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Foreword

In order to provide a basis for discussing the issue of increasing water scarcity and the role of irrigation in the world water balance, FAO's Aquastat programme compiles existing quantitative and qualitative information on water resources, water use and irrigation by country. This report focuses on the work done through the Aquastat surveys to collect and analyse available information on water resources for all countries in the world.

The report presents the concepts and methodology applied in order to compute country-level water resources data. It presents and analyses the key findings at both global and regional levels. A summary table provides the elements of the water balance for each of the 170 countries and territories surveyed.

The report also discusses the limitations of the approach and the information gaps that remain at country level. The aim of the work presented here is to help improve the quality of the knowledge on the state of the world's water resources.

Acknowledgements

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List of acronyms

Aquastat	FAO’s information system on water and agriculture
BRGM	Bureau de Recherche Géologique et Minière
ERWR	External renewable water resources
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
IRWR	Internal renewable water resources
IWMI	International Water Management Institute
TARWR	Total actual renewable water resources
TRWR	Total renewable water resources
WWDR	World Water Development Report

Update and Internet links

The information contained in this report is available on the FAO Web site at:
www.fao.org/landandwater/aglw/aquastat/water_res/index.stm

Glossary

Actual/natural: The adjective qualifies the variable and indicates whether it corresponds to a natural situation, i.e. a measure of the water balance without human influence, or an actual situation, i.e. the conditions at a given time taking into account human influence either through uptake abstraction of water or through agreements or treaties. Natural conditions are considered stable over time while actual situations may vary with time and refer to a given period.

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

Average actual evapotranspiration (mm/year and km^3/year): Double average over space and time of evaporation from water bodies, rivers and plants.

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

External renewable water resources (ERWR) (km^3/year): That part of the country's renewable water resources which is not generated in the country. The ERWR include inflows from upstream countries (groundwater and surface water), and part of the water of border lakes or rivers.

Exploitable water resources (km^3/year) (also called manageable water resources or water development potential): The water resources considered to be available for development under specific economic and environmental conditions. The computation of exploitable water resources considers factors such as dependability of the flow, extractable groundwater, and minimum flow required for non-consumptive use.

Exploitation index (percent): Withdrawals of conventional freshwater resources (surface and groundwater) in relation to total renewable resources.

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

Natural flow (km^3/year): The amount of water that would flow in natural conditions, i.e. without human influence. It contrasts with actual flow, which takes into account upstream abstraction of water and treaties or agreement.

Non-conventional water resources: Total volume of water obtained through the development of new technologies. They are water generations (productions) that come either from desalination of sea and brackish waters or from wastewater regeneration for reuse.

Renewable resources: Total resources that are offered by the average annual natural inflow and runoff that feed each hydrosystem (catchment area or aquifer).

Total actual renewable water resources (TARWR) (km^3/year): The sum of internal renewable water resources and incoming flow originating outside the country. The computation of TARWR takes into account upstream abstraction and quantity of flows reserved to upstream and downstream countries through formal or informal agreements or treaties. It is a measure of the maximum theoretical amount of water actually available for the country.

Total natural renewable water resources (km^3/year): The sum of internal renewable water resources and natural incoming flow originating outside the country. It does not vary with time.

Total natural outflow (km^3/year): Annual natural outflow of surface and groundwater from a country into the sea or a neighbouring country. The Aquastat calculation sheet considers only the outflow into the neighbouring countries (natural in general; actual where there is consumption in the country or reservation for downstream countries).

Other variables in the water balance calculation sheet

All renewable resources are long term annual averages.

(External) groundwater inflow (km^3/year): Groundwater entering the country (usually limited to large aquifers shared by several countries, mostly in the arid zone).

(External) groundwater outflow (km^3/year): Groundwater leaving the country either to the sea or to other countries (usually limited to large aquifers shared by several arid countries). The Aquastat calculation sheet considers only the outflow to neighbouring countries.

(External) surface water/outflow not submitted to agreements or treaties (km^3/year): Average quantity of water leaving the country (including to the sea) and not submitted to treaties.

(External) surface water/flow of bordering rivers not submitted to agreements or treaties (km^3/year): Surface water reaching the country through border rivers.

(External) surface water/outflow to be reserved through agreements or treaties (km^3/year): Surface water to be reserved by treaty for a downstream country.

(External) surface water/inflow secured through agreements or treaties (km^3/year): Part of the water entering the country that is secured through treaties.

(External) surface water/inflow not submitted to agreements or treaties (km^3/year): Part of the external surface water inflow that is not submitted to formal agreements or treaties.

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

Total exploitable water resources (km^3/year): A measure of the part of the resources that is considered available for development. Methods to assess exploitable water resources vary from country to country and depend on the country's economic situation. Assessment of exploitable resources varies with time and should take into account the needs of the environment.

It may be subdivided in three subcomponents: regular surface water, irregular surface water, and regular groundwater.

- Regular or permanent resources refers to the surface or groundwater that is available with an occurrence of 90 percent of the time. In practice, it is equivalent to the low water flow of a river and the flow of groundwater that are often mixed. It includes the flow of groundwater not collected by watercourses flowing into the sea, enclosed lakes and areas of evaporation. It is the resource that is offered for withdrawal, diversion or groundwater extraction with a regular flow.
- Irregular resources is equivalent to the variable component of water resources (e.g. floods) and, exceptionally, groundwater levels (flooding of karstic aquifers). It includes the seasonal

and interannual variations, i.e. seasonal flow or flow during wet years. It is the flow that needs to be regulated (by dams).

Water availability (or available water resources): The terms water resources and water availability are often used as synonyms in the literature. However, these terms are not always defined clearly, leading to possible misinterpretation of the data. Some authors consider water availability to be the water not yet exploited in a given year, while others consider it closer to the concept of exploitable or manageable water resources. For the sake of clarity, the term water availability should be used in the sense of water net balance in a given state of use and exploitation of the resources and not with a meaning of water offer. The 'availability' may be: (i) equal to 'resources' minus 'withdrawal' at the local level of a subsystem, where a part of the water withdrawn cannot be returned into the system; or (ii) equal to 'resources' minus 'final consumption' at a more regional scale (watershed, country), where the balance encompasses all the use systems. This study avoids the term 'water availability' in an attempt to limit possible misinterpretations.

Units used in the report

All the elements of the water balance are expressed in km^3/year.

Area: 1 km^2 = 100 ha

Volume: 1 $km^3 = 1 \times 10^9$ $m^3 = 1\ 000 \times 10^6$ m^3 = 1 000 million m^3.

Chapter 1
Introduction

Water has been a main issue on the international agenda for the last 30 years, starting with the 1st International Conference on Water (Mar de la Plata, 1977), and followed by the International Conference on Water and the Environment (Dublin, 1992) and the 1st World Water Forum (Marrakech, 1997). During the 2nd World Water Forum in The Hague in March 2000, the United Nations pledged to produce a periodic assessment of the state of the world's freshwater resources in the form of the World Water Development Report (WWDR), with which FAO is associated closely. In view of the critical role of water in food production and of the importance of agriculture in global water withdrawal, and in order to provide a basis for the discussion on increasing water scarcity and the future of irrigation in the world, FAO undertook to compile existing information on water resources in the framework of the Aquastat programme.

The Aquastat programme

Developed since 1993 by FAO's Land and Water Development Division, the Aquastat programme is FAO's global information system on water and agriculture with a focus on irrigation. Its main purpose is to select systematically the most reliable information on water resources and water uses in countries and to make it available in a standard format to users interested in global or regional perspectives. Its objectives are:

- To provide users with comprehensive information on the state of agricultural water management across the world, with an emphasis on developing countries and countries in transition, and featuring major characteristics, trends, constraints and prospective changes.
- To support continental and regional analyses by providing systematic, up-to-date and reliable information on water in agriculture and to serve as a tool for large-scale planning and predictive studies.

All the results produced by the Aquastat programme are available as published reports or on CD-ROM and are available on the World Wide Web (regional overviews, country profiles, a glossary, and an atlas of water resources and irrigation in Africa). For specific information by country, the user can query two online databases on: (i) water and agricultural data; and (ii) regional and national institutions dealing with water and agriculture.

Existing sources of global information on water resources

Little information exists on water resources on a regional basis at country level. The only study that produced country figures systematically was conducted in the 1970s. It led to a publication entitled "World water resources and their future" (L'vovitch, 1974), which remains in use as a reference work in this field. Based on a water balance approach and drawing on a large amount of information on stream flow gathered from around the world, it proposed a table of water resources by country, including water resources generated in the country and flows from neighbouring countries. Also based on a water balance approach and following the work of Korzun *et al*. (1974), the publications by Shiklomanov (1997, 1998 and 2000) are the most frequently cited and up-to-date sources of information on water resources at regional and continental level. Shiklomanov (1998) provides country data for 51 countries on available water resources. Other useful compilations are by Gleick (2000) and the World Resources Institute (1994 and 2000). The latter provides the most recent systematic information about water resources at country level. It is mainly a compilation of existing information, including figures from Aquastat. These global data sources often do not indicate the method used to compile and validate their data sets.

In the framework of the Aquastat programme, a major focus has been the development of a consistent basis of assessment of water resources data in order to facilitate comparison between regions and countries. It is an important tool for enhancing regional and global discussion on water resources. The availability of country-level data on water resources is useful for:

- providing a homogenous database for the calculation of national indicators of water resources: resources per inhabitant (current or long term); ratio of demand/resources; and dependency ratio. This is useful for comparing and classifying countries, especially where the situations in the countries are very diverse;
- ensuring consistency in the estimation of the natural water exchanges between countries (transboundary and border flows);
- assessing the level of knowledge on water resources for each country, and highlighting the needs for improvements in knowledge.

This survey gives priority to information available from the countries. It makes no use of global water balance models. Although such a method does not ensure homogeneity in the quality of information collected, it makes the best possible use of local knowledge.

It has devoted particular attention to reducing the risks of double counting for: (i) internal water resources when assessing surface water and groundwater separately; and (ii) external resources when accounting for transboundary waters or border rivers. The overall purpose is to obtain the most reliable and complete set of water resources data by country.

This report provides statistics on water resources for all the countries of the world. It presents a compilation and a critical review of available information. The aim is to help in harmonizing currently available global water resources databases. It covers information sources from the Aquastat country surveys undertaken since 1994, and the most recent available references from national or international sources for North America, Europe and the Pacific region. On the basis of a comparative analysis of water resources data by country according to different sources, FAO has compiled its best estimates of the main elements of the water balance for each country.

Chapter 2 presents the concepts and definitions used by Aquastat. Chapter 3 illustrates the methodology use to compute water resources by country, while Chapters 4 and 5 present and comment on the results at the world level and in an overview of its breakdown into ten regions. An annex (Annex 2) presents a summary table of the main water resources variables. All results are available on the Aquastat Web site.

Chapter 2
Concepts and definitions

The concept of water resources is multidimensional. It is not limited only to its physical measure (hydrological and hydrogeological), the ‘flows and stocks’, but encompasses other more qualitative, environmental and socio-economic dimensions. However, this report focuses on the physical and quantitative assessment of the resource.

Types of water resources

This report focuses on renewable water resources. These are defined as the average manual flow of rivers and recharge of aquifers generated from precipitation.It distinguishes between the natural situation (natural renewable resources), which corresponds to a situation without human influence, and the current or actual situation (Figure 1). The computation of the actual renewable water resources of a country takes account of possible reductions in flow resulting from the abstraction of water in upstream countries. The study also reviews available information on exploitable water resources, i.e. the part of the actual water resources available for beneficial use.

The focus is on freshwater resources. The data collected do not distinguish between different water qualities. Brackish, saline and non-conventional water sources are not accounted for.

Renewable and non-renewable water resources

In computing water resources on a country basis, a distinction is to be made between renewable and non-renewable water resources.

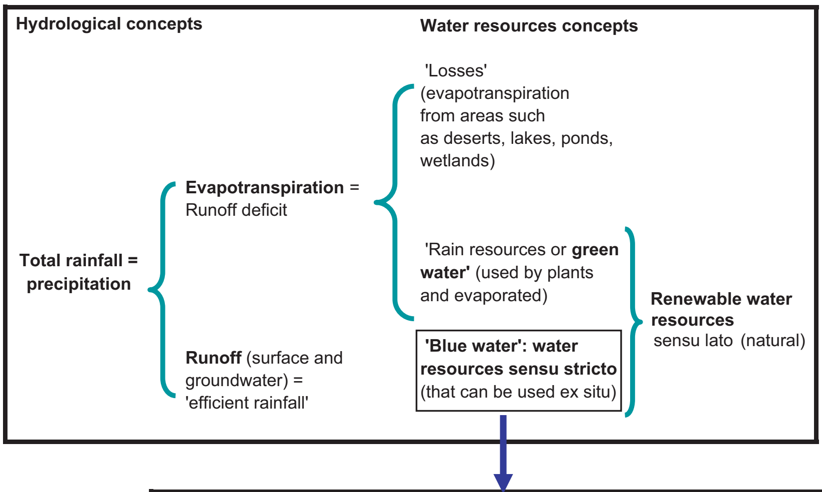
- Renewable water resources are computed on the basis of the water cycle. In this report, they represent the long-term average annual flow of rivers (surface water) and groundwater.
- Non-renewable water resources are groundwater bodies (deep aquifers) that have a negligible rate of recharge on the human time-scale and thus can be considered non-renewable.

Natural and actual renewable water resources

Natural renewable water resources are the total amount of a country’s water resources (internal and external resources), both surface water and groundwater, which is generated through the hydrological cycle. The amount is computed on a yearly basis.

This report also considers actual renewable water resources. These are defined as the sum of internal renewable resources (IRWR) and external renewable resources (ERWR), taking into consideration the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and possible reduction of external flow due to upstream water abstraction. Unlike natural renewable water resources, actual renewable water resources vary with time and consumption patterns and, therefore, must be associated to a specific year.

FIGURE 1
From hydrological concepts to water resources concepts



Different concepts of resources according to criteria

Constraints →		Political, economic	Political, social, economic, environmental
	Natural water resources = Potential or theoretical	**Actual** water resources (1)	**Exploitable or manageable** water resources (2)
Internal resources	Internal natural resources (IRWR)	Actual internal resources (with no constraints of water conservation for downstream country)	Exploitable internal resources
External resources	External natural resources	Actual external resources (taking into account the water reservation by an upstream country or for a downstream country) (3)	Exploitable external resources
Total water resources	**Total natural resources**	**Total actual resources (ARWR)**	**Total exploitable water resources**

Notes:

(1) Actual resources: when taking into account the resources shared with neighbouring countries (geopolitical constraints)

(2) Exploitable resources: according to socio-economic and environmental criteria.

(3) A country may have to reserve for downstream a part of its external resources (e.g. Sudan and Syria).

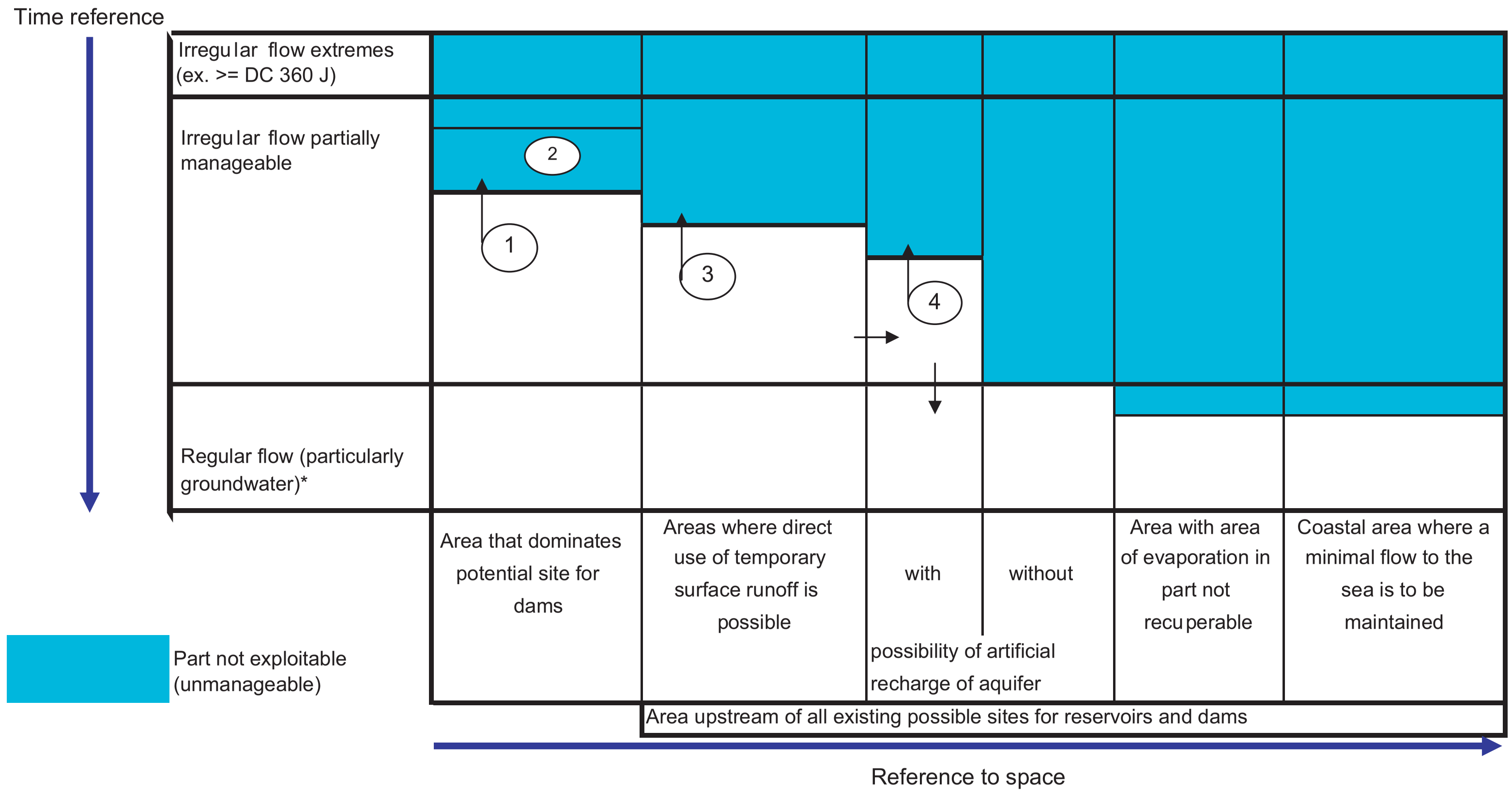
NB: Where one takes into account both the geopolitical constraints and the socio-economic and environmental criteria, one should speak of 'actual and manageable water resources'.

Source: FAO/BRGM, 1996.

Exploitable water resources

Not all natural freshwater, surface water or groundwater, is accessible for use. In this report, exploitable water resources (manageable water resources or water development potential) considers factors such as: the economic and environmental feasibility of storing floodwater behind dams or extracting groundwater; the physical possibility of catching water which naturally flows out to the sea; and the minimum flow requirements for navigation, environmental services, aquatic life, etc. (Figure 2).

FIGURE 2
Water: natural resources and technically exploitable resources



Notes:
1. According to the sum of the capacities of the reservoirs and the variability of the inflow.
2. Flow evaporated from reservoirs and dams (according to their surface).
3. According to the variability of the inflow.
4. According to the intake capacity of the aquifers.
* Reserved flow not included.

Source: FAO/BRGM, 1996.

This concept varies according to:

- natural conditions that may affect the development of water resources (regularity of the water regime, fragmentation of the hydrographic or hydrogeological systems, convenience of the sites for dams, and water quality);
- the importance of demand for water, which will determine the acceptability of internal and external costs of water development and management; it also involves arbitration for allocation between in situ use (reservation) and ex situ use or abstraction.

As it depends on the choice of a set of criteria (physical, socio-economic, environmental, etc.), this concept varies from country to country. It can also evolve according to demand pressures. However, it represents a realistic vision of the renewable resources available for use in a given situation and period.

In general, exploitable resources are significantly smaller than the natural resources (Box 1). Preferably, national data on exploitable water resources should be completed by an indication of the set of criteria considered.

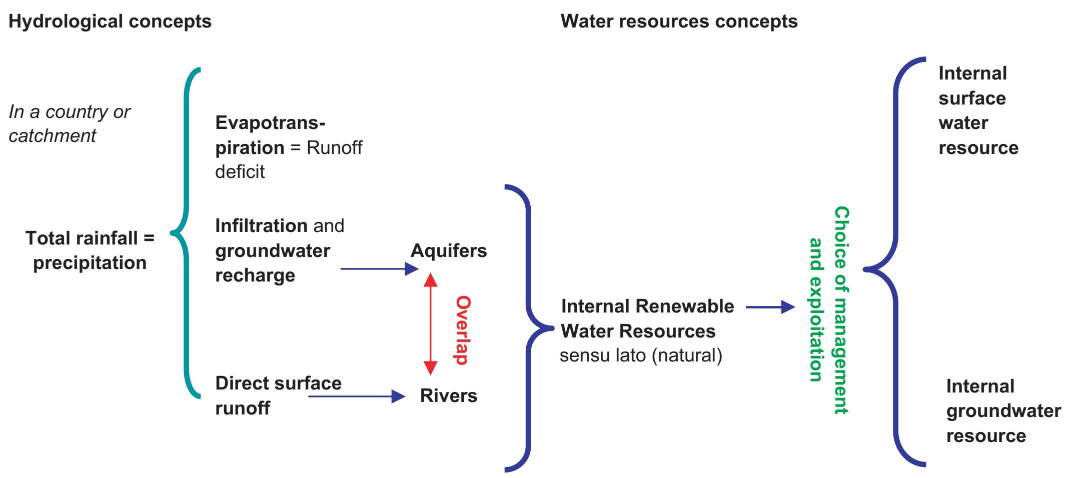
Box 1 – Exploitable water resources in Lebanon

The case of Lebanon illustrates the difference between water resources and exploitable water resources. A large part of the country's water resources is hardly exploitable. The groundwater losses to the sea that are accounted for in the assessment of potential yield (about 0.7 km^3/year) come out as submarine springs. These resources are difficult to mobilize as the karstic channels in which the water flows are subject to mixing with saline water. Similarly, the floodwater running from the small watersheds of the coastal mountains is lost to the sea with little possibility of putting it to beneficial use. Thus, out of total water resources estimated at 4.8 km^3/year, exploitable water resources represent about 2.2-2.5 km^3/year.

Internal renewable water resources, surface water and groundwater

Internal renewable water resources (IRWR) is that part of the water resources (surface water and groundwater) generated from endogenous precipitation (Figure 3). The IRWR figures are the only water resources figures that can be added up for regional assessment and they are used for this purpose.

Figure 3
Surface water and groundwater concepts



Source: FAO/BRGM, 1996.

Although the hydrological cycle links all waters, surface water and groundwater are usually studied separately and represent different development opportunities. Surface water is the water of rivers and lakes; groundwater is the water captured in underground reservoirs.

Surface water flows can contribute to groundwater replenishment through seepage in the river bed. Aquifers can discharge into rivers and contribute their base flow, the sole source of river flow during dry periods. Therefore, the respective flows of both systems are not wholly additive. This report uses the concept of overlap to define the part of the country's water resources that is common to rivers and to aquifers.

External water resources

This study defines external water resources as the part of a country's renewable water resources that enter from upstream countries through rivers (external surface water) or aquifers (external groundwater resources). The total external resources are the inflow from neighbouring countries (transboundary flow) and a part of the resources of shared lakes or border rivers, defined for the purposes of this study through an arbitrary rule (unless defined by an agreement or treaty).

Most of the inflow consists of river runoff, but it can also consist of groundwater transfer between countries (e.g. between Belgium and France, Bulgaria and Romania, or Sudan and Egypt). However, groundwater transfers are rarely known and their assessment requires a good knowledge of the piezometry of the aquifers at the border. In arid areas, they may be important in comparison with surface flow.

In assessing the external flow of a country, this report distinguishes between natural incoming flow and actual incoming flow.

- Natural inflow is the average annual amount of water that would flow into the country in natural conditions, i.e. without human influence.
- Actual inflow is the average annual quantity of water entering the country, taking into account that part of the flow which is secured through treaties or agreements and possible water abstraction in upstream countries.

Outflow

Outflow is the flow of water leaving a country to the sea or to neighbouring countries. Part of the outflow to neighbouring countries may be subject to reservation where a treaty or an agreement allocates a certain flow to a downstream country. This is reflected in the computation of actual water resources by subtracting the allocation for the country's water resources.

Water quality and non-conventional water sources

Water quality

Differences in water quality may be significant locally but are difficult to aggregate in a meaningful way at national level. In addition, water quality must be expressed not only in terms of physical, biological and chemical variables, but also according to quality standards that vary according to use. Therefore, the evaluation of water quality requires the use of a water quality grid, defining quality classes according to several criteria and variables.

Box 2 – Blue water and green water

Although this study does not address these concepts, it is useful to clarify them in order to avoid misinterpreting some of the information presented in the study.

Rainfall may either flow on the surface or underground. It may finally reach the sea or it may return to the atmosphere, evaporated or consumed by the vegetation (two universal paths of the water cycle). In general, only the first type is considered 'water resources' offered by nature to humans. This is especially the point of view of hydrologists, who measure or assess them, and of developers. They consider evaporation as 'losses' (there are only lost for runoff). The use of words such as efficient rainfall or useful rainfall are significant in this regard. However, from an ecological point of view, it is excessive to judge such 'water resources' as useless because they maintain soil moisture and nourish natural and cultivated vegetation in rainfed systems.

Both hydrologists and agronomists distinguish two types of water: blue water and green water. They cannot be summed but contribute to the water potentialities of a country:

- Blue water is the source of supply. It is equivalent to the natural water resources (surface and groundwater runoff).
- Green water is the rainwater directly used and evaporated by non-irrigated agriculture, pastures and forests.

In theory, green water can be assessed as it corresponds (as a maximum) to the volume of the actual evapotranspiration or to the runoff deficits of each catchment. However, such a global calculation is meaningless for local flows that cannot be aggregated by groups of surface units as can be done for blue water. Comparing the difference between the green water and the theoretical needs of the crops is an average indicator for the irrigation needs.

This report considers only inland freshwater and does not distinguish categories according to water quality levels, owing to the unavailability of reliable information. Therefore, it assumes that the water resources it computes are of sufficient quality for beneficial use for agricultural, domestic or industrial purposes.

In countries where freshwater resources are scarce and under pressure, the assessment of freshwater resources is often complemented by an assessment of the available brackish water that can be used for specific purposes (desalination, some types of agricultural production).

Non-conventional water sources

With increasing pressure on natural freshwater in parts of the world, other sources of water are growing in importance. These non-conventional sources of water represent complementary supply sources that may be substantial in regions affected by extreme scarcity of renewable water resources. Such sources are accounted for separately from natural renewable water resources. They include:

- the production of freshwater by desalination of brackish or saltwater (mostly for domestic purposes);
- the reuse of urban or industrial wastewaters (with or without treatment), which increases the overall efficiency of use of water (extracted from primary sources), mostly in agriculture, but increasingly in industrial and domestic sectors. This category also includes agricultural drainage water.

This study does not consider non-conventional water sources in the computation of freshwater resources. Where available, the tables give an indication of the water produced by desalination (FAO, 1997b; Gleick, 2000). Moreover, this report concentrates on 'blue water'and does not consider what is often termed 'green water' (Box 2).

Chapter 3
Method used to compute water resources by country

The method used to assess renewable water resources by country was first described in FAO/BRGM (1996). It consists of a set of rules and guidelines leading to the calculation of the IRWR, the total renewable water resources (TRWR), and the country's dependency ratio.

The method is based on a water resources accounting approach. The TRWR of a country consist of the IRWR plus the external water resources. The IRWR are the amount of water generated inside a country, and the ERWR are the amount of water generated in countries upstream. To avoid double counting, the IRWR is the only variable that can be aggregated for regional or continental assessments.

In order to calculate ERWR, a distinction has been made between natural and actual ERWR. The natural ERWR refer to the amount of water flowing to a country from upstream under natural circumstances. The actual ERWR refer to the amount of external water resources actually available to the country taking into consideration upstream water abstraction and possible agreements with upstream and/or downstream countries.

The TRWR are generally not equal to the amount of water available for use. Therefore, where possible, a compilation has been made of estimations of exploitable water resources per country and included in the country results.

The calculation of renewable water resources is based on long-term averages as available in existing, preferably national, literature. Figure 4 illustrates the hydrological cycle and the components of the country water resources calculations. Figure 5 presents the standard spreadsheet used in the computation and shows the various components of the calculations.

The method consists of the following steps (for each country):

1. Select the most accurate data sources.
2. Assess the IRWR.
3. Assess the natural and actual external water resources entering and leaving the country.
4. Assess the TRWR (actual and natural).
5. Calculate the country's dependency on external water: the dependency ratio.
6. Ensure consistency between countries by cross-checking inflows and outflows between countries.

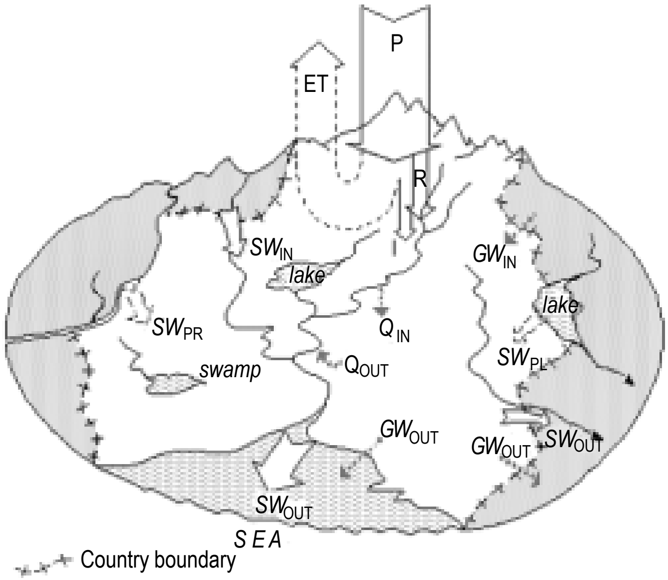
The Aquastat computation sheet (Figure 5) is used to calculate: (i) the IRWR; (ii) the ERWR; (iii) the TRWR; and (iv) the dependency ratio in annual averages (km^3/year).

DATA SOURCES

The data used in computing water resources originate from multiple sources, including grey literature. Most of the data originate from national sources (priority is systematically given to national sources over international reports). A major part of the data originates from the country surveys carried out for 150 countries within the Aquastat programme between 1993 and 2000. A compilation of the individual sources by country is available on the Aquastat Web site (www.fao.org/ag/agl/aglw/aquastat/main/index.htm).

Prior to the calculation, the information collected through the surveys was evaluated, mostly through cross-checking and by comparing the level of detail of the estimates. However, the methodologies behind the estimation of the individual components of the water balance were not always well documented. This made the evaluation more complex.

FIGURE 4
The components of the calculation of water resources by country



Note: P = precipitation, ET = evapotranspiration (sum of the local evapotranspiration and the evaporation from lakes, swamps, etc.), R = total river flow, I = groundwater recharge, Q_{IN} = infiltration of surface water to groundwater, Q_{OUT} = outflow of groundwater to surface water, SW_{IN} = surface water entering the country, SW_{OUT} = surface water leaving the country, GW_{IN} = groundwater entering the country, GW_{OUT} = groundwater leaving the country, SW_{PL} = part of surface water in border lakes, SW_{PR} = part of surface water in border rivers.

Finally, the information in this review stems from multiple sources, with different periods of reference that might vary from country to country. Moreover, the original data were acquired through different methodologies and assumptions, and they might have been extrapolated in time and space. Such variations complicate attempts to determine comparable outcomes.

Figure 5 notes
(1) Overlap between surface and ground water = less than 50 % of groundwater recharge ; only a small part of the groundwater is drained by the rivers (equal to the low flow of water courses). Most of the groundwater escapes and flow out into the sea, or into sebhat in arid areas. In addition, there is probably some infiltration from surface water.
(2) Exploitable resources according to tunisian sources. The exploitability criteria is probably technico-economical. Another tunisian source (Ennabli, 2000) indicate a lower figure : only 1.9 km3/yr are exploitable.
(3) Tunisia has non renewable resources in the south, estimated to be 0.6 km3/yr, extractable over a period of time (50 years?).
Comment (comparison with modelled data)
FAO/AGLW model to assess internal resources based on rainfall, evapotranspiration, and calibration on flow measurement gives 3.2 km3/yr; so slightly lower than the national figure (9 % difference). The difference is not significant.
Source
BP/JM, 2001 from tunisian sources.

FIGURE 5
The Aquastat computation sheet

AQUASTAT

Computation of renewable water resources by country (km^3/year, average)

Country: Tunisia

INTERNAL RENEWABLE WATER RESOURCES (IRWR)

		Source FAO 1997		Area country					
Precipitation		207	mm/yr	16 361 000	ha			33.867	km^3/yr
Water resources produced internally in a 10th frequency dry year									
Surface water produced internally (R)	a	3.100							
Groundwater produced internally (I)	b	1.450							
Overlap (Q_{IN}-Q_{OUT})						0.400	c	(1)	
Total internal renewable water resources		4.550			-	0.400	=	4.150	
		=a+b				=c		d=a+b-c	

EXTERNAL RENEWABLE WATER RESOURCES

		Natural		Actual				
Surface water								
Surface water entering the country (SW_{IN})	e	0.310				From Algeria		
Inflow not sumitted to treaties		0.310		0.310	f			
Inflow submitted to treaties								
Inflow secured through treaties					g			
Accounted inflow		0.310		0.310				
		h=e		i=f+g				
Flow in border rivers (SW_{PR})								
Total flow of border rivers		0.000						
Accounted flow of border rivers	j		k					
Shared lakes (SW_{PL})								
Accounted part of shared lakes	l	0.000			m			
Surface water leaving the country (SW_{OUT})	n	0.160						
Outflow not submitted to treaties				0.160		To Algeria		
Outflow submitted to treaties								
Flow to be reserved by treaties							o	
Surface water: total external (natural)	p=h+l+j	0.310						
Surface water: total external (actual)			q=m+k+f+g	0.310	-	0.000	=	0.310
						r=o		a1=q-r
Groundwater								
Groundwater entering the country (GW_{IN})	s	0.100		From Algeria				0.100
								a2
Groundwater leaving the country (GW_{OUT})	t	0.000			u			
Total								
Total external water resources (natural)	v=p+s	0.410					w=v	0.410
Total external water resources (actual)							x=a1+a2	0.410

TOTAL RENEWABLE WATER RESOURCES (TRWR)

		Total		
		Natural	Actual	
Surface water: total	y=a+p	3.410	3.410	aa=a+a1
Groundwater: total	z=b+s	1.550	1.550	bb=b+a2
Overlap	c	0.400	0.400	c
Water resources: total	wn=y+z-c	4.560	4.560	wa=aa+bb-c
Dependency ratio			8.99 %	=100*(q+a2)/(q+a2+d)

EXPLOITABLE WATER RESOURCES

Regular renewable surface water	bb	0.300			
Irregular renewable surface water	cc	2.175			
Regular renewable groundwater	dd	1.150			
Exploitable water resources: Total	=bb+cc+dd	3.625	(2)		
Non renewable resources		0.600	Nb of years	?	(3)

Assessing internal renewable water resources

The IRWR are equal to the volume of average annual flow of surface water and groundwater generated from precipitation within the country (Equation 1):

$$IRWR = R + I - \underbrace{(Q_{OUT} - Q_{IN})}_{overlap} \qquad \text{(Equation 1)}$$

where:

R = surface runoff, the total volume of the long term average annual flow of surface water generated by direct runoff from endogenous precipitation;

I = groundwater recharge, generated from precipitation within the country;

Q_{OUT} = groundwater drainage into rivers (typically, base flow of rivers);

Q_{IN} = seepage from rivers into aquifers.

Although they are linked through the hydrological cycle, surface water and groundwater resources are often computed separately. Therefore, a simple addition of surface water and groundwater leads to an overestimation of the total amount of freshwater resources produced in the country. In this study, the exchange between the surface water and groundwater resource is called overlap. Box 3 illustrates the complexity of surface water and groundwater interdependency in humid and arid countries and the method used to compute overlap.

Scale and impact of evaporation

Evaporation in rivers, swamps, lakes or large irrigation schemes can have an influence on the estimation of the IRWR (Box 4). In arid areas in large countries, there is a high probability that part of river runoff is lost by evaporation before leaving the country (in some cases, rivers flow to salty depressions where water cannot be put to beneficial use). In such cases, surface water resources should be assessed by measuring runoff upstream of the major loss areas, where they reach their maximum value.

Assessing external renewable water resources and total resources

The ERWR are equal to the volume of average annual flow of rivers and groundwater entering a country from neighbouring countries (Equation 2):

$$ERWR_{natural} = SW_{IN} + SW_{PR} + SW_{PL} + GW_{IN} \qquad \text{(Equation 2)}$$

where:

SW_{IN} = surface water entering the country;

SW_{PR} = accounted flow of border rivers;

SW_{PL} = accounted part of shared lakes;

GW_{IN} = groundwater entering the country.

Although inflow from other countries usually consists of river runoff, it can also consist of groundwater transfer between countries in arid regions. However, groundwater transfers are rarely known and their assessment requires good knowledge of the general behaviour of the aquifers. Where groundwater resources estimates are based on groundwater flow as derived

Box 3 – Surface water and groundwater interdependency or overlap

Summary of the approaches applied for estimating the overlap:

Humid areas

In humid areas, IRWR are assessed from available hydrographs (time-series data on measured surface water discharge). For areas where no measurements are available, data is extrapolated over space from areas where data is available. Where necessary, measured data are corrected to take water abstraction into account. In humid areas, the base flow of rivers consists mainly of drainage of groundwater reservoirs. Thus, estimates of surface water resources include a significant part of the groundwater resources. Therefore, the groundwater resources in humid areas have been assumed to be equal to the base flow of the rivers where data are available.

Semi-arid areas

In semi-arid areas, IRWR are generated mainly from flash-flood events. The groundwater resources are obtained from rainfall infiltration estimates or from analyses of measured groundwater levels/heads in aquifers. The surface water resources are estimated through flash-flood discharge measurements or estimates. Care is required to ensure the correct assessment of the part of surface water flows that recharges the aquifers in order to avoid overestimation of the total water resources.

In **coastal** or **very arid areas**, a large part of the groundwater aquifers is not drained by the rivers and overlap is therefore relatively small.

Examples of relation between surface water and groundwater:

Surface water and groundwater base flow in Morocco: The total groundwater resource equivalent to the aquifer recharge is estimated at 10 km^3/year, of which 3 km^3/year corresponds to the base flow of rivers.

Recharge of aquifer by floods in the Islamic Republic of Iran: The contribution of surface water (floods) to aquifer recharge is estimated at 12.7 km^3/year, out of the total IRWR of 128.75 km^3/year.

Surface water and base flow in Kyrgyzstan: The total groundwater resource equivalent to the aquifer recharge is estimated at 13.6 km^3/year, of which 11.2 km^3/year are drained by the surface hydrologic network, which corresponds to the base flow of rivers. Therefore, the overlap in this case is 11.2 km^3/year.

Box 4 – Influence of evaporation on IRWR

In arid countries, losses by evaporation from wetlands, lakes and rivers reduce the entire flow generated in the country. Losses by evaporation, associated with infiltration, may reduce significantly the surface water flow after it leaves the mountainous part of the basin from where it originates. The losses may reach 100 percent in the case of endorheic basins ending up in evaporative areas called chotts or sebkhas. However, there is a difference between losses in salt-affected evaporative areas, where water does not contribute to any biomass production, and losses in swamp areas, where evapotranspiration produces biomass to sustain aquatic and terrestrial life.

In countries belonging to large international river basins, evaporation losses in swamps and in the river itself may exceed the total IRWR. However, it is difficult to assess the actual evaporation in wetlands, lakes and rivers. For large lakes and dams, actual evaporation is approximated as equal to the potential evaporation. For some countries in Africa, a fair estimate of the net evaporation (this is evaporation minus precipitation, and it is different from potential evaporation) was computed and abstracted from the original national source of the total IRWR where it was known that no corrections had been carried out beforehand. This is the case for Sudan, where the national estimate of evaporation in the wetlands is 68 km^3/year, which corresponds to double the country's IRWR and 45 percent of its TRWR.

Examples of evaporation losses:

- In the province of Yaérés, Cameroon, evaporation from swamps amounts to 5 km^3/year.
- From the Aswan Reservoir in Egypt, it is estimated that 10 km^3/year is lost by evaporation.
- In the inner delta of the Niger River, Mali, evaporation is estimated at 33 km^3/year, equivalent to 50 percent of the country's IRWR.

In humid areas, actual evaporation from rivers, lakes and wetlands represents a smaller amount of the total IRWR in comparison with arid countries.

from the characteristics of the aquifers and piezometric levels, the calculated flow does not correspond necessarily to renewable resources. There are many cases of transboundary flows that are related to the slow draining of huge groundwater reservoirs with negligible upstream recharge.

In the case of bordering rivers and shared lakes, an arbitrary 50-percent rule was applied to distribute the water evenly between two countries. This rule does not imply any consideration of judgement on possible or effective ways of sharing the resources of a border river. The difficulties encountered in setting these computation rules illustrate the arbitrary aspects of the computation of total water resources for bordering water bodies. In some cases, there are known agreements (Box 5).

Box 5 – Examples of shared rivers

1. Shared river completely submitted to a treaty
Nile River transboundary between Egypt and Sudan

- Total natural discharge (average): 84 km^3/year
- Sharing by treaty:
  Egypt: 55.5 km^3/year,
  Sudan: 18.5 km^3/year,
  Losses by evaporation of storage: 10 km^3/year.

2. Shared river partially submitted to an agreement
Syr Darya River (Aral Sea Basin in Central Asia)
Distribution by agreement defined in 1992:
Kazakhstan: 14.5 km^3/year,
Kyrgyzstan: 4.92 km^3/year,
Tajikistan: 7.15 km^3/year,
Uzbekistan: 10.53 km^3/year.

3. Shared river partially submitted to a treaty
Tagus River shared between Portugal and Spain
Total natural average discharge: 18.65 km^3/year:
with a part produced in Spain: 12.2 km^3/year,
with a part produced in Portugal: 6.45 km^3/year.
Average actual flow at the Spanish border with Portugal:
Actual = 9.76 km^3/year
Forecast for 2012 = 9.18 km^3/year.

This study makes a distinction between actual and natural ERWR. The actual ERWR take into account the quantity of flow reserved by upstream (incoming flow) and/or downstream (outflow) countries through formal or informal agreements or treaties, and possible water abstraction occurring in the upstream country. Therefore, the actual ERWR may vary with time. In extreme cases, the value may be negative when the flow reserved to downstream countries is more than the incoming flow (Equation 3).

$$ERWR_{actual} = SW^{1}_{IN} + SW^{2}_{IN} + SW_{PR} + SW_{PL} - SW^{*}_{OUT} + GW_{IN} \quad \text{(Equation 3)}$$

where:

SW^{1}_{IN} = volume of surface water entering the country which is not submitted to treaties;
SW^{2}_{IN} = volume of surface water entering the country which is secured through treaties;
SW_{PR} = accounted flow of border rivers;
SW_{PL} = accounted part of shared lakes;
SW^{*}_{OUT} = volume of surface water leaving the country which is reserved by treaties for downstream countries;
GW_{IN} = groundwater entering the country.

The term treaty is used in a broad sense and does not necessarily imply formal acceptance on both sides of a border about the amount of water to be reserved for each country. Furthermore, treaties cannot always be expressed uniquely in terms of annual flows, and interpretation might be needed for the purpose of this computation. For example, in the Aral Sea Basin, the flow allocation for the individual countries is expressed as a percentage of the actual resources in the basin. Therefore, the amount they receive depends on the amount available, which varies from year to year.

Box 6 describes the rules used to calculate the different components of the water resources. They are neither absolute nor universal. They have been selected to represent all the situations

Box 6 – Rules applied for computing ERWR

Surface water entering the country (SW_{IN})

The mean annual flow measured or estimated at the border of the transboundary river is accounted for as an external resource for the downstream country. It is not deducted from the resources of the donor country except in the case of an agreed apportionment, i.e. a treaty between the countries. Because of the existence of bilateral and multilateral agreements and upstream water consumption, two categories of external water resources are differentiated:

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

A particular case is the situation where part of the runoff entering the country originates in the country itself after it has entered and exited a neighbouring country. In such a case, and where the information is available, this flow is deducted from the incoming flow to avoid double counting. Therefore, net inflows are considered over the country borders. For example, the Pripyat River originates in Ukraine and flows to Belarus where it joins the Dniepr River before it enters Ukraine. In this case, the flow of the Pripyat River from Ukraine to Belarus (5.8 km^3/year) is deducted from the flow of the Dniepr River to Ukraine (32 - 5.8 km^3/year).

Flow in border rivers (SW_{PR})

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

- Where the river exclusively borders the countries without entering any of the adjacent countries nor exiting from them (e.g. the Senegal River between Mauritania and Senegal, the Zambezi River between Zambia and Zimbabwe, and the Prut River between the Republic of Moldova and Romania), the incoming resources are estimated on the basis of the river runoff in the upstream part of the border section. Where the runoff increases substantially from upstream to downstream, the downstream figure is used after subtraction of the part of the runoff generated by the country itself.
- Where the source of the river is in one of the two countries, the rule applies only for the other country. For the originating country, 50 percent of the contribution from the other country could similarly be considered as external resources where known (e.g. the Samur River, which originates in the Russian Federation before it becomes the border between the Russian Federation and Azerbaijan).
- Where the river enters one of the two countries after having divided the two countries, it is considered a transboundary river for the receiving country and all the runoff at the entry point in that country is considered as an external resource. The 50-percent rule applies for the other country.
- Where a treaty exists between the adjacent countries of a river system, the rules applied are those defined in the treaty.

Shared lakes (SW_{PL})

- Where the lake has an outlet into a river (e.g. Lake Victoria enters the Nile River in Uganda), all the runoff at the entrance of the river is accounted for as external resources for the receiving country.
- For all the other countries, an equal share of this runoff can be considered as external resources, after having subtracted the country contribution to the lake. Where this results in a negative value, the external resources are considered to be zero for the country in question. Where the river forms the border between two countries, the rule described above for border rivers applies.
- For lakes without an outlet, the global runoff entering the lake is estimated and shared equally between the adjacent countries, after having deducted the part contributed from the country. Where this results in a negative value, the external resources are considered to be zero for the country in question.
- Artificial lakes have not been accounted for as the flow reduction is an impact of water development and not a natural phenomenon.

Surface water leaving the country (SW_{OUT})

The computation of actual ERWR considers the outflow of surface water only in the case of an agreed apportionment between the upstream and downstream countries.

Groundwater entering the country (GW_{IN})

The mean annual estimated groundwater flow entering the country is accounted for as an external resource.

Groundwater leaving the country (GW_{OUT})

The computation of ERWR does not consider outflow of groundwater.

in the most realistic way possible. Figure 5 presents the standard computation sheet, in which these rules have been applied for the Syrian Arab Republic.

Assessing total renewable water resources and the dependency ratio

The TRWR is the sum of the IRWR and the total ERWR. As with the ERWR, a distinction has been made between the total natural and actual renewable water resources (Equations 4 and 5):

$$TRWR_{natural} = IRWR + ERWR_{natural} \qquad \text{(Equation 4)}$$

where:

IRWR = internal renewable water resources (Equation 1),

$ERWR_{natural}$ = natural external renewable water resources (Equation 2);

$$TRWR_{actual} = IRWR + ERWR_{actual} \qquad \text{(Equation 5)}$$

where:

IRWR = internal renewable water resources (Equation 1),

$ERWR_{actual}$ = actual external renewable water resources (Equation 3).

In order to compare how different countries depend on external water resources, the dependency ratio is calculated. The dependency ratio of a country is an indicator expressing the part of the water resources originating outside the country (Equations 6 and 7).

$$\text{Dependency ratio} = \frac{IWR}{IRWR + IWR} \times 100 \text{ percent} \qquad \text{(Equation 6)}$$

$$IWR = SW_{IN}^{1} + SW_{IN}^{2} + SW_{PR} + SW_{PL} + GW_{IN} \qquad \text{(Equation 7)}$$

where:

IWR = total volume of incoming water resources from neighbouring countries,

IRWR = internal renewable water resources,

SW^1_{IN} = volume of surface water entering the country which is not submitted to treaties,

SW^2_{IN} = volume of surface water entering the country which is secured through treaties,

SW_{PR} = accounted flow of border rivers,

SW_{PL} = accounted part of shared lakes,

GW_{IN} = groundwater entering the country.

This indicator may theoretically vary between 0 and 100 percent. A country with a dependency ratio equal to zero does not receive any water from neighbouring countries. A country with a dependency ratio equal to 100 percent receives all its water from outside without producing any. The indicator does not consider the possible allocation of water to downstream countries.

Assessing exploitable resources

In some cases, countries have estimated the part of their water resources which is exploitable. Where available, the figures on exploitable resources have been included in the spreadsheet as a reference. In general, not all the natural or actual renewable water resources are accessible because of economic, technical and environmental constraints. Therefore, the exploitable

BOX 7 – ASSESSING EXPLOITABLE WATER RESOURCES IN EGYPT

This box presents water withdrawal in Egypt by source of water. The actual primary resource corresponds to the actual TRWR (58.3 km^3/year). If this estimation alone were compared with the actual water withdrawal (66 km^3/year), it would indicate an overexploitation. However, it is not the case here because return flow and infiltration from agricultural fields (secondary resources) represent significant elements in the country's water balance.

Actual primary resources:	58.3 km^3/year
(groundwater, and surface water, internal and external)	
Secondary resources:	8.1 km^3/year
infiltration of irrigation water to groundwater:	4.0 km^3/year
drainage water and conveyance losses returned to the Nile River	4.1 km^3/year
Total exploitable water resources	66 km^3/year
(of which withdrawals of groundwater amount to 5.3 km^3/year plus reuse)	

Source: Amer, 1999.

resources may be significantly smaller than the TRWR. In some exceptional cases, the method used to assess exploitable water resources includes return flow from irrigated fields. This may lead to an estimate of exploitable water resources that is higher than the TRWR, e.g. Egypt (Box 7).

Remarks

National-level data provide an idea of the water situation of a country but they hide the local diversity, particularly in large countries. Therefore, it would be preferable to examine each watershed. Table 1 presents watershed data on Spain as an illustration of the variability of water resources situations within a country.

When examining flows of water between countries, cross-checking of transboundary flows is important. This study used matrices showing exchanges between upstream and downstream countries in order to compare inflow and outflow values and to ensure the overall consistency of the computation of country water resources. Matrices allow for a more detailed representation of the flows between countries and avoid double counting of transboundary (external) flows (they do not consider border rivers) (Figure 6).

TABLE 1
Water resources per watershed in Spain

Total Spain	Watershed	Internal resources	Water resources per capita (1995)	Exploitation index (1995)
		hm^3/year	m^3/year	%
Catchments /cuencas	Total Spain	111 186	2 843	40
	Galicia coast	12 250	6 247	8
	Norte 1	12 689	14 738	6
	Norte 2	13 881	8 616	5
	Norte 3	5 337	7 459	11
	Duero	13 660	6 243	35
	Tajo	10 883	1 786	47
	Guadiana1	4 414	3 339	65
	Guadiana 2	1 061	2 814	26
	Guadalquivir	8 601	1 809	55
	Sur	2 351	1 177	72
	Segura	803	579	285
	Júcar	3 432	838	108
	Ebro	17 967	6 526	72
	Internal watershed of Cataluna	2 787	501	61
	Balearic islands	667	908	54
	Canary Islands	409	263	131

Note:
Exploitation index (%): withdrawals of conventional freshwater resources (surface and groundwater) over total renewable resources (expressed in %).
Source: CEDEX, 2000.

FIGURE 6
Example of transboundary exchanges in Eastern Europe, km³/year

Countries receiving external flows

COUNTRY	BELARUS	MOLDOVA	UKRAINE *	LATVIA	LITHUANIA	RUSSIAN FED.	POLAND	HUNGARY	ROMANIA	TOTAL
BELARUS			Dnepr 19.300 Pripyat (of which 5.8 orig. in Ukraine) 12.700	Daugava (W. Dvina) 14.300	Nemunas 6.800 Tributaries 2.500	0.000	Bug (border) 2.5 of which 0.2 orig. in Belarus not counted			
			32.000	14.300	9.300	0.000	0.000			55.600
MOLDOVA			Dnestr (of which 9.2 orig. in Ukraine) 9.840 Other 0.110							
			9.950							9.950
UKRAINE	Pripyat 5.800	Dnestr 9.200 Prut (border) = 2.90/2 =1.450				Northern Don 3.900	Bug 1.800 San 0.100	Cisa 6.500	Prut (border) = 2.90/2 =1.450	
	5.800	10.650				3.900	1.900	6.500	1.450	30.200
LATVIA	0.000				0.000	Velika 0.670				
	0.000				0.000	0.670				0.670
LITHUANIA	0.000			Lielupe 2.000 Daugava 0.500 Venta 1.300 W. Coast 0.210		Nemunas 0.840 Pregel 0.010	0.000			
	0.000			4.010		0.850	0.000			4.860
RUSSIAN FED.	Dnepr 7.700 W. Dvina 7.200		Northern Don 1.200 Desna ?	0.000	Nemunas (border) not counted		0.000			
	14.900		1.200	0.000	0.000		0.000			16.100
POLAND	Neman 0.100 Bug (border 2.3/2) not counted		0.000		Nemunas 0.040	Pregel 1.990		x ?		
	0.100		0.000		0.040	1.990				2.130
HUNGARY			0.000							
			0.000						0.000	0.000
ROMANIA		0.000	Danube (border) (of which 6.5 + 2.9 orig. in Ukrine) = 126/2 = 63.000							
		0.000	63.000					0.000		63.000
T O T A L	20.800	10.650	106.150	14.300	9.340	5.890	1.900	6.500	1.450	

* : Ukraine receiving: from Europe: 106.150 km³/year. Table water resources: 86.450 km³/year. Difference: 19.7 = 5.8 (Pripyat) + 9.2 (Dnestr) + (2.9 + 6.5)/2 (border Prut and Cisa).

Chapter 4
World water resources by country

Summary of world water resources

This chapter presents the results of the study for the world (Annex 3 Maps 1 and 2). Chapter 5 further develops the analysis of the results for ten large regions of the world showing distinct climate characteristics.

World water resources

Table 2 presents the results of the global water resources review by region (Annex 3 Map 3). This section comments briefly on the particularities which can be observed on a large scale across the world, as well as difficulties which emerge from the information collected. The table in Annex 2 provides details on individual countries and territories. It presents internal, external and total water resources computed according to the method described in Chapter 3 (differentiating between natural and actual resources). It does not indicate the exploitable resources and the non-renewable resources as figures are available for only a few countries. Figures for water resources per inhabitant are as in 2000.

The total water resources in the world are estimated in the order of 43 750 km^3/year, distributed throughout the world according to the patchwork of climates and physiographic structures. At the continental level, America has the largest share of the world's total freshwater resources with 45 percent, followed by Asia with 28 percent, Europe with 15.5 percent and Africa with 9 percent.

In terms of resources per inhabitant in each continent, America has 24 000 m^3/year, Europe 9 300 m^3/year, Africa 5 000 m^3/year and Asia 3 400.1 m^3/year.

The distribution of water

At a country level, there is an extreme variability in TRWR: from a minimum of 10 m^3/inhabitant in Kuwait to more than 100 000 m^3/inhabitant in Canada, Iceland, Gabon and Suriname. For 19 countries or territories, the TRWR per inhabitant are less than 500 m^3; and the number of countries or territories with less than 1 000 m^3/inhabitant is 29. The ten poorest countries in terms of water resources per inhabitant are Bahrain, Jordan, Kuwait, Libyan Arab Jamahirya, Maldives, Malta, Qatar, Saudi Arabia, United Arab Emirates and Yemen. In the large countries, water resources are also distributed unevenly in relation to the population.

In addition to spatial variability, there is a high variability in time within the year or among different years. This study does not include temporal variability but Shiklomanov (2000) provides estimates on a 67-year data set of the minimum and maximum internal resources for 50 countries.

Table 2
World water resources, by region

	Region	Total area (km^2) (FAOSTAT, 1999) (1)	Total population (FAOSTAT, 2000) (2)	Average precipitation 1961-1990 (km^3/year) (IPCC) (3)	Internal resources: total (km^3/year) (4)	External resources: natural (km^3/year)		External resources: actual (km^3/year)	Total resources: natural (km^3/year)	Total resources: actual (km^3/year)	% of world resources	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
1	Northern America	21 899 600	409 895 363	13 384	6 662	47	(5)	47	6 709	6 709	15.2%	16 253	16 368
2	Central America and Caribbean	749 120	72 430 000	1 506	781	6	(6)	6	787	787	1.8%	10 784	10 867
3	Southern America	17 853 960	345 737 000	28 635	12 380	0		0	12 380	12 380	28.3%	35 808	35 808
4	Western and Central Europe	4 898 416	510 784	4 096	2 170	11		11	2 181	2 181	5.0%	4 249	4 270
5	Eastern Europe	18 095 450	217 051 000	8 452	4 449	244		244	4 693	4 693	10.2%	20 498	21 622
6	Africa	30 044 850	793 288 000	20 415	3 950	0		0	3 950	3 950	9.0%	4 980	4 980
7	Near East	6 347 970	257 114 000	1 378	488	3		3	491	491	1.1%	1 897	1 909
8	Central Asia	4 655 490	78 563 000	1 270	261	28		28	289	289	0.6%	3 321	3 681
9	Southern and Eastern Asia	21 191 290	3 331 938 000	24 017	11 712	8		8	11 720	11 720	26.8%	3 515	3 518
10	Oceania and Pacific	8 058 920	25 388 537	4 772	911	0		0	911	911	2.1%	35 869	35 869
	World	**133 795 066**	**6 042 188 900**	**107 924**	**43 764**	**0**		**0**	**43 764**	**43 764**	**100.0%**	**7 243**	**7 243**

Notes:

(1) No FAOSTAT data for Spitsbergen (Norway).

(2) No FAOSTAT data for West Bank (Palestinian Authority); data from Margat and Vallée (2000).

(3) No IPCC data on Near East (Saudi Arabia, West Bank (Palestinian Authority), Gaza Strip (Palestinian Authority)), South Asia (Taiwan Province of China, East Timor), Caribbean (Aruba), Pacific (Polynesia, Guam) so not included in total. For Europe: no IPCC data for Spitsbergen (Norway), Luxembourg and Belgium; national data source used.

(4) No data for various islands in Caribbean (Aruba, Bermuda, Granada, Guadeloupe, Martinique, St. Lucia, St. Vincent, Dominica) Pacific (French Polynesia, Guam, New Caledonia, Samoa, Tonga), Asia (Macao, Hong Kong); so not included in regional and global totals.

(5) 47 km^3/year from Guatemala to Mexico.

(6) 6 km^3/year from North America region (Mexico).

Variability in dry years is important as it may reduce significantly the rainfall and the volume manageable even in relatively humid areas.

Nine countries are the world giants in terms of internal water resources, accounting for 60 percent of the world's natural freshwater (Table 3). At the other extreme, the water poor countries are usually the smallest (notably islands) and arid ones (Table 4). The thresholds of 1 000 and 500 m^3/inhabitant correspond respectively to the water stress and water scarcity levels proposed by Falkenmark (1986). In an average year, 1 000 m^3 of water per inhabitant can be considered as a minimum to sustain life and ensure agricultural production in countries with climates that require irrigation for agriculture.

Thirty-three countries depend on other countries for over 50 percent of their renewable water resources: Argentina, Azerbaijan, Bahrain, Bangladesh, Benin, Bolivia, Botswana, Cambodia, Chad, Congo, Djibouti, Egypt, Eritrea, Gambia, Iraq, Israel, Kuwait, Latvia, Mauritania, Mozambique, Namibia, Netherlands, Niger, Pakistan, Paraguay, Portugal, Republic of Moldova, Romania, Senegal, Somalia, Sudan, Syrian Arab Republic, Turkmenistan, Ukraine, Uruguay, Uzbekistan, Viet Nam and Yugoslavia.

Exploitable renewable resources

The scarcity and disparity of water resources are exacerbated by differing levels of usability (and therefore mobilization costs) and particularly by environmentally sustainable usability. Water quality also differs. Only a part of natural water resources can be contained and utilized. Basin management is generally recommended but is not common practice; it is unsuitable for arid areas (with no functional basin), large karstic zones and highly fragmented basins.

Scarcity and disparity are intensified by the threat and impact of human activity that disrupts water regimes and leads to a deterioration in water quality, and also by the vulnerable nature of some chronically overutilized resources: salinization of coastal aquifers (e.g. Spain and Israel) and the disappearance of sources (e.g. Tunisia). Moreover, the partitions between numerous countries (the Balkans, the Nile Basin) make the situation more complex.

Therefore, the inequalities among countries in accessing freshwater are amplified when considering the differences in development, treatment and rehabilitation works, as are the related costs required to obtain exploitable natural resources. The effort required varies significantly with the accessibility and regularity of the resources. For example, the ratio of exploitable water resources to total renewable resources is close to 100 percent in areas of the Mediterranean where the main source of water is groundwater (Israel, Gaza Strip (Palestinian Authority) and Libyan Arab Jamahiriya) but generally less than 70 percent in countries where surface water resources are important (Turkey, Morocco, Greece, etc.) and even lower where there are major technical constraints (Malta) or political restrictions (Portugal) (Table 5).

Assessment of results

As the data collection was based essentially on a literature review both at a country level and within FAO, the quality of the results is related closely to national data production and reporting systems. The consistency of results at regional level was checked carefully.

TABLE 3
Water rich countries

FAO Code	Country	Average precipitation 1961-1990 (km^3/year)	Internal resources: surface (km^3/year)	Internal resources: groundwater (km^3/year)	Internal resources: overlap (km^3/year)	Internal resources: total (km^3/year)	External resources: natural (km^3/year)	External resources: actual (km^3/year)	Total resources: natural (km^3/year)	Total resources: actual (km^3/year)	IRWR/inhab. (m^3/year)
21	Brazil	15 236	5 418	1 874	1 874	5 418	2 815	2 815	8 233	8 233	31 795
185	Russian Federation	7 855	4 037	788	512	4 313	195	195	4 507	4 507	29 642
33	Canada	5 352	2 840	370	360	2 850	52	52	2 902	2 902	92 662
101	Indonesia	5 147	2 793	455	410	2 838	0	0	2 838	2 838	13 381
41	China, Mainland	5 995	2 712	829	728	2 812	17	17	2 830	2 830	2 245
44	Colombia	2 975	2 112	510	510	2 112	20	20	2 132	2 132	50 160
231	United States of America (Cont.)	5 800	1 862	1 300	1 162	2 000	71	71	2 071	2 071	7 153
170	Peru	1 919	1 616	303	303	1 616	297	297	1 913	1 913	62 973
100	India	3 559	1 222	419	380	1 261	647	636	1 908	1 897	1 249

TABLE 4
Water poor countries

FAO Code	Country	Average precipitation 1961-1990 (km^3/year)	Internal resources: surface (km^3/year)	Internal resources: groundwater (km^3/year)	Internal resources: overlap (km^3/year)	Internal resources: total (km^3/year)	External resources: natural (km^3/year)	External resources: actual (km^3/year)	Total resources: natural (km^3/year)	Total resources: actual (km^3/year)
105	Israel	9.16	0.25	0.50	0.00	0.75	0.92	0.92	1.67	1.67
112	Jordan	9.93	0.40	0.50	0.22	0.68	0.20	0.20	0.88	0.88
124	Libyan Arab Jamahiriya	98.53	0.20	0.50	0.10	0.60	0.00	0.00	0.60	0.60
136	Mauritania	94.66	0.10	0.30	0.00	0.40	11.00	11.00	11.40	11.40
35	Cape Verde	1.70	0.18	0.12	0.00	0.30	0.00	0.00	0.30	0.30
72	Djibouti	5.12	0.30	0.02	0.02	0.30	0.00	0.00	0.30	0.30
225	United Arab Emirates	6.53	0.15	0.12	0.12	0.15	0.00	0.00	0.15	0.15
179	Qatar	0.81	0.00	0.05	0.00	0.05	0.00	0.00	0.05	0.05
134	Malta	0.12	0.00	0.05	0.00	0.05	0.00	0.00	0.05	0.05
76	Gaza Strip (Palestinian Authority)	0.00	0.00	0.05	0.00	0.05	0.01	0.01	0.06	0.06
13	Bahrain	0.06	0.00	0.00	0.00	0.00	0.11	0.11	0.12	0.12
118	Kuwait	2.16	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02

TABLE 5
Exploitable resources in Mediterranean countries

FAO Code	Country	Total population (inh.) (FAOSTAT, 2000)	Total resources: natural (km^3/year)	Total resources: actual (km^3/year)	Exploitable resources (km^3/year)	TRWR (actual)/inhab. (m^3/year)	Exploitable resources/inhab. (m^3/year)	Exploitable resources/natural resources (%)	Exploitability criteria
3	Albania	3 134 000	41.70	41.70	13.00	13306	4148	31.2	Technical-economic
4	Algeria	30 291 000	14.32	14.32	7.90	473	261	55.2	Technical-economic
54	Cyprus	784 000	0.78	0.78	0.54	995	689	69.2	Technical-economic
59	Egypt	67 884 000	86.80	58.30	49.70	859	732	57.3	Technical-economic
68	France	59 238 000	203.70	203.70	100.00	3439	1688	49.1	Technical-economic and environmental
76	Gaza Strip (Palestinian Authority)	1 077 000	0.06	0.06	0.06	52	52	100.0	Physical and technical-economic
84	Greece	10 610 000	74.25	74.25	29.00	6998	2733	39.1	Technical-economic
105	Israel	6 040 000	1.67	1.67	1.64	276	271	98.0	Technical-economic
106	Italy	57 530 000	191.30	191.30	123.00	3325	2138	64.3	Technical-economic (capacity to manage the resources with dams).
121	Lebanon	3 496 000	4.84	4.41	2.19	1261	625	45.2	Technical-economic
124	Libyan Arab Jamahiriya	5 290 000	0.60	0.60	0.64	113	120	105.8	Technical-economic
154	Macedonia, FYR	2 034 000	6.40	6.40	3.00	3147	1475	46.9	Technical-economic taking into account the water resources produced in a dry year (4.8 km^3/year)
134	Malta	390 000	0.05	0.05	0.02	129	39	30.5	Physical criteria: conservation of the saltwater/freshwater equilibrium in the major aquifer: 0.015 km^3/year. It corresponds to safe yield without seawater intrusion.
143	Morocco	29 878 000	29.00	29.00	20.00	971	669	69.0	Technical-economic
174	Portugal	10 016 000	77.40	68.70	13.00	6859	1298	16.8	Mostly technical-economic with some environmental concerns
203	Spain	39 910 000	111.50	111.50	46.30	2794	1160	41.5	Technical-economic
212	Syrian Arab Republic	16 189 000	46.08	26.26	20.60	1622	1272	44.7	Technical-economic
222	Tunisia	9 459 000	4.56	4.56	3.63	482	383	79.5	Technical-economic
223	Turkey	66 668 000	231.70	229.30	110.00	3439	1650	47.5	Technical-economic
245	West Bank (Palestinian Authority)	1 407 000	0.75	0.75	0.71	0	-	-	Physical and technical-economic

TABLE 6
Comparison of water resources data from different sources, the United States of America

	Country: United States of America		Data: km^3/year													
	Source and date of reference	1 Annual average precipitation	Internal natural renewable water resources (annual average)				6 Internal runoff in 10th frequency dry year	7 External renewable resources (a)	8 Total natural resources (5+7)	Actual renewable resources (contemporary annual average)		Exploitable resources (c)				
			2 Surface water runoff	3 Groundwater	4 Overlap	5 Total (2+3-4)				9 Actual external resources (b)	10 Total actual resources (5+9)	Renewable (annual average)				15 Non-renewable (n years)
												11 Regular surface water	12 Irregular surface water	13 Groundwater (d)	14 Total (11+12+13)	
1	USWRc, 1968	5 800 (1)				2 478										
2	FAO/Aquastat															
3	Shiklomanov, 1997					2 810		146.0	2 856							
4	Shiklomanov, 1998															
5	Shiklomanov, 2000					2 930		148.0	3 078							
6	Seckler *et al.*, 1998					2 478										
7	Seckler, 2000								3 048						1 829	
8	Raskin, 1997								2 478							
9	Gleick, 1993					2 478										
10	Gleick, 1998								2 478 (1)							
11	WRI, 2000a & 2000b					2 460		18.0	2 478							
12	OECD					2 460		18.0	2 478							
13	UNECE, 1981					1 890 (1)	1 100 (1)	18.9	2 009					106 (1)		
14	UNECE, 1977	7 116				2 460		-						130 (1)		
15	L'vovitch, 1974	6 398	1 685 (2)	660	-	2 345 (3)		-								
16	USGS, 1977; USWRC					2 478	1 030 (1)									
17	USGS, 1983		3 610	1 300	1 150	3 760		20.0	3 780 (4)							
18	USWRC, 1978 + ICID, 1983	5 800 (1)				3 110	930 (20-year av.)	22.5								

Notes:

col. 1 The data 'average annual volume of precipitation' allows the assessment of the green water volume = rainfall - IRWR (as a first estimation); it is equivalent to the resource for dry agriculture.

col. 7 (a) Surface water and groundwater including the agreed part of border river.

col. 9 (b) Under existing upstream geopolitical constraints (de facto or by agreement).

col. 11-14 (c) According to criteria specific to each country (technical-economic, geopolitical, environmental, etc.).

col. 13 (d) Including under constraint of reservation of sources and water courses.

(1) United States of America only.

(2) Including Alaska 432 km^3/year.

(3) Including Alaska 610 km^3 /year.

(4) Including Alaska 1 346 km^3 /year.

The option chosen was to rely on country information. This was based on the assumption that no regional information can be more accurate than studies carried out at country level. However, there are a number of difficulties when dealing with national sources:

- In most cases, a critical analysis of the available information is necessary to ensure consistency between the different data collected for a country and a river basin.
- Gathering data from different sources highlights similarities between the different sources, contradictions, and errors in data transcription. For example, in Table 6 some references indicate different figures for the United States of America. Such discrepancies could probably be explained by country experts and may be due to different aggregations and accounting methods.
- Very little information exists on water resources in humid Africa.
- In arid and semi-arid climates, abundant literature exists as water plays an important role in economic development. However, access to information on water resources is sometimes restricted for strategic reasons.
- The accuracy and reliability of information vary significantly between regions, countries and types of data. No consistency can be ensured at regional level on the duration and dates of the period of reference.

Data evaluation

This section presents some of the difficulties in computing external water resources.

Precipitation

Precipitation is indicated in the country summary tables as a reference but is not used in the data computation. The average volumes for precipitation given by countries are generally estimated from precipitation maps (isohyets). Country values were obtained from country surveys, but the overall reliability of the results was considered low because of the lack of historical data sets or poor geographical coverage of the country. Therefore, the precipitation data used in this study are based on data prepared and published by the Intergovernmental Panel on Climate Change (IPCC) (New *et al.*, 1999; Mitchell *et al.*, 2001). Box 8 provides some examples of existing monitoring systems.

Box 8 – Hydrological observations and measurements

The quality of knowledge in hydrology is dependent on the availability of historical data sets and therefore on the continuity of data collection. Hence, current efforts at observation and investigation are not of immediate use. The collecting of climate data started in the nineteenth century in some countries (Table 8). However, hydrological and hydrogeological measurements are more recent, and sensitive to political change. Therefore, long historical data sets are rare. However, the longest ones concern arid countries where water development has long been important. An indication of the current efforts to produce basic data is evidenced by the statistics on the measurement networks (precipitation and runoff) gathered by the WMO and presented in Table 7 on the Mediterranean countries.

- This compilation is probably not complete and may have its shortcomings. However, it does highlight very diverse situations:
- Rainfall networks: their density is relatively homogeneous in Europe (about 10 stations per 1 000 km^2), higher in the islands (highest in Malta with 168) and in the small countries of the Near East (Israel, Lebanon), considerably lower in the Maghreb (fewer than 1 per 1 000 km^2 in Algeria and Morocco) and in Turkey, and very low in Egypt and Libyan Arab Jamahiriya (very arid anyway).

Hydrography networks: widely varying density in Europe (2-8 stations per 1 000 km^2) and in the Near East (1-10 stations per 1 000 km^2), and lower in Africa. However, these densities are not comparable as the level of knowledge and the hydrography structures differ greatly.

Surface water (renewable)

The following comments stem from an analysis of the surface water resources at river-basin level and by country:

- The figures on inflow come from national reports. They may correspond either to actual inflow affected by upstream consumption or to theoretical inflow secured through treaties. Therefore, the actual inflow in certain countries may be different from the inflow secured by treaties indicated in the tables.
- Another difficulty related to the inflows or outflows secured by treaties relates to the fact that most treaties establish the exchanges between countries in terms of percentage of basin water resources, whose amount varies from year to year.
- For flows not subject to formal treaties or agreements, the values indicated in the tables should correspond to average annual actual flows in recent years. However, owing to data collection difficulties, the flow average was not obtained systematically for the same period. Therefore, the figures should be considered as best possible estimates.
- The quality of the estimation of internal surface resources depends on:
  i. the density of the hydrometric stations in each country (related to the structure of the hydrography network) and the length of the observation period (Box 8);
  ii. the percentage of the territory where the runoff is measured and where it is calculated from modelling using climate data sets.

TABLE 7
Measurement stations in Mediterranean countries

Country	Pluviometric stations			Hydrometric stations		
	Date of value	Total number	Including > 30 years	Date of value	Total number	Including > 30 years
Spain	1998	4 388	3 562	1998	1 365	615
France	1997	5 371	3 566	1997	3 118	534
Italy	1973	3 600	3 429			
Malta	1983	53	28			
Slovenia	1997	289	263	1997	167	94
Croatia	1997	522	493	1997	252	85
Yugoslavia	1998	797	792	1998	245	103
Albania	1997	114	114	1997	84	25
Greece	1998	1 469	960	1998	255	19
Turkey	1998	605	531	1998	1 184	220
Cyprus	1998	219	207	1998	95	49
Lebanon	1973	203	55	1973		
Israel	1998	584	508	1998	103	47
Egypt	1984	82	62	1984	230	70
Libyan Arab Jamahiriya	1973	148	111	1973	30	-
Tunisia	1973	750	274	1973	197	-
	1994-95	808	1 121	1994-95	183	-
Algeria	1992	1 724	187	1973	160	-
Morocco	1992	273		1973	144	-

Source: Margat, in preparation.

TABLE 8
Observation stations in the world

Continent	Observation period (years)	Total number of hydrometric stations	Used for assessment of water resources
Europe	10-178	6 000	610
Asia	10-120	12 000	800
Africa	5-80	2 000	250
North America	10-30	12 000	300
South America	5-70	3 600	240
Oceania	5-80	3 000	200

Source: Shiklomanov, 1997.

Groundwater (renewable)

Depending on the source, the value provided under groundwater resources may indicate either the groundwater recharge or the groundwater productivity.

It is difficult to evaluate the groundwater flow entering or leaving a country. The transboundary groundwater flows are generally very small in comparison with the surface water flows. Therefore, uncertainties about them do not affect the results significantly. This is also generally the case for the groundwater outflow into the sea, except for Lebanon and some small islands such as Malta.

Total water resources

In the case of conflicting sources of information, the difficulty lies in selecting the most reliable one. In some cases, water resources figures vary considerably from one source to another. There may be various reasons for such differences:

- Differences in computation methods or definitions used in computing water resources.
- Differences in the reference period used to calculate water resources.
- Overestimation of resources where there is double counting of surface water and groundwater.
- Specific problems of transboundary rivers. Methods used by countries to compute transboundary rivers flows are not always transparent.
- Misuse of the concept of renewable water resources. Some sources include extraction of fossil water as part of water resources. Others include secondary sources of water such as wastewater or return flows from agriculture.
- Changes in estimates, often upwards, following improvements in knowledge, methods or measurement networks. For example, for three Maghreb countries (Tunisia, Algeria, and Morocco) the average total flow increased by 20 percent in 20 years, from 38 km^3/year in 1970 to 48 km^3/year in 1990.

Data production

Where national data are absent or not reliable, it may be necessary to obtain estimates from models and satellite imagery. However, while modelled data may be useful, they cannot replace local measurements. The sources rarely provide information on the origin of data (meta-data: which data production, monitoring and treatment schemes; when exceptions from the rules were applied; differences in definitions; etc.) and on data processing (how the data were extrapolated, how data-gap situations were solved, etc.).

Comparison with previous studies

Because of the global approaches used in all but one of the previous studies mentioned in Chapter 1 (Table 9), comparisons between them and the information collected in this report were possible only at continental or global level.

Prior to analysing the figures, some clarification is necessary. First, this study used the figures proposed by L'vovitch (1974) for 10 out of 53 countries in Africa as no better information was found in recent country reports. These ten countries are located in well-endowed regions, and together they account for about 54 percent of the total water resources of the Africa region. Thus, the comparison with L'vovitch's figures is relatively biased.

Table 9
Major assessments of the world's natural internal freshwater resources

Reference	Africa	North & Central America	South America	Asia	Oceania	Europe	World	Comments
	(km^3/year)							
1 L'vovitch, 1974	4 225.0	5 960.0	10 380.0	13 190.0	1 965.0	3 110.0	38 830.0	(1)
2 Korzun *et al.*, 1974	4 600.0	8 120.0	12 200.0	14 100.0	2 510.0	2 970.0	44 690.0	
Korzun *et al.*, 1978	4 570.0	8 200.0	11 760.0	14 410.0	2 390.0	3 210.0	44 490.0	(2)
3 Baumgartner and Reichel, 1975	3 400.0	5 900.0	11 100.0	12 200.0	2 400.0	2 800.0	37 700.0	(3)
4 Gleick, 1993, 2000	4 570.0	8 200.0	11 760.0	14 410.0	2 388.0	3 210.0	44 540.0	(4)
5 Shiklomanov, 1996, 1997	4 047.0	7 770.0	12 030.0	13 508.0	2 400.0	2 900.0	42 650.0	
6 World Resources Institute, 2000	4 040.0	7 770.0	12 030.0	13 508.0	2 400.0	2 900.0	42 650.0	
7 Shiklomanov, 2000	4 050.0	7 890.0	12 030.0	12 510.0	2 400.0	2 900.0	42 780.0	
8 This study	**3 950.2**	**7 443.1**	**12 380.0**	**12 461.0**	**910.7**	**6 619.4 (5)**	**43 764.3**	

Notes:
(1) To add 2 100 km^3/year for the Antarctic.
(2) To add 2 310 km^3/year for the Antarctic.
(3) To add 2 000 km^3/year for the Antarctic.
(4) To add 2 230 km^3/year for the Antarctic.
(5) The Aquastat value for Europe is higher because all of the Russian Federation was included in Europe (working at a country level); the other references separated the Russian Federation into two parts: Europe and Asia.

The figures given by the World Resources Institute were computed using various data sources: FAO (Aquastat), the Institute of Geography of the former Soviet Union, and Shiklomanov (2000). Gleick (1993, 1998 and 2000) provides an exhaustive compilation work and includes data from FAO's Aquastat programme. These indications may help explain the similar results obtained by these different sources.

It is not the purpose of this comparison to explain differences in results. Computing methods and the assumptions they imply are so different that such an exercise would be of limited value. Rather, this study confirms the relatively good knowledge of the state of the world's water resources at global and regional scales. This study indicates a world water resources total of 43 764.3 km^3/year, between the 42 780 km^3/year indicated by Shiklomanov (2000) and the 44 540 km^3/year indicated by Gleick (2001). The main differences relate to two regions: Europe and Oceania. For Europe, the main reason relates to accounting for the Russian Federation. The Aquastat programme considers all the Russian Federation to be in the Europe region whereas the other studies included part of it in Asia. The case of Oceania is unclear but probably relates to accounting for the water resources of the islands (the estimates for Australia are the same).

The potential of models for global water resources assessment

In this study, water resources assessment at country level was based mainly on hydrological information on the main rivers extrapolated to areas where direct measurements were not available. Although all efforts were made to present a standard framework for water resources computation, the methodology used in this study (relying on country information), does not ensure consistency in the water resources assessment methods from one country to another.

In order to overcome this problem and to improve the comparability of the water information at regional and global levels, FAO's Aquastat programme is also working on the development of global GIS-based data sets and modelling tools.

A water balance model has been developed and implemented on Africa. The results are presented in the CD-ROM "Atlas of water resources and irrigation in Africa" (FAO, 2001). Available information on Africa was processed through a continental GIS-based model to provide a comprehensive picture of the different elements of the water balance at continent scale. This approach makes the best use of scattered information and enables extrapolation of point data or data available at country level to develop a credible picture of the situation of the continent's water use and its impact on water resources. It also has the advantage of presenting a homogenous methodology for computing the water balance across the continent.

Description of the model

The model used in the Africa study is simple and performed entirely within the GIS environment. It makes the best possible use of available information, be it regional coverage of the main climate elements of the water balance (precipitation and crop water requirements), soil properties, or irrigation. The model consists of two parts. A vertical soil-water balance model, performed monthly for every grid cell (10 km × 10 km), computes the part of precipitation that does not return to the atmosphere through evapotranspiration. This water, termed surplus in the study, is then routed through the landscape in the rivers by the horizontal part of the model. In GIS, this is performed by generating a grid-based hydrological network based on an available digital elevation model.

Crop water requirements were calculated using the modified Penman-Monteith method as described in FAO (1998c). They were calculated for each grid cell on a monthly time step and compared with the actual evapotranspiration, ETa(m), resulting from the soil water balance model. The difference was then multiplied by the cropping intensity to obtain a monthly grid of irrigation water requirements. The model was calibrated as far as possible against measured natural river-flow data.

Data sources used in the model

The precipitation data used for this study are based on data prepared and published by the International Institute for Applied Systems Analysis (IIASA). For each of the stations used in the gridding exercise, data were averaged over a 30-year period from 1961 to 1990.

Data on reference evapotranspiration used for this study had also been prepared by the IIASA for FAO (FAO, 2000). The resolution of this data set is equal to the resolution of the precipitation data set, 0.5 degrees of latitude by 0.5 degrees of longitude, with mean monthly values for global land areas (excluding Antarctica) for the period 1961-1990. The data set was prepared according to the FAO Penman-Monteith method with limited climate data as described in FAO (1998c). The input data used to calculate ETo are part of the CRU Global Climate Dataset prepared by the Climate Research Unit of the University of East Anglia, the United Kingdom, and distributed through the Web site of the IPCC.

The digital data layer with the drainage pattern used for this project was a 1:5 000 000 line coverage with the rivers of Africa (digitized in 1994 for the UNEP/FAO Desertification Assessment and Mapping Project). The coverage with water bodies originates from the Digital Chart of the World 1:1 000 000. The water bodies of Africa have been characterized (as lake, lagoon, reservoir, etc.) and named (where names were readily available). The data layer as used in this project contains all the water bodies that had a name and were not characterized as rivers.

TABLE 10
Comparison of measured and modelled data for African countries

FAO Code	Country	Internal resources: total (km^3/year)	Calculated internal water resources (FAO, 2001) (km^3/year)	Absolute difference (calculated - country data) (km^3/year)	% difference
7	Angola	184	179	5	-2.9%
32	Cameroon	273	267	6	-2.3%
37	Central African Republic	141	131	10	-7.4%
250	Congo, Democratic Republic of	900	893	7	-0.8%
46	Congo	222	198	24	-10.8%
61	Equatorial Guinea	26	33	7	28.5%
74	Gabon	164	189	25	15.1%
29	Burundi	4	5	1	25.0%
238	Ethiopia	110	110	0	-0.3%
114	Kenya	20	18	2	-8.9%
184	Rwanda	5	6	1	11.5%
215	Tanzania	82	91	9	10.7%
226	Uganda	39	18	21	-53.1%
53	Benin	10	14	4	37.9%
107	Côte d'Ivoire	77	79	2	3.1%
81	Ghana	30	33	3	9.2%
90	Guinea	226	188	38	-16.6%
175	Guinea-Bissau	16	21	5	31.3%
123	Liberia	200	173	27	-13.7%
159	Nigeria	221	244	23	10.2%
197	Sierra Leone	160	124	37	-22.8%
217	Togo	12	9	2	-19.1%
45	Comoros	1	-	0	0.0%
129	Madagascar	337	320	17	-4.9%
4	Algeria	14	15	1	5.8%
59	Egypt	2	1	1	-72.2%
124	Libyan Arab Jamahiriya	1	1	0	66.7%
143	Morocco	29	25	4	-15.2%
222	Tunisia	4	3	1	-22.9%
20	Botswana	3	0	3	-89.7%
122	Lesotho	5	5	0	-4.4%
130	Malawi	16	15	2	-9.5%
144	Mozambique	99	93	6	-6.4%
147	Namibia	6	2	5	-74.0%
202	South Africa	45	43	2	-4.0%
209	Swaziland	3	3	0	-1.5%
251	Zambia	80	88	8	10.1%
181	Zimbabwe	14	13	2	-11.3%
233	Burkina Faso	13	18	6	44.8%
39	Chad	15	15	0.3	2.0%
72	Djibouti	0.3	0.1	0.3	-83.3%
178	Eritrea	3	2	1	-42.9%
75	Gambia	3	2	1	-46.7%
133	Mali	60	27	33	-55.7%
136	Mauritania	0	1	0	25.0%
158	Niger	4	4	1	17.1%
195	Senegal	26	23	3	-12.1%
201	Somalia	6	1	5	-88.3%
206	Sudan	30	24	6	-19.7%

Results of the model and comparison with country-based data

Table 10 compares the IRWR as published by FAO (Aquastat) and presented in this report (table in Annex 2) with the values computed by the model. The calculated values in Table 10 are generally lower than the country-based data. This is especially apparent in the more arid countries. For these countries, the model calculates hardly any runoff while the country statistics indicate some renewable water resources. The water balance model used for this study computes the internally generated water resources (IRWR) by subtracting the total inflow to the country from the total flow accumulation leaving the country, disregarding water leaving the system by evaporation from large lakes and wetlands. In arid areas, this method leads to an underestimation when compared with the results of conventional studies that estimate the water potential through the recharge of groundwater and the river discharge at the points where the runoff is maximum.

Another explanation for the difference with country-based data is that the time-span used for the model is a month. In arid areas, such a long time-span tends to overestimate evaporation, thus reducing the estimate of water resources. It is difficult to assess the reliability of the model's results for the semi-arid and arid countries (e.g. Egypt, Djibouti, Eritrea, Morocco and Namibia). In other cases, the model may give a higher figure than the national statistics as it assesses resources before local evaporations happen. This is the case for the Libyan Arab Jamahiriya, Algeria and Burkina Faso.

In humid areas, the comparison shows a relatively good concordance between country-based and modelled figures. In some countries of the intertropical humid area (Democratic Republic of Congo, Gambia, Mali, Sierra Leone, Somalia and Uganda), the difference between national statistics and calculated ones is negative. This might indicate a problem in these countries' estimates of water resources, in particular in the distinction between internal and external water resources.

This modelling exercise shows how it may be necessary to obtain estimates of water resources from models where national data are absent or unreliable. The model is a useful tool for checking the overall results of the study and for pinpointing possible errors. The model was used to cross-check the Africa data sets. Where there were clear inconsistencies, the country water balances were reviewed and modified as necessary. Therefore, the combined use of country-based data and global water-balance modelling can enhance the overall reliability of the results.

Concluding remarks

This report presents the approach used by FAO to assess natural and actual water resources for the world by country. It deals with renewable freshwater resources and concentrates mainly on the physical assessment of internal and external resources. It presents a picture of the state of the world's water resources that is not only the natural state but also the current situation, taking into account existing uses of water and their implications for countries sharing common river basins. It is also a first attempt, albeit still an incomplete one, to present estimates of exploitable water resources, i.e. the part of the countries' water resources that can be put to beneficial use.

The major characteristics of this approach are:

- It proposes a comprehensive way to: (i) compute surface water resources and groundwater resources; (ii) avoid double counting; and (iii) assess resources in a transparent manner from available national information.

- It is transparent in the way water resources figures are calculated.
- It reviews in depth the water exchanges at border level in order to ensure consistency in the results between countries.
- It introduces the concept of exploitable resources in order to obtain a more realistic estimate of water resources availability.
- It distinguishes clearly between renewable and non-renewable resources.
- It enhances the overall quality of country-based data by comparing them to the results of a global water-balance model. It highlights drawbacks and overestimation in existing data sets. Both tools are mutually reinforcing.

Future improvements

There remains much to do in order to obtain sound statistics on water resources, and particularly standardized data sets, at global level. Therefore, the methodology used in this study to compute water resources is intentionally simple and based on transparent rules. However, more effort needs to be focused on the assessment of the variability of water resources in space (watershed level), in time (dry-year resources) and according to constraints (exploitable resources). Desegregated information at river-basin level is particularly important in large countries with very diverse climate conditions (e.g. Russian Federation, Brazil, United States of America, and China). National averages hide local differences and, for large countries, are of little use for assessing the country’s water situation.

The use of global data sets (meteorological, etc.) coupled with water-balance models can contribute to improving the assessment of water resources as shown above for Africa. This experience should be extended to the rest of the world, keeping in mind that the field-based approaches (based on measurements) and the modelling approaches are complementary.

The future of water resources

This study bases the country-level estimates of natural renewable water resources mainly on climate and hydrological data sets for the last decades of the twentieth century. They are representative of the average flows of the last 25 to 50 years. These averages are considered to be stable and not affected by change. However, there is no certainty that these averages will remain stable in the long term.

There is no certainty today about the extent, dynamics and regional distribution of climate changes forecast for the twenty-first century. However, the potential impacts on water resources cannot be ignored.

The first world projections on this subject such as those made by the University of Kassel (Alcamo *et al*. 1999, for the World Water Vision) provide country projections for 2025 and 2075. Although it may be too early to draw a picture of the future of water resources, water development planning must take into account the uncertainty related to the possible impacts of climate change on water resources within the context of growing water demand.

Chapter 5
Regional overview

For the purposes of this study, the countries of the world have been grouped into ten regions composed of various subregions (below and Annex 1 for details). Annex 3 presents the regional data in the form of maps (Annex 3 Maps 4-13).

Region 1: Northern America

General features

The Northern America region extends over about 21 million km^2, which is 16 percent of the world's land area. It presents a large range of climate and hydrographic situations and can be divided into three subregions:

- Alaska, Canada and Greenland: Alaska (United States of America), Canada and Greenland;
- Mexico: Mexico;
- The United States of America: the United States of America (conterminous states).

Alaska, Canada and Greenland

The climate of Alaska can be divided into three types: pacific, arctic and continental. The Pacific and southeastern coastal area has relatively mild winters and cool summers. The annual precipitation ranges from 1 524 to 3 810 mm. The arctic region north of the Brooks Range has a colder climate. Annual precipitation is less than 127 mm. The interior continental region has the same climate as the Montana Plains. The natural runoff of Alaska is estimated at 801 540 million m^3/year, almost 50 percent of the runoff of the conterminous states of the United States of America.

Canada is the second largest country in the world with a total area of 9 976 180 km^2. Freshwater bodies cover 7.6 percent of its area. Most of Canada lies in the zone of the westerly winds, but the predominance of migrating cyclones and anti-cyclones brings variable winds and weather. Precipitation is high along the Pacific coast, and low in the interior and in the arctic and subarctic regions. The annual precipitation decreases in a northerly direction from 500 mm in the central area to 125 mm in the arctic islands. Precipitation increases again towards the east coast, ranging from 900 mm in Ontario to more than 1 482 mm in Newfoundland. Snow contributes 5 percent of the total precipitation in Vancouver and 23 percent in Montreal.

Canada possesses about 9 percent of the world's freshwater resources. It has four major drainage basins: Atlantic (15 percent), Hudson Bay (38 percent), Arctic (36 percent) and Pacific (10 percent). It also contributes a small part to the flow of the Mississippi-Missouri River. The most important waters draining into the Atlantic Ocean are from the Great Lakes through the Saint Lawrence drainage basin. The Great Lakes store 22 700 km^3 of freshwater, 99 percent of

TABLE 11
Water resources in the Northern America region

Water resources region	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (1) (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
1 Northern America	Alaska, Canada & Greenland	10 312 310	31 439 932	4 253.0	8.3	(1)	4 261.3	63.84	135 273.8	135 537.5
	Mexico	1 958 200	98 872 000	409.0	49.2	(2)	458.2	6.14	4 136.7	4 634.3
	Unites States of America, conterminous	9 629 090	279 583 431	2 000.0	71.0	(3)	2 071.0	30.02	7 153.5	7 407.4
	Northern America	**21 899 600**	**409 895 363**	**6 662.0**	**47.0**	**(4)**	**6 709.0**	**100.00**	**16 252.9**	**16 367.6**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Northern America as % of world	16.4	6.8	15.2			15.3			

Notes:

(1) 8.59 km^3/year from the United States of America (52 km^3/year according to other sources).
(2) 47 km^3/year from Guatemala to Mexico.
(3) 2.2 km^3/year from the United States of America (actual inflow) + 47 km^3/year from Guatemala (Central America region).
(4) From Guatemala.

which is a remnant from the glacial period and so non-renewable. Canada has more than 31 000 freshwater lakes, ranging from 3 km^2 to more than 100 km^2.

Mexico

Mexico, with an area of 1 958 200 km^2, represents 9.2 percent of the region's total area. It is located in the Intertropical Convergence Zone. However, the altitude and maritime influence generate penetrating masses of humid air deriving from the Gulf of Mexico and Pacific Ocean. These two factors moderate the country's temperatures. Precipitation is scarce in the north of the country but more abundant in the southeast and in the valleys of the Gulf of Mexico and of the Pacific, south of the Tropic of Cancer. Precipitation occurs mainly from June to October. The country also experiences extreme meteorological phenomena, such as the tropical cyclones that occur between May and November, affecting the coasts of the Pacific and those of the Gulf of Mexico.

The United States of America

The United States of America consists of 50 states for a total area of 9 363 368 km^2. A block of 48 contiguous states referred to as the conterminous states forms a belt of 7 828 016 km^2 across the continent from the Atlantic Ocean to the Pacific Ocean. This subregion lies more or less within the temperate zone of the northern hemisphere. The other two states are Alaska (1 520 000 km^2) and Hawaii (which is included in the Oceania and Pacific region in this study).

Although spanning only 25 degrees of latitude and less than 60 degrees of longitude, the conterminous states have a variety of climates, vegetation and physical features: steep, rugged mountain ranges; subtropical ranges; deserts; frosted areas; frost-free regions; areas with very short summers; lush forests; vast grasslands; and prairies with extreme variability in temperature and rainfall. Taken as a whole, the conterminous states receive an average of about 762 mm of precipitation annually. Distribution is uneven with averages of 450 mm from the Pacific coast to the Rocky Mountains, and 710 mm from the Rocky Mountains to the Mississippi River and the Atlantic coast.

Water resources

The region's wide range of climates generates a wide spatial variety of hydrological regimes. As a result, the region presents a very uneven distribution in precipitation, water resources and water use.

Table 11 shows the distribution of water resources among the countries of the region. These average figures hide local water scarcity conditions, and the high variability within the countries.

The methodology used to calculate the water resources of the region varies from country to country and is related to the information needed for water management. In the humid areas, water management has focused on flood control and protection. In the arid areas, hydrological studies have focused more on water resources assessment in order to help satisfy relatively high demand, in part for agriculture.

In general, depending on information availability, the water resources balances were estimated mainly on the basis of surface water flows as measured at hydrometric stations. Overall, the region is relatively well endowed with water resources. For an area representing 16 percent of the world's total land surface, the region receives 17 percent of its precipitation and generates 15.3 percent of its water resources. As this region is the home to 7 percent of the world's population, the water resources per person exceed 16 000 m^3/year, much higher than the world average.

In such large countries, the significance of national figures is limited and should be completed by subnational data sets.

Region 2: Central America and Caribbean

General features

The total area of the Central America and Caribbean region is about 728 000 km^2, which is 0.6 percent of the world's total land area. The region can be divided into the following subregions:

- Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama;
- Caribbean: Antigua and Barbuda, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

Central America

This subregion comprises Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. Its total area is 521 598 km^2, or 72 percent of the region. About 80 percent of Central America is mountainous with most of the flat lands located in the coastal areas.

In general, the volcanic range, running through the whole subregion from north to south, serves as the divider between the Pacific and the Atlantic basins. It divides the land asymmetrically, the Pacific coastal flat lands being very narrow with short rivers. The flat lands have been formed from alluvial material from the volcanic ranges.

The climate of Central America is essentially tropical, tempered by its proximity to the sea and by the altitude and local relief characteristics. The Atlantic coast is much more humid than the Pacific coast. Precipitation increases from north to south and from west to east (influenced by the effect that the mountain range exerts on the hot and humid Caribbean currents). The climate has influenced the settlement of the subregion, with most of the population living at altitudes above 1 000 m above sea level (a.s.l).

Caribbean

This subregion consists of two groups of islands: the Greater Antilles and the Lesser Antilles.

Greater Antilles

This group comprises Cuba, Haiti, Jamaica and the Dominican Republic for a total area of 198 330 km^2, about 27 percent of the region's total area. The Greater Antilles are a group of islands located between the Caribbean Sea and the Atlantic Ocean. The largest island is Cuba, followed in terms of area by Hispaniola Island (shared by Haiti and the Dominican Republic).

The Greater Antilles are located in the Intertropical Convergence Zone and are influenced by northern winds. They have a tropical maritime climate, with a dry and a wet season and fairly constant temperatures throughout the year. Temperatures rarely drop below 13 °C.

The population of the Greater Antilles was 30 million inhabitants in 2000 (45 percent of the region's total population) with an average population density of 147 inhabitants/km^2, ranging from 101 inhabitants/km^2 in Cuba to 266 inhabitants/km^2 in Haiti. The population is predominantly urban (60 percent), with 29 percent of the economically active population engaged in agriculture.

Lesser Antilles

The countries of this subregion are Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago. This group of islands has a total area of 8 430 km^2 (about 1 percent of the region's total area). Its economy is based mainly on tourism and associated services. Rainfall distribution is determined by the size, shape, topography, relief and geographic position with respect to the north wind. The average annual rainfall in the subregion is 1 141 mm. However, in the mountainous islands there is an important screen effect on the south coasts, characterized by an arid climate. The dry season is more significant towards the south. Tropical storms occasionally cause hurricanes which, after having passed the Greater Antilles, tend to lay waste the Lesser Antilles as far as Trinidad and Tobago.

Water resources

In this region, highly divided by the relief and islands, the assessment of water resources is often based more on assumptions and extrapolations from climatological data than on hydrometric data measured over long periods.

In this humid region, withdrawal for agriculture and other uses usually represents a negligible percentage of the total water resources. The direct measurements for the estimations of groundwater are scarce and rarely reliable. The indirect method of groundwater assessment through measuring the base flow of rivers is only partially possible in the coastal or insular areas. This is particularly the case for the Greater and Lesser Antilles where groundwater flowing directly to the sea represents a large part of the groundwater resources.

The climate characteristics of the region also generate strong interseasonal and interannual differences in water resources. Meteorological phenomena such as El Niño or tropical storms and hurricanes in the Antilles and Central America alternate with lengthy drought periods. As a consequence, the annual or monthly average estimates of water resources are generally poor indicators of availability.

The region is characterized by a low percentage of water resources shared by several countries (1.7 percent of the region's total water resources).

Overall, the region is relatively well endowed with water resources, receiving 1.4 percent of the world's precipitation and generating 1.8 percent of its water resources. With 1.1 percent of the world's population, the figure for water resources per person in the region can be estimated at about 11 900 m^3/year, about double the world average.

TABLE 12
Water resources in the Central America and Caribbean region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
2 Central America and Caribbean	Caribbean	232 670	37 574 000	92.6	0.0	(1)	92.6	11.86	2 465.7	2 465.7
	Greater Antilles	198 330	30 290 000	81.5			81.5	10.44	2 691.6	2 691.6
	Lesser Antilles	34 340	7 284 000	11.1			11.1	1.42	1 526.1	1 526.1
	Central America continent	521 600	36 257 000	688.4	6.0	(2)	694.4	88.14	18 987.8	19 153.2
	Central America and Caribbean	**754 270**	**73 831 000**	**781.1**	**6.0**	**(2)**	**787.1**	**100.00**	**10 579.3**	**10 660.6**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Central America and Caribbean as % of world	0.6	1.2	1.8			1.8			

Notes:

(1) No exchanges.
(2) 6 km^3/year from Northern America region (Mexico).

Table 12 shows the distribution of water resources among the subregions. These average figures hide the local scarcity conditions that coincide, in general terms, with the most populated areas of the region (along the Pacific coast of Central America).

The figure of 1 000 m^3/inhabitant/year is usually used as an indicator of water scarcity. Although data on the water resources distribution within the Lesser Antilles are not available for all countries, this subregion presents the highest water scarcity in the region: Antigua and Barbuda 776 m^3/inhabitant/year, Barbados 313 m^3/inhabitant/year, and Saint Kitts and Nevis 576 m^3/inhabitant/year.

Region 3: Southern America

General Features

The total area of the region is about 17.8 million km^2, which is 13 percent of the world's total land area. Argentina, Brazil and Mexico together account for almost 65 percent of the region's total area. The region can be subdivided into the following subregions:

- Guyana: Guyana, French Guiana and Suriname;
- Andean: Bolivia, Colombia, Ecuador, Peru and Venezuela;
- Brazil: Brazil;
- Southern: Argentina, Chile, Paraguay and Uruguay.

Guyana

The Guyana subregion includes Suriname, French Guiana and Guyana, countries that in the south are limited by the so-called Guyana Belt. This mountain range is the border dividing these countries and the Brazilian Amazon River basin.

These countries, with an area of 468 240 km^2 (2.1 percent of the region's total area), are dominated by mountainous tropical and savannah forests. The population density in this subregion is low. Most of the population and the main economic activities are concentrated in the coastal zones. Agriculture is based largely on rice and commercial crops, mainly sugar cane.

The subregion has a tropical climate. The coastal area is characterized by two dry and two wet seasons, while one dry and one wet season characterize the rest of the territory. The coastal average annual temperature varies from 23 to 32 °C. In the interior, away from the moderating effect of the sea, temperature variation is higher, especially between day and night. Precipitation is highest in the south, 1 500-2 400 mm/year, and concentrated mainly in the humid season.

Andean

The Andean subregion, with an area of 4 718 320 km^2, represents 26.5 percent of the region's total area and includes Bolivia, Colombia, Ecuador, Peru and Venezuela. The Andes mountain areas cover an important part of the territory and are home to a large population, unlike in Andean areas in Chile and Argentina (included in the Southern subregion).

All the countries in the subregion, except for Bolivia, present three distinct regions: coast, Andes (mountain or sierra), and Amazon forest, each with very different climate characteristics.

The coastal area of Peru and an extensive area of Ecuador are warm and dry because of the Humboldt Current and the influence of the Andes mountain range on the warm and humid air mass coming from the Amazon Basin. Precipitation increases towards the north as the effect of the current declines. For example, in the proximity of the Colombian Pacific coast (Choco Forest) precipitation exceeds 9 000 mm/year while on the Peruvian coast it rarely reaches 25 mm/year. The sierra is cold; temperatures vary according to altitude, and the climate is generally dry. In the Amazon forest, precipitation is abundant and its climate is tropical, hot and humid, with constant temperatures throughout the year.

Brazil

Brazil, with a total area of 8 547 million km^2, covers 48 percent of the region and presents a wide diversity in climate. The south of this subregion is moderate, with homogenous precipitation and a uniform climate (with an average annual temperature of 14-18 °C and rainfall of 1 250-2 000 mm/year). In the southeast, the average annual temperature varies from 18 to 24 °C and the rainfall from 900 to 4 400 mm/year; the central-west has an average annual temperature of 22-26 °C and rainfall of 1 250-3 000 mm/year. The northeast has an average annual temperature of 20-28 °C; it includes the semi-arid lands of Brazil with an average annual precipitation, irregularly distributed, of 750 mm to less than 250 mm. The north (with an average annual temperature of 24-26 °C and 1 500-3 000 mm/year of rainfall) covers almost the whole of the Amazon River basin. This area is home to the world's largest tropical forest, occupying almost half the Brazilian territory. The climate in this subregion is hot and humid.

In the mid-1990s, as a result of government policies on crop diversification during the previous two decades, Brazil was the world's main coffee and sugar-cane producer, and among the world's leading producers of coconuts (second), tobacco (fourth) and cotton (sixth). In addition, it has increased steadily its production of grains (wheat, maize, rice and, above all, soybean). With its wide variety of climates, Brazil produces almost all types of fruits, from typical tropical varieties in the north to citrus and table grapes in the moderate zones in the south.

Southern

The Southern subregion includes Argentina, Chile, Paraguay and Uruguay. Its total area is 4 121 190 km^2 (23.2 percent of the region's total area). Argentina is the largest country in the subregion, accounting for 59 percent of its total area.

The climate in these countries is varied, essentially because of the differences in latitude (about 20-55 °S) and altitude and because of the presence of the Andes. The temperatures are equally variable, but moderate in most of the four countries; exceptions are the south of Chile, Patagonia and the Andes (climate is cold to arctic), and the north of Chile (which has a desert climate).

Water resources

The methodology used to calculate the water resources of the region varies from country to country. In general, according to information availability, the water resources balances were estimated mainly on the basis of surface water flows as measured at hydrometric stations. In humid regions, withdrawals for agriculture and other uses usually represent a negligible percentage of the total water resources. This is not the case in arid and semi-arid zones where such withdrawals constitute an important part of TRWR.

In general, the information collected shows that the water resources balances do not take into account groundwater resources and frequently refer to exploitable water resources rather than to annual recharge. Moreover, in some countries, estimated groundwater recharge is based on a global infiltration coefficient applied to average annual precipitation. The validity of such an approach is debatable.

Owing to the non-availability of groundwater data for several countries, estimates were taken from BRGM (1990), assuming that all the groundwater is converted into surface water through base flow. This hypothesis is probably valid in all the humid zones of the region.

The wide range of climates in the region generates a wide spatial variety of hydrological regimes. As a result, the region shows a very uneven distribution in precipitation, water resources and water use conditions. In the humid areas, water management has always focused on flood control and protection. In the arid areas, hydrological studies have focused more on water resources assessment.

As in Central America, the climate characteristics of the Southern America region also generate strong interseasonal and interannual differences in water resources, aggravated by meteorological phenomena such as El Niño.

Moreover, the average total figures for each country do not reflect the local variations in water availability. It would be useful to provide figures by hydrographic basin rather than by country and to evaluate incoming water balance elements in terms of frequency (dry, moderate and humid years) rather than averages. In this way, it would be possible to describe drought situations more completely and identify possible future areas of tension among water user sectors. However, such information is not available systematically.

Overall, the region is relatively well endowed with water resources, receiving 26 percent of the world's precipitation and generating 28 percent of its water resources. Home to 5.7 percent of the world's population, the water resources per person in the region are about 35 000 m^3/year, well above the world average.

Table 13 shows the distribution of water resources among the subregions. These average figures hide the local scarcity conditions that tend to coincide with the most populated areas of the region. This is the case of Valle Central in Chile, the regions of Cuyo and the South in Argentina, the Peruvian and south Ecuadorian coast, the Cauca and Magdalena valleys in Colombia, the Bolivian Antiplano, the Gran Chaco (shared by Bolivia, Argentina and Paraguay), and northeast Brazil.

In terms of a threshold figure of 1 000 m^3/inhabitant/year, none of the countries in the Southern America region are in a situation of water scarcity. However, the figures per country do hide large internal variations. For example, while Chile presents an annual water availability of 63 064 m^3/inhabitant, Regions I-V and the Metropolitan Region have less than 1 500 m^3/inhabitant, while Regions XI and XII have more than 2 000 000 m^3/inhabitant.

Exchanges

The region is characterized by a high percentage of water resources shared by several countries (more than one-third of the region's total water resources). The computation of water resources

Table 13
Water resources in the Southern America region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
3 Southern America	Andean	4 718 320	112 912 000	5 186.0	52.0	(1)	5 238.0	41.89	45 929.4	46 389.9
	Brazil	8 547 400	170 406 000	5 418.0	2 807.0	(2)	8 225.0	43.76	31 794.7	48 267.1
	Guyana	468 240	1 343 000	463.0		(3)	463.0	3.74	344 750.6	344 750.6
	Southern	4 120 000	61 076 000	1 313.0	523.0	(4)	1 836.0	10.61	21 497.8	30 060.9
	Southern America	**17 853 960**	**345 737 000**	**12 380.0**	**0.0**		**12 380.0**	**100.00**	**35 807.5**	**35 807.5**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Southern America as % of world	13.3	5.7	28.3			28.3			

Notes:

(1) 52 km^3/year that is the part of border river with Brazil + 0 from other regions.
(2) 2 807 km^3/year from Andean subregion (Amazon) + 0 from other regions.
(3) Inflow from Venezuela unknown + 0 from other regions.
(4) 518 km^3/year from Brazil (La Platin River), 5 km^3/year from Bolivia (Andean subregion) + 0 from other regions.

is very complex in the case of border rivers such as the Parana River. In some cases, this study observed large inconsistencies between the runoff data of rivers crossing different countries. The Orinoco River in Venezuela has a unique characteristic: at a certain point it divides into two rivers, one flowing to the Atlantic Ocean and one flowing to the Casiquiare River, an affluent of the Negro River (Amazon Basin).

REGION 4: WESTERN AND CENTRAL EUROPE

General features

The Western and Central Europe region accounts for about 3.7 percent of the world's total land area and 8.4 percent of its population. In this study, the Western and Central Europe region is divided into four relatively homogeneous and hydrologically independent subregions:

- Northern Europe: Denmark, Finland, Iceland, Norway, Spitsbergen (Norway) and Sweden;
- Western Europe: Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland and the United Kingdom;
- Central Europe: Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia and Yugoslavia;
- Mediterranean Europe: Albania, Cyprus, Former Yugoslav Republic of Macedonia, Greece, Italy, Malta, Portugal and Spain.

The Western and Central Europe region includes all of Europe with the exception of Turkey and the countries of the former Soviet Union. The region has diverse climate conditions that affect the patterns of water resources. This variety of climate conditions is due to:

- the configuration of Western and Central Europe, a peninsula of the Eurasian continent rather than a continent;
- a large range of latitude (35-72 °N);
- its large opening to the maritime influence and the development of its coasts over the Arctic Ocean, the Atlantic Ocean, the Mediterranean Sea and the Black Sea.

Overall, water resources are abundant at about 2 200 km^3 in an average year (5 percent of the world's water resources) and 4 270.4 m^3/inhabitant/year. However, water resources are unevenly distributed between countries.

Contrasting climates

Apart from the extreme north (Iceland, northern Sweden and Finland) which has a subarctic climate (cold and relatively dry), the Western and Central Europe region has two types of climates:

- temperate oceanic, with rainfall throughout the year, with a transition to a more continental climate with wider contrasts in temperature and rainfall, and with more marked seasons in central Europe, at altitude (the Alps) and in northern Europe.
- Mediterranean, with dry summers and rainfall in autumn and spring, prevailing in all the southern part of the region.

Therefore, with the triple influences of latitude, topography and distance from the sea, the distribution of precipitation in the region is very diverse, ranging from less than 300 mm/year

Table 14
Water resources in the Western and Central Europe region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
4 Western and Central Europe	Central Europe	1 123 550	115 802 000	284.5	87.9	(1)	372.4	13.11	2 457.0	3 216.0
	Mediterranean Europe	1 095 300	124 408 000	422.8	30.0	(2)	452.8	19.48	3 398.7	3 639.9
	Northern Europe	1 258 080	24 082 000	864.1	0.0	(3)	864.1	39.81	35 881.6	35 881.6
	Western Europe	1 421 486	246 492 000	598.9	14.7	(4)	613.6	27.59	2 429.7	2 489.3
	Western and Central Europe	**4 898 416**	**510 784 000**	**2 170.4**	**10.9**	**(5)**	**2 181.3**	**100.00**	**4 249.1**	**4 270.4**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Western and Central Europe as % of world	3.7	8.4	5.0			5.0			

Notes:

(1) 77 km^3/year from another European subregion and 10.9 km^3/year from Eastern Europe.
(2) 29.95 km^3/year from another European subregion.
(3) No exchanges.
(4) 14.7 km^3/year from another European subregion.
(5) From Eastern Europe.

in many Mediterranean plains to more than 3 000 mm/year on the coast of the Norwegian Sea or in some areas of the Balkans.

The wetter regions are along the Atlantic shores from Spain to Norway, the Alps and their eastern extension. The regions with less rainfall are the Mediterranean plains in Spain and the plains of central Europe (Hungary and Poland).

A high density of small rivers

The development of large river basins has not been possible in such a complex environment, where the distance between mountains and coasts is always short. There are seven main watersheds of more than 100 000 km^2. The major one is the Danube Basin (about 800 000 km^2), which covers about 17 percent of the region; the second largest is the Rhine Basin, which covers about 5 percent of the region.

The geology of the region is also complex, featuring a mix of ancient mountains, plains and sedimentary basins. This has resulted in numerous small to medium aquifers, most of which discharge into the river network. The rivers drain most of the groundwater, although the karstic coastal aquifers in the Mediterranean area usually flow directly into the sea. The surface water and groundwater are interdependent. Hence, the overlap between them is generally high.

Variability of runoff regimes

As a direct consequence of the climate and topographic diversity, the runoff regimes of the European rivers are very diverse. On average, river runoff is about 450 mm/year, varying from less than 50 mm/year in areas such as southern Spain to more than 1 500 mm/year in various areas of the Atlantic coast and of the Alps. The Danube River has the largest flow, 205 km^3/year, but this is less than 10 percent of the total runoff of the region's rivers. The next most important rivers in terms of runoff are, in descending order: the Rhine, Rhone, Po, Vistula and Garonne. These rivers have a combined runoff of 265 km^3/year, about 12 percent of the region's total. The region's rivers are characterized by a wide variety in their flow regimes and in the interannual and seasonal variations in their runoff:

- the glacial regime, with base flow in winter and a high runoff coefficient, in Scandinavia and the Alps;
- the oceanic regime, with moderated variability, more or less regulated by the groundwater, in Western Europe;
- the continental regime, with important runoff deficits and large differences between high and low flow, in Central Europe;
- the Mediterranean regime, with a high interseasonal and interannual variability in runoff, in southern Europe.

Table 14 shows the distribution of water resources among the subregions.

Exchanges

Many water resources systems are shared by two or more countries in the Western and Central Europe region. These shared systems represent 22 percent of the region's water resources. This situation is due in large part to the large number of relatively small countries. The Danube Basin drains 13 countries. The Rhine Basin is shared by seven countries. Most of the major rivers are transboundary or serve as border rivers (the Danube, Rhine, Rhone, Meuse, Oder, Drave, Tagus, Douro, Guadiana, Evros, Escault, etc.).

A number of countries are very dependent on their neighbours for water: Croatia, Hungary, Luxembourg, the Netherlands, Portugal, Romania, Slovakia, Slovenia and Yugoslavia. The same countries are often providers of most of the resources of their neighbours (the case with all the landlocked countries): Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Former Yugoslav Republic of Macedonia, Hungary, Slovakia, Slovenia, Switzerland and Yugoslavia.

Uneven distribution of water resources among the population

The distribution of the European population on the territory is not linked to the geography of water resources. The urbanization level is generally very high. In 2000, renewable water resources per inhabitant ranged from less than 40 m^3/year in Malta and 992 m^3/year in Cyprus to 1 140 m^3/year in Denmark, 85 500 m^3/year in Norway and more than 600 000 m^3/inhabitant in Iceland. Therefore, the average value for the region of 4 342 m^3/inhabitant/year is hardly meaningful, especially as only a small part of these natural resources is exploitable in some places. Some countries rely heavily on external water resources and would fall under the threshold of 1 000 m^3/inhabitant/year if they had to rely only on their internal resources: Hungary (less than 600 m^3/inhabitant/year), and the Netherlands (less than 700 m^3/inhabitant/year).

Subregional analysis

The Northern Europe subregion has very abundant water resources per country and per inhabitant (except Denmark) and its drainage systems are quite large.

The Western Europe subregion has relatively small rivers. The subregion has large international river basins (Rhine, Meuse, Rhone, Elbe, etc.) and related transboundary pollution problems. In view of the relatively low rate of water abstraction for agriculture in the Western Europe subregion, water allocation problems between the countries there are relatively minor.

The Central Europe subregion is the most populated subregion, with several landlocked countries and low rainfall rates. Water resources per inhabitant are less evenly distributed than in the Western Europe subregion. They are organized around a major watershed (Danube) and some secondary watersheds flowing to the Baltic Sea (Oder and Vistula), the North Sea (Elbe) and the Mediterranean Sea (Drin, Maritza and Vardar). Most of the rivers concerned are transboundary.

The Mediterranean Europe subregion has a higher level of water resources per inhabitant than the Western Europe and Central Europe subregions do. However, the water resources are more irregular, divided in numerous small basins, and unevenly distributed among and within countries. The subregion includes two island states: Cyprus and Malta. Pressure on water is relatively high in the subregion, in part due to the need for irrigated agriculture.

Table 15 summarizes the water situation of the countries of the region in terms of water resources per inhabitant and dependency ratio.

Table 15
Classification of Western and Central Europe countries by water resources

	Degree of independence	Resources per capita (m^3/year)			
		Low < 1 000	Average 1 000-10 000	High 10 000-100 000	Very high > 100 000
1	Independence or low dependence	Cyprus, Malta	Denmark, France, Italy, United Kingdom	Finland, Ireland, Norway, Sweden	Iceland
2	Average or high dependence on upstream country		Germany, Greece, Netherlands, Portugal	Albania	
3	One or the other		Austria, Bulgaria, Luxembourg, Romania	Croatia, Hungary, Slovenia, Yugoslavia	
4	Restriction of freedom to provide water to downstream country		Bosnia and Herzegovina, Slovakia, Spain, Switzerland		

Region 5: Eastern Europe

General features

The Eastern Europe region includes the Russian Federation and the eastern European and Baltic states. The total area of the region is about 18 million km^2, covering 13.5 percent of the world's land area of the world and accounting for 3.6 percent of its population. The countries of this region have been grouped in two subregions, based primarily on geographic conditions and, as far as possible, on hydroclimatic homogeneity (although the Russian Federation is subject to a wide variation of geographic and hydroclimatic conditions). The two subregions are:

- Russian Federation: Russian Federation;
- Other European countries of the former Soviet Union: Belarus, Estonia, Latvia, Lithuania, Republic of Moldova, and Ukraine.

Climate

Table 16 summarizes the main climate features of the countries of the Eastern Europe region. It highlights the great variability both between and within countries, from polar to tropical humid. The water resources reflect this climate variability.

Water resources

In terms of annual IRWR per inhabitant, the Eastern Europe region is characterized by an extreme variability: from a minimum of 227 m^3 in the Republic of Moldova to more than 29 000 m^3 in the Russian Federation. However, the water resources in the Russian Federation are very unevenly distributed in relation to the population. In the more densely populated western part, annual renewable surface water resources are estimated at about 2 000 m^3/inhabitant compared with up to 190 000 m^3/inhabitant in the Siberian and Far Eastern regions.

TABLE 17
Water resources in the Eastern Europe region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
5 Eastern Europe	Other European countries of former Soviet Union	1 020 050	71 560 000	136.3	63.1	(1)	199.4	5.49	1 904.9	2 786.6
	Russian Federation	17 075 400	145 491 000	4 312.7	181.0	(2)	4 493.7	94.51	29 642.4	30 886.4
	Eastern Europe	**18 095 450**	**217 051 000**	**4 449.0**	**244.1**	**(3)**	**4 693.2**	**100.00**	**20 497.5**	**21 622.3**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Eastern Europe as % of world	13.5	3.6	10.2			10.7			

Notes:

(1) 16.18 km^3/year from another region and 63.14 km^3/year from Central Europe including 63 km^3/year for the Danube (50 percent of the flow).
(2) 6.54 km^3/year from the other subregion; and 179 km^3/year from other regions (16 km^3/year from Northern Europe, 40 km^3/year from Central Asia,125 km^3/year from Asia).
(3) 40 km^3/year from Central Asia, 125 km^3/year from Southern and Eastern Asia, and 79.14 km^3/year from Western and Central Europe.

TABLE 16
Main climate features of the countries of the Eastern Europe region

Country	Type of climate	Annual precipitation (mm)	
		Average	Range
Belarus	Continental	700	550-800
Estonia	Maritime to continental	632	
Latvia	Maritime to continental	743	600-850
Lithuania	Maritime to continental	748	550-846
Republic of Moldova	Semi-arid	450	370-550
Russian Federation	Polar in the north, maritime along the eastern shores, continental in more than half of the country, moderately warm in the south	589	200-1 000
Ukraine	Semi-arid to continental	500	300-600

The Republic of Moldova is the only country with annual IRWR of less than 1 000 m^3/inhabitant. However, when adding the external flow to the IRWR, all the countries of the Eastern Europe region show total actual renewable water resources in excess of 2 000 m^3/inhabitant. Three countries depend on other countries for more than 50 percent for their renewable water resources: the Republic of Moldova for more than 91 percent of its water resources, Ukraine for 62 percent, and Latvia for 53 percent. All other countries in the region have more than 2 000 m^3/inhabitant/year of IRWR and four countries have more than 10 000 m^3/inhabitant/year.

Table 17 summarizes the distribution of the IRWR among the two subregions and compares the results with their population. The group of former Soviet Union countries has the highest population density and 1 904 m^3/inhabitant/year of IRWR, while the Russian Federation has the lowest population density and more than 29 000 m^3/inhabitant/year.

Exchanges

Although the region as a whole is well endowed in terms of water resources related to the population (more than 21 000 m^3/inhabitant/year), their distribution varies from 232.8 m^3/year/inhabitant for the Republic of Moldova to 30 000 m^3/inhabitant/year for the Far Eastern part of the Russian Federation. In the areas with low IRWR, the network of rivers partly offsets these handicaps and brings the total water resources per inhabitant to an acceptable level. Water resources are distributed among the countries of the region and surrounding countries through an extensive surface water network crossing borders, and occasionally acting as borders between countries. At the time of the Soviet Union, interregional water management was governed through master plans. Since 1990, no specific treaty has been enacted between countries in order to fix the shares of each riparian country in a river system (except in some riparian countries in the Near East region). Table 18 shows the diversity of situations now prevailing in the region.

REGION 6: AFRICA

General features

Africa is a large continent of 53 countries with a wide range of hydrological situations. Indeed, such is the region's diversity, it could be divided into 24 major hydrological units or basin groups: 8 major river basins, draining to the sea (Senegal, Niger, Nile, Shebelli-Juba, Congo,

TABLE 18
Transboundary and border rivers in the Eastern Europe region

Transboundary rivers for which no treaty exists	Upstream country	Downstream country 1	Downstream country 2
Don	Russian Federation	Ukraine	Russian Federation
Pripyat	Ukraine	Belarus	Ukraine
Dniepr	Russian Federation	Belarus	Ukraine
Cisa	Ukraine	Hungary	to Danube
Dvina	Russian Federation	Belarus	Latvia
Pregel	Poland	Russian Federation	
San	Ukraine	Poland	
Irtysh	China	Kazakhstan	Russian Federation
Tobol	Russian Federation	Kazakhstan	Russian Federation
Ishim	Kazakhstan	Russian Federation	
Ural	Russian Federation	Kazakhstan	
Lielupe	Lithuania	Latvia	
Venta	Lithuania	Latvia	
Yenisei	Mongolia	Russian Federation	
Neva	Finland	Russian Federation	
Border rivers for which no treaty exists	**Border countries**	**Upstream countries**	**Downstream countries**
Neman	Lithuania and Russian Federation	Belarus and Lithuania	
Amur	China and Russian Federation	China	Russian Federation
Northern-Western Bug	Poland and Ukraine, Poland and Belarus	Ukraine	Poland
Samur	Russian Federation and Azerbaijan	Russian Federation	
Prut	Republic of Moldova and Romania	Ukraine	
Danube	Ukraine and Romania	many European countries	

Zambezi, Limpopo and Orange rivers); 9 coastal regions grouping several small rivers, also draining to the sea; 5 regions grouping several endorheic drainage basins (Lake Chad, Rift Valley, Okavango, South Interior and North Interior).

For the purposes of this study, the Africa region was divided into seven climate subregions on the basis of geography and climate:

- Northern Africa: Algeria, Egypt, Libyan Arab Jamahiriya, Morocco and Tunisia;
- Sudano-Sahelian: Burkina Faso, Cape Verde, Chad, Djibouti, Eritrea, Gambia, Mali, Mauritania, Niger, Senegal, Somalia and Sudan;
- Gulf of Guinea: Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone and Togo;
- Central Africa: Angola, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon and Sao Tome and Principe;
- Eastern Africa: Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda;
- Indian Ocean Islands: Comoros, Madagascar, Mauritius and Seychelles;
- Southern Africa: Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe.

The information available is uneven and very poor for some of the African countries. Many studies were carried out in the late 1980s and in the 1990s on water resources in African countries, mainly in water scarce areas. In humid countries, little attention is given to the subject and information is rare.

With the exception of the Indian Ocean Islands, all the subregions are between 2 and 9 million km^2 in area, the smallest being the Gulf of Guinea subregion and the largest being the Sudano-Sahelian subregion. A quantitative estimate of the average annual rainfall was available from national sources for 41 out of 53 countries. These data were compared with the recently available digital map of rainfall in Africa. In an attempt to improve the homogeneity of rainfall information, the results from the digital maps were selected, except for the islands (for which no digital map was available). Each subregion has its climate specificity.

Table 19 compares the values for internally produced water resources (including surface water and groundwater) and total renewable resources with precipitation and population for the seven Africa subregions.

Northern Africa

This subregion extends from the Mediterranean climate zone to the desert. It has two rainy seasons in autumn and spring, with a clear, dry summer season. There are major differences within the subregion between the Maghreb (Algeria, Libyan Arab Jamahiriya, Morocco and Tunisia) and Egypt. The Maghreb has climates changing from north to south, a divided and dispersed hydrography (some average-sized rivers only in Morocco), and an important endorheic zone (especially in the Sahara). It has scarce resources but very few transboundary exchanges. Egypt has an arid climate and a simplified hydrography with only one river, the Nile River flowing from the highlands of Ethiopia, Rwanda and Burundi. It has very reduced internal resources.

Northern Africa has very limited water resources, with less than 10 mm/year on average and it is in a situation of very severe water scarcity, with values per inhabitant varying between 200 and 700 m^3/year. In terms of internal water resources, it is the poorest subregion in Africa (1.2 percent of the continent's total internal water resources) and it is the subregion with the highest percentage of external water resources (63 percent) due to the Nile River, which serves only one country.

However, the Sahara has very important fossil groundwater reserves of major sedimentary aquifers such as the Continental Sahara, Murzuk, and the Nubian Basin. These resources are common to various countries.

Sudano-Sahelian

The subregion is marked by a climate zoning from north to south, from arid to tropical climates. The hydrographic system is not dense but structured around major transboundary river basins such as the Nile and the Niger, flowing across subregions. The subregion is also characterized by important endorheism, structural as in the case of Lake Chad, or functional as in the case of the large inner deltas of the Niger and Nile rivers, resulting in important evaporation and reduction in runoff. The groundwater flows are important and there are significant exchanges between surface water and groundwater. The runoff regimes are irregular.

TABLE 19
Water resources in the Africa region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
6 Africa	Central Africa	5 328 660	87 518 000	1 912.2	37.8	(1)	1 950.0	48.41	21 849.0	22 280.9
	Eastern Africa	2 924 970	165 961 000	260.0	2.1	(2)	262.1	6.58	1 566.6	1 579.3
	Gulf of Guinea	2 119 270	176 651 000	951.8	73.0	(3)	1 024.8	24.09	5 388.0	5 801.3
	Indian Ocean Islands	594 270	18 638 000	345.4	0.0	(4)	345.4	8.74	18 532.6	18 532.6
	Northern Africa	5 752 890	142 802 000	49.5	85.0	(5)	134.5	1.25	346.3	941.5
	Southern Africa	4 738 520	102 221 000	271.2	37.4	(6)	308.6	6.86	2 652.8	3 019.0
	Sudano-Sahelian	8 587 030	99 583 000	160.2	213.9	(7)	374.1	4.06	1 608.7	3 756.4
	Africa	**30 045 610**	**793 374 000**	**3 950.2**	**0.0**		**3 950.2**	**100.00**	**4 979.0**	**4 979.0**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Africa as % of world	22.4	13.1	9.0			9.0			

Notes:

(1) 37.8 km^3/year from other subregions (4 km^3/year from Sudano-Sahelian, 1.8 km^3/year from Eastern, and 32 km^3/year from Southern (Zambia)). Nothing from other regions.
(2) 2.1 km^3/year from other subregions (2 km^3/year from Central, and 0.1 km^3/year from Sudano-Sahelian). Nothing from other regions.
(3) 73 km^3/year from other subregions (44 km^3/year from Sudano-Sahelian, and 29 km^3/year from Central (Cameroon)). Nothing from other regions.
(4) No external resources.
(5) 85 km^3/year are mostly the Nile (natural) from Sudano-Sahelian (Sudan). Nothing from other regions.
(6) 37.44 km^3/year from other subregions (36.3 km^3/year from Central, and 1.14 km^3/year from Eastern). Nothing from other regions.
(7) 213.87 km^3/year from other subregions (61.37 km^3/year from Gulf of Guinea, 28 km^3/year from Central, and 124.5 km^3/year from Eastern). Nothing from other regions.

Overall, the water resources are limited and very unequally distributed across the subregion. The subregion receives 57 percent of its resources from outside, mostly from the Fouta Djalon in Guinea, considered the water tower of western Africa (source of the Gambia, Senegal, Niger and Chari rivers) and from the highlands of eastern Africa (Nile, Shebelli and Juba rivers from Ethiopia). It is the second poorest subregion in Africa in terms of water (less than 5 percent of the continent's internal water resources). Like Northern Africa, this subregion has a high potential of fossil groundwater reserves (the Senegal-Mauritania Basin, the Lullemeden Basin in Niger, and the Chad Basin) but they have not been estimated properly and they are difficult to access in some cases.

Gulf of Guinea

The subregion benefits from a monsoon-type, tropical humid climate. The hydrographic system is dense but divided in many small systems. Its main river basin is the Niger (Africa's second river by average flow), shared between ten countries. The subregion's internal resources represent 25 percent of the continent's total water resources. Groundwater represents one-third to one-half of the subregion's total water resources, with important overlap between surface water and groundwater systems.

Central Africa

This subregion has a humid equatorial climate in the south with long rainy seasons. A dense and concentrated hydrographic networks feeds two major rivers: the Congo River (the world's second largest river after the Amazon River) and the Ogooué River (Africa's third largest river).

Water resources are abundant and represent 48.4 percent of the continent's internal resources. The groundwater component is important but the overlap with surface waters is high. This subregion is a major provider of water to neighbouring subregions.

Eastern Africa

This subregion is characterized by diversified climate conditions (tropical humid to semi-arid) and two rainy seasons: autumn and spring. The hydrographic network is not dense and there is no major river except the Nile River in Ethiopia. However, the subregion is home to Africa's largest lake (Lake Victoria).

The water resources are limited (6.5 percent of the continent's internal resources) and the subregion does not receive much water from outside. Groundwater resources are important and there is a high overlap with surface runoff. This subregion provides water to the Sudano-Sahelian subregion through the Nile River.

Indian Ocean Islands

This subregion encompasses very diverse situations. It includes: (i) Madagascar, a large island with a climate varying from tropical humid in the north to semi-arid in the south; and (ii) various archipelagos of small islands in a tropical humid climate zone.

This subregion ranks third in terms of water resources. Madagascar is the continent's second richest country in terms of water after the Democratic Republic of Congo. The groundwater contribution is low but with a high overlap. The other small islands have abundant water resources, but these are mainly groundwater and scattered within their territories.

Southern Africa

This subregion has a very diverse climate, from subtropical humid to arid. It has various major river basins, all transboundary: Zambezi, Limpopo and Orange. The Okavango Basin in Botswana is endorheic.

The water resources are modest (7 percent of the continent's total), mainly internal to the subregion, and very unequally distributed within it. Important external resources enter from the Central Africa subregion (mostly through the Zambezi Basin). Important groundwater reserves can be accessed but are in part not renewable, especially in South Africa.

Water resources in the Africa region

The Africa region represents an important part of the world in terms of land and water: 22.4 percent of the world's land area, and 9 percent of the world's actual water. With only 13 percent of the world's population, Africa has reasonable resources with 4 979 m^3/inhabitant/year at the continent level. However, although they cover the largest part of the continent, the Northern Africa and Sudano-Sahelian subregions contribute only 1.2 and 4.06 percent respectively of the Africa region's total water resources. The Southern Africa subregion also has a very low runoff coefficient (9 percent).

In addition, the Africa region shows very diverse hydrographic conditions:

- The size of the drainage water systems varies greatly from country to country. The Congo River basin represents 30 percent of the continent's runoff. Together, the continent's ten major rivers provide 50 percent of its total runoff.
- The endorheic basins represent one-third of the continent's area.
- The possibilities for developing water infrastructures, in particular dams, are limited. Moreover, such infrastructures are often subject to high silting rates, in particular in the arid and semi-arid regions. In the Maghreb, the useful life of a dam is often less than 50 years (Margat/OSS, 2001). In Sudan, the Khams el Girba Reservoir lost 40 percent of its theoretical useful capacity (1 300 million m^3) between 1965 and 1977, with an average sedimentation rate of 80 million tonnes/year.
- Groundwater recharge is a critical factor for the development of arid and semi-arid countries. The distribution between surface water and groundwater illustrates the difference between arid and humid subregions. In arid subregions (Northern Africa, Sudano-Sahelian and Southern Africa), groundwater recharge is important and a large part of groundwater resources is not connected to the river system. The base flow of the rivers is usually low, and the overlap between surface water and groundwater is small. On the other hand, in humid subregions (Gulf of Guinea and Central Africa), aquifers are connected to the river system and groundwater constitutes almost the entire base flow of rivers. Thus, overlap is almost equal to the groundwater resources.
- In arid regions, evaporation from wetlands and lakes plays a major role and may substantially limit the amount of water resources available for use. In Sudan, Mali and Botswana, the quantity of water leaving the country is less than the quantity of the water flowing into the country. The river flows in these countries decrease progressively, mainly as a result of the high rates of evaporation in internal deltas. This is the case with the Nile River, the Niger River, the Okavango River, and the semi-endorheic Saharian watercourses. The present

study reviewed the water balance of these major water bodies carefully. In some cases, water resources were calculated upstream of the major evaporative areas (Mali, Uganda and Egypt). For Sudan, water resources were computed taking into account evaporative losses in the wetlands of the Sudd.

- The water scarcity that prevails in the arid countries has forced national economies to find alternative ways to satisfy the demand for freshwater. Some countries convert an increasing amount of water from poor quality aquifers (brackish water) into usable water. Similarly, treatment and reuse of wastewater is a common practice in countries in the Northern Africa subregion. Information on reused treated wastewater exists for most of the countries but there is probably a large amount of non-treated wastewater which is reused for agriculture around the main cities and which is not reported.

Exchanges and shared resources

Africa has large rivers crossing several climate regions. These play a major role in the water exchanges in the subregions. The Nile, Niger, Chari, Senegal, Okavango and Orange rivers all contribute to important transfers of water from wet to dry regions (Table 20). The countries of the Sahel in western Africa receive about 50 km^3/year from their southern neighbours. Considering the Africa region as a whole, these transfers of water from humid to arid zones represent 50 percent of the water resources of the arid zones.

Another specificity of the Africa region is the non-renewable groundwater reserves located in the large sedimentary aquifers systems (Continental aquifer, Nubian sandstones, Sahel and Chad watersheds, Kalahari, etc.). These systems represent an important resource for the arid zones in view of the limited availability of renewable water resources. They are particularly important for Saharan countries such as Algeria, Egypt, Libyan Arab Jamahiriya, Niger and Tunisia. In these systems, the reserves considered exploitable can amount to many thousand million cubic metres. The Libyan Arab Jamahiriya depends heavily on fossil groundwater to cover its current water demand.

Region 7: Near East

General features

For the purposes of this study, the Near East region was divided into three subregions with some common characteristics:

- Arabian Peninsula: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, and Yemen;
- Caucasus: Armenia, Azerbaijan and Georgia;
- Middle East: Gaza Strip (Palestinian Authority), Iraq, Islamic Republic of Iran, Israel, Jordan, Lebanon, Syrian Arab Republic, Turkey, and West Bank (Palestinian Authority).

The Near East region as considered here represents an area of 6.34 million km^2 and includes 250 million people.

The common feature of climates in the region is that they are dry. These dry climates create major irrigation needs. However, there is a sharp contrast between countries with temperate regions to provide them with abundant water resources (e.g. Turkey) and countries adjacent to dry and desert areas with very limited water resources.

TABLE 20
Transboundary and border rivers in the Africa region

Transboundary and border rivers for which no treaty exists		
Transboundary or border river	Riparian countries, from upstream to downstream	
Buzi	Zimbabwe, Mozambique	
Cavally	Guinea, Côte d'Ivoire, Liberia	
Chiloango	Democratic Republic of Congo, Angola	
Comoé	Burkina Faso, Côte d'Ivoire	
Congo-Zaire	Zambia, Tanzania, Burundi, Rwanda, Central African Republic, Cameroon, Congo, Angola, Democratic Republic of Congo	
Corubal	Guinea, Guinea-Bissau	
Crocodile River (Limpopo)	Botswana, Zimbabwe, South Africa, Mozambique	
Cross	Cameroon, Nigeria	
Elephants River (Limpopo)	South Africa, Mozambique	
Gêba	Senegal, Guinea-Bissau	
Komati	South Africa, Swaziland, Mozambique	
Lake Chilwa	Malawi, Mozambique	
Lake Chiuta	Malawi, Mozambique	
Limpopo	Botswana, Zimbabwe, South Africa, Mozambique	
Mono	Togo, Benin	
Okavango	Angola, Namibia, Botswana	
Omo-Gibe (Rift Valley)	Ethiopia, Sudan, Uganda, Kenya	
Pendjari (Volta Basin)	Benin, Burkina Faso, Togo, Ghana	
Pungoé	Zimbabwe, Mozambique	
Ruvuma	Mozambique, Tanzania	
Save	Zimbabwe, Mozambique	
Senegal	Guinea, Mali, Mauritania, Senegal	
Shebelli and Juba	Ethiopia, Somalia	
Usutu	South Africa, Swaziland, Mozambique	
Volta	Mali, Burkina Faso, Benin, Togo, Côte d'Ivoire, Ghana	
Zambezi	Angola, Namibia, Botswana, Zimbabwe, Zambia, Tanzania, Malawi, Mozambique	
Transboundary and border rivers for which a treaty exists		
Transboundary or border river	*Riparian countries tied by a treaty, from upstream to downstream*	*Other riparian countries not tied by the treaty, from upstream to downstream*
Nile	Sudan, Egypt	Rwanda, Burundi, Uganda, Kenya, Ethiopia, Eritrea
Orange	Lesotho, South Africa	Botswana, Namibia
Gambia	Guinea, Senegal, Gambia	
Lake Chad	Nigeria, Niger, Chad, Cameroon	Algeria, Sudan, Central African Republic
Niger	Guinea, Côte d'Ivoire, Mali, Burkina Faso, Benin, Niger, Chad, Cameroon, Nigeria	Algeria

Notes:

The table may not be complete. Information is based on all rivers mentioned in FAO (1997a) and the Transboundary Freshwater Dispute Database (available at: http://terra.geo.orst.edu/users/tfdd/).

The table includes only those treaties made between currently existing states (not other treaties signed between colonial powers).

Source: Prepared by FAO/AGLW from multiple sources.

Water scarcity

The Near East is the region of the globe with the lowest figures in terms of absolute and per inhabitant water resources, even when considering the contribution of rivers flowing in from more humid regions of Anatolia (the Euphrates River) and the Caucasus.

Precipitation in the region is very low and variable, and the region's water resources are particularly sensitive to drought. During dry years, which occur approximately every ten years, rainfall can be as low as one-third of its long-term average. Typically, the development of surface water resources requires the construction of increasingly expensive flow-regulation systems (dams), with environmental impacts that threaten their long-term sustainability.

While the Near East region covers 4.7 percent of the world's total land area and contains 4.25 percent of its population, the region's water resources are only about 1.1 percent of the world's TRWR. The countries of the Near East region have less water resources per person than the world average. The TRWR per inhabitant are less than 1 000 m^3/inhabitant in 10 out of 18 countries. When considering only the IRWR, the number of countries under stress is higher. Large differences exist also between the subregions. The Arabian Peninsula has very limited water resources, with less than 10 mm/year of rainfall on average, and is in a situation of very severe water scarcity, with values between 200 and 700 m^3/inhabitant/year. In contrast, the Middle East subregion shows much higher values, due mostly to the abundant flows generated in the mountainous areas of Turkey and of the Caucasus subregion.

Furthermore, the water resources distribution within the region is far from uniform (Table 21). Topography, distance from the sea, latitude and resulting hydroclimatic conditions, the diversity of the hydrographic networks and of the geological structures, and transboundary rivers are all factors that give rise to extremely contrasting water situations.

Non-conventional water resources

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 freshwater.

Some oil-rich countries convert a significant amount of saline water from the sea or from poor-quality aquifers (brackish water) into drinking-water. The total use of desalinated water in the Near East region is estimated to be 3.93 km^3/year (Gleick, 2000). 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 total for the region (Saudi Arabia alone accounts for 47 percent).

Similarly, wastewater treatment and reuse is becoming a common practice in the Near East region. Figures for produced and treated wastewater are available for some countries but may be underestimates. In most countries, there are few wastewater treatment plants. Information on reused treated wastewater exists for most of the countries but is probably not reliable.

Water resources

In terms of their water resources, the three subregions of the Near East region are rather independent of one another and there is practically no exchange of water between them. The Near East countries can be classified in three categories:

1. Countries relying mostly on significant internal resources: the Islamic Republic of Iran, Lebanon and the countries characterized by high IRWR due to their favourable geographic situation (Turkey and the Caucasian countries). This group is characterized by a dependency ratio of less than 50 percent and IRWR in excess of 1 000 m^3/inhabitant/year. Some of these countries contribute heavily to the provision of water to downstream countries (Lebanon, Turkey and the Islamic Republic of Iran) through the river systems.
2. Countries with a significant part of their resources of external origin: Iraq and the Syrian Arab Republic. This group may be identified by a dependency ratio of more than 50 percent.

TABLE 21
Water resources in the Near East region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (4) (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
7 Near East	Arabian Peninsula	3 003 230	46 958 000	7.7	0.0	(1)	7.7	1.58	163.8	163.8
	Caucasus	186 100	17 090 000	75.3	18.4	(2)	93.7	15.44	4 407.0	5 483.7
	Middle East	3 158 640	193 066 000	404.7	3.2	(3)	407.9	82.98	2 096.3	2 112.6
	Near East	**6 347 970**	**257 114 000**	**487.7**	**3.2**		**490.9**	**100.00**	**1 897.0**	**1 909.2**
	World	**133 845 436**	**6052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Near East as % of world	4.7	4.2	1.1			1.1			

Notes:

(1) No external resources.
(2) From Middle East (Turkey, Islamic Republic of Iran) subregion.
(3) From Central Europe (Bulgaria) region.
(4)

Transboundary or border river	Riparian countries tied by a treaty	Other riparian countries not tied by the treaty
Arax	Turkey, Armenia and Azerbaijan	Islamic Republic of Iran

Iraq has IRWR in excess of 1 000 m^3/inhabitant/year. In this category, the major problem in assessing water resources lies in estimating the transboundary surface water and groundwater flows. These countries are also characterized by significant differences between natural and actual resources. In this study, special attention was given to the estimation of the actual flows, based on the information available.

3. Countries with very limited renewable internal and external water resources such as Israel and Jordan. This group is characterized by IRWR of less than 1 000 m^3/inhabitant/year and a dependency ratio of less than 50 percent. These countries face a critical situation in terms of water resources. Depending on their geographical position and their geological characteristics, they have adopted different approaches to meet their internal water demand. Some of them (Jordan, Saudi Arabia and Bahrain) have substantial non-renewable groundwater resources, partly shared with neighbouring countries and for which each country adopts different mining policies. The remaining countries do not have other significant groundwater reserves at their disposal either because of their size (Qatar and the United Arab Emirates) or because of the geology of the country.

Region 8: Central Asia

General features

The main features of the climate of countries in the Central Asia region are a great variability from country to country and within countries (Table 22). The same applies to water resources. The region can be divided into two subregions:

- Aral Sea countries: Kazakhstan and Uzbekistan;
- Other countries: Afghanistan, Kyrgyzstan, Tajikistan and Turkmenistan.

Table 22
Climate variability in the Central Asia region

Country	Type of climate	Annual precipitation (mm)	
		Average	Range
Afghanistan	Continental, semi-arid	320	100-800
Kazakhstan	Continental	344	100-1 600
Kyrgyzstan	Continental	533	150-1 000
Tajikistan	Continental	691	100-2 400
Turkmenistan	Semi-arid	191	80-300
Uzbekistan	Continental, semi-arid to arid	287	97-878

Although the Central Asia region covers 3.5 percent of the world's total land area and contains 1.3 percent of its population, its water resources are only about 0.7 percent of the world's TRWR. However, the region is reasonably endowed with water (3 320.5 m^3/inhabitant/year). The figures in the column external resources in Table 23 correspond to either actual inflow affected by upstream consumption or to inflow secured through treaties. Therefore, the actual inflow may be higher than the inflow secured through treaties indicated in the table for certain countries (e.g. Uzbekistan). Another difficulty related to the inflows or outflows secured by treaties relates to the fact that in most cases the treaties fix the exchanges between countries in terms of percentage of basin water resources, which vary from year to year.

This is the case with the countries around the Aral Sea. The inflows indicated here are somewhat theoretical as they have been calculated on the basis of an estimate of the average annual water resources for the whole Aral Sea Basin (Amu Darya and Syr Darya) and of water allocation defined as a percentage of part (65-70 percent) of the total basin water resources, according to the master plans for water resources development in the Amu Darya (1987) and Syr Darya (1984) basins, endorsed by the Interstate Agreement of 18 February 1992.

TABLE 23
Water resources in the Central Asia region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
8 Central Asia	Aral Sea countries	3 172 300	41 053 000	91.8	37.8	(1)	129.6	35.17	2 235.2	3 155.9
	Other countries	1 483 190	37 510 000	169.1	2.1	(2)	171.2	64.83	4 508.4	4 564.4
	Central Asia	**4 655 490**	**78 563 000**	**260.9**	**28.3**	**(3)**	**289.2**	**100.00**	**3 320.5**	**3 680.5**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Central Asia as % of world	3.5	1.3	0.6			0.7			

Notes:

(1) 63.03 km^3/year from another subregion and 27.47 km^3/year from other regions (5 km^3/year from Eastern Europe (Russian Federation) and 22.47 km^3/year from Asia (China)).

(2) 17.23 km^3/year from the Aral Sea subregion and 0.81 km^3/year from the Near East region (Islamic Republic of Iran).

(3) External resources are those from other regions as indicated in the previous notes.

For the flows that are not subject to formal treaties or agreements, the values indicated in Table 23 correspond to average annual actual flows in recent years. However, owing to difficulties in collecting reliable data, the flow average was not calculated systematically over the same period.

The Aral Sea

The Aral Sea, located in a depression in the Turan Plain, is fed by two major rivers: the Amu Darya in the south, and the Syr Darya in the north. These rivers originate in the southwestern Pamir and Tien Shan mountain ranges respectively. The combined basin of these two rivers has a total area of about 1.9 million km^2 and spreads over six countries. In Kazakhstan, all the flow of the Turgay, Sarysu, Chu and Talas rivers is lost in the desert or is directed to natural depressions. It can be considered that these rivers are not part of the Aral Sea Basin sensu stricto.

The assessment of natural flow in the basin is hampered by the large amounts of water withdrawn from the rivers since the 1950s for irrigation purposes. Reconstructing long-term time series, the average annual renewable surface water resources in the Aral Sea Basin are estimated at 116 km^3, of which 78 km^3 in the Amu Darya Basin and 37 km^3 in the Syr Darya Basin (Table 24). For a 20-year return period, the values are 47 km^3 for the Amu Darya and 21 km^3 for the Syr Darya.

Before 1960, the level of the Aral Sea was more or less stable. Its surface area was about 66 000 km^2 and its volume about 1 060 km^3. The Aral Sea received water from the following sources: surface water (the total average discharge of the Amu Darya and Syr Darya to the Aral Sea was about 47-50 km^3/year), groundwater inflow (5-6 km^3/year), and precipitation over the Aral Sea (5.5-6.5 km^3/year). The total volume of 57.5-62.5 km^3/year compensated the evaporation from the lake, estimated at about 60 km^3/year. The level of the Aral Sea was then fluctuating about 50-53 m above the average level of the oceans. The difference between the renewable surface water resources of the Aral Sea Basin, estimated at 115.6 km^3/year, and the necessary discharge to the Aral Sea for a stable water balance, estimated at 47-50 km^3/year, could have been available for use in the basin, i.e. about 65.6-68.6 km^3/year. The average mineral content of the seawater was estimated at 10 g/litre in 1960.

In the 1960s, the development of irrigation in the Soviet part of the Aral Sea Basin increased the irrigated area from about 4.5 million ha in 1960 to almost 7 million ha in 1980. The population rose from 14 million inhabitants in 1960 to about 27 million inhabitants in 1980. Total water

TABLE 24
Renewable surface water resources of the Aral Sea Basin

Country or zone	Area			Renewable surface water resources					
	km^2	% of basin area	% of country area	Amu Darya Basin		Syr Darya Basin		Aral Sea Basin	
				km^3/year	% of basin	km^3/year	% of basin	km^3/year	% of basin
South Kazakhstan	540 000	28	20	-	0.0	4.50	12.1	4.5	3.9
Turkmenistan	466 600	24	96	0.98	1.2	-	0.0	0.98	0.8
Uzbekistan	447 400	23	100	4.70	6.0	4.84	13.0	9.54	8.3
North Afghanistan	234 800	12	36	6.18	7.9	-	0.0	6.18	5.3
Tajikistan	141 670	7	99	62.90	80.2	0.40	1.1	63.30	54.8
Kyrgyzstan	117 500	6	59	1.93	2.5	27.25	73.4	29.18	25.2
Total	1 947 970	100		76.69	97.7	36.99	99.6	113.68	98.3
Basin *				78.46	100.0	37.14	100.0	115.60	100.0

* Time series and methods used for water resources computation for the basin as a whole and for each country may vary. This explains the difference between the total of countries and the value for the whole basin.

Table 25
Transboundary and border rivers in the Central Asia region

Transboundary rivers for which no treaty exists	Upstream country	Downstream country 1	Downstream country 2
Murghab	Afghanistan	Turkmenistan	
Tarim	Kyrgyzstan	China	
Ili	Kyrgyzstan and China	Kazakhstan	
Emel	China	Kazakhstan	
Irtysh	China	Kazakhstan	Russian Federation
Border rivers for which no treaty exists	**Border countries**	**Upstream countries**	**Downstream countries**
Atrek	Turkmenistan and Islamic Republic of Iran	Turkmenistan and Islamic Republic of Iran	
Transboundary and border rivers for which a treaty exists	**Riparian countries tied by a treaty**	**Other riparian countries not tied by the treaty**	
Amu Darya and tributaries	Tajikistan, Kyrgyzstan, Uzbekistan and Turkmenistan	Afghanistan	
Syr Darya and tributaries	Tajikistan, Kyrgyzstan, Uzbekistan and Kazakhstan		
Chu, Talas and Assa	Kyrgyzstan and Kazakhstan		
Atrek	Turkmenistan and Islamic Republic of Iran		
Tedzhen	Turkmenistan and Islamic Republic of Iran	Afghanistan	

withdrawal increased from 64.7 km^3 in 1960 to 120 km^3 in 1980, of which more than 90 percent for agricultural purposes, and resulted in the disruption of the prevailing water balance in the basin. Today, the inflow to the Aral Sea is estimated at 1-2 km^3/year from the Syr Darya and 5-10 km^3/year from the Amu Darya.

Exchanges

Water resources are distributed among the countries of the Central Asia region and surrounding countries through an extensive network of rivers either crossing borders or acting as borders between countries. At the time of the Soviet Union, water management was governed through master plans. After the ending of the Soviet Union, treaties had to be enacted in order to allocate water to the various riparian countries.

Table 25 shows the diversity of the situations now prevailing in the Central Asia region in terms of water exchanges.

Region 9: Southern and Eastern Asia

General features

The total area of the Southern and Eastern Asia region is about 20.4 million km^2, which is 15 percent of the world's total land area. China and India together account for about 63 percent of this area. The region can be divided into five subregions as follows:

- Indian Subcontinent: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka;
- Eastern Asia: China, Democratic People's Republic of Korea, and Mongolia;

- Far East: Japan and Republic of Korea;
- Southeast Asia: Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam;
- Islands: Brunei, Indonesia, Malaysia, Papua New Guinea and Philippines.

Indian Subcontinent

The Indian Subcontinent subregion extends over an area of 3 961 680 km^2, about 18 percent of the region's total area. It comprises Bangladesh, Bhutan, India, Nepal, Maldives, Pakistan and Sri Lanka. The geomorphology of these countries consists of a large portion of floodplains along the Indus and Ganges river basins, some terraces and hilly areas, and the mountainous terrain of the Himalayas, with the world's highest peak (Mount Everest, 8 848 m a.s.l.) located in the Nepal Himalayas.

The subregion experiences a tropical monsoon climate, with significant seasonal variations in rainfall and temperature. About 80 percent of the total precipitation occurs during the monsoon period. The climate year includes two monsoon periods: the southwest monsoon (June-September), which brings most of the rainfall; and the northeast monsoon (November-March), relatively light compared with the southwest monsoon. The highest temperatures are registered during the dry season (generally from March to May) with 43 °C in Bangladesh and 40 °C in northwest India.

The average annual precipitation in the subregion is about 1 279 mm, varying from less than 150 mm in the northwest desert of Rajasthan, India, to more than 10 m in the Khasi Hills in northeast India.

Eastern Asia

The Eastern Asia subregion includes China, Mongolia and the Democratic People's Republic of Korea (DPR Korea). It extends over an area of 11 285 070 km^2, which is about 55 percent of the region's total area and 8.4 percent of the world's total land area. This region is mainly mountainous with about 80 percent of the landmass lying above 1 000 m a.s.l.

The monsoon determines the climate in eastern and southern China. In the rest of the subregion, the climate is generally characterized by long cold winters caused by the north and northwest winds from Siberia with temperatures ranging from -20 to -40 °C. Precipitation is more important in the summer months (May/June to August/September). Large parts of southern Mongolia and central China suffer from a very arid climate and are facing severe water scarcity problems.

The average annual precipitation in the subregion is 597 mm, varying from less than 25 mm in the Tarim and Qaidam basins in China to 1 520 mm in DPR Korea. Among the factors affecting agricultural production in the region are: low soil moisture and air humidity in spring and early summer; and frosts in spring and autumn.

Far East

The Far East subregion includes Japan and the Republic of Korea. The total area is 477 060 km^2, or 2 percent of the total area of the region. Mountains cover almost 70 percent of the total area. Mount Fuji in Japan is the highest peak at 3 776 m a.s.l.

The climate in the region shows four distinct seasons. Winds and the mountainous topography divide the landmass into two typical climate zones: the Pacific coastal zone, marked by the summer monsoon which blows from the Pacific Ocean bringing warmer temperatures and rain; and the continental zone, characterized by the winter monsoon from the Asian continent, which brings freezing temperatures and heavy snowfalls. The average annual precipitation in the region is 1 634 mm, most falling during the summer months from June to September. The region is often struck by typhoons that cause severe crop damage mainly during summer and early autumn.

Southeast Asia

The Southeast Asia subregion with an area of 1 939 230 km^2, or 9.5 percent of the total area of the region, is composed of Myanmar and the four riparian countries of the lower Mekong Basin (Cambodia, Thailand, Viet Nam and Lao PDR). Mountains and hills are the main physiographical features, covering about two-thirds of the total area, with the highest point situated at 5 800 m a.s.l in the extreme north of Myanmar. The extensive plains along the Mekong, Red and Ayeyarwady rivers are frequently subject to flooding.

The climate is governed mainly by the alternating between the wet season, characterized by the southwest monsoon (May-October) with heavy rainfall, and the dry season, characterized by the northeast monsoon (November-February), which is relatively cool and dry. About 75 percent of the total rainfall occurs during the wet season. This pattern results in a large difference in the water level in rivers between the wet and the dry seasons. The water level in the Mekong River may differ by up to 20 m between the two seasons. The average annual rainfall in the region is 1 877 mm, ranging from 500 mm in the central dry zone in Myanmar and 650 mm in Phan Rang in Viet Nam to more than 4 000 mm in the mountains of Rakhine in Myanmar and Bac Quang in Viet Nam.

Islands

This subregion includes the countries of the Indian and North Pacific oceans from Malaysia to Papua New Guinea and characterized by their insular nature. Its land area extends over 3 002 930 km^2, which is about 15 percent of the area of the region. The relief is dominated by extensive lowland plains and swamps. These contrast sharply with high mountain ranges, with the highest point situated at 5 030 m a.s.l. in the volcanic mountains of Indonesia.

The climate of the region is tropical and monsoonal, characterized by the uniformity of temperature (27 °C throughout the year) and high humidity (70-80 percent). The region is under the influence of two main airstreams: the northeast monsoon, blowing from October to March and responsible for heavy rainfall, and the southwest monsoon, occurring between May and September. Many islands in the subregion are liable to extensive flooding and typhoon damage during the period from June to September. The average annual rainfall in this subregion is 2 823 mm, ranging from less than 1 000 mm in Port Moresby to more than 8 000 mm in some mountainous areas in Papua New Guinea.

Water resources

The large range of climates encountered in the Southern and Eastern Asia region generates a variety of hydrological regimes. The region has some of the most humid climates (with annual precipitation above 10 m in places), which give rise to major rivers. In other parts, the region has a very arid climate, with closed hydrologic systems. As a result, the region shows a very uneven distribution of its water resources and of its water use conditions. In the humid areas, water management concerns have been dominated largely by flood-control considerations. This is the case in the Mekong, Brahmaputra and Ganges basins. In the arid areas such as central China, hydrological studies have focused more on water resources assessment.

The hydrology of the region is dominated by the typical monsoon climate, which induces large interseasonal variations in river flows. In this context, average annual values of river flows are a poor indicator of the amount of water resources available for use. In the absence of flow regulation, most of the water flows during a short season when it is usually less needed. A fair estimate of water resources available for use to a country should include figures on low flow. However, such information is available only for a very limited number of countries. In Bangladesh, the surface flow of the driest month represents only 18 percent of the annual average; in Indonesia, it is 17 percent. In India, the flow distribution of selected rivers in the monsoon period represents 75-95 percent of the total annual flow. In north China, 70-80 percent of the annual runoff is concentrated in the rainy season. As a first approximation, the amount of water readily available for use is between 10 and 20 percent of the TRWR in the absence of storage.

The information collected on the countries in the region does not make it possible to distinguish between the actual and natural flows of the major rivers, i.e. the impact of irrigation and other water withdrawals on runoff. In this survey, figures were systematically considered as natural flow. This option may result in a slight underestimation of natural flow in some cases. In at least one case (the Ganges River), the withdrawals in the upstream country (India) are known to affect significantly the volumes of water available to the downstream country (Bangladesh). This has led to the recent signing of a treaty between the two countries on procedures for managing the river flow. In view of the hydrological regime of the rivers in the region, it can be assumed that runoff in the countries in the Southeast Asia and Islands subregions is not affected significantly by withdrawals, while the difference between natural and actual flow may be much more important in the arid regions (especially China).

In terms of shared water resources, the region is characterized on the one hand by a series of insular countries between which no exchange is possible, and on the other hand by a zone in which shared river basins play a critical role and make the computation of water resources relatively complex (Southeast Asia subregion). In several cases, large inconsistencies were noted when comparing the flow at borders as recorded by neighbouring countries, e.g. the runoff of the main rivers flowing from China to India.

Overall, the region is relatively well endowed with water resources. While representing 15.8 percent of the world's land surface, it receives 22 percent of its precipitation and produces 27 percent of its water resources. However, as the region is home to 55.2 percent of the world's population, the amount of water resources per inhabitant is about half the world average. Table 26 shows the distribution of water resources among the five subregions. The relative aridity of the countries of the Eastern Asia subregion is shown by the precipitation, which is between two and five times less than the average of the other subregions. In terms of water resources per inhabitant, the Indian Subcontinent, Eastern Asia and Far East subregions show the lowest figures while the figures for the Southeast Asia and Islands subregions are considerably higher than the world average.

TABLE 26
Water resources in the Southern and Eastern Asia region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of internal water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
9 Southern and Eastern Asia	Eastern Asia	11 285 090	1 307 238 000	2 981.2	15.8	(1)	2 997.0	25.45	2 280.5	2 292.6
	Far East	477 060	173 836 000	494.9	4.9	(2)	499.7	4.23	2 846.6	2 874.5
	Indian Subcontinent	4 487 450	1 331 975 000	1 761.2	359.1	(3)	2 120.3	15.04	1 322.2	1 591.8
	Islands	3 018 420	319 855 000	4 707.1	0.0	(4)	4 707.1	40.19	14 716.4	14 716.4
	Southeast Asia	1 939 230	207 075 000	1 768.1	237.8	(5)	2 005.9	15.10	8 538.4	9 686.6
	Southern and Eastern Asia	**21 207 250**	**3 339 979 000**	**11 712.4**	**7.7**	**(1)**	**11 720.1**	**100.00**	**3 506.7**	**3 509.0**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	South and Eastern Asia as % of world	15.8	55.2	26.8			26.8			

Notes:

(1) 8.09 km^3/year from other subregions (0.84 km^3/year from Indian Subcontinent, 7.25 km^3/year from Southeast Asia (Viet Nam)) and 7.69 km^3/year from another region (Central Asia).

(2) From Eastern Asia (DPR Korea).

(3) 359.02 km^3/year from a subregion (China, Eastern Asia) + an unknown volume from another region (Central Asia - Afghanistan, Kabul River). Therefore, total external resources exceed 359.02 km^3/year.

(4) Islands, so no external resources.

(5) 237.77 km^3/year from other subregions: 20 km^3/year from Indian Subcontinent (India), 217.77 km^3/year from Eastern Asia (China).

Figures for produced and treated wastewater are available only for some countries and are often underestimates. Information on reused treated wastewater exists only for China and Japan, where the reused treated wastewater is reserved for the industrial sector. In addition, Japan and the Maldives produce about 40 million m^3/year and 0.37 million m^3/year of water respectively by desalination of seawater.

Region 10: Oceania and Pacific

General features

The Oceania and Pacific region covers a total area of 8 million km^2, or 6 percent of the world's total land area, and is home to 0.4 percent of the world's population. It can be subdivided into two subregions:

- Australia: Australia;
- Other countries: Fiji, Hawaii (United States of America), New Caledonia (France), New Zealand, Polynesia (France), Solomon Islands, and other Pacific islands.

The countries of this region are mostly islands of very different types as they range from 18 000 km^2 to 7 million km^2 in area. Therefore, there are no exchanges of water resources between the countries and no homogeneity in their situations. Some of the islands have a tropical climate governed mainly by the change between the wet season, with heavy rainfall, and the dry season. About 75 percent of the total rainfall occurs during the wet season. This results in a large difference in the water level in rivers between the wet and the dry seasons.

The large islands such as Australia and New Zealand have different climates (from very dry to humid). Australia is dry, with an uneven geographical and seasonal distribution of rainfall. River flows are highly variable, under the influence of an erratic climate. Diversion of water into irrigation has altered river runoffs significantly, leading in some cases to the reversal of the flow of some rivers. Australia has one of the world's largest aquifer systems, the Great Artesian Basin (GAB) estimated at 1.7 million km^2 and a storage volume of 8.7 km^3. Each year the GAB supplies 0.57 million m^3 of water for a variety of uses dominated by pastoral enterprises.

Table 27 presents the water resources of the countries of the region. Some countries, mainly islands, have been omitted because of lack of data.

TABLE 27
Water resources in the Oceania and Pacific region

Water resources regions	Water resources subregions	Total area (km^2) (FAOSTAT, 1999)	Total population (inh.) (FAOSTAT, 2000)	Internal resources: total (km^3/year)	External resources: actual (km^3/year)		Total resources: actual (km^3/year)	% of water resources of the region	IRWR/inhab. (m^3/year)	TRWR (actual)/inhab. (m^3/year)
10. Oceania and Pacific	Australia	7 741 220	19 138 000	492.0	0.0		492.0	54.00	25 708.0	25 708.0
	Other countries	346 200	7 111 537	419.0	0.0		419.0	46.00	58 869.1	58 869.1
	Oceania and Pacific	**8 087 420**	**26 249 537**	**911.0**	**0.0**		**911.0**	**100.00**	**34 692.0**	**34 692.0**
	World	**133 845 436**	**6 052 577 900**	**43 764.3**	**0.0**		**43 764.3**		**7 230.7**	**7 230.7**
	Oceania and Pacific as % of world	6.0	0.4	2.1			2.1			

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Annex 1
List of water regions and subregions

America

1. Northern America

Alaska, Canada and Greenland	Alaska (United States of America), Canada, Greenland.
Mexico	Mexico.
United States of America	United States of America (conterminous states).

2. Central America and Caribbean

Central America continent	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama.
Caribbean	Antigua and Barbuda, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago.
Greater Antilles	Cuba, Dominican Republic, Haiti, Jamaica.
Lesser Antilles	Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago.

3. Southern America

Guyana	Guyana, French Guiana, Suriname.
Andean	Bolivia, Colombia, Ecuador, Peru, Venezuela.
Brazil	Brazil.
Southern	Argentina, Chile, Paraguay, Uruguay.

Europe

4. Western and Central Europe

Northern Europe	Denmark, Finland, Iceland, Norway, Spitsbergen (Norway), Sweden.
Western Europe	Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, Switzerland, United Kingdom.

Central Europe	Bulgaria, Bosnia and Herzegovina, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, Yugoslavia.
Mediterranean Europe	Albania, Cyprus, Former Yugoslav Republic of Macedonia, Greece, Italy, Malta, Portugal, Spain.

5. Eastern Europe

Russia	Russian Federation.
Other European countries of former Soviet Union	Belarus, Estonia, Latvia, Lithuania, Republic of Moldova, Ukraine.

AFRICA

6. Africa

Northern Africa	Algeria, Egypt, Libyan Arab Jamahiriya, Morocco, Tunisia.
Sudano-Sahelian	Burkina Faso, Cape Verde, Chad, Djibouti, Eritrea, Gambia, Mali, Mauritania, Niger, Senegal, Somalia, Sudan.
Gulf of Guinea	Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo.
Central Africa	Angola, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome and Principe.
Eastern Africa	Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda.
Indian Ocean Islands	Comoros, Madagascar, Mauritius, Seychelles, Réunion (France).
Southern Africa	Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe.

ASIA

7. Near East

Arabian Peninsula	Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen.
Middle East	Gaza Strip (Palestinian Authority), Iraq, Islamic Republic of Iran, Israel, Jordan, Lebanon, Syrian Arab Republic, Turkey, West Bank (Palestinian Authority).
Caucasus	Armenia, Azerbaijan, Georgia.
Missing data in the water resources report:	Gaza Strip (Palestinian Authority), West Bank (Palestinian Authority).

8. Central Asia

Aral Sea countries	Kazakhstan, Uzbekistan.
Other countries	Afghanistan, Kyrgyzstan, Tajikistan, Turkmenistan.

9. Southern and Eastern Asia

Eastern Asia	China, Democratic People's Republic of Korea, Mongolia.
Far East	Japan, Republic of Korea.
Indian Subcontinent	Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka.
Islands	Brunei, Indonesia, Malaysia, Papua New Guinea, Philippines.
Southeast	Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam.

Missing data in the water resources report:

China Hong Kong SAR, China Macao SAR, East Timor, Singapore, Taiwan Province of China.

Oceania

10. Oceania and Pacific

Australia	Australia
Other countries	Fiji, Hawaii (United States of America), New Caledonia (France), New Zealand, Polynesia (France), Solomon Islands, other Pacific islands.

Annex 2

Water resources per country and territory

FAO Code	ISO-3 Code	Country or territory	Total area (FAOSTAT, 1999)	Total population (FAOSTAT, 2000)	Average precipitation 1961-1990 (IPCC)		Internal resources: surface	Internal resources: groundwater	Internal resources: overlap	Internal resources: total	External resources: natural	External resources: actual	Total resources: natural	Total resources: actual (1)	Dependency ratio	IRWR per capita	TRWR (actual) per capita	Water region
			km^2	1 000 inhab.	(km^3/year)		(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	%	m^3/year inhab.	m^3/year inhab.	
2	AFG	Afghanistan	652 090	21 765	213.4		-	-	-	55.0	10.0	10.0	65.0	65.0	15.4	2 527	2 986	8
3	ALB	Albania	28 750	3 134	42.7	(2)	23.1	6.2	2.4	26.9	14.8	14.8	41.7	41.7	35.5	8 583	13 306	4
4	DZA	Algeria	2 381 740	30 291	211.5		13.2	1.7	1.0	13.9	0.4	0.4	14.3	14.3	2.9	459	473	6
7	AGO	Angola	1 246 700	13 134	1 258.8		182.0	72.0	70.0	184.0	0.0	0.0	184.0	184.0	0.0	14 009	14 009	6
8	ATG	Antigua and Barbuda	440	65	0.5	(2)	-	-	-	0.1	0.0	0.0	0.1	0.1	0.0	800	800	2
9	ARG	Argentina	2 780 400	37 032	1 642.1		276.0	128.0	128.0	276.0	538.0	538.0	814.0	814.0	66.1	7 453	21 981	3
1	ARM	Armenia	29 800	3 787	16.8		6.3	4.2	1.4	9.1	1.5	1.5	10.5	10.5	13.8	2 395	2 780	7
10	AUS	Australia	7 741 220	19 138	4 136.9		440.0	72.0	20.0	492.0	0.0	0.0	492.0	492.0	0.0	25 708	25 708	10
11	AUT	Austria	83 860	8 080	93.1		55.0	6.0	6.0	55.0	22.7	22.7	77.7	77.7	29.2	6 807	9 616	4
52	AZE	Azerbaijan	86 600	8 041	38.7		6.0	6.5	4.4	8.1	22.2	22.2	30.3	30.3	73.2	1 009	3 765	7
12	BHS	Bahamas	13 880	304	17.9		-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	66	66	2
13	BHR	Bahrain	690	640	0.1		0.004	0.0	0.0	0.004	0.11	0.11	0.12	0.1	96.6	6	181	7
16	BGD	Bangladesh	144 000	137 439	383.8		83.9	21.1	0.0	105.0	1 105.6	1 105.6	1 210.6	1 210.6	91.3	764	8 809	9
14	BRB	Barbados	430	267	0.6	(2)	0.01	0.07	0.00	0.08	0.00	0.00	0.08	0.08	0.0	301	301	2
57	BLR	Belarus	207 600	10 187	128.3		37.2	18.0	18.0	37.2	20.8	20.8	58.0	58.0	35.9	3 652	5 694	5
255	BEL	Belgium	30 510	10 249	25.8		12.0	0.9	0.9	12.0	6.3	6.3	18.3	18.3	34.4	1 171	1 786	4
23	BLZ	Belize	22 960	226	39.1	(2)	-	-	-	16.0	2.6	2.6	18.6	18.6	13.8	70 796	82 102	2
53	BEN	Benin	112 620	6 272	117.0		10.0	1.8	1.5	10.3	14.5	14.5	24.8	24.8	58.5	1 642	3 954	6
18	BTN	Bhutan	47 000	2 085	103.4	(2)	95.0	-	-	95.0	0.0	0.0	95.0	95.0	0.0	45 564	45 564	9
19	BOL	Bolivia	1 098 580	8 329	1 258.9		277.4	130.0	103.9	303.5	319.0	319.0	622.5	622.5	51.2	36 443	74 743	3
80	BIH	Bosnia and Herzegovina	51 130	3 977	52.6		-	-	-	35.5	2.0	2.0	37.5	37.5	5.3	8 926	9 429	4
20	BWA	Botswana	581 730	1 541	241.8		1.7	1.7	0.5	2.9	11.5	11.5	14.4	14.4	79.9	1 882	9 345	6
21	BRA	Brazil	8 547 400	170 406	15 235.7		5 418.0	1 874.0	1 874.0	5 418.0	2 815.0	2 815.0	8 233.0	8 233.0	34.2	31 795	48 314	3
26	BRN	Brunei Darussalam	5 770	328	15.7		8.5	0.1	0.1	8.5	0.0	0.0	8.5	8.5	0.0	25 915	25 915	9
27	BGR	Bulgaria	110 910	7 949	67.4		20.1	6.4	5.5	21.0	0.3	0.3	21.3	21.3	1.4	2 642	2 680	4
233	BFA	Burkina Faso	274 000	11 535	204.9		8.0	9.5	5.0	12.5	0.0	0.0	12.5	12.5	0.0	1 084	1 084	6
29	BDI	Burundi	27 830	6 356	33.9		3.5	2.1	2.0	3.6	0.0	0.0	3.6	3.6	0.0	566	566	6
115	KHM	Cambodia	181 040	13 104	344.6		116.0	17.6	13.0	120.6	355.5	355.5	476.1	476.1	74.7	9 201	36 333	9
32	CMR	Cameroon	475 440	14 876	762.5		268.0	100.0	95.0	273.0	12.5	12.5	285.5	285.5	4.4	18 352	19 192	6
33	CAN	Canada	9 970 610	30 757	5 352.2		2 840.0	370.0	360.0	2 850.0	52.0	52.0	2 902.0	2 902.0	1.8	92 662	94 353	1
35	CPV	Cape Verde	4 030	427	0.9	(2)	0.2	0.1	0.0	0.3	0.0	0.0	0.3	0.3	0.0	703	703	6
37	CAF	Central African Republic	622 980	3 717	836.7		141.0	56.0	56.0	141.0	3.4	3.4	144.4	144.4	2.4	37 934	38 849	6
39	TCD	Chad	1 284 000	7 885	413.2		13.5	11.5	10.0	15.0	28.0	28.0	43.0	43.0	65.1	1 902	5 453	6
40	CHL	Chile	756 630	15 211	1 151.6	(2)	884.0	140.0	140.0	884.0	38.0	38.0	922.0	922.0	4.1	58 116	60 614	3
41	CHN	China, Mainland	9 561 000	1 252 952	5 994.7		2 711.5	828.8	727.9	2 812.4	17.2	17.2	2 829.6	2 829.6	0.6	2 245	2 258	9

FAO Code	ISO-3 Code	Country or territory	Total area (FAOSTAT, 1999)	Total population (FAOSTAT, 2000)	Average precipitation 1961-1990 (IPCC)		Internal resources: surface	Internal resources: groundwater	Internal resources: overlap	Internal resources: total	External resources: natural	External resources: actual	Total resources: natural	Total resources: actual (1)	Dependency ratio	IRWR per capita	TRWR (actual) per capita	Water region
			km²	1 000 inhab.	(km³/year)		(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	%	m³/year inhab.	m³/year inhab.	
214	TWN	China, Taiwan Prov. of	35 960	22 181	87.4	(2)	63.0	4.0	0.0	67.0	0.0	0.0	67.0	67.0	0.0	3 021	3 021	9
44	COL	Colombia	1 138 910	42 105	2 974.6		2 112.0	510.0	510.0	2 112.0	20.0	20.0	2 132.0	2 132.0	0.9	50 160	50 635	3
45	COM	Comoros	2 230	706	2.0	(2)	0.2	1.0	0.0	1.2	0.0	0.0	1.2	1.2	0.0	1 700	1 700	6
46	COG	Congo	342 000	3 018	562.9		222.0	198.0	198.0	222.0	610.0	610.0	832.0	832.0	73.3	73 559	275 679	6
250	COD	Congo, Dem. Republic of	2 344 860	50 948	3 618.1		899.0	421.0	420.0	900.0	383.0	383.0	1 283.0	1 283.0	29.9	17 665	25 183	6
48	CRI	Costa Rica	51 100	4 024	149.5		75.1	37.3	0.0	112.4	0.0	0.0	112.4	112.4	0.0	27 932	27 932	2
107	CIV	Côte d'Ivoire	322 460	16 013	434.7		74.0	37.7	35.0	76.7	4.3	4.3	81.0	81.0	5.3	4 790	5 058	6
98	HRV	Croatia	56 540	4 654	62.9		27.2	11.0	0.5	37.7	67.8	67.8	105.5	105.5	64.3	8 101	22 669	4
49	CUB	Cuba	110 860	11 199	148.0		31.6	6.5	0.0	38.1	0.0	0.0	38.1	38.1	0.0	3 404	3 404	2
50	CYP	Cyprus	9 250	784	4.6		0.6	0.4	0.2	0.8	0.0	0.0	0.8	0.8	0.0	995	995	4
167	CZE	Czech Republic	78 870	10 272	53.4		13.2	1.4	1.4	13.2	0.0	0.0	13.2	13.2	0.0	1 280	1 280	4
54	DNK	Denmark	43 090	5 320	30.3		3.7	4.3	2.0	6.0	0.0	0.0	6.0	6.0	0.0	1 128	1 128	4
72	DJI	Djibouti	23 200	632	5.1	(2)	0.3	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	475	475	6
56	DOM	Dominican Republic	48 730	8 373	68.7		21.0	11.7	11.7	21.0	0.0	0.0	21.0	21.0	0.0	2 507	2 507	2
58	ECU	Ecuador	283 560	12 646	591.8		432.0	134.0	134.0	432.0	0.0	0.0	432.0	432.0	0.0	34 161	34 161	3
59	EGY	Egypt	1 001 450	67 884	51.4	(2)	0.5	1.3	0.0	1.8	85.0	56.5	86.8	58.3	96.9	27	859	6
60	SLV	El Salvador	21 040	6 278	36.3		17.6	6.2	6.0	17.8	7.5	7.5	25.2	25.2	29.6	2 827	4 019	2
61	GNQ	Equatorial Guinea	28 050	457	60.5		25.0	10.0	9.0	26.0	0.0	0.0	26.0	26.0	0.0	56 893	56 893	6
178	ERI	Eritrea	117 600	3 659	45.1		-	-	-	2.8	3.5	3.5	6.3	6.3	55.6	765	1 722	6
63	EST	Estonia	45 100	1 393	28.2		11.7	4.0	3.0	12.7	0.1	0.1	12.8	12.8	0.7	9 126	9 195	5
238	ETH	Ethiopia	1 104 300	62 908	936.0		110.0	40.0	40.0	110.0	0.0	0.0	110.0	110.0	0.0	1 749	1 749	6
66	FJI	Fiji	18 270	814	47.4		-	-	-	28.6	0.0	0.0	28.6	28.6	0.0	35 074	35 074	10
67	FIN	Finland	338 150	5 172	181.4		106.8	2.2	2.0	107.0	3.0	3.0	110.0	110.0	2.7	20 688	21 268	4
68	FRA	France	551 500	59 238	478.0		176.5	100.0	98.0	178.5	25.2	25.2	203.7	203.7	12.4	3 013	3 439	4
69	GUF	French Guiana	90 000	165	260.6		-	-	-	134.0	0.0	0.0	134.0	134.0	0.0	812 121	812 121	3
74	GAB	Gabon	267 670	1 230	490.0		162.0	62.0	60.0	164.0	0.0	0.0	164.0	164.0	0.0	133 333	133 333	6
75	GMB	Gambia	11 300	1 303	9.5		3.0	0.5	0.5	3.0	5.0	5.0	8.0	8.0	62.5	2 302	6 140	6
76	-	Gaza Strip	380	1 077	0.1		0.00	0.05	0.00	0.05	0.01	0.01	0.06	0.06	17.9	43	52	7
73	GEO	Georgia	69 700	5 262	71.5		56.9	17.2	16.0	58.1	5.2	5.2	63.3	63.3	8.2	11 047	12 035	7
79	DEU	Germany	357 030	82 017	250.0		106.3	45.7	45.0	107.0	47.0	47.0	154.0	154.0	30.5	1 305	1 878	4
81	GHA	Ghana	238 540	19 306	283.2		29.0	26.3	25.0	30.3	22.9	22.9	53.2	53.2	43.0	1 569	2 756	6
84	GRC	Greece	131 960	10 610	86.1		55.5	10.3	7.8	58.0	16.3	16.3	74.3	74.3	21.9	5 467	6 998	4
85	GRL	Greenland	341 700	56	759.0	(2)	-	-	-	603.0	0.0	0.0	603.0	603.0	0.0	10 767 857	10 767 857	1
89	GTM	Guatemala	108 890	11 385	217.3	(2)	100.7	33.7	25.2	109.2	2.1	2.1	111.3	111.3	1.9	9 592	9 773	2
90	GIN	Guinea	245 860	8 154	405.9		226.0	38.0	38.0	226.0	0.0	0.0	226.0	226.0	0.0	27 716	27 716	6
175	GNB	Guinea-Bissau	36 120	1 199	57.0		12.0	14.0	10.0	16.0	15.0	15.0	31.0	31.0	48.4	13 344	25 855	6
91	GUY	Guyana	214 970	761	513.1		241.0	103.0	103.0	241.0	0.0	0.0	241.0	241.0	0.0	316 689	316 689	3
93	HTI	Haiti	27 750	8 142	40.0		10.9	2.2	0.0	13.0	1.0	1.0	14.0	14.0	7.2	1 598	1 723	2

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			km²	1 000 inhab.	(km³/year)		(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	%	m³/year inhab.	m³/year inhab.	
95	HND	Honduras	112 090	6 417	221.4		86.9	39.0	30.0	95.9	0.0	0.0	95.9	95.9	0.0	14 949	14 949	2
97	HUN	Hungary	93 030	9 968	54.8		6.0	6.0	6.0	6.0	98.0	98.0	104.0	104.0	94.2	602	10 433	4
99	ISL	Iceland	103 000	279	199.8	(2)	166.0	24.0	20.0	170.0	0.0	0.0	170.0	170.0	0.0	609 319	609 319	4
100	IND	India	3 287 260	1 008 937	3 558.8		1 222.0	418.5	380.0	1 260.5	647.2	636.1	1 907.8	1 896.7	33.9	1 249	1 880	9
101	IDN	Indonesia	1 904 570	212 092	5 146.5		2 793.0	455.0	410.0	2 838.0	0.0	0.0	2 838.0	2 838.0	0.0	13 381	13 381	9
102	IRN	Iran, Islamic Republic of	1 633 190	70 330	372.4		97.3	49.3	18.1	128.5	9.0	9.0	137.5	137.5	6.6	1 827	1 955	7
103	IRQ	Iraq	438 320	22 946	94.7		34.0	1.2	0.0	35.2	61.2	40.2	96.4	75.4	53.3	1 534	3 287	7
104	IRL	Ireland	70 270	3 803	78.6		48.2	10.8	10.0	49.0	3.0	3.0	52.0	52.0	5.8	12 885	13 673	4
105	ISR	Israel	21 060	6 040	9.2		0.3	0.5	0.0	0.8	0.9	0.9	1.7	1.7	55.1	124	276	7
106	ITA	Italy	301 340	57 530	250.8		170.5	43.0	31.0	182.5	8.8	8.8	191.3	191.3	4.6	3 172	3 325	4
109	JAM	Jamaica	10 990	2 576	22.5		5.5	3.9	0.0	9.4	0.0	0.0	9.4	9.4	0.0	3 651	3 651	2
110	JPN	Japan	377 800	127 096	630.2		420.0	27.0	17.0	430.0	0.0	0.0	430.0	430.0	0.0	3 383	3 383	9
112	JOR	Jordan	89 210	4 913	9.9		0.4	0.5	0.2	0.7	0.2	0.2	0.9	0.9	22.7	138	179	7
108	KAZ	Kazakhstan	2 724 900	16 172	680.4		69.3	6.1	0.0	75.4	34.2	34.2	109.6	109.6	31.2	4 664	6 778	8
114	KEN	Kenya	580 370	30 669	401.9		17.2	3.0	0.0	20.2	10.0	10.0	30.2	30.2	33.1	659	985	6
116	PRK	Korea, Dem. People's Rep.	120 540	22 268	127.0	(2)	66.0	13.0	12.0	67.0	10.1	10.1	77.1	77.1	13.1	3 009	3 464	9
117	KOR	Korea, Republic of	99 260	46 740	126.5	(2)	62.3	13.3	10.7	64.9	4.9	4.9	69.7	69.7	7.0	1 387	1 491	9
118	KWT	Kuwait	17 820	1 914	2.2		0.0	0.0	0.0	0.0	0.02	0.02	0.02	0.02	100.0	0	10	7
113	KGZ	Kyrgyzstan	199 900	4 921	106.5	(2)	44.1	13.6	11.2	46.5	0.0	- 25.9	46.5	20.6	0.0	9 439	4 182	8
120	LAO	Lao PDR	236 800	5 279	434.4		190.4	37.9	37.9	190.4	143.1	143.1	333.6	333.6	42.9	36 071	63 184	9
119	LVA	Latvia	64 600	2 421	41.4		16.5	2.2	2.0	16.7	18.7	18.7	35.4	35.4	52.8	6 914	14 642	5
121	LBN	Lebanon	10 400	3 496	6.9	(2)	4.1	3.2	2.5	4.8	0.04	- 0.4	4.8	4.4	0.8	1 373	1 261	7
122	LSO	Lesotho	30 350	2 035	23.9		5.2	0.5	0.5	5.2	0.0	- 2.2	5.2	3.0	0.0	2 570	1 485	6
123	LBR	Liberia	111 370	2 913	266.3		200.0	60.0	60.0	200.0	32.0	32.0	232.0	232.0	13.8	68 658	79 643	6
124	LBY	Libyan Arab Jamahiriya	1 759 540	5 290	98.5	(2)	0.2	0.5	0.1	0.6	0.0	0.0	0.6	0.6	0.0	113	113	6
126	LTU	Lithuania	65 200	3 696	42.8		15.4	1.2	1.0	15.6	9.3	9.3	24.9	24.9	37.5	4 210	6 737	5
256	LUX	Luxembourg	2 586	437	2.4		1.0	0.1	0.1	1.0	2.1	2.1	3.1	3.1	67.7	2 288	7 094	4
154	MKD	Macedonia, FYR	25 710	2 034	15.9		5.4	-	-	5.4	1.0	1.0	6.4	6.4	15.6	2 655	3 147	4
129	MDG	Madagascar	587 040	15 970	888.2		332.0	55.0	50.0	337.0	0.0	0.0	337.0	337.0	0.0	21 102	21 102	6
130	MWI	Malawi	118 480	11 308	140.0		16.1	1.4	1.4	16.1	1.1	1.1	17.3	17.3	6.6	1 427	1 528	6
131	MYS	Malaysia	329 750	22 218	948.2		566.0	64.0	50.0	580.0	0.0	0.0	580.0	580.0	0.0	26 105	26 105	9
132	MDV	Maldives	300	291	0.6		0.00	0.03	0.00	0.03	0.00	0.00	0.03	0.03	0.0	103	103	9
133	MLI	Mali	1 240 190	11 351	349.6		50.0	20.0	10.0	60.0	40.0	40.0	100.0	100.0	40.0	5 286	8 810	6
134	MLT	Malta	320	390	0.2	(2)	0.00	0.05	0.00	0.05	0.00	0.00	0.05	0.1	0.0	129	129	4
136	MRT	Mauritania	1 025 520	2 665	94.7		0.1	0.3	0.0	0.4	11.0	11.0	11.4	11.4	96.5	150	4 278	6
137	MUS	Mauritius	2 040	1 161	4.2		2.0	0.7	0.5	2.2	0.0	0.0	2.2	2.2	0.0	1 904	1 904	6
138	MEX	Mexico	1 958 200	98 872	1 472.0		361.0	139.0	91.0	409.0	48.2	48.2	457.2	457.2	10.5	4 137	4 624	1
146	MDA	Moldova, Republic of	33 850	4 295	15.2	(2)	1.0	0.4	0.4	1.0	10.7	10.7	11.7	11.7	91.4	233	2 712	5

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			km²	1 000 inhab.	(km³/year)		(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	(km³/year)	%	m³/year inhab.	m³/year inhab.	
141	MNG	Mongolia	1 566 500	2 533	377.4		32.7	6.1	4.0	34.8	0.0	0.0	34.8	34.8	0.0	13 739	13 739	9
143	MAR	Morocco	446 550	29 878	154.7		22.0	10.0	3.0	29.0	0.0	0.0	29.0	29.0	0.0	971	971	6
144	MOZ	Mozambique	801 590	18 292	827.2	(2)	97.0	17.0	15.0	99.0	117.1	117.1	216.1	216.1	54.2	5 412	11 814	6
28	MMR	Myanmar	676 580	47 749	1 414.6	(2)	874.6	156.0	150.0	880.6	165.0	165.0	1 045.6	1 045.6	15.8	18 442	21 898	9
147	NAM	Namibia	824 290	1 757	235.3		4.1	2.1	0.0	6.2	39.3	11.8	45.5	17.9	65.7	3 506	10 211	6
149	NPL	Nepal	147 180	23 043	220.8	(2)	198.2	20.0	20.0	198.2	12.0	12.0	210.2	210.2	5.7	8 601	9 122	9
150	NLD	Netherlands	41 530	15 864	32.3		11.0	4.5	4.5	11.0	80.0	80.0	91.0	91.0	87.9	693	5 736	4
156	NZL	New Zealand	270 530	3 778	468.4	(2)	-	-	-	327.0	0.0	0.0	327.0	327.0	0.0	86 554	86 554	10
157	NIC	Nicaragua	130 000	5 071	310.9		185.7	59.0	55.0	189.7	7.0	7.0	196.7	196.7	3.5	37 417	38 787	2
158	NER	Niger	1 267 000	10 832	190.8		1.0	2.5	0.0	3.5	30.2	30.2	33.7	33.7	89.6	323	3 107	6
159	NGA	Nigeria	923 770	113 862	1 062.3		214.0	87.0	80.0	221.0	65.2	65.2	286.2	286.2	22.8	1 941	2 514	6
162	NOR	Norway	323 880	4 469	458.0	(2)	376.0	96.0	90.0	382.0	0.0	0.0	382.0	382.0	0.0	85 478	85 478	4
221	OMN	Oman	212 460	2 538	26.6	(2)	0.9	1.0	0.9	1.0	0.0	0.0	1.0	1.0	0.0	388	388	7
165	PAK	Pakistan	796 100	141 256	393.3	(2)	47.4	55.0	50.0	52.4	181.4	170.3	233.8	222.7	76.5	371	1 576	9
166	PAN	Panama	75 520	2 856	203.3		144.1	21.0	17.7	147.4	0.6	0.6	148.0	148.0	0.4	51 618	51 814	2
168	PNG	Papua New Guinea	462 840	4 809	1 454.1		801.0	-	-	801.0	0.0	0.0	801.0	801.0	0.0	166 563	166 563	9
169	PRY	Paraguay	406 750	5 496	459.5		94.0	41.0	41.0	94.0	242.0	242.0	336.0	336.0	72.0	17 103	61 135	3
170	PER	Peru	1 285 220	25 662	2 233.7	(2)	1 616.0	303.0	303.0	1 616.0	297.0	297.0	1 913.0	1 913.0	15.5	62 972	74 546	3
171	PHL	Philippines	300 000	75 653	704.3		444.0	180.0	145.0	479.0	0.0	0.0	479.0	479.0	0.0	6 332	6 332	9
173	POL	Poland	323 250	38 605	194.0		53.1	12.5	12.0	53.6	8.0	8.0	61.6	61.6	13.0	1 388	1 596	4
174	PRT	Portugal	91 980	10 016	78.6		38.0	4.0	4.0	38.0	39.4	30.7	77.4	68.7	44.7	3 794	6 859	4
177	PRI	Puerto Rico	8 950	3 915	18.4		-	-	-	7.1	0.0	0.0	7.1	7.1	0.0	1 814	1 814	2
179	QAT	Qatar	11 000	565	0.8		0.001	0.050	0.000	0.051	0.002	0.002	0.1	0.1	3.8	90	94	7
182	REU	Réunion (France)	2 510	721	7.5	(2)	4.5	2.8	2.3	5.0	0.0	0.0	5.0	5.0	0.0	6 935	6 935	6
183	ROM	Romania	238 390	22 438	151.9		42.0	8.3	8.0	42.3	169.6	169.6	211.9	211.9	80.0	1 885	9 445	4
185	RUS	Russian Federation	17 075 400	145 491	7 854.7	(2)	4 036.7	788.0	512.0	4 312.7	194.6	194.6	4 507.3	4 507.3	4.3	29 642	30 980	5
184	RWA	Rwanda	26 340	7 609	31.9		5.2	3.6	3.6	5.2	0.0	0.0	5.2	5.2	0.0	683	683	6
188	KNA	Saint Kitts and Nevis	360	38	0.5	(2)	0.004	0.020	0.000	0.024	0.000	0.000	0.024	0.024	0.0	621	621	2
193	STP	Sao Tome and Principe	960	138	3.1	(2)	-	-	-	2.2	0.0	0.0	2.2	2.2	0.0	15 797	15 797	6
194	SAU	Saudi Arabia	2 149 690	20 346	126.8	(2)	2.2	2.2	2.0	2.4	0.0	0.0	2.4	2.4	0.0	118	118	7
195	SEN	Senegal	196 720	9 421	135.0		23.8	7.6	5.0	26.4	13.0	13.0	39.4	39.4	33.0	2 802	4 182	6
197	SLE	Sierra Leone	71 740	4 405	181.2		150.0	50.0	40.0	160.0	0.0	0.0	160.0	160.0	0.0	36 322	36 322	6
200	SGP	Singapore	620	4 018	1.5		-	-	-	0.6	0.0	0.0	0.6	0.6	0.0	149	149	9
199	SVK	Slovakia	49 010	5 399	40.4		12.6	1.7	1.7	12.6	37.5	37.5	50.1	50.1	74.9	2 334	9 279	4
198	SVN	Slovenia	20 250	1 988	23.5		18.5	13.5	13.4	18.7	13.2	13.2	31.9	31.9	41.4	9 391	16 031	4
25	SLB	Solomon Islands	28 900	447	87.5		-	-	-	44.7	0.0	0.0	44.7	44.7	0.0	100 000	100 000	10
201	SOM	Somalia	637 660	8 778	180.1		5.7	3.3	3.0	6.0	7.5	7.5	13.5	13.5	55.6	684	1 538	6
202	ZAF	South Africa	1 221 040	43 309	603.9	(2)	43.0	4.8	3.0	44.8	5.2	5.2	50.0	50.0	10.4	1 034	1 154	6

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			km^2	1 000 inhab.	(km^3/year)		(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	(km^3/year)	%	m^3/year inhab.	m^3/year inhab.	
203	ESP	Spain	505 990	39 910	321.7		109.5	29.9	28.2	111.2	0.3	0.3	111.5	111.5	0.3	2 786	2 794	4
-	-	Spitsbergen			43.0		-	-	-	28.1	0.0	0.0	28.1	28.1	0.0	-	-	4
38	LKA	Sri Lanka	65 610	18 924	112.3		49.2	7.8	7.0	50.0	0.0	0.0	50.0	50.0	0.0	2 642	2 642	9
206	SDN	Sudan	2 505 810	31 095	1 043.7	(2)	28.0	7.0	5.0	30.0	119.0	34.5	149.0	64.5	76.9	965	2 074	6
207	SUR	Suriname	163 270	417	380.6		88.0	80.0	80.0	88.0	34.0	34.0	122.0	122.0	27.9	211 031	292 566	3
209	SWZ	Swaziland	17 360	925	13.7		-	-	-	2.6	1.9	1.9	4.5	4.5	41.5	2 854	4 876	6
210	SWE	Sweden	449 960	8 842	280.7		170.0	20.0	19.0	171.0	3.0	3.0	174.0	174.0	1.7	19 340	19 679	4
211	CHE	Switzerland	41 290	7 170	63.5		40.4	2.5	2.5	40.4	13.1	13.1	53.5	53.5	24.5	5 635	7 462	4
212	SYR	Syrian Arab Republic	185 180	16 189	46.7	(2)	4.8	4.2	2.0	7.0	39.1	19.3	46.1	26.3	80.3	432	1 622	7
208	TJK	Tajikistan	143 100	6 087	98.9	(2)	63.3	6.0	3.0	66.3	33.4	- 50.3	99.7	16.0	16.7	10 892	2 625	8
215	TZA	Tanzania	945 090	35 119	1 012.2		80.0	30.0	28.0	82.0	9.0	9.0	91.0	91.0	9.9	2 335	2 591	6
216	THA	Thailand	513 120	62 806	832.4		198.8	41.9	30.7	210.0	199.9	199.9	409.9	409.9	48.8	3 344	6 527	9
217	TGO	Togo	56 790	4 527	66.3		10.8	5.7	5.0	11.5	3.2	3.2	14.7	14.7	21.8	2 540	3 247	6
220	TTO	Trinidad and Tobago	5 130	1 294	11.3	(2)	-	-	-	3.8	0.0	0.0	3.8	3.8	0.0	2 968	2 968	2
222	TUN	Tunisia	163 610	9 459	33.9	(2)	3.1	1.5	0.4	4.2	0.4	0.4	4.6	4.6	9.0	439	482	6
223	TUR	Turkey	774 820	66 668	459.5		186.0	69.0	28.0	227.0	4.7	2.3	231.7	229.3	1.0	3 405	3 439	7
213	TKM	Turkmenistan	488 100	4 737	78.7		1.0	0.4	0.0	1.4	59.5	23.4	60.9	24.7	97.1	287	5 218	8
226	UGA	Uganda	241 040	23 300	284.5		39.0	29.0	29.0	39.0	27.0	27.0	66.0	66.0	40.9	1 674	2 833	6
230	UKR	Ukraine	603 700	49 568	341.0		50.1	20.0	17.0	53.1	86.5	86.5	139.6	139.6	61.9	1 071	2 815	5
225	ARE	United Arab Emirates	83 600	2 606	6.5		0.2	0.1	0.1	0.2	0.0	0.0	0.2	0.2	0.0	58	58	7
229	GBR	United Kingdom	242 910	59 634	296.3		144.2	9.8	9.0	145.0	2.0	2.0	147.0	147.0	1.4	2 431	2 465	4
234	URY	Uruguay	176 220	3 337	222.9		59.0	23.0	23.0	59.0	80.0	80.0	139.0	139.0	57.6	17 681	41 654	3
-	USA	USA, Alaska	-	627	-		-	-	-	800.0	180.0	180.0	980.0	980.0	18.4	1 276 055	1 563 168	1
-	USA	USA, Conterminous	9 629 090	279 583	5 800.8		1 862.0	1 300.0	1 162.0	2 000.0	71.0	71.0	2 071.0	2 071.0	3.4	7 153	7 407	1
-	USA	USA, Hawaii	-	1 212	32.0		5.2	13.2	0.0	18.4	0.0	0.0	18.4	18.4	0.0	15 187	15 187	10
235	UZB	Uzbekistan	447 400	24 881	92.3		9.5	8.8	2.0	16.3	-	34.1	72.2	50.4	77.4	657	2 026	8
236	VEN	Venezuela	912 050	24 170	1 710.1		700.1	227.0	204.7	722.5	510.7	510.7	1 233.2	1 233.2	41.4	29 890	51 021	3
237	VNM	Viet Nam	331 690	78 137	604.0		353.5	48.0	35.0	366.5	524.7	524.7	891.2	891.2	58.9	4 690	11 406	9
245	-	West Bank	6 080	1 407	-		0.07	0.68	0.00	0.75	0.00	0.00	0.75	0.75	0.0	535	535	7
249	YEM	Yemen	527 970	18 349	88.3		4.0	1.5	1.4	4.1	0.0	0.0	4.1	4.1	0.0	223	223	7
186	YUG	Yugoslavia	102 170	10 552	81.2		42.4	3.0	1.4	44.0	164.5	164.5	208.5	208.5	78.9	4 170	19 759	4
251	ZMB	Zambia	752 610	10 421	767.4		80.2	47.0	47.0	80.2	25.0	25.0	105.2	105.2	23.8	7 696	10 095	6
181	ZWE	Zimbabwe	390 760	12 627	270.5		13.1	5.0	4.0	14.1	5.9	5.9	20.0	20.0	29.5	1 117	1 584	6

Notes:

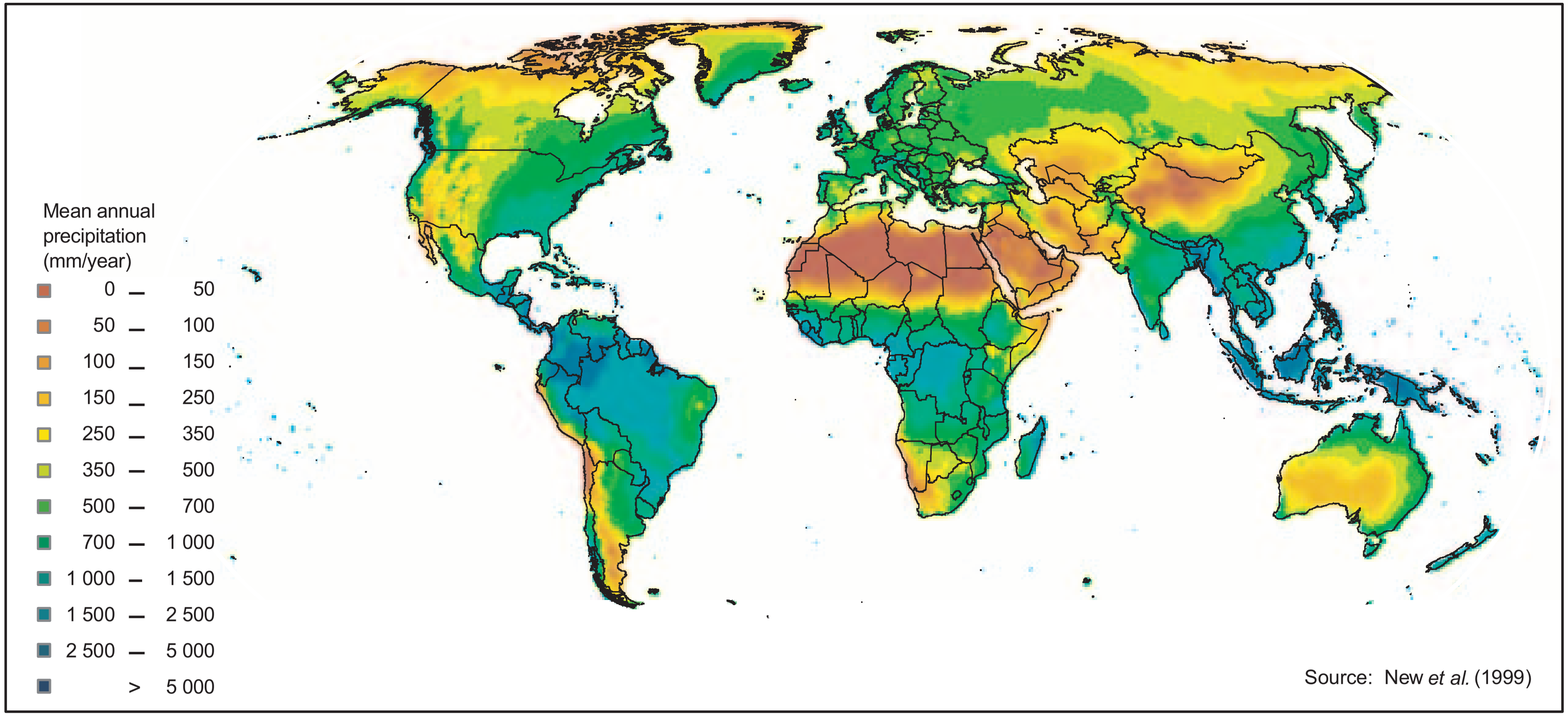
(1) Aggregation of data possible only for internal renewable water resources and not total renewable water resources, as that would result in double counting of shared water resources.

(2) Large discrepancies between national and IPCC data on rainfall average. In some cases, IPCC data were modified to ensure consistency with water resources data.

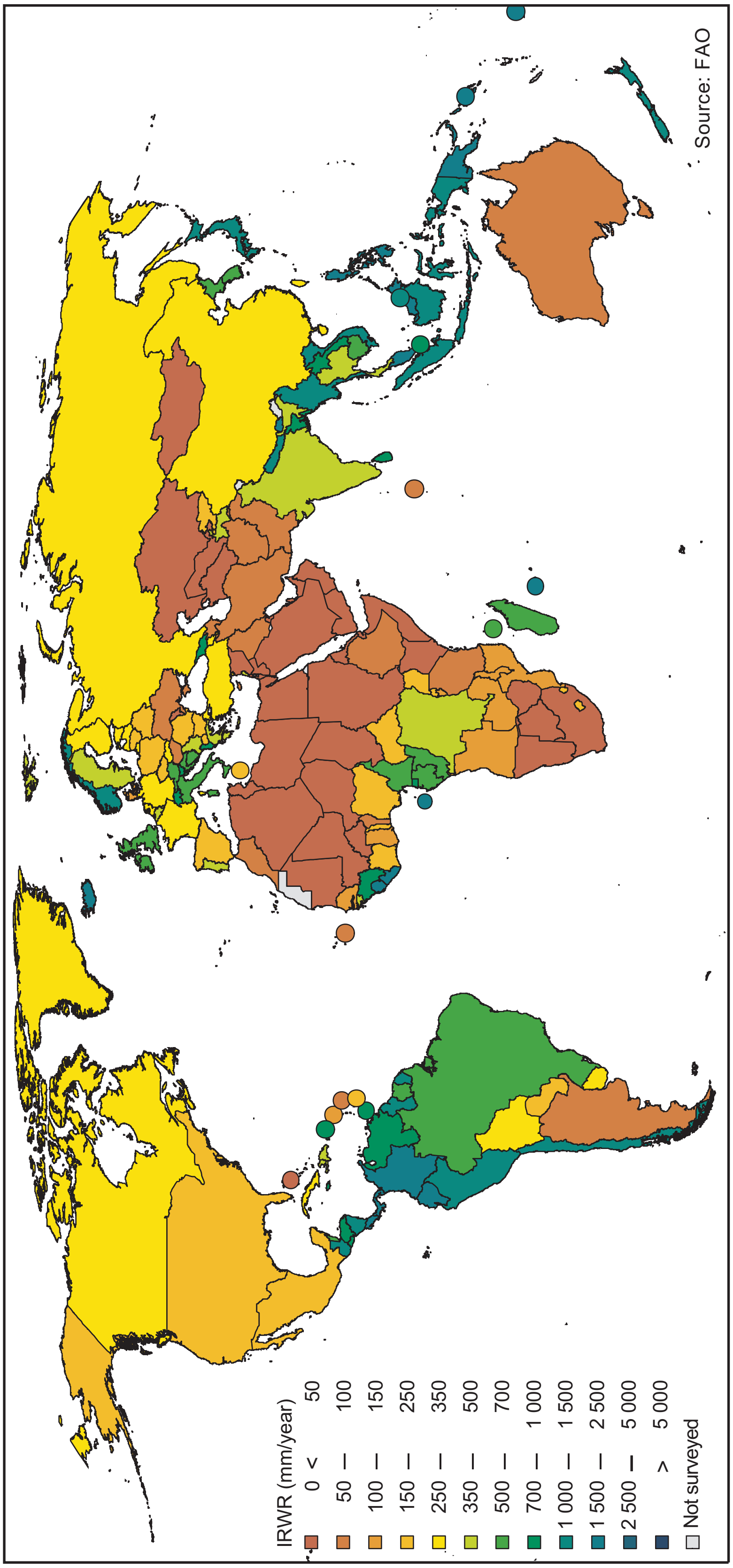
No water resources data available for Aruba, Bermuda, Dominica, East Timor, French Polynesia, Grenada, Guadeloupe, Guam, Martinique, New Caledonia, Saint Helena, Saint Lucia, Saint Vincent and Grenadines, Samoa, Seychelles, Tonga and Western Sahara.

Annex 3
Maps

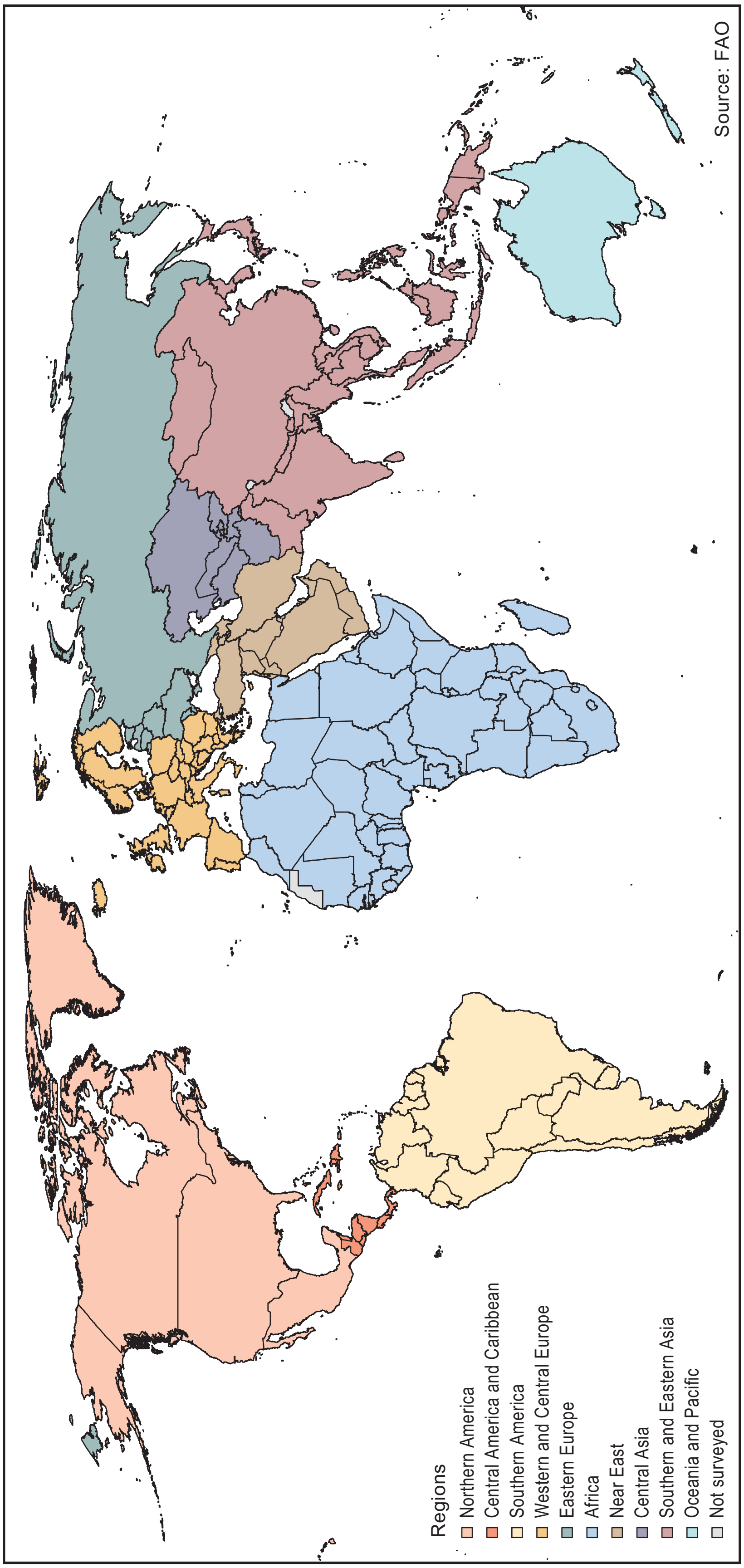
MAP 1
World map of mean annual precipitation, 1961–1990



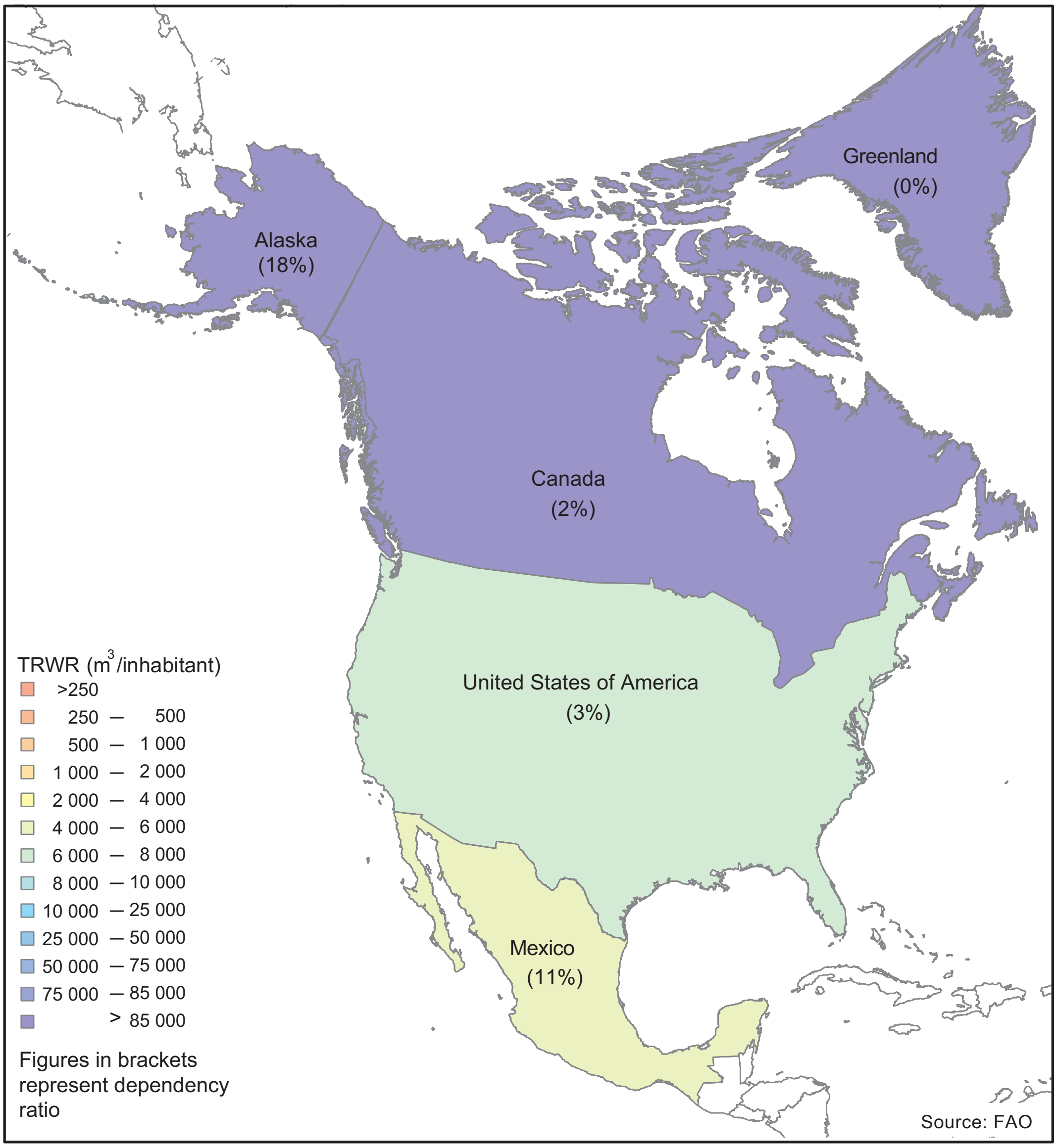
MAP 2
World map of internal renewable water resources (IRWR), per country



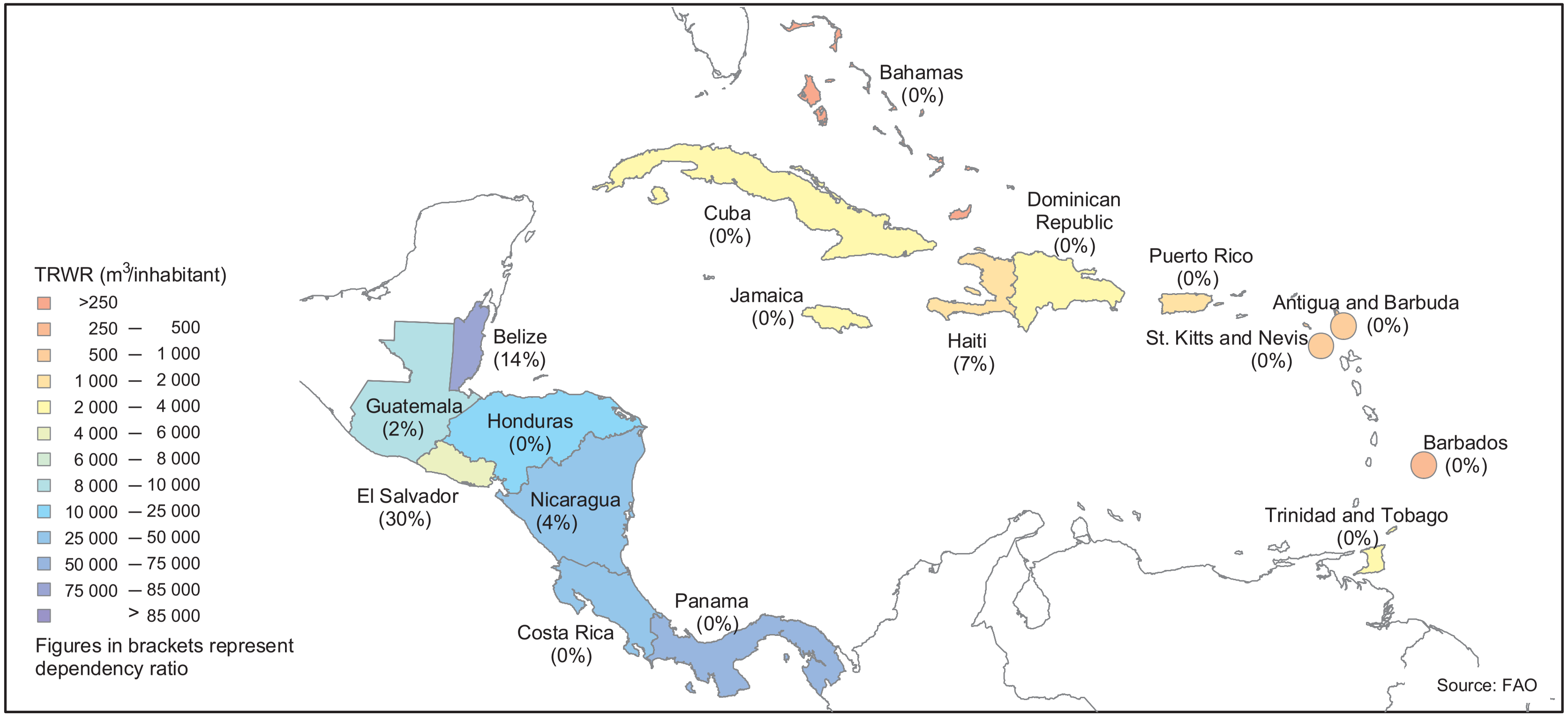
MAP 3
Division of the world in ten regions



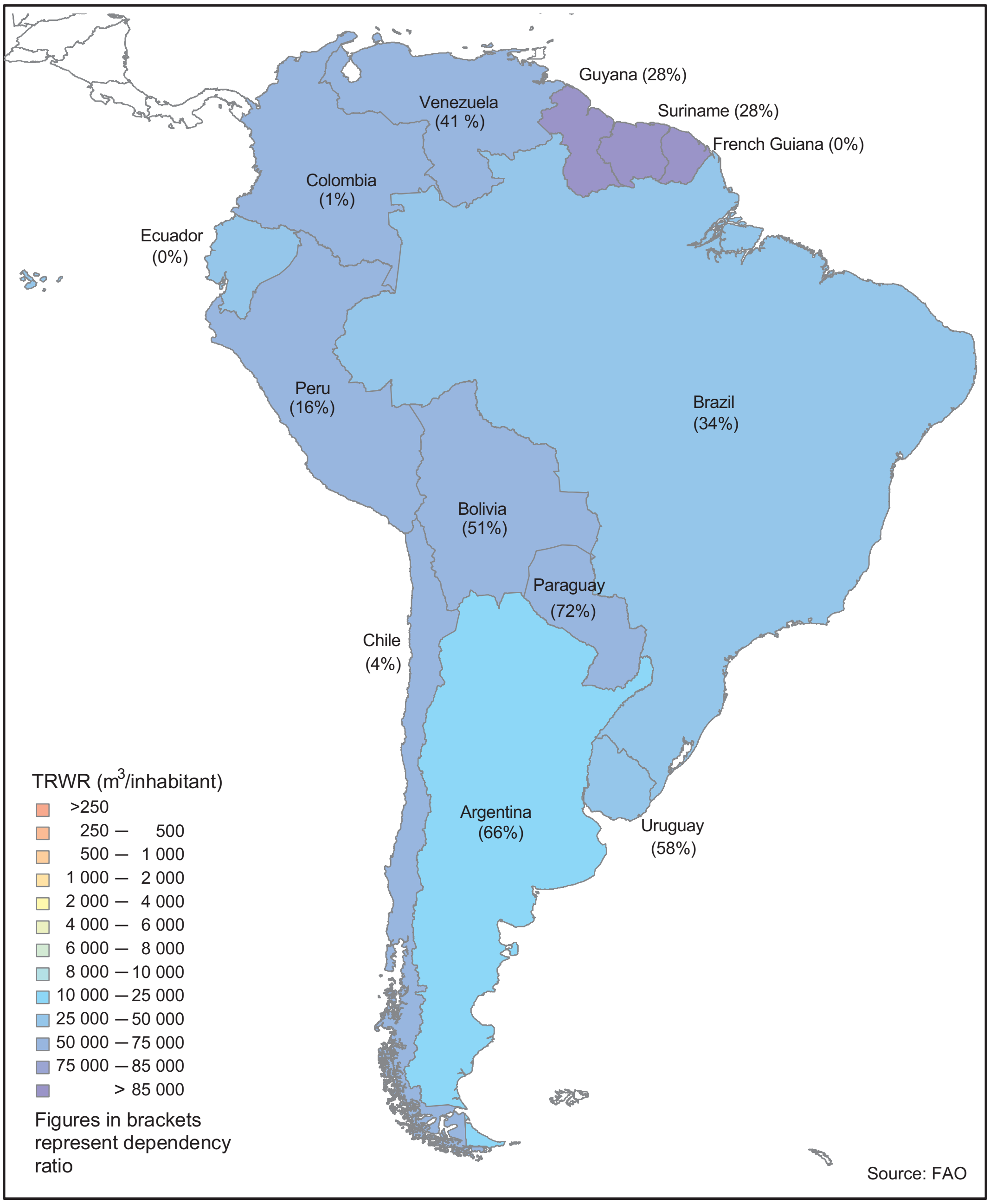
MAP 4
Water resources in the Northern America region, total renewable water resources (TRWR) and dependency ratio



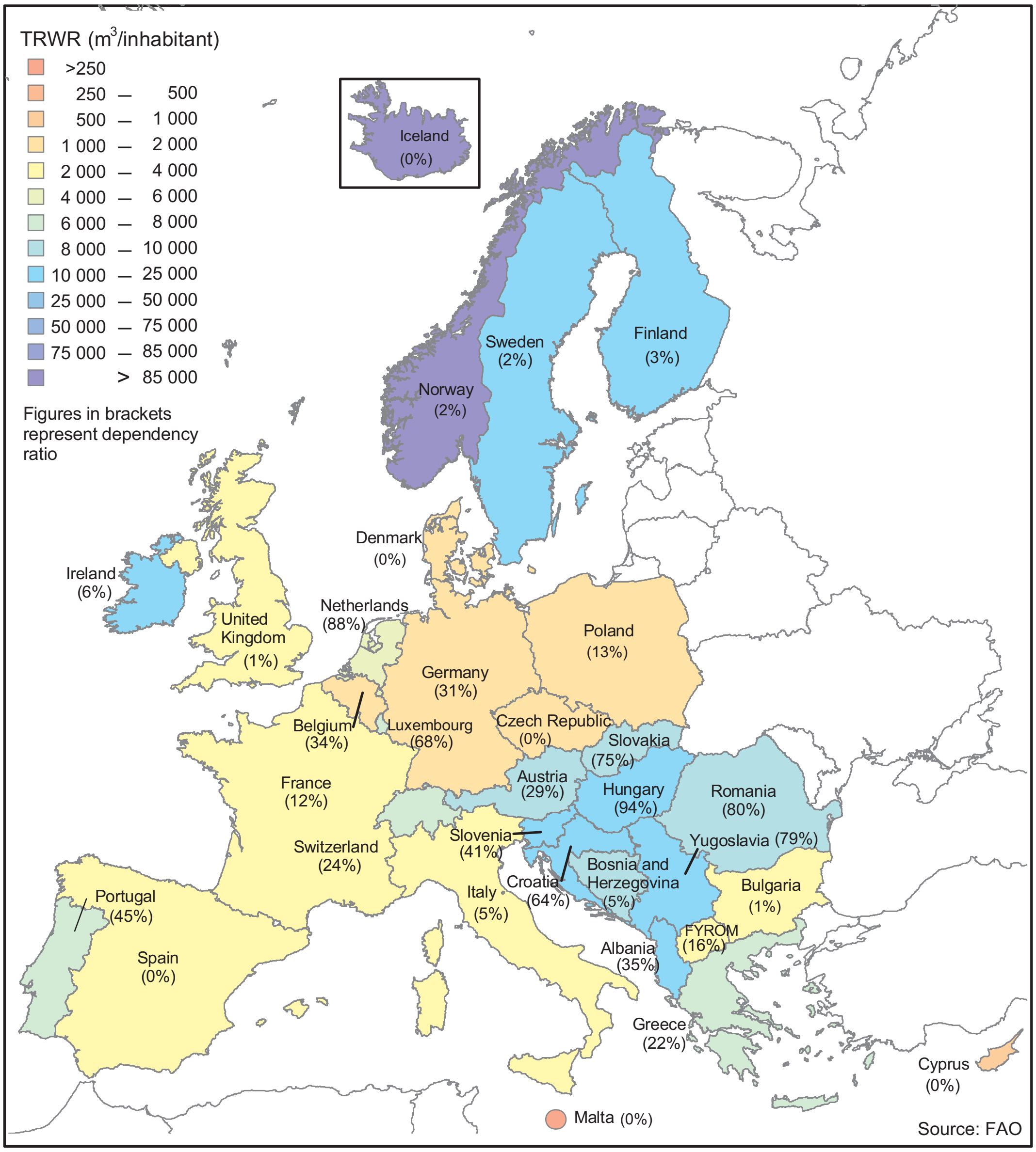
MAP 5
Water resources in the Central America and Caribbean region, total renewable water resources (TRWR) and dependency ratio



Map 6
Water resources in the Southern America region, total renewable water resources (TRWR) and dependency ratio



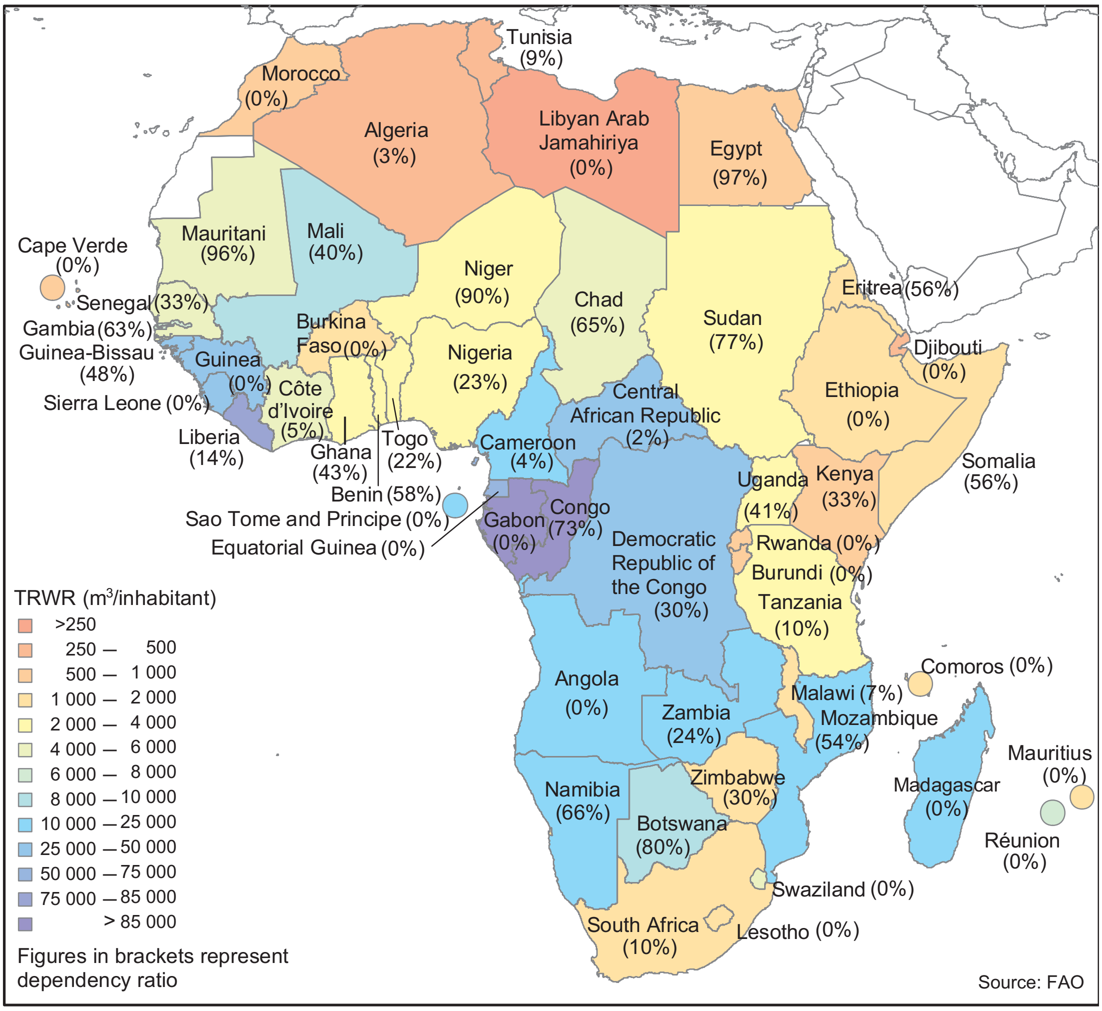
MAP 7
Water resources in the Western and Central Europe region, total renewable water resources (TRWR) and dependency ratio



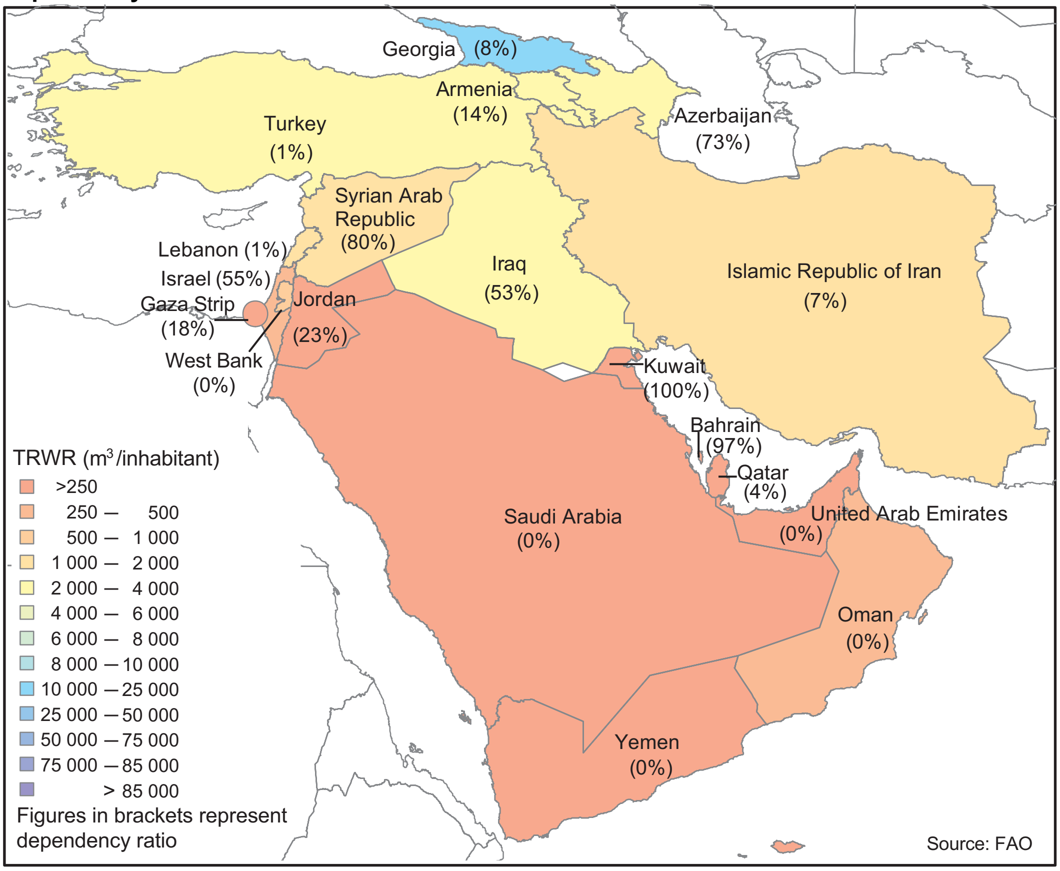
MAP 8
Water resources in the Eastern Europe region, total renewable water resources (TRWR) and dependency ratio

MAP 9

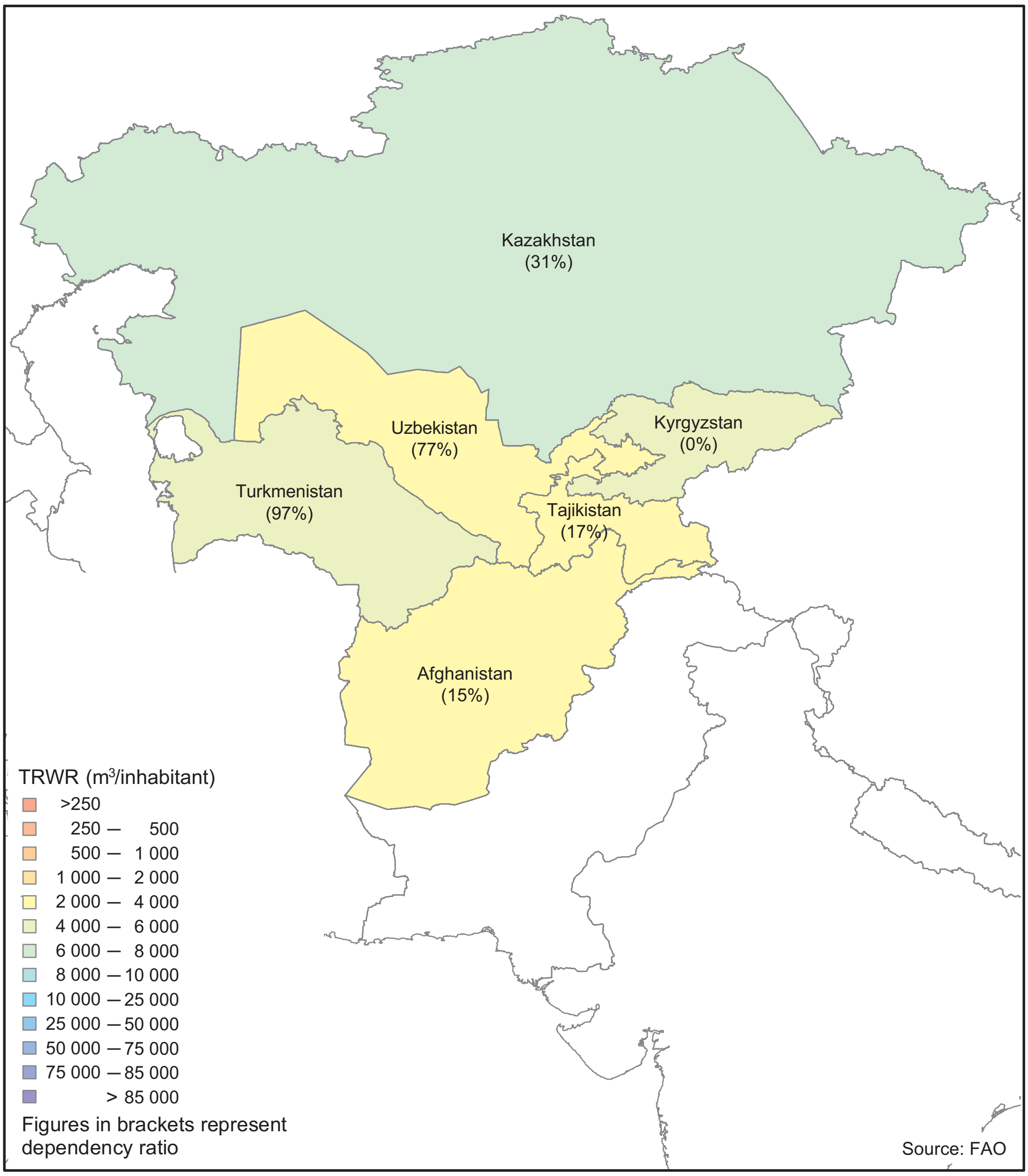
Water resources in the Africa region, total renewable water resources (TRWR) and dependency ratio



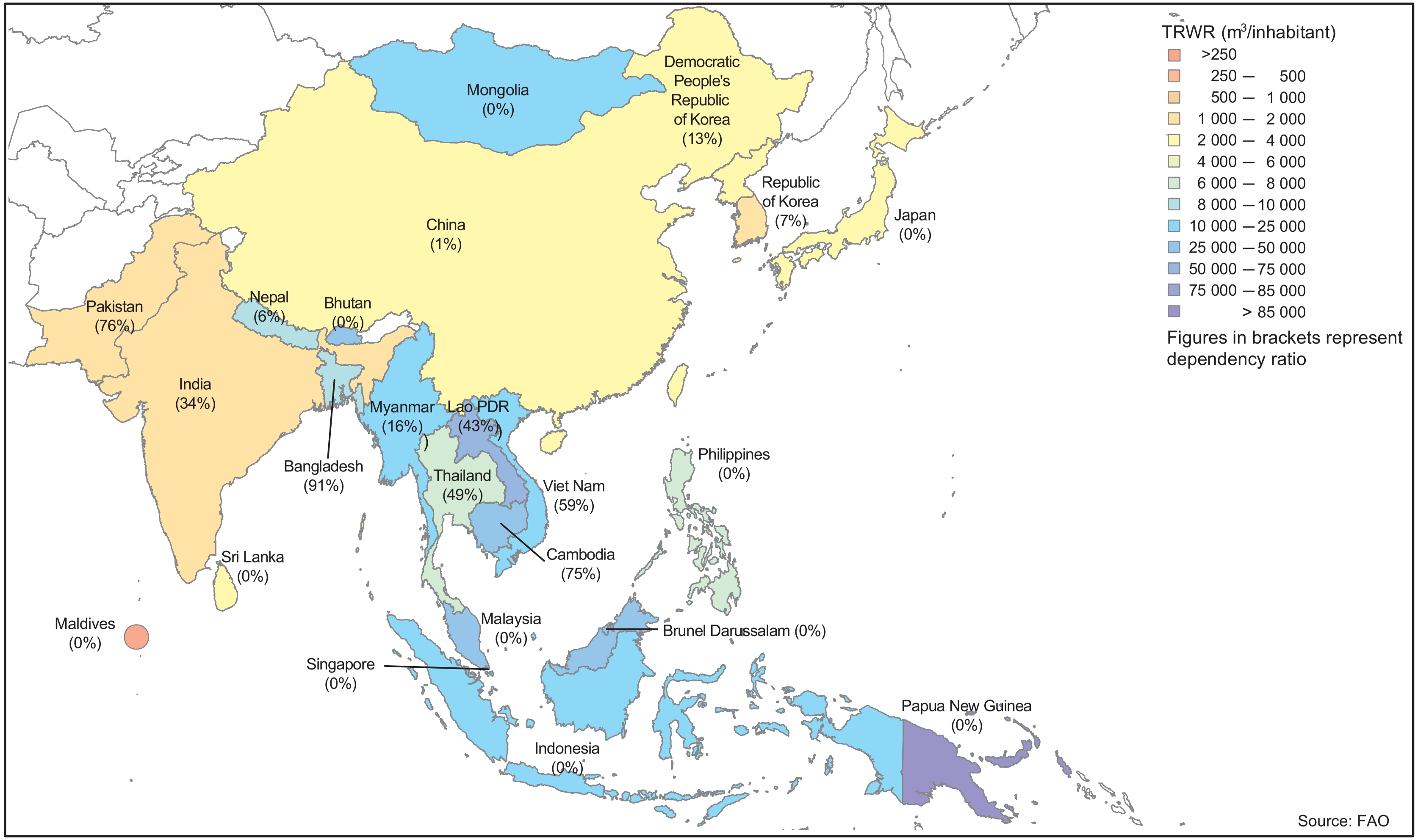
Map 10
Water resources in the Near East region, total renewable water resources (TRWR) and dependency ratio



Map 11
Water resources in the Central Asia region, total renewable water resources (TRWR) and dependency ratio



Map 12
Water resources in the Southern and Eastern Asia region, total renewable water resources (TRWR) and dependency ratio



Map 13
Water resources in the Oceania and Pacific region, total renewable water resources (TRWR) and dependency ratio

Annex 4
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FAO's Aquastat programme compiles existing quantitative and qualitative information on water resources, water use and irrigation by country. This report focuses on the work done through the Aquastat surveys to collect and analyse available information on water resources for all countries in the world. It introduces the concepts and methodology applied to compute country-level water resources data, and presents and analyses the key findings at both global and regional levels. A summary table provides the elements of the water balance for each of the 170 countries and territories surveyed.

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