WATER RESOURCES AND THEIR USE IN AGRICULTURE IN ARAB COUNTRIES

1. INTRODUCTION

Considering that the bulk of the world's water resources is used in agriculture and that demand for food requirements is increasing rapidly, the role of water resources management, through efficient irrigation systems and techniques, has recently assumed greater importance in increasing food production in order to achieve global food security. The efficient use of water resources in agriculture through improving irrigation systems and techniques is, therefore, one of the most urgent needs and prerequisites for sustainable food production, particularly in water-scarce regions.

Water is a scarce resource in arid and semi-arid areas of the Arab countries in West Asia and North-eastern Africa where most of those countries in this region are facing severe pressures due to limited opportunities for the exploitation of new water resources. These pressures are expected to increase in the face of expanding populations and the increased per capita water use associated with economic development. In addition, within the recognition that climate change is a significant factor in water resource planning, there is consensus that most of the arid and semi-arid regions of the world can expect an increase in water stress.

In the light of these challenges, this paper attempts to provide a clear picture of the state of water resources and their use in agriculture in the Arab countries with emphasis on the importance of groundwater resources and irrigation systems. For this purpose, the 22 Arab countries have been grouped in four sub-regions based primarily on geographic conditions and, as far as possible, on hydro-climatic homogeneity. These sub-regions are hereafter referred to as Maghreb, North-eastern Africa, Arabian Peninsula and Middle East (see Table A.1 in the Annex).

2. GEOGRAPHY, POPULATION AND LAND USE

The 22 Arab countries are dispersed over a large geographical region in North Africa, the Middle East and West Asia. With a total land area of

about 13.7 million square kilometres (km^2) and a total population of almost 305 million in 2003, the Arab countries accounted for 10.2% of the world total land area and 4.8% of its total population (Table 1). Their total population (45% of which is rural) increased between 1990-2003 by an average annual rate of 2.7% against 1.5% of that of the world total[1].

With 6 million km^2, the Maghreb covers the largest area in the region and with 0.7 million km^2, the Middle East covers the smallest one. Therefore, population density is lowest in the Maghreb (13 inhabitants per km^2) and highest in the Middle East (79 inhabitants per km^2). The least densely populated countries are Libya and Mauritania (3 inhabitants per km^2). In contrast, Bahrain is the most densely populated country with 958 inhabitants per km^2 followed by Palestine (591 inhabitants per km^2), Lebanon (430 inhabitants per km^2), Comoros (332 inhabitants per km^2) and Kuwait (139 inhabitants per km^2). All the remaining countries have less than 100 inhabitants per km^2 (Table A.1 in the Annex).

TABLE 1: POPULATION AND LAND AREA

	Population 2003			**Land Area**	**Density**
	Total (million)	Urban %	Rural %	(million km^2)	(persons per km^2)
Maghreb	81.25	61	39	6.04	13
North-eastern Africa	112.74	42	58	4.02	28
Arabian Peninsula	53.26	63	37	2.91	18
Middle East	57.35	66	34	0.72	79
All Arab Countries	**304.6**	**55**	**45**	**13.69**	**22**
% of World	4.8			10.2	

Source: Table A.1 in the Annex.

The area extending between the Atlantic Ocean and the Arab Gulf is covered with vast deserts. The Great Desert (the Sahara), extending between the Atlantic Ocean and the Red Sea, comprises large parts of the Maghreb and North-eastern Africa. The area extending between the Red Sea and the Arab Gulf includes the Rub Al Khali (Empty Quarter) desert in the south of the Arabian Peninsula and the Badiat-EI-Sham desert in the north of the Arabian Peninsula.

Many mountain ranges can be found in the region. In the center of the Great Desert, several mountains appear, with the highest peak at an

[1] SESRTCIC Database (BASEIND).

elevation of 3000 meters at Tebetsy Mountain in Libya. In addition to these internal mountains, there are mountain ranges running parallel to the coasts of the Mediterranean and Red Seas. The Atlas mountain range occupies the northwestern corner of the Maghreb, with its peak in Morocco at an elevation of 4165 meters. In Lebanon, the Lebanon mountain chain has its highest crest at just over 3000 meters and in Yemen, there is a mountain peak at an elevation of 3268 meters[2].

TABLE 2: LAND USE IN AGRICULTURE (Million Hectares)

	Agricultural Area	Arable Land	Permanent Crops	Permanent Pasture
Maghreb	135.3	21.1	4.0	110.2
North-eastern Africa	182.8	20.3	1.0	161.5
Arabian Peninsula	193.4	5.3	0.6	187.6
Middle East	25.7	10.9	1.5	13.2
All Arab Countries	**537.2**	**57.6**	**7.1**	**472.5**
As % of:				
World	10.8	4.2	5.4	13.6
Developing countries	17.3	7.7	6.5	21.0

Source: Table A.2 in the Annex.

The Arab countries have a total agricultural area of 537.2 million hectares[3] or 39.4% of their total land area. The bulk of their agricultural area (88% or 472.5 million hectares) is permanent pastureland used for grazing of livestock. The total arable land of the Arab countries covers an area of 57.6 million hectares or 10.7% of their total agricultural area[4]. The permanent crops land covers an area of 7.1 million hectares or only 1.3% of the agricultural area[5] (Tables 2 and 3).

Land use in agriculture in the Arab countries reflects large differences at both the individual country and sub-regional levels. With the largest agricultural area, the Arabian Peninsula has the smallest arable and permanent crops land areas. This is due to the fact that the bulk of the agricultural area (97% or 187.6 million hectares) is permanent pastureland used for the grazing of livestock. In contrast, with the

[2] FAO, "General Summary on Near East Region", Information System on Water and Agriculture (AQUASTAT).

[3] Agricultural area is the sum of arable, permanent crops and permanent pastures land areas. 1 hectare = 0.01 km^2.

[4] Arable land is the land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens, and land temporarily fallow.

[5] Permanent crops land is the area cultivated with crops that occupy the land for long periods and that do not need to be replanted after each harvest. This does not include woodland and forests.

smallest agricultural area, the Middle East leads the other sub-regions in terms of arable and permanent crops land areas (42.5% and 6% of the agricultural area, respectively).

TABLE 3: LAND USE IN AGRICULTURE (Percentages)

	Agricultural Area as % of Land Area	% of Agricultural Area		
		Arable Land	Permanent Crops	Permanent Pasture
Maghreb	23.5	15.6	2.9	81.4
North-eastern Africa	45.4	11.1	0.5	88.4
Arabian Peninsula	62.4	2.7	0.3	97.0
Middle East	35.4	42.5	6.0	51.5
All Arab Countries	**39.4**	**10.7**	**1.3**	**88.0**
World	37.0	27.6	2.7	69.7
Developing countries	41.0	24.0	3.5	72.5

Source: Table A.3 in the Annex.

At the individual country level, Egypt (85.3%), Iraq (57%), Comoros (54.4%), Lebanon (51.7%) and Syria (33.4%) have, in a descending order, the highest shares of arable land in agricultural area. In terms of the share of permanent crops land in agricultural area, Lebanon (43.5%), Bahrain (40%), Comoros (35.4%), United Arab Emirates (33.5%) and Palestine (31%) recorded, in a descending order, the highest shares (Table A.3 in the Annex). In contrast, Djibouti (0.1%), Mauritania (1.2%) and Saudi Arabia (2.1%) recorded the lowest shares of arable land in agricultural area. Moreover, it is observed that permanent crops land is negligible in countries such as Djibouti, Mauritania, Somalia and Saudi Arabia.

While the percentage of agricultural area in total land area of the Arab countries is comparable to the average of the developing countries or even slightly higher than that of the world average, the percentage of their arable and permanent crops land areas in total agricultural area is still significantly below the average levels of the world and the developing countries (Table 3). This is due, among other things, to the unsatisfactory use of land in agriculture, particularly due to the scarcity of water resources and the use of insufficient irrigation systems and techniques.

3. WATER RESOURCES

3.1. Overview

Because of the aridity prevailing in most of the Arab countries, particularly those in the sub-regions of west Asia and Northeastern Africa, the Arab region is the poorest in the world in terms of water resources, both globally and per inhabitant. This is true even when we consider the contribution of rivers flowing from the bordering regions. However, water resources distribution within this vast region is far from being uniform. Land relief, location with respect to the sea, latitude and resulting hydro-climatic conditions, diversity in hydrographical and geological structures and matching or mismatching of the river basins with the national territories all give rise to extremely different water situations.

Many Arab countries are characterized by long coastal boundaries. The coasts are located on the Atlantic Ocean, the Mediterranean Sea, the Red Sea, the Gulf of Aden, the Arab Gulf, the Gulf of Oman and the Arabian Sea. In addition, some international rivers cross the region; the most important of which are the Nile in Sudan and Egypt, which originates outside the region in the Equatorial Lake, and the Euphrates and Tigris flowing from Turkey in Syria and Iraq. Smaller rivers like the Jordan and the Orontes (flowing in Lebanon through Syria and Turkey) also play a fundamental role in international relations regarding water resources in the Arab region.

In this paper, a distinction has been made between renewable and non-renewable water resources. Renewable water resources (RWR) are that part of the water resources generated from endogenous precipitation. They are computed on the basis of the water cycle by adding up the long-term average annual flow of rivers and lakes (surface water) and recharge groundwater reservoirs. Non-renewable water resources are groundwater bodies (deep aquifers) that have a negligible rate of recharge on the human time-scale and thus can be considered non-renewable.

Total renewable water resources (TRWR) are the total amount of a country’s water resources and defined as the sum of internal renewable water resources (IRWR) and external renewable water resources (ERWR), i.e. the incoming flow originating outside the countries' borders. A distinction is also made between natural TRWR, which is computed by assessing the long-term yearly average of water flow without any human influence, and actual TRWR, which is the maximum

amount of water actually available for a country. Actual flow takes into account abstraction in upstream countries and the volumes allocated through formal or informal agreements or treaties between countries[6].

3.2. Renewable Water Resources

Although the Arab countries cover 10.2% of the total area of the world, they receive only 2.1% of the world's average annual precipitation[7] and have as little as 0.3% of its annual renewable water resources. Their total annual internal renewable water resources (IRWR) accounted for only 6.3% of their average annual precipitation, as against the world average of 40.6% (Table 4). It is obvious that the four sub-regions of the Arab countries have very limited internal water resources, with less than 50 km^3/year on average and suffer severe water scarcity, particularly in the case of Arabian Peninsula countries, with only 169 m^3/year per inhabitant.

TABLE 4: INTERNAL RENEWABLE WATER RESOURCES (IRWR)

	Average Annual Precipitation	**Annual Internal Renewable Water Resources (IRWR)**		
	km^3/year	**km^3/year**	**As % of precipitation**	**Per capita (m^3/year)**
Maghreb	593.3	48.1	8.1	619
North-eastern Africa	1282.3	39.3	3.1	364
Arabian Peninsula	251.3	7.8	3.1	169
Middle East	158.3	48.5	30.6	986
All Arab Countries	**2285.2**	**143.7**	**6.3**	**512**
World	107924	43764	40.6	7243
As % of World	**2.1**	**0.3**		

Source: Table A.4 in the Annex.

In fact, the averages of internal renewable water resources per capita in the Arab countries are among the lowest in the world. The average for all Arab countries is 512 m³/inhabitant per year, as against 7243 m³/year per inhabitant for the whole world. It ranges from zero in Kuwait, which has practically no internal renewable water resources, to about 1700 m³/inhabitant per year in Comoros. Internal renewable water resources

[6] The methodology used in computing different types of water resources is available in FAO's AQUASTAT Database (http://www.fao.org/ag/aglw/aquastat/dbase).

[7] Average precipitation stands for the double average over space and time of the precipitation (i.e. water falling) on the country in a year (rain, snow or hail).

per capita are below 500 m³/year in 15 out of the 22 Arab countries (see Table A.4 in the Annex).

Even when considering the contribution of the rivers flowing from the bordering and more humid regions of tropical Africa (the Nile flowing in Sudan and Egypt) and Turkey (the Euphrates and Tigris flowing in Iraq and Syria), the Arab countries are still among the poorest in the world in terms of water resources. This is true considering the figures on total renewable water resources (TRWR) both natural and actual as presented in Table 5 below and Table A.4 in the Annex. The average of 1116 m^3/year actual TRWR per capita of the Arab countries is still significantly lower than the 7243 m^3/year of the world average; it is below 500 m³/year in 12 countries reflecting an extreme variability: from a minimum of 10 m^3/inhabitant in Kuwait to more than 4000 m^3/inhabitant in Mauritania (Table A.4 in the Annex).

TABLE 5: TOTAL RENEWABLE WATER RESOURCES (TRWR) AND DEPENDENCY RATIO

	TRWR (km^3/year)		**Actual TRWR per capita**	**Dependency Ratio (*)**
	Natural	**Actual**	**m^3/year**	**(%)**
Maghreb	59.9	59.9	771	19.7
North-eastern Africa	250.8	137.8	1278	71.5
Arabian Peninsula	7.94	7.92	172	1.7
Middle East	149.01	107.81	2191	55.0
All Arab Countries	**467.65**	**313.43**	**1116**	**54.2**
World	43764	43764	7243	
As % of World	**1.1**	**0.7**		

Source: Table A.4 in the Annex.
(*) The part of the total renewable water resources originating outside the country or the region.

Furthermore, some Arab countries depend to a large extent for their renewable water resources (RWR) on water flows originating outside their borders. This situation reflects a high dependency ratio of 54.2% in the group of the Arab countries (Table 5). The Arab countries in the North-eastern Africa recorded the highest water resources dependency ratio of 71.5% followed by the countries in the Middle East with 55%, the Maghreb with 19.7% while countries in the Arabian Peninsula recorded the lowest ratio of only 1.7%.

TABLE 6: COUNTRIES WITH TRWR DEPENDENCY RATION ABOVE 50%

Country	IRWR km^3/year	TRWR Actual km^3/year	Dependency Ratio (%)	Main Source of Incoming Water
Kuwait	0.0	0.02	100.0	Groundwater from Saudi Arabia
Egypt	1.8	58.3	96.9	Nile river
Bahrain	0.004	0.1	96.6	Groundwater from Saudi Arabia
Mauritania	0.4	11.4	96.5	Senegal river
Syria	7.0	26.3	80.3	Euphrates and Tigris rivers
Sudan	30.0	64.5	76.9	Nile river
Somalia	6.0	13.5	55.6	Shebelli and Juba rivers
Iraq	35.2	75.4	53.3	Euphrates and Tigris rivers

Source: Table A.4 in the Annex.

As shown in Table 6, four Arab countries depend for over 90% for their RWR on water flows from other countries. Those are Bahrain (96.6%) and Kuwait (100%) depending on groundwater flows from Saudi Arabia; Egypt (96.9%) depends on the Nile River from Ethiopia, and Mauritania (96.5%) on Senegal River. Two countries, Syria and Sudan, are intermediate countries in that they depend to a large extent, around 80%, on upstream countries for their RWR (mainly 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). To a lesser extent, but still with over 50% dependent on other countries are Somalia (55.6%) and Iraq (53.3%).

3.3. The Importance of Groundwater Resources

The scarcity and disparity of water resources in the Arab countries are aggravated, in some cases, by the low levels of usability and quality where only small parts of natural water resources can be contained and utilised. Such a situation is usually intensified by the impact of human activity that disrupts water regimes and leads to a deterioration in water quality. Examples of such a situation include, among others, salinization of coastal aquifers (e.g. in Palestine) and the disappearance of sources (e.g. in Tunisia).

The inequalities among countries in accessing freshwater resources, therefore, reflect to a large extent the differences in development, treatment and rehabilitation works, and the related costs required to obtain exploitable natural resources. The effort required varies significantly with the accessibility and regularity of the resources. For example, the ratio of exploitable water resources to TRWR is close to 100% in countries where the main source of water is groundwater such

as Libya, Palestine, Saudi Arabia and the United Arab Emirates, but generally less than 70% in countries where surface water resources are important such as Egypt, Sudan and Morocco. However, the shortness of the data prevents the presentation of a clear picture of exploitable water resources where figures are available for only a few Arab countries (see Table A.5 in the Annex).

The distribution between surface water and groundwater illustrates the differences between arid and humid sub-regions. In arid sub-regions, such as the Arabian Peninsula, groundwater recharge is important and a critical factor for the development of the countries in this sub-region. On average, 62.8% of IRWR in the Arabian Peninsula are groundwater. At the individual country level, groundwater resources accounted for more than 50% of the IRWR in 13 Arab countries and higher than 70% in 9 of those countries (Table A.5 in the Annex). On the other hand, the less arid Arab countries with rivers, such as Sudan and Egypt where a large part of groundwater resources is not connected to the river system, evaporation from wetlands and lakes plays a major role and may substantially limit the amount of water resources available for use. The quantity of water leaving those countries is less than that flowing into them since the Nile River flows decrease progressively, mainly as a result of the high rates of evaporation in internal deltas.

The water scarcity that prevails in the arid Arab countries has forced the national authorities to find alternative ways to satisfy the demand for freshwater. Some Arab countries, particularly oil-rich countries in the Arabian Peninsula, convert a significant amount of saline water from the sea or from poor-quality aquifers (brackish water) into usable and even drinking-water. The total use of desalinated water in the Arab countries is estimated to be 1.7 km^3/year where three countries (Saudi Arabia, the United Arab Emirates and Kuwait) are by far the largest users of desalinated water, accounting for 78.6% of the total Arab countries (calculated using the data in Table A.5 in the Annex). Similarly, treatment and reuse of wastewater is becoming a common practice in some Arab countries, particularly in the Arabian Peninsula. Though the data on reused treated wastewater exists for most of the Arab countries, there is probably a large amount of non-treated wastewater which is reused for agriculture but is not reported.

Another specificity of the Arab countries with few renewable water resources is the dependence on important non-renewable groundwater basins, partly shared with neighbouring countries. The non-renewable groundwater reserves located in large sedimentary aquifers systems represent an important water resource for the arid zones in these countries due to the limited availability of renewable water resources. They are particularly important for countries such as Algeria, Egypt, Libya, Palestine, Saudi Arabia, Tunisia and the United Arab Emirates. Libya, which depends heavily on fossil groundwater to cover its current water demand, is a typical example in this context. Therefore, the largest part of the total water withdrawn in those countries is fossil water. However, although groundwater reservoirs may allow storage of huge quantities of water, they cannot be considered sustainable in the long term, as the lack of present recharge would result in the slow depletion of the aquifers. Moreover, the water level decline and the resulting increase in the cost of pumping as well as the deterioration of the water quality in some areas may also make the abstraction of fossil water less attractive with time.

4. WATER WITHDRAWAL AND USE IN AGRICULTURE: PRESSURE ON WATER RESOURCES

The total water withdrawal[8] in the Arab countries accounts for 7.1% of that of the world total. It makes up 1.6 times their internal renewable water resources (IRWR) and 73.7% of their actual TRWR, as against only 8.1% for the whole world. However, while 87.3% of the total water withdrawal in the Arab countries is directed towards agriculture, as against 69% for the whole world, the agricultural water withdrawal[9] in those accounts for only 9% of that of the world (Table 7).

At the sub-regional level, the North-eastern Africa has, in absolute terms, the highest levels of both total and agricultural water withdrawals. Only 3 countries (Egypt, Somalia and Sudan) in this sub-region accounted for almost half of total and agricultural water withdrawals in the Arab countries (47.3% and 46.2%, respectively) with Egypt alone withdrawing 30% (calculated using the data in Table A.6 in the Annex). However, the Middle East sub-region has the highest level

[8] Total water withdrawal is the annual quantity of water withdrawn for agricultural, industrial, and domestic purposes. The use of desalinated and treated wastewater is thus included.

[9] Including irrigation and livestock watering.

of water withdrawal for agriculture (92.2% of total withdrawal). Therefore, as is shown in the next section, the largest part of the arable land area in the Middle East sub-region is irrigated. At the individual country level, Somalia and Sudan are the countries with the largest percentage of water withdrawal directed to agriculture (100% and 97%, respectively) while Kuwait, with 52%, is the country with the lowest percentage.

Water withdrawal, expressed as a percentage of internal renewable water resources, is an indicator of the region's or the country's capacity to rely on its own renewable sources of water (the pressure on the renewable water resources). Roughly speaking, pressure on water resources is considered high when this percentage is above 25%. While Lebanon recorded a percentage of 28.5%, only one country (Djibouti) in the Arab region is below the 25% limit (see Table A.6 in the Annex). Values above 100% indicate that the country or the region relies, at least, partly on renewable water resources flowing from outside, non-conventional water resources (desalinated water and treated wastewater) or mining its groundwater resources.

TABLE 7: WATER USE IN AGRICULTURE

	Total Withdrawal			**Agricultural Withdrawal**		
	km^3/year	% of IRWR	% of Actual TRWR	km^3/year	% of total with-drawal	% of Actual TRWR
Maghreb	28.07	58.4	46.9	23.42	83.4	39.1
North-eastern Africa	109.27	278.0	79.3	93.207	85.3	67.6
Arabian Peninsula	28.65	369.4	361.7	25.15	87.8	317.6
Middle East	65.04	134.1	60.3	59.99	92.2	55.6
All Arab Countries	**231.02**	**160.8**	**73.7**	**201.77**	**87.3**	**64.4**
World	3240.0	8.1	8.1	2235.6	69.0	5.1
As % of world	**7.1**			**9.0**		

Source: Table A.6 in the Annex.

In North-eastern Africa, where water withdrawal accounts for 278% of IRWR (Table 7), water transfer plays a crucial role (the Nile flows into the region from upstream countries outside the region). In contrast, in the Arabian Peninsula, where this percentage is 369.4%, the deficit is mainly reduced by the use of fossil and non-conventional water sources. At the individual country level, annual water withdrawal is greater than the internal renewable water resources in 13 Arab countries (see Table A.6 in the Annex). However, 5 of these countries (Egypt, Iraq, Mauritania, Sudan and Syria) benefit from rivers flowing in from

upstream countries, resulting in an annual water withdrawal that is greater than the internal renewable water resources. The remaining 8 countries are those of the Arabian Peninsula (except Kuwait), Libya and Jordan. In these countries, water withdrawal is greater than the internal renewable water resources and they have to rely on groundwater and non-conventional water resources. Yet, it remains to say that while some other countries (such as Tunisia) have relatively high rates of use of their internal renewable water resources, they do not benefit much from groundwater or non-conventional water resources or even incoming water. It is then likely that those countries will have to rely increasingly on alternative sources of water in the future.

5. IRRIGATION AND WATER MANAGED AREAS

5.1. Irrigation Areas

The term 'irrigation area' or 'area under irrigation' refers to the area of land equipped to provide water, other than direct rainfall, to the crops. It includes areas equipped for full and partial (f/p) control irrigation[10], spate irrigation[11] areas, and equipped wetland and inland valley bottoms[12]. It does not include flood recession cropping areas[13] which, when added to the other mentioned areas, the total irrigation area is then called the water managed area, as is shown in Table 8.

According to this definition, the total irrigation area in the Arab countries covers 15.7 million hectares or 5.7% of that of the world (Table 8). The bulk of the total irrigation area of the Arab countries is concentrated in a few countries in North-eastern Africa and the Middle East. The total irrigation area of only 4 countries in these two sub-regions (Iraq, Egypt, Sudan and Syria) accounts for 64.3% of the total

[10] Physical area of irrigation schemes developed and managed either by government, private estates or farmers, and where a full or partial control of the water is achieved; gardening is included.

[11] It is a method of random irrigation using the floodwaters of a normally dry system. It is practised by building earthen diversion banks across a dry watercourse. The floods or spates are diverted into embanked fields, where the water is pounded until total infiltration.

[12] Parts of cultivated wetlands and inland valley bottoms which have been equipped with water control structures such as intakes, canals, etc.

[13] Areas along rivers where cultivation occurs in the areas exposed as floods recede. The special case of floating rice is included in this category.

irrigation area in all Arab countries (calculated using the data in Table A.7 in the Annex).

TABLE 8: TOTAL IRRIGATION AREA AND WATER MANAGED AREA (000 hectares)

	f/p control (1)	Spate (2)	Equip. wet/ivb (3)	Total irrigation area	Flood recession cropping	Water managed area
Maghreb	2483	335	0	2818	64	2882
North-eastern Africa	5182	282	0	5464	0	5464
Arabian Peninsula	2307	103	0	2410	0	2410
Middle East	5059	0	0	5059	0	5059
All Arab Countries	**15031**	**720**	**0**	**15751**	**64**	**15815**
World				276719	27757	304476
As % of World				**5.7**	**0.2**	**5.2**

Source: Table A.7 in the Annex.
Notes: (1) Full/partial (f/p) control irrigation equipped area. (2) Spate irrigation area. (3) Equipped wetland and inland valley bottoms.

Full or partial irrigation is by far the most widespread type of irrigation, covering 95.4% of the total irrigation area (calculated using the figures in Table 8). In relative terms, spate irrigation is most important in the Maghreb (covering 11.6% of its water managed area) and North-eastern Africa. The spate irrigation area of only 4 countries in these two sub-regions (Algeria, Morocco, Somalia and Sudan) accounts for 81% of the total spate irrigation area in all Arab countries. In contrast, equipped wetland and inland valley bottoms (ivb) are not reported in any of the Arab countries. On the other hand, with 56.6% of its water managed area, flood recession cropping is practised in only Mauritania (see Table 7 in the Annex).

TABLE 9: IRRIGATION AREA AS % OF TOTAL LAND, AGRICULTURAL AND ARABLE AREAS

	Total Irrigation Area As % of		
	Total land area	Agricultural area	Arable area
Maghreb	0.5	2.1	13.3
North-eastern Africa	1.4	3.0	27.0
Arabian Peninsula	0.8	1.2	45.6
Middle East	7.0	19.7	46.3
All Arab Countries	**1.2**	**2.9**	**27.3**
World	3.3	6.8	19.7
Developing countries	5.2	8.1	34.6

Source: Table A.8 in the Annex.

The total irrigation area in the Arab countries makes only 1.2% of their total land area and 2.9% of their agricultural area, as against 3.3% and 6.8% for the whole world and 5.2% and 8.1% for the developing countries (Table 9). It also accounts for 27.3% of their total arable land area, as against 34.6% for the developing countries and 19.7% for the world. The share of irrigation area in agricultural land varies considerably between sub-regions and countries. In the Middle East, 46.3% of the arable area is equipped for irrigation, playing a crucial role in agricultural production. The part of arable land area under irrigation is also important in the Arabian Peninsula (45.6%), but less so for the other sub-regions, particularly the Maghreb. However, it is crucial for some Arab countries like Egypt where the whole arable land is under irrigation. The part of arable land area under irrigation is less than 20% in 6 countries, half of which are in the Maghreb. In contrast, the total irrigation area exceeds the arable land area in Bahrain, Egypt, Oman and United Arab Emirates (see Table A.8 in the Annex).

5.2. Sources of Irrigation Water

There are three possible sources of irrigation water in the Arab countries: surface water, groundwater (renewable or fossil) and non-conventional sources (treated wastewater and desalinated water). Spate irrigation and flood recession cropping areas are all irrigated by surface water[14]. Table 10 shows the origin of irrigation water for the full or partial (f/p) control irrigation equipped areas. As is shown in this table, the origin of irrigation water in the Arab countries consists mainly of surface water (70.1%), but there are significant differences between the sub-regions and countries.

The large contribution of surface water is found to be in North-eastern Africa (95.6%) and the Middle East (77.8%). This reflects the fact that these sub-regions' hydrology is dominated by three rivers: the Nile, the Euphrates and the Tigris. In contrast, the contribution of groundwater is most important in the Arabian Peninsula (96.4%). On the other hand, non-conventional water for irrigation is used in 8 countries and plays a fairly important role in the drier sub-regions of the Arabian Peninsula

[14] It is a method of irrigation where the water is applied to the land (from rivers and lakes) by allowing it to flow by simple gravity, before infiltrating. It includes various systems depending upon the relative magnitude of the surface flooding phase and infiltration phase after accumulation: furrow, border, basin, and flooded irrigation of rice.

and the Maghreb. In Kuwait, for example, 39% of the irrigated area is irrigated by non-conventional water (treated wastewater and desalinated water). This percentage reaches 13.6% in Bahrain and less than 6% in all the other countries (see Table A.9 in the Annex).

TABLE 10: SOURCES OF IRRIGATION WATER

	% of full/partial (f/p) control irrigation area		
	Surface water	**Ground-water**	**Non-conventional sources**
Maghreb	61.9	37.2	0.9
North-eastern Africa	95.6	4.3	0.1
Arabian Peninsula	2.4	96.4	1.2
Middle East	77.8	22.1	0.1
All Arab Countries	**70.1**	**29.5**	**0.3**

Source: Table A.9 in the Annex.

5.3. Irrigation Techniques

Data on the irrigation techniques used in full or partial (f/p) irrigation schemes are available fully for 13 countries and partially for Algeria (see Table A.10 in the Annex). Based on this data, surface irrigation is by far the most widely used technique in the Arab countries, practised on 80.3% of the total full or partial control irrigation area. On the other hand, sprinkler irrigation[15] is practised on 22.8% and micro-irrigation[16] on only 2.8% of the total area.

In Libya and Saudi Arabia, sprinkler irrigation is by far the most predominant (100% and 64% respectively), while in Jordan and the United Arab Emirates, micro-irrigation is the most widely used technique; being practised on over half of their full/partial control irrigation areas (59.4% and 56.7% respectively). Together, sprinkler irrigation and micro-irrigation techniques are practised on 38.7% of the full/partial control irrigation area in Lebanon and 36% in Kuwait (see Table A.10 in the Annex). In particular, the arid countries, without large

[15] It is a method of irrigation by applying water under pressure when the water is sprinkled in the form of artificial rain through lines carrying distribution components: rotary sprinklers, diffusers with permanent water streams and perforated pipes.

[16] It is a method of irrigation (with different techniques) when water is applied to and causing wetting of only part of the soil in the field at the base of the plant (plant root zone) in small but frequent quantities, i.e. drop by drop. It includes the following terms or systems: trickle irrigation, drip irrigation, daily flow irrigation, drop irrigation and sip irrigation.

rivers, choose to develop more intensively the micro-irrigation and sprinkler irrigation techniques to save water.

TABLE 11: IRRIGATION TECHNIQUES

	As % of full/partial (f/p) control irrigation area		
	Surface irrigation	**Sprinkler irrigation**	**Micro-irrigation**
Maghreb	88.4	44.5	0.7
North-eastern Africa	93.8	3.6	2.6
Arabian Peninsula	47.7	48.6	3.6
Middle East	91.0	4.8	4.2
All Arab countries	**80.3**	**22.8**	**2.8**

Source: Table A.10 in the Annex.

5.4. Irrigation Intensity and Irrigation Potential

Two indicators are frequently used to assess irrigation intensity. First, the rate of use of land equipped for irrigation, which is that part of the area equipped for full/partial (f/p) control irrigation actually irrigated and used for crop production at least once a year. Second, the cropping intensity, which is the ratio between irrigated crops area and the physical area equipped for irrigation (i.e. the water managed area). In general, these figures are not reliable at the country level (see Table A.11 in the Annex).

Moreover, in some cases, it is not possible in practice to distinguish between these two indicators. This is due to the possibility that one part of the equipped area is not used for certain reasons (abandoned, water shortage, etc.), while the remaining part is cultivated in double or triple cropping. Moreover, figures may vary significantly from one year to another, particularly in the areas where irrigation schemes are facing water availability problems.

However, for 19 countries, information was available on the part of the area equipped for full/partial control irrigation which is actually irrigated (see Table A.11 in the Annex). In all these countries, the rate of the use of the equipped area is greater than 50% and in 5 countries it is reported to be 100%. It is also difficult to get reliable information on cropping intensity for the reasons explained above. However, the available figures show a cropping intensity of 1.66 for Egypt, 1.19 for Syria and Mauritania, 1.15 for Oman and 1.08 for Jordan. In Lebanon, the

cropping intensity is reported to be 1, and it is also so in Saudi Arabia, Bahrain and Kuwait, probably because no cropping is possible during the hot season.

On the other hand, methods used by countries to estimate their irrigation potential, which is the area of land suitable for irrigation development, vary with significant influence on the results. In computing water available for irrigation, some countries only consider the renewable water resources, while others, especially arid countries, include the availability of groundwater or non-conventional water resources. For this reason, comparison between countries should be made with caution. Thus it is not possible to systematically add up country figures to obtain regional or sub-regional estimates of irrigation potential.

By far, the largest irrigation potential is concentrated in Iraq and Egypt and is based only on renewable water resources (see Table A.11 in the Annex). Some arid countries, where no agriculture is possible without irrigation, tend to consider the arable land area as the irrigation potential area, for the development of which they would certainly have to rely on the use of groundwater and non-conventional sources of water. This means that, for those countries, any extension of the existing irrigation area would require more of these resources if no improvement in water use efficiency is brought about.

6. AGRICULTURAL PERFORMANCE AND FOOD PRODUCTION

As is shown in the above section, the Arab region is the poorest in the world in terms of the availability of water for agriculture, where aridity is prevailing in many countries in the region. Furthermore, inadequate use of land and water resources for agriculture due to the use of insufficient irrigation systems limited the irrigated agricultural areas in most parts of the region. Consequently, this has undoubtedly reflected, as shown in this section, in the unsatisfactory performance of agriculture and food production of many Arab countries in the region.

Employing 30% of the total population and contributing 9.1% to the total GDP of the Arab countries, agriculture is still considered as a primary economic activity and is assumed to play a significant role in the economies of many of those countries. This is particularly true for the Arab countries in the North-eastern Africa and, to a lesser extent, for

those in the Maghreb (see Table 12). In contrast, agriculture plays a limited role in the economies of the countries in the Arabian Peninsula, where, except in Yemen and Oman, agriculture accounts for less than 10% of GDP (Table A.12 in the Annex).

TABLE 12: POPULATION IN AGRICULTURE AND SHARE OF AGRICULTURE IN GDP

	Population in Agriculture 2003		Share of Agriculture in GDP (%)
	(millions)	% of total	
Maghreb	21.9	27.0	11.3
North-eastern Africa	48.2	42.8	19.5
Arabian Peninsula	12.66	23.8	4.2
Middle East	8.6	15.0	14.8
All Arab Countries	**91.36**	**30.0**	**9.1**
World	2673.6	43.0	4.0
Developing Countries			12.0
% of World	3.4		

Source: Table A.12 in the Annex.

Drought is a recurring phenomenon in the Arab region causing sharp annual fluctuations in crop and livestock production in many countries, but its impact is most evident in cereal production. Data on agricultural production of the Arab countries in 2003 (Table 13) indicate that total cereal production of those countries (52.2 million tons) accounts for only 3.4% of the world total.

TABLE 13: AGRICULTURAL PRODUCTION 2003 (1000 tons)

	Cereals	Fruit and Vegetables	Meat
Maghreb	14061	15648	1622
North-eastern Africa	26159	24933	2308
Arabian Peninsula	2884	6491	1088
Middle East	9068	11843	1043
All Arab Countries	**52172**	**58915**	**6061**
% of World	**2.5**	**4.5**	**2.4**

Source: Table A.13 in the Annex.

Moreover, cereal production in the Arab countries concentrates in those countries in the North-eastern Africa, where only 4 countries (Egypt, Sudan, Somalia and Comoros) produced 50% of the total cereal production of all Arab countries (calculated using the data in Table 13). When the cereal production of Morocco is added, the five countries

alone produced 65.4% of the total cereal production of all Arab countries. In contrast, cereal production in most of the countries in the Arabian Peninsula and the Middle East is very poor, since the two sub-regions together produced 22.9% of the total cereal production of all Arab countries. A similar performance has also been observed in the case of fruit and vegetables and meat.

According to FAO's reports on "The State of Food and Agriculture", agricultural production did not keep pace with the rapidly increasing demand for food in most of the Arab countries, resulting in a widening food gap that had to be filled by imports. Some of those countries remained a large importer of food and agricultural products, especially cereals, followed by dairy products, sugar and vegetables. This makes those countries vulnerable to any sharp rise in the international prices of cereals. In this context, it is worth mentioning that 8 Arab countries were classified as food-deficit countries[17] (see Table A.14 in the Annex). Moreover, food shortages caused by drought and civil strife continued to affect some countries. For example, Somalia, Sudan, Iraq and Jordan were among the countries facing food emergencies in the world[18].

TABLE 14: PREVALENCE OF UNDERNOURISHMENT

	Number of under-nourished people (million)		**Proportion of total population (%)**	
	1995-97	**2000-02**	**1995-97**	**2000-02**
Maghreb	**3.7**	**4.0**	**6.2**	**6.1**
North-eastern Africa	**13.6**	**16.9**	**12.5**	**14.1**
Arabian Peninsula	**6.6**	**7.6**	**17.4**	**16.0**
Middle East	**2.2**	**4.1**	**5.5**	**9.0**
All Arab Countries	**26.1**	**32.6**	**10.6**	**11.7**
Developing Countries	796.7	814.6	18.0	17.0
% of Developing Countries	3.3	4.0		

Source: Table A.14 in the Annex.

Considering this situation, the number of undernourished people in the Arab countries has been increasing over the past decade. In absolute terms, 32.6 million people in 13 Arab countries, for which the data are

[17] The countries which are net importers of basic foodstuffs with per capita GNP in 1995 not exceeding the level set by the World Bank to determine eligibility for International Development Association (IDA) 'soft loan' assistance.
[18] FAO, "The State of Food and Agriculture 2003-2004".

available, were undernourished during the period 2000-2002 compared to 26.1 during the period 1995-97 (see Table A.14 in the Annex). This represents 11.7% of the total population in these countries in the former period compared to 10.6% in the latter one. The number of undernourished people in Arab countries accounted for 4% of the total undernourished people in developing countries in 2000-2002 compared to 3.3% in 1995-97. However, these average figures hide a wide range of variation among the sub-regions and countries. Somalia is still one of the most food-insecure countries in the world, where 75% of the population is undernourished. The proportion of undernourished people is still more than 30% in Yemen and 27% in the Sudan. The undernourishment in Iraq (14%) has not improved in recent years.

7. CONCLUTION AND RECOMMENDATIONS

Receiving only 2.1% of the world's precipitation and having as little as 0.3% of its renewable water resources, the Arab countries are the poorest in the world in terms of water resources, both globally and per inhabitant. Furthermore, many Arab countries depend to a large extent for their renewable water resources on water flows originating outside their borders (the dependency ratio for Arab countries as a group is 54.2%). At the same time, the Arab countries rely heavily on their limited renewable surface and underground water resources for agriculture (87.3% of their total water withdrawal is diverted for agriculture). All this makes water a scarce factor in agricultural production particularly food production in these countries, (total irrigation area accounts for only 2.9% of their agricultural area).

Drought is a recurring phenomenon in the Arab region and causes sharp annual fluctuations in agricultural production, especially in food crop production. In many Arab countries, agricultural production did not keep pace with the rapidly increasing demand for food, resulting in a widening food gap that is to be filled by imports. Four countries alone (Egypt, Morocco, Algeria and Sudan) produce 72.5% of the total cereal production of the Arab countries. The Arab region is, therefore, becoming increasingly more dependent on imported food products. Moreover, the number of undernourished people in the Arab countries has been increasing over the past decade and the region still contains 8 of the most food deficit and insecure countries in the world, where some of them are still facing food emergencies due to drought.

The use of water in agriculture is not adequately and efficiently addressed by most of the Arab countries where sustainability of the existing irrigation systems is at stake. While surface irrigation is by far the most widely used system in irrigation, practised on 80.3% of the total full and partial control irrigation area, the most water-saving system through micro-irrigation techniques is only practised on 2.8% of the total irrigation area. Consequently, huge amounts of the water diverted for irrigation are wasted at the farm level through either deep percolation or surface runoff. These quantities may not be lost when one considers water use in the regional context, since return flows become part of the usable resources elsewhere. However, these losses often represent foregone opportunities for water because they delay the arrival of water at downstream diversions and almost produce poorer quality water at the regional level.

Another related problem is that water for irrigation is practically free in many countries in the region, mainly because farmers cannot afford to pay water charges and due also to other social obstacles to charging a fee on water for irrigation and even for other uses. However, this, in turn, provides little incentive for farmers to invest in water-saving technologies such as micro-irrigation techniques. Rather, it encourages them to overuse water. At the same time, the alternative of pumping and piping fossil and/or desalinated water over long distances for agricultural production, as attempted by some Arab countries, is an exceptional occurrence and would not be sustainable over the long term. Therefore, unless further progress in the management of the scarce water resources is made, particularly regarding irrigation efficiency, the Arab region appears to be structurally unable to feed its increasing population and will probably need to rely more and more on 'virtual water'[19], i.e. imports of food production.

Taking all the above into account, efficient irrigation systems in Arab countries have a vital role to play in sustainable food production and agricultural development in the future. However, irrigated agriculture in the region faces a number of difficult problems. One of the major concerns is the generally poor efficiency with which water resources have been used for irrigation. The future emphasis must be directed

[19] 'Virtual water' refers to the volume of water embedded in commodities that are imported, both food and non-food. As 1 ton of wheat production requires approximately 1000 m^3 of water, the importation of 1 million tons of wheat would correspond to the purchase of 1 billion m^3 of water from abroad (see J.A. Allan, 1999).

towards increasing the efficiency of water use systems and increasing water productivity, getting more crops per drop, as well as moving seriously towards tapping new non-conventional water resources to increase agricultural productivity. In this connection, concerted and focused development efforts by the Arab countries should emphasise on the following issues:

- Increasing the productivity of land or a fuller use of land and water resources by the development of efficient irrigation systems and techniques in order to achieve sustainable increases in food production.

- The suitability of land for irrigated agriculture should be assessed within the process of land evaluation (which crops to grow where) or the selection of suitable land, cropping, and irrigation system. This process should be physically and financially practicable and economically viable.

- Promoting and providing modern techniques and water-saving technologies of irrigation as well as shifting from surface irrigation system to pressurized irrigation will contribute to the goal of achieving sustainable food production.

- Developing capacity building, extension services, training and education in irrigation and water resources management for sustainable food production and agricultural development in rural areas.

- Quantitative targets for new irrigation development and improvement of the existing irrigation schemes are to be estimated on the basis of food requirements, agro-climatic zones and availability of water and land.

- Improving planning with users' participation at the planning and design stages of new irrigation schemes and/or the rehabilitation of the existing schemes as well as providing extension and training services to maximize the positive socio-economic impacts of irrigation projects and improve their sustained operation.

REFERENCES

FAO Database (FAOSTAT), www.fao.org/faostat/.

FAO's Information System on Water and Agriculture (AQUASTAT), www.fao.org/aquastat/.

FAO, "The State of Food and Agriculture 2003-2004", FAO, Rome 2004.

FAO, "General Summary on Near East Region", Information System on Water and Agriculture (AQUASTAT) FAO, Rome 2002.

FAO, "Review of World Water Resources By Country", Water Reports No. 23, FAO, Rome 2003.

J.A. Allan (1999), "A Convenient Solution". UNESCO Courier, February 1999, quoted in FAO, the State of Food and Agriculture 2001, p. 171.

SESRTCIC (Ankara Centre), SESRTCIC Database (BASEIND), Ankara Centre, May 2005.

World Bank, "World Development Indicators", various issues.

ANNEX

TABLE A.1: TOTAL POPULATION AND LAND AREA

Sub-regions/Countries	Population 2003			Land Area	Density
	Total (million)	Urban % of total	Rural % of total	(000) km^2	Persons per km^2
Maghreb	**81.25**	**61**	**39**	**6037.89**	**13**
Algeria	31.81	58	42	2381.74	13
Libya	5.66	88	12	1759.54	3
Mauritania	2.84	60	40	1030.40	3
Morocco	31.03	57	43	710.85	44
Tunisia	9.91	67	33	155.36	64
North-eastern Africa	**112.74**	**42**	**58**	**4023**	**28**
Comoros	0.74	33	67	2.23	332
Djibouti	0.81	83	17	21.98	37
Egypt	68.00	45	55	995.45	68
Somalia	9.60	28	72	627.34	15
Sudan	33.59	38	62	2376.00	14
Arabian Peninsula	**53.26**	**63**	**37**	**2911.7**	**18**
Bahrain	0.68	90	10	0.71	958
Kuwait	2.48	100	0	17.82	139
Oman	2.54	77	23	309.50	8
Qatar	0.63	100	0	11.52	55
Saudi Arabia	22.70	87	13	1960.58	12
United Arab Emirates	3.78	86	14	83.60	45
Yemen	20.45	25	75	527.97	39
Middle East	**57.35**	**66**	**34**	**723.05**	**79**
Iraq	26.34	68	32	432.16	61
Jordan	5.41	80	20	89.30	61
Lebanon	4.40	90	10	10.23	430
Palestine	3.65	67	33	6.18	591
Syria	17.55	51	49	185.18	95
All Arab Countries	**304.6**	**55**	**45**	**13695.64**	**22**
As % of World	4.8			10.2	

Source: SESRTCIC Database (BASEIND).

Land area is the area of the country excluding the area under inland water bodies (major rivers and lakes). 1 km^2 = 100 hectares, or 1 hectare = 0.01 km^2.

TABLE A.2: AGRICULTURAL USE OF LAND AREA 2002 (000 Hectares)

Sub-regions/Countries	Land Area	Agricult. Area	Arable Land	Permant. Crops	Permant. Pasture
Maghreb	**576816**	**135311**	**21135**	**3971**	**110205**
Algeria	238174	40065	7665	600	31800
Libya	175954	15450	1815	335	13300
Mauritania	102522	39750	488	12	39250
Morocco	44630	30283	8396	887	21000
Tunisia	15536	9763	2771	2137	4855
North-eastern Africa	**402420**	**182752**	**20259**	**998**	**161495**
Comoros	223	147	80	52	15
Djibouti	2318	1301	1		1300
Egypt	99545	3400	2900	500	
Somalia	62734	44071	1045	26	43000
Sudan	237600	133833	16233	420	117180
Arabian Peninsula	**310029**	**193412**	**5284**	**568**	**187560**
Bahrain	71	10	2	4	4
Kuwait	1782	151	13	2	136
Oman	30950	1081	38	43	1000
Qatar	1100	71	18	3	50
Saudi Arabia	214969	173794	3600	194	170000
United Arab Emirates	8360	571	75	191	305
Yemen	52797	17734	1538	131	16065
Middle East	**72633**	**25701**	**10921**	**1534**	**13246**
Iraq	43737	10090	5750	340	4000
Jordan	8893	1142	295	105	742
Lebanon	1023	329	170	143	16
Palestine	602	381	113	118	150
Syria	18378	13759	4593	828	8338
All Arab Countries	**1361898**	**537176**	**57599**	**7071**	**472506**
As % of:					
World	10.2	10.8	4.2	5.4	13.6
Developing countries	17.9	17.3	7.7	6.5	21.0

Source: FAO Database (FAOSTAT).

TABLE A.3: AGRICULTURAL USE OF LAND AREA 2002 (Percentages)

Sub-regions/Countries	Agricult. Area (% of land area)	% of Agricultural Area		
		Arable Land	Permant. Crops	Permant. Pasture
Maghreb	**23.5**	**15.6**	**2.9**	**81.4**
Algeria	16.8	19.1	1.5	79.4
Libya	8.8	11.7	2.2	86.1
Mauritania	38.8	1.2	0.0	98.7
Morocco	67.9	27.7	2.9	69.3
Tunisia	62.8	28.4	21.9	49.7
North-eastern Africa	**45.4**	**11.1**	**0.5**	**88.4**
Comoros	65.9	54.4	35.4	10.2
Djibouti	56.1	0.1	0.0	99.9
Egypt	3.4	85.3	14.7	0.0
Somalia	70.3	2.4	0.1	97.6
Sudan	56.3	12.1	0.3	87.6
Arabian Peninsula	**62.4**	**2.7**	**0.3**	**97.0**
Bahrain	14.1	20.0	40.0	40.0
Kuwait	8.5	8.6	1.3	90.1
Oman	3.5	3.5	4.0	92.5
Qatar	6.5	25.4	4.2	70.4
Saudi Arabia	80.8	2.1	0.1	97.8
United Arab Emirates	6.8	13.1	33.5	53.4
Yemen	33.6	8.7	0.7	90.6
Middle East	**35.4**	**42.5**	**6.0**	**51.5**
Iraq	23.1	57.0	3.4	39.6
Jordan	12.8	25.8	9.2	65.0
Lebanon	32.2	51.7	43.5	4.9
Palestine	63.3	29.7	31.0	39.4
Syria	74.9	33.4	6.0	60.6
All Arab Countries	**39.4**	**10.7**	**1.3**	**88.0**
World	37.0	27.6	2.7	69.7
Developing countries	41.0	24.0	3.5	72.5

Source: Derived from Table A.2 above.

TABLE A.4: SUMMARY OF RENEWABLE WATER RESOURCES (km^3/year)

Sub-regions/Countries	Average Precipit-ation	IRWR: Surface	IRWR: Ground-water	IRWR: Overlap	IRWR: Total	External Resources: Natural
Maghreb	**593.3**	**38.6**	**14**	**4.5**	**48.1**	**11.8**
Algeria	211.5	13.2	1.7	1.0	13.9	0.4
Libya	98.5	0.2	0.5	0.1	0.6	0.0
Mauritania	94.7	0.1	0.3	0.0	0.4	11.0
Morocco	154.7	22.0	10.0	3.0	29.0	0.0
Tunisia	33.9	3.1	1.5	0.4	4.2	0.4
North-eastern Africa	**1282.3**	**34.7**	**12.6**	**8**	**39.3**	**211.5**
Comoros	2.0	0.2	1.0	0.0	1.2	0.0
Djibouti	5.1	0.3	0.0	0.0	0.3	0.0
Egypt	51.4	0.5	1.3	0.0	1.8	85.0
Somalia	180.1	5.7	3.3	3.0	6.0	7.5
Sudan	1043.7	28.0	7.0	5.0	30.0	119.0
Arabian Peninsula	**251.3**	**7.305**	**4.85**	**4.4**	**7.755**	**0.132**
Bahrain	0.1	0.004	0.0	0.0	0.004	0.11
Kuwait	2.2	0.0	0.0	0.0	0.0	0.02
Oman	26.6	0.9	1.0	0.9	1.0	0.0
Qatar	0.8	0.001	0.050	0.0	0.051	0.002
Saudi Arabia	126.8	2.2	2.2	2.0	2.4	0.0
United Arab Emirates	6.5	0.2	0.1	0.1	0.2	0.0
Yemen	88.3	4.0	1.5	1.4	4.1	0.0
Middle East	**158.3**	**43.37**	**9.83**	**4.7**	**48.5**	**100.55**
Iraq	94.7	34.0	1.2	0.0	35.2	61.2
Jordan	9.9	0.4	0.5	0.2	0.7	0.2
Lebanon	6.9	4.1	3.2	2.5	4.8	0.04
Palestine	0.1	0.07	0.73	0.0	0.80	0.01
Syria	46.7	4.8	4.2	2.0	7.0	39.1
All Arab Countries	**2285.2**	**123.975**	**41.28**	**21.6**	**143.655**	**323.982**
World	107924				43764	
% of World	**2.1**				**0.3**	

Source: FAO, "Review of World Water Resources By Country", Water Reports No. 23, FAO, Rome, 2003.

Notes:

(a) km^3 = billion m^3.

(b) IRWR (Total) = IRWR (Surface) + IRWR (Groundwater) – IRWR (Overlap).

TABLE A.4 SUMMARY OF RENEWABLE WATER RESOURCES (km^3/year)* (Continued)

Sub-regions/Countries	External Resources: Actual	TRWR: Natural	TRWR: Actual	IRWR per capita (1)	TRWR: Actual per capita (1)	Dependency ratio (%) (2)
Maghreb	**11.8**	**59.9**	**59.9**	**619**	**771**	**19.7**
Algeria	0.4	14.3	14.3	459	473	2.9
Libya	0.0	0.6	0.6	113	113	0.0
Mauritania	11.0	11.4	11.4	150	4278	96.5
Morocco	0.0	29.0	29.0	971	971	0.0
Tunisia	0.4	4.6	4.6	439	482	9.0
North-eastern Africa	**98.5**	**250.8**	**137.8**	**364**	**1278**	**71.5**
Comoros	0.0	1.2	1.2	1700	1700	0.0
Djibouti	0.0	0.3	0.3	475	475	0.0
Egypt	56.5	86.8	58.3	27	859	96.9
Somalia	7.5	13.5	13.5	684	1538	55.6
Sudan	34.5	149.0	64.5	965	2074	76.9
Arabian Peninsula	**0.132**	**7.94**	**7.92**	**169**	**172**	**1.7**
Bahrain	0.11	0.12	0.1	6	181	96.6
Kuwait	0.02	0.02	0.02	0	10	100.0
Oman	0.0	1.0	1.0	388	388	0.0
Qatar	0.002	0.1	0.1	90	94	3.8
Saudi Arabia	0.0	2.4	2.4	118	118	0.0
United Arab Emirates	0.0	0.2	0.2	58	58	0.0
Yemen	0.0	4.1	4.1	223	223	0.0
Middle East	**59.31**	**149.01**	**107.81**	**986**	**2191**	**55.0**
Iraq	40.2	96.4	75.4	1534	3287	53.3
Jordan	0.2	0.9	0.9	138	179	22.7
Lebanon	-0.4	4.8	4.4	1373	1261	0.8
Palestine	0.01	0.81	0.81	535 **(3)**	535 **(3)**	17.9
Syria	19.3	46.1	26.3	432	1622	80.3
All Arab Countries	**169.742**	**467.65**	**313.43**	**512**	**1116**	**54.2**
World		43764	43764	7243	7243	
% of World		**1.1**	**0.7**			

Source: FAO, "Review of World Water Resources By Country", Water Reports No. 23, FAO, Rome, 2003.

(1) m^3/year per inhabitant.

(2) The part of TRWR originating outside the country or the region.

(3) For West Bank. However, for Gaza Strip, the figures are 43 and 52, respectively.

TABLE A.5: EXPLOITABLE, NON-CONVENTIONAL AND GROUNDWATER RESOURCES

Sub-regions/Countries	Exploitable Water (km^3/year)	Exploitable as % of Natural TRWR	Ground-water as % of IRWR	Desalinated Water (million m^3)	Reused Treated Wastewater (million m^3)
Maghreb			**29.1**	**147.4**	**120**
Algeria	7.90	55.2	12.2	64	0
Libya	0.64	106.7	83.3	70	100
Mauritania	-	-	75.0	1.7	0
Morocco	20.00	69.0	34.5	3.4	0
Tunisia	3.63	78.9	35.7	8.3	20
North-eastern Africa	-	-	**32.1**	**25.6**	**200**
Comoros	-	-	83.3	0	0
Djibouti	-	-	0.0	0.1	0
Egypt	49.70	57.3	72.2	25	200
Somalia	-	-	55.0	0.1	0
Sudan	-	-	23.3	0.4	0
Arabian Peninsula	**-**	**-**	**62.5**	**1516.7**	**436.2**
Bahrain	-	-	0.0	44.1	8
Kuwait	-	-	0.0	231	52
Oman	-	-	100.0	34	26
Qatar	-	-	98.0	98.6	25.2
Saudi Arabia	-	-	91.7	714	217
United Arab Emirates	-	-	50.0	385	108
Yemen	-	-	36.6	10	0
Middle East	**-**	**-**	**20.3**	**2**	**422.3**
Iraq	-	-	3.4	0	0
Jordan	-	-	71.4	2	50.3
Lebanon	2.85	59.4	66.7	0	2
Palestine	0.77	95.1	91.3	-	-
Syria	20.60	44.7	60.0	0	370
Arab Countries	**-**	**-**	**28.7**	**1691.7**	**1178.5**

Source: FAO Database (FAOSTAT).

TABLE A.6: WATER WITHDRAWAL AND USE IN AGRICULTURE (PRESSURE ON WATER RESOURCES)

Sub-regions/Countries	Total Withdrawal			Agricultural Withdrawal		
	km^3/year	% of IRWR	% of Actual TRWR	km^3/year	% of total withdrawal	% of Actual TRWR
Maghreb	**28.07**	**58.4**	**46.9**	**23.42**	**83.4**	**39.1**
Algeria	6.07	43.7	42.4	3.94	65	27.6
Libya	4.81	801.7	801.7	4.27	89	711.7
Mauritania	1.70	425.0	14.9	1.50	88	13.2
Morocco	12.76	44.0	44.0	11.48	90	39.6
Tunisia	2.73	65.0	59.3	2.23	82	48.5
North-eastern Africa	**109.27**	**278.0**	**79.3**	**93.207**	**85.3**	**67.6**
Comoros	-	-	-	-	-	-
Djibouti	0.01	3.3	3.3	0.007	89	2.3
Egypt	68.65	3813.9	117.8	53.85	78	92.4
Somalia	3.30	55.0	24.4	3.28	100	24.3
Sudan	37.31	124.4	57.8	36.07	97	55.9
Arabian Peninsula	**28.65**	**369.4**	**361.7**	**25.15**	**87.8**	**317.6**
Bahrain	0.30	7500.0	300.0	0.17	57	170.0
Kuwait	0.45		2250.0	0.23	52	1150.0
Oman	1.35	135.0	135.0	1.23	91	123.0
Qatar	0.29	568.6	290.0	0.21	72	210.0
Saudi Arabia	17.32	721.7	721.7	15.42	89	642.5
United Arab Emirates	2.31	1155.0	1155.0	1.57	68	785.0
Yemen	6.63	161.7	161.7	6.32	95	154.1
Middle East	**65.04**	**134.1**	**60.3**	**59.99**	**92.2**	**55.6**
Iraq	42.70	121.3	56.6	39.38	92	52.2
Jordan	1.02	145.7	113.3	0.76	75	84.4
Lebanon	1.37	28.5	31.1	0.92	67	20.9
Palestine	-		-	-	-	-
Syria	19.95	285.0	75.9	18.93	95	72.0
All Arab Countries	**231.02**	**160.8**	**73.7**	**201.77**	**87.3**	**64.4**
World (1990)	3240.0	8.1	8.1	2235.6	69.0	5.1

Source: FAO Database (FAOSTAT).

TABLE A.7: TOTAL IRRIGATION AREA AND WATER MANAGED AREA (000 hectares)

Sub-regions/Countries	f/p control (1)	Spate (2)	Equip. Wet/ivb. (3)	Total irrigation area	Flood recession cropping	Water managed area
Maghreb	**2483**	**335**	**0**	**2818**	**64**	**2882**
Algeria	448	112	0	560	0	560
Libya	470	0	0	470	0	470
Mauritania	49	0	0	49	64	113
Morocco	1156	189	0	1345	0	1345
Tunisia	360	34	0	394	0	394
North-eastern Africa	**5182**	**282**	**0**	**5464**	**0**	**5464**
Comoros	-	-	-	-	-	-
Djibouti	1	0	0	1	0	1
Egypt	3400	0	0	3400	0	3400
Somalia	50	150	0	200	0	200
Sudan	1731	132	0	1863	0	1863
Arabian Peninsula	**2307**	**103**	**0**	**2410**	**0**	**2410**
Bahrain	4	0	0	4	0	4
Kuwait	13	0	0	13	0	13
Oman	73	0	0	73	0	73
Qatar	13	0	0	13	0	13
Saudi Arabia	1731	0	0	1731	0	1731
United Arab Emirates	76	0	0	76	0	76
Yemen	397	103	0	500	0	500
Middle East	**5059**	**0**	**0**	**5059**	**0**	**5059**
Iraq	3525	0	0	3525	0	3525
Jordan	77	0	0	77	0	77
Lebanon	104	0	0	104	0	104
Palestine	20	0	0	20	0	20
Syria	1333	0	0	1333	0	1333
All Arab Countries	**15031**	**720**	**0**	**15751**	**64**	**15815**
World				276719	27757	304476
As % of World				**5.7**	**0.2**	**5.2**

Source: FAO's Information System on Water and Agriculture (AQUASTAT).

Notes: (1) Full/partial (f/p) control irrigation equipped area.

(2) Spate irrigation area.

(3) Equipped wetland and inland valley bottoms.

TABLE A.8: TOTAL IRRIGATION AREA AS % OF TOTAL LAND, AGRICULTURAL AND ARABLE AREAS

Sub-regions/Countries	Total Irrigation Area As % of		
	Total land area	Agricultural area	Arable area
Maghreb	**0.5**	**2.1**	**13.3**
Algeria	0.2	1.4	7.3
Libya	0.3	3.0	25.9
Mauritania	0.0	0.1	10.0
Morocco	3.0	4.4	16.0
Tunisia	2.5	4.0	14.2
North-eastern Africa	**1.4**	**3.0**	**27.0**
Comoros	-	-	-
Djibouti	0.0	0.1	100.0
Egypt	3.4	100.0	117.2
Somalia	0.3	0.5	19.1
Sudan	0.8	1.4	11.5
Arabian Peninsula	**0.8**	**1.2**	**45.6**
Bahrain	5.6	40.0	200.0
Kuwait	0.7	8.6	100.0
Oman	0.2	6.8	192.1
Qatar	1.2	18.3	72.2
Saudi Arabia	0.8	1.0	48.1
United Arab Emirates	0.9	13.3	101.3
Yemen	0.9	2.8	32.5
Middle East	**7.0**	**19.7**	**46.3**
Iraq	8.1	34.9	61.3
Jordan	0.9	6.7	26.1
Lebanon	10.2	31.6	61.2
Palestine	3.3	5.2	17.7
Syria	7.3	9.7	29.0
All arab Countries	**1.2**	**2.9**	**27.3**
World	**3.3**	**6.8**	**19.7**
Developing countries	**5.2**	**8.1**	**34.6**

Source: FAO Database (FAOSTAT).

TABLE A.9: SOURCE OF IRRIGATION WATER

Sub-regions/Countries	% of full/partial (f/p) control irrigation area		
	Surface water	Ground-water	**Non-conventional sources**
Maghreb	**61.9**	**37.2**	**0.9**
Algeria	-	-	-
Libya	-	-	-
Mauritania	90.4	9.6	0.0
Morocco	68.3	31.1	0.6
Tunisia	37.3	60.7	2.0
North-eastern Africa	**95.6**	**4.3**	**0.1**
Comoros	-	-	-
Djibouti	0.0	100.0	0.0
Egypt	95.4	4.5	0.1
Somalia	-	-	-
Sudan	96.0	4.0	0.0
Arabian Peninsula	**2.4**	**96.4**	**1.2**
Bahrain	0.0	86.4	13.6
Kuwait	0.0	61.0	39.0
Oman	0.0	100.0	0.0
Qatar	0.0	94.2	5.8
Saudi Arabia	3.2	95.6	1.2
United Arab Emirates	0.0	100.0	0.0
Yemen	0.0	100.0	0.0
Middle East	**77.8**	**22.1**	**0.1**
Iraq	93.8	6.2	0.0
Jordan	39.7	54.6	5.7
Lebanon	54.3	45.7	0.0
Palestine	53.7	46.3	0.0
Syria	39.8	60.2	0.0
All arab countries	**70.1**	**29.5**	**0.3**

Source: FAO's Information System on Water and Agriculture (AQUASTAT).

TABLE A.10: IRRIGATION TECHNIQES

Sub-regions/Countries	% of full/partial (f/p) control irrigation area		
	Surface irrigation	Sprinkler irrigation	**Micro-irrigation**
Maghreb	**88.4**	**44.5**	**0.7**
Algeria	-	9.0	-
Libya	0.0	100.0	0.0
Morocco	90.2	9.4	0.4
Tunisia	82.8	15.5	1.7
North-eastern Africa	**93.8**	**3.6**	**2.6**
Egypt	93.8	3.6	2.6
Arabian Peninsula	**47.7**	**48.6**	**3.6**
Bahrain	83.3	3.3	16.7
Kuwait	60.0	12.0	24.0
Oman	93.5	2.6	3.2
Saudi Arabia	34.0	64.0	2.0
United Arab Emirates	37.3	6.0	56.7
Yemen	100.0	0.0	0.0
Middle East	**91.0**	**4.8**	**4.2**
Jordan	31.3	9.4	59.4
Lebanon	61.4	23.9	14.8
Syria	96.8	3.0	0.2
All Arab Countries	**80.3**	**22.8**	**2.8**

Source: FAO's Information System on Water and Agriculture (AQUASTAT).

TABLE A.11: IRRIGATION INTENSITY AND IRRIGATION POTENTIAL

Sub-regions/Countries	Rate of equipped area (f/p) actually irrigated (%)	Irrigated crops area (000 hectares)	Cropping intensity ratio	Irrigation Potential Area (000 hectares
Maghreb				
Algeria	82.2	-	-	730
Libya	51.1	-	-	750
Mauritania	54.4	135	1.19	221
Morocco	-	1073	0.85	1653
Tunisia	90.7	308	0.80	563
North-eastern Africa				
Djibouti	60.4	0.4	0.40	1
Egypt	100.0	5379	1.66	4435
Somalia	-	164	0.82	240
Sudan	63.2	1012	0.52	2784
Arabian Peninsula				
Bahrain	100.0	3	1.00	4
Kuwait	100.0	5	1.00	25
Oman	100.0	71	1.15	86
Qatar	66.4	9	0.69	62
Saudi Arabia	100.0	1608	1.00	1620
United Arab Emirates	81.7	55	0.82	76
Yemen	-	-	-	490
Middle East				
Iraq	54.9	-	-	5554
Jordan	-	69	1.08	85
Lebanon	-	88	1.00	178
Syria	-	1204	1.19	1250
All Arab Countries				

Source: FAO's Information System on Water and Agriculture (AQUASTAT).

TABLE A.12: POPULATION IN AGRICULTURE AND SHARE OF AGRICULTURE IN GDP

Sub-regions/Countries	Population in Agriculture 2003		Share of Agriculture in GDP (*)
	(million)	% of total	(%)
Maghreb	**21.9**	**27**	**11.3**
Algeria	7.5	24	10
Libya	0.3	5	8
Mauritania	1.5	52	21
Morocco	10.3	34	16
Tunisia	2.3	24	12
North-eastern Africa	**48.2**	**42.8**	**19.5**
Comoros	0.6	72	39
Djibouti	-	-	4
Egypt	22.6	31	17
Somalia	5.4	75	
Sudan	19.6	58	40
Arabian Peninsula	**12.66**	**23.8**	**4.2**
Bahrain	0.07	1	1
Kuwait	0.03	1	1
Oman	1.0	34	2
Qatar	0.06	1	1
Saudi Arabia	1.9	8	5
United Arab Emirates	0.1	4	4
Yemen	9.5	47	15
Middle East	**8.6**	**15**	**14.8**
Iraq	2.8	16	15
Jordan	0.6	10	2
Lebanon	0.1	3	12
Palestine	0.4	11	7
Syria	4.7	27	23
All Arab Countries	**91.36**	**30**	**9.1**
World	**2673.6**	**43**	**4**
Developing countries			**12**
As % of World	**3.4**		

Sources: FAO Database (FAOSTAT).

(*) Average 1999-2003. World Bank, World Development Indicators, various issues.

TABLE A.13: AGRICULTURAL PRODUCTION 2003 (1000 tons)

Sub-regions/Countries	Cereals	Fruit and Vegetables	Meat
Maghreb	**14061**	**15648**	**1622**
Algeria	4227	4615	553
Libya	215	1142	142
Mauritania	153	31	79
Morocco	7963	6759	598
Tunisia	1503	3101	250
North-eastern Africa	**26159**	**24933**	**2308**
Comoros	21	67	2
Djibouti			
Egypt	19231	21523	1445
Somalia	497	336	163
Sudan	6410	3007	698
Arabian Peninsula	**2884**	**6491**	**1088**
Bahrain		32	17
Kuwait	3	193	83
Oman	6	478	42
Qatar	6	73	15
Saudi Arabia	2353	3109	642
United Arab Emirates	0	1344	74
Yemen	516	1262	215
Middle East	**9068**	**11843**	**1043**
Iraq	2541	4312	233
Jordan	80	1455	123
Lebanon	144	1699	203
Palestine	68	750	116
Syria	6235	3627	368
All Arab Countries	**52172**	**58915**	**6061**
World	**2075309**	**1322454**	**253528**
% of World	**2.5**	**4.5**	**2.4**

Source: FAO Database (FAOSTAT).

TABLE A.14: PREVALENCE OF UNDERNURISHMENT

Sub-regions/Countries	Number of people undernourished (million)		Proportion of total population (%)	
	1995-97	2000-02	1995-97	2000-02
Maghreb	**3.7**	**4.0**	**6.2**	**6.1**
Algeria	1.7	1.7	6	5
Libya			< 2.5	< 2.5
Mauritania (*)	0.3	0.3	11	10
Morocco (*)	1.7	2.0	6	7
Tunisia			< 2.5	< 2.5
North-eastern Africa	**13.6**	**16.9**	**12.5**	**14.1**
Egypt (*)	2.2	2.4	3	3
Somalia (*)	4.8	6.0	67	75
Sudan (*)	6.6	8.5	23	27
Arabian Peninsula	**6.6**	**7.6**	**17.4**	**16.0**
Kuwait	0.1	0.1	5	5
Saudi Arabia	0.8	0.8	4	3
United Arab Emirates			< 2.5	< 2.5
Yemen (*)	5.7	6.7	36	36
Middle East	**2.2**	**4.1**	**5.5**	**9.0**
Iraq	1.2	3.0	7	14
Jordan	0.3	0.4	7	7
Lebanon	0.1	0.1	3	3
Syria (*)	0.6	0.6	4	4
All Arab countries	**26.1**	**32.6**	**10.6**	**11.7**
Developing countries	**796.7**	**814.6**	**18**	**17**
As % of DCs	**3.3**	**4.0**		

Source: FAO, "The State of Food Insecurity in the World 2001".
(*) In addition to Djibouti, these countries were classified as of may 1997 as food-deficit countries.