Section I

Presentation of the survey

Introduction

It is in FAO's mandate, as stated in Article 1 of its constitution, to "collect, analyse, interpret and disseminate information related to nutrition, food and agriculture". Within this framework FAO launched in 1993 a programme known as AQUASTAT, its global information system on water and agriculture (http://www.fao.org/nr/aquastat). AQUASTAT collects, analyses and disseminates data and information, by country, on water recourses and water use, with emphasis on agriculture, which is targeted at users in international institutions, national governments and development agencies. Its goal is to support agricultural and rural development through sustainable use of water and land by providing the most accurate information presented in a consistent and standard way and more specifically:

- up-to-date and reliable data by country
- methodologies and definitions for information on the water resources and irrigation sector
- systematic descriptions on the state of agricultural water management by country
- predictions of future agricultural water use and irrigation developments
- in-depth analysis through diverse thematic studies
- contribution to major international publications
- answers to requests from governments, research institutions, universities, non-governmental organizations and individuals.

At the time of launch, priority was given to Africa, which initiated the AQUASTAT publication series (FAO, 1995). The survey continued with the Near East (FAO, 1997a), the countries of the former Soviet Union (FAO, 1997b), South and East Asia (FAO, 1999), Latin America and the Caribbean (FAO, 2000). In 2005, the African continent was updated (FAO, 2005).

Ten years after the first publication on the Near East region, it appeared necessary to update the data and to identify the main changes in water use and irrigation that had occurred there. However, the countries forming the region in this publication are not to the same as the ones in the previous publication. While in the first publication the composition of the Near East region was determined by the countries covered by FAO's Regional Office for the Near East, it was judged more logical to follow in AQUASTAT the regional distribution given in FAO's Water Report 23 "Review of world water resources by country" (2003). In that report the world was divided into ten large regions as shown in Figure 7. It was also decided to call the region "Middle East" rather than "Near East", since Near East is considered to be a subregion of the Middle East.

To the two objectives of the previous publication (FAO, 1997a) a third has been added in this new survey of the Middle East region:

- to provide for every country the most accurate status of rural water resources management, with a special focus on irrigation, by featuring major characteristics, trends, constraints and prospective changes in irrigation and in water resources;
- to support regional analyses by providing systematic, up-to-date and reliable information on the status of water resources and of agricultural water management that can serve as a tool for regional planning and predictive studies;
- to prepare a series of chronological data in order to highlight the major changes that have occurred in the last decade on national and regional scales.

To obtain the most reliable information possible, the survey is organized as follows:

1. Review of literature and existing information at country and sub-country level.
2. Collection of information by country using a detailed questionnaire filled in by national consultants, international consultants, or the AQUASTAT team at FAO.
3. Compilation and critical analysis of the information collected using data-processing software developed for this survey, and selection of the most reliable information.
4. Preparation of country profiles and submission to national authorities responsible for water resources or water management for verification, correction and approval.
5. Preparation of the final profile, the tables and the figures presenting the information by country.
6. Updating of the on-line database.
7. Preparation of the general regional analysis, the figures and the regional tables.

Where possible, AQUASTAT has made use of national capacity and competence. While collecting the information by country, preference was given to national experts as they have a better knowledge of their own country and easier access to national or so-called 'grey' documents, which are not available outside the country. The choice of the countries for which a national consultant was recruited depended on several factors, namely: the importance of irrigation in the country; the availability of an expert; the scarcity of data observed during the previous survey; and the funds available. For about half of the countries concerned, a national consultant assisted the AQUASTAT team.

Country profiles

Country profiles are prepared in English, which is the FAO official language in the Middle East region. They describe the state of water resources and water use in the respective countries, as well as the state of agricultural water management. The aims are to describe the particularities of each country and the problems met in the development of the water resources and, in particular, irrigation. They summarize the irrigation trends in the country and the prospects for water management in agriculture as described in the literature. The country profiles have been standardized and organized in sections according to the following model:

- ➢Geography, climate and population
- ➢Economy, agriculture and food security
- ➢Water resources and water use
- ➢Irrigation and drainage development
- ➢Water management, policies and legislation related to water use in agriculture
- ➢Environment and health
- ➢Prospects of agricultural water management
- ➢References and additional information

Standardized tables are used for each country. A hyphen (-) indicates that no information is available. As most information is available only for a limited number of years, the tables present the most recent reliable information and indicate the year to which it refers. In the AQUASTAT database, however, all available information is accessible.

The information in the country profiles is much more detailed than that in the first AQUASTAT survey of 1997. In order to establish a more complete picture of the agricultural water sector in each country, it addresses issues related to water and to irrigation that were not previously included. Some issues have been added in response to user demand.

Data collection, processing and reliability

The main sources of information were:

- National policies, and water resources and irrigation master plans
- National reports, yearbooks and statistics
- Reports from FAO and other projects
- International surveys
- Results and publications from national and international research centres
- The internet.

Furthermore, the following sources systematically provide certain data:

- FAOSTAT (http://faostat.fao.org/). This is the only source used for variables of area (total, arable land and permanent crops) and population (total, rural, urban, female, male, and economically active). An exception has been made for those countries where all the cultivated area is irrigated and where there is a difference between the AQUASTAT data related to area of irrigation and the FAOSTAT data related to cultivated area (arable land and permanent crops). In that case the data obtained by AQUASTAT through this survey are retained. FAOSTAT data on areas are provided every year by the countries through the FAO representations.
- World Development Indicators (http://www.worldbank.org/data/). This is the World Bank's premier annual compilation of data on development. This source provides the data on gross domestic product (GDP).
- The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF). These organizations provide access to data on improved water sources under their Joint Monitoring Programme for Water Supply & Sanitation (JMP) (www.wssinfo.org/).
- The United Nations Development Programme (UNDP). The UNDP provides the Human Development Index (HDI) (http://hdr.undp.org/statistics/data/).

In total, more than 50 variables have been selected and these are presented in the national tables attached to the respective profiles. They are ordered in categories corresponding to the various sections of the profiles: characteristics of the country and population; water resources and use; and irrigation and drainage. A detailed description of each variable is given in the glossary in the next chapter. Additional tables have been added to the country profiles where information is available, especially in order to specify regional or river basin data.

In most cases, a critical analysis of the information is required in order to ensure the general coherence of information collected for a given country. Where several sources result in divergent or contradictory information, preference is given to information collected at national or sub-national levels rather than at regional or world levels. Moreover, except in the case of evident errors, official sources are privileged. As regards shared water resources, the comparison of information between countries has made it possible to verify and complete the data concerning the flows of transboundary rivers and to ensure coherence at a river basin level. This information has been added more in detail in the country water balance sheets, which are available at http://www.fao.org/nr/water/aquastat/water_res/index.stm.

In spite of these precautions, the accuracy, reliability and frequency with which information is collected vary considerably according to the region, the country and the category of information. These considerations are discussed in the profiles.

The regional analysis tables show the period 1997–2007 as the period between the two surveys. The AQUASTAT team justifies this choice by virtue of the slow evolution of data for different years for each country. However, should more precision be required, the summary tables and the on-line database specify the exact year for the items of national data.

Glossary of terms used in this study

The following definitions have been used for the variables presented in the country profiles, the tables and the database.

Access to improved drinking water sources (%)

Percentage of the total population using improved water sources. An "improved" source is one that is likely to provide "safe" water, such as a household connection, a borehole, etc. Current information does not yet allow us to establish a relationship between access to safe water and access to improved sources, but WHO and UNICEF are examining this relationship. Figures are provided by WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation website (http://www.wssinfo.org/)

Actually irrigated area as percent of the total area equipped (%)

Percent of area equipped for irrigation that is actually irrigated in any given year, expressed in percentage. Irrigated land that is cultivated more than once a year is counted only once.

Agricultural drainage water (km^3/year)

This is water withdrawn for agriculture but not consumed and returned. It does not go through special treatment and therefore should be distinguished from reused wastewater. It can be reused further downstream for irrigation, for example.

Annual crops (ha)

Area of land under temporary (annual) crops, which are crops with a growing season lasting between several months and about one year and which need to be re-sown or replanted after each harvest, such as cereals and vegetables.

Arable land (ha)

Land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included. Data for arable land is not meant to indicate the amount of land that is potentially cultivable.

Area of the country (ha)

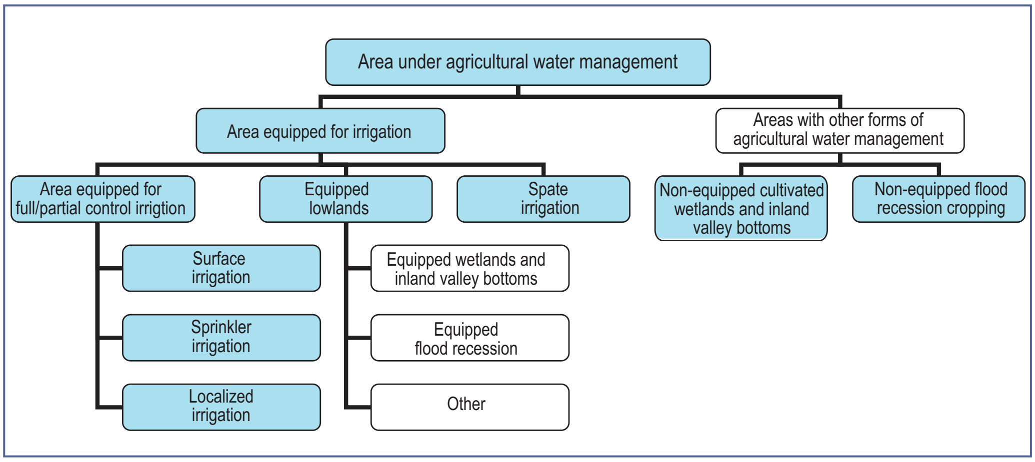
Total area of the country, including area under inland water bodies. Possible variations in the data may be due to updating and revisions of the country data and not necessarily to any change of area.

Area equipped for irrigation: total (ha)

Area equipped to provide water (via irrigation) to crops. It includes areas equipped for full/partial control irrigation, equipped lowland areas, pastures, and areas equipped for spate irrigation.

Area under agricultural water management (ha)

Sum of total area equipped for irrigation and areas with other forms of agricultural water management (non-equipped flood recession cropping area and non-equipped cultivated wetlands and inland valley bottoms). The classification adopted by AQUASTAT is presented in the following diagram. The blue ones are available in the AQUASTAT database and an explanation of each of them is given in this glossary.



Average annual increase of the area equipped for irrigation (%)

This increase is calculated with the following formula: new area = $(1+i)^n$ x old area, where "n" is the number of years in the period considered between the two AQUASTAT surveys and "i" is the average annual increase. The percentage is equal to (100 x i).

Cropping intensity: irrigated area (%)

The number of times the same area is cropped in one year (referring to area equipped for full/partial control irrigation). If available, the area effectively irrigated is used for the calculation of cropping intensity. If not available, the equipped area is used. The calculation only refers to irrigated crops. This means that in a country with one or two wet seasons only the crops grown under irrigation are taken into consideration. The crops grown on the full/partial control equipped area during the wet season without irrigation (but using the residual soil humidity) are not included in the irrigated crop area when calculating cropping intensity.

Cultivable area (ha)

Area of land potentially fit for cultivation. This term may or may not include part or all of the forests and rangeland. Assumptions made in assessing cultivable land vary from country to country. In this survey, national figures have been used whenever available, despite possible large discrepancies in computation methods.

Cultivated area (ha)

The sum of the arable land area and the area under permanent crops.

Dam capacity (km^3)

Total cumulative storage capacity of all large dams. According to ICOLD (International Commission on Large Dams), a large dam is a dam with a height of 15 m or more from the foundation. If dams are 5-15 metres high and have a reservoir volume of more than three million m^3, they are also classified as large dams. However, each country has its own definition of large dams and if information on other dams in a country is available it is also included. The value indicates the theoretical initial capacity, which does not change with time. The current or actual dam capacity is the state of the dams at a given time that can be decreased by silting. Detailed information on African dams can be found in the AQUASTAT geo-referenced database on African dams on http://www.fao.org/ag/agl/aglw/aquastat/damsafrica/index.stm.

Dependency ratio (%)

Indicator expressing the percent of total renewable water resources originating outside the country. This indicator may theoretically vary between 0 percent and 100 percent. A country with a dependency ratio equal to 0 percent does not receive any water from neighbouring countries. A country with a dependency ratio equal to 100 percent receives all its renewable water from upstream countries, without producing any of its own. This indicator does not consider the possible allocation of water to downstream countries.

Depletion of renewable groundwater resources: rate (km^3/year)

Annual amount of water withdrawn from renewable aquifers which is not replenished (average overexploitation of aquifers). When the action is continuous, it is a form of overdraft of rechargeable aquifers or mining. Over a long period of time, there is a risk of depleting the aquifer when the abstraction exceeds the recharge.

Desalinated water produced (million m^3/year)

Water produced annually by desalination of brackish or salt water. It is estimated annually on the basis of the total capacity of water desalination installations.

Drained area in area equipped for irrigation (ha)

Irrigated area where drainage is used as an instrument to control salinity, pounding and waterlogging. This refers mainly to the area equipped for surface irrigation and to the equipped wetland and inland valley bottoms (the first part). Areas equipped for sprinkler irrigation and for localized irrigation do not really need a complete drainage system, except perhaps some small structures to evacuate the water in case of heavy rainfall. Flood recession cropping areas (the second part) are not considered as being drained. A distinction can be made between areas drained with surface drains (a system of drainage measures, such as natural or human-made drains meant to divert excess surface water away from an agricultural area in order to prevent inundation) and the area drained with subsurface drains (a human-made system that induces excess water and dissolved substances to flow through the soil to open wells, moles, pipe drains and/or open drains, from where it can be evacuated for final disposal).

Drained area in non-irrigated area (ha)

Area cultivated and not irrigated, where drainage is used to remove excess water from the land surface and/or the upper soil layer to make humid/wet land more productive. A distinction should be made between drainage in humid countries and drainage in semi-arid countries. In humid countries, it refers mainly to the areas which normally are flooded and where flood mitigation has taken place. A distinction could be made between 'pumped' drainage, 'gravity' drainage and 'tidal' drainage. In semi-arid countries, it refers to the area cultivated and not irrigated where drainage is used to remove excess water from the land surface and/or upper soil layer to make humid/wet land more productive.

Drained area: total (ha)

Sum of the drained portions of area equipped for irrigation and non-irrigated land area.

Exploitable water resources: regular renewable groundwater (km^3/year)
Average groundwater flow that is available 90 percent of the time, and economically/ environmentally viable to extract.

Exploitable water resources: regular renewable surface water (km^3/year)
Annual average quantity of surface water that is available 90 percent of the time. In practice, it is equivalent to the low water flow of a river. It is the resource that is offered for withdrawal or diversion with a regular flow.

Exploitable water resources: irregular renewable surface water (km^3/year)
Irregular surface water resources are equivalent to the variable component of water resources (e.g. floods). It includes the seasonal and inter-annual variations, i.e. seasonal flow or flow during wet years. It is the flow that needs to be regulated.

Exploitable water resources: total (km^3/year)
Exploitable water resources (also called manageable water resources or water development potential) are considered to be available for development, taking into consideration factors such as: the economic and environmental feasibility of storing floodwater behind dams, extracting groundwater, the physical possibility of storing water that naturally flows out to the sea, and minimum flow requirements (navigation, environmental services, aquatic life, etc). Methods to assess exploitable water resources vary from country to country.

Flood-protected area (ha)
Area of land protected by flood control structures.

Flood recession cropping area: non-equipped but cultivated (ha)
Areas along rivers where cultivation occurs in the areas exposed as floods recede and where nothing is undertaken to retain the receding water. The special case of floating rice is included in this category.

Fossil groundwater: abstraction (km^3/year for a given period)
Annual amount abstracted from deep aquifers with a very low rate of renewal (less than 1 percent per year) so considered to be non-renewable or “fossil”.

Full/partial control irrigation: area equipped for localized irrigation (ha)
Localized irrigation is a system where the water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. There are three main categories: drip irrigation (where drip emitters are used to apply water slowly to the soil surface), spray or micro-sprinkler irrigation (where water is sprayed to the soil near individual plants or trees) and bubbler irrigation (where a small stream is applied to flood small basins or the soil adjacent to individual trees).
The following other terms are also sometimes used to refer to localized irrigation: micro-irrigation, trickle irrigation, daily flow irrigation, drop-irrigation, sip irrigation, diurnal irrigation.

Full/partial control irrigation: area equipped for sprinkler irrigation (ha)
A sprinkler irrigation system consists of a pipe network, through which water moves under pressure before being delivered to the crop via sprinkler nozzles. The system basically simulates rainfall in that water is applied through overhead spraying. These systems are also known as overhead irrigation systems.

Full/partial control irrigation: area equipped for surface irrigation (ha)

Surface irrigation systems are based on the principle of moving water over the land by simple gravity in order to moisten the soil. They can be subdivided into furrow, borderstrip and basin irrigation (including submersion irrigation of rice). Manual irrigation using buckets or watering cans is also included. Surface irrigation does NOT refer to the method of transporting the water from the source up to the field, which may be done by gravity or by pumping.

Full/partial control irrigation: total area equipped (ha)

This is the sum of surface irrigation, sprinkler irrigation and localized irrigation. The text uses indifferently the expressions "full control" and "full/partial control".

Full/partial control irrigation: area equipped irrigated from groundwater (ha)

Portion of the full control irrigation area that is irrigated from wells (shallow wells and deep tube wells) or springs.

Full/partial control irrigation: area equipped irrigated from surface water (ha)

Portion of the full control irrigation area that is irrigated from rivers or lakes (reservoirs, pumping or diversion).

Full/partial control irrigation: area equipped irrigated from mixed and other sources of water (ha)

Portion of the full/partial control irrigation area that is irrigated from mixed surface water and groundwater or from non-conventional sources of water such as agricultural drainage water, treated wastewater or desalinated water.

Full/partial control irrigation schemes (ha)

Areas of irrigation schemes, usually classified as large, medium, and small schemes. Criteria used in this classification are given in the tables.

Gross Domestic Product (GDP)

GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current United States dollars (US$). Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used. Figures provided by the World Development Indicators (WDI), the World Bank's premier annual compilation of data about development (http://devdata.worldbank.org/data-query/).

Harvested irrigated crop area (ha)

Total harvested irrigated crop area. It refers to the crops grown under full control irrigation. Areas under double irrigated cropping (same area cultivated and irrigated twice a year) are counted twice. Therefore the total area may be larger than the full/partial control equipped area, which gives an indication of the cropping intensity. The total is only given if information on all irrigated crops in the country is available.

Households in irrigation

Total number of households living directly on earnings from fully or partially controlled irrigation schemes.

Human Development Index (HDI)

This is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development: (1) a long and healthy life, as measured by life expectancy at birth; (2) knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight); (3) a decent standard of living, as measured by GDP per capita (Purchasing Power Parity or PPP US$). Figures provided by UNDP (http://hdr.undp.org/en/statistics/indices/hdi/).

Irrigated grain production: total (t)

The total quantity of cereals harvested annually in the irrigated area. Several harvests per year on the same area are counted several times.

Irrigation: total area (ha)

See *Area equipped for irrigation: total (ha).*

Irrigation potential (ha)

Area of land which is potentially irrigable. Country/regional studies assess this value according to different methods. For example, some consider only land resources, others consider land resources plus water availability, others include economical aspects in their assessments (such as distance and/or difference in elevation between the suitable land and the available water) or environmental aspects, etc. If available, this information is given in the individual country profiles. The figure includes the area already under agricultural water management.

Lowland areas: area equipped for irrigation (ha)

The land equipped for irrigation in lowland areas includes:

i. cultivated wetland and inland valley bottoms (IVB) that have been equipped with water control structures for irrigation and drainage (intake, canals, etc.);
ii. areas along rivers where cultivation occurs making use of structures built to retain receding flood water;
iii. developed mangroves and equipped delta areas.

Permanent crops (ha)

Crops are divided into temporary and permanent crops. Permanent crops are sown or planted once and then occupy the land for some years and do not need to be replanted after each annual harvest, such as cocoa, coffee and rubber. This category includes flowering shrubs, fruit trees, nut trees and vines, but excludes trees grown for wood or timber.

Precipitation in depth: average (mm/year)

Long-term average (over space and time) of annual endogenous precipitation (produced in the country) in depth.

Precipitation in volume: average (km^3/year)

Long-term average (over space and time) of annual endogenous precipitation (produced in the country) in volume.

Population: economically active population (inhabitants)

The number of all employed and unemployed persons (including those seeking work for the first time). It covers employers; self-employed workers; salaried employees; wage earners; unpaid workers assisting in a family or farm or business operation; members of producers' cooperatives; and members of the armed forces. The economically active population is also called the labour force.

Population: economically active population in agriculture (inhabitants)

Part of the economically active population engaged in or seeking work in agriculture, hunting, fishing or forestry (agricultural labour force). The economically active population refers to the number of all employed and unemployed persons (including those seeking work for the first time). It covers employers, self-employed workers, salaried employees, wage earners, unpaid workers assisting in a family or farm or business operation, members of producers' cooperatives, and members of the armed forces. The economically active population is also called the labour force.

Population: total (inhabitants)

According to the FAO definition, the total population usually refers to the present-in-area (de facto) population, which includes all persons physically present within the present geographical boundaries of countries at the mid-point of the reference period.

Population: urban, rural (inhabitants)

Usually the urban area is defined and the remainder of the total population is defined as rural. In practice, the criteria adopted for distinguishing between urban and rural areas vary from country to country. However, these criteria can be roughly divided into three major groups: classification of localities of a certain size as urban; classification of administrative centres of minor civil divisions as urban; and classification of centres of minor civil divisions on a chosen criterion which may include type of local government, number of inhabitants or proportion of population engaged in agriculture. Thus, the urban and rural population estimates in this domain are based on the varying national definitions of urban areas.

Population affected by water-related diseases (inhabitants)

Three types of water-related diseases exist:

i. water-borne diseases are those diseases that arise from infected water and are transmitted when the water is used for drinking or cooking (for example cholera, typhoid);
ii. water-based diseases are those in which water provides the habitant for host organisms of parasites ingested (for example shistomasomiasis or bilharzia);
iii. water-related insect vector diseases are those in which insect vectors rely on water as habitat but transmission is not through direct contact with water (for example malaria, onchocerciasis or river blindness, elephantiasis).

Power irrigated area as percentage of total area equipped for irrigated (%)

Percent of irrigation area where pumps are used for water supply from the source to the scheme, expressed in percentage. It includes also areas where water is drained out with human- or animal-driven water lifting devices.

Renewable water resources: internal (km³/year)

Internal Renewable Water Resources (IRWR): long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation. Double counting of surface water and groundwater resources is avoided by deducting the overlap from the sum of the surface water and groundwater resources.

Renewable water resources: external (km³/year)

External Renewable Water Resources (ERWR) are that part of the country's renewable water resources that are not generated within the country. They include inflows from upstream countries (groundwater and surface water), and part of the water of border lakes or rivers.

Renewable water resources: total natural (km³/year)

Total Natural Renewable Water Resources (TRWR_natural): the long-term average sum of internal renewable water resources (IRWR) and external natural renewable water resources (ERWR_natural). It corresponds to the maximum theoretical yearly amount of water actually available for a country at a given moment.

Renewable water resources: total actual (km³/year)

Total Actual Renewable Water Resources (TRWR_actual): the sum of internal renewable water resources (IRWR) and external actual renewable water resources (ERWR_actual). It corresponds to the maximum theoretical yearly amount of water actually available for a country at a given moment.

Return flow

That part of the water used for agricultural, domestic or industrial purposes which is returned to rivers or aquifers after use.

Safe yield of water systems (million m³)

Amount of water (in general, the long term average amount) which can be withdrawn from the groundwater basin or surface water system without causing undesirable results. This concept concerns mostly groundwater (flow extractable without over exploitation). For the rivers, it is more common to speak of reserved flow (reservation constraint for the environment).

Salinized area by irrigation (ha)

Irrigated area affected by salinization, including formerly irrigated land abandoned because of declining productivity caused by salinization. It does not include naturally saline areas. In general, each country has its own definition of salinized area.

Soil and water conservation

A combination of in-situ water conservation and soil conservation measures. Soil conservation measures comprise any set of measures intended to control or prevent soil erosion or to maintain fertility. Water conservation includes the usage of berms or bunds to slow or stop the migration of surface water.

Spate irrigation: equipped area for irrigation (ha)

Spate irrigation, also sometimes referred to as floodwater harvesting, is a method of informal irrigation using the floodwaters of a normally dry water course or riverbed (wadi). These systems are in general characterized by a very large catchment upstream (2 005 000 ha) with a ratio of "catchment area: cultivated area" = between 100:1 10 000:1. There are two types of spate irrigation:

1. floodwater harvesting within streambeds, where turbulent channel flow is collected and spread through the wadi where the crops are planted; cross-wadi dams are constructed with stones, earth, or both, often reinforced with gabions;
2. floodwater diversion, where the floods or spates from the seasonal rivers are diverted into adjacent embanked fields for direct application. A stone or

concrete structure raises the water level within the wadi to be diverted to the nearby cropping areas.

Temporary crops (ha)
See *Annual crops.*

Wastewater: produced volume (km^3/year)
Annual quantity of wastewater generated in the country, in other words, the quantity of water that has been polluted by adding waste. The origin can be domestic use (used water from bathing, sanitation, cooking, etc.) or industrial wastewater routed to the wastewater treatment plant. It does not include agricultural drainage water, which is the water withdrawn for agriculture but not consumed and returned to the system.

Wastewater: treated volume (km^3/year)
Quantity of generated wastewater that is treated in a given year and discharged from treatment plants (effluent). Wastewater treatment is the process to render wastewater fit to meet applicable environmental standards for discharge. Three broad phases of traditional treatment can be distinguished: primary, secondary and tertiary treatment. Discharge standards vary significantly from country to country, and therefore so do the phases of treatment. For the purpose of calculating the total amount of treated wastewater, volumes and loads reported should be shown only under the "highest" type of treatment to which it is subjected.

Wastewater: treated reused (million m^3/year)
Quantity of treated wastewater which is reused in a given year. Wastewater treatment is the process to render wastewater fit to meet applicable environmental standards for recycling or reuse.

Water harvesting area (ha)
Areas where rainwater is collected and either directly applied to the cropped area and stored in the soil profile for immediate uptake by the crop (runoff irrigation) or stored in a water reservoir for future productive use (for example used for supplementary irrigation). Rainwater harvesting includes:

i. roof water harvesting is mainly used for domestic purposes and sometimes as water supply for family gardens;
ii. micro-catchment water harvesting is characterized by a relatively small catchment area C (< 1 000 m^2) and cropping area CA (< 100 m^2) with ratio C:CA = 1:1 to 10:1. The farmer usually has control over both the catchment area and the target area. These systems are used for the irrigation of a single tree, fodder shrubs or annual crops. The construction is mainly manual. Examples are pits, semi-circular bunds, Negarim micro-catchment, eyebrow terrace, contour bench terrace, etc.;
iii. macro-catchment water harvesting collects water that flows over the ground as turbulent runoff and channel flow.

These systems are characterized by a large catchment area C ('external' catchment area of 1 000 m^2 200 ha), located outside the cultivated area CA, with a ratio C:CA = 10:1 to 100:1. The systems are mainly implemented for the production of annual crops. The construction is manual or mechanized. Examples are trapezoidal bunds, large semi-circular bunds, stone bunds, etc.

Water managed area (ha)
See *Area under agricultural water management.*

Water withdrawal for agriculture (million m^3/year)

Annual quantity of water withdrawn for irrigation and livestock purposes. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater, use of agricultural drainage water, desalinated water and treated wastewater. It includes water withdrawn for irrigation purposes and for livestock watering, although depending on the country this last category sometimes is included in domestic water withdrawal. As far as the water withdrawn for irrigation is concerned, the value far exceeds the consumptive use of irrigation because of water lost in distribution from its source to the crops. The term "water requirement ratio" (sometimes also called "irrigation efficiency") is used to indicate the ratio between the net irrigation water requirements or crop water requirements, which is the volume of water needed to compensate for the deficit between potential evapotranspiration and effective precipitation over the growing period of the crop, and the amount of water withdrawn for irrigation including the losses. In the specific case of paddy rice irrigation, additional water is needed for flooding to facilitate land preparation and for plant protection. In that case, irrigation water requirements are the sum of rainfall deficit and the water needed to flood paddy fields. At scheme level, water requirement ratio values can vary from less than 20 percent to more than 95 percent. As far as livestock watering is concerned, the ratio between net consumptive use and water withdrawn is estimated at between 60 percent and 90 percent. By default, livestock water use is accounted for in agricultural water use. However, some countries include it in domestic water withdrawal.

Water withdrawal for livestock (million m^3/year)

Some countries include this in domestic water withdrawal, others in agricultural water withdrawal.

Water withdrawal for municipal or domestic use (million m^3/year)

Annual quantity of water withdrawn for municipal or domestic purposes. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and the potential use of desalinated water or treated wastewater. It is usually computed as the total water withdrawn by the public distribution network. It can include that part of the industries which is connected to the domestic network. The ratio between the net consumption and the water withdrawn can vary from 5 to 15 percent in urban areas and from 10 to 50 percent in rural areas.

Water withdrawal for industry (million m^3/year)

Annual quantity of water withdrawn for industrial uses. It includes renewable water resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and potential use of desalinated water or treated wastewater. Usually, this sector refers to self-supplied industries not connected to any distribution network. The ratio between net consumption and withdrawal is estimated at less than 5 percent.

Water withdrawal: total (million m^3/year)

Annual quantity of freshwater withdrawn for agricultural, industrial and domestic purposes. It includes renewable freshwater resources as well as potential over-abstraction of renewable groundwater or withdrawal of fossil groundwater and eventual use of desalinated water or treated wastewater. It does not include other categories of water use, such as for cooling of power plants, mining, recreation, navigation, fisheries, etc., which are sectors that are characterized by a very low net consumption rate.

Waterlogged area by irrigation (ha)

Part of the land that is waterlogged because of irrigation. Waterlogging is the state of land in which the water table is located at or near the surface, resulting in a decline in crop yields. Irrigation can contribute to the raising of the level of the aquifers. The non-saturated area of soils can become too small and the soils are over-saturated with water. If recharge to groundwater is greater than natural drainage, there is a need for additional drainage to avoid waterlogging.

Waterlogged area not irrigated (ha)

Part of the land in non-irrigated cultivated areas that is waterlogged. Waterlogging is the state of land in which the water table is located at or near the surface resulting in a decline of crop yields.

Wetlands and inland valley bottoms

Wetland and inland valley bottoms (IVB) that have not been equipped with water control structures but are used for cropping. They are often found in Africa. They will have limited (mostly traditional) arrangements to regulate water and control drainage.

Section II

Regional analysis

Composition of the Middle East region

The Middle East region has been grouped into four subregions, based on geographical and climatic homogeneity, which has a direct influence on irrigation. These subregions (Figure 8) and the countries and territories they include are:

- **Arabian Peninsula**: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen.
- **Caucasus**: Armenia, Azerbaijan, Georgia.
- **Islamic Republic of Iran.**
- **Near East**: Iraq, Israel, Jordan, Lebanon, Occupied Palestinian Territory, Syrian Arab Republic, Turkey.

The Arabian Peninsula and the Caucasus are identical to the subregions with these names in the previous reports, *Irrigation in the Near East Region in figures* (FAO, 1997) and *Irrigation in the countries of the Former Soviet Union in figures* (FAO, 1997) respectively, which allows for comparison with the earlier data. The Islamic Republic of Iran is considered separately because it has not a clear geographical, climatic or hydrologic homogeneity with any of the other three subregions. The Near East subregion in this report is similar but not identical to the Middle East subregion included in the previous report *Irrigation in the Near East Region in figures* (FAO, 1997): Cyprus and Malta have been removed from this subregion, while Israel and the Occupied Palestinian Territory (including the West Bank and Gaza Strip) have been added.

This regional overview presents distinguishing features arising from the new data collected on a national scale for issues addressed in the country profiles. The interest of this new survey lies in the updating of data and in the trends during the last ten years.

Geography, climate and population

The total area of the Middle East region is 6.56 million km², or almost 5 percent of the world's emerged landmass (Table 1, Table 42, Table 52). Out of the total of 18 countries, the three largest (Saudi Arabia, Islamic Republic of Iran and Turkey, in decreasing order) represent 71 percent of this territory, while the smallest seven (Bahrain, Occupied Palestinian Territory, Lebanon, Qatar, Kuwait, Israel and Armenia) constitute barely 1.5 percent. The cultivated area is estimated at 64 million ha, or 39 percent of the cultivable land in the region. This percentage is lowest in the Arabian Peninsula, where the cultivated area is only 5 percent of the cultivable land and where cultivation almost entirely depends on irrigation, whereas in the Near East subregion the cultivated area represents 84 percent of the cultivable area (Table 1).

Average annual rainfall, estimated at 238 mm for the region, varies from less than 100 mm in parts of the Arabian Peninsula to over 1 000 mm in Georgia in the Caucasus (Figure 9).

Total population was estimated at 283 million inhabitants in 2005, representing about 4.4 percent of the world's population (Table 2, Table 43, Table 52). Turkey and the Islamic Republic of Iran are the most populous countries, containing together over half of the population of the Middle East region (Table 43 and Figure 1). The part of the population living in rural areas in the region (34 percent) is below the world average (51 percent), due to the low rural population in most of the countries of the region, especially in the Arabian Peninsula. In Bahrain, Israel, Kuwait, Lebanon, Qatar, Saudi Arabia and the United Arab Emirates, rural population accounts for less than 15 percent of the total. In the most populated countries, Turkey and the Islamic Republic of Iran, rural population represents one-third of the total population, in the Caucasus and the Syrian Arab Republic it is almost half and in Yemen almost three-

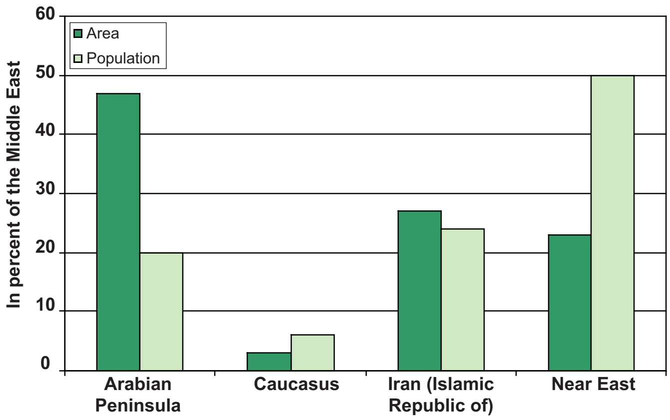
TABLE 1
Regional distribution of cultivable and cultivated areas

Subregion	Total area (ha)	Cultivable areas (ha)	Cultivated areas (around 2005)	
			Area (ha)	In % of cultivable areas (%)
Arabian Peninsula	310 029 000	58 967 029	2 733 849	5
Caucasus	18 610 000	8 697 733	3 685 700	42
Iran (Islamic Republic of)	174 515 000	51 000 000	18 107 000	36
Near East	153 303 000	47 304 400	39 570 000	84
Total region	**656 457 000**	**165 969 162**	**64 096 549**	**39**

TABLE 2
Regional distribution of area and of population

Subregion	Area		Population 2005					
	km²	% of Middle East	Population (millions)	% of Middle East	% living in rural areas	Population density (inhab./km²)	Economically active population as % of total	% economically active population in agriculture
Arabian Peninsula	3 100 290	47	56.8	20	35	18	38	19
Caucasus	186 100	3	15.9	6	47	85	39	25
Iran (Islamic Republic of)	1 745 150	27	69.5	24	32	40	40	24
Near East	1 533 030	23	140.8	50	33	92	41	31
Total region	**6 564 570**	**100**	**283.0**	**100**	**34**	**43**	**40**	**27**

FIGURE 1
Regional distribution of areas and population



quarters. The average population density of 43 inhabitants/km² conceals wide variations (Figure 10). The four most densely populated countries are Bahrain, Occupied Palestinian Territory, Lebanon and Israel, with 1 024, 615, 344 and 324 inhabitants/km², respectively (Table 43). On the other hand, most countries of the Arabian Peninsula are not very densely populated (18 inhabitants/km² on average), especially Oman and Saudi Arabia, which only have 8 and 11 inhabitants/km² respectively. In 2006, almost 10 percent of the total population of the Middle East region had no access to safe drinking water. In the same year, average life expectancy was 71 years.

ARABIAN PENINSULA

The Arabian Peninsula, consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen, covers an area of about 3.1 million km², or 47 percent of the Middle East region (Table 2). Saudi Arabia covers almost 70 percent of the area of this subregion. Each of the countries in the Arabian Peninsula has access to the sea. Out of a total cultivable area of 59 million ha, only 2.7 million ha are cultivated, or 5 percent of the potential. The main reason for this low percentage is lack of water for irrigation. The subregion is bordered to the north by Jordan and Iraq, to the east by the Persian Gulf and the Gulf of Oman, to the south by the Arabian Sea and the Gulf of Aden, and to the west by the Red Sea and Egypt. The climate is dry with very limited water resources. Annual average precipitation in the region reaches only 117 mm, ranging from 62 mm in Oman to 121 mm in Kuwait and 167 in Yemen, which allows no cultivation without irrigation in all countries except in Yemen where rainfed production is possible in the highlands.

The population of the Arabian Peninsula was 57 million in 2005, of which 80 percent lives in Saudi Arabia and Yemen (Table 43). About 35 percent of the population lives in rural areas (Table 2). The average population density in the subregion, 18 inhabitants/km², is lower than the average density of the Middle East region as a whole, which is 43 inhabitants/km². The population is concentrated mainly on the coasts, where density can reach 1 024 inhabitants/km², as in Bahrain, while the desert is practically uninhabited (Figure 10). The overall annual population growth of 3.2 percent in the period 1995–2005 and 3.9 percent in the previous decade (1985–1995) is extremely high, mostly because of immigrant labourers.

CAUCASUS

The Caucasus covers three countries, Armenia, Azerbaijan and Georgia, and is located in the north of the Middle East region, between the Black Sea in the west and the Caspian Sea in the east. It is situated at the southern foothills of the Greater Caucasus mountain range, which is considered the boundary between Europe and Asia. The highest peak in the region stands at about 5 000 m above sea level. Large areas around the Black Sea, the Caspian Sea and the river deltas are lowlands. The total area of the Caucasus is 0.2 million km², or only 3 percent of the total area of the Middle East region (Table 2). Azerbaijan, bordering the Caspian Sea, represents about 50 percent of this territory (Table 42). Georgia, bordering the Black Sea, represents about 34 percent. Armenia, finally, covers only 16 percent and is landlocked. The cultivable area is 8.7 million ha, 50 percent of which is in Azerbaijan, and in 2005 about 3.7 million ha was cultivated, or almost 42 percent of the cultivable area. The climate varies from typical dry continental, with average summer temperatures up to 27 ºC, to warm, humid, subtropical in the northwest near the Black Sea coast, with average temperature of 22 ºC in summer and 5 ºC in winter. Average annual precipitation is 702 mm, varying from 200 mm in the Ararat valley in central Armenia to 1 700 mm in western Georgia. In the southern and eastern parts of this region irrigation is necessary, but drainage is also required in larges areas to reduce irrigation-induced salinization.

In 2005 about 16 million people lived in the Caucasus, which is equal to a density of 85 inhabitants/km^2 (Table 2). National average densities range from 64 inhabitants/km^2 in Georgia, to 101 inhabitants/km^2 in Armenia (Table 43). About 47 percent of this population is rural. Population in this subregion decreased by almost 0.1 percent per year in the period 1995–2005, Armenia accounting for 0.7 percent per year of the decrease, and Georgia for 1.2 percent. Only in Azerbaijan has the population increased in the last ten years, with a yearly growth rate of 0.8 percent.

ISLAMIC REPUBLIC OF IRAN

The Islamic Republic of Iran, located at the eastern part of the Middle East region, covers an area of 1.74 million km^2, which represents almost 27 percent of total area of the region. It is almost nine times the area of the Caucasus subregion and slightly less than the area of the entire Arabian Peninsula. It is bordered to the north by the Caucasus, the Caspian Sea and Turkmenistan, to the east by Afghanistan and Pakistan, to the south by the Gulf of Oman and the Persian Gulf, and to the west by Iraq and Turkey. The cultivable area is 51 million ha, of which about one-third was cultivated in 2005. Annual precipitation is 228 mm, varying from less than 50 mm in the desert to 2 275 mm near the Caspian Sea in the north.

Almost one-quarter of the total population of the Middle East region lives in the Islamic Republic of Iran, which has a density of almost 40 inhabitants/km^2. Almost one-third of the population is rural. Annual population growth was only 1.1 percent in the period 1995–2005.

NEAR EAST

The Near East subregion comprises seven countries and territories: Iraq, Israel, Jordan, Lebanon, Occupied Palestinian Territory, Syrian Arab Republic and Turkey. The total area is 1.5 million km^2, representing 23 percent of the total area of the Middle East (Table 2 and Table 42). Of the total cultivable area of 47 million ha, about 40 million ha were cultivated in 2005, which is 84 percent of the potential. The subregion is bordered to the north by the Black Sea and the Caucasus, to the east by the Islamic Republic of Iran, to the south by Kuwait and Saudi Arabia and to the west by Egypt and the Mediterranean Sea. The annual average precipitation is 440 mm, varying from 94 mm in Jordan to 823 mm in Lebanon.

The population in the Near East subregion was 141 million inhabitants in 2005, of which 52 percent live in Turkey (Table 43). Average density was estimated at 92 inhabitants/km^2, ranging from 64 inhabitants/km^2 in Jordan to 615 inhabitants/km^2 in the Occupied Palestinian Territory (Table 43). About one-third of the population is rural. Annual population growth ranges from barely 1.2 percent in Lebanon to 3.5 percent in the Occupied Palestinian Territory, with a regional average of 2.1 percent in the period 1995–2005.

Economy, agriculture and food security

The economy of the Middle East region is dominated by oil and in the Arabian Peninsula countries the gross domestic product (GDP) per capita is among the highest values of the world. On the other hand, conflicts between some of the countries have a negative effect on the stability of the region. The sum of national GDPs in 2007 amounted to US$1 978 470 million, which is 3.6 percent of world GDP. It corresponds to a GDP of about US$5 160/inhabitant, ranging from US$800/inhabitant in Yemen to more than US$52 000/inhabitant in Qatar. As far as the Human Development Index (HDI) is concerned (range = 0–1), the countries rank between the 23rd and the 108th place out of a total of 177 countries, except for Yemen which holds the 153rd place with a HDI of 0.508. Israel, with 0.932, has the highest HDI in the region. The HDI for Iraq is unknown.

In 2006, the added value of the primary sector (agriculture) contributed 6.3 percent to the GDP of the Middle East region. It ranged from 0.4 percent in Kuwait (2000) and 0.9 percent in Bahrain (2002), to 18.3 percent in the Syrian Arab Republic and 19.6 percent in Armenia. In most countries less than 25 percent of the economically active population is engaged in the farming sector (Table 2 and Table 43). Oman (32 percent), Turkey (43 percent) and Yemen (45 percent) are exceptions. Most Arabian Peninsula countries have less agriculture and more industries, especially oil, and services. In the Caucasus countries, since the end of the Soviet era a transformation process has occurred, with transition towards a market economy. In Armenia and Azerbaijan industry is the main sector, followed by services and agriculture, while in Georgia services is the most important sector, followed by industry and agriculture. The Near East is the subregion with more economically active people involved in agriculture. Turkey is responsible for this higher percentage of active agricultural workers. The cultivated area per person economically active in agriculture varies from a low 0.2 ha/person in Oman and 0.4 ha/person in Yemen and Qatar to over 6 ha/person in Israel and more than 9 ha/person in Iraq and Lebanon, giving an average for the region of 2.1 ha/person.

Water resources

One of the problems encountered during this update is the confusion between "water resources" and "water supply sources" when information is provided. This report concentrates on "water resources" rather than "water supply sources":

Water resources are natural potential; they are *state variables* indicating the state of the resources, with conjunctural variations, that are renewable and stable (except in the case of climate change) or non-renewable.

Water supply sources give information on the origin of water withdrawn or produced for use. They are *decision variables*, with an underlying evolution, that are subject to an inventory, coherent with statistics on "water use", with the reference date to be specified.

RENEWABLE WATER RESOURCES

The volume of annual precipitation in the Middle East region is estimated at about 1 564 km^3, equal to a regional average of 238 mm/year, but with significant disparities between countries (Table 3 and Figure 9). The driest country is Oman with 62 mm/year on average, followed by the other countries of the Arabian Peninsula, which is the driest subregion in the Middle East with an average of 117 mm/year. Jordan in the Near East subregion also has a low average annual precipitation, below 100 mm, while Lebanon is the rainiest country with 823 mm, followed by Turkey with 643 mm. The Caucasus countries receive an average precipitation of 702 mm/year with Georgia having about 1 065 mm. Average annual precipitation in the Islamic Republic of Iran is 228 mm.

While the Middle East region covers 4.9 percent of the total area of the world and contains 4.4 percent of its population, its water resources, which total 484 km^3, are only about 1.1 percent of the total renewable water resources of the world (Table 52 and Figure 11). Moreover, large differences exist between the 19 countries and territories, as shown in Table 44.

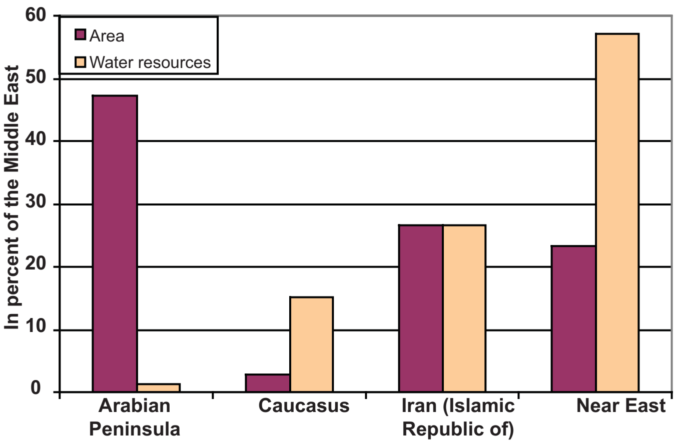
Turkey accounts for 47 percent of Middle East region's resources on only 12 percent of the region's area, following the Islamic Republic of Iran, which accounts for 27 percent (Figure 2). On the other hand, the Arabian Peninsula is the most disadvantaged subregion with only 1 percent of the renewable water resources for an area equivalent to 47 percent of the Middle East. Kuwait has no internal renewable water resources. In the Arabian Peninsular, with the exception of land serviced by spate irrigation, all irrigated production is reliant upon groundwater pumping and associated 'quanats'.

TABLE 3
Regional distribution of the water resources

Subregion	Annual precipitation		Annual internal renewable water resources		
	Height	Volume	Volume	% of the Middle East	Per inhabitant (2005)
	(mm)	(million m^3)	(million m^3)	(%)	(m^3)
Arabian Peninsula	117	362 041	6 110	1	108
Caucasus	702	130 582	73 104	15	4 597
Iran (Islamic Republic of)	228	397 894	128 500	27	1 849
Near East	439	673 531	276 376	57	1 964
Total Region	**238**	**1 564 048**	**484 090**	**100**	**1 711**

FIGURE 2

Regional distribution of area and water resources



For the region as a whole, the renewable shallow groundwater circulation associated with alluvial deposits in wadis channels and extensive alluvial fans are important sources of water for potable water supply, stock watering and localized irrigation. The resources of these localized aquifer systems are dependant on indirect recharge from intermittent flows in watercourses. Other sources of renewable groundwater are also obtained from where outcrops of permeable limestones and sandstones accept direct recharge from rainfall. The distinction between direct and indirect recharge processes is important to make in any water resource accounting at basin or aquifer system level. Indirect recharge processes tend to dominate so that the frequency, magnitude and duration of runoff events are important indicators of groundwater resource recharge.

Due to population growth, there has been a decrease in average annual internal renewable water resources (IRWR) per inhabitant since the previous AQUASTAT survey. In 2005, the average per habitant IRWR was 1 717 m^3 for the region, ranging from 0 m^3 in Kuwait to 6 m^3 in Bahrain and to 12 993 m^3 for Georgia (Table 44). The distribution of total actual renewable water resources (TARWR) is different because of transboundary river basins, with values ranging from 7 m^3 per inhabitant in Kuwait and 33 m^3 in the United Arab Emirates to 14 155 m^3 in Georgia (Figure 12).

TABLE 4

Countries and territories with water resources of less than 500 m^3/inhabitant per year

Country	Internal renewable water resources/ inhabitant/year		Total renewable water resources/ inhabitant/year	
	1995	2005	1995	2005
	(m³)			
Bahrain	7	6	206	160
Israel	140	112	331	265
Jordan	124	120	161	164
Kuwait	0	0	11	7
Occupied Palestinian Territory	310	219	320	226
Qatar	93	69	96	71
Saudi Arabia	134	98	134	98
Syrian Arab Republic	477	375	1 791	882
United Arab Emirates	79	33	79	33
Yemen	283	100	283	100

Table 4 presents the IRWR and TARWR for ten countries and territories where resources per inhabitant are very limited. With respect to IRWR, their resources are lower than the cut-off point of 500 m^3/inhabitant per year, considered to be the threshold for absolute water scarcity. With respect to TARWR, all except the Syrian Arab Republic remain below this threshold: Saudi Arabia, United Arab Emirates and Yemen do not benefit from any outside contributions (dependency ratio of zero); Qatar and the Occupied Palestinian Territory benefit only slightly (ratio lower than 10 percent); and Bahrain, Israel, Jordan and Kuwait have a high dependency ratio despite low external renewable resources. Only the Syrian Arab Republic has a relatively high proportion of external renewable resources, although it is still in a situation of chronic water scarcity (threshold 1 000 m^3/inhabitant per year).

TRANSBOUNDARY WATERS

The main transboundary rivers in the Middle East region are the Euphrates–Tigris flowing to the Persian Gulf, the Kura–Araks flowing to the Caspian Sea, the Asi–

TABLE 5
The four most important transboundary river basins in the Middle East region

Basin	Area		Countries included	Area of country in basin (km^2)	As percentage of total area of basin %
	km^2	% of the Middle East			
Euphrates-Tigris	879 790	13.4	Iraq	407 880	46.4
			Turkey	192 190	21.8
			Iran (Islamic Republic of)	166 240	18.9
			Syrian Arab Republic	96 420	11.0
			Saudi Arabia	16 840	1.9
			Jordan	220	0.03
Kura-Araks	190 250	2.9	Azerbaijan	60 020	31.5
			Iran (Islamic Republic of)	37 080	19.5
			Georgia	34 560	18.2
			Armenia	29 800	15.7
			Turkey	28 790	15.1
Asi-Orontes	24 660	0.4	Syrian Arab Republic	16 910	68.6
			Turkey	5 710	23.1
			Lebanon	2 040	8.3
Jordan	18 500	0.3	Jordan	7 470	40.4
			Israel	6 830	36.9
			Syrian Arab Republic	1 910	10.3
			Occupied Palestinian Territory	1 620	8.8
			Lebanon	670	3.6
Total	**1 113 200**	**17.0**			

Orontes flowing to the Mediterranean Sea and the Jordan flowing to the Dead Sea. These four transboundary river basins cover 17 percent of the total area of the Middle East region (Table 5 and Figure 13).

Some major aquifers in the region can also be considered transboundary, the most notable being the Disi aquifer which straddles Jordan and Saudi Arabia.

A more detailed description of these four transboundary basins is given in the chapter entitled *Description of four transboundary river basins.*

WATER RESOURCES IN ENDOREIC BASINS

Generated by both the dominant aridity of the climate and structural geological conditions, an endhoreic basin, also called closed or interior basin, is a basin which has no outflow to the sea. This is a major characteristic of the hydrography of the Middle East region. The endhoreism in the Middle East region is either structural, in the case of completely closed basins surrounded by a continuous watershed line (such as exist in the Islamic Republic of Iran and Turkey, or the basin of the Dead Sea), or functional, in the case where the basins are theoretically exoreic or open but where the local outflow never reaches the sea (such as exist in Saudi Arabia or the United Arab Emirates) (Figure 14).

By definition, in the water balance of an endhoreic basin the rainfall is equal to the evapotranspiration and final runoff is equal to zero. However, superficial runoff and recharge of aquifers take place in part of the basin and can offer locally exploitable water resources. Estimation of those resources is based on the distinction in each endhoreic basin between an upstream “producing” zone, where water courses and aquifers have a runoff that significantly increases from upstream to downstream, and a downstream “consuming” zone, where runoff decreases from upstream to downstream and which can coincide with an evaporation area or an interior lake, such as the Dead Sea or Lake Van in Turkey. Determining the exact border between these two zones is very difficult, because it can be unstable. It is a matter of determining for each water course the point where the average natural discharge is maximal and taking measurements there. But the real discharges are often influenced, which complicates the evaluation. “Consuming” zones with decreasing runoff can be included in exoreic basins (basins having an outflow

TABLE 6
Average potential runoff in endorheic basins in the Middle East region

Endorheic basin	Country	Average potential runoff km³/year	
Dead Sea:			
Yarmouk–Jordan	Israel, Jordan. Lebanon, Occupied Palestinian Territory, Syrian Arab Republic		1.5
Other	Israel, Occupied Palestinian Territory		0.1
Akarcay	Turkey*	0.5	7.9
Burdur		0.5	
Konya		4.5	
Van		2.4	
Barada–Awaj	Syrian Arab Republic	1.0	2.15
Alep		0.8	
El Badia–Hamad		0.35	
Markasi	Islamic Republic of Iran*	48.3	65.0
Hamoon		3.0	
Sarakhs		5.7	
Oroomieh		8.0	
Arabian Desert	Saudi Arabia	0.5	1.3
	Jordan	0.07	
	Oman	0.5	
	Yemen	0.2	
Total (rounded)			**78**

* Caspian basin excluded

to the sea), in arid or semi-arid zones, such as happens for example in the Euphrates–Tigris basin.

Table 6 shows natural renewable water resources (i.e. total runoff) of the endhoreic basins in the Middle East region, although a uniform estimation approach is not guaranteed.

NON-RENEWABLE GROUNDWATER AQUIFERS IN THE MIDDLE EAST REGION

Deep aquifer systems with significant stores of freshwater provide important sources of supply to municipal and agriculture uses. However, these large systems generally experience low rates of recharge (less than 1/100 or 1/1 000 of their stock in an average year). In many instances these groundwater resources are referred to as “fossil aquifers” since the bulk of the storage was emplaced during much wetter climatic periods. Dating of these waters indicates emplacement occurring between one thousand to several tens of thousand years before the present. These resources are particularly precious in arid and semi-arid zones and have been progressively depleted as pumping technology and energy availability has evolved. Non-renewable water resources can be defined as an economically recoverable ‘stock’, such as oil or minerals.

The Middle East region contains one of the most important multi-layered aquifer systems centred on the Arabian Peninsula and extending over an area of around 1.5 million km², mainly in Saudi Arabia and continuing into Jordan in the northwest and the Gulf countries in the east (Figure 15). Khater (2003) identifies three main sub-systems: (i) the Cambrian-Triassic Western Arabia sandstone aquifer system comprising the Saq, Tabuk, Wajid and Minjur aquifers; (ii) the Cretaceous Central Arabia sandstone aquifer system comprising the Biyadh and Wasia sandstones; (iii) the Tertiary Eastern Arabia carbonate aquifer system comprising the Umm er Radhuma and Dammanm aquifers together with later Neogene sands and limestones. This huge multilayer sedimentary basin (with a thickness up to 4 500 m) comprises several aquifers one above the other, from Cambrian (“Saq”) in Jordan and north-western Saudi Arabia to the superficial Neogene aquifers along the eastern margin of Arabian peninsular. The combined stock is estimated to be in the order of 2 000 km³ and the actual replenishment around 1 km³/year. However, water quality throughout the system is variable with salinities ranging from an average of 1 000 ppm in the Saq to 150 000 ppm in parts of the Biyadh system. The whole multi-layered system has been extensively exploited for several decades, particularly following the introduction of deep submersible pumps: approximately 380 km³ are estimated to have been extracted in 25 years (between 1975 and 2000).

DAMS

The total dam capacity in the Middle East region is 870 km³. Turkey, Iraq and the Syrian Arab Republic contain more than 93 percent of the total dam capacity, most of it in the Euphrates–Tigris Basin. Turkey’ accounts for 651 km³ (75 percent of the Middle

East) and Iraq accounts for 140 km^3 (16 percent of the Middle East). The Caucasus countries have 3 percent of the total dam capacity, of which 82 percent is located in Azerbaijan. The Arabian Peninsula countries have a small dam capacity, representing 0.2 percent only (Table 7). Twelve dams in the Middle East region have a capacity over 5 km^3, most of them in the Euphrates–Tigris basin, except the Mingechevir dam located in Azerbaijan in the Kura Basin and the Hirfanli and Atinkaya dams located in Turkey in the Black Sea Basin. In total these twelve large dams account for 234 km^3, or 27 percent of the total dam capacity in the Middle East region. The dam with the largest capacity is the Samarra–Tharthar (73 km^3) in Iraq, followed by the Ataturk dam (49 km^3) and the Keban dam (31 km^3), both in Turkey (Table 8).

TABLE 7
Regional distribution of dams

Subregion	Dam capacity	
	km^3	% of the Middle East
Arabian Peninsula	1.5	0.2
Caucasus	26.4	3.0
Iran (Islamic Republic of)	31.6	3.6
Near East	810.8	93.2
Total region	**870.3**	**100.0**

NON-CONVENTIONAL SOURCES OF WATER

The water scarcity that prevails in the region has forced and will continue to force national economies to find alternative ways to satisfy the demand for water. The reuse of treated wastewater and water desalination take place mainly in dry countries seeking to increase their limited sources of water. Some oil-rich countries convert a significant amount of saline water from the sea or from poor-quality aquifers (brackish water) into drinking water. Similarly, wastewater treatment and reuse is becoming a common practice in the Middle East region. Countries such as Armenia and Georgia have not yet developed non-conventional sources of water because they have enough renewable water resources.

Total treated wastewater reused in the Middle East region is 2 663 million m^3 (Table 9). On a subregional scale, the Near East subregion accounts for 72 percent of the total reused treated wastewater, the Arabian Peninsula for 22 percent and the Caucasus for 6 percent. Country-wise, Turkey accounts for 38 percent of the total reused treated wastewater of the Middle East region, followed by the Syrian Arab Republic, Israel and United Arab Emirates with 21, 10 and 9 percent respectively. Saudi Arabia and Azerbaijan each represent 6 percent of the total.

The total use of desalinated water in the Middle East region is estimated to be 3 225 million m^3/year. On a subregional scale, the Arabian Peninsula accounts for 87.4 percent

TABLE 8
Dams in the Middle East region with a capacity larger than 5 km^3

Dam	River	Basin	Capacity (km^3)	Surface area (km^2)	Main use*	Country
Samarra–Tharthar	Tigris	Tigris	72.8	2 170	F	Iraq
Ataturk	Fırat	Euphrates	48.7	817	I, H	Turkey
Keban	Fırat	Euphrates	31.0	675	H	Turkey
Mingechevir	Kura	Kura	15.7	605	I, H, F	Azerbaijan
Mosul	Tigris	Tigris	12.5	326	I	Iraq
Al Tabka	Euphrates	Euphrates	11.2	-	-	Syrian Arab Republic
Karakaya	Firat	Euphrates	9.6	268	H	Turkey
Haditha	Euphrates	Euphrates	8.2	500	I, H	Iraq
Dokan	Lesser Zab	Tigris	6.8	270	I	Iraq
Hirfanlı	Kızılırmak	Black Sea	6.0	263	H, F	Turkey
Altınkaya	Kızılırmak	Black Sea	5.8	118	H	Turkey
Karkheh	Karkheh	Karkheh	5.6	166	I, H, F	Iran (Islamic Republic of)
Total			**233.9**	**6 178**		

* I = irrigation; H = Hydropower, W = water supply; F = Flood protection

TABLE 9
Regional distribution of non-conventional sources of water and their uses

Subregion	Wastewater			Desalinated water	Reused agricultural drainage water
	Produced	Treated	Reused treated		
	million m³/year				
Arabian Peninsula	2 119	1 290	594	2 820	-
Caucasus	5 243	259	161	0	-
Iran (Islamic Republic of)	3 080	130	-	200	-
Near East	4 976	2 624	1 908	205	3 911
Total region	**15 418**	**4 303**	**2 663**	**3 225**	**3 911**

of the total desalinated water and the Near East subregion and the Islamic Republic of Iran for 6.4 percent and 6.2 percent respectively. The Caucasus has not started to produce desalinated water because its renewable resources are not as limited as in the Arabian Peninsula and the Near East countries. In absolute terms, three countries (Saudi Arabia, the United Arab Emirates and Kuwait) are by far the largest users of desalinated water, accounting for 77 percent of the region's total. Saudi Arabia uses an annual 1 033 million m^3 and United Arab Emirates and Kuwait 950 and 420 million m^3 respectively (Table 46 and Figure 16). The Occupied Palestinian Territory has not developed these techniques because of lack of economic resources; however reused treated wastewater in the Gaza Strip amounts to 10 million m^3.

Only three countries, Iraq, Lebanon and the Syrian Arab Republic, provide data about reused agricultural drainage water, which amounts to 1 500 million m^3, 165 million m^3 and 2 246 million m^3 respectively.

Water withdrawal

WATER WITHDRAWAL BY SECTOR

Data on water withdrawal by sector refer to the gross quantity of water withdrawn annually for a given use. Table 45 presents the distribution of water withdrawal by country for the three large water-consuming sectors: agriculture (irrigation and livestock watering), water supply (domestic/municipal use) and industry. Although able to mobilize a significant portion of water, requirements for energy purposes (hydroelectricity), navigation, fishing, mining, environment and leisure activities have a low rate of net water consumption. For this reason, they are not included in the calculation of the regional withdrawals but they do appear in the country profiles where information is available.

For most countries, the methods used for calculation or the measurements for obtaining the values of withdrawals are not specified.

Total annual water withdrawal for the Middle East region is 271.5 km^3, which is around 7 percent of world withdrawals (Table 10 and Table 52). About 84 percent of inventoried withdrawals are by agriculture, which is higher than the value for global agricultural water withdrawal (70 percent). However, this figure varies by country. In the Syrian Arab Republic, Saudi Arabia, Oman, Yemen and the Islamic Republic of Iran, agricultural withdrawal accounts for more than 85 percent of the total water withdrawal, while in Bahrain, Occupied Palestinian Territory, Kuwait, Israel and Qatar it represents less than 60 percent. The Caucasus countries use 73 percent of their withdrawal for agriculture. The annual precipitation in this subregion allows rainfed agriculture, which is not feasible in dry countries, such as most of the Arabian Peninsula.

The Islamic Republic of Iran, Iraq and Turkey cover the highest withdrawals in the Middle East region, accounting for 34 percent, 24 percent and 15 percent respectively. Saudi Arabia is the country with the highest withdrawals in the Arabian Peninsula at 9 percent of the total withdrawals in the Middle East. These four countries have both the highest area under irrigation and the highest population. Azerbaijan accounts for 73 percent of the total withdrawal in the Caucasus (Table 45). Water withdrawal per inhabitant is 963 m^3/year, but this average conceals significant variations between countries. The figure ranges from 113 m^3/inhabitant in the Occupied Palestinian Territory to 1 452 m^3/inhabitant in Azerbaijan and 2 632 m^3/inhabitant in Iraq. In the Arabian Peninsula, Saudi Arabia and United Arab Emirates account for the highest annual per capita withdrawal with 963 and 889 m^3/inhabitant respectively (Figure 17).

TABLE 10
Regional distribution of water withdrawal by sector

Subregion	Annual withdrawal by sector									
	Agriculture		Municipalities			Industry		Total		
	million m^3	% of total	million m^3	% of total	m^3 per capita	million m^3	% of total	million m^3	% of Middle East	m^3 per capita
Arabian Peninsula	29 279	86	3 905	11	69	915	3	34 100	13	600
Caucasus	12 244	73	1 722	10	108	2 693	16	16 659	6	1 048
Iran (Islamic Republic of)	86 000	92	6 200	7	89	1 100	1	93 300	34	1 342
Near East	98 978	78	13 509	11	96	14 925	12	127 413	47	905
Total region	**226 501**	**84**	**25 337**	**9**	**90**	**19 633**	**7**	**271 472**	**100**	**963**

Municipal water withdrawal per inhabitant is 90 m³/year for the Middle East region as a whole, with variations between countries from 13 m³/inhabitant in Yemen to 51 m³/inhabitant in Jordan, 245 m³/inhabitant in Bahrain and 280 m³/inhabitant in Armenia. Industrial water withdrawal per inhabitant is 70 m³/year for the Middle East on average. However, this figure also varies considerably at country level. In seven countries it amounts to less than 10 m³/inhabitant per year, especially Yemen, where industrial water withdrawal is 3 m³/inhabitant per year, whereas in Azerbaijan and Iraq the figures are 280 and 337 m³/inhabitant per year respectively.

WATER WITHDRAWAL BY SOURCE

Data on water withdrawal by source refer to the gross quantity of water withdrawn annually from all the possible sources, which are divided into freshwater resources and non-conventional sources of water. Table 11 presents the distribution of water withdrawal by subregion, distinguishing between freshwater (surface water and groundwater), desalinated water, reused treated wastewater and reused agricultural drainage water.

For most countries, the methods used for calculation or the measurements for obtaining the values of the withdrawal by source are not specified. For the countries for which recent data were not available or were not reliable, estimations that take into account total water withdrawal by sector have been used, given that total water withdrawal by source and total water withdrawal by sector must be equal.

Total annual water withdrawal by source is 271.5 km³ for the Middle East region (Table 11). Freshwater accounts for 96.4 percent of total water withdrawal, reused agricultural drainage water for 1.4 percent, desalinated water for 1.2 percent and reused treated wastewater for 1.0 percent. Considering the 14 countries for which data on surface water and groundwater withdrawal is available, surface water withdrawal represents 48 percent of the freshwater withdrawal and groundwater 52 percent in the region. In the Arabian Peninsula, groundwater is the largest source of freshwater withdrawal, amounting to 84 percent of the total, while in the Caucasus countries surface water accounts for 87 percent of the total freshwater withdrawal. Turkey's surface water withdrawal represents 73 percent of the total freshwater withdrawal, whereas in Iran and Jordan groundwater withdrawal accounts for almost 60 percent (Table 46). The Arabian Peninsula countries are the most advanced regarding non-

TABLE 11
Regional distribution of water withdrawal by source

Subregion	Annual withdrawal by source										
	Freshwater*				Non-conventional source of water						Total water withdrawal
	Surface water	Ground-water	Total		Desalinated water		Reused treated wastewater		Reused** agricultural drainage water		
	million m³	million m³	million m³	% of total	million m³	% of total	million m³	% of total	million m³	% of total	million m³
Arabian Peninsula	2 087	28 718	30 701	90.0	2 805	8.2	594	1.8	-	0.0	34 100
Caucasus	14 021	1 867	16 498	99.0	0	0.0	161	1.0	-	0.0	16 659
Iran (Islamic Republic of)	40 000	53 100	93 100	99.8	200	0.2	-	0.0	-	0.0	93 300
Near East*/**	-	-	121 389	95.3	205	0.2	1 907	1.5	3 911	3.0	127 413
Total region	**-**	**-**	**261 688**	**96.4**	**3 210**	**1.2**	**2 663**	**1.0**	**3 911**	**1.4**	**271 472**

* In the Near East subregion the distribution between surface water and groundwater withdrawal is known only for three out of the seven countries: Jordan, Lebanon and Turkey, which respectively withdrew 294 million m³, 396 million m³ and 31 500 million m³ of surface water and 553 million m³, 700 million m³ and 10 500 million m³ of groundwater.

** Only three countries in the Middle East, all in the Near East subregion, provided data on reused agricultural drainage water: Iraq, Lebanon and the Syrian Arab Republic, which reported 1 500 million m³ , 165 million m³ and 2 246 million m³ respectively.

conventional sources of water: desalinated water represents 8 percent and reused treated wastewater 2 percent of the total water withdrawal. Saudi Arabia and United Arab Emirates account for 32 percent and 29 percent respectively of the use of desalinated water in the Middle East region. In the Caucasus countries there is no desalinated water and reused treated wastewater represents only 1 percent on average. Turkey, the Syrian Arab Republic and Israel register the largest reuse of treated wastewater in the Middle East region with 38, 21 and 10 percent respectively (Figure 16). In the Syrian Arab Republic reused agricultural drainage water amounts to 2 246 million m^3.

THE WATER INDICATOR OF THE MILLENNIUM DEVELOPMENT GOALS

The Millennium Development Goal (MDG) water indicator, which is the total freshwater withdrawal as a percentage of total renewable freshwater resources, reflects the overall anthropogenic pressure on freshwater resources. In many areas, water use is unsustainable: withdrawal exceeds recharge rates and the water bodies are overexploited. The depletion of water resources can have a negative impact on aquatic ecosystems and, at the same time, undermine the basis for socio-economic development.

When relating freshwater withdrawal to the renewable water resources in the Middle East region, the Arabian Peninsula stands out with values over 100 percent in all the countries, except Oman, indicating that more water is withdrawn than the quantity annually renewed on a long-term basis, thus depleting the freshwater resources and using fossil groundwater. At country level, Kuwait has by far the highest water indicator, 2 075 percent, meaning that large use is made of fossil groundwater (Table 12 and Table 46). The United Arab Emirates and Saudi Arabia follow, with 1 867 percent and 936 percent respectively. In contrast, freshwater withdrawal in Oman represents 84 percent of renewable water resources (Figure 18).

TABLE 12
MDG* Water Indicator by country

Country	Freshwater withdrawal	Total actual renewable freshwater resources	MDG Water Indicator
	Total	TARWR**	Total freshwater withdrawal as percentage of TARWR
	million m^3	million m^3	%
Armenia	2 827	7 769	36
Azerbaijan	12 050	34 675	35
Bahrain	239	116	206
Georgia	1 621	63 330	3
Iran	93 100	137 515	68
Iraq	64 493	75 610	85
Israel	1 552	1 780	87
Jordan	848	937	90
Kuwait	415	20	2 075
Lebanon	1 096	4 503	24
Occupied Palestinian Territory	408	837	49
Gaza Strip	123	71	173
West Bank	157	766	21
Oman	1 175	1 400	84
Qatar	221	58	381
Saudi Arabia	22 467	2 400	936
Syrian Arab Republic	13 894	16 797	83
Turkey	39 100	213 562	18
United Arab Emirates	2 800	150	1 867
Yemen	3 384	2 100	161

* MDG - Millennium Development Goals
** TARWR – Total Actual Renewable Water Resources

TABLE 13
Evaporation losses from artificial reservoirs

Country	(Large) Dam capacity (km^3)	Reservoir surface area (km^2)	Evaporation of open water body (mm/year)	Evaporation losses from reservoirs (km^3/year)
Armenia	1.4	112	620	0.07
Azerbaijan	21.5	979	690	0.68
Georgia	3.4	383	590	0.22
Iran	31.6	1 167	1 050	1.22
Iraq	118.5	4 359	1 410	6.15
Turkey	157.0	9 926	720	7.15
Total	**333.4**			**15.49**
Total region	**870.0**			

In other areas of the Middle East region the percentage of use of renewable water resources is lower, with total freshwater withdrawal amounting to less than 100 percent of renewable water resources in most of the countries. Only in the Gaza Strip does withdrawal reach 173 percent of the total renewable water resources. The countries in which water withdrawal represents the smallest proportion of total renewable water resources are Lebanon, Turkey and Georgia, with values of 24 percent, 18 percent and 3 percent respectively.

EVAPORATION LOSSES FROM ARTIFICIAL RESERVOIRS

For six countries information on surface areas of the reservoirs behind the dams is available: Armenia, Azerbaijan, Georgia, Iran, Iraq (partial) and Turkey. Using, for each of these countries, an estimate for evaporation from open water bodies, the total annual evaporation losses from these reservoirs amounts to about 15.5 km^3 (Table 13).

However, these data should be looked at with caution and a more in-depth study would be necessary to confirm and complete the information for the whole region. Once this information is available it should be added to the sectoral (agricultural, municipal and industrial) water withdrawal figures.

Irrigation and water management

IRRIGATION POTENTIAL

Methods used by countries to estimate their irrigation potential vary, with significant influence on the results. In computing water available for irrigation, some countries only consider renewable water resources, while others, especially arid countries, include the availability of fossil or non-conventional sources of water. For this reason, comparison between countries should be made with caution. In the case of transboundary rivers, calculation by the individual countries of their irrigation potential in the same river basin may lead to double counting of part of the shared water resources. It is therefore not possible to systematically add up country figures to obtain regional estimates of irrigation potential.

Already, as shown in the previous Chapter, many countries of the Middle East region rely for a considerable part on fossil groundwater and non-conventional sources of water, or are depleting their renewable freshwater resources. For those countries any extension of existing irrigation would require more fossil groundwater or non-conventional sources of water if no improvement in water use efficiency and productivity is made.

The largest irrigation potential is concentrated in the Islamic Republic of Iran, with 5.6 million ha, based only on renewable water resources (Table 48). The Syrian Arab Republic and United Arab Emirates estimate that their irrigation potential is lower than the area equipped for irrigation at present. The reason for this may be the increasing demand for water for domestic and industrial purposes, groundwater depletion already taking place, and failure to take into account the availability of non-conventional water. They are also among the countries that have developed non-conventional sources of water. For these two countries, and those countries without data, irrigation potential is estimated as the total area equipped for irrigation, in order to be able to calculate a regional average. The irrigation potential of the Middle East region is estimated at more than 38.4 million ha, of which 76 percent corresponds to the Islamic Republic of Iran, Turkey and Iraq. The Caucasus countries account for 12 percent of the total irrigation potential of the Middle East region, whereas the Arabian Peninsula countries represent barely 7 percent.

Arid countries, where no agriculture is possible without irrigation, tend to consider the cultivable area as the potential irrigation area, for the development of which they would certainly have to rely on the use of fossil groundwater and non-conventional sources of water.

TYPOLOGY OF IRRIGATION AND WATER MANAGEMENT

Depending on the subregions, irrigation is seen as a necessary technique without which agricultural production would be practically impossible in dry countries, or as a means to increase productivity and cropping intensity and to favour crop diversification in the most humid countries.

The total area where water other than direct rainfall is used for agricultural production has been named “area under water management”. The term “irrigation” refers to areas equipped to supply water to crops. Table 47 and Table 48 present the distribution by country of these areas under water management, making a distinction between areas under irrigation, which is the sum of full/partial control irrigation areas, spate irrigation areas, and equipped lowlands (wetlands, inland valley bottoms and flood recession areas) and areas under other forms of water management, which are non-equipped lowlands (wetlands, inland valley bottoms and flood recession cropping areas). The distinction between irrigation and water management is sometimes difficult. In particular, the demarcation between equipped and non-equipped lowland areas is often vague, and for that reason only one figure for non-equipped flood recession cropping area has been provided in the region, by the Islamic Republic of Iran.

The total area equipped for irrigation covers more than 23.3 million ha in the Middle East region, but the geographical distribution is very uneven, both from subregion to subregion and from country to country (Table 14, Figure 19 and Figure 20). More than 71 percent of the area equipped for irrigation is concentrated in the Islamic Republic of Iran (35 percent), in Turkey (21 percent) and in Iraq (15 percent). Within the Arabian Peninsula, Saudi Arabia has the largest area equipped for irrigation, accounting for 7 percent of the total area of the Middle East region, followed by Yemen which represents 3 percent. Finally, the Caucasus countries have 9 percent of the area equipped for irrigation, which is a high value taking into account that their total area is only 3 percent of the Middle East region.

Spate irrigation is typical of dry countries. In this survey only a figure for Yemen has been provided, amounting to 217 541 ha (Table 15 and Table 47). Equipped lowlands are frequent in countries with more renewable freshwater resources, such as Georgia and Turkey, amounting to 31 500 ha and 13 000 ha respectively. However, the figure for Yemen also is 7 799 ha.

Full/partial control irrigation, which covers 23.1 million ha, is by far the most widespread form of irrigation in the Middle East region. It accounts for 98.9 percent of the area equipped for irrigation, of which 71 percent is concentrated in three countries (the Islamic Republic of Iran, Iraq and Turkey).

Irrigation is practiced on 36 percent of the total cultivated area of the region (Table 15 and Figure 21). This percentage is much higher in the Arabian Peninsula, 99 percent, because of the fact that it is only in Yemen that rainfed crops can be cultivated. In the other countries of the Arabian Peninsula farming would be impossible without irrigation.

TABLE 14
Regional distribution of areas under water management

Subregion	Area equipped for irrigation		Non-equipped cultivated lowlands	Total area under water management
	ha	% of Middle East	ha	ha
Arabian Peninsula	2 719 867	12	-	2 719 867
Caucasus	2 132 320	9	-	2 132 320
Iran (Islamic Republic of)	8 131 564	35	10 000	8 141 564
Near East	10 364 960	44	-	10 364 960
Total region	**23 348 711**	**100**	**10 000**	**23 358 711**

TABLE 15
Regional distribution of irrigated areas

Subregion	Equipped for full/partial control irrigation	Spate irrigation	Equipped lowlands	Total area equipped for irrigation		
				Area	% of Middle East	% of cultivated area
	(ha)	(ha)	(ha)	(ha)	(%)	(%)
Arabian Peninsula	2 494 527	217 541	7 799	2 719 867	12	99
Caucasus	2 100 820	-	31 500	2 132 320	9	58
Iran (Islamic Republic of)	8 131 564	-	-	8 131 564	35	45
Near East	10 351 960	-	13 000	10 364 960	44	26
Total region	**23 078 871**	**217 541**	**52 299**	**23 348 711**		
% of area equipped	**98.9**	**0.9**	**0.2**	**100**	**100**	**36**

TABLE 16
Regional distribution of full/partial control irrigation techniques

Subregion	Surface irrigation		Sprinkler irrigation		Localized irrigation		Total
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
Arabian Peninsula	1 215 747	48.7	1 042 227	41.8	236 553	9.5	2 494 527
Caucasus	1 894 892	90.2	174 000	8.3	31 928	1.5	2 100 820
Iran (Islamic Republic of)	7 431 564	91.4	280 000	3.4	420 000	5.2	8 131 564
Near East	9 435 860	91.2	510 750	4.9	405 350	3.9	10 351 960
Total region	**19 978 063**	**86.6**	**2 006 977**	**8.7**	**1 093 831**	**4.7**	**23 078 871**

FULL/PARTIAL CONTROL IRRIGATION TECHNIQUES

Table 16 presents the subregional distribution of irrigation techniques used on areas under full/partial control irrigation. For countries where techniques were described in the previous publication and where no new data are available, this report uses the earlier values for the analysis in Table 16, and includes the difference between the total area of the previous survey and of the present survey under surface irrigation. Table 49, however, provides the exact data available by country and the year to which they refer. As shown in Table 16, surface irrigation, which accounts for 86 percent of the irrigation techniques, greatly exceeds pressurized irrigation techniques, which are sprinkler irrigation (9 percent) and localized irrigation (5 percent).

Pressurized irrigation techniques are concentrated mainly in the Arabian Peninsula where sprinkler and localized irrigation are practised on over half of the area. This region is dry but it also contains some of the most advanced countries in the use of these techniques. For example, localized irrigation in the United Arab Emirates represents 86 percent and sprinkler irrigation in Saudi Arabia represents 60 percent of the irrigation techniques in the country. However, in the Arabian Peninsula, surface irrigation also still is practised on almost half of the area. In fact in all countries, except Saudi Arabia and the United Arab Emirates, it is practised on more than three-quarters of the area and in Yemen it is almost the only technique used. In the Caucasus, the area under surface irrigation accounts for around 90 percent of the area equipped for full or partial control irrigation, sprinkler irrigation represents 8 percent and localized irrigation 2 percent. In Iraq almost the entire area is under surface irrigation, while in the Islamic Republic of Iran, the Syrian Arab Republic and Turkey surface irrigation accounts for around 90 percent of the irrigation techniques. In Jordan localized irrigation represents 81 percent, and in Lebanon sprinkler irrigation represents almost 30 percent and localized irrigation 9 percent of the irrigation techniques.

ORIGIN OF WATER IN FULL/PARTIAL CONTROL IRRIGATION

Table 17 presents available data concerning the origin of irrigation water in the areas under full/partial control irrigation: surface water, groundwater, mix of surface water and groundwater, and non-conventional sources of water. Data are available for all countries, except Israel. For the purpose of the analysis in Table 17, it was assumed that 50 percent of the area in Israel was irrigated with surface water and 50 percent with groundwater. Finally, for the earlier data, the percentages for each of the sources were retained and applied to the areas under full/partial control at present. Therefore, these values are in order of magnitude only and are not an exact reflection of the real situation. However, it seemed worth attempting to complete the data based on the field knowledge of the AQUASTAT team in order to form a more precise picture of the sources of water used for irrigation in the Middle East region. In Table 50, however, the exact information as available is given for all countries.

With respect to “other sources of water”, Lebanon and the Syrian Arab Republic use a mix of surface water and groundwater, while Bahrain, Jordan, Kuwait, Qatar, Saudi Arabia and Turkey have started using non-conventional sources of water to

TABLE 17

Regional distribution of the origin of water used in full/partial control irrigation

Subregion	Surface water		Groundwater		Other sources				Total
	Area	% of total	Area	% of total	Mix of surface water and groundwater		Non-conventional sources of water		Area
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
Arabian Peninsula	0	0.0	2 439 485	97.8	0	0.0	55 043	2.2	2 494 527
Caucasus	2 004 470	95.4	96 350	4.8	0	0.0	0	0.0	2 100 820
Iran (Islamic Republic of)	3 078 054	37.9	5 053 510	62.1	0	0.0	0	0.0	8 131 564
Near East	7 402 927	71.5	2 181 448	21.1	604 400	0.3	163 185	7.1	10 351 960
Total region	**12 485 451**	**54.1**	**9 770 793**	**42.4**	**604 400**	**0.1**	**218 228**	**3.4**	**23 078 871**

increase their resources (Tables 17 and 50). Kuwait accounts for the highest percentage of non-conventional sources, with 39 percent.

Surface water is the main source of water for irrigation in the Middle East region as a whole (54 percent), since countries such as Turkey and Iraq, which have large areas under irrigation, irrigate mainly with surface water (78 percent and 94 percent respectively), mainly coming from the Euphrates–Tigris Basin. In the Caucasus countries, surface water accounts on average for 94 percent of the area equipped for irrigation and comes mainly from the Kura–Araks Basin. In this subregion non-conventional sources of water are not used since it is not as dry as in the other subregions. In contrast, the Arabian Peninsula has no area irrigated by surface water and the Islamic Republic of Iran, Jordan and the Occupied Palestinian Territory feed their irrigation systems mainly with groundwater.

SCHEME SIZES

The definition of large schemes varies from one country to another. While certain countries, such as Bahrain, the Islamic Republic of Iran and Oman, consider a scheme of 50 ha to be large, other countries, such as Georgia, Jordan, Lebanon and Turkey use a minimum area of 1 000 ha for a scheme to be classified large. Azerbaijan even considers large schemes those over 20 000 ha. The Arabian Peninsula schemes are the smallest ones, since Qatar and Saudi Arabia consider a scheme of 100 ha and 200 ha respectively to be large (Table 18).

Rather than by its size, a scheme is often described by its type of management: small private farms, commercial farms, communal schemes or public schemes.

Table 18 shows the scheme sizes in several countries and the criteria used. If no recent information on scheme sizes is available, the information of the previous survey is used, as is the case for Azerbaijan, Bahrain, Saudi Arabia and Turkey.

TABLE 18

Scheme sizes in some countries

Country	Year	Criteria	Small	Medium	Large	Total area
		ha	ha	ha	ha	
Armenia	2006	200	55 697	-	217 863	273 560
Azerbaijan	1995	10 000–20 000	77 420	192 600	1 183 000	1 453 020
Bahrain	1994	50	2 885	-	280	3 215
Georgia	2007	500–1 000	103 770	90 350	207 170	401 290
Iran (Islamic Republic of)	2003	10–50	4 000 000	3 281 564	850 000	8 131 564
Jordan	2004	100–1 000	37 500	6 000	35 360	78 860
Lebanon	2000	100–1 000	24 400	22 070	43 530	90 000
Oman	2004	2 - 8	23 456	22 548	12 846	58 850
Qatar	2001	20–100	1 703	5 272	5 960	12 935
Saudi Arabia	1992	5–200	450 000	730 000	428 000	1 608 000
Turkey	1994	1 000	2 265 360	-	1 805 390	4 070 750

Cultivation in full/partial control irrigation schemes

LEVEL OF USE OF AREAS EQUIPPED FOR FULL/PARTIAL CONTROL IRRIGATION

It is difficult to calculate the areas actually irrigated for the Middle East region as a whole because information is missing for most of the countries in both AQUASTAT surveys. Where a country did not have new data, those of the previous survey are used. Given that data about actually irrigated areas are available for only 7 out of the 18 countries, Table 19 focuses on these countries.

Use rates vary considerably among those the countries providing such data. In Bahrain and Yemen the total area equipped for full or partial control irrigation is actually irrigated. Jordan has a rate exceeding 90 percent and Turkey a rate of 87 percent. Armenia and Saudi Arabia have use rates lower than 70 percent and Qatar even has a use rate of only 49 percent. In numerous cases, low rates are explained by deterioration of the infrastructure owing to a lack of maintenance (caused by a lack of experience or the use of non-adapted techniques) or political and economic reasons. Other causes are: inadequate management of technical means of production under irrigation, soil impoverishment, local instability and insecurity, and the reduction of public funds allocated to irrigation.

CROPPING INTENSITY

Cropping intensity, another indicator of the use of equipped areas, is calculated based on the area actually irrigated in full or partial control irrigation for the 7 countries for which that information is available. For the other 11 countries, it is estimated equal to the area equipped for full or partial control irrigation. Thus cropping intensity is probably underestimated because the area actually irrigated might be smaller than equipped area in several of these 11 countries. The calculation only refers to irrigated crops. This means that in a country with one or two wet seasons only the crops grown under irrigation are taken into consideration. The crops grown on the full/partial control equipped area during the wet season without irrigation (but using the residual soil humidity) are not included in the irrigated crop area when calculating cropping intensity.

National cropping intensity ranges from 31 percent in Georgia to 138 percent in Jordan (Table 51). In the Islamic Republic of Iran and the Arabian Peninsula cropping intensity is 106 and 105 percent respectively (Table 20). In the Near East and the Caucasus subregions it amounts to 87 and 85 percent respectively.

Table 21 shows the cropping intensity for those countries where the area effectively irrigated is available and therefore it is easier to evaluate the real situation. As shown, figures range from 100 percent, meaning that one crop per year is irrigated, to 138 percent in Jordan.

The calculation of cropping intensity is straightforward for dry countries because irrigation is indispensable for the growing of

TABLE 19
Distribution of actually irrigated areas in some countries

Country	Area equipped for full/partial control irrigation	Actually irrigated	
		Area	% of equipped areas
	(ha)	(ha)	(%)
Armenia	273 530	176 000	64
Bahrain	4 015	4 015	100
Jordan	78 860	72 009	91
Qatar	12 935	6 322	49
Saudi Arabia	1 730 767	1 191 351	69
Turkey	4 970 000	4 320 000	87
Yemen	454 310	454 310	100

TABLE 20
Cropping intensity over area actually irrigated

Subregion	Area equipped for full/partial control irrigation	Area actually irrigated in full/partial control irrigation	% of equipped areas	Harvested irrigated crop areas	Cropping intensity
	(ha)	(ha)	(%)	(ha)	(%)
	(1)	(2)	(3) = 100 * (2)/(1)	(4)	= 100 × (4)/(2)
Arabian Peninsula	2 494 527	1 948 498	78	2 055 644	105
Caucasus	2 100 820	2 003 290	95	1 693 581	85
Iran (Islamic Republic of)	8 131 564	8 131 564	100	8 592 544	106
Near East	10 351 960	9 691 182	94	8 386 858	87
Total region	**23 078 871**	**21 774 534**	**94**	**20 728 627**	**95**

TABLE 21
Cropping intensity over area actually irrigated in some countries

Country	Area equipped for full/partial control irrigation	Area actually irrigated in full/partial control irrigation	Harvested irrigated crop areas	Cropping intensity
	(ha)	(ha)	(ha)	(%)
	(1)	(2)	(3)	= 100 × (3)/(2)
Armenia	273 530	176 000	176 000	100
Bahrain	4 015	4 015	4 015	100
Jordan	78 860	72 009	99 029	138
Qatar	12 935	6 322	6 928	110
Saudi Arabia	1 730 767	1 191 351	1 204 958	101
Turkey	4 860 800	4 320 000	4 206 000	100
Yemen	454 310	454 310	527 038	116

crops in all seasons. However, the calculation is more problematic for countries with one or more wet seasons. For two crop cycles a year, only one is irrigated (during the dry season), the second uses soil moisture provided by the precipitation. Therefore, the cropping intensity (irrigated crops only) is 100 percent on the area considered, while the harvested area is double.

IRRIGATED CROPS IN FULL/PARTIAL CONTROL SCHEMES

Table 22 shows the subregional distribution of irrigated crops for those countries and territories that have provided such information. The equipped areas with several crop cycles a year are counted several times, which explains why the total is superior to the physically equipped areas or physically actually irrigated areas in some countries (Table 51). This also gives an idea of the cropping intensity under irrigation (see below). Georgia is included in the total irrigated crops area, but it is not in the distribution of each crop because there is no data available.

Cereals represent 44 percent of the harvested irrigated crop area, of which wheat constitutes 60 percent. The group of vegetables, roots and tubers, and pulses are the second most widespread crop, representing 16 percent. Irrigated fodder follows with 9 percent, and cotton represents 6 percent of the harvested irrigated crop area. Permanent crops account for 15 percent.

In the Arabian Peninsula, cereals and perennial crops are the dominant crops, representing 39 percent and 31 percent respectively, followed by fodder which accounts for 15 percent. The United Arab Emirates has the largest area of perennial crops (mainly dates) at 82 percent of the total irrigated crops area of the country. In Oman and Bahrain perennial crops represent 58 and 55 percent respectively. In the Caucasus countries, perennial crops only account for 10 percent on average, whereas cereals represent 55 percent and vegetables 12 percent. In the Islamic Republic of Iran, Turkey and Iraq, the countries with the largest irrigated crop area, cereals account for 48, 21 and 70 percent respectively. In the Islamic Republic of Iran and in Turkey,

TABLE 22
Regional distribution of irrigated crops under full/partial control irrigation

Subregion	Wheat	Barley	Maize	Rice	Cereals not specified	Vegetables, roots and tubers and pulses	Fodder	Cotton	Fruit trees	Annual crops not specified	Permanent crops not specified	Total
						(1 000 ha)						
Arabian Peninsula	532.79	36. 78	31.45	0.00	206.73	247.43	300.02	17.25	34.75	55.23	592.80	2 055.23
	(26%)	(2%)	(2%)	(0%)	(10%)	(12%)	(15%)	(1%)	(2%)	(3%)	(29%)	(100%)
Caucasus*	645.92	164.81	36.294	2.57	9.30	195.65	26.00	78.16	0.00	256.510	152.31	1 693.58
	(41%)	(11%)	(2%)	(0.2%)	(1%)	(12%)	(2%)	(5%)	(0%)	(16%)	(10%)	(100%)
Iran (Islamic Republic of)	2 634.11	607.49	275.94	628.11	0.07	1 111.03	878.18	143.23	216.24	1 044.14	1 054.03	8 592.55
	(31%)	(7%)	(3%)	(7%)	(0%)	(13%)	(10%)	(2%)	(3%)	(12%)	(12%)	(100%)
Near East	1 602.09	876.82	608.49	197.00	7.06	1 765.01	575.97	929.29	272.89	848.23	704.01	8 386.86
	(19%)	(10%)	(7%)	(2%)	(0%)	(21%)	(7%)	(11%)	(3%)	(10%)	(8%)	(100%)
Total region*	**5 414.90**	**1 685.89**	**952.18**	**827.68**	**223.16**	**3 319.12**	**1 780.18**	**1 167.93**	**523.87**	**2 204.11**	**2 503.15**	**20 728.22**
	(26%)	**(8%)**	**(5%)**	**(4%)**	**(1%)**	**(16%)**	**(9%)**	**(6%)**	**(3%)**	**(11%)**	**(12%)**	**(100%)**

* Georgia is not included in the distribution of crops because there is no available data, but it is included in the total for the region.

irrigated fodder represents around 10 percent. In the Islamic Republic of Iran, Turkey and Saudi Arabia it accounts for 49, 27 and 12 percent respectively of the total area under this crop in the Middle East.

The Islamic Republic of Iran has 76 percent of the area under rice in the Middle East, followed by Iraq with 15 percent. In Turkey vegetables (including roots and tubers) account for 23 percent. Turkey and the Islamic Republic of Iran have 35 percent and 34 percent respectively of the total area of vegetables (including roots and tuber crops) in the Middle East region. Turkey and the Islamic Republic of Iran represent 53 and 33 percent of the total area of pulses, followed Yemen, which accounts for 6 percent. Cotton is the main industrial crop and covers 6 percent of the total irrigated crop area in the Middle East region. Cotton cultivation is concentrated in Turkey (55 percent), the Syrian Arab Republic (23 percent), the Islamic Republic of Iran (12 percent) and Azerbaijan (7 percent) (Table 51). Other industrial crops are sugarcane, olives and bananas. Citrus is found mainly in the Islamic Republic of Iran (50 percent), Turkey (23 percent), Iraq (15 percent) and the Syrian Arab Republic (6 percent). In Lebanon, citrus accounts for 36 percent of the total irrigated crop area of the country.

Trends in the last ten years

During the previous survey the population of the Middle East region was 236 million, slightly more than 4.1 percent of the world's population. At present it is 283 million, or about 4.4 percent of the world's population. Population density has risen from 41 to 43 inhabitants/km^2. The annual rate of population growth over the last ten years is 1.8 percent, a sharp decrease from the 3.1 percent/year for 1984–1994. While ten years ago about 36 percent of the population in the Middle East region lived in a rural environment, at present it is 34 percent (Table 2 and Table 43). This indicates that there is low migration towards cities.

WATER WITHDRAWAL BY SECTOR

On a sectoral basis, the proportions of water withdrawal have changed only slightly: agricultural water withdrawal has decreased by 2 percent, while municipal and industrial withdrawals have increased by 1 percent each. However, total water withdrawal has grown by 29 percent over the last ten years (Table 23).

Between the two survey dates, withdrawal per inhabitant has also increased (by 72 m^3). This growth is due to a per capita increase in the Islamic Republic of Iran and in the Near East subregion of 301 and 87 m^3 respectively, while in the Arabian Peninsula Region and in the Caucasus subregion withdrawal per inhabitant has decreased by 22 and 380 m^3 respectively.

Looking at the municipal sector, water withdrawal per capita has increased from 74 m^3/year, or 203 litres/day, to 89 m^3/year, or 316 litres/day. There is quite some variation between the subregions and countries. In the Arabian Peninsula subregion it has increased from 67 to 69 m^3/year, while in the Near East subregion there has been an increase from 71 to 96 m^3/year. However, in the Caucasus subregion it has decreased from 148 to 108 m^3/year. Qatar and Iraq have the largest increases, from 120 to 214 m^3/year and from 63 to 149 m^3/year respectively, while the United Arab Emirates has the largest decrease, from 263 to 137 m^3/year. Moreover, in Georgia, Azerbaijan and Lebanon water withdrawal per capita has decreased by 65, 38 and 16 m^3/year respectively.

In agriculture, the annual water withdrawal per hectare of area equipped for irrigation seems to have increased from 8 650 m^3 to 9 700 m^3. The reason for this is not fully clear. It could be a result of data quality or changed cropping pattern. In the

TABLE 23
Trends in water withdrawal by sector

Subregion	Year	Annual water withdrawal by sector								
		Agriculture		Municipal		Industry		Total		
		km^3	% of total	km^3	% of total	km^3	% of total	km^3	% of Middle East	m^3 per inhabitant
Arabian Peninsula	1997	21.2	87	2.6	11	0.5	2	24.3	12	622
	2007	29.3	86	3.9	11	0.9	3	34.1	13	600
Caucasus	1997	15.6	68	2.4	10	4.9	22	22.9	11	1 428
	2007	12.2	73	1.7	10	2.7	16	16.7	6	1 048
Iran (Islamic Republic of)	1997	64.2	92	4.4	6	1.5	2	70.0	33	1 041
	2007	86.0	92	6.2	7	1.1	1	93.3	34	1 342
Near East	1997	78.7	85	8.1	9	6.1	7	92.9	44	818
	2007	99.0	78	13.5	11	14.9	12	127.4	47	905
Total region	**1997**	**179.7**	**86**	**17.5**	**8**	**13.0**	**6**	**210.2**	**100**	**891**
	2007	**226.5**	**84**	**25.3**	**9**	**19.6**	**7**	**271.5**	**100**	**963**

Near East subregion it has gone from 8 678 m^3 to 9 549 m^3, in the Islamic Republic of Iran from 8 832 m^3 to 10 576 m^3 and in the Arabian Peninsula subregion from 9 487 m^3 to 10 765 m^3. However, in the Caucasus subregion it has decreased from 7 072 m^3 to 5 742 m^3. In Iraq it has increased from 11 172 m^3 to 14 752 m^3 while in the United Arab Emirates it has decreased from 21 115 m^3 to 14 616 m^3. These data should be used with caution since, as mentioned above, the reason for the general increase is not fully clear.

WATER WITHDRAWAL BY SOURCE

For the Middle East region as a whole, annual freshwater withdrawal has increased from 206 km^3 to 262 km^3, which represents an annual increase rate of 2.4 percent (Table 24). Desalinated water has doubled from 1.5 km^3 to 3.2 km^3, equal to an annual increase of 7.6 percent, and reused treated wastewater has increased in volume at an annual rate of 12 percent, from 2.4 to 6.6 km^3. This shows the necessity of using non-conventional sources of water in the Middle East region. However, freshwater remains by far the most important source, accounting for 96 percent of the total and decreasing by only two points from 98 percent in 1997.

The countries with data on non-conventional sources of water are practically the same as in the previous survey, with all of them increasing the quantity of water withdrawn. In 2007 Iraq and Lebanon report using desalinated water, while in 1997 no data was available. In the same year Azerbaijan, Israel and Turkey report using treated wastewater, while in 1997 there was no data available. Iraq, Lebanon and the Syrian Arab Republic report using agricultural drainage water. On a subregional level, the Arabian Peninsula Region now desalinates 1 303 million m^3 more than in 1997. In particular, the United Arab Emirates and Saudi Arabia have increased annual desalinated water use by 565 and 319 million m^3 respectively. In the Caucasus, total withdrawal has decreased from last survey, mainly due to a decrease in the actually irrigated area. Reused treated wastewater accounts for 161 million m^3 in this subregion compared with 0 in 1997. In the Near East subregion withdrawal has increased for both freshwater and non-conventional sources of water, especially reused treated wastewater and agricultural drainage water, which are up from 2 percent to 4.6 percent of the total withdrawals of this region. However, some caution is needed here. Reused agricultural drainage water is reported only in 2007 by Lebanon and the Syrian Arab

TABLE 24
Trends in water withdrawal by source

Subregion	Year	Annual withdrawal by source						
		Freshwater		Non-conventional sources of water				Total water withdrawal
		Total		Desalinated water		Reused treated wastewater and agricultural drainage water**		
		Million m^3	% of total	Million m^3	% of total	Million m^3	% of total	Million m^3
Arabian Peninsula	1997	22 390	92.0	1 517	6.2	436	1.8	24 343
	2007	30 701	90.0	2 805	8.2	594	1.8	34 100
Caucasus	1997	22 926	100.0	0	0.0	0	0.0	22 926
	2007	16 498	99.0	0	0.0	161	1.0	16 659
Iran (Islamic Republic of)	1997	70 031	100.0	3	0.0	0	0.0	70 034
	2007	93 100	99.8	200	0.2	0	0.0	93 300
Near East*	1997	90 917	97.9	28	0.0	1 922	2.1	92 867
	2007	121 389	95.3	205	0.2	5 818	4.6	127 413
Total region	**1997**	**206 264**	**98.2**	**1 548**	**0.7**	**2 359**	**1.1**	**210 170**
	2007	**261 688**	**96.4**	**3 210**	**1.2**	**6 574**	**2.4**	**271 472**

*In 2007 only three countries in the Near East subregion provided data for reused agricultural drainage water amounting to 3 911 million m^3 in total (see Table 11 in Chapter 9), which represents 3 percent of the withdrawal in the Near East subregion and 1.4 percent in the Middle East region. In 1997 only Iraq provided this data (1 500 million m^3).

*The Occupied Palestinian Territory is not included in figures for 1997 because there is no available data.

Republic. This does not mean that it was equal to 0 in the previous survey just that no data were available at that time.

AREAS UNDER IRRIGATION

Table 25 presents the trends in the area under irrigation during the last ten years. It should be taken into account that the information for some of the countries is for earlier years as new data was not provided (Table 47).

For the Middle East region, the increase in the equipped area is 12 percent, which is equal to an annual rate of 1.31 percent using a weighted year index. The weighted year index is calculated by allocating to the year for each country a weighting coefficient proportional to its area equipped for irrigation, therefore giving more importance to countries with the largest areas under irrigation.

The area under full or partial control irrigation has an annual rate of increase of 1.35 percent, which is a little higher than the annual rate for total irrigation. This is explained by the fact that the area of spate irrigation has not increased as much as the area of full or partial control irrigation and also because equipped lowlands area have decreased since 1997.

The Arabian Peninsula has an annual rate of increase of more than 2.2 percent. The rate for the United Arab Emirates is 13 percent, the largest increase in equipped areas in the Middle East region. However, this could also be explained by the reclassification of areas previously indicated as non-equipped, which have been counted as equipped areas this time because of better knowledge of the field situation. Other countries in the Arabian Peninsula, such as Kuwait, Bahrain and Yemen, have shown annual rates of increase of 4 percent, while the annual increase in Saudi Arabia and Qatar is close to zero. Oman has recorded a drop in the areas equipped for irrigation, with an annual rate of –0.4 percent.

The Caucasus is the only subregion where the area under irrigation has not increased. The rate of abandonment of full or partial control irrigation area has been almost 0.4 percent per year in this period (–0.7 percent in Georgia, –0.4 percent in Armenia and –0.2 percent in Azerbaijan). Reasons are civil strife, war, vandalism and theft, as well as problems associated with land reform, the transition to a market economy, and the loss of markets with traditional trading partners, high pumping costs, which all have contributed to the widespread deterioration of the irrigation conveyance systems.

In the Near East subregion the annual increase rate is 1.7 percent. The Syrian Arab Republic has an annual rate of increase of around 4 percent; while in Lebanon it is close

TABLE 25
Regional trends in the areas under irrigation

Subregion	Year	Irrigation (ha)				
		Full/partial control irrigation	Spate irrigation	Equipped lowlands	Total irrigation	Annual increase
		(1)	(2)	(3)	(4) = (1) + (2) + (3)	%
Arabian Peninsula	1997	2 139 887	98 320	-	2 238 207	2.2
	2007	2 494 527	217 541	7 799	2 719 867	
Caucasus	1997	2 176 467	-	31 500	2 207 967	–0.4
	2007	2 100 820	-	31 500	2 132 320	
Iran (Islamic Republic of)	1997	7 264 194		-	7 264 194	1.1
	2007	8 131 564	-	-	8 131 564	
Near East	1997	8 974 819	-	115 164	9 089 983	1.7
	2007	10 351 960	-	13 000	10 364 960	
Total region	**1997**	**20 555 237**	**98 320**	**146 664**	**20 800 351**	**1.3**
	2007	**23 078 871**	**217 541**	**52 299**	**23 348 711**	
Change		+2 523 634	+119 221	- 94 365	+2 548 360	

to zero. Jordan has shown a drop in areas equipped for irrigation, at an annual rate of –0.9 percent.

Spate irrigation has increased in area by 0.1 million ha (121 percent), all in Yemen, which is the only country in the region reporting information on spate irrigation. The area of equipped lowlands has decreased by 94 365 ha. This may be due to the fact that in Turkey this area was previously included in the category of equipped lowlands but is now considered to be equipped for full/partial control irrigation, probably due to improved infrastructure.

IRRIGATION TECHNIQUES

Table 26 presents the trends in irrigation techniques. To facilitate the comparison between 1997 and 2007, data has been estimated for Kuwait, Qatar and Saudi Arabia, taking into account either the previous survey or the current survey. Iraq, Israel and the Occupied Palestinian Territory are not included in the Near East subregional figures as data was not obtained for these countries in both the previous and the present survey. Therefore, it should be considered that the real area is larger than the total presented below, for every technique.

The area under surface irrigation, the most important technique, has increased by 1.4 million ha (9 percent). However, in all subregions except the Caucasus, the relative importance of surface irrigation has decreased. Sprinkler irrigation has increased by 0.3 million, which represents a growth rate of 18 percent for this technique. While its relative importance has become less in the Arabian Peninsula and the Caucasus, it has grown especially in the Islamic Republic of Iran and the Near East subregion. Localized irrigation, which is the technique that requires less water, has increased in area by 0.7 million ha, representing a growth rate of 424 percent during the ten years. Its relative importance has increased in all subregions. It is developing most, however, in the Arabian Peninsula, where the percentage compared with the other techniques has increased from 3.5 to 10 percent; the Islamic Republic of Iran and the Near East follow with increases from 0.6 to 5.2 percent and from 1.0 to 3.5 percent respectively. These regions include the driest countries in the world, but are also among the more developed regions, two factors favouring the adoption of these techniques.

IRRIGATED CROPS

The main change in the last ten years has been a decrease in wheat-growing areas and their proportion in the whole area under full/partial control irrigation. This reduction has occurred mainly because of the increase in other cereals, especially barley but also maize and rice. Irrigated cereals as a percentage of total irrigated crops have decreased

TABLE 26
Regional trends in the irrigation techniques on the full/partial control irrigation areas

Subregion	Year	Surface irrigation		Sprinkler irrigation		Localized irrigation		Total
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
Arabian Peninsula	1997	1 027 876	48.0	1 037 281	48.5	75 145	3.5	2 140 302
	2007	1 097 000	46.0	1 042 227	44.0	236 553	10.0	2 369 480
Caucasus	1997	1 926 249	88.5	247 400	11.4	2 818	0.1	2 176 467
	2007	1 922 210	90.3	174 000	8.2	31 928	1.5	2 128 138
Iran (Islamic Republic of)	1997	7 173 494	98.8	47 200	0.6	43 500	0.6	7 264 194
	2007	7 431 564	91.4	280 000	3.4	420 000	5.2	8 131 564
Near East*	1997	4 861 584	92.9	320 549	6.1	53 686	1.0	5 235 819
	2007	5 894 860	89.6	454 500	6.9	228 600	3.5	6 577 960
Total region*	**1997**	**14 989 203**	**89.1**	**1 652 430**	**9.8**	**175 149**	**1.1**	**16 816 782**
	2007	**16 339 334**	**85.0**	**1 950 727**	**10.2**	**917 081**	**4.8**	**19 207 141**
Change		+1 350 131	+9	+298 297	+18	+741932	+424	+2 390 359

* Iraq, Israel and the Occupied Palestinian Territory are not included

from 60 percent in 1997 to 44 percent in 2007. The area under permanent crops has increased from 6 to 15 percent, indicating that a higher percentage of irrigated area is dedicated to these crops. The area under vegetables and cotton has also increased, while the area under fodder has decreased from 11 percent to 9 percent. These statistics must be considered with caution as Israel and the Occupied Palestinian Territory were not included in the previous survey and therefore old data are not available.

USE RATE OF AREAS EQUIPPED FOR IRRIGATION

Amongst the five countries for which information is available, i.e. Armenia, Bahrain, Qatar, Saudi Arabia and Turkey, three have seen their rate of use for equipped areas improve in the last ten years, in two it has decreased, and in one it has remained the same. Areas actually irrigated in Armenia have increased from 60 percent of equipped areas in 1995 to 64 percent in 2006, while there has been a small decrease in equipped areas. The same holds for Turkey, where areas have increased from 74 to 87 percent between 1994 and 2006. Conversely, two countries have experienced a reduction in the use of their irrigation systems. In Qatar, the area actually irrigated has declined from 66 percent in 1993 to 47 percent in 2004, for almost the same equipped areas. In Saudi Arabia the use rate has fallen from 100 percent to 69 percent between 1992 and 1999, for a slight increase in equipped area. In Bahrain, the area actually irrigated represented 100 percent of the equipped areas in 1994 and in 2000. While a more extensive use of equipped areas in the first two countries can be explained by the rehabilitation of degraded schemes, it is often the degradation of equipment that justifies the abandonment of equipped areas in the latter group of countries.

Legislative and institutional framework of water management

In 14 out of the 18 countries of the Middle East region for which information is given, water management is generally based on a water code, on a specific water law or on several water laws. Armenia and Azerbaijan have a Water Code, signed in 2002 and 1997 respectively. A specific Water Law has been enacted in Georgia (1997), the Islamic Republic of Iran (1982), Israel (1959), Lebanon (2000), Occupied Palestinian Territory (1996) and Yemen (2002). In six other countries (Iraq, Jordan, Oman, Qatar, Saudi Arabia and the Syrian Arab Republic) certain aspects of water management such as pollution, drilling, irrigation or water rights are regulated, but these specific arrangements are not grouped in a water code. In Iraq a law on irrigation was enacted in 1995. In Jordan, laws and regulations are imposed to enable the authorities and other bodies to perform their duties in respect of water. In Oman, several decrees concerning water and irrigation have been enacted, and in Qatar a decree was issued to govern drilling of wells and use of groundwater. In Saudi Arabia various water laws are under revision and reformulation, although there are still grey areas of overlapping responsibilities regarding irrigation and the control and implementation of water reuse for irrigation. In the Syrian Arab Republic, over 140 laws that address water have been passed since 1924. No information is available for Bahrain, Kuwait, Turkey and the United Arab Emirates; however, these countries have institutions responsible for water management or water supply.

The national institutions responsible for the management and planning of irrigation development are, for a large majority of the Middle East countries (12 out of 18), departments or divisions within the Ministry of Agriculture. In Azerbaijan irrigation management depends on the State Committee of Amelioration and Water Management, in Jordan on the Ministry of Water and Irrigation and in Kuwait on the Public Authority for Agricultural Affairs and Fish Resources. In the Syrian Arab Republic there is a Ministry of Irrigation, and in Turkey the General Directorate of State Hydraulic Works (DSI) and the General Directorate of Rural Services (GDRS) are responsible for irrigation and drainage development activities.

The management and conservation of water resources are generally the responsibility of a different ministry (environment, nature protection, natural resources, energy or water resources), although in Israel it falls to the Water Commission (part of the Ministry of National Infrastructures), in the Occupied Palestinian Territory to the Palestinian Water Authority, in Qatar to the Permanent Water Resources Committee, in the Syrian Arab Republic to the Council of General Commission for Water Resource Management, and in the United Arab Emirates to the General Water Resources Authority. Municipal water supply and wastewater treatment depend in some countries on another ministry again (such as territorial administration, health, public works or housing and construction).

The management of the irrigation systems is generally performed jointly by the State, as regards the primary infrastructure or public systems, and by user associations or independent users for the secondary and tertiary infrastructure or private systems. There are countries where water user associations do not exist, such as Lebanon. In the Caucasian countries, after the Soviet period there was a disengagement of the State from the irrigation sector and subsequent creation of user associations that are now in place or in the pipeline. In Turkey, the General Directorate of State Hydraulic

Works began an Accelerated Transfer Program (ATP) in 1993, transferring irrigation systems management to users. In most of the countries surface water and groundwater are state property and the right to use either is acquired through licences. In many countries landowners have priority for water taken from a well on their land. There are exceptions such as Bahrain, where groundwater is property of the landowners.

Water tarification is used in Armenia, Azerbaijan, Israel, the Islamic Republic of Iran, Lebanon, the Syrian Arab Republic and Turkey. In Israel, urban users pay much higher rates for water than farmers, and irrigation water is subsidized, though the subsidy has declined since 1987. In the United Arab Emirates water used for agriculture is free of charge while water for municipal use, which is mostly desalinated water, is subsidized by the State. Charges on wastewater discharge exist in Azerbaijan. The government of Bahrain is planning an appropriate pricing system for excess water utilization. In Armenia, the State budget finances about 50 percent of the annually assessed operation and maintenance (O&M) requirements of the water services for irrigation. In Jordan, the funds for the public irrigation schemes and dams come from international loans and the national budget, while in the private sector irrigation projects, investors and owners pay for the full cost of construction and for the rehabilitation and the annual running O&M cost. In Kuwait, the Industrial Bank of Kuwait (IBK) is responsible for administering the "agriculture and fisheries credit portfolio", which is a fund for soft loans for investment in agriculture and fisheries. Finally, in the United Arab Emirates 50 percent of the costs of the infrastructures such as bubbler, drip and sprinkler irrigation are subsidized by the government.

Most countries are making considerable technical, policy and institutional progress within the water sector. The region manages sophisticated irrigation and drainage systems, and has spearheaded advances in desalination technology. Governments in some cities have shifted from direct provision of water supply services to regulation of services provided by independent or privately owned utilities. In some countries, farmers have begun managing irrigation infrastructure and water allocations. Some countries have established agencies to plan and manage water at the level of the river basin. To implement the new policies, most governments have established ministries that manage water resources and staffed them with well-trained and dedicated professionals. However, these efforts have not led to the expected improvements in water outcomes for several reasons. One issue is that cropping choices are a key determinant of water use in agriculture and they are affected far more by the price the farmer can get for those crops than by the price of irrigation services (World Bank, 2007).

Environment and health

In the Middle East region, surface water and groundwater quality is commonly affected by agricultural, industrial and municipal wastewater. Also, the quality of groundwater has drastically deteriorated due to over-pumping and subsequent salinization. In the Caucasus countries the largest source of pollution is municipal wastewater, which pollutes rivers downstream of large cities with organic matter, suspended solids, surfactants, etc, followed by industrial and agricultural wastewater discharges. In the Near East subregion, water quality of rivers, such as the Euphrates and Tigris, is affected by return flow from irrigation projects and municipal and industrial wastewater. Groundwater quality is decreasing because of overexploitation of aquifers and leaching of fertilizers and pesticides. Deterioration of the quality of irrigation water is increasing owing to the use of treated wastewater, particularly in drought years. In the Arabian Peninsula, groundwater availability may be further reduced due to groundwater salinization in coastal areas and groundwater pollution in urban areas and areas of intensive agriculture.

The overexploitation of aquifers (when water withdrawal exceeds water recharge) and the subsequent lowering in their levels is a problem in all the countries of the Arabian Peninsula and in the Near East, such as Israel, Jordan and the Occupied Palestinian Territory. This overexploitation is at the origin of seawater intrusion and/or the upward diffusion of deeper saline water in at least Bahrain, Gaza Strip, Israel, Oman and Qatar, which leads to a deterioration of groundwater quality. Using saline groundwater for irrigation may increase soil salinity. The use of fossil water, which is water from aquifers whose rate of renewal is very slow and which are therefore considered non-renewable, will cause depletion of the aquifers in the long term.

Scarcity of water resources, severe climatic conditions, pollution of groundwater, unsuitable cropping patterns and incorrect cultural practices lead to soil degradation and cause desertification. In addition to these factors, improper farm layouts and erroneous irrigation designs, together with poor water management, intensify the problem of desertification. Consecutive accumulation of salts year after year degrades the soils and renders them unproductive, this being regarded as the main reason for the abandonment of farms.

Arid areas are sensitive to salinization problems because the volume of rainwater dissolving the salts generated by the soil is low. By extracting water from the soil, evaporation and evapotranspiration tend to increase salt concentrations. Direct evaporation from the soil surface causes a rapid accumulation of salt in the top layers. When significant amounts of water are provided by irrigation with no adequate provision for leaching of salts, the soils rapidly become salty and unproductive. Water storage in the reservoirs, where evaporation is intense, tends to increase the salt concentration of the stored water. For all these reasons, the Middle East is a region subject to salinization, a problem that has been recognized for a long time. However, assessment of salinization at national level is a difficult enterprise and very little information on the subject could be found during the survey. Furthermore, no commonly agreed methods exist to assess the degree of irrigation-induced salinization. New figures on areas salinized by irrigation were available for only 5 of the 19 countries and territories, and for that reason figures from last survey for 6 more countries have been used (Table 27). In the near future, more information on salinization will probably become available and strategies to improve the situation should be defined, as this has been recognized as a priority by most of the Middle East countries. Considering the 11 countries which have reported figures,

TABLE 27
Salinization in irrigation areas in some countries

Country	Salinization		
	Year	ha	% of equipped area
Armenia	2006	20 415	7
Azerbaijan	2003	635 800	45
Bahrain	1994	1 065	34
Georgia	2002	113 560	26
Iran (Islamic republic of)	1993	2 100 000	29
Israel	1993	27 820	14
Jordan	1989	2 280	4
Kuwait	1994	4 080	86
Lebanon	2001	1 000	1
Syrian Arab Republic	1989	60 000	6
Turkey	2004	1 519 000	30

TABLE 28
Drainage in irrigation areas in some countries

Country	Drainage		
	Year	ha	% of equipped area
Armenia	2006	34 457	13
Azerbaijan	2003	608 336	43
Bahrain	1994	1 300	41
Georgia	1996	31 800	7
Iran (Islamic republic of)	2002	1 508 000	19
Israel	1987	100 000	52
Jordan	2005	10 506	13
Kuwait	1994	2	0
Lebanon	2001	3 000	3
Oman	2006	0	0
Saudi Arabia	2007	10 850	1
Syrian Arab Republic	1993	273 000	27
Turkey	2006	340 890	7

around 28 percent of the irrigated areas is under salinization on average. The situation is of particular concern in Kuwait, where the area salinized by irrigation exceeds 85 percent of the total equipped area for irrigation. In Azerbaijan, salinization affects 45 percent of the equipped area and in Bahrain, Turkey, and the Islamic Republic of Iran around 30 percent. In Lebanon or Jordan on the other hand the figures are only 1 and 4 percent respectively.

One of the measures needed to prevent irrigation-induced waterlogging and salinization in arid and semi-arid regions is the installation of drainage facilities. Drainage, in combination with adequate irrigation scheduling, allows for the leaching of excess salts from the plant root zone. Figures on drained areas are available for 13 of the 19 countries of which 5 are from the previous survey, since no new information could be obtained (Table 28). About 16 percent of the area equipped for irrigation in these countries has been provided with drainage facilities, varying from 0 percent in Kuwait and Oman to over 50 percent in Israel.

Only 7 out of the 19 countries of the Middle East region have reported information about water-related diseases for this survey, although these diseases are also represented in other countries of the region. The major factors favouring the development and dispersion of these diseases are as follows:

- the orientation towards the use of wastewater to meet water shortage
- lack of infrastructure, especially related to wastewater treatment and disposal
- lack of health awareness and proper handling of polluted water
- non-existence of regulations related to the protection of the environment and public health.

In Armenia, more than 1 600 persons were affected with water-related diseases in 2006 and more than 1 100 malaria cases were reported by 1998 although, owing to epidemic control interventions, the number of autochthonous malaria cases has decreased, dropping to 8 in 2003. In Georgia, the poor quality of water has resulted in several outbreaks of infectious intestinal diseases and epidemics. In Iran, water-related diseases are prevalent in some irrigated areas where the water is also used for domestic purposes, although the extent is unknown. In Jordan, contaminated water is a source of many human infections causing diarrhoea and other diseases, to which children are more exposed than adults. In Lebanon, water-related diseases, especially diarrhoea, are one of the leading causes of mortality and morbidity among children under five. In addition, health problems resulting from exposure to water pollutants often result in health care expenditures and absence from work. Typhoid and hepatitis due to water quality result in a larger number of sick persons. In the Syrian Arab Republic, 900 000 cases of waterborne diseases caused by water pollution were reported in 1996. There are also high rates of infantile diarrhoea and typhoid and hepatitis infections have increased. Animals are also attacked by several diseases, such as tapeworm and pulmonary tuberculosis and others, resulting from the use of untreated wastewater for fodder crop irrigation. In Turkey, the two major water-related diseases connected with irrigation and water resources development are schistosomiasis (bilharzias) and malaria. Schistosomiasis occurs sporadically, but the implementation of the large-scale projects within the Southeastern Anatolia Project (GAP) may eventually lead to epidemics. Malaria has long been a significant health problem in the country and is still common in areas of irrigation and water resources development.

Prospects for agricultural water management

Countries in the Middle East region consider water and irrigation management a key factor in the use and conservation of their water resources. In the near future, agricultural water management in the countries of the Middle East region for which information is available will take into consideration the following: control of groundwater abstraction in order to reduce overexploitation, use of non-conventional sources of water, improvement of the irrigation infrastructure and drainage network, rehabilitation and construction of dams, improvement of the water quality in irrigation, increasing water use efficiency and recovery of the expenses for water supply service. In some countries, in order to release the State budget from high expenditures related to water resources management, it has been considered necessary to involve the private sector. Developing water user associations is considered a priority in some countries.

In countries such as Iraq, Jordan and the Syrian Arab Republic, water will be a limiting factor over the next years. Iraq expects that between 2020 and 2030 a situation may arise in which there will be a shortage in the Tigris and Euphrates owing to the increasing demand in the riparian countries. Since water shortages are forecast to occur with the development of irrigation, solutions have to be found for an integrated basin-level planning of water resources development. Jordan expects that within the next years all its available water resources will be developed. The available renewable water will never be enough to meet the escalating water demand. Water deficit will have to be met by extracting groundwater at rates not exceeding the safe yields, desalination of brackish and saline water and seawater, rationing of the water demand and improving the country's water management. The Syrian Arab Republic estimates that its irrigation potential is lower than the area equipped for irrigation at present.

According to available information, the current use of non-conventional sources of water (desalination and/or reuse of treated wastewater) concerns 16 out of the 18 countries of the Middle East region. Only Armenia and Georgia do not use these sources of water as their resources are not as low as in other countries of the Middle East. Non-conventional sources of water are expected to develop considerably in the future to mitigate the lack of available resources in most of the Middle East countries. Bahrain, Israel, Jordan, Kuwait, Qatar and United Arab Emirates include in their respective prospects for water management the increase of desalinated water and treated wastewater in the near future. The Islamic Republic of Iran, Lebanon, Occupied Palestinian Territory, Saudi Arabia, and Turkey include principally the development of reused treated wastewater. For Armenia, Azerbaijan, Georgia, Iraq and Yemen only, no information is available regarding an increase of non-conventional sources of water in the near future. Groundwater recharge with advanced wastewater treatment technologies could also be an option which is being taken into consideration in some countries, such as Kuwait and Qatar. However, there is a lack of experimental data on groundwater recharge, so that efforts should be focused in this direction.

Increasing water use efficiency will be possible by adopting efficient localized farm irrigation methods and irrigation scheduling. Increasing the net benefit per unit of land and water could be possible by reducing the growth of crops with high water requirements. In the Caucasian countries and in Turkey, donors and international financial institutions have developed projects dealing with the rehabilitation of irrigation and drainage. In Qatar interest-free loans will be provided to farmers to promote modernizing irrigation systems with a repayment period of several years.

The determination of relevant prices, which should recover the expenses for water supply service, is said to be one of the principles of effective water resources management. In Israel, increasing water tariffs is also a solution to reduce water demand for municipal gardening, home gardening, the domestic sector and the agricultural sector. Qatar is looking at the possibility of introducing a pricing system for water consumption with penalties for extravagant water use and incentives for water saving.

Information regarding specific water plans for the near future is available for some countries. In Armenia, the sub-programme on irrigated agriculture of the Millennium Goal programme aims to find a solution to the existing problems of irrigation systems. In Lebanon, the Water Plan 2000–2010 defines the strategy to satisfy Lebanon's future water needs. In Oman, a National Water Resources Master Plan was prepared in 2000 to establish a strategy and plan for the period 2001–2020 for the sustainable development, management and conservation of water resources. In Saudi Arabia, a Future Plan of Agriculture has been developed which calls for reducing water demand through a policy of diversification of agricultural production, taking into account the comparative advantages of each region of the country. In Turkey, irrigation investment in the GAP which will finish at the end of 2010 comprises 910 000 ha in the Euphrates River Basin and 540 000 ha in the Tigris River Basin planned for irrigation. In Yemen, specific objectives of the second Five-Year Plan are the optimal exploitation of available water resources, improving the means and techniques for water resources recovery and for feeding aquifers, and protecting water resources from pollution.

Although they already exist in some countries, water transfers are not included in any water plan presented for the future or in major prospects for water management in the Middle East region.

Regarding transboundary river basins, riparian countries need to prepare joint water management plans for each basin in order to avoid lack of communication, conflicting approaches, unilateral development, and inefficient water management practices which cause international crisis in these countries. In that direction, in 2008 Turkey, the Syrian Arab Republic and Iraq decided to cooperate on water issues by establishing a water institute that will consist of 18 water experts from each country to work towards the solution of water-related problems. The institute will conduct its studies at the facilities of the Ataturk Dam, the largest dam in Turkey, and plans to develop projects for the fair and effective use of transboundary water resources.

Water professionals across the Middle East region recognize the need to focus more on integrated management of water resources and on regulation rather that provision of services. The region has seen major advances, but on the whole, progress towards better management has been slow. A series of technical and policy changes to the water sector in most Middle East countries is needed if they are to accelerate on water policy and avoid the economic and social hardships that might otherwise occur. The changes include planning that integrates water quality and quantity and considers the entire water system; promotion of demand management; tariff reform for water supply, sanitation and irrigation; strengthening of government agencies; decentralizing responsibility for delivering water services to financially autonomous utilities; and stronger enforcement of environmental regulations. The water sectors of the region will need to tackle three types of scarcity – scarcity of physical resources, scarcity of organization capacity and scarcity of accountability for achieving sustainable outcomes – in order to reduce the region's water management problems so that water can achieve its potential contribution to growth and employment (World Bank, 2007).

Description of four transboundary river basins

EUPHRATES–TIGRIS RIVER BASIN

Geography, climate and population

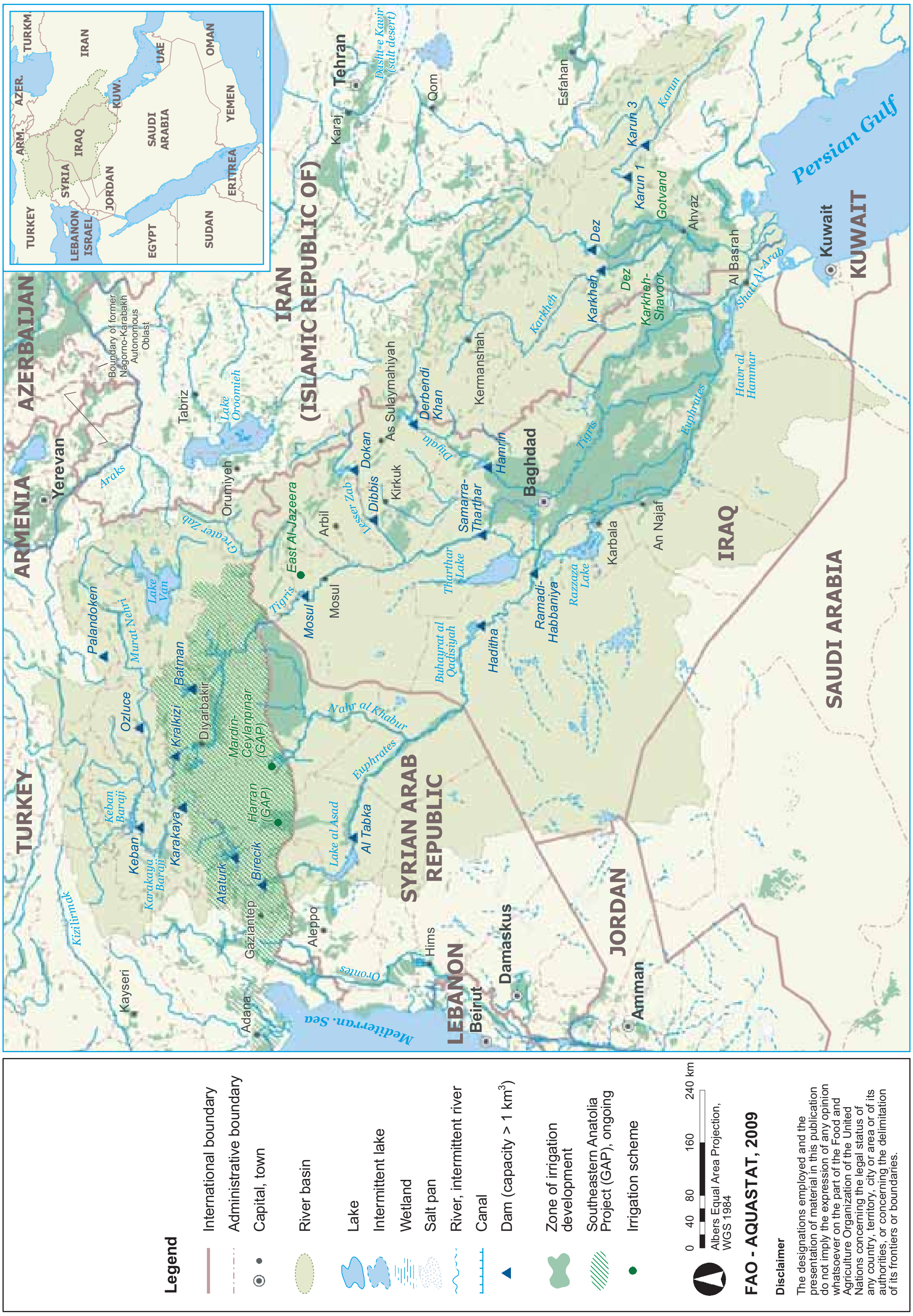
The Euphrates–Tigris River Basin is a transboundary basin with a total area of 879 790 km² distributed between Iraq (46 percent), Turkey (22 percent), the Islamic Republic of Iran (19 percent), the Syrian Arab Republic (11 percent), Saudi Arabia (1.9 percent) and Jordan (0.03 percent) (Lehner *et al*, 2008) (Table 29 and Figure 3). The Islamic Republic of Iran is riparian only to the Tigris, and Jordan and Saudi Arabia are riparian only to the Euphrates. Both the Euphrates and the Tigris rise in the mountains of eastern Turkey and the basin has high mountains to the north and west and extensive lowlands to the south and east. Two-thirds of their courses go through the highlands of eastern Anatolia in Turkey and the valleys of the Syrian and Iraqi plateaus before descending into the arid plain of Mesopotamia (Kibaroglu, 2002). The Euphrates and Tigris join near Qurna (Iraq) in a combined flow called Shatt Al-Arab, which empties into the Persian Gulf. However, more upstream within Iraq both rivers are also connected through the construction of several canals.

Most of the Euphrates–Tigris River Basin has a sub-tropical Mediterranean climate with wet winters and dry summers. In the mountainous headwater areas freezing temperatures prevail in winter and much of the precipitation falls in the form of snow. As the snow melts in spring the rivers rise, augmented by seasonal rainfall which reaches its maximum between March and May. In southeastern Turkey as well as in the north of the Syrian Arab Republic and Iraq the climate is characterized by rainy winters and dry warm summers. Average annual precipitation in the Euphrates–Tigris River Basin is estimated at 335 mm, although it varies all along the basin area (New *et al*, 2002). In the Mesopotamian Plain the annual rainfall is rarely above 200 mm, while it reaches 1 045 mm in other places in the basin. The summer season is exceedingly hot and dry with midday temperatures approaching 50 ºC and with daytime relative humidity as low as 15 percent. These climatic conditions demonstrate that both the Euphrates and the Tigris flow through arid and semi-arid regions within the Syrian Arab Republic and Iraq, since 60 percent of the Syrian territory receives less than 250 mm/year of precipitation and 70 percent of Iraq receives on average 400 mm/year (Kibaroglu, 2002). The annual average temperature of the entire Euphrates–Tigris River Basin is 18 ºC. The average temperature of the basin in January is 5 ºC, though it can decrease to -11 ºC in the coldest places in the basin. In July, the average temperature

TABLE 29
Country areas in the Euphrates-Tigris River Basin

Basin	Area		Countries included	Area of country in basin (km²)	As % of total area of the basin	As % of total are of the country
	km²	% of the Middle East				
Euphrates–Tigris	879 790	13	Iraq	407 880	46.4	93.1
			Turkey	192 190	21.8	24.5
			Iran (Islamic Republic of)	166 240	18.9	9.5
			Syrian Arab Republic	96 420	11.0	52.1
			Saudi Arabia	16 840	1.9	0.8
			Jordan	220	0.03	0.2

FIGURE 3
Euphrates-Tigris river basin



of the Euphrates–Tigris River Basin reaches 31 ºC, although in the hottest places it can increase to 37 ºC (New *et al, 2002).*

Water resources

The Euphrates originates in the eastern highlands of Turkey, between Lake Van and the Black Sea, and is formed by two major tributaries, the Murat and the Karasu. It enters the Syrian territory at Karkamis, downstream from the Turkish town of Birecik. It is the joined by its major tributaries, the Balik and Khabur, which also originate in Turkey, and flows southeast across the Syrian plateaus before entering the Iraqi territory near Qusaybah. Of the Euphrates Basin 28 percent lies in Turkey, 17 percent in the Syrian Arab Republic, 40 percent in Iraq, 15 percent in Saudi Arabia, and just 0.03 percent in Jordan. The Saudi Arabian stretch of the Euphrates dries in summer; there are no perennial rivers. The Euphrates river is 3 000 km long, divided between Turkey (1 230 km), the Syrian Arab Republic (710 km), and Iraq (1 060 km), whereas 62 percent of the catchment area that produces inputs into the river is situated in Turkey and 38 percent in the Syrian Arab Republic. It is estimated that Turkey contributes 89 percent of the annual flow and the Syrian Arab Republic 11 percent. The remaining riparian countries contribute very little water.

The Tigris, also originating in eastern Turkey, flows through the country until the border city of Cizre. From there it forms the border between Turkey and the Syrian Arab Republic over a short distance and then crosses into Iraq at Faysh Khabur. The Tigris river is 1 850 km long, with 400 km in Turkey, 32 km on the border between Turkey and the Syrian Arab Republic and 1 418 km in Iraq. Of the Tigris Basin 12 percent lies in Turkey, 0.2 percent in the Syrian Arab Republic, 54 percent in Iraq and 34 percent in the Islamic Republic of Iran. Turkey provides 51 percent, Iraq 39 percent, and the Islamic Republic of Iran 10 percent of the annual water volume of the Tigris, but because of unfavourable geographic and climatic conditions the latter cannot use the water of the Tigris for agriculture or hydropower (Kaya, 1998). Within Iraq, several tributaries flow into the river coming from the Zagros Mountains in the east, thus all on its left bank. From upstream to downstream there are:

- the Greater Zab, which originates in Turkey. It generates 13.18 km³/year at its confluence with the Tigris; 62 percent of the total area of this river basin of 25 810 km² is in Iraq;
- the Lesser Zab, which originates in the Islamic Republic of Iran and which is equipped with the Dokan Dam (6.8 km³). The river basin of 21 475 km² (of which 74 percent is in Iraqi territory) generates about 7.17 km³/year, of which 5.07 km³ of annual safe yield after construction of the Dokan Dam;
- the Al-Adhaim or Nahr Al Uzaym, which drains about 13 000 km² entirely in Iraq. It generates about 0.79 km³/year at its confluence with the Tigris. It is an intermittent stream subject to flash floods;
- the Diyala, which originates in the Islamic Republic of Iran and which drains about 31 896 km², of which 75 percent in Iraqi territory. It is equipped with the Derbendi Khan Dam and generates about 5.74 km³/year at its confluence with the Tigris;
- the Nahr at Tib, Dewarege (Doveyrich) and Shehabi rivers, draining together more than 8 000 km². They originate in Iranian territory, and together bring into the Tigris about 1 km³/year of highly saline waters;
- the Karkheh, the main course of which is mainly in the Islamic Republic of Iran and which, from a drainage area of 46 000 km², brings about 6.3 km³ yearly into Iraq, namely into the Hawr Al Hawiza during the flood season, and into the Tigris River during the dry season

The Shatt Al-Arab is the river formed by the confluence downstream of the Euphrates and the Tigris and it flows into the Persian Gulf after a course of only

190 km. The Karun River, originating in Iranian territory, has a mean annual flow of 24.7 km^3 and flows into the Shatt Al-Arab just before it reaches the sea, bringing a large amount of freshwater.

The average annual discharge of the Euphrates and Tigris rivers together is difficult to determine due to the large yearly fluctuation. According to the records for 1938–1980, there have been years when 68 km^3 were observed in the two rivers in the mid–1960s, and years when the amount was over 84 km^3 in the mid–1970s. On the other hand, there was the critical drought year with less than 30 km^3 at the beginning of the 1960s. Such variation in annual discharge makes it difficult to develop an adequate water allocation plan for competing water demand from each sector as well as fair sharing of water among neighbouring countries (UNDG, 2005). The annual flow of the Euphrates River Basin from Turkey to the Syrian Arab Republic is 28.1 km^3, of which 26.9 km^3 corresponds to the Euphrates main river, and 30.0 km^3 from the Syrian Arab Republic to Iraq. The annual flow of the Tigris River Basin from Turkey to Iraq is 21.3 km^3. The Tigris borders the Syrian Arab Republic only over a short distance in the east and therefore very little annul flow, estimated at 1.25 km^3/year, can be available for the Syrians (Abed Rabboh, 2007). The annual flow of the tributaries of the Tigris from Iran to Iraq is 10 km^3.

Turkey finds itself in a strategically strong position as the only country in the Euphrates–Tigris River Basin to enjoy abundant surface water and groundwater resources. The Syrian Arab Republic depends heavily on the water of the Euphrates. Iraq is also reliant upon the Euphrates, but uses the Tigris River as well as an alternative source of water (Hohendinger, 2006).

Groundwater aquifers in Iraq consist of extensive alluvial deposits of the Tigris and Euphrates and are composed of Mesopotamian-clastic and carbonate formations. The alluvial aquifers have limited potential because of poor water quality. The alluvial aquifers contain large volume reservoirs: and annual recharge is estimated at 620 million m^3 from direct infiltration of rainfall and surface water runoff.

Water quality

Downstream riparian countries complain about the quality of the water. Turkey's use of water has so far been limited mainly to hydropower generation and irrigation. While the former use is considered non-consumptive and not directly linked to water quality, the return flow from irrigation causes water pollution, which in turn affects potential downstream uses. Equally important are natural causes of environmental concern in the sense that some residual characteristics common to both rivers exacerbate the damaging effects of human pollution. Notable natural causes are the high rate of evaporation, sharp climatic variations, the accumulation of salts and sediments, poor drainage and low soil quality in the lower reaches of the Tigris and Euphrates (Erdem, after 2002).

In Iraq, the present quality of water in the Tigris near the Syrian border is assumed to be good, including water originating in both Turkey and Iraq. Water quality degrades downstream, with major pollution inflows from urban areas such as Baghdad due to poor infrastructure of wastewater treatment. Water quality of the Euphrates entering Iraq is less than the Tigris, currently affected by return flow from irrigation projects in Turkey and the Syrian Arab Republic, and expected to get worse as more land comes under irrigation. The quality is further degraded at such times as flood flows are diverted into off-stream storage in Tharthar and later returned to the river system. Salts in Tharthar are absorbed by the water stored therein. The quality of the water in both the Euphrates and the Tigris is further degraded by return flows from land irrigated in Iraq as well as urban pollution. The amount and quality of water entering southern Iraq from the Iranian territory is largely unknown, although it is clear that flows are impacted by irrigation return flow originating in the Islamic Republic of Iran (UNDG, 2005).

The deterioration of water quality and the heavy pollution from many sources are becoming serious threats to the Euphrates–Tigris River Basin. A problem is that there is no effective water monitoring network, making it difficult to address water quality and pollution, as the sources of pollution cannot be precisely identified. Hence, the rehabilitation and reconstruction of the water monitoring network is urgently needed for water security.

Water-related development in the basin

The Euphrates and Tigris were the cradle of the early Mesopotamian civilizations and irrigation made it possible for the local people to develop agriculture. This resulted in the development of great ancient civilizations, where water played an important role. Mesopotamia, the land between the Euphrates and the Tigris, remained the centre of many different civilizations and gave life to millions of inhabitants up to modern times (AU, 1997). Unfortunately, as is usually the case, the seasonal distribution of the availability of water does not coincide with the irrigation requirements of the basin. The typical low water season in the Euphrates occurs from July to December, reaching its lowest point in August and September when water is most needed to irrigate the region's winter crops (Akanda *et al*, 2007). In the area close to the two river systems, rainfed farming is possible, although supplementary irrigation would raise yield and allow several cropping seasons. In the Mesopotamian Plain, however, the evaporative demand is very high and crops require intensive irrigation because of low annual rainfall and hot and dry summers. The total area equipped for irrigation in the Euphrates–Tigris River Basin is estimated to be around 6.5–7 million ha, of which Iraq accounts for approximately 53 percent, the Islamic Republic of Iran for 18 percent, Turkey for 15 percent and the Syrian Arab Republic for 14 percent. Agricultural water withdrawal is approximately 68 km^3.

Iraq was the first riparian country to develop engineering projects in the basin. The Al Hindiya and Ramadi-Habbaniya dams on the Euphrates were constructed in 1914 and in 1951 respectively, both for flood control and irrigation (Kaya, 1998). By the mid–1960s, the development of irrigated agriculture in Iraq far surpassed the development in the Syrian Arab Republic and Turkey. During this period, Iraq was irrigating over five times as much land in the river basin as the Syrian Arab Republic and nearly ten times as much as Turkey. To continue its efforts to use the water of these rivers efficiently and to provide irrigation water for the land between the Euphrates and the Tigris rivers, Iraq began constructing in the 1960s a 565 km long canal, the Third River (also called Saddam River), between the Euphrates and Tigris, which was completed in 1992. In the late 1970s, as part of the effort to prevent flood damage, Iraq built another canal to divert excess water from the Tigris into Lake Thartar. Since then, Iraq has built other similar canals linking Lake Thartar to the Euphrates and again connecting the lake with the Tigris. Iraq has also built dams on the Euphrates and Tigris to produce hydropower, such as the Haditha Dam completed in 1985 (Korkutan, 2001). In 1991 a large irrigation project, the North Al-Jazeera irrigation project, was launched in order to serve approximately 60 000 ha by using a linear-move sprinkler irrigation system with water stored by the Mosul Dam. Another irrigation project, the East Al-Jazeera irrigation project, involved the installation of irrigation networks on more than 70 000 ha of previously rainfed land near Mosul. These projects were part of a scheme to irrigate 250 000 ha in the Al-Jazeera plain.

The Syrian Arab Republic began exploiting the water of the Euphrates for irrigation and hydropower in the early 1960s. The Tabqa Dam was built on the Euphrates in 1973, mainly with the help of the then Soviet Union. The purpose of this major dam was to meet the Syrian Arab Republic's water and energy needs. The Bath Dam, completed in 1986, was the second Syrian dam on the Euphrates river. However, the hydropower capacity of the Bath Dam was not of the same scale as the Tabqa Dam.

The Bath Dam had a limited capacity for electricity generation and provided relatively little water for irrigation. The Tishreen Dam, the third Syrian dam on the Euphrates, mainly designed for hydropower, is still under construction. Since the Tigris river forms the border with Turkey, the Syrian Arab Republic could not build reservoirs to store or divert the water of this river without the cooperation of its neighbour on the other bank (Korkutan, 2001).

Turkey began constructing its first dam on the Euphrates River, the Keban Dam near Keban Strait, in the mid–1960s and finished the project in 1973. The second dam on the Euphrates was the Karakaya Dam, completed in 1988. This was the first dam built as part of the implementation of the Southeastern Anatolia Project (GAP). Like the Keban Dam, the purpose of the Karakaya Dam was to produce hydropower. The third dam on the Euphrates River was the Ataturk Dam, the most important in the GAP Project, completed in 1992. It was designed to store water for large-scale irrigation as well as for the generation of hydropower (Korkutan, 2001).

Table 30 shows the large dams in the Euphrates–Tigris River Basin, i.e. dams with a height of more than 15 metres or with a height of 5–15 metres and a reservoir capacity larger than 3 million m^3 according to the International Commission on Large Dams (ICOLD).

Transboundary water issues

During the 20th century various bilateral attempts at cooperation were made within the Euphrates–Tigris Basin. In 1920 the French and British governments, as the mandatory powers in Mesopotamia, signed a treaty regarding utilization of the water of the Euphrates and Tigris. The Turco–French Protocol, signed in 1930, committed the Turkish and French governments to coordinate any plans to use the water of the Euphrates. The principle of mutual cooperation over water development was extended in a Protocol annexed to the 1946 Treaty of Friendship and Good Neighbourly Relations between Turkey and Iraq. The agreement encompassed both rivers and their tributaries, and both countries agreed that the control and management of the Euphrates and Tigris rivers depended to a large extent on the regulation of flow in the Turkish source areas. At that time Turkey and Iraq agreed to share related data and consult with each other in order to accommodate both countries' interests. The 1946 Treaty mandated a committee to implement these agreements. However, none of this occurred because of different conflicts among the riparian countries (Kaya, 1998).

As the population of the region progressively increases, the demand for agricultural products increases and hence also the number of water supply projects. In 1973, Turkey constructed the Keban Dam in the Euphrates River Basin. The Syrian Arab Republic soon followed suit with the Tabqa Dam, also completed in 1973 and filled in 1975. The filling of these dams caused a sharp decrease in downstream flow and the quantity of water entering Iraq fell by 25 percent, causing tension between the countries (El Fadel *et al.*, 2002). The tension eased when the Syrian Arab Republic released more water from the dam to Iraq. Although the terms of the agreement were never made public, Iraqi officials have privately stated that the Syrian Arab Republic agreed to take only 40 percent of the river's water, leaving the remainder for Iraq (Kaya, 1998). In 1976, Turkey pledged to release 350 m^3/s from the Euphrates downstream and later in the same year increased the minimum flow to 450 m^3/s, also in an effort to reduce tensions.

In 1977, Turkey announced plans for the region's largest water development project ever, the Southeastern Anatolia Project (GAP), which included 22 dams and 19 hydropower projects to be built on the Euphrates–Tigris. This project is intended to provide irrigation, hydropower, and socio-economic development in Turkey. The Syrian Arab Republic and Iraq fear that the project will lead to reduced river flows and leave little water for use in their countries' agricultural and energy projects (Akanda *et*

TABLE 30

Large dams in the Euphrates-Tigris River Basin

Country	Name	Nearest city	River	Year	Height (m)	Capacity (million m³)	Main use *
Turkey							
	Keban	Elazig	Firat	1975	210	31 000	H, F
	Karakaya	Diyarbakir	Firat	1987	173	9 580	H
	Ataturk	Sanliurfa	Firat	1992	169	48 700	I, H
	Ozluce	Bingol	Peri	2000	144	1 075	H
	Kralkizi	Diyarbakir	Maden	1997	126	1 919	H
	Kuzgun	Erzurum	SerCeme	1996	110	312	I, H
	Dicle	Diyarbakir	Dicle	1997	87	595	I, H, W
	Batman	Batman	Batman	1999	85	1 175	I, H, F
	Erzincan	Erzincan	Goyne	1997	81	8	I
	Zernek	Van	Hosap	1988	80	104	I, H
	Kockopru	Van	Zilan	1992	74	86	I, H, F
	Kayalikoy	Kirklareli	Kaya	1986	72	150	I
	Demirdoven	Erzurum	Timar	1996	67	34	I
	Tercan	Erzincan	Tuzla	1988	65	178	I, H
	Birecik	Sanliurfa	Firat	2000	63	1 220	I, H
	Sarimehmet	Van	Karasu	1991	62	134	I
	Sultansuyu	Malatya	Sultansuyu	1992	60	53	I
	Mursal	Sivas	Nih	1992	59	15	I, H
	Surgu	Malatya	Surgu	1969	55	71	I
	Polat	Malatya	Findik	1990	54	12	I
	Goksu	Diyarbakir	Goksu	1991	52	62	I
	Kayacik	Karaburun		2002	50	117	I
	Hancagiz	Gaziantep	Nizip	1989	45	100	I
	Camgazi	Adiyaman	Doyran	1999	45	56	I
	Medik	Malatya	Tohma	1975	43	22	I
	Hacihidir	sanliurfa	sehir	1989	42	68	I
	K. Kalecik	Elazig	Kalecik	1974	39	13	I
	Gayt	Bingol	Gayt	1998	36	23	I
	Devegecidi	Diyarbakir	DevegeCidi	1972	33	202	I
	Dumluca	Mardin	Bugur	1991	30	22	I
	Karkamis	Kahramanmaras	Firat	2000	29	157	H
	Cip	Elazig	Cip	1965	23	7	I
	Palandoken	Erzurum	GedikCayiri	1997	19	1 558	I
	Porsuk	Erzurum	Masat	1994	17	770	I
					Total	**99 598**	
Syrian Arab Republic							
	Al Tabka	At Thawrah	Euphrates	-	-	11 200	
					Total	**11 200**	
Iraq							
	Mosul	Mosul	Tigris	1983	131	12 500	I
	Derbendi Khan	Ba'qubah	Diyola river	1962	128	3 000	I
	Dokan		Lesser Zab	1961	116	6 800	I
	Haditha	Haditha	Euphrates	1984	57	8 200	I, H
	Hamrin	Ba'qubah	Diyola river	1980	40	4 000	
	Dibbis		Lesser Zab	1965	15	3 000	I
	Samarra - Tharthar	Samarra	Tigris	1954	-	72 800	F
					Total	**110 300**	
Iran (Islamic Republic of)							
	Karoun 3	Eizeh	Karoun	2004	205	2 970	I, H
	Dez	Andimeshk	Dez	1962	203	2 856	I, H, W
	Karoun 1	Masjedsoleyman	Karoun	1976	200	3 139	I, H
	Masjedsoleyman	Masjedsoleyman	Karoun	2001	177	230	I, H
	Gavoshan	Kamyaran	Gaveh roud	-	136	550	I, H, W
	Karkheh	Andimeshk	Karkheh	2001	127	5 575	I, H, F
	Vahdat	Sanandaj	Gheshlagh	-	80	224	I, H, W
	Eilam	Eilam	Baraftab & Chaviz	-	65	71	I, W
	Guilangharb	Guilangharb	Guilangharb	-	51	17	I
	Shahghasem	Yasouj	Parikedoun	1996	49	9	I
	Hana	Samirom	Hana	1996	36	48	I
	Bane	Bane	Banechay	-	20	4	W
	Chaghakhor	Boldaji	Aghbolagh	1992	13	42	I
	Zarivar	Marivan	Zarivar	-	11	97	I
					Total	**15 832**	
					TOTAL	**236 930**	

* I = irrigation; H = Hydropower, W = Water Supply; F = Flood protection

al, 2007). The construction of the Ataturk Dam in Turkey, one of the GAP projects, was completed in 1992.

In 1983, Turkey, Iraq and the Syrian Arab Republic established the Joint Technical Committee for Regional Waters to deal with all water issues among the Euphrates–Tigris Basin riparian countries and to ensure that the procedural principles of consultation and notification were followed, as required by international law. However, this group disintegrated after 1993 without any progress (Akanda *et al*, 2007).

In 1984, Turkey proposed a "Three-staged plan for optimal, equitable and reasonable utilization of the transboundary watercourses of the Euphrates–Tigris Basin". This plan, which conforms to the principle of equitable utilization, proposes that the riparian countries jointly conduct and complete inventory studies and evaluation of water and land resources. This plan would promote objective data-gathering in the basin. After evaluation of all the data the proposed projects could be compared, based on their economic and social merits, and those deemed more beneficial could be implemented. The plan considers the basin to be a whole system, underlining the interdependence of its elements, as required by the UN Watercourses Convention (Kaya, 1998). For its part, the Syrian Arab Republic has proposed the following formula for water allocation: each riparian country will notify the other riparian countries of its demands on each river separately; the capacities of both rivers in each riparian country shall be calculated and, if the total demand exceeds the total supply of a given river (as is sure to be the case), the exceeding amount will be deducted proportionally from the demand of each riparian country (El Fadel *et al*, 2002).

In 1987, an informal agreement between Turkey and the Syrian Arab Republic guaranteed the latter a minimum flow of the Euphrates River of 500 m^3/sec throughout the year (15.75 km^3/year).

According to an agreement between the Syrian Arab Republic and Iraq signed in 1990, the Syrian Arab Republic agrees to share the Euphrates water with Iraq on a 58 percent (Iraq) and 42 percent (the Syrian Arab Republic) basis, which corresponds to a flow of 9 km^3/year at the border with Iraq using the figure of 15.75 km^3/year from Turkey (FAO, 2004b).

In 2001, a Joint Communiqué was signed between the General Organization for Land Development (GOLD) of the government of the Syrian Arab Republic and the GAP Regional Development Administration (GAP-RDA), which works under the Turkish Prime Minister's Office. This agreement envisions supporting training, technology exchange, study missions, and joint projects, but is limited because it only involves Turkey and the Syrian Arab Republic (Akanda *et al*, 2007).

In 2002, a bilateral agreement between the Syrian Arab Republic and Iraq was signed concerning the installation of a Syrian pump station on the Tigris River for irrigation purposes. The quantity of water drawn annually from the Tigris River, when the flow of water is in the average, will be 1.25 km^3, with a drainage capacity proportional to the aimed surface of 150 000 ha (FAO, 2002)

In April 2008, Turkey, the Syrian Arab Republic and Iraq decided to cooperate on water issues by establishing a water institute that will consist of 18 water experts from each country to work towards solving water-related problems among the three countries. This institute will conduct its studies at the facilities of the Ataturk Dam, the dam with the largest reservoir capacity in Turkey, and plans to develop projects for the fair and effective use of transboundary water resources (Yavuz, 2008).

Table 31 lists the main historical events in the Euphrates–Tigris River Basin.

KURA–ARAKS RIVER BASIN

Geography, climate and population

The Kura-Araks River Basin is a transboundary basin with a total area of about 190 110 km^2 of which 65 percent is located in the South Caucasus countries:

TABLE 31
Chronology of major events in the Euphrates-Tigris River Basin

Year	Plans/projects/treaties/conflicts	Countries involved	Main aspects
1914	Al Hindiya dam on the Euphrates	Iraq	For flood control and irrigation purposes
1920	Treaty regarding utilization of the waters of the Euphrates and the Tigris rivers	France and Great Britain	
1930	Turco-French Protocol	Turkey and France	Coordinates any plans to use the waters of the Euphrates.
1946	Treaty of Friendship and Good Neighbourly Relations	Turkey and Iraq	Extended the principle of mutual cooperation over water development in both rivers. Sharing of related data.
1951	Ramadi Habbaniya dam on the Euphrates	Iraq	For flood control and irrigation purposes.
1960s	Start of the construction of the "Third River"	Iraq	565 km canal between the Euphrates and the Tigris (completed in 1992).
1970s	Construction of several canals	Iraq	Linking Lake Thartar to the Euphrates, and connecting the lake with the Tigris.
1973	The Kevan dam	Turkey	First dam on the Euphrates for Turkey. Construction started in the 1960s. For hydropower purposes.
1973	The Tabqa dam	Syrian Arab Republic (with the help of the USSR)	First dam on the Euphrates for the Syrian Arab Republic, to meet water and energy needs.
1975	Filling of the Tabqa dam conflict	Syrian Arab Republic and Iraq (Saudi Arabia and possibly USSR mediated)	Major sources of conflict between Syrians and Iraqis addressed. Finally the Syrian Arab Republic released more water from the dam to Iraq.
1976	Release of 350 m^3/s from the Euphrates downstream	Turkey	Prevented tension between the Syrian Arab Republic and Iraq, regarding the filling of the Tabqa Dam.
1977	Southeastern Anatolia Project (GAP)	Turkey	Turkey announced plans for GAP, which included 22 dams and 19 hydropower installations on the Euphrates-Tigris.
1983	Establishment of Joint Technical Committee for Regional Waters	Turkey, Iraq, and the Syrian Arab Republic	Dealing with water issues between the basin riparian countries, to ensure principles of consultation and notification as required by international law. This group disintegrated after 1993 without any progress having been made.
1984	Turkey proposes a "Three-staged plan"	Turkey (indirectly Syrian Arab Republic and Iraq)	For optimal, equitable and reasonable utilization of the transboundary watercourses of the Euphrates-Tigris basin. Conforms to the principle of equitable utilization.
1985	The Haditha dam	Iraq	Dam on the Euphrates river to produce hydropower.
1986	The Bath dam	Syrian Arab Republic	Second dam on the Euphrates for the Syrian Arab Republic. Small-scale electric generation and small amount of water for irrigation.
1987	Informal agreement guaranteed 500 m^3/s of the Euphrates from Turkey to the Syrian Arab republic	Turkey and the Syrian Arab Republic	The Syrian Arab Republic has accused Turkey of violating this agreement a number of times.
1988	The Karakaya dam	Turkey	Second dam on the Euphrates. First dam built under the GAP. For production of hydropower.
1990	Agreement between the Syrian Arab Republic and Iraq to share the Euphrates water	Syrian Arab Republic and Iraq	The Syrian Arab Republic agrees to share the Euphrates' water with Iraq on a 58 percent (Iraq) and 42 percent (the Syrian Arab Republic) basis. Corresponds to a flow of 9 km^3/year.
1992	Completion of the Ataturk dam	Turkey	Third dam on the Euphrates for Turkey, the most important one under the GAP project. For irrigation and hydropower. The filling of the dam, shutting off the river flow for a month, causes conflict with Syrians and Iraqis.
2001	Joint Communiqué	GOLD (Syrian Arab Republic), and GAP-RDA (Turkey)	Supporting training, technology exchange, study missions, and joint projects.
2002	Bilateral Agreement concerning the installation of a Syrian pump station on the Tigris river	Syrian Arab Republic and Iraq	For irrigation purposes.
2008	Cooperation on water issues by establishing a water institute	Turkey, the Syrian Arab Republic and Iraq	18 water experts from each country to work toward the resolution of water-related problems.

FIGURE 4
Kura-Araks river basin

TABLE 32
Country areas in the Kura-Araks River Basin

Basin	Area		Countries included	Area of country in basin (km^2)	As % of total area of the basin	As % of total area of the country
	km^2	% of the Middle East				
Kura-Araks	190 250	2.90	Azerbaijan	60 020	31.5	69.3
			Iran (Islamic Republic of)	37 080	19.5	2.1
			Georgia	34 560	18.2	49.6
			Armenia	29 800	15.7	100.0
			Turkey	28 790	15.1	3.7

31.5 percent in Azerbaijan, 18.2 percent in Georgia and 15.7 percent in Armenia. The remaining part is distributed between the Islamic Republic of Iran (19.5 percent of the basin) and Turkey (15.1 percent) (Lehner *et al*, 2008) (Table 32 and Figure 4). The Kura-Araks River Basin is situated south of the Caucasus Mountains. Its borders are northeastern Turkey, central and eastern Georgia, and the northwestern part of the Islamic Republic of Iran. It contains all the territory of Armenia and more than two-thirds of Azerbaijan. The Kura River rises in Georgia and the Araks River in Turkey and both join in Azerbaijan about 150 km before its mouth at the Caspian Sea.

The geographical location of the South Caucasus at the border where the humid Mediterranean and dry continental air masses meet, the complex mountainous relief and other factors have conditioned the diversity of climate zones across the region, from everlasting snow caps and glaciers to warm humid subtropical forests and humid semi-desert steppes. Average annual precipitation in the basin is estimated at 565 mm, although it varies all along the basin territory. The annual average temperature of the entire Kura–Araks River Basin is estimated at 9 ºC. Average temperature in January is -4 ºC although it can drop to -13 ºC in the coldest places of the basin. In July, average temperature reaches 22 ºC, although in the hottest places it can increase to 28 ºC (New *et al*, 2002). The climate of Armenia, which is entirely located in the basin, is highland continental: hot summers and cold winters. Average annual temperature is 5.5 °C. Summer in Armenia is moderate, with the average temperature for July at 16.7 °C, and in the Ararat Valley it varies in the range of 24–26 °C. Winters are quite cold, with an average temperature of -6.7 °C. Total annual precipitation in Armenia is 592 mm. The driest regions are the Ararat Valley and the Meghri region, where the annual precipitation is 200–250 mm. The maximum precipitation, observed in high mountainous areas, is more than 1 000 mm annually. Azerbaijan is situated at the northern extremity of the subtropical zone and two-thirds of the country is located in the Kura–Araks River Basin. Its climatic diversity is caused by the complicated geographical location and landscape, the proximity of the Caspian Sea, the effect of the sun’s radiation, and air masses of different origin. The climate in Azerbaijan is continental. Arid weather with average summer temperatures above 22 °C is observed in the lowlands. In the mountain regions, temperatures may be below 0 °C in winter. Humid tropical weather is observed in the coastal zone near the Caspian Sea, mainly in the Lankaran lowlands in the southeast. The average precipitation is estimated at 447 mm/year. Almost half of Georgia, the eastern part, is located in the Kura–Araks River Basin, which has a subtropical dry climate with relatively cold winters and arid, hot summers. The average precipitation varies between 500 and 1 100 mm/year. About 80 percent of the rainfall occurs from March to October, while the longest dry period is about 50–60 days. Drought years are common. There is a need for irrigation in the areas where precipitation is less than 800 mm/year. Average temperatures vary between –1 °C in January and 22 °C in July.

Finally, as far as Turkey and the Islamic Republic of Iran are concerned, while a considerable part of the basin, 15 and 19 percent, respectively, is located in these countries, only a small part of each country, 4 and 2 percent respectively, is located in the Kura–Araks River Basin.

Average population densities are 128 persons/km^2 in Armenia, 93 persons/km^2 in Azerbaijan, and 78 persons/km^2 in Georgia. There are three cities with an excess of 1 million inhabitants in the South Caucasus: Baku (Azerbaijan), Tbilisi (Georgia), and Yerevan (Armenia) (Ewing, 3003).

A majority of the population of the Caucasus still lives below the poverty line. Gross Domestic Product (GDP) has decreased roughly by 50 percent since 1991, poverty levels have reached 60–80 percent, and unemployment has skyrocketed. Even though all three countries have shown signs of macroeconomic recovery and progress in the implementation of structural reforms, there has been emigration from the region to the Russian Federation, Turkey, the Persian Gulf, and the West (Vener, 2006).

Water resources

The Kura River, with a total length of 1 515 km, rises in Georgia and flows into Azerbaijan before entering the Caspian Sea. It has an average discharge of 0.575 km^3/year. Two of its tributaries rise in Turkey: the Mtkvari, with an inflow from Turkey estimated at 0.91 km^3/year, and the Potskhovi, with an inflow estimated at 0.25 km^3/year. The inflow of the Debet River, a southern tributary of the Kura River, is estimated at 0.89 km^3/year from Armenia to Georgia. The annual flow from Georgia to Azerbaijan of the Kura Basin is 11.9 km^3 and the annual flow of the Agstay from Armenia to Azerbaijan is about 0.35 km^3.

The Araks River originates in Turkey and after 300 km forms part of the international border between Armenia and Turkey, then for a very short distance between Azerbaijan and Turkey, between Armenia and the Islamic Republic of Iran, and between Azerbaijan and the Islamic Republic of Iran. The Araks River is about 1 072 km long and it has an average discharge of 0.21 km^3/year (Berrin and Campana, 2008). The total annual flow from Armenia to Azerbaijan through the Araks River and its tributaries (Arpa, Vorotan, and Vokhchi) is estimated at about 5.62 km^3, and from the Islamic Republic of Iran is estimated at 7.5 km^3. The Araks River joins the Kura River in Azerbaijan about 150 km before its mouth at the Caspian Sea.

With respect to storm water and sewage effluent discharges, the Kura–Araks River Basin receives 100 percent of Armenia's, 60 percent of Georgia's, and 50 percent of Azerbaijan's deficit (Berrin and Campana, 2008).

The South Caucasus countries are faced with water quantity and quality problems. In general terms, Georgia has a lot of water, Armenia has some shortages due to poor management, and Azerbaijan has a lack of water; moreover, its groundwater is of poor quality. In Georgia, the main use of the Kura–Araks water is agriculture. In Armenia it is agriculture and industry whereas in Georgia drinking water is withdrawn from a large fresh groundwater stock. In Azerbaijan, the Kura–Araks water is the primary source of freshwater, and 70 percent of drinking water comes from these rivers. In general, water is used for municipal, industrial, irrigation, fishery, recreation, and transportation purposes. The main water use is agriculture, followed by industry and households uses (Berrin and Campana, 2008).

Water quality

During the Soviet era and also in the post-Soviet period, large volumes of effluents were discharged into surface water bodies by the municipal, industrial and agriculture sectors, causing pollution of both surface water and groundwater. The largest source of pollution is municipal wastewater, which pollutes the rivers downstream of large cities with organic matter, suspended solids, surfactants, etc. Industrial wastewater discharges also are high, polluting surface water with heavy metals, oil products, phenols and other hazardous substances. In Georgia, for example, large industrial facilities producing manganese, ammonia, machinery, etc. together with arsenic, copper and gold mining and processing plants, oil refineries and power plants pollute the river bodies of the Black Sea and the Caspian Sea basins with heavy metals, oil products, phenols and other toxic substances. In Armenia and Azerbaijan, different industries also have discharged high loads of pollutants into the Kura and Araks rivers and their tributaries (UNEP, 2002). Agricultural return flows also contribute to the Kura–Araks pollution with pesticides such as DDT (Berrin and Campana, 2008). On its way through Turkey and the Islamic Republic of Iran, there is also a large populated area with an advanced industry, which increases the pollution in the Kura–Arak rivers.

Water-related development in the basin

The total area equipped for irrigation in the Kura–Araks River Basin is estimated at between 2 and 2.5 million ha, of which Azerbaijan accounts for approximately 45 percent, the Islamic Republic of Iran 21 percent, Georgia 14 percent, Armenia 11 percent and Turkey 8 percent. Agricultural water withdrawal is about 19 km^3.

During the Soviet era, the Caucasus was an important agricultural region that supported the entire USSR. Soviet agriculture was highly inefficient and suffered from poorly equipped infrastructure. At present, agriculture remains the main sector in the region, employing a significant amount of the population. In the Soviet period, from the 1970s to 1980s, industry in the Caucasus was well developed. The major industrial sectors were oil and gas, chemicals and machinery, ferrous and non-ferrous metals, cement, fertilizer, light manufacturing, and food processing. This rapid industrial development resulted in increased environmental pressures. After the USSR was dismantled, industrial production declined sharply because of the energy crisis and the dissolution of economic ties among the former Soviet Republics. Recently, some signs of industrial revival have appeared. However, the growth rate is still insignificant (Vener, 2006).

The main Kura and Araks rivers have only two reservoirs but the tributaries have more than 130 major reservoirs. Table 33 shows the large dams in the Kura–Araks River Basin, i.e. dams with a height of more than 15 metres or with a height of 5–15 metres and a reservoir capacity greater than 3 million m^3 according to the International Commission on Large Dams (ICOLD).

Transboundary water issues

During the Soviet era, water resources management of the basin was contingent upon the policy that the USSR was implementing at the time. In the 1960s and 1970s, surface water quality standards for a broad spectrum of substances were established. Domestic sewage was required to enter wastewater treatment facilities and undergo both mechanical and biological treatment. Meanwhile, no standards, guidelines or management practices existed for controlling diffused source pollution. Until 1991, there were no taxes on water pollution. Only water use fees were employed, introduced in 1982. In essence, they served more to finance state water protection programmes rather than to give an incentive to water users to conserve a resource. Legal requirements, existing laws, regulations and standards were frequently ignored or violated, because of their strictness and unfeasibility (UNEP, 2002). In the Soviet period the USSR signed an agreement with Turkey concerning the use of the Araks River, according to which the water of this transboundary river is divided equally between the countries. According to another agreement signed between the USSR and the Islamic Republic of Iran, the water of the Araks River is divided equally between them.

When Armenia, Azerbaijan and Georgia became independent states, the three countries had neither water resources management regulations nor water codes. However, each country has adopted water codes within the last 15 years: Armenia in 1992 and revised in 2002 according to the European Union Water Framework Directives

TABLE 33
Large dams in the Kura-Araks River Basin

Country	Name	Nearest City	River	Year	Height (m)	Capacity (million m³)	Main use*
Armenia	Spandaryan	Sistan	Vorotan	1989	83	257	I, H, O
	Azat	Artashat	Azat	1976	76	70	I, H, O
	Her-her	Vayk	Arpa	1993	74	26	I, H
	Tolors	Sistan	Sisian	1975	69	96	I, H
	Akhuryan	Maralik	Akhuryan	1981	59	525	I
	Aparan	Aparan	Qasakh	1966	52	91	I
	Kechut	Jermuk	Arpa	1981	50	25	I, O
	Hakhum	Berd (Ijevan)	Hakhum	1985	45	12	I
	Shamb	Sistan	Vorotan	1970	41	14	H
	Tavush	Berd	Tavush	1973	37	5	I
	Karnut	Gyumri	Akhuryan	1973	35	25	I
					Total	**1 146**	
Azerbaijan	Sarsang	Terter	Terter	1976	125	565	I, F, H
	Mingechevir	Mingechevir	Kura	1953	80	15 730	I, W, F, H, N, R
	Shamkir	Shamkir	Kura	1983	70	2 677	I, W, F, H
	Agstafachay	Kazax	Agstafachay	1969	53	120	I, F
	Araz	Nakhchivan	Araz	1971	40	1 350	I, W, F, H
	Xachinchay	Agdam	Xachinchay	1964	38	23	I, F
	Ayrichay	Sheki	Ayrichay	1986	23	81	I, F
					Total	**20 546**	
Georgia	Jinvali	Dusheti	Pshavis Aragvi	1985	102	520	I, W, H
	Sioni	pianeti	Iori	1963	85	325	I, H
	Dalis Mta	Dedoplistskaro	Iori	0	38	180	I
	Tblisi-Samgori	Tbilisi	Iori	1956	15	308	I, W, R
					Total	**1 333**	
Iran (Islamic Republic of)	Sabalan	Meshkin shahr	Ghare Sou	2006	89	105	I, W
	Makou	Makou	Zangmar	0	78	150	I, W, H
	Satarkhan	Ahar	Ahar Chay	1998	78	135	I, W
	Yamchi	Ardebil	Balkhli Chay	2004	67	82	I, W
	Zenouz	Zenouz	Zenouz Chay	2004	60	6	I
	Aras	Jolfa	Aras	0	42	1 350	I, H
	Arasbaran	Kalibar	Silinchay	2003	34	25	I
	Ghourichay	Ardebil	Ghourichay	1996	33	20	I
	Shourabil	Ardebil	Balkhli	2001	10	14	I
					Total	**1 887**	
Turkey	Arpacay	Kars	ArpaCay	1983	59	525	
	Catoren	Eskisehir	Harami	1987	45	47	
	Beyler	Kastamonu	Incesu	1994	42	25	
	Patnos	Agri	Gevi	1992	38	33	
					Total	**630**	
					TOTAL	**25 542**	

* I = irrigation; H = Hydropower, W = Water Supply; F = Flood protection; N = Navigation; R = Recreation

(EU-WFD), and Georgia and Azerbaijan in 1997. Nevertheless, there is no uniform control or management system for the rivers and, in the post-Soviet period, no water quality monitoring by the riparian countries. While the three countries are willing to cooperate on water-related issues since they recognize their dependency on the basin, whose waters they must share, they have not resolved their political, economic, and social issues. Currently no water treaties exist among the three countries, a condition directly related to the difficult political situation in the region.

In 1997, an agreement on environmental protection was signed between the governments of Georgia and Azerbaijan. In 1998, a similar agreement was signed between Georgia and Armenia. According to both agreements, the governments will cooperate in creating specifically protected areas within the transboundary ecosystems.

Azerbaijan and the Islamic Republic of Iran have an agreement on the protection of the Araks River (UNECE, 2004).

In 2002, the Republic of Armenia Commission on Transboundary Water Resources was established, chaired by the Head of the Water Resources Management Agency. This

TABLE 34
Chronology of major events in the Kura-Araks River Basin

Year	Plans/projects/treaties/conflicts	Countries involved	Main aspects
Soviet period	Agreement concerning the use of the water of the Araks river	USSR and Turkey	The water of the Araks river is divided equally between them.
Soviet period	Agreement concerning the use of the water of the Araks river	USSR and the Islamic Republic of Iran	The water of the Araks river is divided equally between them.
1960s–1970s	Surface water quality standards	USSR	Surface water quality standards for a broad spectrum of substances was established.
1982	Water use fees	USSR	
1992	Water code in Armenia	Armenia	In 2002 the code was revised according to the European Union Water Framework Directives.
1997	Water code in Azerbaijan	Azerbaijan	
1997	Water code in Georgia	Georgia	
1997	Agreement on environmental protection	Georgia and Azerbaijan	Cooperation in creating specifically protected areas within the transboundary ecosystems.
1998	Agreement on environmental protection	Georgia and Armenia	Cooperation in creating specifically protected areas within the transboundary ecosystems.
1999–2001	Integrated water resources management plan for Armenia	Armenia	The World Bank funded the development of this plan.
2000–2002	South Caucasus water management project	South Caucasus countries	Strengthening the cooperation among water-related agencies and integrating water resources management.
2000–2006	Joint river management programme on monitoring and assessment of water quality on transboundary rivers	South Caucasus countries	Prevention, control and reduction of transboundary pollution impact.
2002–2007	South Caucasus river monitoring project	South Caucasus countries	Established social and technical infrastructure for international, cooperative, transboundary river water quality and quantity monitoring, data sharing and watershed management system.
2002	Republic of Armenia commission on transboundary water resources was established	Armenia	This commission together with corresponding commissions in neighbouring countries resolved the issues related to transboundary water resources use and protection.
2005-2006	Reducing transboundary degradation in the Kura-Araks river basin project	South Caucasus countries, the Islamic Republic of Iran	To ensure that the quality and quantity of the water throughout the Kura-Araks river system meets the short and long-term needs of the ecosystem and the communities relying upon the ecosystem.
2004–2008	Caucasus-Georgia strategic plan	Georgia	Support for the South Caucasus regional water management programme as a principal component of its regional conflict prevention and confidence-building objectives.

commission, together with corresponding commissions of neighbouring countries, deals with issues related to transboundary water resources use and protection.

Table 34 shows the main historical events in the Kura–Araks River Basin.

ASI-ORONTES RIVER BASIN

Geography, climate and population

The Asi-Orontes River Basin is a transboundary basin with a total area of about 24 660 km^2 of which 69 percent is located in the Syrian Arab Republic, 23 percent in Turkey and 8 percent in Lebanon (Lehner *et al*, 2008) (Table 35 and Figure 5). The Asi-Orontes is the only river in the region flowing in northern direction, draining from western Asia to the Levant coastline of the Mediterranean Sea. The river rises in the mountains of Lebanon and flows 40 km in Lebanon to continue into the Syrian Arab Republic for about 325 km before arriving in Turkey for its last reach of 88 km to the Mediterranean Sea (UNESCO-IHE, 2002). The river rises in the great springs of

FIGURE 5
Asi-Orontes river basin

TABLE 35
Country areas in the Asi-Orontes River Basin

Basin	Area		Countries included	Area of country in basin (km^2)	As % of total area of the basin	As % of total area of the country
	km^2	% of the Middle East				
Asi-Orontes	24 660	0.38	Syrian Arab Republic	16 910	68.6	9.1
			Turkey	5 710	23.1	0.7
			Lebanon	2 040	8.3	19.6

Labweh on the east side of the Bekaa Valley and it runs in a northern direction, parallel with the coast, falling 600 m through a rocky gorge. Leaving this, it expands into the Qattinah Lake, having been dammed back in antiquity. The valley now widens out into the rich district of Hama, below which lie the broad meadow-lands of Amykes, containing the sites of ancient Apamea. This central Asi–Orontes valley ends at the rocky barrier of Jisr al-Hadid, where the river is diverted to the west and the plain of Antioch opens. Two large tributaries from the north, the Afrin and Karasu, reach it here through the former Lake of Antioch or Lake Amik, which is now drained through the artificial Nahr al-Kowsit channel. Passing north of the modern Antakya (ancient Antioch) the Asi–Orontes plunges southwest into a gorge and falls 50 m in 16 km to the sea just south of the little port of Samandagi.

The average annual precipitation in the basin is estimated at 644 mm, although it varies all along the basin area. Annual average temperature of the entire Asi–Orontes River Basin is estimated at 16 °C. Average temperature in the basin in January is 6 °C, although it can drop to –1 °C in the coldest places of the basin. In August, the average temperature reaches 25 °C, rising to 28 °C in the hottest places (New *et al*, 2002). In the Lebanese part of the Asi–Orontes Basin, the climate is semi-arid to arid, with annual rainfall below 400 mm (Estephan *et al*, 2008). In the Syrian part, the western mountains receive precipitation ranging from 600 to 1 500 mm, while in the eastern parts of the basin it is much lower, ranging from 400 to 600 mm (FAO, 2006). The Turkish part of the basin is a transition zone between the Mediterranean and Eastern Anatolian climatic zones. While a southeastern climate prevails in the eastern part of this basin, the western parts is dominated by a Mediterranean climate.

Water resources

The Asi–Orontes River and its tributaries collect the runoff from the highlands and plateau areas situated on both sides of the rift valley. The average annual flow of the river is estimated at 2 400 million m^3, but the surface water amount in the basin has been re-estimated at 1 110 million m^3 (FAO, 2006). The Al-Azraq spring is a very important tributary to the Asi–Orontes with an annual flow of more than 400 million m^3. There are several bid springs: Al Ghab, Al Rouj, and Al Zarka (FAO, 2006).

The annual flow from Lebanon to the Syrian Arab Republic is 415 million m^3, of which an informal agreement between these two countries attributes 80 million m^3 to Lebanon and the rest to the Syrian Arab Republic. The natural annual flow from the Syrian Arab Republic to Turkey is estimated at 1 200 million m^3, while the actual flow amounts to 12 million m^3.

The intensive use of groundwater by agriculture in the last decade has resulted in depletion of the water storage in the aquifers, lowering of the groundwater table and considerable reduction of the spring yield. The average annual discharge of 26 springs in Al Ghab valley dropped from 18.5 m^3/s in the period 1965–71 to 9.7 m^3/s in 1992–93 and declined steadily to 4.2 m^3/s in 1995–96. The amount of groundwater in the Syrian part of the Asi–Orontes Basin is estimated at 1 607 million m^3; most of it flows as springs (1 134 million m^3) and the rest (473 million m^3) is stored into aquifers and withdrawn from wells for irrigation and water supply.

Water quality

Water quality is good in the headwaters, while due to anthropogenic inputs associated with agricultural, urban, and industrial activities it deteriorates in the middle section of the river.

Water-related development in the basin

The total area equipped for irrigation in the Asi–Orontes River Basin is estimated at 300 000–350 000 ha, of which approximately 58 percent in the Syrian Arab Republic, 36 percent in Turkey, and 6 percent in Lebanon. Agricultural water withdrawal is approximately 2.8 km^3.

The Asi–Orontes Basin is an important agricultural area, contributing to the regional economy.

In the Lebanese Bekaa valley, the most important crops are fruits, vegetables, field crops, and forests and rangeland. However, poor management of natural resources and poor integration of production systems produce low farm income and unsustainable farming (Estephan *et al*, 2008). To obtain water for irrigation, two water regulators have been placed in Lebanon on the Asi–Orontes (El-Fadel *et al*, 2002).

In the Syrian part of the basin the total area irrigated increased from 155 300 ha in 1989 to around 215 000 ha in 2008. The expansion of irrigation using groundwater has been most intensive in the Al Ghab valley and the Mohafazat of Idleb. In the Al Ghab region, the areas irrigated with groundwater have increased and the areas irrigated with surface water have decreased. The annual amount of groundwater used for water supply, irrigation and industry is more than 1 607 million m^3, while the annual renewable amount in aquifers is less than 473 million m^3, meaning an over-abstraction of 1 134 million m^3 (FAO, 2006).

In the Syrian Arab Republic, regulation of the Asi–Orontes River flow to increase its irrigation capacity began with the reconstruction of the ancient Qattinah Dam in 1937, completed in 1976, and the construction of the dams at Rastan and Mhardeh on the main river stream in 1960, the first large dams built in the Syrian Arab Republic. These reservoirs control about 12 600 km^2 of the Asi–Orontes drainage basin upstream of Mhardeh. The total capacity of the three reservoirs (495 million m^3) represents about 45 percent of the estimated average annual flow yield. Until 2002 the dams built in the Syrian part of the basin numbered 41, with total a reservoir capacity of 741 million m^3, all built on tributaries of the Asi–Orontes River. Among the dams with large reservoir capacity is the Zeyzoun Dam (71 million m^3) which had been damaged in 2002. The Zeita Dam, one of the most recently built dams, will have a total capacity of 80 million m^3 (SPC, 2009).

In Turkey, the Lake of Antioch or Lake Amik was a large freshwater lake in the Asi–Orontes River Basin in Hatay Province which is now drained through the artificial channel Nahr al-Kowsit. Sedimentary analysis suggests that Lake Amik was formed, in its final state, in the past 3 000 years by episodic floods and silting up of the outlet to the Asi–Orontes. This dramatic increase in the lake's area displaced many settlements; the lake became an important source of fish and shellfish for the surrounding area and the city of Antioch. The lake was drained during a period from the 1940s–1970s. The most important dams located on the Turkish side of the basin are the Karamanli Dam and the Yarseli Dam. Table 36 shows the large dams in the Asi–Orontes River Basin, i.e. dams with a height of more than 15 metres or with a height of 5–15 metres and a reservoir capacity greater than 3 million m^3 according to the International Commission on Large Dams (ICOLD).

Transboundary water issues

Mainly non-navigable and of relatively little use for irrigation, the Asi–Orontes derives its historical importance from the convenience of its valley for traffic from

TABLE 36
Large dams in the Asi-Orontes River Basin

Country	Name	Nearest city	River	Year	Height (m)	Capacity (million m^3)	Main use*
Syrian Arab Republic	Al Rastan	Hims	Asi-Orontes	1960	67	228	I
	Qattinah	Hims	Asi-Orontes	1976	7	200	I
	Mhardeh	Hamah	Asi-Orontes	1960	41	67	I
	Zeyzoun	Hamah	-	1995	43	71	I
	Kastoun	Hamah	-	1992	20	27	I
Turkey	Karamanli (Hatay)	Hatay	Bulanik	1985	35	2 000	I
	Yarseli	Hatay	BeyazCay	1989	42	55	I
					Total	**2 648**	

* I = irrigation; H = Hydropower, W = Water Supply; F = Flood protection; R = recreation; N = Navigation; O = Other

TABLE 37
Chronology of major events in the Asi-Orontes River Basin

Year	Plans/projects/treaties/conflicts	Countries involved	Main aspects
1937	Reconstruction of the Qattinah dam	Syrian Arab Republic	Reconstruction of the ancient Qattinah dam, completed in 1976.
1939	French colonization of the Syrian Arab Republic	Syrian Arab Republic, Turkey, France	The Asi-Orontes terminates in Hatay (Alexandretta) province, which is Syrian land given to Turkey by France in 1939 during the French colonization of the Syrian Arab Republic.
1940s–1970s	Lake Amik drained	Turkey	Lake Amik was drained in the period running from the 1940s to the 1970s.
1950s	Ghab Valley Project	Syrian Arab Republic, Turkey, Lebanon	The Syrian Arab Republic applied for World Bank loans to build its Ghab Valley Project. Turkey requested that the project be revised. Later, the Syrian Arab Republic withdrew its requests for the loans it had negotiated.
1994	Agreement on water quantity	Lebanon, Syrian Arab Republic	Bilateral agreement, concerning the division of the water of the Asi-Orontes river between the Syrian Arab Republic and Lebanon.
2002	Floods	Syrian Arab Republic, Turkey	El Zeyzoun dam, located near the city of Hama in the Syrian Arab Republic, suddenly released about 70 million m^3. 22 Syrians lost their lives and the flood damaged some villages in the Syrian Arab Republic and cultivated land in Turkey.
2009	Agreement to develop the "Asi Friendship dam"	Syrian Arab Republic, Turkey	Turkey and the Syrian Arab Republic have agreed in principle to develop the "Asi Friendship Dam," to be built on the Asi-Orontes River on the border between the Syrian Arab Republic and Turkey.

north to south; roads from the north and northeast, converging at Antioch, follow the course of the stream up to Hims, where they built the Al-Rastan Dam, before forking to Damascus and to the Syrian Arab Republic and the south. The Asi–Orontes has long been a boundary marker. For the Egyptians it marked the northern extremity of *Amurru*, east of Phoenicia. For the Crusaders in the 12th century, the Asi–Orontes River became the permanent boundary between the Principality of Antioch and that of Aleppo.

The Syrian Arab Republic has been using 90 percent of the total flow, which reaches an annual average of 1 200 million m^3 at the Turkish-Syrian border. Out of this total capacity, only a meagre 12 million m^3 enter Turkey after heavy use by the Syrian Arab Republic.

In August 1994, the Lebanese and Syrian governments reached a water-sharing agreement on the Asi–Orontes River, according to which Lebanon receives 80 million m^3/year and the remaining 335 million m^3 are for the Syrian Arab Republic if the river's flow inside Lebanon is 400 million m^3 or more during that given year. If this figure falls below 400 m^3, Lebanon's share is adjusted downwards, relative to the reduction in flow. Wells in the river's catchments area that were already operational before the agreement are allowed to remain operational, but no new wells are permitted.

In 2009 Turkey and the Syrian Arab Republic have agreed in principle to develop the "Asi Friendship Dam", to be built on the Asi–Orontes River on the border between the Syrian Arab Republic and Turkey. The dam is expected to be approximately 15 m high with a capacity of 110 million m^3. Of that total, 40 million m^3 will be used to prevent flooding and the rest for energy production and irrigation. The idea to build a shared dam on the Asi–Orontes River has been discussed over the years between Turkey and the Syrian Arab Republic, but political differences between the countries held them back until now.

Table 37 shows the main historical events in the Asi–Orontes River Basin.

JORDAN RIVER BASIN

Geography, climate and population

The Jordan River Basin is a transboundary basin with a total area of about 18 500 km^2 of which 40 percent is located in Jordan, 37 percent in Israel, 10 percent in the Syrian Arab Republic, 9 percent in the West Bank, and 4 percent in Lebanon (Lehner *et al*, 2008) (Table 38 and Figure 6). The headwater of the 250 km long Jordan River originates from three rivers, the Dan, the Banias and the Hasbani, which merge at a point 5 km south of the northern Israeli border then flow south through the Hula Valley to join Lake Tiberias. With the outflow of the Jordan River from Lake Tiberias, the Lower Jordan River receives the water from its main tributary, the Yarmouk River. The Yarmouk River originates in Jordan, then forms the border between Jordan and the Syrian Arab Republic and then between Jordan and Israel, before flowing into the Lower Jordan River. The river then continues flowing south, forming the border between Israel and the West Bank to the west and Jordan to the east and finally ends in the Dead Sea (Green Cross Denmark, 2006).

Ecosystems in the region are extremely diverse, ranging from sub-humid Mediterranean environments to arid climates across very small distances. Climate projections for the eastern Mediterranean indicate future aridification (GLOWA, 2007). The average annual precipitation in the basin is estimated at 380 mm, although it varies all along the basin area (New *et al*, 2002). The Upper Basin, north of Lake Tiberias, has an annual precipitation of up to 1 400 mm, while the Lower Jordan Basin has an average annual precipitation rate of 100 mm only at its southern end. The largest part of the fertile land in the basin is located in Jordan and the West Bank, along the eastern and western banks of the Jordan River and the side wadis, in an area with annual rainfall of less than 350 mm. Other portions of the catchment area in the Syrian Arab Republic and Israel enjoy higher annual rainfall, more than 500 mm per year (Venot *et al*, 2006). The average annual temperature of the entire Jordan River Basin is around 18 °C. The average temperature of the Jordan River Basin in January is 9 °C,

TABLE 38
Country areas in the Jordan River Basin

Basin	Area		Countries or territories included	Area of country in basin (km^2)	As % of total area of the basin	As % of total area of the country
	km^2	% of the Middle East				
Jordan	18 500	0.28	Jordan	7 470	40.4	8.4
			Israel	6 830	36.9	32.9
			Syrian Arab Republic	1 910	10.3	1.0
			West Bank	1 620	8.8	28.7
			Lebanon	670	3.6	6.4

FIGURE 6
Jordan river basin

although it can drop to 5 °C in the coldest places. In August, the average temperature of the Jordan River Basin reaches 26 °C, rising to 30 °C in the hottest places (New *et al*, 2002).

Water resources

The Upper Jordan River Basin, north of Lake Tiberias, contributes the vast majority of the water while the Lower Jordan River Basin, which represents 40 percent of the entire Jordan River Basin, makes a much smaller contribution (Venot *et al*, 2006). The Yarmouk River, which is the main water course in this latter part of the Valley, joins the Jordan River in an area partly occupied by Israel. During the summer, most side streams dry up completely and capturing the winter floodwaters is one of the most critical aspects of water resources management in the Jordan River Basin. If these waters are not diverted or stored, they flow directly to the Dead Sea (Green Cross Italy, 2006).

The total natural discharge of the basin is subject to extreme seasonal and annual variations. In February, for example, the river may carry as much as 40 percent of its total annual flow, but in each of the summer and autumn months, when water is most needed, it carries only 3–4 percent of its annual discharge. In drought periods like 1987–91 the water discharge of the Jordan River Basin can be reduced by up to 40 percent over the whole year (Libiszewski, 1995). The annual flow entering Israel corresponding to the Jordan Basin includes 138 million m^3 from Lebanon (Hasbani River), 125 million m^3 from the Syrian Arab Republic and 20 million m^3 from the West Bank. The natural annual flow of the Yarmouk River from the Syrian Arab Republic to Jordan is estimated at 400 million m^3. However, the total actual flow at present is much lower as a result of the drought and upstream Syrian development works done in the 1980s. The Yarmouk River is the main source of water for the King Abdullah Canal (KAC), the backbone of development in the Jordan Valley. A main tributary of the Jordan River in Jordan, controlled by the King Talal Dam and also feeding the KAC, is the Zarqa River. There are also 6–10 small rivers, called "Side Wadis", going from the mountains in Jordan to the Jordan Valley.

Surface water accounts for 35 percent of the existing water resources in the basin, groundwater aquifers account for 56 percent of the resources, while reused wastewater and other non-conventional sources of water represent around 9 percent. The surface water of the Jordan River Basin is the main surface water resource available for relatively stable use in the region. It is the major source of water for Israel and Jordan and also supports the many aquifers in both countries, extending the reliance on the river (Green Cross Italy, 2006). The three main aquifers in the system are west of the Jordan River and are central to the water supply of Israel, Jordan and the Occupied Palestinian Territories: the western (or mountain) aquifer, the northeastern aquifer, and the eastern aquifer.

The region has one of the lowest per capita water resources worldwide, well below the typical absolute water scarcity threshold of 500 m^3/year per capita, except for Lebanon (Table 39). Moreover, water demand continues to increase rapidly due to high population growth rates and economic development (GLOWA, 2007).

TABLE 39
Internal and total actual renewable water resources per capita in 2006 in m^3/year

Country or Territory	Internal renewable water resources	Total actual renewable water resources
Israel	110	261
Jordan	119	164
Lebanon	1 184	1 110
Occupied Palestinian Territory	209	215
Syrian Arab Republic	367	865

Water quality

Due to the continuous drop in water levels in Lake Tiberias since 1996, in 2001 regulations in Israel lowered the minimum "red line" from 213 m below sea level to minus 215.5 m. The risks associated with reduced water levels are enormous: ecosystem instability and deterioration of water quality, damage to nature and landscape assets, receding shorelines and adverse impacts on tourism and recreation. Salinity in the lake has been alleviated by diverting several major saline inputs at the northwest shore of the lake into a "salt water canal" leading to the southern Jordan River. This canal removes about 70 000 tonnes of salt (and 20 million m^3 of water) from the lake each year. The salt water canal is also used to remove treated sewage from Tiberias and other local authorities along the western shoreline away from Lake Tiberias and into the Lower Jordan River. In the catchment area, a concerted effort has been made to lower the nutrient load by changing agricultural and irrigation practices, by cutting back the acreage of commercial fishponds and by introducing new management techniques. Sewage treatment plants have been improved and a new drainage network that recycles most of the polluted water within the watershed has been constructed. Around the lake, public and private beaches and recreation areas with appropriate sanitary facilities have been developed. Pollution and sewage from settlements and fishponds near the shores are treated and diverted from the lake.

Much of Amman's wastewater treated effluent is discharged in the Zarqa River and is impounded by the King Talal Dam, where it gets blended with fresh floodwater and is subsequently released for irrigation use in the Jordan Valley. The increased supply of water to Jordan's cities came about at the expense of spring flows discharging into such streams as the Zarqa River, Wadi Shueib, Wadi Karak, Wadi Kufrinja and Wadi Arab. The flow of freshwater in these streams has been reduced as a result of increased pumping from the aquifers, and the flow has been replaced with the effluent of treatment plants, a process that has transformed the ecological balance over time.

Water-related development in the basin

The total area equipped for irrigation in the Jordan River Basin is estimated at 100 000–150 000 ha, of which approximately 32 percent in Jordan, 31 percent in Israel, 30 percent in the Syrian Arab Republic, 5 percent in the West Bank, and 2 percent in Lebanon. Agricultural water withdrawal is approximately1.2 km^3.

In Jordan, intensive irrigation projects have been implemented since 1958, when the Government decided to divert part of the Yarmouk River water and constructed the East Ghor Canal (later named King Abdullah Canal or KAC). The King Talal Dam on the Zarqa River also diverts the water into the KAC. The canal was 70 km long in 1961 and was extended three times between 1969 and 1987 to reach a total length of 110.5 km. The construction of dams on the side wadis and the diversion of the flows from other wadis have allowed the development of irrigation over a large area. At the same time, wells have been drilled in the Jordan Valley to abstract groundwater, not only for domestic purposes but also for irrigation. Irrigation projects from surface water resources are mainly located in the Jordan River Valley (JRV) and the side wadis linked with the Jordan River Basin. Irrigation schemes in the JRV have been constructed, rehabilitated, operated and maintained by the government. In the first projects in the north, concrete-lined canals were constructed equipped with all irrigation structures to convey and distribute irrigation water on volumetric basis. Additional irrigation schemes were constructed during the 1970s and 1980s following the extension of the KAC, and through the construction of dams, and diversion of side wadis springs and streams. From the 1990s onwards the open canal irrigation schemes were converted to pressurized irrigation systems.

Israel has constructed the Cross Israel Water Carrier, which starts at the northern end of Lake Tiberias and diverts water via massive pipelines across the Jezreel Valley and south along the coastal plain, terminating in Beersheba. Across Israel, the government has built smaller pipelines radiating out over the farmland to bring water for irrigation. The entire system, completed in 1964, forms a water grid, easily controlled and measured.

TABLE 40
Large dams in the Jordan River Basin

Country	Name	Nearest city	River	Year	Height (m)	Capacity (million m³)	Main use*
Jordan	King Talal	Jarash	Zarqa River	1987	108	75	I, F, H, N
	Karamah	Al-Balqa (J)	Wadi Al Mallaha	1998	45	53	I, F, R
	Wadi Arab	Irbid	Wadi Arab	1986	84	20	I, W, F, N, R
	Shurabil Bin Hasna	Irbid	Wadi Ziglab	1967	48	4	I, W, F
	Kafrein	Al-Balqa	Wadi Kafrein	1997	37	9	I, F, R, O
	Shueib	Al-Balqa	Wadi Shueib	1969	32	2	I, F, O
Jordan and Syrian Arab Republic	Wadha (Unity)	Irbid (J) Dara (S)	Yarmouk River	2007	87	110	I, W, F, O H
					Total	273	

* I = irrigation; H = Hydropower, W = Water Supply; F = Flood protection; R = recreation; N = Navigation; O = Other

In the West Bank, localized irrigation systems are used to irrigate vegetables. A small percentage of vegetables is still irrigated by traditional methods, as well as the majority of citrus trees. Farmers usually use plastic lined pools to store their shares of fresh spring water and mix them with brackish well water. Then water is pumped and applied through trickle irrigation systems. From nearly all wells water is pumped into steel pipes which convey the water to the irrigation systems directly in the farms. As the pumping costs are high, the cost per unit water is high and thus farmers need to improve distribution and conveyance efficiency through the use of pipes.

In the Syrian Arab Republic surface irrigation is the prevailing irrigation system. Basin irrigation is the predominant technique used in surface irrigation and most of the irrigated wheat and barley are irrigated by this method. Irrigation field efficiency is reportedly to be in general below 60 percent.

Table 40 shows the large dams in the Jordan River Basin, i.e. dams with a height of more than 15 metres or with a height of 5–15 metres and a reservoir capacity larger than 3 million m³ according to the International Commission on Large Dams (ICOLD).

Transboundary water issues

While the idea of developing a water sharing strategy for the whole basin was recognized as early as 1913, when the Franjieh Plan was proposed, and 1955, when the Johnston Plan was devised, not one single plan has been completely adhered to. The Franjieh Plan was intended for the irrigation of the Jordan Valley, to generate hydropower and to transfer Yarmouk River flow (100 million m³) to Lake Tiberias (Sofer *et al.*, 1999). The Johnston Plan called for the allocation of 55 percent of available water in the basin to Jordan, 36 percent to Israel, and 9 percent to the Syrian Arab Republic and Lebanon. However, it was never signed by the countries involved.

In 1951, Jordan announced its plan to divert part of the Yarmouk River via the East Ghor Canal to irrigate the East Ghor area of the Jordan Valley. In response, Israel began the construction of its National Water Carrier (NWC) in 1953. In 1964, the NWC opened and began diverting water from the Jordan River Valley. This diversion led to the Arab Summit of 1964, where a plan was devised to begin diverting the headwater of the Jordan River to the Syrian Arab Republic and Jordan. From 1965 to 1967 Israel attacked these construction projects in the Syrian Arab Republic and along with other factors this conflict escalated into the Six Day War in 1967 when Israel completely destroyed the Syrian diversion project and took control of the Golan Heights, the West Bank, and the Gaza Strip. This gave Israel control of the Jordan River's headwater and of significant groundwater resources. The most recent direct water-related conflict occurred in 1969 when Israel attacked Jordan's East Ghor Canal due to suspicions that Jordan was diverting excess amounts of water (Green Cross Italy, 2006). Later on, Israel and Jordan acquiesced to the apportionment contained in the non-ratified 1955 Johnston Plan for sharing the Jordan River Basin's water (Milich and Varady, 1998). In 1978, Israel invaded Lebanon, giving Israel temporary control of the Wazzani spring/stream feeding the Jordan River (Attili *et al.*, after 2003).

Inter-Arab conflicts have also often arisen, but have only been small-scale low-level conflicts. The terms of the 1987 agreement between the Syrian Arab Republic and Jordan defined the Syrian share of the Yarmouk and limited the Syrian Arab Republic to building 25 dams with a holding capacity of 156 million m^3. To date, the Syrian Arab Republic has built 37 dams on the four recharge wadis of the Yarmouk River with a total holding capacity of 211 million m^3 (i.e. 55 million m^3 in violation of the agreement). The Syrian Arab Republic's continuous well drilling in the Yarmouk Basin negatively impacts the base flow in the river, reducing it by approximately 30 percent (Green Cross Italy, 2006). The Wadha (Unity) Dam on the Yarmouk River was included in the agreement, with a height of 100 m and a storage capacity of 225 million m^3. Jordan would receive 75 percent of the water stored and the Syrian Arab Republic would receive all of the hydropower generated. In 2003 the height of the dam was reduced to 87 m and the storage capacity became 110 million m^3. The dam was completed in 2007.

Since the start of the Peace Process in the early 1990s, bilateral agreements and common principles have been signed between Israel and Jordan and Israel and the Palestinian Authority, but no multilateral plan or agreement has been negotiated and even the bilateral ones have been put under pressure and frequently violated in times of natural or political crisis.

In July 1994, Israel and Jordan signed The Washington Declaration and negotiated the Treaty of Peace, signed in October 1994. The treaty spells out allocations for both the Yarmouk and Jordan rivers and calls for joint efforts to prevent water pollution. This peace treaty established the Israel–Jordan Joint Water Committee (IJJWC), comprised of three members from each country. The Committee was tasked to seek experts and advisors as required, and form specialized subcommittees with technical tasks assigned. The two countries undertook to exchange relevant data on water resources through the IJJWC and also agreed to cooperate in developing plans for purposes of increasing water supplies and improving water use efficiency. It also specified the volumes of water to be used, stored, and transferred by and to each country during a "summer" and a "winter" season (Milich and Varady, 1998). Jordan is entitled to store 20 million m^3 of the Upper Jordan winter flow on the Israeli side (in Lake Tiberias) and get it back during the summer months. Jordan can build a dam on the Yarmouk downstream of the diversion point of Yarmouk water to the KAC. Jordan can also build a dam of 20 million m^3 capacity on the Jordan River and on its reach south of Lake Tiberias on the border between Jordan and Israel. Because Israel is to provide only 50 million m^3/year of additional water to Jordan, insufficient to allow the Jordanians to cover their annual deficit, the two countries have agreed to cooperate in finding sources to supply Jordan with an additional quantity of 50 million m^3/year of water of drinkable standards, within one year from the entry into force of the treaty. To protect the shared water of the Jordan and Yarmouk rivers against any pollution or harm, each country is to jointly monitor the quality of water along their boundary, building monitoring stations to be operated under the guidance of the IJJWC. Israel and Jordan are each to prohibit the disposal of municipal and industrial wastewater into the Yarmouk or Jordan River before treatment to standards allowing unrestricted agricultural use (Milich and Varady, 1998).

Interpretation of several terms of the treaty has at times had an uneven history. On the positive side is the June 1995 completion of a pipeline making the physical connection between the Jordan River immediately south of its exit from Lake Tiberias and the King Abdullah Canal in Jordan. Moreover, the provision of the additional

50 million m^3/year that Israel promised to Jordan went ahead on schedule. However, the article which calls for cooperation so that Jordan acquires 50 million m^3 more per year led to a "mini crisis" between the two countries in May 1997. At the heart of the dispute was Jordan's demand for an immediate transfer of 50 million m^3, which was to have been obtained by the construction of two internationally financed dams in Jordan. However, neither Jordan nor Israel was successful in obtaining the necessary financing. Finally, Israel agreed to supply Jordan with 25 million m^3 of water per year for three years as an interim solution, until the desalination plant is erected.

Recent dialogue and peace treaties have lead to increased cooperation regarding the development of future water resources projects. For instance, the 1994 and 1997 Israel–Jordan agreements led to discussions on the possibility of building a canal from the Red Sea to the Dead Sea to produce desalinated water with hydropower. It should be mentioned, however, that in their fervour to reach an accord, apparently both the Jordanians and the Israelis negotiated without coordinating their moves with the relevant ministries. Therefore, important issues remain open or vague and conflicts have arisen as a result. For example, in 1999, due to drought Israel decided to reduce the quantity of water piped to Jordan by 60 percent, which caused a sharp response from that country. Disputes of such nature are not unexpected in the future. However, the peace agreements have had the benefit of restricting such conflicts to political rather than military solutions. The fact that the Joint Water Commission for Israel and the Palestinian Authority have continued to meet to discuss critical issues even during the current period of hostilities illustrates the progress that has already been made (Green Cross Italy, 2006).

More than 30 years of Israeli occupation of the West Bank and Gaza Strip have been accompanied with a series of laws and practices targeting Palestinian land and water resources. In 1993, the "Declaration of Principles on Interim Self-Government Arrangements" was signed between Palestinians and Israelis, which called for Palestinian autonomy and the removal of Israeli military forces from Gaza and Jericho. Among other issues, this bilateral agreement called for the creation of a Palestinian Water Administration Authority and cooperation in the field of water, including a Water Development Programme prepared by experts from both sides, which will also specify the mode of cooperation in the management of water resources in the Occupied Palestinian Territory. Between 1993 and 1995, Israeli and Palestinian representatives negotiated to broaden the provisional agreement to encompass the greater West Bank territory. In September, 1995, the "Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip", commonly referred to as "Oslo II", was signed. The question of water rights was one of the most difficult to negotiate, with a final agreement postponed for inclusion in the negotiations regarding final status arrangements. However tremendous compromise was achieved between the two sides: Israel recognized the Palestinian water rights – during the interim period a quantity of 70–80 million m^3 should be made available to the Palestinians – and a Joint Water Committee was established to manage cooperatively West Bank water and to develop new supplies. This Committee also supervises joint patrols to investigate illegal water withdrawals. No territory whatsoever was identified as being necessary for Israeli annexation due to access to water resources (Wolf, 1996). In 2003, the Roadmap for Peace, developed by the United States, in cooperation with the Russian Federation, the European Union, and the United Nations (the Quartet), was presented to Israel and the Palestinian Authority to seek a final and comprehensive settlement of the Israel–Palestinian conflict.

The basis for Israeli–Syrian negotiations is the premise of an exchange of the Golan Heights for peace (Wolf, 1996). In 1967 Israel seized the Golan Heights from the Syrian Arab Republic during the six-day war. The Golan Heights control the main water sources of Israel. Israel's only lake and its main source of freshwater, supplying the country with a third of its water, is fed from the Golan Heights. Conquered in 1967, they have been under Israeli law, jurisdiction, and administration since 1981, which, however, has not been recognized by the United Nations Security Council. The crux of the territorial dispute is the question of which boundaries Israel would withdraw to; the boundaries between Israel and the Syrian Arab Republic have included the international boundary between the British and French mandates from 1923, the Armistice Line from 1949 and the cease fire lines from 1967 and 1974. The Syrian position has been to insist on a return to the borders of 1967, while Israel refers to the boundaries of 1923. The only distinction between the two lines is the inclusion or exclusion of the three small areas with access to the Jordan and Yarmouk rivers (Wolf, 1996). In 2008, negotiations between Israel and the Syrian Arab Republic started with the objective to solve the conflict of the Golan Heights.

In 2002, the water resources of the Hasbani Basin became a source of mounting tensions between Lebanon and Israel, when Lebanon announced the construction of a new pumping station at the Wazzani springs. The springs feed the Hasbani River, which rises in the south of Lebanon and crosses the frontier ('Blue Line') to feed the Jordan River and subsequently the Sea of Galilee, which is used as Israel's main reservoir. The pumping station was completed in October 2002. Its purpose was to provide drinking and irrigation water to some 60 villages on the Lebanese side of the Blue Line. The Israelis complained about the lack of prior consultation whereas the Lebanese contended that the project was consistent with the 1955 Johnston Plan on the water resources of the region.

In 2004 and 2005 Jordan got only around 119 and 92 million m^3/year from the Yarmouk River and from Lake Tiberias respectively. This is only around 10 percent of the total flow of the Upper Jordan and Yarmouk rivers. It is also much less than the water share from these two basins proposed by the Johnston plan through his negotiations in 1950s.

In 2007, Jordan and the Syrian Arab Republic agreed to expedite the implementation of agreements signed between the two countries, especially with regards to shared water in the Yarmouk River Basin. They also agreed to continue a study on the Yarmouk River Basin based on previous studies. Currently, the Joint Jordanian–Syrian Higher Committee is discussing how to make use of the Yarmouk River Basin water and how to protect Yarmouk water against depletion. Talks will also include preparations for winter and storage at the Wadha (Unity) Dam in the Yarmouk River.

Table 41 shows the main historical events in the Jordan River Basin.

TABLE 41
Chronology of major events in the Jordan River Basin

Year	Plans/projects /treaties/conflicts	Countries & territories involved	Main aspects
1913	Franjieh Plan	Ottoman Commission	Irrigation of the Jordan Valley, transferring Yarmouk River flows to Lake Tiberias, generating electricity.
1951	Jordan announced Plan	Jordan	Jordan Plan to divert part of the Yarmouk river via the East Ghor canal.
1953	Israel began construction of the National Water Carrier (NWC)	Israel	Resulting in military skirmishes between Israel and the Syrian Arab Republic.
1955	Johnston Plan	USA. Riparian countries	Allocation of water: 55% for Jordan, 36% for Israel, 9% each to the Syrian Arab Republic and Lebanon. Not signed because Arab riparian countries insisted the USA was not impartial.
1964	The NWC opened and began diverting water from the Jordan River Valley	Israel	This diversion led to the Arab Summit of 1964.
1964	Arab Summit	Arab League	A plan was devised to begin diverting the headwaters of the Jordan River to the Syrian Arab Republic and Jordan.
1965–1967	Israel attacked construction projects in the Syrian Arab Republic	Israel, Syrian Arab Republic	This conflict, along with other factors escalated in the Six Day War in 1967.
1967	Six Day War	Egypt, Israel, Jordan, Syrian Arab Republic, Occupied Palestinian Territory	Israel destroyed the Syrian diversion project and took control of the Golan Heights, the West Bank and the Gaza Strip. Palestinian irrigation pumps on the Jordan River were destroyed or confiscated after the Six Day War and Palestinians were not allowed to use Jordan River water. Israel introduced quotas on existing Palestinian irrigation wells and did not allow any new ones.
1969	Israel attacked Jordan's East Ghor Canal	Israel and Jordan	Because of suspicions that Jordan was diverting excess amounts of water. Later on, Israel and Jordan acquiesced to the apportionment contained in the non-ratified Johnston Plan.
1978	Israel's invasion of Lebanon	Israel and Lebanon	Giving Israel temporary control of the Wazzani spring/stream feeding the Jordan.
1987	Syrian Arab Republic and Jordan agreement	Syrian Arab Republic and Jordan	Defined the Syrian share of the Yarmouk and limited the Syrian Arab Republic to 25 dams with a capacity of 156 million m^3. The Wadha (Unity) Dam was included.
1993	Declaration of Principles on Interim Self-Government Arrangements	Israel, Occupied Palestinian Territory	Called for Palestinian autonomy. Creation of the Palestinian Water Administration Authority. Water Development Programme.
1994	Washington Declaration and Treaty of Peace	Israel and Jordan	Israel and Jordan signed The Washington Declaration, ending the state of belligerency and negotiated the Treaty of Peace. Allocations for Yarmouk and Jordan rivers and efforts to prevent water pollution.
1995	Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip (Oslo II)	Israel, the West Bank, and the Gaza Strip	Israel recognized Palestinian water rights (during the interim period a quantity of 70–80 million m^3 to be made available to the Palestinians). A Joint Water Committee was established to cooperatively manage West Bank water and to develop new supplies.
1996	Israel tries to begin talks on water resources with the Syrians	Israel and Syrian Arab Republic	Syrian Arab Republic refuses because of the conflict concerning the Golan Heights.
1999	Israel reduces the quantity of water piped to Jordan by 60 percent	Israel and Jordan	Due to drought. This reduction caused a sharp response from Jordan.
2002	The Wazzani Conflict	Israel, Lebanon	Lebanon announced the construction of a new pumping station at the Wazzani springs causing tension between Israel and Lebanon.
2003	Roadmap for Peace	Israel, Occupied Palestinian Territory, The Quarter	Purpose: to end of the Israel-Palestinian conflict.
2007	Jordan and Syrian Arab Republic agreements	Jordan and Syrian Arab Republic	Implementation of agreements signed between the two countries, especially with regard to shared water in the Yarmouk river basin.
2008	Negotiations between Israel and the Syrian Arab Republic	Israel and Syrian Arab Republic	Negotiations are taking place in order to resolve the the Golan Heights conflict.