Water Status in the ESCWA Region

Presented By:
Dr. Rawya Kansoh

BACKGROUND

The region covered by the ESCWA member countries is about 4.75 million square kilometers, of which about 97.7 per cent is classified as arid and semi arid. Therefore, water in this region is very scarce. The per capita water share is just above the international poverty thresh hold of 1000 m^3/capita/year. Not only that, but:

- 8 ESCWA countries have less than 500 m^3/capita/year (Bahrain, Jordan, Kuwait, Qatar, Palestenian Authority, Saudi Arabia, UAE, Yemen) and
- 6 countries out of the eight (Bahrain, Jordan, Kuwait, Qatar, UAE, Yemen) have even less than 200 m^3/capita/year and are among the world's 15 poorest countries in water

BACKGROUND-*Continued*

•Water resources issues are more significant in this region than in any other part of the world. At present, a clear imbalance between available water resources and water demands exists in most of the countries of the region, with the remaining countries approaching critical conditions.

ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA

Map No. 3938 Rev. 1 UNITED NATIONS
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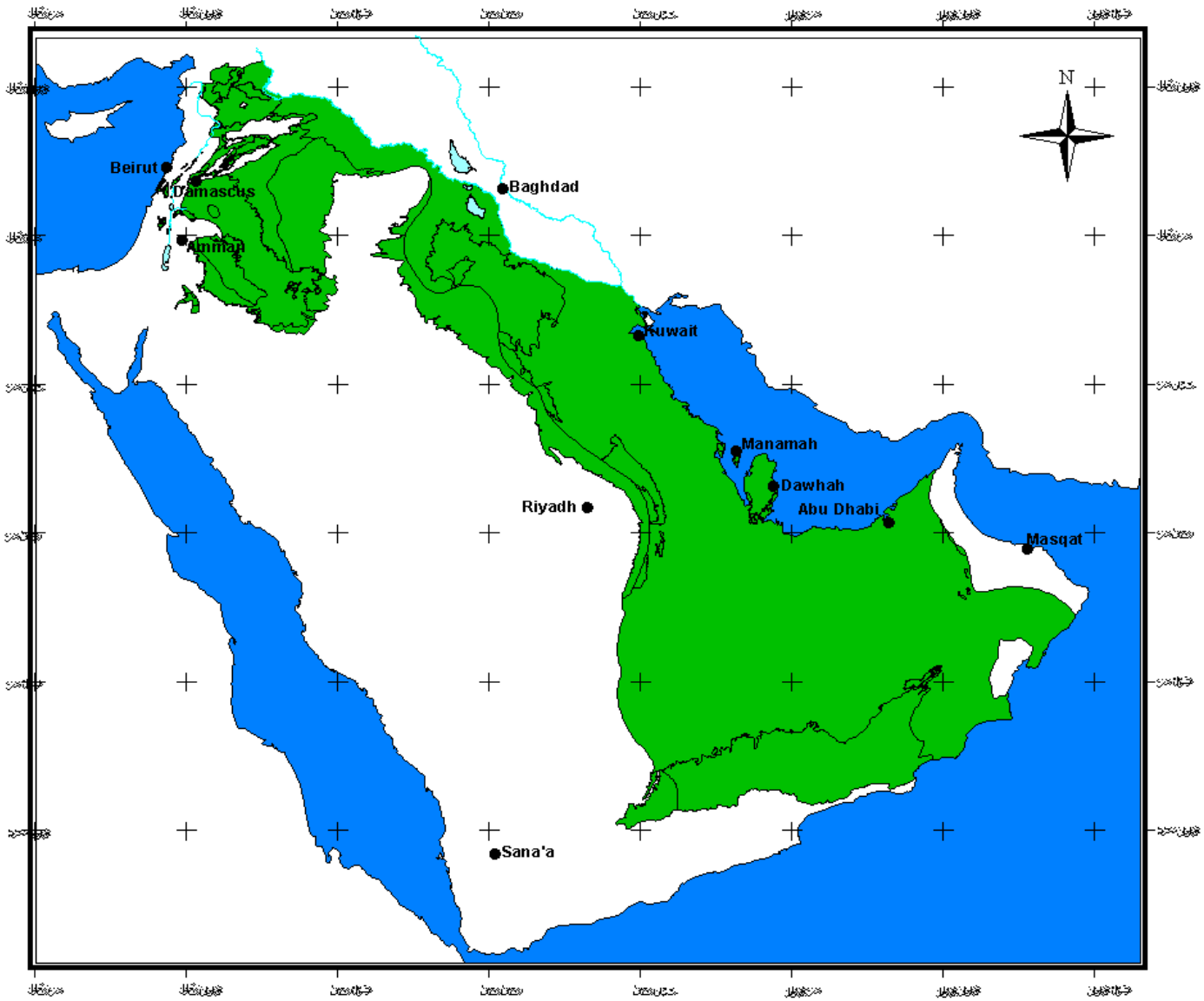
Department of Public Information
Cartographic Section

Extent of Major Paleogene Aquifer Systems



Water Resources Status in the ESCWA Region

- The region covered by the ESCWA member countries is about 4.75 million square kilometers, and 97.7 per cent of this area is classified as arid and semi arid

- The ESCWA region can be classified into three groups depending on the climatic, hydrological and geological regimes.

Water Resources Status in the ESCWA Region *Continued*

- **The first group** consists of countries situated in arid zones. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.
- **The second group** countries are situated in semi arid zones. Palestine and some parts of Jordan and Yemen.
- **The third group** countries are situated in relatively semi-arid zones. Egypt, Iraq, Lebanon and the Syrian Arab Republic

TABLE 1. RENEWABLE AND NON-CONVENTIONAL WATER RESOURCES

	Conventional water resources [a/b/c]			Non-conventional water resources			
Country/Area	Surface water	Ground water recharge	Ground water use	Desalination	Wastewater & Drainage reuse	Water consumption	Utilization %
Bahrain	0.2	100	258	75	17.5 (3)*	310	309
Egypt	55500	4100	4850	6.6	4920 (3800)	65760	102
Iraq	70370	2000	513	7.4	1500	49100	78
Jordan	350	277	486	2.5	61	760	121
Kuwait	0.1	160	405	388	30	701	439
Lebanon	2500	600	240	1.7	2	1225	40
Oman	918	550	1644	51	23	1721	117
Qatar	1.4	85	185	131	28	298	345
Saudi Arabia	2230	3850	14430	795	131 (24)	16300	268
Syria	16375	5100	3500	2	1447 (1270)	9810	46
U.A.E.	185	130	900	455	108	1223	388
W. bank & Gaza Strip	30	185	200	0.5	2	440	205
Yemen	2250	1400	2200	9	52	2900	779
Total	150710	18738	29811	1925	8322	150548	

Source: Completed by ESCWA Secretariat from country paper prepared at EGM and international sources 1995, 1996, 1997, and 1999.

a/ The flow of the Tigris and Euphrates rivers can be reduced by upstream abstraction in Turkey.

b/ ACSAD paper submitted to the 2nd Symposium on Water resources development and Uses in the Arab World, Kuwait, 8-10 March 1997.

c/ Consolidated Arab Economic Report 1997.

* Drainage water reuse

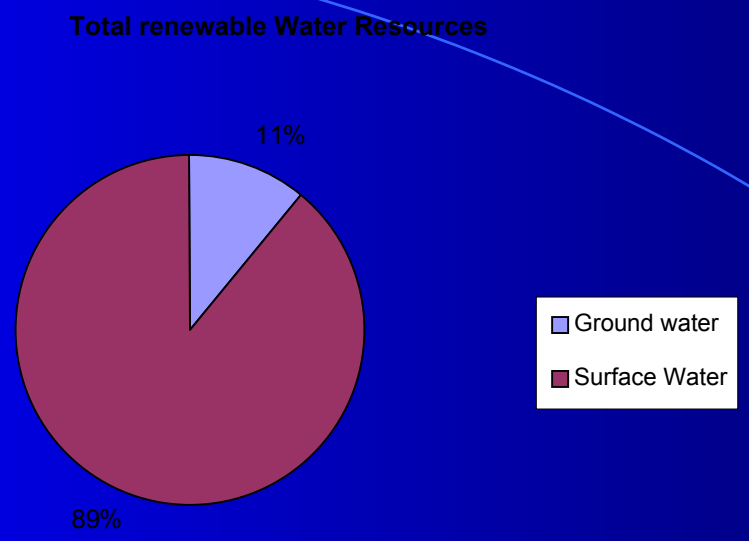
TABLE 2. GROUND WATER DEPENDENCY IN THE REGION IN MCM

Country/Area	Renewable water Resources					Ground water use (MCM)
	Surface water (MCM)	Ground water (MCM)	Total (MCM)	Ground water Dependency (%)	Total Renewable & Non-conv. Res., (MCM)	
Bahrain	0.2	100	100.2	99.80	196	258
Egypt	55500	4100	59600	6.88	68,327	4850
Iraq	70370 *	2000	72370	2.76	73877	513
Jordan	350	277	627	44.18	691	486
Kuwait	0.1	160	160.1	99.94	578	405
Lebanon	2500	600	3100	19.35	3104	240
Oman	918	550	1468	37.47	1542	1644
Qatar	30	185	215	86.05	218	200
Saudi Arabia	1.4	85	86.4	98.38	245	185
Syria	2230	3850	6080	63.32	7030	14430
UAE	16375 *	5100	21475	23.75	24194	3500
Palestine Auth.	185	130	315	41.27	878	900
Yemen	2250	1400	3650	38.36	3711	2200
Total, BCM	150.71	18.54	169.25	10.95	184590	29811

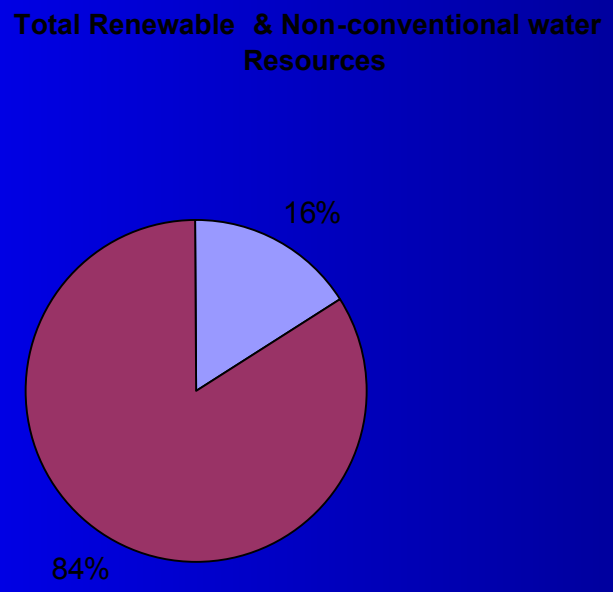
Source: Papers presented at the EGM on Non-conventional Water Resources on the Application of Appropriate Technology for the

Management of Groundwater Resources in the ESCWA Region. October 27-30, Manama, Bahrain 1997.

Figure (1) Water Resources in percentage



GW contribution to total annual renewable resources is at 11 %



GW contribution to total Renewable and non-Conventional resources is at 16 %

TABLE 3. SUFFICIENCY OF RENEWABLE WATER RESOURCES IN THE ESCWA REGION

Country/ Area	Renewable water resources (mcm)			Annual water per capita** $(m)^3$			Sustainability indicator*** (%)		
	Surface water	Ground water	Total	1997	2015	2025	1997	2000	2025
Bahrain	0.2	100	100.2	137	131	99	309	349	608
Egypt	55,500	4,100	59,600	925	698	658	110	115	145
Iraq	70370	2000	72370	2,963	1,832	1,359	68	88	118
Jordan	475	277	752	168	78	70	101	168	235
Kuwait	0.1	160	160.1	89	62	57	438	500	874
Lebanon	2,500	600	3,100	995	437	341	40	53	124
Oman	918	550	1,468	613	403	309	117	103	169
Qatar	1.4	85	86.4	98	70	60	345	580	943
Saudi Arabia	2,230	3,850	6,080	311	182	150	268	292	398
Syrian Arab Republic	16,375*	5,100	21,475	1,438	948	609	46	80	110
U.A.E.	185	130	315	137	103	67	388	692	1,015
W. Bank & Gaza Strip	30	185	215	-	-	-	205	230	600
Republic of Yemen	2250	1,400	3,650	303	165	114	79	72	97
Total	**152,335**	**18.5**	**169,372**	**-**	**-**	**-**	**-**	**-**	**-**

Source: Papers presented at the EGM on Non-conventional Water Resources on the Application of Appropriate Technology for the Management of Groundwater Resources in the ESCWA Region. October 27-30, Manama, Bahrain 1997.

* The flow of rivers can be reduces by upstream abstraction;

** Water barrier index. Renewable resources/population;

*** Sustainability indicator. Water use/renewable resource. Future sustainability is based on 2000 and 2025 water demand programs (10-20% indicate better management practices while more than 4% mismanagement).

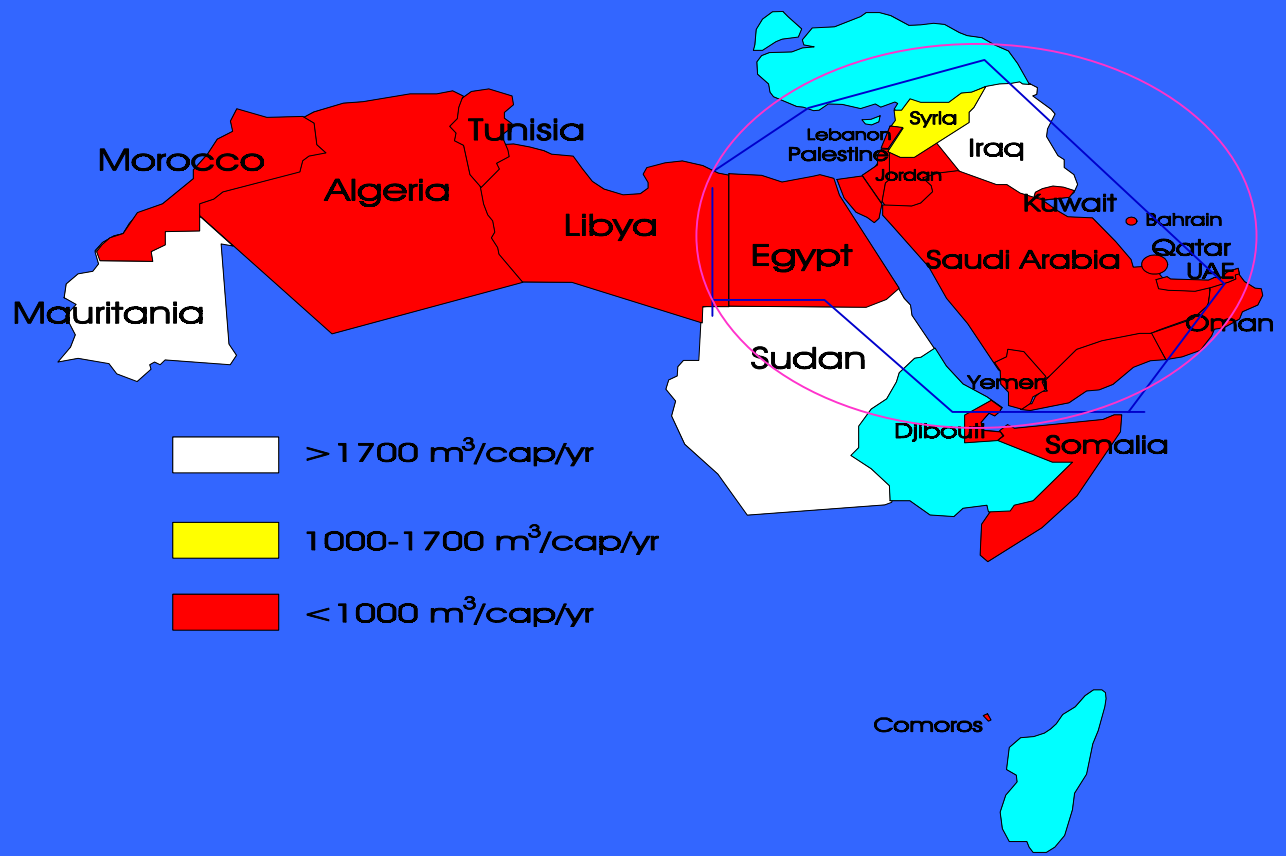
\- Indicates data not available.

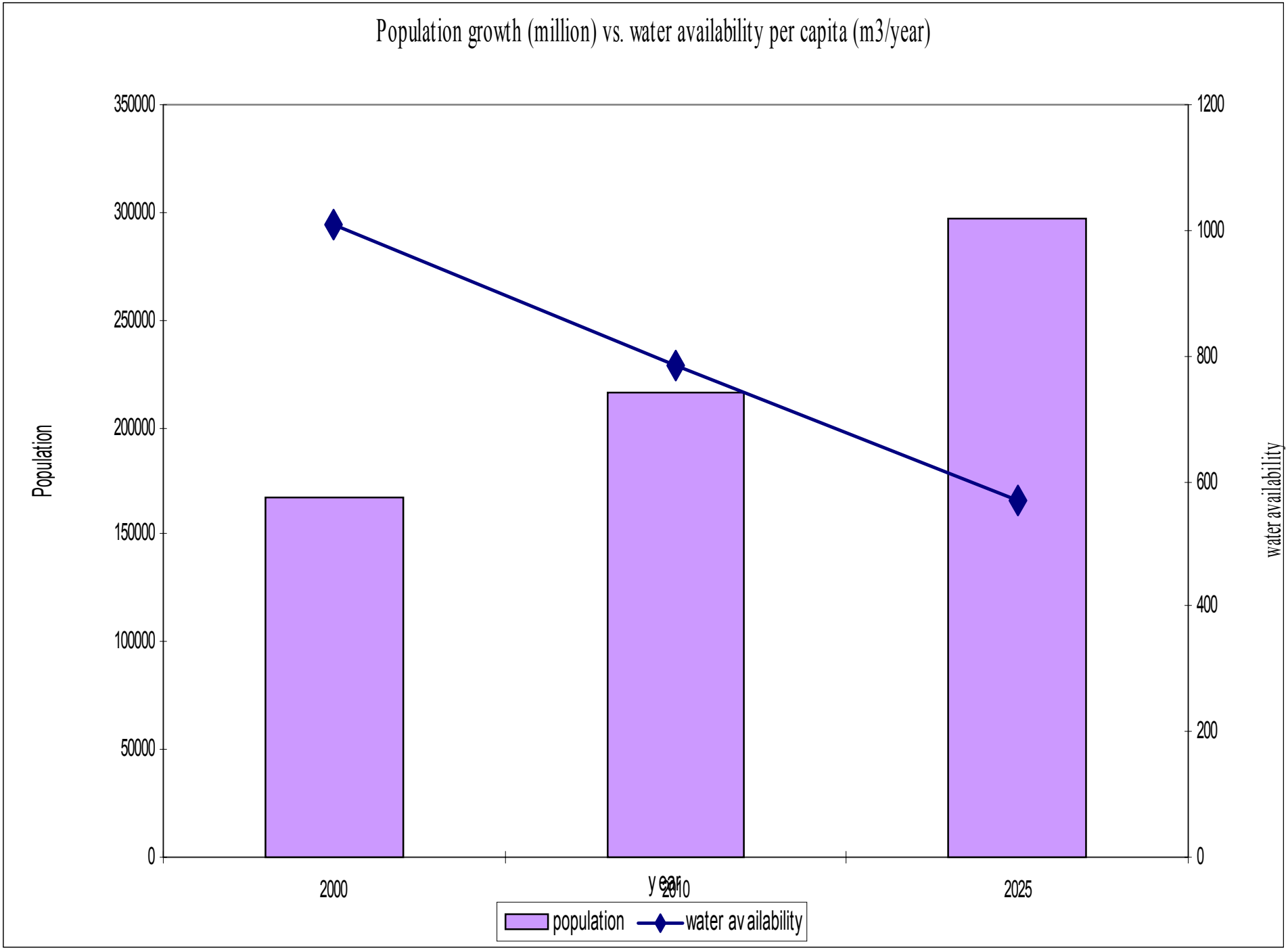
Water Scarcity-1975

Annual Renewable Water Resources - m^3/cap/yr
1975

Water Scarcity - 2050 Medium Projection

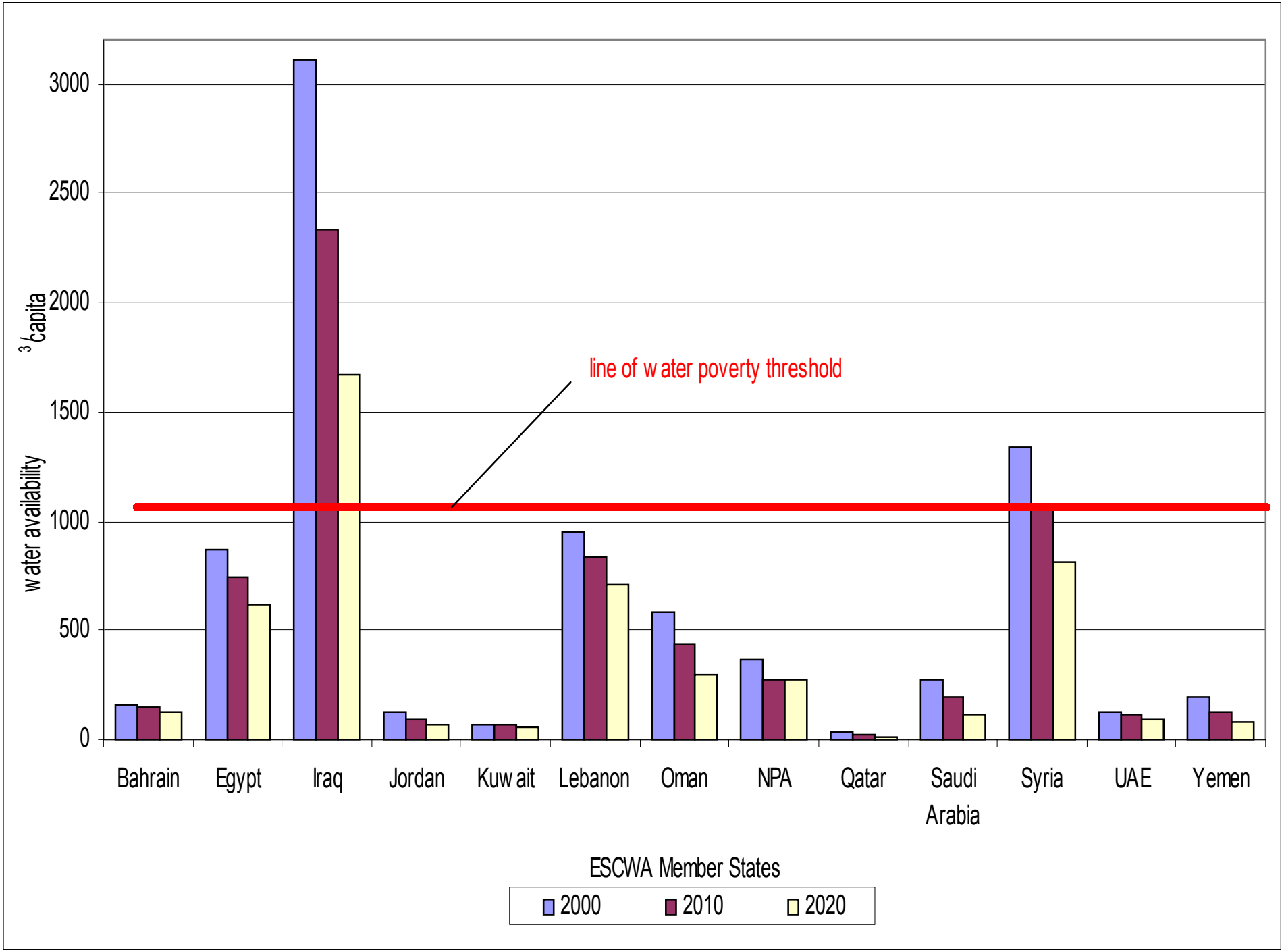
Annual Renewable Water Resources - m^3/cap/yr
2050
(Note: Based on present gross water consumption and "medium" population forecast)

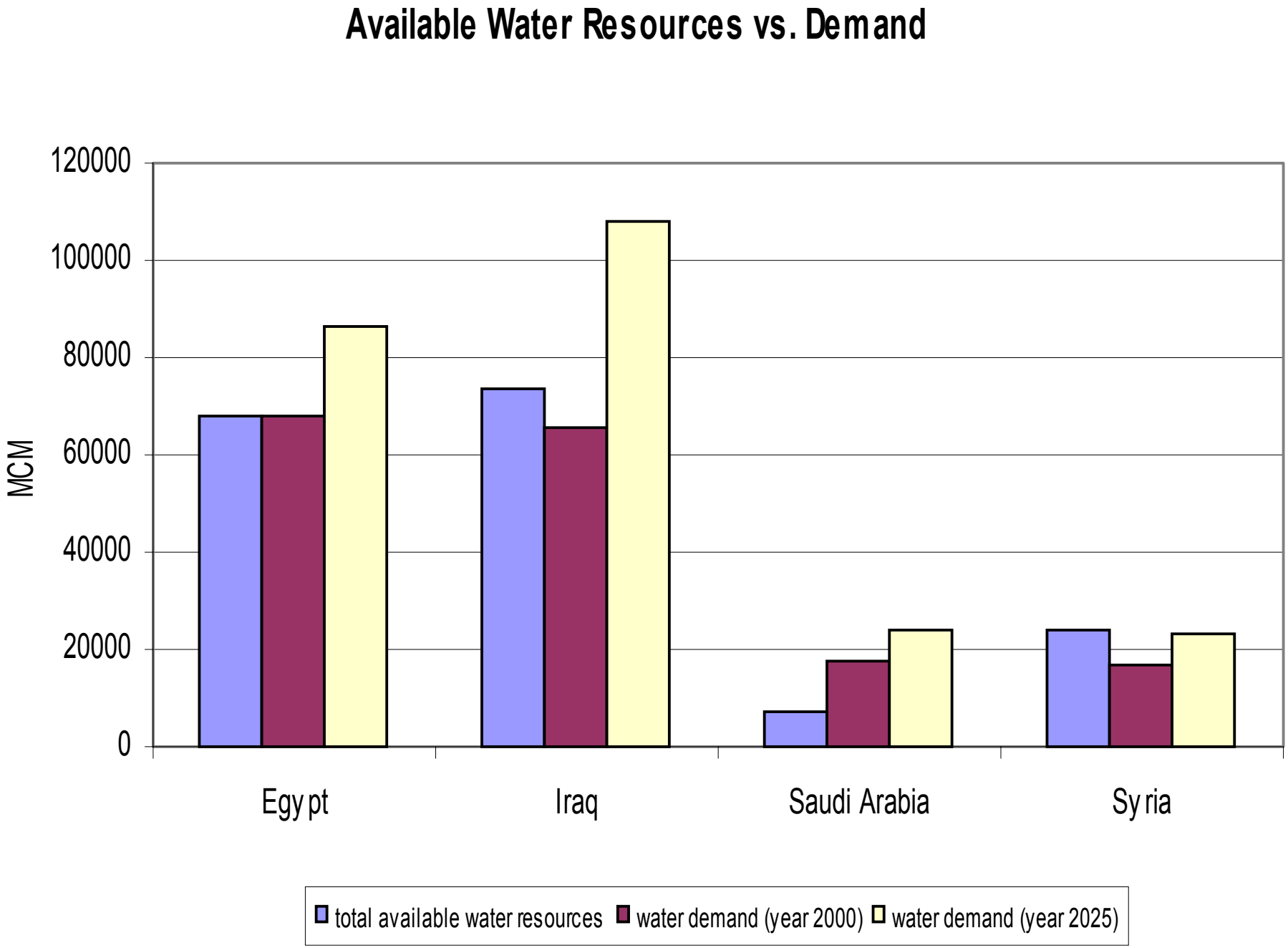



Population growth (million) vs. water availability per capita (m3/year)
Population
water availability
year
350000
300000
250000
200000
150000
100000
50000
0
1200
1000
800
600
400
200
0
2000
2010
2025
population
water availability

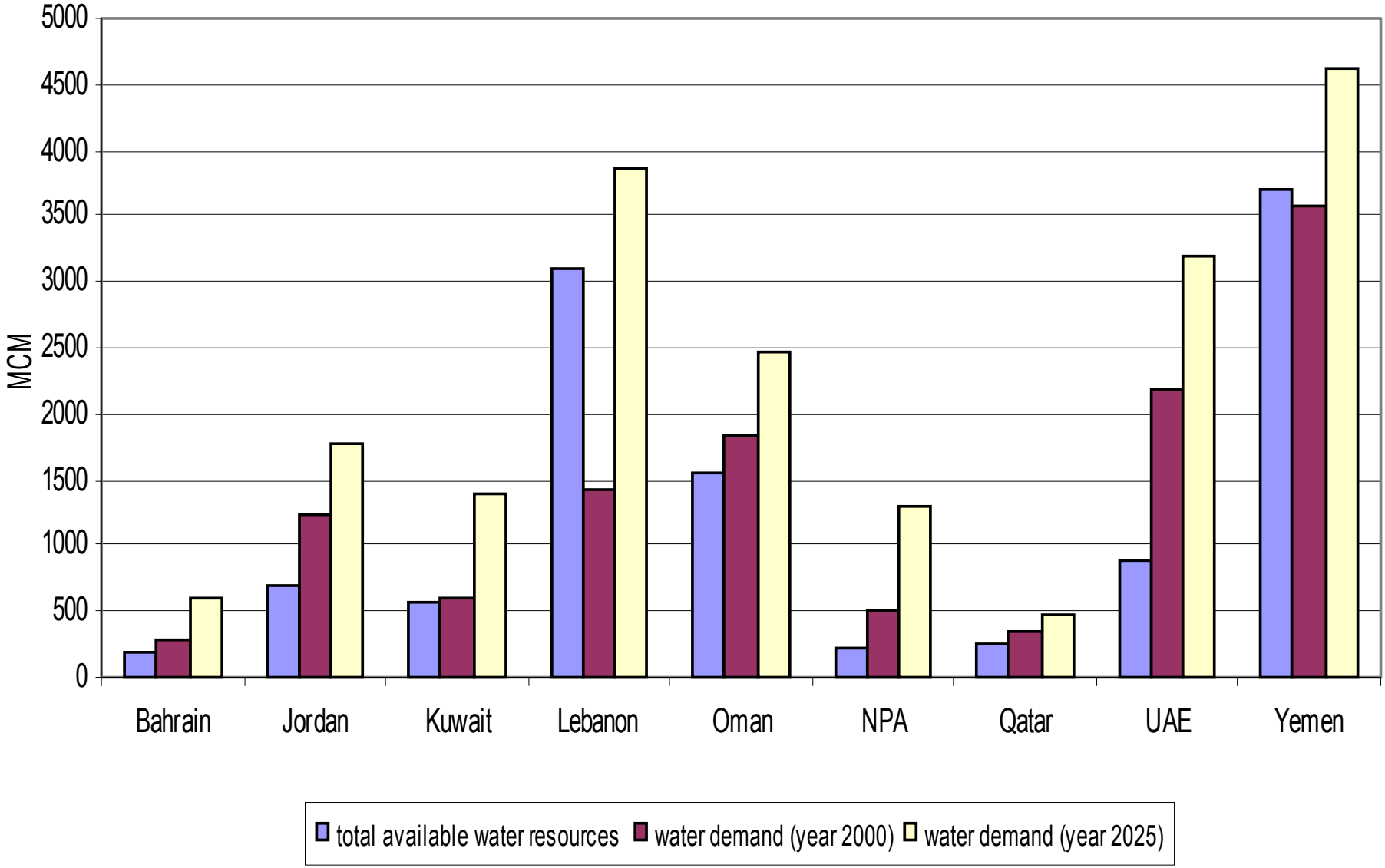
Water Availability

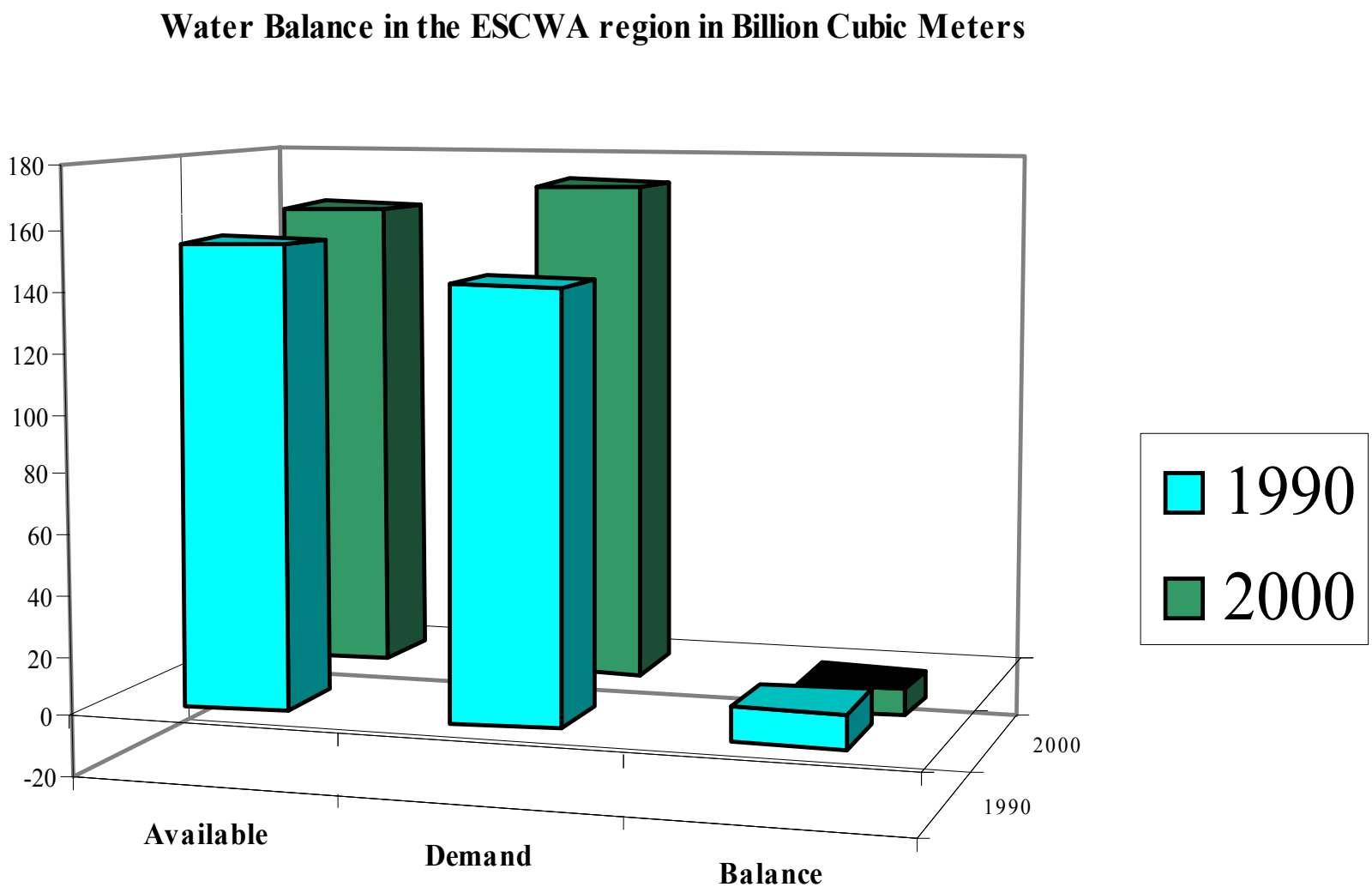
- The continually increasing imbalance between supply and demand is hindering the social and economic development in the region


3000
2500
2000
1500
1000
500
0
water availability
3/capita
line of water poverty threshold
Bahrain
Egypt
Iraq
Jordan
Kuwait
Lebanon
Oman
NPA
Qatar
Saudi Arabia
Syria
UAE
Yemen
ESCWA Member States
2000
2010
2020


Available Water Resources vs. Demand
120000
100000
80000
60000
40000
20000
0
MCM
Egypt
Iraq
Saudi Arabia
Syria
total available water resources
water demand (year 2000)
water demand (year 2025)

Available Water Resources vs. Demand




Water Balance in the ESCWA region in Billion Cubic Meters
180
160
140
120
100
80
60
40
20
0
-20
Available
Demand
Balance
2000
1990
1990
2000

Water Allocation

- The agricultural sector is the largest water user in the region estimated as 83 % of the total water use

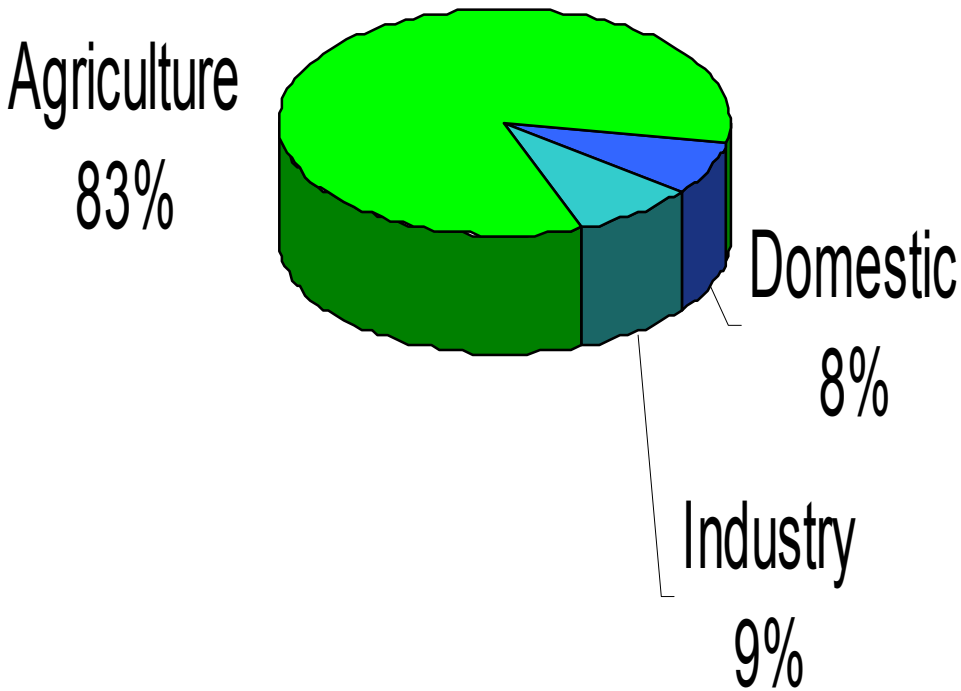
- Domestic water requirement at 8 % and industrial requirement at 9 % represent only a small fraction of the total water utilized

Water Desalination

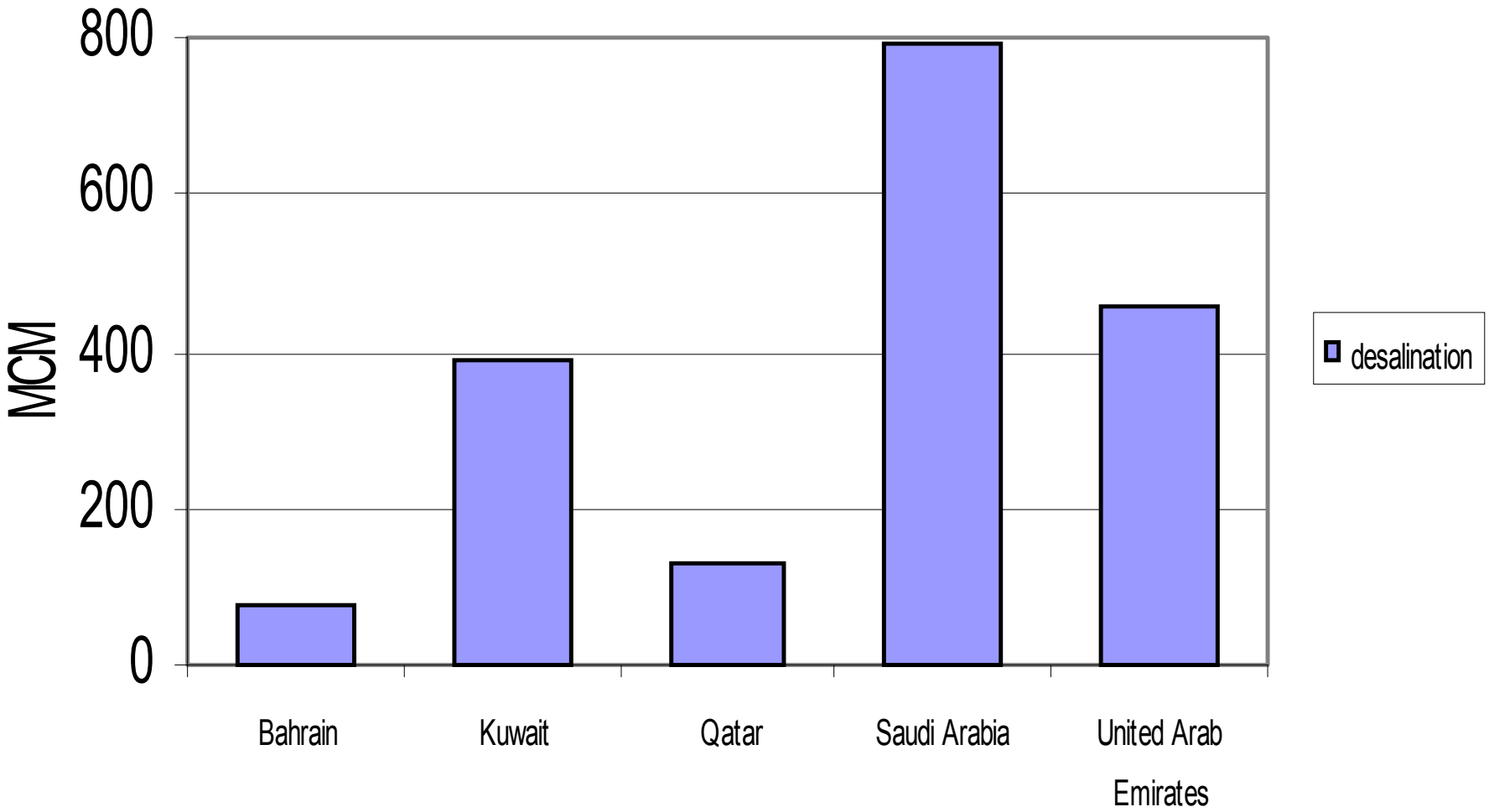
- ESCWA region has become a world leader in sea and brackish water desalination

- About 1.81 BCM is produced in the GCC countries meeting more than 70 % of their domestic water requirments

year 2000



Amount of Desalination in the ESCWA Region



Water Resources Status in the ESCWA Region *Continued*

- In the ESCWA region groundwater quantity and quality is being threatened by the various development activities
- Groundwater over-exploitation from excessive and uncontrolled pumping is common in Jordan, GCC countries, the Syrian Arab Republic and Yemen.
- Groundwater quality is deteriorating as a result of seawater intrusion into the aquifers in Bahrain, Oman, Qatar, the United Arab Emirates and Yemen.

Introduction
Continued

- The major quality degradation indicators include: (1) increased salinity, (2) pollution from nitrogenous wastes, agricultural and human-made; (3) contamination from agro-chemicals, such as pesticides, pathogens, toxic and heavy metals, etc.

- It becomes imperative that member states enhance their capacity on groundwater remedial techniques and protection of their groundwater sources

Groundwater Pollution
A. Sources of Water Quality Deterioration

- Resources degradation in the region can be attributed to a number of causes, the most important among them are:

  – (a)An increase in the discharge of untreated or inadequately treated domestic and industrial water;

    (b)Discharge from agro-processing in drainage water;

    (c)Discharge of hazardous and toxic industrial wastes;

    (d)Saline agricultural drainage from large-scale irrigation

    (e)Overdraft of groundwater

B. Sources of Ground Water Pollution

- Population increase resulted in a dramatic rise in urban dwellers in most countries of the region
- The rise of industry have increased the demand for fresh water and poor control on industrial water discharge
- Infiltration of domestic sewage from unsewered sanitation & leaking sewers
- Irrigation without proper drainage
- Over-exploitation of fresh water aquifers along coastal zone has resulted in intrusion of brackish water
- Irrigation with surface water is a major cause of soil and groundwater salinization

C. Classification of Pollution Sources

- ***Point Source pollution***

  The problems caused will depend on the nature of the pollutant

- ***Diffuse source pollution***

- ***Accidental pollution***

- ***Acidification***

  It can affect groundwater via the soil

Table 4. Classification of Pollution Sources

Category	Sources
1. Sources Designed to discharge Substances	* Septic tanks and Cesspools * Injection Wells * Land Application
2. Sources Designed to Store, Treat and/or Dispose Substances	* Land fills * Open Dumps * Residential Disposal * Surface Impoundments * Mine Wastes * Material Stockpiles * Graveyards * Animal Burials * Above-Ground Storage Tanks * Underground Storage Tanks * Containers * Open Incineration and Detonation Sites * Radioactive-Waste-Disposal Sites
3. Sources Designed to Retain Substances During Transport	* Pipelines * Material Transport and Transfer
4. Sources Discharging Substances as a Consequence of Other Planned Activities	* Irrigation * Pesticide Application * Fertilizer application * Farm Animal Wastes *Salt Application for Highway Deicing * Home Water Softeners * Urban Runoff *Percolation of Atmospheric Pollutants * Mine Drainage
5. Sources Providing a Conduit for Contaminated Water Enter Aquifers	* Production Wells * Monitoring Wells and Exploration Borings * Construction Excavations
6. Naturally Occurring Sources Created and/or Exacerbated by Human Activities	* Groundwater-Surface water interaction * Natural Leaching * Saltwater Intrusion

D. Impacts of Groundwater Pollution

- ***Impact on the environment***

  Primary caused directly by inputs, and secondary caused by outputs such as flow regulation.

- ***Impact on human health***

  Water resources development is closely linked to water-related diseases through pools of wastewater that seeps contaminated water to the ground contribute to polluting the groundwater and creating a health hazard.

- ***Socio-economic impact***

  Socio-economic development in the ESCWA region is dependent on the availability of adequate water resources

GROUND WATER POLLUTION SOURCES

INDUSTRIAL

DOMESTIC & URBAN

AGRICULTURE

SALT WATER INTRUSION

E. Groundwater Vulnerability to Contamination

- Groundwater vulnerability refers to whether or not an aquifer will become contaminated as a result of activities at the land surface is defined as "the contaminants to reach a specified position in the groundwater system"

- Groundwater can be contaminated by

  1- localized releases from sources such as hazardous waste disposal sites, municipal landfills, surface impoundments, underground storage tanks, gas and oil pipelines, back-siphoning of agricultural chemicals into wells

  2-substances released at or near the soil surface including pesticides, fertilizers, septic tank leachate, and contamination from other nonpoint sources

E. Groundwater Vulnerability to Contamination *Continued*

- Groundwater contamination is likely to occur in areas having shallow water tables and sandy soils with high recharge rates.

- Many methods for predicting groundwater vulnerability are based on analytical, statistical and empirical methods. The favored approach at the present is to produce maps of groundwater vulnerability to man-made pollution.

Groundwater Rehabilitation

- The selection of rehabilitation methods depends on the contaminated media, contaminants, remediation objectives, current status, and location of polluted sites, time, and availability to complete the treatment, funding and technologies to be used and remediation techniques

A. In situ physical treatment

1. *In situ physical treatment*

(a) *Air Sparging*

The injection of gas under pressure into well(s) installed within the saturated zone to volatize contaminants dissolved in groundwater

(b) *Blast-Enhanced fracturing*

(c) *Directional Wells*

(d) *Groundwater Recalculation Wells*

(e) Hydraulic and Pneumatic Fracturing

(f) *In Situ Flushing*

A. In situ physical treatment *Continued*

2. *In situ stabilization/solidification chemical treatment*

(a) Permeable Reactive Barriers

(b) Thermal Enhancements

3. *Biological treatment*

(a) Bioslurping

(b) Intrinsic Bioremediation

(c) Monitored Natural Attenuation

(d) Phytoremediation

4. *Electrokinetics*

Involves the application of low intensity direct electrical current in the ground on each side of a contaminated area of soil, causing ion migration

B. Groundwater Flow Modeling

- Models are intended to simulate the groundwater flow, water recharge and saltwater concentration and dispersion will help in:

  (a) Comparing groundwater level field measurements with calculated groundwater level fluctuation;

  (b) Predicting calculations with the calibrated model to develop concepts for groundwater extraction;

  (c) Salt and contaminant flow transport

- Several groundwater simulation numerical models are available and existing such as flow models, multiphase flow and transport models, salt water intrusion & solute transport models

B. Groundwater Flow Modeling *Continued*

Selected list of available groundwater flow models:

3DFEMFAT – 3-D Finite Element Model of Flow and Transport through Saturated-Unsaturated Media

AQUA3D –3D Groundwater Flow and Contaminant Transport Model

AQUIFEM-N -Finite Element Aquifer Flow Model

AT123D –Analytical Groundwater Transport Model for Long-term Pollutant Fate and Migration

BIOF&T2-D/3-D – Biodegradation, Flow and Transport in the Saturated/Unsaturated Zones

BIOPLUME III-Transport of Dissolved Hydrocarbons Under the Influence of Oxygen-Limited Biodegradation

BIOSLUPR-Multiphase Hydrocarbon Vacuum Enhanced Recovery (Bioslurping) and Transport

FEEFLOW-Finite Element Subsurface Flow System

Filter Drain –Design of Side Drains, Bottom Drains, and Underdrains

FLONET/TRANS –2-D Cross-Sectional Steady-State Groundwater Flow and Transport Model

FLOWPART II –2-D Groundwater Flow, Remediation, and Wellhead Protection Model

GFLOW 2000 –Analytic Element Model with Conjunctive Surface Water and Groundwater FLOW and a MODFLOW Model Extract Feature.

GMS-Groundwater Modeling System-Sophisticated Groundwater Modeling Environment for MODFLOW, MODPATH, MT3D, RT3D, FEMWATER, SEAM3D, SEEP2D, PEST, UTCHEM, and UCODE

B. Groundwater Flow Modeling
Continued

Groundwater Vitas – Advanced Model Design and Analysis for MODFLOW, MODPATH, MT3D, PEST,B and UCODE

HST3D –3-d Heat and Solute Transport Model

KYSPILL – Unique groundwater Pollution Forecasting System

MARS 2-D/3-D – groundwater Multiphase Area Remediation Simulation Model

Micro-Fem -Finite-Element Program for Multiple –Aquifer Steady-State and Transient Groundwater Flow modeling

MOC –Computer Model of 2-D Solute Transport and Dispersion in Groundwater

MOCDENSE –Two-constituent Solute Transport Model for Groundwater having Variable Density

ModelGIS –Interface Linking Groundwater Models to ARC/INFO

MODFLOW –Three –Dimensional Finite Difference Ground-water Flow Model

MODFLOW-SURFACT –MODFLOW-Based Groundwater Flow and Contaminant Transport Model

SLAEM/MILAEM –Analytic Element Models-model regional groundwater flow in systems of confined aquifers, unconfined aquifers and leaky aquifers

SUTRA –2-D Saturated/Unsaturated transport Model

TWODAN -2-D Analytic groundwater Flow Model for Windows

VAM2D –2-D Variably-Saturated Groundwater Analysis Model

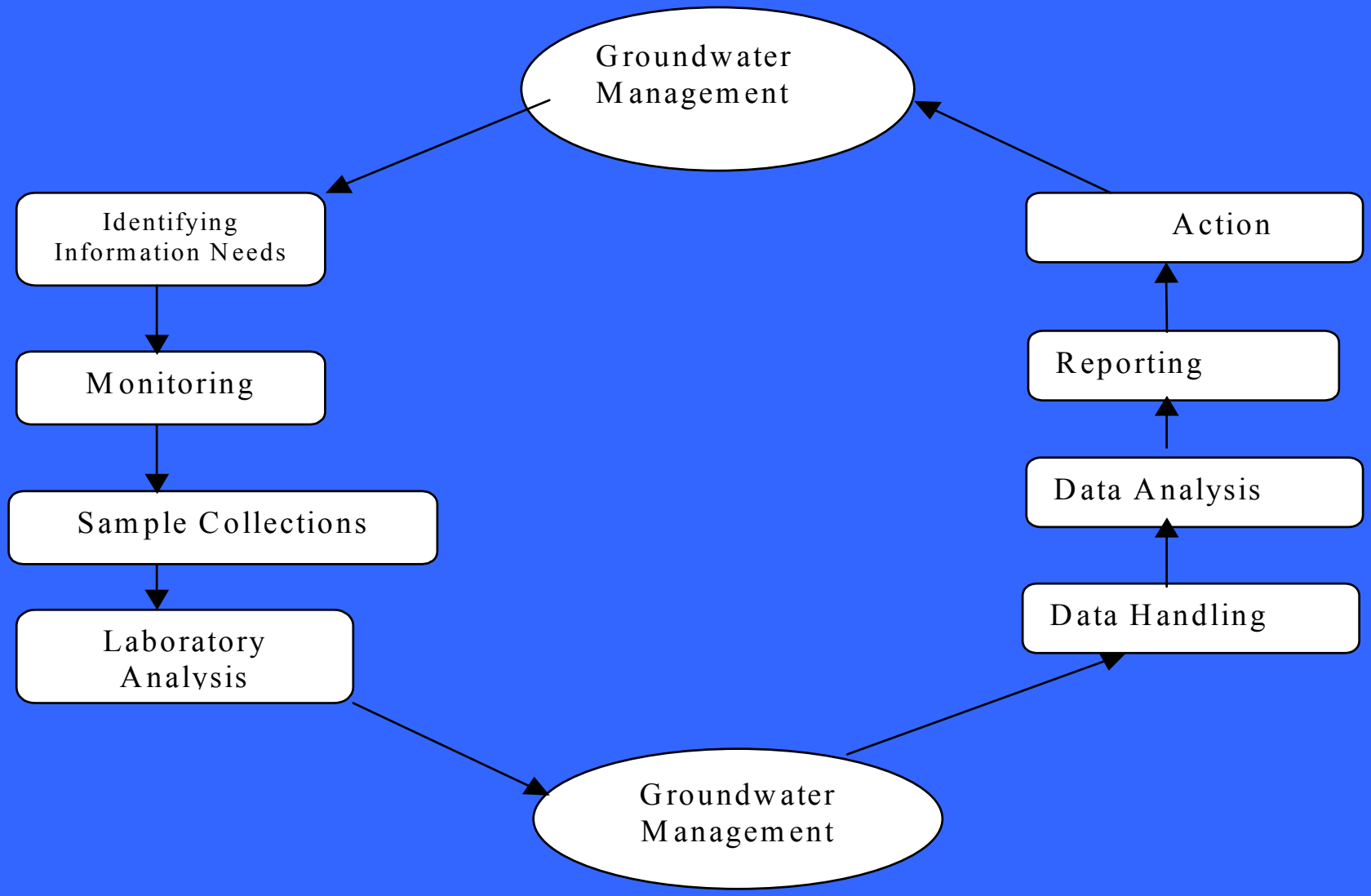
WinFlow – Analytical Steady State and Transient Groundwater Flow Model

Groundwater Pollution Control and Management

- The aim of groundwater management is to ensure the sustainability of the resources and environment

- Long-term effective management of available groundwater resources requires attention to depletion and pollution

Figure 3. Groundwater Management Flowchart



Groundwater Pollution Control and Management *Continued*

- The process of monitoring and evaluation consists of a sequence of related activities which start with the identification of information needs and ends with the use of the information
- The aim of monitoring is to provide information that can help in the protection of the resource from degradation.

(a) Specific Purposes of Groundwater Monitoring

(1)Determination of the depth to water table

(2)Determination of the direction of groundwater flow and movement

(3)Evaluation of water balance components

(4)Determination of contact with mineralized bodies of groundwater, especially the sea-fresh water interface in coastal aquifers;

(5)Calibration of groundwater models;

(6)Assessment of environmental impacts of water projects

Groundwater Pollution Control and Management
Continued

(b) Advantages of Groundwater Monitoring

(1) (1)It is cost-effective

(2) (2) It guarantees a regular reporting of the desired information

(3) It prevents changes in approach

(4) It warrants sound and unbiased statistical testing of hypotheses

By monitoring, one can clearly obtain the knowledge of the areas where quality standards are not met

(c) Principles for groundwater quality

(1) High level of protection

(2) Precautionary principle

(3) Preventive action

(4) Damage to be rectified at source

(5) Polluter pays principle

(6) Integration

(7) The use of available scientific and technical data

(8) Monitoring requirements

(9) Transparency, public participation and accountability

Conclusion

A. Issues Contributing to the Groundwater Deterioration

Groundwater resources may often be local in nature, but they have global significance in relation to poverty, health, economic development, and the environment

1. The lack of groundwater monitoring and data availability.
2. The need for integrated approaches to groundwater management that include regulatory, economic, technical and other measures.
3. The importance of taking action despite gaps in information. Delaying action while further information is collected may result in irreversible damage to resources.
4. The need to involve communities in management of groundwater sources including the collection of groundwater information that can increase stakeholder understanding of management needs and options.

B. Recommendations

- 1. There is a need for improved assessment monitoring of groundwater conditions and their implications for key uses.
- 2. The profile of groundwater needs to be raised commensurate with its importance as a strategic resource.
- 3. Initiate management where problems are evident regardless of data limitations.
- 4. Increase investment in groundwater management, capacity building, monitoring infrastructure, research and management projects.
- 5. Protect the groundwater aquifers from pollution and apply rehabilitation techniques when needed.
- 6. Stress on public awareness campaign, role of women, and the community participation towards preserving groundwater from pollution and depletion.

B. Recommendations
Continued

- 7. In urban areas, there is a pressing need to take more integrated approach to the management of groundwater and wastewater interactions and to the interaction between public and private systems.
- 8. Develop a strategic initiative that enhances awareness oriented toward decision makers and the public of the importance of groundwater resources, the significance of emerging problems and the practical responses available to address such problems.
- 9. The empowerment of people at the local level to manage their groundwater and water resources.
- 10. Develop a combination of technical, economic, social, and institutional approaches to management that reflect local conditions.
- 11. Technology transfer, capacity building, and research development must take place to transfer this knowledge on to the practical field level of restoring and re-establishing old practices of water management

United Nations Economic Commission of Western Asia (UN-ESCWA)
Energy, Natural Resources and Environment Division (ENRED)

Natural Resources Section

Major Challenge

Major problematic water issues

- Lack of understanding of integrated approach to water resources development and management
- Imbalance between supply and demand
- Past emphasis on water supply development
- Continuous mining and pollution of groundwater resources
- Fragmented institutional arrangements

Actions to be taken to improve water resources management

- Formulation of effective water policies and strategies
- Availability of adequate financial resources
- Encouragement of stakeholders' participation
- Achievement of water allocation among water consuming sectors
- Update and enforcement of water legislation
- Enhancement of capacity building
- Achievement of regional cooperation on shared water resources

The Natural Resources Section

In view of the above, the program activities of ENRED's Natural Resources Section (NRS) comprises studies, expert group meetings and training workshops which contribute towards increasing awareness of the seriousness of water problems in the region, and encouraging the decision makers and water professionals to give priority to improve and integrate water planning and management into all development activities. In this regard, the NRS also works to strengthen cooperation among ESCWA's members to make water a venue of cooperation.

THE NATURAL RESOURCES SECTION-*Continued*

The tasks of NRS are to:

- Strengthen Member States capacities to sustain, utilize and manage their water resources,
- Contribute toward assessment and integrated water management within a sustainable development framework,
- Promote regional and inter-regional cooperation for the sustainable utilization, management and protection of shared water resources,
- Propose guidelines and strategies for cooperation between and among Member States to achieve water resources conservation and protection.

NRS program activities for the current biennium include studies and assessments in selected priority areas in the water sector, expert group meetings, training workshops . The program of work of the NRS is approved by the inter-governmental water committee.

CURRENT ACTIVITIES

STUDIES:

- Assessment of the legal aspects of the management of shared water resources in the ESCWA region
- The role of desalinated water in augmenting the water supply in selected ESCWA Member countries
- Implications of groundwater rehabilitation on water resources protection and conservation: artificial recharge and water quality improvement
- The enhancement of institutional arrangements for water legislation enforcement and improvement of institutional functions in selected ESCWA Member countries
- ·Development and maintenance of ESCWA homepage on water

EXPERT GROUP MEETINGS (EGM)

- The legal aspects of the management of shared water resources (held from 8-11 June, 2000 in Sharm El-Sheikh/Egypt)

- Implications of Groundwater rehabilitation on water resources protection and conservation (held from 14-17 November, 2000 in Beirut/Lebanon)

Besides the mentioned EGM's the fourth session Committee on Water Resources was held in Beirut/Lebanon in November 2000.

EXTRA BUDGETARY ACTIVITIES

In support of NRS's activities the technical advisory cooperation project with the German Government, implemented by the Federal Institute for Geosciences and Natural Resources (BGR) contributes a four module program that involves integrated water resources management, enhancing coordination mechanisms over shared water resources in the region, upgrading of the water database through GIS development, and capacity-building development activities.

RECENT NRS PUBLICATIONS

- Harmonization of Environmental Standards in Water Sector in the ESCWA Member States

  (E/ESCWA/ENR/1999/11)

- Updating the Assessment of Water Resources in ESCWA Member Countries

  (E/ESCWA/ENR/1999/13)

- Development of Fresh Water Resources in the Rural Areas of the ESCWA Region by Using Non-conventional Techniques

  (E/ESCWA/ENR/1999/16)

- Progress Achieved in the Implementation of Chapter 18 of Agenda 21, with Emphasis on Water for Sustainable Agricultural Production

  (E/ESCWA/ENR/1999/22)

ACHIEVEMENTS

- Computerized database on water resources in the region with special emphasis on shared aquifers

- Tens of publications concerning water management, water legislation, economics, and desalination in the region

- Periodic assessment of water resources availability and use in the region

- Establishment of the regional water training network

- Enhanced awareness and cooperation among Member states regarding various