arabian Peninsula of 13,700 Mcm and 10,680 Mcm, respectively, by 2025.
- Other assumptions of Scenario 1 and 2 as given.

Scenario 1 appears pessimistic and represents the worst case scenario. However, justifications for its consideration are as follows: 1) West Asia is located in arid region, with 80% of its land classified as desert or semi-desert; 2) Most of the easy and promising water sources have been developed, remaining locations require heavy investments, laborious investigations and intensive research programs; 3) the potential conflicts concerning shared water resources (constitute a sizeable magnitude of the total resources) requires lengthy and difficult negotiations before equitable reconciliation is attainable, which has resulted in the postponement of many water development schemes; and 4) the countries of West Asia have been affected strongly by regional wars and disputes that inflamed since the last three decades with no permanent settlement, which have drastically affected the economy of the region and have upset the socio-economic development plans of all member countries, resulting in the postponement of many water development schemes.

The anticipated achievements in this Scenario would focus on the reduction of 20% of the agricultural water demand by 2025 as prescribed in Appendix A. This saving will result from agricultural researches in the field of maximizing agricultural productivity per unit of water, and application of appropriate technologies, including biotechnologies.

5.3 Scenario 3 - Supply Augmentation and Policy Remedies

Even with the augmentation and policy remedies the Arabian Peninsula will continue to experience an increasing water deficit, from 11.2 Bcm in 1995 to 20.6 Bcm by 2025. The percentage water balance to demand will, more or less, level off at 40%. On the other hand, the Mashreq will continue to enjoy a surplus of water resources all through the projection period, varying between 31.9 Bcm in 1995 to 4.9 Bcm in 2025. Nevertheless, the percentage of balance to water demands will decrease from 47.9% in 1995 to a critical 4.9% by 2025. For the West Asia as a whole, a deficit of 1.4 Bcm in water resources will be experienced in 2015 rising to 15.7 Bcm in 2025. Percentage of water balance to demand will gradually fall from 21.5% to -10.6% in the period 1995 to 2025.

It is evident that scenario 3 is to be preferred and constitutes an appropriate base for an alternative strategy to secure sustainable development of water resources. Even so, it is clear that the Arabian Peninsula will continue to experience a deficit in its water resources if its targets of maximum food security are adhered to, and its population growth rates continue as projected. This will call either for mining some 400 Bcm of shallow and deep groundwater resources during the projected period, of which these water usefulness is questionable with the expected deterioration of groundwater quality deterioration, or for significant imports of agricultural produce to cover the deficit. In the Mashreq, potential conflicts over shared water resources remain a fundamental pressing issue for early equitable settlements.

6. Water Resources Policy Implementation

The overall objectives of these proposed alternative water policies for the countries of West Asia is to secure long term water supplies while meeting strict criteria for socio-economic, financial and environmental sustainability and public health requirements. The actions set out below are based primarily on the lessons from "Scenario 3 - Supply Augmentation and Policy Remedies", and seem to offer the most promising alternatives. They are focused specifically on the acute problems of water supply and management in the West Asia region, and are aimed to encourage:

- the appropriate development of conventional and non-conventional water resources;
- the resolution of conflicts over shared water resources;
- a marked improvement in the efficiency of water use; and
- a substantial decrease in water demand

Procedures towards implementation the water resources policy can be classified under five categories of actions as follows:

6.1 Planning and Analysis

Water Policy formulation is very data intensive. Reliable data are the basis for the sound planning and implementation of water policy. Comprehensive hydrological data are required to complete the full inventory of the existing quantity and quality of water resources, along with time series for trend analysis and to calculate design parameters for waterworks. Data should be scrutinized to eliminate any exaggeration, and collection of data should be well planned and continuous to provide information to assess the performance of the water schemes after implementation and its effect on the downstream users. Scarcity of water resources in West Asia is aggravated by the potential conflicts that has risen between the member countries and their neighbours, and would seriously affect preparing sustainable soci-economic development plans in future if not reconciled earlier. The development of additional water resources in the region will require well planned, detailed and integrated studies of the potential for surface, groundwater, and non-conventional water resources, and cooperation between member states in these studies. Only then can the most appropriate and economically feasible options be selected from among the many recognised techniques, including rain water harvesting, surface storage, groundwater recharge, wastewater reuse, weather modifications,

6.4 Water Conservation

Records and studies indicate the excessive and wasteful use of water in all sectors (agricultural, domestic and industrial) throughout West Asia. Huge water losses of at least 45% in agriculture arise from inefficient irrigation systems, while there is a 20% leakage from water supply networks and general 10% losses during industrial use. All countries of West Asia must incorporate into their water resources management plans conservation programs to cut down water losses.

In the agricultural sector this can be approached by:

- Review the economics of irrigation and agricultural production, and re-appraising agricultural policies.
- Improving the efficiency of traditional irrigation systems, introducing appropriate modern irrigation technology (e.g. application of laser levelling for basin irrigation fields, lining field irrigation canals), and promoting water conservation techniques among farmers and water users.
- Reviewing current irrigation incentives and tariffs, implementing the necessary legislation to enforce and update regulations on water use and strict enforcement of regulations.
- Improve extension services and programs to raise awareness among the public and farmers to the economic value of water as a precious, scarce, and viable resource.
- Providing subsidies/soft loans to encourage application of modern irrigation systems.

In the domestic and industrial sectors this may require:

- Restructuring water pricing to reflect the true costs, including environmental costs of maintenance and operation of water supply works and desalination and wastewater treatment plants. Water tariffs in most countries of the Arabian Peninsula are too low to encourage rational water use.
- Review water-pricing mechanisms and apply escalating tariffs for increasing water consumption.
- Install modern water saving technology for distribution systems and households.
- Improve leakage detection in water supply networks.
- Modify building codes to promote efficient use of wastewater for landscaping.
- Apply heavy pollution charges against industrial units violating regulation.
- Industrial units should be obliged to treat water before recharging it into water, lakes or sea.

6.5 Projects and Programs

Water projects and programs represent the final outcome of the process of water policy review. They constitute a component of the action plan, which should be consistent with overall water strategies. During detailed feasibility studies, any proposed projects and programs must undergo comprehensive review and assessment before implementation, including cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), environmental impact assessment (EIA), and economic and financial analysis.

7. Action Program for Implementation

It is suggested that each country of West Asia appoint a national council, if not existing yet, whose members are ministers responsible for water resources development, management and utilization, to coordinate at the highest political level, and formulate, the overall water policy of the country. A technical body (secretariat/committee), to be suggested by the council, and composed of senior scientists, economists, engineers, lawyers from concerned ministries and authorities, university and research institutes, and public agencies and stakeholders including (if the country political system permits) representatives of the water users would help the council and ensure fair institutional and inter-ministerial coordination at the national level.

The water strategy should consider the water sector development, demand, protection, and sustainable use in the medium and long term (15-30 years). A lot of data and information are needed to

Ismail, N, 1995, Strategic Projection for Planning and Management of Water Resources in the GCC Countries. Attaawun, vol. 10, pp. 47-62 (in Arabic).

MSE/UNDP, 1997, Country Study: the State of Environment in Syria (Draft). Syrian Ministry of Environmental Affairs, Syria.

UNSPD. 1997. World Urbanization Prospects: The 1996 Revision (Annex tables). United Nations Secretariat Population Division. New York.

World Bank, 1997, World Development Indicators.

WRI/UNEP/UNDP/WB, 1996, World Resources 1996-1997. World Resources Institute (WRI), UNEP, UNDP, and the World Bank. Oxford University Press, New York and London.

Table (2): Projection of Population in West Asia (1000)

Sub-region/ country/territory	Projection Period							Percentage Ratio (2025 to 1995)
	1995	2000	2005	2010	2015	2020	2025	
Arabian Peninsula								
Bahrain	557	618	671	717	766	816	863	155
Kuwait	1 691	1 966	2 192	2 390	2 576	2 752	2 904	172
Oman	2 207	2 717	3 302	3 986	4 752	5 610	6 538	296
Qatar	548	599	648	693	734	764	782	143
Saudi Arabia	18 255	21 661	25 255	29 222	33 483	37 919	42 363	232
U.A.E	2 210	2 444	2 660	2 869	3 049	3 185	3 297	149
Yemen	15 027	18 118	21 577	25 452	29 781	34 540	39 589	263
Sub-Total	40 495	48 123	56 305	65 329	75 141	85 586	96 336	238
Mashreq								
Iraq	20 095	23 109	26 668	30 422	34 248	38 013	41 600	207
Jordan	5 377	6 330	7 371	8 458	9 579	10 735	11 894	221
Lebanon	3 009	3 289	3 535	3 742	3 961	4 193	4 424	147
N.P.A.	2 400	2 955	3 598	4 362	5 286	6 354	7 528	314
Syria	14 203	16 126	18 237	20 468	22 652	24 563	26 303	185
Sub-total	45 084	51 809	59 409	67 452	75 724	83 858	91 749	204
Grand Total	**85 579**	**99 932**	**115 714**	**132 781**	**150 865**	**169 444**	**188 085**	**220**

Source: UN SPD, 1997.

Table (3): Water Use in West Asia 1995 (Mcm)

Sub-region/ Country/Territory	Domestic	Industry	Agriculture	Total	Per Capita Water Use m^3/year	Population (1000)
Arabian Peninsula						
Bahrain	107	19	161	287	515	557
Kuwait	297	13	323	633	374	1 691
Oman	85	6	1 150	1 241	562	2 207
Qatar	85	17	337	439	801	548
Saudi Arabia	2 387	193	18 575	21 155	1 159	18 255
U.A.E	600	73	1 539	2 212	1 001	2 210
Yemen	470	69	3 280	3 819	254	15 027
Sub-total	4 031	390	25 365	29 786	735	40 495
Rate of Water use (L/d/cap)	273	26	1 716	2 015		
% of Water Use	13.5	1.3	85.2	100		
Mashreq						
Iraq	1 179	344	47 584	49 107	2 444	20 095
Jordan	245	50	1 088	1 383	257	5 377
Lebanon	415	60	750	1 225	407	3 009
N.P.A.	64	0	155	219	91	2 400*
Syria	773	175	13 618	14 566	1 026	14 203
Sub-total	2 676	629	63 195	66 500	1 475	45 084
Rate of Water use (L/d/cap)	163	38	3 840	4 041		
% of Water Use	4	1	95	100		
Grand Total	6 707	1 019	88 560	96 286	1 123	85 579
Rate of Water use (L/d/cap)	215	32	2 828	3 075		
% of Water Use	7	1.0	92	100		

* N.P.A.:National Palestinian Authority figure (1994).

Sources: Data from verified Country reports, GCC (1996), UN SPD (1997).

Table (6) : Matrix of Problems and Critical Issues in the Water Sector of West Asia

Problem Type	Evidence	Source	Relative Importance
Limited water resources.	Decrease of per capita available water with time.	- Arid region. - Frequent drought cycles. - Growing population. - Adopted food self-sufficiency policies	Slow down socioeconomic development plans.
Shared water resources disputes.	- Decrease of surface flow at border. - Remarkable lowering of water table at borders. - Local water resources fully used.	- Reconciliation of conflicts not concluded. - Failure of planning and forecasting for future development.	Involve major percent of available water of West Asia.
Inefficient water use.	- Irrigation losses 45%. - Excessive leakage from supply networks. - Wasteful water use.	- Extensive traditional irrigation practice. - Old water supply networks and no sufficient funds for maintenance and leak detection. - Lack of awareness, realistic pricing and stringent regulation.	Excessive losses of available water.
Internal water allocation conflicts.	- Increasing competition among sectoral users.	- Growing water demand. - Limited water resources.	Increasing water scarcity.
Water quality deterioration.	- Contamination of surface water. - Groundwater depletion. - Sea water intrusion. - Loss of Agricultural lands.	- Discharge of untreated affluent (domestic, industrial) in water courses. - Over exploitation of groundwater. - Lack of strict penalties. - Irrational water demand. - Insufficient studies.	- Water related diseases. - Soil damage. - Complicated groundwater problems. - Negative impact on environment.
Inferior quality of services.	- lack of sewage system in large areas. - Water related diseases. - Groundwater pollution.	- shortage of financing. - Growing population. - Fast pace Urbanization.	Influence on development and welfare.
Weak institutions.	- Duplication of efforts. - Inefficient water management.	- Ill defined responsibilities. - Inadequate technical capabilities and training. - Lack of coordination.	- Poor water resources development. - Inefficient services.

Policy Remedies)

Sub-region / Year	1995	2000	2005	2010	2015	2020	2025
Arabian Peninsula							
Available Water Resources	18.64	19.92	21.17	22.52	24.05	25.70	27.42
Total Water Demand	29.79	32.10	34.45	37.20	40.38	44.25	48.00
Water Balance	-11.15	-12.19	-13.28	-14.68	-16.33	-18.54	-20.57
% W.Balance/Demand	-37.43	-37.96	-38.56	-39.46	-40.45	-41.91	-42.87
Mashreq							
Available Water Resources	98.35	99.10	100.16	101.23	102.30	103.37	104.45
Total Water Demand	66.50	71.04	76.13	81.60	87.35	93.86	99.54
Water Balance	31.85	28.05	24.03	19.63	14.94	9.51	4.90
% W.Balance/Demand	47.90	39.48	31.57	24.05	17.11	10.14	4.93
West Asia							
Available Water Resources	116.99	119.01	121.32	123.75	126.34	129.07	131.87
Total Water Demand	96.29	103.15	110.57	118.80	127.73	138.10	147.54
Water Balance	20.70	15.86	10.75	4.95	-1.39	-9.03	-15.67
% W.Balance/Demand	21.50	15.38	9.72	4.16	-1.09	-6.54	-10.62

Assumptions :

1. *UN projection of population (1997) is applied.*
2. *Development of conventional and non-conventional water resources as Scenario II.*
3. *Demand Management and rational utilization of water: maintaining present (1995) per capita water consumption patterns in domestic and industry resulting in gradual saving reaching 2280 Mcm in the Arabian Peninsula and 4715 Mcm in the Mashreq in 2025, increasing irrigation efficiency, water pricing, etc. resulting in further gradual saving in water demands of about 8400 Mcm in the Arabian Peninsula and 9000 Mcm in the Mashreq in 2025.*

Table (10) Proposed Policy Matrix for Water Sector in West Asia

Policy	Planning and analysis	Legal and Institutional	Economic Regimes	Projects and programs
Priority of water supply for domestic, industry and agriculture, respectively.	• Water resources assessment & development. • Population growth projection. • Water demand projections. • Water quality monitoring.	• Protection zones for surface water supplemental, well-field, springs, and catchment area. • New competent authorities. • Control illicit connections. • Training of staff	• Increasing water tariffs for high segments of water demands. • Provision funds for M&O and new water facilities. • Strict regulation and penalties. • Wide application of metering system. • Water viewed as economic commodity. • Full participation of users. • Control of industrial intake & discharge points.	• Hydrological and hydrogeological studies. • Continuous maintenance of water facilities, and networks. • Construction of water purification plants, desalination plants for future needs. • Information, education and campaign to change consumer behaviour. • Improve sanitation condition
Settlement of shared water resources conflicts	• Negotiation. • Data and information.	• Regional/ international cooperation.		• Monitoring water flow (quality and quantity). • Drainage water treatment
Rational water use	• Mapping of connections to detect leakage.	• regulation to support water saving measures • detect and control illicit connections • Full application of metering system. • Adequate institutions and staff training for proper water use control.	• Proper water pricing. • Rotational check of metering system and reviewing water-supply costing.	• Application of water saving technologies and facilities. • Studies for rational water utilisation. • Information, education campaign to change consumer behaviour. • Regular calibration of meters. • Leakage detection and control. • Regular maintenance and rehabilitation of network.
Groundwater protection	• Comprehensive groundwater quality monitoring. • Conjunctive use of surface and groundwater.	• Controlling rate of pumping to prevent mining the reserve. • Coordination between concerned institutions for efficient management. • Application of metering system. • Adopt detailed well drilling licensing. • Stringent penalties for groundwater depletion and contaminations.	• Change irrigation charge system to be based on volume of drawn water. • Cancel subsidy for well drilling. • Appropriate incentives for application of water irrigation technology. • Review water tariff for domestic and industrial abstraction.	• Application of water saving technologies. • Update studies on groundwater availability for sustainable water management. • Artificial recharge. • Public awareness, campaign and educational programs.

Table (7) : Water Balance in West Asia (1000Mcm) - Scenario I (Business as Usual)

Sub-region / Year	1995	2000	2005	2010	2015	2020	2025
Arabian Peninsula							
Available Water Resources	18.64	18.64	18.64	18.64	18.64	18.64	18.64
Total Water Demand	29.79	33.70	37.70	42.19	47.18	52.95	58.68
Water Balance	-11.15	-15.06	-19.06	-23.55	-28.54	-34.30	-40.04
% W.Balance/Demand	-37.43	-44.68	-50.56	-55.82	-60.49	-64.79	-68.23
Mashreq							
Available Water Resources	98.35	98.35	98.35	98.35	98.35	98.35	98.35
Total Water Demand	66.50	72.95	80.06	87.69	95.74	105.00	113.26
Water Balance	31.85	25.40	18.29	10.66	2.61	-6.66	-14.91
% W.Balance/Demand	47.9	34.82	22.84	12.16	2.73	-6.34	-13.16
West Asia							
Available Water Resources	116.99	116.99	116.99	116.99	116.99	116.99	116.99
Total Water Demand	96.29	106.65	117.76	129.88	142.92	157.95	171.93
Water Balance	20.70	10.34	-0.77	-12.89	-25.93	-40.96	-54.94
% W.Balance/Demand	21.50	9.7	-0.66	-9.92	-18.14	-25.93	-31.96

Assumptions:

1. *No development of new water sources after 1995 is foreseen.*
2. *UN projection of population (1997) is applied.*
3. *Water demand for domestic and industry is secured.*
4. *Rates for Water consumption as shown in Appendix A.*
5. *Improvement in agricultural production researches to cut, eventually, 20% of agricultural water demand by 2025 as in Appendix A.*
6. *Settlement of shared water resources disputes.*

Table (8) : Water Balance in West Asia (1000Mcm) - Scenario II (Supply Augmentation)

Sub-region / Year	1995	2000	2005	2010	2015	2020	2025
Arabian Peninsula							
Available Water Resources	18.64	19.92	21.17	22.52	24.05	25.70	27.42
Total Water Demand	29.79	33.70	37.70	42.19	47.18	52.95	58.68
Water Balance	-11.15	-13.78	-16.54	-19.67	-23.14	-27.24	-31.26
% W.Balance/Demand	-37.43	-40.90	-43.87	-46.62	-49.03	-51.45	-53.27
Mashreq							
Available Water Resources	98.35	99.10	100.16	101.23	102.30	103.37	104.45
Total Water Demand	66.50	72.95	80.06	87.69	95.74	105.00	113.26
Water Balance	31.85	26.15	20.10	13.54	6.56	-1.64	-8.81
% W.Balance/Demand	47.9	35.84	25.11	15.44	6.85	-1.56	-7.78
West Asia							
Available Water Resources	116.99	119.01	121.32	123.75	126.34	129.07	131.87
Total Water Demand	96.29	106.65	117.76	129.88	142.92	157.95	171.93
Water Balance	20.70	12.36	3.56	-6.13	-16.58	-28.88	-40.07
% W.Balance/Demand	21.50	11.59	3.02	-4.72	-11.60	-18.28	-23.30

Assumptions :

1. Available water resources are developed as follows:

- *Groundwater at 100Mcm per year i.e. 3000 Mcm for each sub-region in 2025 (including artificial recharge and water harvesting).*
- *Desalination plants capacity is increased gradually to reach 3260 Mcm in the Arabian Peninsula in 2025, unchanged in Mashreq.*
- *Wastewater plants capacity is gradually increased to reach 5090 Mcm in the Arabian Peninsula (40% of domestic water) and 3000 Mcm in the Mashreq in 2025.*
- *Irrigation water reuse is gradually increased to reach 1622 Mcm in the Mashreq in 2025.*

2. UN projections of population (1997) are applied, Domestic and industrial consumption are secured, Rates of water consumption as shown in Appendix A, and Improvement in agricultural production researches, and settlement of shared water resources disputes as in Scenario I.

Table (9): Water Balance in West Asia (1000Mcm) - Scenario III (Supply Augmentation and

Table 1: Available Water Resources in West Asia (1995)

Sub-region / country / territory	Conventional Water Resources (Mcm)				Non-Conventional Water Resources (Mcm)			
	Surface Water	Groundwater			Desalination	Waste Water	Agricultural Drainage	Total
		Reserve [5]	Recharge [6]	Used				
Arabian Peninsula Sub-region								
Bahrain	-	-	- [7]	239	56	55	0	111
Kuwait	-	-	- [7]	255	240	103	0	343
Oman	1 450	10 500	955	1 223	34	26	0	60
Qatar	-	2 500	50	286	126	103	0	229
Saudi Arabia	3 210	84 000	2 340	17 000	795	526	30	1 351
U.A.E	150	20 000	125	1 615	385	102	0	487
Yemen	3 500	13 500	1 550	2 930	9	20	0	29
Sub-total	8 310 [1]	130 500	5 020	23 547	1 645	937 [2]	30	2 612
Mashreq Sub-region								
Iraq	60 000 [3]	NA [4]	2 000	NA	NA	77	0	77
Jordan	692	12 000	275	418	3	58	0	61
Lebanon	4 800	1 300	3 000	200	2	2	0	4
N.P.A.	710	NA	340	200	0	0	0	0
Syria	22 100	NA)	2 900	7 780	2	177	1 210	1 389
Sub-total	88 302	13 300	8 515	8 598	7	314	1 210	1 531
Grand Total	96 612	143 800	13 535	32 145	1 652	1 251	1 240	4 143

(1) Most are seasonal flow of wadi systems; (2) Represent capacity of wastewater treatment facilities, only 392 Mcm is reused for irrigation, the remains are used either for recharge purposes or disposed of to the sea; (3) Figures are subject of conflict between Turkey, Syria and Iraq (not yet reconciled); (4) No data available; (5) Groundwater reserves are rough estimates that need thorough verification; (7) Figures represent recharge to shallow alluvial aquifers in the Arabian Peninsula, recharge to deep aquifers in the Arabian Peninsula is estimated at 2700 Mcm/yr; (7) Recharge to aquifers by underflow from equivalent aquifers in Saudi Arabia, Bahrain = 90-110 Mcm/yr, Kuwait = 58-117 Mcm/yr.

Sources: compiled from GCC, 1996; FAO, 1997; AlZubari, 1997; AlAlawi and Abdulrazzak 1993, and official country reports.

adequately form the base on which the strategy would be formulated with possible suitable options. The work plan would include several stages with a number of parameters relevant to each stage. These are: 1) Collection and review of existing data and information; 2) Review and evaluation of previous development studies; 3) Current conditions of water resources, population growth, socio-economic conditions, land use, and water utilization and related legislation in force; 4) Evaluation of water resources potential; 5) Water demands forecast; 6) Water resources development planning framework; 7) Water resources management, institutional reform, water facilities; 8) rough estimate of total cost; 9) Evaluation of strategy formulation: financial, economic, and social analyses.

According to the evaluation result, the selected options and alternative for strategy formulation could be decided and programs, water projects, tariffs, new technologies and legal institutional reform could be recommended.

Water policies are usually projected over longer period and have normally unforeseen impact which is difficult to measure in details and my not be implemented as proposed, but respond to current need and priorities. Water policies may require continuous monitoring for progress, re-evaluation or even revision of priorities that meet obstacles, and therefore, monitoring policy actions would benefit policy management.

8. Acknowledgement

This study is funded by the United Nations Environment Program, The Regional Office of West Asia (UNEP/ROWA).

9. References

ACSAD, 1997, Water Resources and its Utilisation in the Arab World. Proceedings of the 2nd Water Resources Seminar, March 8-10, Kuwait.

Al-Alawi and Mohammed Abdulrazzak, 1993, Water in the Arabian Peninsula: Problems and Perspectives; in Water in the Arab World: Perspectives and prognoses, Division of Applied Sciences, Harvard University.

Al-Kuwaiti, KA, Al-Dhofar, MS, and AR Al-Jughaiman, 1999, Efforts on Raising Irrigation Water Use Efficiency in Al-Hassa Region, Saudi Arabia. Proceedings of the Fourth Gulf Water Conference, 13-17 February, Bahrain, Water Science and Technology Association.

Al-Zubari WK, 1997, Towards the establishment of a total Water Cycle Management and Re-use program in the GCC Countries. Proceedings of the 7th Regional meeting of Arab IHP committees 8-12 September 1997, Rabat, Morocco.

AOAD/95/RG, 1995, Water Use Policies in Arab Agriculture.

Arab Fund, 1995, The Economic Arabic Report, Sept. 1995.

Bushnak, AA, 1995, Desalination Technology and Economics. MEC Conference: Putting a Price on Water, 16-19 January, Bahrain.

FAO, 1993, The State of Food and Agriculture, 1993, FAO, Rome.

FAO, 1997, Irrigation in the Near East in figures. Water Report No.9, Rome.

GCC, 1996, Economic Report. No. 11. GCC General Secretariat, Riyadh, Saudi Arabia.

Government of Lebanon, 1997, The Country Study: Biological Diversity in Lebanon. Ministry of Agriculture, Lebanon.

Hamad, I, Abdelgawad, G, and F Fares, 1997, Barada River Water Quality and its use in Irrigated Agriculture, Case Study. UNEP-ROWA/AGU Regional Workshop on the Technologies of Wastewater Treatment and Reuse, 2-4 June, Bahrain.

rational exploitation of groundwater aquifers, water importation, and desalination of brackish and sea water.

Modelling is a useful technique to assess complicated water source systems and, provided that the data are reliable and adequate, offers planners and decision makers useful projections of sustainable aquifer yields, estimates of long term supplies and demands and approaches to optimising the use and allocation.

6.2 Legal and Institutional Reforms

Water legislation is closely linked with the development of other natural resources, especially in arid regions such as West Asia where environmental conditions are vulnerable and sensitive to deterioration. Water legislation in West Asia is not keeping pace with the demand for water resources and there is an urgent need to review critically all of the existing legislation and how it relates to the policy options under review. The main areas of legislation that require amendment includes water rights, water abstraction, water quality and environmental standards, water charging policy, water pollution and environment protection, groundwater protection from depletion and contamination, wastewater treatment, and solid waste disposal.

Amended legislation itself will not be effective in implementing new policy without a significant reorganisation of the water administrations, especially the decentralisation of the power and influence of the central governmental bodies responsible for water resources development and management. Indeed, institutional weakness constitutes a major constraint on the management of water resources in most of the countries of West Asia. This is a direct consequence of ill-defined responsibilities of the institutions dealing with water research, investigation and studies, planning and management, and the absence of updated powerful legislation to enforce coordination and collaboration between the different authorities at local, regional and national levels. Cross-sectoral coordination between the water, agriculture, housing, industry, and planning governmental directorates is also required for efficient and successful policy formulation. Capacity building among the technical staff of research institutes and other water and agricultural administrations is also badly needed to keep pace with the fast progress in researches achieved in various field of water, agricultural technologies, and socio-economic sciences, and to prepare competent generation of scientists and professionals to efficiently mange the limited water resources under the prevailing arid environment.

6.3 Economic Considerations

There are strong links between the national economy and water resources management. National development strategies directly influence water allocation and use as in the case of strategies for food self-sufficiency, while policies to promote exports and foreign exchange earnings from highly priced cash crops call for increased investments in irrigation schemes. The implementation of effective and efficient water resources policies are greatly hindered by the shortage of financial resources, therefore future sustainable water policies must have positive impacts on central government finances from new tax revenues, prices and charges, and the reduction of subsidies.

Economic incentives could provide effective instruments to rationalise water use provided that they do not act against other key economic factors. Possible incentives include water tariffs for domestic and industry water supply, charges for abstraction, irrigation, wastewater and pollution, and soft loans for modernising equipment. While setting economic charges for polluting water may be the best way of discouraging industrial water pollution, with pollution charges proportional to the volume and the quality of effluent, difficulties may be encountered in implementation through lack of enforcement procedures. The same caveat applies also for irrigation charges, based on metering consumption, area irrigated, type of crop, or length of irrigation time. Groundwater pricing should be based on quantity-based prices and charges as it is both economically and administratively efficient (FAO, 1993) to encourage conservation and efficient use.

Scenario2 takes further into consideration the outcome of the intensive foreseen investigations and research works in various fields for both conventional and non-conventional water sources that would eventually yield an additional 6,000 Mcm in conventional water resources and an additional 8,870 Mcm in non-conventional water resources by 2025.

In Scenario 3, extensive research, investigation, development and reform programs would be essential to develop the additional water resources foreseen in Scenario 2, and affect optimum rationalization of water use, minimization of water losses to gain by 2025 about 24,400 Mcm. This might be achieved through the resolutions of the major snags and problems that impede efficient use of the limited available water resources as outlined in Table (10).

It should be noted that all scenarios are quantitative and do not take into account the impact of groundwater overdraft on the quality of groundwater withdrawn. i.e., it assumes withdrawn water will be usable. Mining and over-exploitation of shallow and deep aquifers, particularly in the Arabian Peninsula, will be associated with an inevitable deterioration of water quality and loss of groundwater usefulness and readiness, in addition to salinization of agricultural lands, which in turn will affect these projections in a dynamic manner.

The results of these Scenarios are shown in Tables (7), (8), and (9), whereas proposed remedy policies with scope of desired actions for implementation are outlined in Table (10). The successful implementation would be the milestone for paving the long intricate path towards coping with the water scarcity in this region. However, failure to achieve the set targets of saving the agricultural water demand would result in deterioration of both the quantity and quality of water supplies, widening food deficits, deterioration of standard of living, inflamed social unrest and possible regional conflicts. Furthermore, the assumptions built into the other Scenarios will delay these problems, not solve them, unless stringent measures are put into force, and policy shifts, including population policies, are strictly implemented.

5.1 Scenario 1 - Business as Usual

The Arabian Peninsula will suffer from acute water shortages and would fail to fulfill the set policy of maximum food production. Water balance will maintain a deficit all through. Percentage of deficit to water demand will increase from -37.4% in 1995 to -68.2% in 2025. Total water deficit of some 40 Bcm in 2025 is foreseen.

The Mashreq sub-region will be better off up to the year 2015, where water balance will be on the positive side up to this year. Percentage of water balance to water demand will be reduced from +47.9% in 1995 to -13.2% in 2025. A water deficit of about 15 Bcm is foreseen in 2025. The major problem encountered in this sub-region is the reconciliation of the shared water resources with the neighboring countries, which will considerably affect the development plans of most countries if earlier equitable resolution is not reached.

For West Asia as a whole, this Scenario suggests a deficit starting in 2005 and escalating to 55 Bcm in 2025. Percentage of water balance to total demand will vary from +21.5% in 1995 to -32% in 2025. The above results assume fulfilling the reduction in agricultural water demand and settlement of dispute of shared water resources as stipulated in the assumption.

5.2 Scenario 2 - Supply Augmentation

Under the assumed supply augmentation, water deficit in the Arabian Peninsula will be slightly reduced to 31.3 Bcm in 2025, while the percentage deficit in the water balance to total demand will increase from 37.4% in 1995 to 53.3% in 2025. In contrast, there should be relatively smaller deficit in overall water resources in the Mashreq (-9 Bcm) in 2025, and the percentage of water balance to total demand will decrease from +47.9% in 1995 to a critical -7.8% in 2025.

For West Asia as a whole, there will be a deficit of 6.1 Bcm in 2010 reaching 40 Bcm in 2025, mainly due to Arabian Peninsula deficit. Percentage of water balance to the demand will drop from +21.5% in 1995 to -23.3% in 2025.

resources in 1995 of 117 Bcm (96,612 Mcm surface water, 16,235 Mcm rechargeable groundwater and 4,143 Mcm non-conventional water resources; Table 1), the anticipated water demand in 2025 of 172 Bcm (Table 5) and the deteriorating water stress index, it is clear that current water resources cannot satisfy future water demand much past 2005, unless positive steps are taken soon to manage and rationalise water demands, increase and augment supply, and impose realistic controls on use.

The Arabian Peninsula is already suffering from a deficit in water resources. The 1995 total annual water demand of 29.8 Bcm is estimated to grow to 58.7 Bcm by 2025, whereas the total available water could hardly exceed 18.6 Bcm. Under these circumstances it will be difficult to maintain the regional emphasis on maximum food production and the widespread import of foodstuffs will become necessary. Currently the water deficit is compensated for mainly by the over exploitation of shallow and deep fossil aquifers, in addition to the extensive installation of highly expensive desalination plants, with the negative impacts of fast depletion of aquifer reserves and deteriorating water quality and salinization of agricultural lands. Furthermore, existing wastewater treatment facilities can cope with only 35% of the urbanised and industrial waste disposal. Pollution from inappropriate disposal of untreated wastewater will create health hazards through the contamination of shallow groundwater aquifers.

The countries of the Peninsula have made great efforts in developing additional sources of water and augmenting their water supply. These efforts are represented essentially by the extensive installation of highly expensive desalination plants, expansion in wastewater reuse, and constructing dams to capture and store surface runoff for irrigation and enhancing shallow aquifer recharge. At present the total capacity of the dams in the Arabian Peninsula is about 795 Mcm (475 Saudi Arabia, 180 Yemen, 80 UAE, and 58 Oman). It is anticipated that desalination plants output will reach about 3,000 Mcm by the year 2020. However, this volume would be able to satisfy less than 34% of the projected domestic water demands for the year 2020, and to secure domestic needs groundwater withdrawal to compensate for the remaining volumes would become inevitable. Treated wastewater reuse in agriculture, at best, can reach up to 4,000 Mcm (about 40% of the projected domestic water demand) by the year 2025. This volume could contribute by only a small fraction (about 9%) of the anticipated agricultural water demands by the year 2025.

On the other hand, conservation and demand management have not taken much attention as one of the major component in the water management programs in the countries of the Peninsula. Conservation measures should be concentrated on the agricultural sector, the largest water consumer in the Peninsula at about 85% of the total water used, and where major and effective saving can be achieved. Current irrigation efficiencies are low at 30-45% levels, resulting from the widespread use of traditional irrigation practices, and the lack of monitoring and tariffs for irrigation water. In the domestic sector, present per capita water use is high, averaging 275 L/d (range 85-745 L/d), due to lack of public awareness and low water tariffs that do not discourage excessive water use or waste.

These issues are all aggravated by a general weakness among the institutions dealing with water affairs, by inadequate technical capabilities and training, and from unsatisfactory coordination with other concerned water authorities.

The Mashreq sub-region, with nearly six times the renewable water resources of the Arabian Peninsula, is in a much better situation. However, available water resources (98.4 Bcm) can, theoretically, only sustain the projected use up to the year 2015 (95.7 Bcm). The main obstacle facing this sub-region is the potential conflicts that are outcropping concerning the equitable distribution of a sizeable portion of the shared water resources (surface and groundwater) between the member states and their neighbours. This has not yet been resolved, and could be a serious issue to disturb forthcoming development plans and hinder reliable future planning, if not reconciled. Furthermore, strict control measures are called for to curb current problems related to over exploitation, inefficient reuse of wastewater, and untreated industrial waste and pollution of shallow aquifers. Institutional capacity building and enforcement of legislation also require attention.

Table 6 summarizes the prevailing problems and critical issues in the water sector of West Asia, arranged in a descending order of seriousness. These problems are common in countries of both sub-

urban uses (irrigating gardens, parks, and road ornamentals), fodder crops irrigation, and highway landscaping (Al-Zubari, 1997), which does not give these waters their economical value under the present water shortage conditions in the Peninsula. The remainder is dumped at disposal areas to infiltrate the shallow aquifers, or to the sea.

However, most of the Arabian Peninsula countries have ambitious plans for the expansion in the utilization of reclaimed wastewater as a strategically alternative source to meet their future demands of irrigation water and to reduce groundwater abstraction. Recycled treated wastewater volumes are expected to increase to about 3,000 Mcm by the year 2020, with water used mainly as a substitute for groundwater in irrigation. In the Mashreq, wastewater, except in large cities, is discharged into watercourses and only part of it (about 240 Mcm/yr) is reused for irrigation purposes.

Recycled irrigation water is not used much in the Arabian Peninsula since excess irrigation water infiltrates the lower horizons and ultimately reaches the groundwater table; only in Saudi Arabia, in Al-Hassa Oasis about 30 Mcm/yr of irrigation water is reused in agriculture by mixing it with groundwater (Al-Kuwaiti et al., 1999). In the Mashreq sub-region only Syria exploits these water sources, some 1,210 Mcm being recycled annually. This source has, however, future potential given proper irrigation practices are applied. Other forms of non-conventional water sources, such as rainwater harvesting, weather modification, etc. are still in the research stage.

3. Status of Population Growth and Water Demand

Population growth in West Asia is a major issue affecting all sustainable socio-economic development. The estimated 1995 population was 85.6 million (UNSPD, 1997) with an average growth rate of 3.73% for the Arabian Peninsula, considered the highest rate global wise (Arab Fund, 1995) and 3.0% for the Mashreq countries. The large increase in the population was due to marked improvement in the standard of living and health of the population, and in the case of the Arabian Peninsula, due to the influx of a large number of expatriates in order to meet the fast-growing development demand for manpower (expatriate population in the Peninsula countries range from 25% to 85%). Furthermore, population policies that have been adopted in some countries of the region during the last three decades encouraged population growth with different economic instruments, which took various forms of subsidies and incentives. Social traditions, appropriate economic climate and religious beliefs played an important role in mounting population growth, which became difficult to control at later stage. Generally, policies for controlling population increase have failed to produce significant results.

Population projections for the countries of West Asia over the period of 1995-2015 are given in Table 2 (UNSPD, 1997). It is anticipated that total population of West Asia will reach about 188 million by the year 2025 (96 million for the Arabian Peninsula and 92 million for the Mashreq).

In the past two decades, the need felt for food security, or food self-sufficiency in certain items, for the fast growing population have prompted decision-makers in most of West Asia countries to encourage agriculture. This was made through subsidy and incentive programs, and has resulted in a large scale expansion of farming activities with substantial water requirements, satisfied in the case of the Arabian Peninsula sub-region by mining the deep aquifers. Furthermore, unregulated pumping along with lack of enforcement of rules against unlawful drilling, and poor irrigation practices has resulted in substantially excessive agricultural consumption (Alalawi and Abdulrazzak, 1993).

The national economy of most countries of West Asia depends on oil and oil-related industries, commerce, light industries and agriculture in this descending order. Due to the fast increase in population and urbanisation, domestic water and industry needs are escalating at rates that the available water resources cannot keep pace with. Furthermore, the adopted policy of food self-sufficiency imposes continual constraints on the allocation of water resources, which would otherwise reduce the share for agriculture in favour of increased domestic and industrial demand. These needs are exaggerated by the lack of effective conservation programs and inadequate tariffs and charges for water use, leading to high per capita water consumption rates in the domestic sector.

- Continuous deterioration of water quality and reduction in the yield of heavily exploited aquifers;
- Modest programs for the treatment of water and sewage from developing urban communities;
- Inefficient methods of wastewater treatment and solid waste disposal; and
- Lack of a solution to the issue of rapid population growth.

2. Status of Water Resources

Conventional Water Resources

The great majority of the region (>72%) has an annual rainfall of less than 100 mm. Some 18% receive between 100-300 mm and less than 10% between 300-1300 mm (ACSAD, 1997). About 80% of the region is therefore classified as semi-desert or desert land (AOAD, 1995), 16% is subject to desertification and only 11% is suitable for agriculture (of which 2.5% is under irrigation and 8.6% under rainfed cultivation).

Estimates of conventional (surface and groundwater) and non-conventional (desalinated water, wastewater and agricultural drainage) water resources in the region as of 1995 are given in Table 1. Annual rainfall provides around 434,000 million cubic meters (Mcm) (ACSAD, 1997), of which 41% falls in the Mashreq, and 59 % in the Arabian Peninsula. The Mashreq is potentially better in surface water resources, having two shared river system (Tigris and Euphrates) which originate from the temperate zone outside the border with annual rainfall over 700 mm. It also has a number of short perennial coastal and inland rivers, which are fed by winter rainfall - 40 in Lebanon, draining more than 46% of the country's precipitation (Government of Lebanon, 1997), and a series of sizeable karstic springs located at the slopes and feet of the mountains. The surface water resources are estimated at about 88,300 Mcm in the Mashreq sub-region.

By contrast, the Arabian Peninsula is poor in surface water resources due to the infrequent and low amounts of rainfall. The only areas receiving enough rainfall to generate reasonable amounts of runoff are the southwestern parts of Saudi Arabia, most of Yemen, the southern parts of United Arab Emirates, and the southern parts of Oman. Annual surface runoff volume in the Peninsula is estimated to average 8,310 Mcm with very high yearly variation. These waters are utilized in flood irrigation, and impounded behind dams, and they also usually recharge the alluvial aquifers beneath wadis (Alalawi and Abdulrazzak, 1993).

Groundwater exists in both sub-regions, including both shallow and deep aquifers. In the Arabian Peninsula, groundwater in the shallow alluvial aquifers, located along the main wadi channels and the flood plains of drainage basins, is the only renewable water resource, with an approximate annual recharge of 5,020 Mcm/yr. The estimated annual recharge is better for Mashreq (8,515 Mcm/yr) where rain frequently fall at low/medium intensity with long duration which favours groundwater recharge. The reserves of shallow aquifers are estimated at 130,500 Mcm in the Arabian Peninsula and a crude figure of 13,300 Mcm is available for the Mashreq. The coastal alluvial aquifers, particularly of the Arabian Peninsula, are subject to salt-water intrusion due to extensive groundwater withdrawal for domestic and irrigation purposes. This has caused salinization of coastal agricultural lands, resulting in the reduction of the agricultural production, and the complete loss of some arable land.

The main source of water for the countries of the Arabian Peninsula is the non-renewable fossil groundwater stored in the sedimentary deep aquifers. These store significant amounts of groundwater that is thousands of years old. Deep groundwater reserves are estimated at 2,175 Bcm with the major portion (1,919 Bcm) located in Saudi Arabia (Alalawi and Abdulrazzak, 1993). However, recharge to all deep aquifers is estimated at a very limited 2.7 Bcm per year. The quality of the deep aquifers varies greatly, being suitable for domestic consumption in only few areas. Most of the water from these deep aquifers is used for agricultural purposes.

Groundwater resources of West Asia in general, and the Arabian Peninsula in particular, are in a critical conditions because the volumes withdrawn far exceed natural recharge rates, resulting in