WATER RESOURCES OF THE NEAR EAST REGION: A REVIEW

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Foreword

In order to provide a rational basis for the discussion on increasing water scarcity and the potential for irrigation expansion in the Near East, FAO undertook to compile existing information on the water resources of the Region. Similar to a previous study on water resources of African countries, this survey is based essentially on country-based statistics and information contained in sector studies and master plans. Due account has been taken of the interaction of groundwater and surface water and of the problem of transboundary flows.

It is believed that the statistical data presented here reflect the most up-to-date information on water resources availability in the region. In addition to this booklet, a comprehensive publication of the state of water and irrigation in the Near East, including individual country profiles, has been prepared under the framework of the AQUASTAT programme. It is hoped that this publication will be useful to both decision-makers and professionals in the water sector.

Acknowledgements

This report is based on the results of the AQUASTAT survey for the member countries of FAO's Regional Office for the Near East. The survey was coordinated by Karen Frenken, Jean-Marc Faurès and Mathieu Bousquet from the FAO Land and Water Development Division and Selim Sarraf from the FAO Regional Office for the Near East. Data on water resources were reviewed and evaluated by Philippe Pallas and Jean Margat, who are the authors of this report.

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Glossary of terms used in this survey

Average precipitation: (mm/year and km^3/year) Double average over space and time of water falling on the country in a year.

Dependency ratio: (%) That part of the total renewable water resources originating outside the country.

External renewable water resources: (km^3/year). That part of the country's renewable water resources shared with neighbouring countries, be it upstream or downstream.

Internal renewable water resources: (km^3/year) Average annual flow of rivers and recharge of groundwater generated from endogenous precipitation.

Manageable water resources: (km^3/year) That part of the water resources which is considered to be available for development under specific economic conditions. This figure considers factors such as the dependability of the flow floods, extractable groundwater, minimum flow required for non-consumptive use, etc. Also called water development potential.

Natural flow: (km^3/year) The amount of water which would flow under natural conditions, i.e., without human influence.

Overlap: (km^3/year) That part of the water resources which is common to both surface water and groundwater.

Potential yield: (km^3/year) Total amount of water resources, be it surface water or groundwater, generated by the hydrological cycle on a yearly basis. It is a physical concept.

Total actual renewable water resources: (km^3/year) The sum of internal renewable water resources and incoming flow originating outside the country, taking into consideration the quantity of flows reserved to upstream and downstream countries through formal or informal agreements or treaties. This gives the maximum theoretical amount of water actually available for the country.

Total natural renewable water resources: (km^3/year) The sum of internal renewable water resources and natural incoming flow originating outside the country.

Water resources of the Near East Region: a review

This review was carried out in the framework of an initiative by FAO related to the development of the information system on water use in agriculture and for rural development called AQUASTAT. Developed in 1993-94 and implemented first for Africa in 1995, then for the Near East in 1996, this system aims at collecting country and sub-country information based on key indicators of rural water resources management with specific attention to irrigation and drainage. The programme collects information at country level, mostly through FAO offices in the countries and with the help of national and international resource persons. More than 200 major bibliographic references have been consulted, mainly consisting of sector studies (agriculture, water resources), master plans (water resources management, irrigation), as well as national and regional statistics and studies when available. The countries referred to in this paper are the 29 countries member of the FAO Regional Office for the Near East as at 1 May 1996. They are: Afghanistan, Algeria, Bahrain, Cyprus, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Kyrgyzstan, Lebanon, Libya, Malta, Mauritania, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tajikistan, Tunisia, Turkey, Turkmenistan, United Arab Emirates and Yemen (Figure 1). The water resources data collected within the region have been assembled here to constitute a reference document based on information emanating from countries or regional organizations.

Data collection and analysis

Detailed descriptions of the data collection and analysis procedures, as well as concepts and conventions used to assess water resources, are presented in the previous paper describing the water resources of African countries resulting from the AQUASTAT survey for Africa (FAO, 1995). They are summarized below.

Very little information exists at present on water resources on a regional basis at country level. The only systematic country-based study was conducted in the 1970s, and led to the publication of a book entitled *"World Water Resources and their Future"* (L'vovich, 1974) which is still used today as a reference in that field. Based on a water balance approach and on a large amount of information on stream flow gathered around the world, it proposed a table of water resources by country, including water resources generated in the country, as well as flows from neighbouring countries. The works of Korzun *et al.* (1974) and later of Shiklomanov (1990, 1993), based on a water balance approach, are the most frequently quoted and the most up-to-date source of information on water resources at regional and continental level. An updated version of this information is to be published soon in the framework of UNESCO's International Hydrology Programme.

The World Resources Institute (1996) provides the most recent systematic information about water resources at country level. In Table 13.1 a figure is given for water resources for each country as well as for incoming water. It is mainly a compilation of existing information, including figures taken from L'vovitch (1974).

The present survey is principally based on information emanating from countries or regional organizations. Apart from sectoral reviews and water resources development master plans, reports from regional organizations, such as the Arab Center for the Study of Arid Zones and Dry Lands (ACSAD), and country reports for the International Conference on Water and the Environment (Dublin, Ireland, 1992) were also important sources of information. The option to rely on country information to perform this survey was based on the assumption that no regional approach can be more accurate than studies carried out at country level.

An arid or semi-arid climate prevails in most countries of the Near East Region where water plays a determinant role for economic development. It is not surprising therefore that, while abundant literature exists on the subject, access to information on water resources is still often restricted for reasons related to its sensitivity at regional level.

Another kind of problem originated from the creation of new independent states in Central Asia for which no breakdown of information on water resources was previously available.

Due to the difficulty in collecting the information, the survey refers only to long-term yearly averages, with no consideration of variability. For this reason, no consistency can be ensured at regional level on the duration and dates of the period of reference.

Taking these problems into account, the selection of the most reliable information was based on several criteria including the source of information, the conceptual approach used to access water resources and the expected accuracy of the data. Cross-checking of information on transboundary river flows was carried out systematically to ensure consistency of the database at regional level.

CONCEPTUAL CONSIDERATIONS AND CONVENTIONS USED IN THE SURVEY

Potential yield and water development potential

Several approaches can be followed when assessing water resources at country level. In all cases a distinction has to be made between

BOX 1: MANAGEABLE WATER RESOURCES OF LEBANON

The case of Lebanon shows the difference between potential yield and water development potential. A large part of the country's potential yield estimated by various authors is hardly manageable: the groundwater losses to the sea which are accounted for in the assessment of potential yield, estimated at around 0.7 km^3/year, are coming out as submarine springs and can hardly be mobilized since the karstic channels in which water is flowing are subject to mixing with saline water. Similarly the floods running from small catchments of the coastal mountains are lost in the sea with little possibility of being put into beneficial use. Thus, out of a potential yield of about 4.8 km^3/year, manageable water resources represent probably about 2.2 to 2.5 km^3/year.

potential yield and water development potential, also called manageable water resources. Potential yield is defined as the total amount of water resources, be it surface water or groundwater, which is generated by the hydrological cycle on an average yearly basis, while manageable water resources consider other factors such as the economic feasibility of storing part of the flood water behind dams or extracting groundwater, the physical possibility of catching water which naturally flows out to the sea, the minimum flow requirement for navigation, the environment, aquatic life, etc. Obviously the water development potential can never be higher than the potential yield and, in fact, it usually represents only a small fraction of it. The major constraints to the use of the manageable water resources figure for assessing water resources at regional scale are the absence of principles to compute it and the dependence on a series of local factors (Box 1) which makes comparative studies difficult to perform. Furthermore, water development potential can change with time - for example with new economic conditions prevailing in a country or as a result of increased water consumption in upstream countries - while potential yield has a physical meaning and could only be affected by changes in climatic conditions. In this review, the potential yield was used as the indicator to assess water resources by country.

Surface water and groundwater interdependency

Although they are linked through the hydrological cycle, surface water and groundwater resources are often computed separately. One of the major risks in assessing surface water and groundwater separately lies in the possible double counting of part of the resource. Surface water resources are usually computed by measuring or assessing total river flow occurring in a country on a yearly basis. Groundwater resources are expressed as a measure of aquifer recharge through infiltration.

BOX 2: SURFACE WATER AND GROUNDWATER: BASEFLOW IN MOROCCO

In Morocco, the total groundwater flow equivalent to the aquifer recharge is estimated at 10 km^3, out of which 3 km^3 correspond to the baseflow of the rivers.

- In humid areas of the region (high mountain ranges of Algeria, Iran, Lebanon, Morocco, Pakistan and Turkey), the baseflow of the rivers originates from groundwater through springs and direct outflow from the aquifer to the river. In those areas, the surface water estimates thus include a part of the resources which can also be considered as groundwater and could be developed through wells. Where possible, i.e., where data are available, the groundwater resources in humid areas have been considered as equivalent to the baseflow of the rivers (including direct groundwater flow to the sea).

BOX 3: RECHARGE OF AQUIFER BY FLOODS IN IRAN

In Iran, the contribution of surface water (flood) to aquifer recharge is estimated at 12.7 km^3/year, out of total internal renewable water resources of 128.75 km^3/year.

- In arid and semi-arid areas, most of the groundwater recharge occurs through infiltration of short-lived surface flow (flash floods) in the plains. In those areas, the groundwater resources are assimilated to the groundwater recharge derived either from rainfall infiltration estimates or from the characteristics of the aquifers and piezometric levels, while the surface water resources are estimated through a few flash flood discharge measurements and extrapolation to nearby rivers. In this case, it happens frequently that both flood estimates and groundwater resources resulting from infiltration of the same floods are summed up for assessing the total water resources, thus leading to an overestimation of these resources.

In both cases, the correct assessment of water resources has made it necessary to estimate that part of the water resources which is common to both surface water and groundwater sub-systems. In this survey, this common part has been called overlap. A correct estimate of water resources is obtained by subtracting this overlap from the sum of surface water and groundwater resources computed separately.

In the Near East Region, the computation of overlap is further complicated by the fact that a mixture of the situations described above may occur in different climatic zones of the same country.

The role of scale in water resources assessment

It is generally admitted that water resources decrease proportionally with increasing basin area. This is explained by the fact that time spent by water to reach the outlet increases with the size of the basin, increasing the opportunity for loss by evaporation, especially in arid areas. The consequence of this is that the water resources estimated by considering the flow at the outlet of a basin are always less than the sum of the flows generated from a combination of sub-basins. In arid countries, losses by evaporation, associated with infiltration, may significantly reduce the surface water flow after it leaves the mountainous part of the basin from where it originates. The losses may even reach 100% in the case of endorheic basins ending up in evaporative areas called *chotts* or *sebkhas*. In countries belonging to large international river basins, losses by evaporation in swamps and

in the river itself may exceed the water resources produced within the country (see Box 4). However, there is a difference between the losses in salt-affected evaporative areas, where water does not contribute to any biomass production, and 'losses' in swamp areas occurring as evapotranspiration producing biomass used to maintain aquatic and terrestrial life. In the present review water losses in wetlands and swamp areas are not considered as potential water resources.

> **BOX 4: LOSSES OF THE NILE IN SUDAN**
>
> In Sudan, a global estimate of evaporation in the wetlands gives a figure of 68 km^3/year, which corresponds to twice the internal renewable water resources of the country and 45% of the total resources of the country.

A similar phenomenon may occur for the groundwater flow which may disappear through evaporation without being drained by rivers.

These examples show that assessment of the renewable water resources in arid countries should not be based on discharge measurements at the major basins' outlets or at the border with other countries, as such an approach may lead to an important underestimation of the water resources. Instead, water resources should be assessed upstream of the loss areas and where maximum discharge is observed. The available hydrological data should therefore be used selectively with the particular objective of estimating the surface and groundwater flows before they disappear.

Computation of water resources

In computing water resources on a country basis, a distinction must be made between renewable and non-renewable resources, and between internal and total water resources. In this paper, the term *Internal renewable water resources* (IRWR) refers to the average annual flow of rivers and recharge of groundwater generated from endogenous precipitation. It is a combination of surface water and groundwater, in which double counting has been avoided in the way described earlier.

The computation of *Total renewable water resources* requires the assessment of water flowing from neighbouring countries (natural or actual flows). By definition, total water resources computed by country are not additive at regional level. The definition implies that unused water, accounted for as a resource in upstream countries, is also considered a resource in downstream countries.

Total natural renewable water resources (NRWR) is the sum of IRWR and natural incoming flow originating outside the country. *Natural incoming flow* is the average annual amount of water which would flow into the country in natural conditions, i.e., without human influence. *Total actual renewable water resources (ARWR)* is the sum of IRWR and actual external flow, taking into account the quantity of flow reserved by upstream (incoming flow) and/or downstream (outflow) countries through formal or informal agreements or treaties, and reduction of flow due to upstream consumption. This figure may vary with time. It may be negative when the flow reserved to downstream countries is more than the incoming flow.

Incoming flow, be it natural or actual, consists most of the time of river runoff but, in arid regions, it can also consist of groundwater transfer between countries. However, groundwater transfers are rarely known and their assessment requires a good knowledge of the general behaviour of the aquifers. When groundwater resources estimates are made on the basis of groundwater flow derived from the characteristics of the aquifers and piezometric levels, the calculated flow does not necessarily correspond to renewable resources: the large aquifers of the Near East Region (the Nubian Sandstone of Northeastern Africa, the great Al-Irq aquifer of Northwestern Africa, the Eastern Mediterranean aquifer, the Hauran and Jabal Al-Arab aquifer, the Upper Jazirah

aquifer and the aquifer of the Northern Arabian Peninsula) show many cases of transboundary flow related to the slow draining out of these huge groundwater reservoirs with negligible upstream recharge.

The *dependency ratio* of a country (dr) is an indicator expressing the part of the water resources originating outside the country. It is computed as follows:

$$dr = \frac{Ia}{IRWR + Ia} \times 100\ (\%)$$

where *IRWR* is the internal renewable water resources and *Ia* is the actual amount of water flowing in from neighbouring countries.

This indicator may theoretically vary between 0% and 100%. When dr = 0%, the country does not receive water from neighbouring countries. A country with dr = 100% receives all its water from outside without producing any. This indicator does not consider the possible allocation of water to downstream countries.

The term *renewable* is used in opposition to fossil waters which have a negligible rate of recharge on the human scale and can thus be considered *non-renewable*. Non-renewable resources are usually expressed either in terms of volumes or extractable flow, while renewable resources are always a measure of flow.

In this review, both the internal and total renewable water resources were computed. The internal water resources figure is the only quantity which can be summed for regional or continental assessment, and it has been used for this purpose.

Rules have to be set for the computation of incoming water resources. The rules described in Box 5 are neither absolute nor universal. They have been selected with the purpose of representing all the situations

BOX 5: RULES USED FOR COMPUTING INCOMING WATER RESOURCES

Transboundary rivers
The mean annual flow measured or estimated at the border is accounted for as an external resource for the downstream country. It is not deducted from the resources of the donor country, except in the case of an agreed apportionment between the countries. While internally-produced water resources are a quantity which should not vary with time, incoming flow may decrease with an increasing use by the upstream country. The bi- and multi-lateral agreements, and the situations resulting from the actual water consumption in the countries located upstream, have made it necessary to differentiate two categories of external resources for each of the 'receiving' countries:

- **natural flow** corresponding to long-term average flow not affected or before being affected by upstream consumption;
- **actual flow** corresponding to a given period which takes into account water allocation from upstream, be it through an agreement or from a factual situation, and/or agreed or accepted commitments towards downstream countries.

A particular case is the situation where part of the runoff entering the country originates in the country itself, after having flowed into the upstream country. In such a case, and when the information is available, this flow is deducted from the incoming flow to avoid double counting.

Border rivers
As a general rule, 50% of the river flow is assigned to each of the bordering countries. Several situations exist:

- The river exclusively borders the countries without entering into any of the riverine countries nor coming from them (this is the case of the Senegal river between Mauritania and Senegal). In such a case, the incoming resources are estimated on the basis of the runoff of the river in the upstream part of the border section. When the runoff increases substantially from upstream to downstream, the downstream figure is used after subtraction of the part of the runoff generated by the country itself.
- If the source of the river is in one of the two countries, the rule applies only for the other country. For the originating country, 50% of the contribution from the other country could similarly be considered as external resources when known.
- If, on the contrary, the river enters one of the two countries after having divided the two countries, it is considered a transboundary river for the receiving country, in which case all the runoff at the entry point in the country is considered external resources. The 50% rule applies for the other country.

in the most realistic way possible. In summary, in the case of transboundary rivers, the mean annual flow at the border is considered as an external resource for the receiving country. In the case of bordering rivers or lakes, an arbitrary 50% rule is applied to distribute the water between the two countries (it should be stressed that these rules have been set for the purpose of this exercise, and that they do not imply any consideration of judgement on possible or effective ways to share the resources). The difficulties encountered in setting these computation rules also show the arbitrary aspects of computation of total water resources for bordering water bodies, as compared to the indisputable measure of internal resources.

An example of a water resources computation sheet is shown in Box 6. The section related to internal renewable water resources (IRWR) indicates the surface water and the groundwater resources and the overlap, which is then deducted from the sum of the water resources estimated separately in order to obtain IRWR (7 km^3 in this case). The section related to external renewable water resources (ERWR) shows the various components of the incoming and outgoing surface water and groundwater flows. Further computational details are shown in the footnotes.

The content of shaded cells is purely informative and is not taken into account in the computation. The *part under agreement* refers to that part of the water entering or leaving the country which is subject to a formal or informal agreement or treaty. *Agreement* is understood here in a very broad sense and does not necessarily imply formal acceptance on both sides of a border on the amount of water to be reserved for each country. Furthermore, agreements cannot always be expressed uniquely in terms of annual flows and interpretation might be needed for the sake of the water balance computation. Declared commitment by the upstream country, even when not formally approved by all parties, have also been included. The *part secured through agreement* refers to that part of the *part under agreement* which is reserved for

BOX 6: EXAMPLE OF COMPUTATION OF WATER RESOURCES

AQUASTAT

Water resources computation sheet (in km3/year, average)

Syria

INTERNAL RENEWABLE WATER RESOURCES				
Surface water produced internally	4.800			
Groundwater produced internally	4.200			
Overlap			2.000	
Total internal renewable water resources (IRWR)	9.000		- 2.000	= 7.000
EXTERNAL RENEWABLE WATER RESOURCES	Natural	Actual	Ref year :	1995
External surface water				
Surface water entering the country	28.730 (1)			
Part not under agreements		1.930		
Part under agreements		26.800 (2)		
Part secured through agreements		16.180 (3)		
S.T: Part accounted for in the country's balance	28.730	18.110		
Flow of border rivers				
Total	18.000	18.000 (4)		
Part accounted for in the country's balance	9.000	9.000		
Shared lakes				
Part accounted for in the country's balance	0.000	0.000		
Surface water leaving the country	31.975 (5)			
Part not under agreements		1.575		
Part under agreements		30.400		
Part to be substracted from the country's balance			9.200 (6)	
Total external surface water (natural)	37.730			= 37.730
Total external surface water (actual)		27.110	- 9.200	= 17.910
External groundwater				
Groundwater entering the country				
Part accounted for in the country's balance	1.350	1.350 (7)		
Groundwater leaving the country	0.250	0.250 (8)		
Total external groundwater (natural)	1.350			= 1.350
Total external groundwater (actual)		1.350		= 1.350
Total external water resources (natural)				39.080
Total external water resources (actual)				19.260

TOTAL RENEWABLE WATER RESOURCES (TRWR)

SUMMARY	Internal	External		Total	
		Natural	Actual	Natural	Actual
Surface water resources	4.800	37.730	17.910	42.530	22.710
Groundwater resources	4.200	1.350	1.350	5.550	5.550
Overlap	2.000			2.000	2.000
Total	7.000	39.080	19.260	46.080	26.260

Dependency ratio: 80.3 %

Notes:

(1) Euphrates (26.29); Tributaries of Euphrates (1.62); Afrine (0.19); Sajour (0.12); Orontes 0.51 km3/yr.

(2) Total flow of Euphrates + Orontes subject to agreement or commitment from upstream country.

(3) Euphrates 15.75 (500 m3/s: flow guaranteed by Turkey while filling the Ataturk reservoir)); Orontes 0.43 km3/yr.

(4) Natural flow of the Tigris river at the border between Syria and Iraq.

(5) Orontes (Nat.1.2;Act.0.012); Afrine (Nat.0.25); Euphrates (Nat.30;Act.9(58%)); Yarmouk (Nat. 0.4;Act.0.2); Baniyas (Nat.0.125) km3/yr.

(6) 58% of Euphrates river flow (9 km3/yr) to Iraq + 0.2 km3/yr (Yarmouk river) to Jordan.

(7) from Turkey (Khabour; 1.2); from Lebanon 0.15 km3/yr

(8) Dan springs.

the country. The *part to be subtracted from the country's balance* refers to that part of the *part under agreement* which has to be reserved for the downstream countries. In all cases the *part accounted for in the country's balance* is computed according to the rules described in Box 5.

RESULTS OF THE SURVEY BY COUNTRY

Table 1 presents the results of the review in terms of water resources by country. Surface water and groundwater have been presented in a non-additive way, that is to say their common part appears in both columns. The reason for this choice is that in most cases this is how the resources are presented in the country studies, and there is no objective reason to subtract the common part either from one or the other category. To make the computation of internal renewable water resources possible, a third column was added where the common part between surface water and groundwater was indicated. Internally produced water resources are computed by removing this overlap from the sum of surface water and groundwater. External renewable water resources are also presented in Table 1 and have been computed following the rules described in the previous section.

The internal renewable water resources per inhabitant in the Near East Region are among the lowest in the world. The average for the region is 1 577 m^3/year per inhabitant in 1995, against over 7 000 m^3/year per inhabitant for the whole world. It ranges from almost 0 for Kuwait, which has practically no internal renewable water resources, to about 10 000 m^3/year per inhabitant for Tajikistan and Kyrgyzstan (Figure 3). For 16 out of the 29 countries the internal renewable water resources per inhabitant are below 500 m^3/year and for 11 of them even the total actual renewable water resources are below 500 m^3/year (Table 2 and Figure 4).

TABLE 1
Summary table of water resources for the Near ERast
(all figures in km^3/year, except when explicitly mentioned)

#	COUNTRY	Population (1995)	Internal renewable water resources					External renewable water resources				Total renewable water resources			Dependency ratio
			Surface water	Ground-water	Overlap	Total	IRWR per inhabitant	Surface water		Groundwater		Natural	Actual	ARWR per inhabitant	
						2+3-4	m3/inhab.yr	Natural	Actual	Natural	Actual	5+7+9	5+8+10	m3/inhab.yr.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Afghanistan	20 141 000				55.000	2 731	10.000	10.000	0.000	0.000	65.000	65.000	3 227	15.4
2	Algeria	27 939 000	13.200	1.700	1.000	13.900	498	0.400	0.400	0.000	0.000	14.300	14.300	512	2.8
3	Bahrain	564 000	0.004	0.000	0.000	0.004	7	0.000	0.000	0.112	0.112	0.116	0.116	206	96.6
4	Cyprus	742 000	0.830	0.300	0.230	0.900	1 213					0.900	0.900	1 213	0.0
5	Djibouti	577 000				0.300	520	0.000	0.000			0.300	0.300	520	0.0
6	Egypt	62 931 000	0.500	1.300	0.000	1.800	29	84.000	55.500	1.000	1.000	86.800	58.300	926	96.9
7	Iran	67 283 000	97.300	49.300	18.100	128.500	1 910	9.010	9.010			137.510	137.510	2 044	6.6
8	Iraq	20 449 000	34.000	1.200	0.000	35.200	1 721	61.220	40.220	0.000	0.000	96.420	75.420	3 688	53.3
9	Jordan	5 463 000	0.400	0.500	0.220	0.680	124	0.200	0.200	0.000	0.000	0.880	0.880	161	22.7
10	Kuwait	1 547 000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.020	0.020	0.020	0.020	13	100.0
11	Kyrgyztan	4 745 000	47.230	13.000	13.000	47.230	9 954	0.000	-35.630	0.000	0.000	47.230	11.600	2 445	0.0
12	Lebanon	3 009 000	4.100	3.200	2.500	4.800	1 595	0.037	-0.393	0.000	0.000	4.837	4.407	1 465	0.8
13	Libya	5 407 000	0.100	0.500	0.000	0.600	111	0.000	0.000		0.000	0.600	0.600	111	0.0
14	Malta	366 000	0.0005	0.015	0.000	0.0155	42	0.000	0.000	0.000	0.000	0.016	0.016	42	0.0
15	Mauritania	2 274 000	0.100	0.300	0.000	0.400	176	11.000	11.000	0.000	0.000	11.400	11.400	5 013	96.5
16	Morocco	27 028 000	23.000	10.000	3.000	30.000	1 110	0.000	0.000	0.000	0.000	30.000	30.000	1 110	0.0
17	Oman	2 163 000	0.930	0.955	0.900	0.985	455	0.000	0.000	0.000	0.000	0.985	0.985	455	0.0
18	Pakistan	140 947 000	243.000	55.000	50.000	248.000	1 760	181.370	170.270	0.000	0.000	429.370	418.270	2 968	40.7
19	Qatar	551 000	0.001	0.050	0.000	0.051	93	0.000	0.000	0.002	0.002	0.053	0.053	96	3.8
20	Saudi Arabia	17 880 000	2.200	2.200	2.000	2.400	134	0.000	0.000	0.000	0.000	2.400	2.400	134	0.0
21	Somalia	9 250 000	5.700	3.300	3.000	6.000	649	9.740	9.740	0.000	0.000	15.740	15.740	1 702	61.9
22	Sudan	28 098 000	28.000	7.000	0.000	35.000	1 246	119.000	53.500	0.000	0.000	154.000	88.500	3 150	77.3
23	Syria	14 661 000	4.800	4.200	2.000	7.000	477	37.730	17.910	1.350	1.350	46.080	26.260	1 791	80.3
24	Tajikistan	6 101 000	61.800	6.000	6.000	61.800	10 129	20.000	-22.300	0.000	0.000	81.800	39.500	6 474	24.5
25	Tunisia	8 896 000	2.310	1.210	0.000	3.520	396	0.600	0.600	0.000	0.000	4.120	4.120	463	14.6
26	Turkey	61 945 000	192.800	20.000	16.800	196.000	3 164	4.700	-12.238	0.000	0.000	200.700	183.762	2 967	1.8
27	Turkmenistan	4 099 000	1.000	0.000	0.000	1.000	244	70.000	70.000	0.000	0.000	71.000	71.000	17 321	98.6
28	United Arab Emirates	1 904 000	0.150	0.120	0.120	0.150	79	0.000	0.000	0.000	0.000	0.150	0.150	79	0.0
29	Yemen	14 501 000	4.000	1.500	1.400	4.100	283	0.000	0.000	0.000	0.000	4.100	4.100	283	0.0
	TOTAL	561 461 000				885.336	1 577								

TABLE 2
Countries with IRWR below 500 m^3/inhabitant per year (1995)

Country	Internal renewable water resources per inhabitant m^3/year	Total actual renewable water resources per inhabitant m^3/year
Countries with IRWR < 500 and ARWR < 500:		
Kuwait	0	13
Bahrain	7	206
Malta	42	42
United Arab Emirates	79	79
Qatar	93	96
Libya	111	111
Jordan	124	161
Saudi Arabia	134	134
Yemen	283	283
Tunisia	396	463
Oman	455	455
Countries with IRWR < 500 and ARWR > 500:		
Egypt	29	926
Mauritania	176	5 013
Turkmenistan	244	17 321
Syria	477	1 791
Algeria	498	512

For only four countries (Turkey, Kyrgyzstan, Tajikistan and Afghanistan) the internal renewable water resources per inhabitant are above 2 000 m^3/year and three of them act as 'water towers' for the region, with large amounts of water flowing to downstream countries: Turkey (the Euphrates and the Tigris rivers mainly), Kyrgyzstan and Tajikistan (the Amu Darya and Syr Darya). Two countries, Syria and Sudan, are intermediate countries. They depend to a large extent (around 80%) on upstream countries for their renewable water resources (the Euphrates from Turkey and the Nile from Ethiopia), but on the other hand they are located upstream from other countries depending on the same rivers (Iraq and Egypt respectively). Five countries depend on other countries for over 90% of their renewable water resources: Turkmenistan, Egypt and Mauritania for surface

TABLE 3
Countries with a renewable water resources dependency ratio above 50%

Country	Internal renewable water resources million m³/year	Actual renewable water resources million m³/year	Dependency ratio %	Main source of incoming water
Kuwait	0	20	100.0	Groundwater from Saudi Arabia*
Turkmenistan	1 000	71 000	98.6	Amu Darya River
Egypt	1 800	58 300	96.9	Nile River
Bahrain	4	116	96.6	Groundwater from Saudi Arabia
Mauritania	400	11 400	96.5	Senegal River
Syria	7 000	26 260	80.3	Euphrates, Tigris Rivers
Sudan	35 000	88 500	77.3	Nile River
Somalia	6 000	15 740	61.9	Shebelli, Juba Rivers
Iraq	35 200	75 420	53.3	Euphrates, Tigris Rivers

* *Mainly brackish groundwater.*

water and Kuwait and Bahrain for groundwater. To a lesser extent, but still over 50% dependent on other countries, are Somalia and Iraq (Table 3 and Figure 5).

REGIONAL ANALYSIS

Common characteristics

Because of its climate, the Near East is the region of the globe showing lowest figures of water resources in absolute terms and per inhabitant, even when considering the contribution of rivers flowing in from more humid regions of tropical Africa (the Nile River) or Himalayan Asia (the Indus River) (Figure 2). Furthermore, the water resources distribution within this vast region extending over three continents is far from being uniform. Land relief, location from the sea, latitude and resulting hydro-climatic conditions, the diversity of the hydrographic networks and of the geologic structures, trans-boundary rivers, all these factors give rise to extremely contrasted water situations.

Sub-regional analysis

The Near East can be subdivided into five sub-regions showing some common geographical characteristics (Figure 1). From a water resources point of view, the five sub-regions are rather independent from each other and there is practically no exchange of water between them. Approximately 27% of the natural renewable water resources, and 24% of its actual renewable water resources, are generated outside the region (Table 4).

TABLE 4
Internal, external and total renewable water resources by sub-regions in km³/year

Sub-region	Internal renewable water resources	External renewable water resources related to sub-regions				Origin	Total renewable water resources	
		Surface water		Groundwater				
		Natural	Actual	Natural	Actual		Natural	Actual
Maghreb	48.42	48.42	11.00			Senegal River upstream Mauritania	59.42	59.42
North-eastern Africa	43.10	128.74	128.74			Nile River upstream of Sudan (119) + rivers from Ethiopia and from Kenya to Somalia (9.74)	171.84	171.84
Arabian Peninsula	7.69	0.00	0.00			No external flow	7.69	7.69
Middle East	244.60	0.00	0.00	0.00	0.00	No external flow	244.60	244.60
Central Asia	541.53	183.68	141.38			Shared flow of Arax River (2.31) + inflow from India (181.37) - reserved outflow of Amu Darya and Syr Darya to Uzbekistan (42.3)	725.21	682.91
Total	885.34	323.42	281.12	0.00	0.00		1 208.76	1 166.46

While the Near East covers 14% of the total area of the world and contains 10% of its population, its water resources are only about 2% of the total renewable water resources of the world. Further to this, large differences exist between the five sub-regions, as is shown in Table 5. Maghreb, Northeastern Africa and the Arabian Peninsula have very limited water resources, with less than 10 mm on average, and are in a severe situation of water scarcity, with values per inhabitant varying between 200 and 700 m^3/year. In contrast, the Middle East and Central Asia show much higher values, due to the abundant flows generated in the mountainous areas of Turkey and in the Himalayas.

TABLE 5
Sub-regional distribution of renewable water resources

Region	Area	Population 1995	Mean annual precipitation		Mean annual internal renewable water resources			
	'000 km^2	'000 inhabitants	mm	km^3	mm	km^3	in % of prec.	m^3 per inhab.
Maghreb	5 777	71 544	86	495	8	48	9.8	677
Northeastern Africa	4 168	100 856	306	1 275	10	43	3.4	427
Arabian Peninsula	3 103	39 110	79	246	2	8	3.1	197
Middle East	1 512	106 635	421	637	162	245	38.4	2 294
Central Asia	3 926	243 316	304	1 195	138	541	45.3	2 226
Total Near East	18 486	561 461	208	3 848	48	885	23.0	1 577
World	134 223	5 716 407	820	110 000	298	40 000	36.4	7 000
N. East as % of world	13.8	9.8		3.5		2.2		22.5

Note: Rainfall figures have been estimated for Afghanistan, Tajikistan and Turkmenistan

Hydrological analogies

From the viewpoint of their water resources, the Near East countries can be classified into three categories:

1. **Countries relying mostly on significant internal water resources**: Morocco, Lebanon, Cyprus, Iran, and the countries characterized by high IRWR due to their favourable geographic situation (Turkey, Kyrgystan, Tajikistan and Afghanistan). Pakistan is in a particular situation; it shows a significant dependency ratio (more than 40%) and its IRWR is not exceptionally high (1760 m^3/inhabitant/year). However, it has been included in this category grouping countries which are not in a critical water situation. This group is characterized by a dependency ratio lower than 50% and IRWR higher than 1000 m^3/inhabitant per year. The countries corresponding to these criteria are shown in Table 6.

TABLE 6
Countries with IRWR > 1000 m^3/year and dependency ratio < 50%

Country	IRWR per inhabitant in m^3/year	Dependency ratio (%)
Tajikistan	10 129	24.5
Kyrgyzstan	9 954	0.0
Turkey	3 164	1.8
Afghanistan	2 731	15.4
Iran	1 910	6.6
Pakistan	1 760	40.7
Lebanon	1 595	0.8
Cyprus	1 213	0.0
Morocco	1 110	0.0

2. **Countries with a significant part of their water resources of external origin**: This group may be identified by a dependency ratio higher than 50% (Table 7).

Two of these countries, Iraq and Sudan, have IRWR higher than 1000 m^3/inhabitant per year and can therefore be considered in a better situation than the other countries of the group since they are theoretically less dependent on external resources for their development.

TABLE 7
Countries with dependency ratio > 50%

Country	IRWR per inhabitant in m^3/year	Dependency ratio (%)
Iraq	1 721	53.3
Somalia	649	61.9
Sudan	1 246	77.3
Syria	477	80.3
Mauritania	176	96.5
Bahrain	7	96.6
Egypt	29	96.9
Turkmenistan	244	98.6
Kuwait	0	100.0

In the countries of this category, the major problem in assessing water resources lies in estimating the transboundary surface water and groundwater flows. When possible, the natural flow (not affected by water consumption in the upstream countries) and the actual flow for each country belonging to an international river basin have been derived from the available information.

Two countries, Bahrain and Kuwait, are also included in this group because they receive water from a large groundwater basin extending over the northeastern part of Saudi Arabia. However, the groundwater flow from Saudi Arabia is probably not related to present recharge and the external resources of Kuwait and Bahrain should theoretically not be considered as entirely renewable.

3. **Countries with very limited renewable internal and external water resources (IRWR < 1000 m^3/inhabitant per year and dependency ratio < 50 %)**: All these countries (Table 8) face a difficult and, for some of them, critical water scarcity situation. Depending on their geographical position and their geological characteristics, they adopted different approaches to meet their internal water demand:

TABLE 8
Countries with IRWR < 1000 m^3/inhabitant/year and dependency ratio < 50%

Country	IRWR per inhabitant in m^3/year	Dependency ratio (%)
Algeria	498	2.8
Djibouti	520	0.0
Jordan	124	22.7
Libya	111	0.0
Malta	42	0.0
Oman	455	0.0
Qatar	93	3.8
Saudi Arabia	134	0.0
Tunisia	396	14.6
United Arab Emirates	79	0.0
Yemen	283	0.0

- Some of them (Algeria, Tunisia, Libya, Jordan and Saudi Arabia) have substantial non-renewable groundwater resources, partly shared with neighbouring countries and for which each country adopts different mining policies.
- The remaining countries do not have other significant groundwater reserves at their disposal either because of the dimensions of the country (Djibouti, Qatar, United Arab Emirates, Malta) or because of the geology of the country which did not allow the creation of important groundwater reserves during the pluvial periods of the Quaternary (Oman, Yemen).

In Table 9, an attempt has been made to assess the part of groundwater mining in the total water withdrawal of some countries. It also includes Kuwait and Bahrain which benefit from fossil groundwater resources of external origin and Malta, which is overexploiting its renewable groundwater resources resulting in seawater intrusion.

TABLE 9
Utilization of non-renewable sources of water in some countries

Country	Groundwater mining as % of total water withdrawal
Kuwait	46.5
Bahrain	40.2
Malta	32.2
United Arab Emirates	70.9
Qatar	14.9
Libya	90.0
Jordan	17.5
Saudi Arabia	79.7

CONCLUSION

The purpose of this study was the compilation and analysis of available information in order to draw a regional picture of the situation of water resources in the Near East Region. The study was part of a larger effort to assess the water resources and use in the Near East Region which resulted in a comprehensive review of water use for agriculture at country level (FAO, in press).

The main characteristic of the water resources in the Near East Region is certainly the scarcity which becomes even more apparent when compared to the water demand (FAO, in press). The water scarcity which prevails in the region has forced, and will force even more in the future, national economies to find alternative ways to satisfy the demand for fresh water. Some oil-rich countries already convert a significant amount of saline water from the sea or from poor quality aquifers into usable water. Similarly, treatment and reuse of waste water is becoming a common practice in the Near East. The total use of desalinated water in the Near East is estimated at 1 727 million m^3/year. In absolute terms, three countries, Saudi Arabia, the United Arab Emirates and Kuwait, are by far the largest users of desalinated water with 77% of the total for the Region, Saudi Arabia alone accounting for 41% (Table 10).

The total quantity of reused treated wastewater in the Near East is estimated at 1 200 million m^3/year. Syria, Saudi Arabia and Egypt are the largest users of treated wastewater in absolute terms, accounting for almost 66% of all the wastewater reused in the Region, with Syria alone accounting for almost 31%.

Considering the use of both desalinated water and treated wastewater, the above five countries account for almost 80% of the total for the Near East (Table 10 and Figure 6).

TABLE 10
Countries using the largest quantities of desalinated water and treated wastewater

Country	Use of non-conventional sources of water								
	desal. water 10^6 m^3/year	in % of total withdr.	in % of withdr. of country	treated waste-water 10^6 m^3/year	in % of total withdr.	in % of withdr. of country	total non-convent. 10^6 m^3/year	in % of total withdr.	in % of withdr. of country
Saudi Arabia	714	41.3	4.20	217	18.1	1.28	931	31.8	5.48
United Arab Emirates	385	22.3	18.26	108	9.0	5.12	493	16.8	23.38
Kuwait	231	13.4	42.94	52	4.3	9.67	283	9.7	52.61
Syria	-	-	-	370	30.8	2.57	370	12.6	2.57
Egypt	25	1.5	0.05	200	16.7	0.36	225	7.7	0.41
Other 24 countries	372	21.5	0.09	253	21.1	0.06	625	21.4	0.15
Total Near East	1 727	100.0	0.34	1 200	100.0	0.23	2 927	100.0	0.57

Another indicator of the importance of water scarcity in the Region is the amount of food the region must import to compensate for the lack of water necessary for agricultural production.

Table 11 shows estimates of the unit amount of water which could be necessary under the prevailing climatic conditions of the region to produce selected food items.

TABLE 11
Water equivalent of main food products in Near East

Product	Unit	Equivalent water in 100 m^3 per unit
Bovine, Cattle	Head	4
Sheep and goats	Head	0.5
Cereals	Metric ton	1.5
Meat bovine fresh	Metric ton	20
Meat poultry fresh	Metric ton	6
Meat sheep fresh	Metric ton	10
Citrus fruits	Metric ton	1
Palm oil	Metric ton	2
Pulses	Metric ton	1
Roots and tubers	Metric ton	1

On the basis of FAO trade statistics (FAO, 1995b), net import of food can be estimated for each country and transformed into water equivalents. The results are presented in Table 12, which shows that net food import represents 86.5 km^3 of water per year. This volume is comparable to the total natural flow of the Nile River at Aswan (84 km^3/year). A negative figure indicates that export exceeds import. This is the case of Turkey, which is a net exporter of cereals and animals (sheep and goats essentially), and of Mauritania, and Somalia which are net exporters of animals.

TABLE 12
Water equivalent of import of food in the Near East Region (1994)

Country	Water equivalent in 1000 m^3 of net import*
Afghanistan	273 100
Algeria	12 396 700
Bahrain	679 600
Cyprus	888 700
Djibouti	1 100
Egypt	18 171 100
Iran	11 518 600
Iraq	2 179 800
Jordan	3 467 200
Kuwait	2 783 600
Kyrgystan	NA
Lebanon	1 765 800
Libya	3 236 600
Malta	313 700
Mauritania	-1 700
Morocco	2 419 100
Oman	1 349 000
Pakistan	3 490 100
Qatar	657 300
Saudi Arabia	13 863 200
Somalia	-851 000
Sudan	1 118 300
Syria	1 014 000
Tajikistan	NA
Tunisia	2 463 200
Turkey	-3 467 900
Turkmenistan	NA
United Arab Emirates	3 362 000
Yemen	3 375 100
Total	86 466 300

Net import = import-export

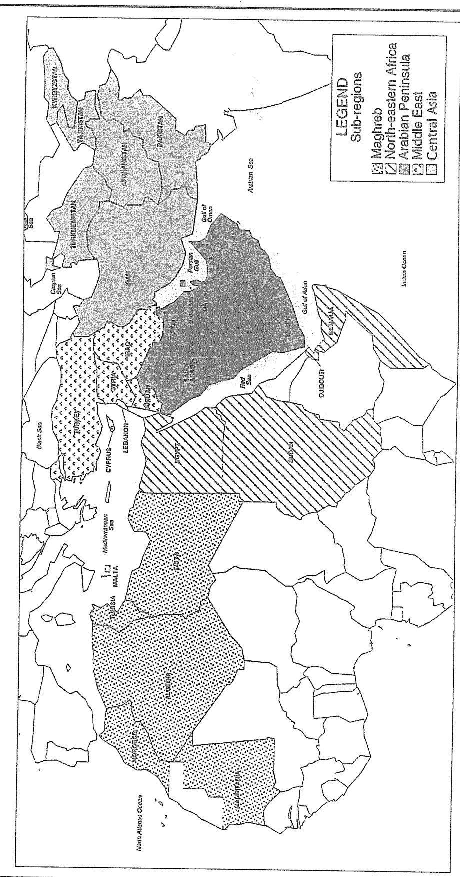

FIGURE 1
The countries and the five sub-regions of the Near East Region

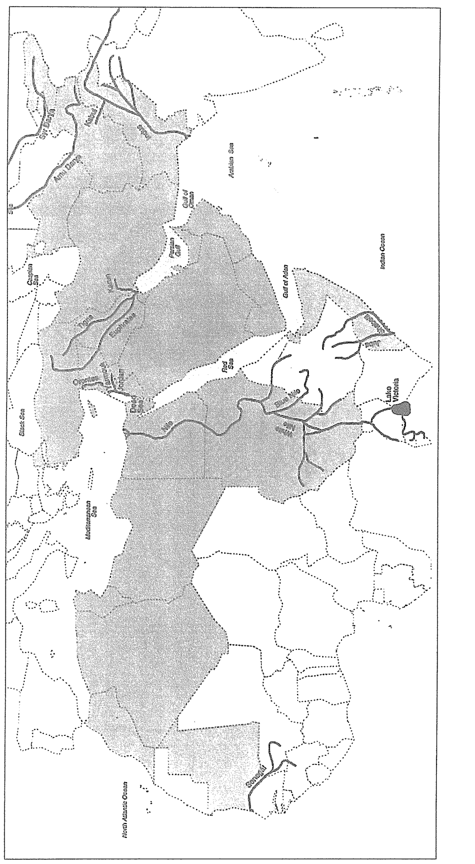

FIGURE 2
Major rivers in the Near East Region

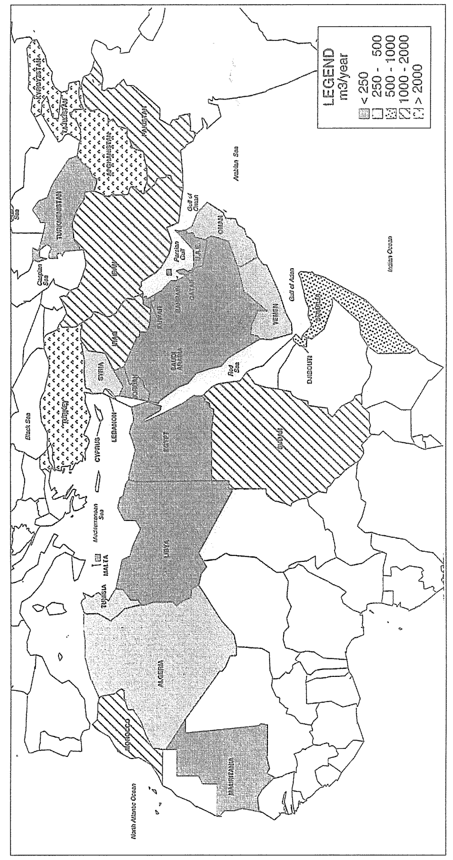

FIGURE 3
Annual internal renewable water resources per inhabitant (1995)

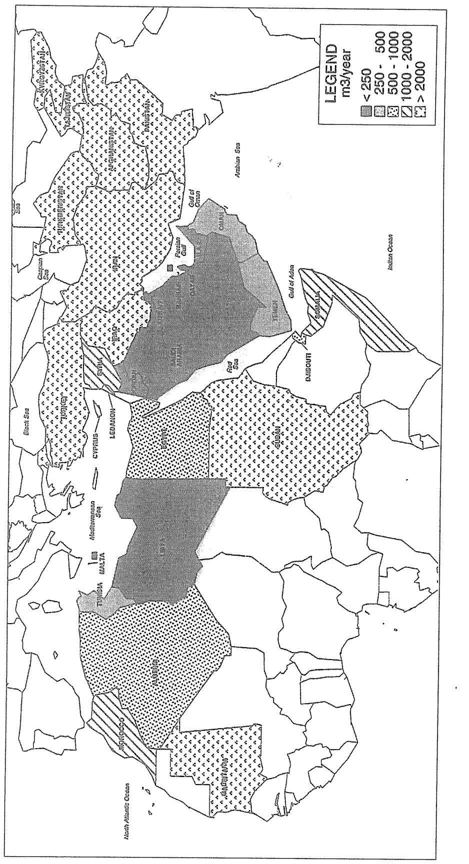

FIGURE 4
Annual actual renewable water resources per inhabitant (1995)

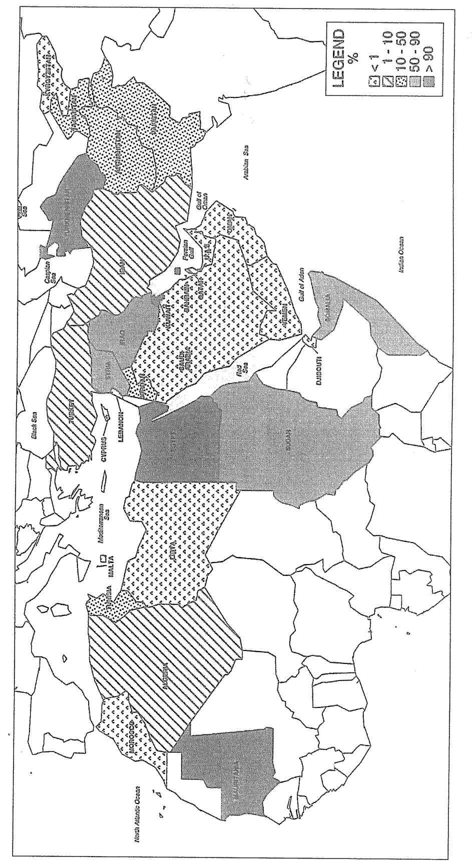

FIGURE 5
Renewable water resources dependency ratio

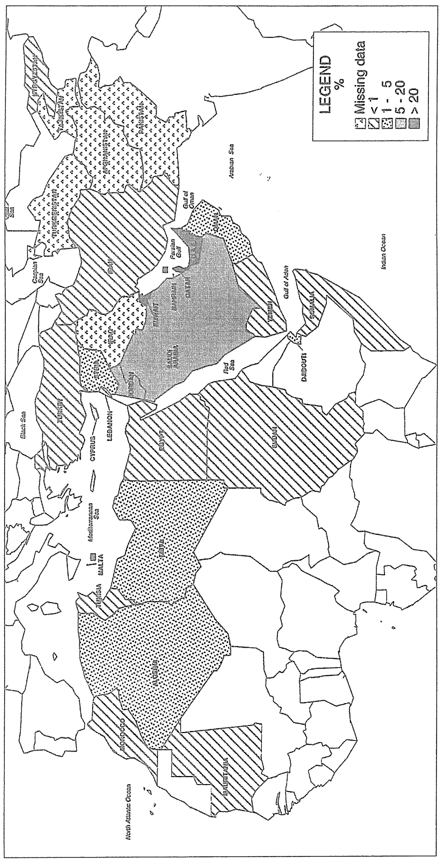

FIGURE 6
Use of non-conventional sources of water (as a percentage of total water withdrawal)

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