UNEP, Still Pictures

Freshwater

Global overview

Resources

The total volume of water on Earth is about 1 400 million km^3 of which only 2.5 per cent, or about 35 million km^3, is freshwater (see table opposite). Most freshwater occurs in the form of permanent ice or snow, locked up in Antarctica and Greenland, or in deep groundwater aquifers. The principal sources of water for human use are lakes, rivers, soil moisture and relatively shallow groundwater basins. The usable portion of these sources is only about 200 000 km^3 of water — less than 1 per cent of all freshwater and only 0.01 per cent of all water on Earth. Much of this available water is located far from human populations, further complicating issues of water use.

The replenishment of freshwater depends on evaporation from the surface of the oceans. About 505 000 km^3, or a layer 1.4 metres thick, evaporates from the oceans annually. Another 72 000 km^3 evaporates from the land. About 80 per cent of all precipitation, or about 458 000 km^3/year, falls on the oceans and the remaining 119 000 km^3/year on land. The difference between precipitation on land surfaces and evaporation from those surfaces (119 000 km^3 minus 72 000 km^3 annually) is run-off and groundwater recharge — approximately 47 000 km^3 annually (Gleick 1993). The figure opposite shows one estimate of the average annual water balance of major continental areas, including precipitation, evaporation and run-off. More than one-half of all run-off occurs in Asia and South America, and a large fraction occurs in a single river, the Amazon, which carries more than 6 000 km^3 of water a year (Shiklomanov 1999).

Water scarcity

About one-third of the world's population lives in countries suffering from moderate-to-high water stress — where water consumption is more than 10 per cent of renewable freshwater resources. Some 80 countries, constituting 40 per cent of the world's population, were suffering from serious water shortages by the mid-1990s (CSD 1997a) and it is estimated that in less than 25 years two-thirds of the world's people will be living in water-stressed countries (CSD 1997b). By 2020, water use is expected to increase by 40 per cent, and 17 per cent more water will be required for food production to

meet the needs of the growing population (World Water Council 2000a).

The three major factors causing increasing water demand over the past century are population growth, industrial development and the expansion of irrigated agriculture. Agriculture accounted for most freshwater withdrawal in developing economies in the past two decades. Planners have always assumed that growing demand would be met by taming more of the hydrological cycle through building more infrastructure. The damming of rivers has traditionally been one of the main ways to ensure adequate water resources for irrigation, hydropower generation and domestic use. About 60 per cent of the world's largest 227 rivers have been strongly or moderately fragmented by dams, diversions or canals, with effects on freshwater ecosystems (WCD 2000). This infrastructure has provided important benefits in the form, for example, of increased food production and hydroelectricity. There have also been major costs. Over the past 50 years, dams have transformed the world's rivers, displacing some 40-80 million people in different parts of the world (WCD 2000), and causing irreversible changes in many of the ecosystems closely associated with them.

Emphasis on water supply, coupled with weak enforcement of regulations, has limited the effectiveness of water resource management, particularly in developing regions. Policy-makers have now shifted from entirely supply solutions to demand management, highlighting the importance of using a combination of measures to ensure adequate supplies of water for different sectors. Measures include improving water use efficiency, pricing policies and privatization. There is also a new emphasis on integrated water resources management (IWRM), which takes into account all the different stakeholders in water resource planning, development and management (CSD 1997b).

Irrigated agriculture

Agriculture accounts for more than 70 per cent of freshwater drawn from lakes, rivers and underground sources. Most is used for irrigation which provides about 40 per cent of world food production (CSD 1997a). Over the past 30 years, the area of land under irrigation has increased from less than 200 million ha to more than 270 million ha (FAO 2001). During the same period, global water withdrawals rose from about 2 500 km^3 to

Major stocks of water

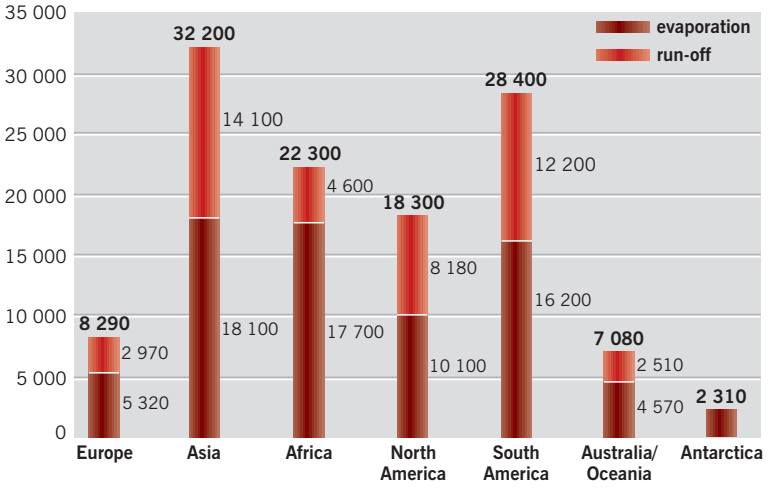
	volume (1 000 km^3)	*% of total water*	*% of total freshwater*
Salt water			
Oceans	1 338 000	96.54	
Saline/brackish groundwater	12 870	0.93	
Salt water lakes	85	0.006	
Inland waters			
Glaciers, permanent snow cover	24 064	1.74	68.7
Fresh groundwater	10 530	0.76	30.06
Ground ice, permafrost	300	0.022	0.86
Freshwater lakes	91	0.007	0.26
Soil moisture	16.5	0.001	0.05
Atmospheric water vapour	12.9	0.001	0.04
Marshes, wetlands*	11.5	0.001	0.03
Rivers	2.12	0.0002	0.006
Incorporated in biota*	1.12	0.0001	0.003
Total water	**1 386 000**	**100**	
Total freshwater	**35 029**		**100**

Source: Shiklomanov 1993

Notes: totals may not add exactly due to rounding

** Marshes, wetlands and water incorporated in biota are often mixed salt and freshwater*

Precipitation, evaporation and run-off by region (km^3/year)

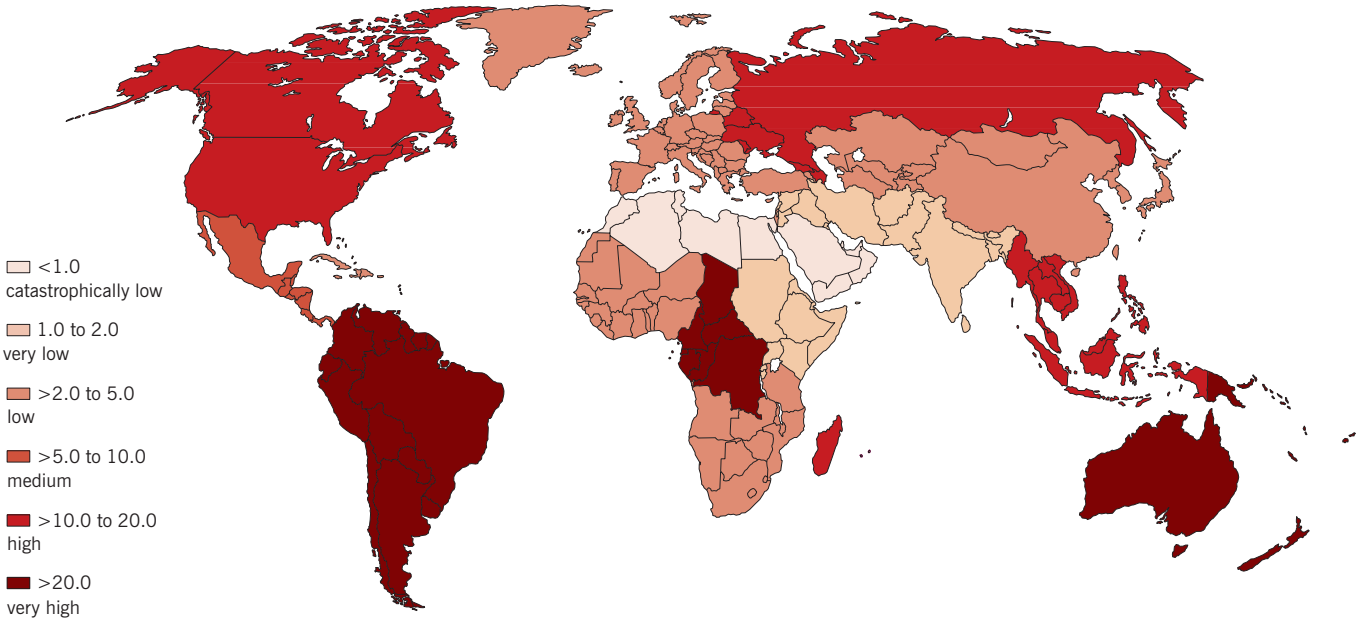


Height of bars shows total precipitation; darker areas represent evaporation while lighter areas show run-off. Total annual precipitation on land is 119 000 km^3, of which 72 000 km^3 evaporates, leaving some 47 000 km^3 of run-off

Notes: regions do not correspond exactly to GEO regions; run-off includes flows to groundwater, inland basins, and ice flows of Antarctica

Source: Shiklomanov 1993

Water availability by sub-region in 2000 (1 000 m^3 per capita/year)



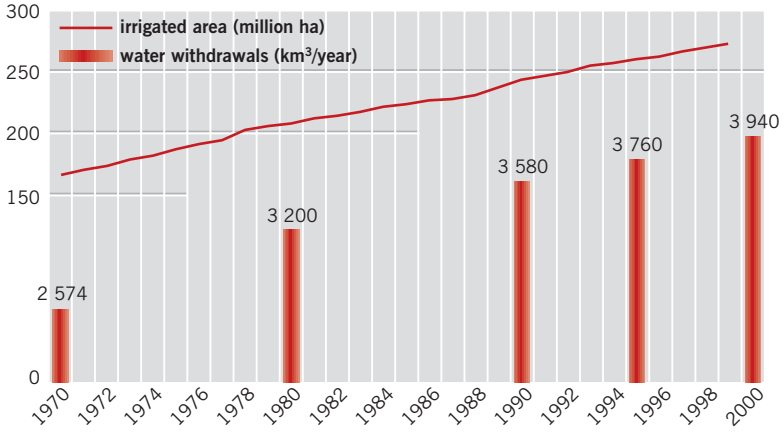
Map shows water availability measured in terms of 1 000 m^3 per capita/year

Source: compiled from UNDP, UNEP, World Bank and WRI 2000 and United Nations Population Division 2001

more than 3 500 km^3 (Shiklomanov 1999). Poor management has resulted in the salinization of about 20 per cent of the world's irrigated land, with an additional 1.5 million ha affected annually (CSD 1997a), significantly reducing crop production (WCD 2000). The countries most severely affected are mainly in arid and semi-arid regions.

Response measures have included national action programmes, water policy review and reform, promotion of increased water-use efficiency, and irrigation technology transfer. At the global level, FAO initiated a global information system, AQUASTAT, in 1993 which provides data on the use of water in agriculture (FAO 2001).

Global irrigated area and water withdrawals



Since 1970 global water withdrawals have mirrored the rise in irrigated area. Some 70 per cent of withdrawals are for agriculture, mostly for irrigation which provides 40 per cent of the world's food

Source: FAO 2001, Shiklomanov 1999

Water and sanitation

For many of the world's poorer populations, one of the greatest environmental threats to health remains the continued use of untreated water. While the percentage of people served with improved water supplies increased from 79 per cent (4.1 billion) in 1990 to 82 per cent (4.9 billion) in 2000, 1.1 billion people still lack access to safe drinking water and 2.4 billion lack access to improved sanitation (WHO and UNICEF 2000). Most of these people are in Africa and Asia. Lack of access to safe water supply and sanitation results in hundreds of millions of cases of water-related diseases, and more than 5 million deaths, every year (see box right). There are also large, but poorly quantified adverse impacts on economic productivity in many developing countries.

The importance of meeting basic human needs for water has always played a major role in water policy. One of the earliest comprehensive water conferences was held in 1977 in Mar del Plata, Argentina. The focus on human needs led to the International Drinking Water Supply and Sanitation Decade (1981–90) and the efforts of the United Nations and other international organizations to provide basic

The costs of water-related diseases

- two billion people are at risk from malaria alone, with 100 million people affected at any one time, and 1-2 million deaths annually
- about 4 billion cases of diarrhoea and 2.2 million deaths annually: this is the equivalent of 20 jumbo jets crashing every day
- intestinal worms infect about 10 per cent of the population of the developing world
- about 6 million are blind from trachoma
- 200 million people are affected with schistosomiasis

Sources: CSD 1997a, WHO and UNICEF 2000

water services (UN 2000). The concept of meeting basic water needs was reaffirmed during the 1992 Earth Summit in Rio de Janeiro and expanded to include ecological water needs. A recent United Nations report (UN 1999) recognized that all people require access to adequate amounts of safe water, for drinking, sanitation and hygiene. Most recently, the Second World Water Forum and Ministerial Conference in The Hague in 2000 (see box below right) produced a strong statement from more than 100 ministers in support of re-emphasizing basic human needs as a priority for nations, international organizations and donors.

Providing urban dwellers with safe water and sanitation services has remained a particular challenge. Some 170 million developing country urban dwellers were provided with safe water and 70 million with appropriate sanitation during the first half of the 1990s but this had limited impact because about 300 million more urban residents still lacked access to safe water supply, while nearly 600 million lacked adequate sanitation by the end of 1994 (CSD 1997b). However, a major area of success in many developing countries is related to investments in wastewater treatment over the past 30 years which have 'halted the decline in – or actually improved – the quality of surface water' (World Water Council 2000b).

Water quality

Water quality problems can often be as severe as those of water availability but less attention has been paid to them, particularly in developing regions. Sources of pollution include untreated sewage, chemical discharges, petroleum leaks and spills, dumping in old mines and pits, and agricultural chemicals that are washed off or seep downward from farm fields. More than half of the world's major rivers are 'seriously depleted and polluted, degrading and poisoning the surrounding ecosystems, threatening the health and livelihood of people who depend on them' (World Commission on Water 1999).

In the 1990s, many new efforts were made to monitor water quality and institute better policies and programmes (Meybeck, Chapman and Helmer 1990). For example, water quality monitoring programmes have been established for many international river basins, including the Danube, the Rhine, the Mekong, the Plate and the Nile. The UNEP-Global Environment Monitoring System (GEMS) Water Programme also provides water quality data and information for both assessment and management purposes.

Groundwater

About 2 billion people, approximately one-third of the world's population, depend on groundwater supplies, withdrawing about 20 per cent of global water (600-700 km^3) annually — much of it from shallow aquifers (UNDP and others 2000). Many rural dwellers depend entirely on groundwater.

The issues of groundwater use and quality have until recently received far less attention (particularly in some developing regions) than surface water, and data on groundwater stocks and flows are even less reliable. However, in Europe, much attention has been paid to groundwater quality because many settlements depend on such resources for water supply. Generally, groundwater resources are vulnerable to a variety of threats, including overuse and contamination (see table on page 154).

When use exceeds natural recharge over a long period, groundwater levels drop. Parts of India, China,

Vision 21: global targets for water supply and sanitation

To address issues plaguing the provision of water supply and sanitation to the developing world, the Water Supply and Sanitation Collaborative Council (WSSCC) presented the following global targets, called Vision 21, at the Second World Water Forum at The Hague in March 2000:

- by 2015, reduce by one-half the proportion of people without access to hygienic sanitation facilities;
- by 2015, reduce by one-half the proportion of people without sustainable access to adequate quantities of affordable and safe water;
- by 2025, provide water, sanitation and hygiene for all.

Source: WSSCC 2000

Groundwater quality problems

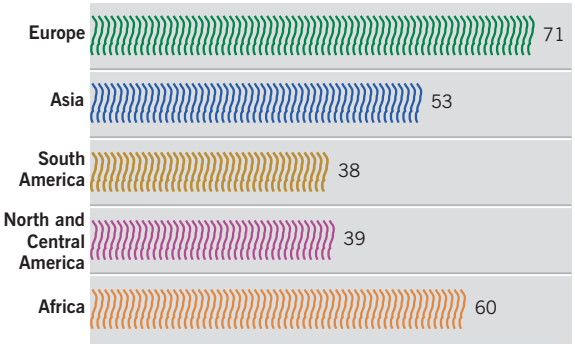
Problem	*Causes*	*Concerns*
Anthropogenic pollution	Inadequate protection of vulnerable aquifers against human-made discharges and leachates from: ● urban and industrial activities; ● intensification of agricultural cultivation	Pathogens, nitrates, ammonium salts, chlorine, sulphates, boron, heavy metals, DOC, aromatic and halogenated hydrocarbons nitrates, chlorine, pesticides
Naturally occurring contamination	Related to pH-Eh evolution of groundwater and dissolution of minerals (aggravated by anthropogenic pollution and/or uncontrolled exploitation)	Mainly iron, fluorine and sometimes arsenic, iodine, manganese, aluminium, magnesium, sulphates, selenium and nitrates (from paleo-recharge)
Well-head contamination	Inadequate well design and construction allowing direct intrusion of polluted surface water or shallow groundwater	Mainly pathogens

Source: Foster, Lawrence and Morris 1998

West Asia, the former Soviet Union, the western United States and the Arabian Peninsula are experiencing declining water tables, limiting the amount that can be used and raising the costs of pumping to farmers (Postel 1997, UNEP 1999). Overpumping of groundwater can lead to salt-water intrusion in coastal areas. In Madras, India, for example, saltwater intrusion has moved 10 km inland, contaminating wells (UNEP 1996).

Concern over growing problems related to groundwater resources has galvanized the international community, governments and other stakeholders to start addressing them. For example, the Second World Water Forum in March 2000 organized a special workshop on groundwater. Some of the recommendations arising from the workshop included the need to raise public awareness and 'improve information availability, quality and accessibility to stakeholders, technical specialists and policy-makers' (World Water Forum 2000).

Numbers of international river basins



A total of 261 river basins are shared by two or more countries

Notes: regions do not correspond exactly to GEO regions; the Jurado, shared by Colombia and Panama, is included in South America
Source: Wolf and others 1999

Transboundary water management

Water is widely shared among nations, regions, ethnic groups and communities. A total of 261 rivers (see graphic left), covering 45.3 per cent of the total land area (excluding Antarctica), are shared by two or more countries (Wolf and others 1999), making transboundary water resources management one of the most important water issues today.

Disputes over shared water resources have a long history. Water has been used as a tool and weapon of conflict, access to water has been a source of dispute and contention, and major water development projects (for example dam construction) have led to violence and civil strife (Gleick 1998). But shared waters can also be a source of cooperation. This is particularly evident today with the increase in the number of initiatives related to river basin management regimes and institutions committed to bilateral and/or multilateral management of transboundary water resources. This can be traced back to the 1966 Helsinki Rules which laid the foundation for international principles for shared watercourses and

influenced many specific river treaties. The Rules were subsequently followed up by various international efforts, including particularly the work of the UN International Law Commission, which led in 1997 to the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses. The impact of this new convention is already being felt with the 14-member Southern African Development Community (SADC) adapting many of its principles in its revised protocol on shared watercourses.

The recognition of river basin organization over the past 30 years has also resulted in the establishment of the International Network of Basin Organizations (INBO) in 1996 (see box), while other initiatives include the 1998 International Conference on Water and Sustainable Development, which declared that 'a common vision of riverine countries is needed for the efficient management and effective protection of transborder water resources'. The conference's priority action programme (Bernard 1999) emphasized the need to:

- facilitate the exchange of accurate and harmonized information among riverine countries;
- promote consultation at all levels, especially within pertinent international institutions and mechanisms; and
- define medium-range priority action programmes of common interest to improve water management and decrease pollution.

The International Network of Basin Organizations

The International Network of Basin Organizations had a total of 125 member organizations in 49 countries in 1998. Its objectives are to:

- establish a network of organizations interested in global river basin management, and facilitate exchanges of experiences and expertise among them;
- promote the principles and means of sound water management in sustainable development cooperation programmes;
- facilitate the implementation of tools for institutional and financial management, for programming and for the organization of data banks;
- promote information and training programmes for the different actors involved in water management including local elected officials, users' representatives and the executives and staff of member organizations;
- encourage education of the population, the young in particular; and
- evaluate ongoing actions and disseminate their results.

Source: INBO 2001

Water and ecosystems

Water development projects during the 20th century have had significant impacts on freshwater ecosystems by eliminating marshes and wetlands, removing water for other uses, altering flows, and contaminating water with industrial and human wastes. In many rivers and lakes, ecosystem functions have been lost or impaired. In some areas, growing water demand has led to reductions in the volume of large rivers, affecting riverine and adjacent coastal areas (CSD 1997a). Reproductive failures and death in various wildlife species, particularly at higher levels in the food chain, have been reported as a result of high withdrawals of water (CSD 1997a).

Wetlands are an important freshwater ecosystem influencing not only species distribution and biodiversity in general but also human settlements and activities. They provide natural flood control, carbon storage, natural water purification, and goods such as fish, shellfish, timber and fibre (UNDP, UNEP, World Bank and WRI 2000). While information on the real extent of wetlands globally remains unreliable, recent estimates show that they may cover at least 12.8 million km^2 (Finlayson and others 1999). Human activities, including agriculture and settlements, have caused serious damage to freshwater ecosystems and contributed to the loss of about 50 per cent of the world's wetlands during the 20th century (Finlayson and others 1999). This damage to ecosystems reduces water quality and quantity, leading to a reduction in the effective availability of water for human use.

The total area of wetlands lost during the past 30 years is difficult to assess because of paucity of data and lack of accurate global information on the original extent of wetlands (UNDP and others 2000). However, a 1992 review of Ramsar sites (wetlands designated as 'important' under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat) showed that 84 per cent were either threatened or experiencing ecological changes (Dugan and Jones 1993).

There has recently been a marked shift in water policy as policy-makers recognize that ecosystems require adequate water supplies to sustain normal functions and biodiversity conservation. Since 1992, new water policies have been developed that address the goal of preserving and allocating water for the environment — a change since the 1972 Stockholm

Conference which focused mainly on protecting air and water quality, and paid no attention to water for ecosystems. Although large projects involving dams are becoming less common due to limited sites, rising costs and general opposition, 349 dams more than 60 metres high were under construction in 1998 (UNDP and others 2000, WCD 2000). The remaining large free-flowing rivers are now found only in the tundra regions of North America and the Russian Federation, and in smaller basins in Africa and Latin America. There is now a growing emphasis on increasing water-use efficiency and increased productivity with the limited resources available (Postel 1997, Postel 1999, Gleick 1998). Throughout the world there are great opportunities to meet human needs with less water by:

- using existing technology (such as drip irrigation, low-flow toilets, and better industrial processes);
- changing irrigation technology;
- finding and stopping wasteful leaks;
- changing wasteful practices (such as irrigating during the day, using potable water for landscape irrigation);
- charging proper prices for water; and
- changing human activities (shifting to more water-efficient crops, changing industrial processes away from water-intensive production).

Ministerial Declaration on Water Security in the 21st Century

Some 120 ministers of water attending the Second World Water Forum held at The Hague in March 2000 adopted a declaration aimed at achieving world water security. The declaration noted the following as the main challenges of this new century:

- **Meeting basic needs:** to recognize that access to safe and sufficient water and sanitation are basic human needs and are essential to health and well-being, and to empower people, especially women, through a participatory process of water management.
- **Securing the food supply:** to enhance food security, particularly of the poor and vulnerable, through the more efficient mobilization and use, and the more equitable allocation of water for food production.
- **Protecting ecosystems:** to ensure the integrity of ecosystems through sustainable water resources management.
- **Sharing water resources:** to promote peaceful cooperation and develop synergies between different uses of water at all levels, whenever possible, within and, in the case of boundary and transboundary water resources, between states concerned, through sustainable river basin management or other appropriate approaches.
- **Managing risks:** to provide security from floods, droughts, pollution and other water-related hazards.
- **Valuing water:** to manage water in a way that reflects its economic, social, environmental and cultural values for all its uses, and to move towards pricing water services to reflect the cost of their provision. This approach should take account of the need for equity and the basic needs of the poor and the vulnerable.
- **Governing water wisely:** to ensure good governance, so that the involvement of the public and the interests of all stakeholders are included in the management of water resources.

Source: World Water Forum 2000

Policies and institutions for water management

The Commission for Sustainable Development (CSD) has reported that many countries lack adequate legislation and policies for efficient and equitable allocation and use of water resources. Progress is, however, being made with the review of national legislation and enactment of new laws and regulations.

Concern has also been expressed about the growing incapacity of national hydrological services and agencies, particularly in developing countries, to assess their respective water resources. Many agencies have experienced reductions in observation networks and staff despite increases in water demand. A number of response measures have been undertaken including the World Hydrological Cycle Observing System (WHYCOS), which has been implemented in several regions. Its main objective is to contribute to the improvement of national and regional water resource assessment capabilities (CSD 1997b).

Many different kinds of organizations play a role in water policy decisions, from national governments to local community groups. Over the past decades, however, there has been a growing emphasis on increasing the participation and responsibility of small, local groups and an acknowledgement that communities have an important role to play in water policy.

The Ministerial Declaration at The Hague in March 2000 (see box) called for 'Governing water wisely: to ensure good governance, so that the involvement of the public and the interests of all stakeholders are included in the management of water resources' (World Water Forum 2000).

The private sector has recently begun to expand its role in water management. The 1990s saw a rapid increase in the rate and extent of privatization of previously publicly managed water systems. Private water companies are increasingly serving the needs of growing cities by taking over contracts from public agencies to build, own and operate some or even all of a municipal system. At the same time, concerns have

been growing about how best to ensure equitable access to water for the poor, finance projects and share risks.

Conclusion

The development of water supply infrastructure dominated policy options for most of the two decades following 1972 but many innovative approaches to water resources management were introduced in the 1990s.

Major policy trends in this period include:

- recognition of both the social and economic value of water;
- emphasis on efficient allocation of water;
- recognition of catchment management as critical to effective management of water resources;
- greater cooperation by river basin states to ensure equitable distribution of resources;
- improved data collection;
- recognition of the role of all stakeholders in water management;
- adoption of integrated water resources management as a strategic policy initiative; and
- recognition of growing water scarcity due to various factors, including population and industrial growth, and increased pollution.

While developed countries have made significant strides in addressing water quality issues, the situation has actually worsened in developing countries, with many of them experiencing rising water demand and pollution. More countries are facing water stress or scarcity.

References: Chapter 2, freshwater, global overview

Bernard, A. (1999). *International Cooperation Through River Basin Commissions*. Ramsar Convention Bureau http://www.ramsar.org/cop7_doc_20.2_e.htm [Geo-2-116]

CSD (1997a). *Comprehensive Assessment of the Freshwater Resources of the World. Report of the Secretary-General*. United Nations Economic and Social Council http://www.un.org/documents/ecosoc/cn17/1997/ecn171997-9.htm [Geo-2-117]

CSD (1997b). *Overall Progress Achieved Since the United Nations Conference on Environment and Development. Report of the Secretary-General. Addendum - Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources*. United Nations Economic and Social Council http://www.un.org/documents/ecosoc/cn17/1997/ecn171997-2add17.htm [Geo-2-118]

Dugan, P.J. and Jones, T. (1993). Ecological Changes in Wetlands: A Global Overview. In M. Moser, R.C. Prentice and J. van Vessems (eds.), *Waterfowl and Wetland Conservation in the 1990s: A Global Perspective.* Slimbridge, United Kingdom, International Waterfowl and Wetlands Research Bureau

FAO (2001). AQUASTAT — FAO's information system on water and agriculture http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastatweb/main/html/background.htm [Geo-2-119]

Finlayson, C.M., Davidson, N.C., Spiers, A.G. and Stevenson, N.J. (1999). Global wetland inventory - current status and future priorities. *Marine and Freshwater Research* 50, 8, 717–28

Foster, S., Lawrence, A. and Morris, B. (1998). *Groundwater in Urban Development: Assessing Management Needs and Formulating Policy Strategies*. Washington DC, World Bank

Gleick, P.H. (1993). *Water in Crisis: A Guide to the World's Freshwater Resources*. New York, Oxford University Press

Gleick, P.H. (1998). *The World's Water 1998-1999*. Washington DC, Island Press

INBO (2001). *INBO Home Page*. International Network of Basin Organizations http://www.oieau.fr/riob/friobang.htm [Geo-2-120]

Meybeck, M., Chapman, D. and Helmer, R. (1990). *Global Freshwater Quality: A First Assessment*. Cambridge, Massachusetts, Basil Blackwell

Postel, S. (1997). *Pillar of Sand: Can the Irrigation Miracle Last?* New York, W.W. Norton and Company

Postel, S. (1999). *Last Oasis: Facing Water Scarcity*. New York, W.W. Norton and Company

Shiklomanov, I.A. (1993). World freshwater resources. In P. H. Gleick (ed.), *Water in Crisis: A Guide to the World's Freshwater Resources*. New York, Oxford University Press

Shiklomanov, I.A. (1999). World Water Resources and their Use. *Database on CD Rom*. Paris, UNESCO

UNDP, UNEP, World Bank and WRI (2000). *World Resources 2000-2001*. Washington DC, World Resources Institute

UNEP (1996). *Groundwater: A Threatened Resource*. Nairobi, UNEP

UNEP (1999). *GEO-2000*. United Nations Environment Programme. London and New York, Earthscan

UN (1999). *Comprehensive Assessment of the Freshwater Resources of the World. Report of the Secretary-General*. United Nations Division for Sustainable Development http://www.un.org/esa/sustdev/freshwat.htm [Geo-2-121]

UN (2000). *Drinking Water Supply and Sanitation Update. Report No UNE/CN 17/2000/13*. New York, Commission on Sustainable Development

United Nations Population Division (2001). *World Population Prospects 1950-2050 (The 2000 Revision)*. New York, United Nations www.un.org/esa/population/publications/wpp2000/wpp2000h.pdf

WCD (2000). *Dams and Development: A New Framework for Decision-Making. The Report of the World Commission on Dams*. London, Earthscan http://www.damsreport.org/wcd_overview.htm [Geo-2-122]

WHO and UNICEF (2000). *Global Water Supply and Sanitation Assessment 2000 Report*. Geneva and New York, World Health Organization and United Nations Children's Fund http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm [Geo-2-123]

World Commission on Water (1999). *World's Rivers in Crisis - Some Are Dying; Others Could Die*. World Water Council http://www.worldwatercouncil.org/Vision/6902B03438178538C125683A004BE974.htm [Geo-2-124]

World Water Council (2000a). *World Water Vision Commission Report: A Water Secure World. Vision for Water, Life and the Environment*. World Water Council http://www.worldwatercouncil.org/Vision/Documents/CommissionReport.pdf [Geo-2-125]

World Water Council (2000b). *World Water Vision: Making Water Everyone's Business*. London, Earthscan

World Water Forum (2000). *Ministerial Declaration of The Hague on Water Security in the 21st Century*. World Water Forum http://www.worldwaterforum.net/index2.html [Geo-2-126]

WSSCC (2000). *Vision 21: A Shared Vision for Water Supply, Sanitation and Hygiene and a Framework for Future Action*. Geneva, World Health Organization

Freshwater: Africa

Africa's renewable water resources average 4 050 km^3/year, providing in the year 2000 an average of about 5 000 m^3 per capita/year — significantly less than the world average of 7 000 m^3 per capita/year and less than one-quarter of the South American average of 23 000 m^3 per capita/year (Shiklomanov 1999 and United Nations Population Division 2001).

However, the distribution of both surface water and groundwater is uneven. For example, the Democratic Republic of Congo is the wettest country, with average annual internal renewable water resources of 935 km^3 compared to the region's driest country Mauritania, where the annual average is 0.4 km^3 (UNDP, UNEP, World Bank and WRI 2000). The spatial distribution of water resources in the region does not coincide with the highest population densities, resulting in many areas (particularly urban centres) being water stressed or dependent on external sources of water.

At least 13 countries suffered water stress or scarcity (less than 1 700 m^3 per capita/year and less than 1 000 m^3 per capita/year respectively) in 1990 and the number is projected to double by 2025 (PAI 1995). This presents a major challenge to water planners in terms of supply and distribution.

Groundwater is a major source of water in the region, contributing 15 per cent of Africa's resources (Lake and Souré 1997). The major aquifers are found in the northern Sahara, Nubia, Sahel and Chad basins as well as the Kgalagadi (Kalahari). Groundwater is used for domestic and agricultural consumption in many areas, particularly the more arid sub-regions where surface water resources are limited. However, areas heavily dependent on groundwater reserves are also at risk of water shortages, as water is extracted far more rapidly than it is recharged.

Variability of water resources

Africa experiences large spatial variations in rainfall, with 95 per cent of the total falling in the central and southwestern wet equatorial zone (Lake and Souré 1997). Severe droughts have been recorded in the Sahel and in the Northern, Eastern and Southern sub-regions over the past 30 years.

As a result, a number of inter-basin water transfer schemes have been developed. For example, in South Africa where 60 per cent of the run-off originates from one-fifth of the land area, large volumes of water are transported by inter-basin transfer schemes to major industrial centres such as Johannesburg (Goldblatt and others 2000). However, these schemes can exert significant pressure on the environment as reduced natural flows impact on downstream ecosystems.

Responses to water shortage in the Seychelles and Mauritius include desalinization, water rationing by the hotel and manufacturing industries, and recycling of domestic wastewater. These measures are expected to produce savings of about 240 million m^3/year in the long-term (Government of Mauritius and ERM 1998). In Egypt, severe water shortages have also prompted schemes to recycle agricultural drainage water to meet growing agricultural demand.

As in other regions, the major factors influencing water availability in Africa include growing domestic consumption for drinking water and sanitation, irrigated agriculture and industrialization (which also is a source of pollution and affects water quality). Losses from domestic water distribution systems account for significant wastage. Similarly, many irrigation systems are outdated. In South Africa, up to 50 per cent of irrigation water is lost due to leakages (Global Water Partnership 2000). In some countries, however, efforts are being made to improve water use efficiency.

Access to safe water and sanitation

Some 62 per cent of Africans had access to an improved water supply in 2000. Even so, rural Africans spend much time searching for water and 28 per cent of the global population without access to improved water supplies live in Africa. Women are particularly affected as they are often responsible for the family's water needs. Urban areas are better

Rainfall variability in the Lake Chad basin

Lake Chad in 1973 and 1997; red colour denotes vegetation on the lake bed

Source: NASA 2001

Over the past 30 years, the surface area of Lake Chad has varied considerably — from 25 000 to 2 000 km^2 — due to rainfall variability over the past 30 years. The lake supports globally important wildlife, particularly migratory birds. The economic activities of about 20 million people are based on the lake's resources. A new GEF-funded project in the Lake Chad Basin aims to decrease environmental degradation by improving cooperation between interested and affected parties, with the benefits from project-related activities accruing to the local communities.

Source: Coe and Foley 2001

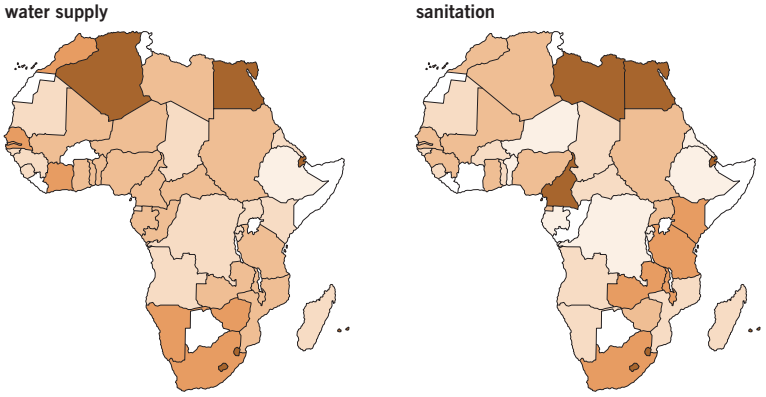
supplied, with 85 per cent of the population having access to improved water supplies. In rural areas, the average is 47 per cent, with 99 per cent of the rural population in Eritrea having no sanitation coverage. The total African population with access to improved sanitation was 60 per cent in 2000. Again, urban populations fared better, with an average 84 per cent having improved sanitation compared to an average 45 per cent in rural areas (WHO and UNICEF 2000).

Poor water supply and sanitation lead to high rates of water-related diseases such as ascariasis, cholera, diarrhoea, dracunculiasis, dysentery, eye infections, hookworm, scabies, schistosomiasis and trachoma. About 3 million people in Africa die annually as a result of water-related diseases (Lake and Souré 1997). In 1998, 72 per cent of all reported cholera cases in the world were in Africa.

Poor water supply and sanitation lead to contamination of surface and groundwater, with subsequent effects on plant, animal and human communities. The economic costs can be high. In Malawi, for example, the total cost associated with water degradation was estimated at US$2.1 million in 1994 (DREA Malawi 1994). These costs included the need for water treatment, the development of human resources and reduced labour productivity. Meeting basic water and sanitation needs is also expensive. In Nigeria, a recent study estimates the future cost of water supply and environmental sanitation to be US$9.12 billion during 2001–10 (Adedipe, Braid and Iliyas 2000).

Governments are trying to improve the situation with environmental management policies that include waste management and urban planning, and by making environmental impact assessments compulsory for large projects. One of the major regional policy initiatives was the 1980 Lagos Plan of Action, which urged member states to formulate master plans in the sectors of water supply and agriculture (OAU 1980). The Plan was influenced by the 1977 United Nations Water Conference's Mar del Plata Action Plan and the 1978 African regional meeting on water-related issues. Despite these initiatives, a lack of human and financial resources, and equipment for implementation and enforcement, still limit progress.

Water supply and sanitation coverage: Africa



In the year 2000, 62 per cent of Africans had access to improved water supplies and 60 per cent to sanitation — but coverage was poor in large areas of the continent

Source: WHO and UNICEF 2000

Deteriorating water quality

Freshwater and groundwater pollution is a growing concern in many areas, further limiting access to safe water. Poor water quality leads not only to water-related diseases but also reduces agricultural production, which means that more foodstuffs and agricultural products must be imported. Poor water quality also limits economic development options, such as water-intensive industries and tourism, a situation that is potentially disastrous to developing countries in Africa.

To counter this problem, many countries have established or enforced effluent water standards and rehabilitated wastewater treatment facilities. Other responses include schemes in Central Africa for purification and decontamination of freshwater systems, and public awareness campaigns. Although

Sludge disposal in Cairo

A study launched in Cairo in 1995 has shown that wastewater treatment can address not only the Egyptian city's water pollution problems but also open new opportunities for business and agriculture. The Greater Cairo Wastewater Project will produce about 0.4 million tonnes of sludge or biosolids annually from wastewater treatment.

The study was initiated under the Mediterranean Environmental Technical Assistance Programme funded by the European Investment Bank and promoted by the Cairo Wastewater Organization. Initial results show that sludge can be effective in growing wheat, berseem clover, forage maize and grape vines. Digested sludge offers significant nitrogen fertilizer replacement value to farmers; no harmful effects of biosolids on crops were detected in field trials; and the benefits of spreading biosolids on newly reclaimed soils are expected to increase with cumulative applications. Farmers in Egypt are prepared to pay for bio-solids due to the scarcity of manure and the high costs of inorganic fertilizers.

Source: UNCSD 1999

only recently implemented, these responses have been locally successful in improving access to drinking water and raising awareness.

In Eastern and Southern Africa, the widespread invasion of the water hyacinth (*Eichornia crassipes*) is a further cause of deteriorating water quality. The water hyacinth forms dense mats that block water channels, disrupting flow patterns. Decaying mats of the weed generate bad odours and lead to eutrophication of the water body. Areas afflicted by the water hyacinth include Lakes Victoria and Kariba, and some rivers. Affected countries have begun biological and chemical control programmes, in addition to mechanical clearance, with some success (Global Water Partnership 2000). Watercourses in West Africa are similarly threatened by *Salvinia molesta* and *Typha* species.

Wetlands

Wetland habitats in Africa cover about 1.2 million km^2 (Finlayson and others 1999). However, wetlands are threatened by both pollution and reclamation.

Loss of wetlands in Southern Africa is thought to have contributed to the severity of the flooding in 1999-2000, which affected 30 000 families and 34 000 hectares of farmland (Mpofu 2000). To prevent further wetland degradation, 27 African countries had signed and ratified the 1987 Ramsar Convention as of December 1998, placing 75 sites covering some 14 million ha under protection (Frazier 1999).

Integrated water resources management

A shift towards integrated water resources management (IWRM) is one of the new policy initiatives that have been adopted in Africa to address the issues raised above. Integrated water resources management is not limited to the national level but also includes basins shared by two or more states. The Nile Basin Initiative, launched in 1999, is a joint programme of action between 10 Nile countries. The objectives are to ensure sustainable resource development, security, cooperation and economic integration. In Southern Africa, the eight basin states of the Zambezi have been cooperating under the Zambezi River System Action Plan but efforts to establish a Zambezi Basin Commission have been slow. Another example of regional cooperation is in the Lake Victoria area, where in 1995 a GEF-funded project was established to focus primarily on fisheries management, pollution control, control of invasive weeds, and catchment land use management.

References: Chapter 2, freshwater, Africa

Adedipe, N.O., Braid, E.J., and Iliyas, M.H. (2000). *Development of Strategy/Action Plan and Implementation Guidelines for the National Water Supply and Sanitation Policy.* Abuja, UNICEF and Nigerian Federal Ministry of Water Resources

Coe, M. and Foley, J. (2001). Human and Natural Impacts on the Water Resources of the Lake Chad Basin. *Journal of Geophysical Research* 27 February 2001, Vol. 106, No. D4

DREA Malawi (1994). *National Environmental Action Plan Vol. 1*. Lilongwe, Malawi Department of Research and Environmental Affairs

Finlayson, C.M., Davidson, N.C., Spiers, A.G., and Stevenson, N.J. (1999). Global wetland inventory: current status and future priorities. *Marine Freshwater Resources* 50, 717–27

Frazier, S. (ed., 1999). *A Directory of Wetlands of International Importance*. Wageningen, Wetlands International and Ramsar Convention Bureau

Global Water Partnership (2000). *Southern African Vision for Water, Life and the Environment in the 21st Century and Strategic Framework for Action Statement*. Global Water Partnership Southern Africa Technical Advisory Committee http://www.gwpsatac.org.zw/vision/chapter10.html [Geo-2-101]

Goldblatt, M., Ndamba, J., van der Merwe, B., Gomes, F., Haasbroek, B. and Arntzen, J. (2000). *Water Demand Management: Towards Developing Effective Strategies for Southern Africa*. Harare, IUCN ROSA

Government of Mauritius and ERM (1998). *Mauritius NEAP II: Strategy Options Report.* Port Louis, Government of Mauritius and Environmental Resources Management

Government of Mauritius (1994). *National Physical Development Plan.* Port Louis, Ministry of Housing, Lands and Country Planning

Lake, W. B. and Souré, M. (1997). *Water and Development in Africa*. International Development Information Centre http://www.acdi–cida.gc.ca/xpress/dex/dex9709.htm [Geo-2-103]

Mpofu, B. (2000). *Assessment of Seed Requirements in Southern African Countries Ravaged by Floods and Drought 1999/2000 Season*. SADC Food Security Programme, Food, Agriculture and Natural Resources http://www.sadc-fanr.org.zw/sssd/mozcalrep.htm [Geo-2-104]

NASA 2001. *A Shadow of a Lake: Africa's disappearing Lake Chad.* NASA Goddard Space Flight Center http://www.gsfc.nasa.gov/gsfc/earth/environ/lakechad/chad.htm [Geo-2-327]

OAU (1980). *Lagos Plan of Action for the Economic Development of Africa: 1980-2000*. Addis Ababa, Organization of African Unity

PAI (1995). *Sustaining Water: An Update*. Washington DC, Population Action International, Population and Environment Programme

Shiklomanov, I.A. (1999). *World Water Resources: Modern Assessment and Outlook for the 21st Century*. St Petersburg, Federal Service of Russia for Hydrometeorology and Environment Monitoring, State Hydrological Institute

UNCSD (1999). *Cairo Sludge Disposal Study*. United Nations Commission on Sustainable Development http://www.un.org/esa/sustdev/success/cairo_st.htm [Geo-2-105]

UNDP, UNEP, World Bank and WRI (2000). *World Resources 2000-2001*. Washington DC, World Resources Institute

United Nations Population Division (2001). *World Population Prospects 1950-2050 (The 2000 Revision)*. New York, United Nations

WHO and UNICEF (2000). *Global Water Supply and Sanitation Assessment 2000 Report*. Geneva and New York, World Health Organization and United Nations Children's Fund http://www.who.int/water_sanitation_health/Globassessment/Glassessment6.pdf [Geo-2-111]

WMO (1997). *Comprehensive Assessment of the Freshwater Resources of the World: assessment of water resources and water availability in the world*. Geneva, WMO

Freshwater: Asia and the Pacific

The Asia and the Pacific Region accounts for about 36 per cent of global run-off. Even so, water scarcity and pollution are key issues and the region has the lowest per capita availability of freshwater: renewable water resources amounted to about 3 690 m^3 per capita/year in mid-1999 for the 30 largest countries in the region for which records are available (UNDP, UNEP, World Bank and WRI 2000 and United Nations Population Division 2001). In absolute terms, China, India and Indonesia have the largest water resources, more than one-half of the region's total. Several countries, including Bangladesh, India, Pakistan and the Republic of Korea, already suffer from water scarcity or water stress. More will do so as populations and consumption increase. Agriculture is the biggest consumer (86 per cent), with smaller amounts going to industry (8 per cent) and domestic use (6 per cent) (compiled from UNDP, UNEP, World Bank and WRI 2000).

Water scarcity

Many countries do not have sufficient water to meet demand, with the result that aquifer depletion due to overextraction is common. Moreover, the scarcity of water is accompanied by a deterioration in the quality of available water due to pollution and environmental degradation. Dams and reservoirs coupled with deforestation in some watersheds have reduced stream water levels, lowered water tables, degraded riparian wetlands and diminished freshwater aquatic diversity. Excessive demand for groundwater in coastal cities such as Bangkok, Dhaka, Jakarta, Karachi and Manila has led to saline intrusion and ground subsidence.

Government policies and strategies have traditionally been concerned with increasing supply. However, policies have recently become increasingly focused on an integrated approach to water resource management by emphasizing demand management measures such as efficient water use, conservation and protection, institutional arrangements, legal, regulatory and economic instruments, public information and inter-agency cooperation. Common elements in the national policies and strategies now being adopted include integration of water resources development and management into socio-economic development; assessment and monitoring of water resources; protection of water and associated resources; provision of safe drinking water supply and sanitation; conservation and sustainable use of water for food production and other economic activities; institutional and legislative development; and public participation.

In India, a new irrigation management policy aims to improve water application efficiency through the use of modern technologies such as drip/sprinkler irrigation and better on-farm irrigation measures. In the Republic of Korea, where agriculture uses more than 50 per cent of water resources, the government's water resources development plan for the 21st century highlights measures that relate to increased food production with efficient water use (Kwun 1999). Decentralized water management is also being encouraged in countries such as China where city or provincial authorities are authorized to manage water resources. In India, multidisciplinary units in charge of developing comprehensive water plans have been established in some states. Stakeholder participation has reduced operational costs in countries such as Pakistan by involving communities in the development of water supply, sanitation, and water pollution prevention facilities and their maintenance.

Progress has also been made in adopting a basin-wide approach. The Indus Basin water-sharing accord

Lake Toba–Lake Champlain Sister Lakes Exchange

North–South cooperation between organizations in Indonesia and the United States has contributed to enhanced catchment management in the Lake Toba watershed — the world's largest volcanic crater lake, which covers about 4 000 km^2. The Indonesian lake, which suffers from degraded water quality, loss of biological diversity and invasions of troublesome non-native plants and animals, has benefited from institutional cooperation between the Lake Toba Heritage Foundation and the Lake Champlain Basin Programme (LCBP) in Vermont, United States. The Foundation used part of a grant from the United States Agency for International Development to establish a sister lakes relationship with the LCBP. The exchange programme has helped address freshwater management issues in the Lake Toba catchment using experiences from another catchment and region.

The programme demonstrates the following lessons:

- freshwater lakes of the world share similar management challenges;
- some of the greatest challenges have to do with managing a resource shared by multiple jurisdictions in a large geographic area;
- many of the management solutions require successful citizen and stakeholder involvement; and
- management experience can be directly transferred to other countries.

Source: UNCSD 1999

Improved water supply and sanitation coverage: Asia and the Pacific

In the year 2000, 81 per cent of Asians had access to improved water supplies but only 48 per cent — the lowest of any region — to sanitation

Source: WHO and UNICEF 2000

between India and Pakistan, the acclaimed Water Sharing Treaty between India and Bangladesh, the India–Bhutan cooperation on hydropower development and India–Nepal cooperation in harnessing transboundary rivers are examples of transboundary cooperation on water management in South Asia.

A major challenge is to change the fragmented sub-sectoral approaches to water management that have caused conflict and competition in the past, and to design and implement integrated mechanisms, particularly for projects that transcend sub-sectors.

Water pollution

Over the years, water pollution has emerged as a major issue. Pollutants include pathogens, organic matter, nutrients, heavy metals and toxic chemicals, sediments and suspended solids, silt and salts.

South Asia — particularly India — and Southeast Asia are facing severe water pollution problems. Rivers such as the Yellow (China), Ganges (India), and Amu and Syr Darya (Central Asia) top the list of the world's most polluted rivers (World Commission on Water 1999). In cities in the developing countries of the region, most water bodies are now heavily polluted with domestic sewage, industrial effluents, chemicals and solid wastes. Most rivers in Nepal's urban areas have been polluted and their waters are now unfit for human use, while drinking water in Kathmandu is contaminated with coliform bacteria, iron, ammonia and other contaminants (UNEP 2001).

Water pollution has affected human health. In the Pacific Islands, especially in some atoll communities, use of polluted groundwater for drinking and cooking has led to health problems such as diarrhoea, hepatitis, and occasional outbreaks of typhoid and cholera. Groundwater in districts of West Bengal, India, and in some villages in Bangladesh, for example, is contaminated with arsenic at levels as much as 70 times higher than the national drinking water standard of 0.05 mg/litre. While pollution is a factor, arsenic contamination is also due to natural phenomena. According to one report, 'With the majority of the country's 68 000 villages potentially at risk, UN scientists estimate that the arsenic may soon be killing 20 000 Bangladeshis a year' (Pierce 2001).

Inadequate water supply and poor sanitation cause more than 500 000 infant deaths a year as well as a huge burden of illness and disability in the region (UNEP 1999). Some 8–9 per cent of the total Disability Adjusted Life Years (DALYs) are due to diseases related to inadequate water supply and poor sanitation in India and other countries (World Bank 2000). Cholera is prevalent in many countries, particularly those where sanitation facilities are poor such as Afghanistan, China and India (WHO 2000).

Of the global population without access to improved sanitation or water supply, most live in Asia (WHO and UNICEF 2000, see map above). In the Southwest Pacific sub-region, water supply and sanitation appear to be relatively good, with 93 per cent of the population having access to improved sanitation and 88 per cent to improved water supply (WHO and UNICEF 2000). These figures are strongly biased by the large and well-served population of Australia, however. Only an estimated 48 per cent of the Asian population has sanitation coverage (WHO

Water pollution in Australia

In Australia, the quality of water in many inland waterways has declined due to human activities within catchments (Ball and others 2001). Sediments, nutrients and toxic materials as well as excessive growth of aquatic weeds have affected aquatic ecosystems. Response measures include the Urban Storm Water Initiative, the Industry Partnership Programme and Waterwatch Australia that together aim to monitor and improve the health of urban waterways. A number of state and territory-based programmes have also been introduced, together with community programmes such as Streamwatch and Waterwatch. In addition, local authorities are developing storm water management plans for urban catchments with financial support from state and territory agencies. Storm water is increasingly seen as a resource to be collected and utilized rather than a waste for disposal.

Source: Australia State of the Environment Committee 2001

and UNICEF 2000) — less than in any other region of the world. The situation is worse in rural areas, where only 31 per cent of the population have improved sanitation, compared to 78 per cent coverage in urban areas.

During the past decade, several countries have started to address the water quality problem by implementing large-scale programmes and action plans to rehabilitate degraded streams and depleted aquifers. These programmes are typically given legislative or statutory authority such as that provided by Thailand's National Water Quality Act, the Philippine Water Quality Code, India's Environment Protection Act, China's Water Law and the Republic of Korea's Water Quality Preservation Act (UNESCAP 1999). Success stories with respect to rehabilitation and protection of water quality of rivers come from those countries where water policies promote a multisectoral and multidisciplinary approach to the management of water resources.

Clean-up campaigns for rivers, canals, lakes and other water bodies have become widespread. The programmes have often been successful in improving water quality and, occasionally, have led to the adoption of new water quality standards and water use regulations. They have also increased awareness of the need to reduce pollutant loads through wastewater treatment, reuse and recycling of sewage and industrial wastewater, introduction of low-cost technologies, and strict control of industrial and municipal effluent. There have been a number of successes in water reuse and recycling in the industrialized countries of the region.

Water quality has been improved in China, Japan, the Republic of Korea and Singapore as a result of initiatives to address water pollution. In Japan, the government has set environmental quality standards and made remarkable improvements: in 1991, 99.8 per cent of water samples met standards for heavy metals and toxins in Japan (RRI 2000). In 2000, the rate of industrial wastewater treatment across China was 94.7 per cent (SEPA 2001). Action in Singapore means that Singaporeans can now enjoy drinkable piped water straight from the tap.

References: Chapter 2, freshwater, Asia and the Pacific

Australia State of the Environment Committee (2001). *Coasts and Oceans,* Australian State of the Environment Report 2001 (Theme Report). Canberra, CSIRO Publishing on behalf of the Department of the Environment and Heritage

Kwun, S. (1999). *Water for Food and Rural Development,* Country Paper of the Republic of Korea Regional Consultation Meeting for ICIDVision for Subsector. Kuala Lumpur, 17–19 May 1999

Pierce, F. (2001). Death in a Glass of Water. *The Independent.* 19 January 2001 http://www.independent.co.uk/story.jsp?story=51508 [Geo-2-106]

RRI (2000). *Japan Environmental Policy.* Resource Renewal Institute http://www.rri.org/envatlas/asia/japan/jp-conc.html#Water [Geo-2-107]

SEPA (2001). *Report of the State of the Environment in China 2000.* Beijing, State Environmental Protection Administration

UNCSD (1999). *Lake Toba–Lake Champlain Sister Lakes Exchange.* United Nations Commission on Sustainable Development http://www.un.org/esa/sustdev/success/watenfed.htm [Geo-2-108]

UNDP, UNEP, World Bank and WRI (2000). *World Resources 2000-2001*. Washington DC, World Resources Institute

UNEP (1999). *GEO-2000*. United Nations Environment Programme. London and New York, Earthscan

UNEP (2001). *Nepal: State of the Environment 2001.* Bangkok, MoPE/HMGN/ICIMOD/SACEP/NORAD/UNEP

UNESCAP (1999). *ESCAP Population Data Sheet, Population and Development Indicators for Asia and the Pacific, 1999.* Bangkok, United Nations Economic and Social Commission for Asia and the Pacific

United Nations Population Division (2001). *World Population Prospects 1950-2050 (The 2000 Revision)*. New York, United Nations www.un.org/esa/population/publications/wpp2000/wpp2000h.pdf

WHO (2000). *Communicable Disease Surveillance and Response. Global Cholera Update.* World Health Organization http://www.who.int/emc/diseases/cholera/choltbl1999.html [Geo-2-109]

WHO and UNICEF (2000). *Global Water Supply and Sanitation Assessment 2000 Report*. Geneva and New York, World Health Organization and United Nations Children's Fund http://www.who.int/water_sanitation_health/Globassessment/Glassessment7.pdf [Geo-2-112]

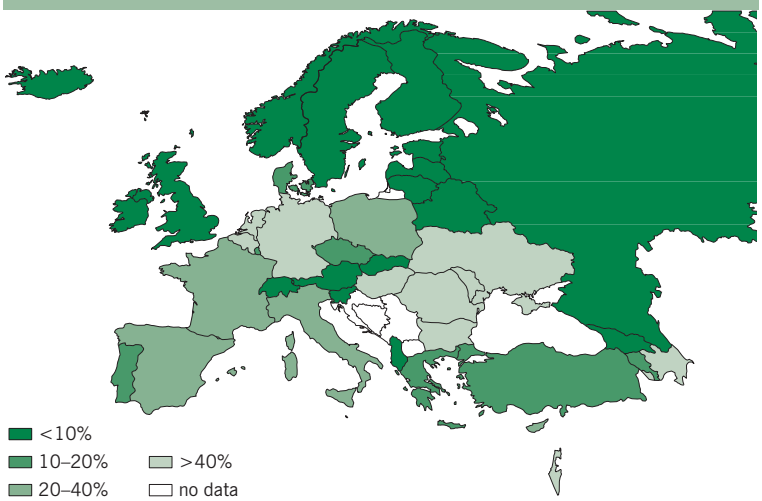
World Commission on Water (1999). *World's Rivers in Crisis - Some Are Dying; Others Could Die.* World Water Council http://www.worldwatercouncil.org/Vision/6902B03438178538C125683A004BE974.htm [Geo-2-110]

World Bank (2000). *Health and Environment. Environment Strategy Paper.* World Bank http://lnweb18.worldbank.org/essd/essd.nsf/GlobalView/HealthandENV.pdf/$File/HealthandENV.pdf [Geo-2-113]

Freshwater: Europe

Water resources are unevenly distributed in Europe. Annual average run-off ranges from 3 000 mm in western Norway to 100-400 mm over much of central Europe and less than 25 mm in central and southern Spain (ETC/WTR 2001). Traditionally, most European countries rely more on surface water than on groundwater, which is often used only for public water supply (EEA 1999a, Eurostat 1997). Data for assessing water quantity trends are rather poor but relatively good for water quality. Water pollution is a serious issue throughout Europe. Though some progress has been made in pollution reduction in Western Europe, the situation is less promising in Central and Eastern Europe (CEE).

Water stress in Europe (withdrawals as % of renewable resources)



Water stress occurs in parts of Europe, notably in the irrigated areas of CEE and the highly industrialized countries of Western Europe

Source: compiled from UNDP, UNEP, World Bank and WRI 2000

Water quantity

Europe abstracts a relatively small portion of its total renewable water resources. Western Europe abstracts, on average, around 20 per cent (EEA 1999b), although this ranges from less than 5 per cent in the northern countries to more than 40 per cent in Belgium, Germany and the Netherlands. The Russian Federation, with 9 per cent of the world's water resources, abstracts less than 2 per cent annually (RFEP 2000). However, water quantity problems do occur in areas with low rainfall and high population density, and in large land areas under irrigated agriculture, especially in Mediterranean countries and in CEE.

In the central part of Western Europe, most of the water supply is used as a coolant in energy production. This water is returned to its source more or less unchanged and can be re-used. In southern countries of Western Europe, where water resources are less abundant, agriculture consumes far more than the other sectors — about 80 per cent, compared to 20 per cent for urban and industrial use (ETC/WTR 2001). Some 80 per cent of the water used for irrigation evaporates.

The amount of water abstracted for public water supply in Western Europe fell by 8–10 per cent between 1985 and 1995 as a result of improved industrial and domestic water use efficiency (ETC/WTR 2001). However, a significant increase in agricultural water use occurred in southern Europe because irrigated farmland has increased by nearly 20 per cent since the mid-1980s. In CEE, there has been a marked decline in water consumption for industrial purposes due to economic restructuring but the demand from urban areas and for irrigated agriculture is growing steadily (EEA 1998).

There is little legislation controlling water use in Europe. Traditionally, quantity problems have been dealt with by increasing storage capacities through reservoirs and water transfer schemes. However, demand reduction measures are now in place in several countries in Western Europe. These, together with greater awareness of water use in general, have reduced public consumption. The domestic and industrial sectors have become increasingly water-efficient. Examples of water conservation measures include: metering; increased charges and taxes; restrictions on garden watering; reducing leakage; user education and widespread use of more efficient appliances such as low and dual flush toilets, and washing machines that consume less water.

Abstraction charges and pricing mechanisms are valuable for improving the sustainability of water use in agriculture and deserve more attention because water prices for agricultural use are often lower than for other users. For instance, a recent study (Planistat 1998) found that in the French Adour-Garonne basin, the drinking water supply is almost entirely self-financing (about 98 per cent) but the irrigation tariff covers only 30–40 per cent of the total cost of the services. Other agricultural reforms include planting crops with lower water demands and introducing more efficient irrigation systems. In CEE, all these less conventional measures are being applied but a major

challenge will be to reduce leakage — losses sometimes exceed 50 per cent (EEA 1998).

Water quality

Overloading with organic matter, nitrogen and phosphorus in the 1970s and 1980s resulted in eutrophication of seas, lakes, rivers and groundwater throughout Europe. The main source of nitrogen is fertilizers in run-off from agricultural land. Most phosphorus comes from households and industry wastewater, though in areas with intensive agriculture in Western Europe, phosphorus from agriculture approaches 50 per cent of the total load (EEA 2001). In Western Europe, fertilizer consumption has fallen since the mid-1980s but eutrophication has continued due to increased nutrient run-off from intensive livestock production. In CEE, use of agrochemicals has declined markedly since the early 1990s, resulting in a reduction of nitrogen-phosphorus fertilizer use by about 50 per cent (Czech Republic 1999, Republic of Hungary 1999).

Pollution of groundwater is another serious problem, mainly associated with nitrates and pesticides from agriculture (EEA 1998). In the Russian Federation alone, more than 2 700 sources of groundwater were identified as polluted in 1999 (RFEP 2000).

Phosphorus discharges from urban wastewater treatment plants in Western Europe have fallen significantly (50–80 per cent) since the early 1980s, largely due to the huge increase in treatment of wastewater (ETC/WTR 2001) and wide-scale introduction of phosphorus-free detergents. By the end of the 1990s, 90 per cent of Western Europeans were connected to sewers and 70 per cent to wastewater treatment plants (ETC/WTR 2001). In CEE, however, 30–40 per cent of households were not yet connected to sewers by 1990 and treatment was inadequate (EEA 1999c). Since 1990, most Accession Countries have started to invest heavily in sewage collection and treatment but its high cost is one of the major financial issues in the accession process (Republic of Slovenia 1999). In the Eastern European countries of the former Soviet Union, little has been done to improve wastewater treatment.

Many lakes that had high phosphorus concentrations in the early 1980s have lower concentrations today. However, only slight changes in phosphorus concentrations have been observed in initially less-affected lakes (EEA 2000). This is mainly due to accumulation and (delayed) release of phosphorus from lake bottoms or continued contamination from small, scattered dwellings and from agricultural sources. Overall, water quality in many European lakes is still poor (ETC/WTR 2001). Heavy pollution in Western European rivers such as the Rhine has declined significantly since 1980 (ETC/WTR 2001) but improvements have been less significant in southern and Central Europe. In Eastern Europe, the situation is different. In the Russian Federation and Ukraine, the two most industrialized countries of the former Soviet Union, discharge of polluted water into rivers increased in the second half of the 1980s and in the 1990s, despite an alleged clean-up campaign for the Volga and Ural rivers as early as 1972 (see box above).

Poor water quality impacts human health. In Europe, however, outbreaks of water-borne diseases affecting less than 20 per cent of the supplied population are rarely detected. Even so, occasional outbreaks of water-borne diseases such as gastro-intestinal infections, affecting much of the population, are reported across Europe, even from countries with high standards of supply (WHO 1999). Lead from old distribution pipes and, in Eastern Europe, contaminated wells can affect the neuro-behavioural development of children (EEA/WHO 1999).

At sub-regional level, various EU Directives tackle water quality issues. Implementation of the Drinking Water and Nitrate Directives has been unsatisfactory in most member states, although the Urban Wastewater Treatment Directive has led to a decrease in organic matter discharges by two-thirds and in nutrients by one-half (ETC/WTR 2001). Further improvements are likely as more countries invest in new infrastructure to

How the Volga and the Ural were not cleaned up

In the early 1970s, funds of 1.2 billion roubles were allocated for a clean-up plan for the Volga and the Ural rivers (Bush 1972) — one of the first publicly announced projects to clean up industrial rivers and safeguard the water supply. Many ministries were charged with negligence or slowness in implementing measures to correct the problem and with failing to make full use of the capital investment allotted for water protection measures. The authorities were given until 1980 to implement the measures needed to ensure a complete end to the discharge of untreated wastewater into the Volga-Ural river basins. However, by the end of the 1980s, the pollution level of the Volga and its tributaries was still assessed as 'extremely high', and it continued to increase in the 1990s.

Source: Interstate Statistical Committee 1999

comply with the objectives of the Directive. The same will be true for Accession Countries in Central Europe.

The mixed success of these measures can be related to the absence of integrated policies for water management. Policy development currently focuses on sustainable watershed management and freshwater protection through integration of quantity and quality aspects. Integration may be improved by the Water Framework Directive which aims to achieve good surface water status in all European water bodies by 2015 and addresses the issue of integrated management of water resources at the catchment level (EEA 1999a).

Policy and legislative framework

There are many multilateral and bilateral agreements for the management of transboundary waters. At the pan-European level, the 1992 UNECE Convention of the Protection and Use of Transboundary Watercourses and International Lakes strengthens national measures, obliging parties to prevent, control and reduce water pollution from point and non-point sources. It also includes provisions for monitoring, research and development, consultations, warning and alarm systems, mutual assistance, institutional arrangements, and the exchange and protection of information, as well as public access to information. A Protocol on Water and Health is awaiting entry into force.

At the watershed level, transboundary initiatives include the Convention on Cooperation for the Protection and Sustainable Use of the River Danube and the new Convention for the Protection of the Rhine. The Danube Convention pledges the signatories to work together to conserve, improve and rationally use the surface and ground waters in the Danube Catchment basin; to control hazards originating from accidents in the river area; and to contribute to reducing the pollution loads of the Black Sea from sources in the catchment area. The new Rhine Convention, adopted at the January 2001 Conference of Rhine Ministers, will be the basis for international cooperation of the riparian countries and the EU, replacing the Agreement on the International Commission for the Protection of the Rhine against Pollution (Bern 1963) and the 1976 Convention for the Protection of the Rhine against Chemical Pollution. The new convention fixes targets for international cooperation for sustainable development of the Rhine, further improvement of its ecological state, holistic flood protection and defence. In addition to aspects of water quality and quantity, including flood-related problems, groundwater problems in relation to the Rhine will in future be included in the convention's provisions (ICPR 2001).

References: Chapter 2, freshwater, Europe

Bush, K. (1972). Steps towards Pollution Control in the USSR. *Radio Liberty Research,* 6 April 1972, pp.1-7

Czech Republic (1999). *State Environmental Policy.* Prague, Ministry of the Environment

EEA (1998). *Europe´s Environment: The Second Assessment.* Copenhagen, European Environment Agency

EEA (1999a). *Groundwater Quality and Quantity in Europe. Environmental Assessment Report No.3*. Copenhagen, European Environment Agency

EEA (1999b). *Sustainable Water Use in Europe – Sectoral Use of Water. Environmental Assessment Report No.1*. Copenhagen, European Environment Agency

EEA (1999c). *Environment in the European Union at the Turn of the Century. Environmental Assessment Report No.2.* Copenhagen, European Environment Agency

EEA (2000). *Environmental Signals 2000. Environmental Assessment Report No. 6.* Copenhagen, European Environment Agency

EEA (2001). *Environmental Signals 2001. Environmental Assessment Report No. 8*. Copenhagen, European Environment Agency

EEA and WHO (1999). *Children in Their Environment: Vulnerable, Valuable, and at Risk*. Background briefing for the 3rd European Ministerial Conference on Environment and Health, Copenhagen, World Health Organization Regional Office for Europe and European Environment Agency

ETC/WTR (2001). European Topic Centre on Water http://water.eionet.eu.int/Databases [Geo-2-114]

Eurostat (1997). *Estimations of Renewable Water Resources in the European Union*. Luxembourg, Statistical Office of the European Communities

ICPR (2001). *Home Page*. International Commission for the Protection of the Rhine http://iksr.firmen-netz.de/icpr/ [Geo-2-115]

Interstate Statistical Committee (1999) *Official Statistics of CIS countries. CD-ROM*. Moscow, Interstate Statistical Committee of the Commonwealth of Independent States

Planistat (1998). *A Study on Water Economics – Integrated Report*. A study for the European Commission – DG XI.B.1. Paris, Planistat Group

Republic of Hungary (1999). *National Environmental Programme 1997-2002* Budapest, Ministry of Environment.

Republic of Slovenia (1999). *National ISPA Strategy of the Republic of Slovenia: Environmental Sector.* Llubljana, Ministry of Environment and Physical Planning

RFEP (2000). *Government Report on the State of the Environment in the Russian Federation in 1999*. Moscow, State Committee of the Russian Federation on Environmental Protection

UNDP, UNEP, World Bank and WRI (2000). *World Resources 2000-2001*. Washington DC, World Resources Institute

United Nations Population Division (2001). *World Population Prospects 1950-2050 (The 2000 Revision)*. New York, United Nations www.un.org/esa/population/publications/wpp2000/wpp2000h.pdf

WHO (1999). *Overview of Environment and Health in Europe in the 1990s.* Report prepared for the 3rd European Conference on Environment and Health. Geneva, World Health Organization

Freshwater: Latin America and the Caribbean

The Latin America and Caribbean Region is rich in renewable water resources with more than 30 per cent of the world's total. However, three hydrographic regions — the Gulf of Mexico Basin, the South Atlantic Basin and the La Plata Basin — covering 25 per cent of the region's territory, are home to 40 per cent of the population and contain only 10 per cent of the region's water resources (WWC 2000).

Most water-related problems transcend national boundaries although there are marked differences between sub-regions and countries. The major challenges are: decreasing per capita water availability due to population growth, urban expansion, deforestation and climate change; deteriorating water quality arising from untreated sewage, excessive use of fertilizers and pesticides, and industrial pollution — particularly from the mining and energy industries; and outdated institutional and legal frameworks.

Availability and use

Water availability varies greatly, with South America being the richest sub-region. Some countries suffer from water shortages, and loss of aquatic biodiversity and habitats, with some Caribbean islands approaching or below water scarcity levels (WWC 2000). Sharp differences also exist within countries.

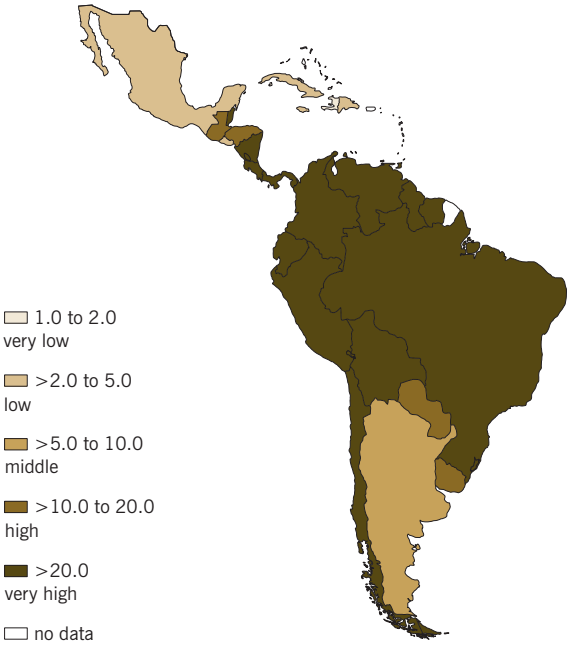
In most Caribbean small island states, rainfall is the sole source of freshwater (Antigua and Barbuda, the Bahamas and Barbados use desalinated water). In South America, groundwater reserves are of great importance and are estimated at 3 million km^3 (GWP 2000). Mexico is particularly dependent on groundwater, which accounts for one-third of all reported freshwater extraction and for two-thirds of urban drinking water (CATHALAC 1999, WWC 1999).

Agriculture and industry are the major consumers of water in the region, followed by domestic consumption. Irrigated agriculture is one of the fastest expanding uses of freshwater. The amount of land under irrigated agriculture increased from 10 million ha in 1970 to more than 18 million ha in 1998 (FAOSTAT 2001). Water withdrawals for irrigation range from 56 per cent of total withdrawals in the Caribbean to 78 per cent in Mesoamerica. There is a general lack of efficiency in irrigation technology and practice (World Bank 1999). Some recent institutional reforms have attempted to address this. In Mexico, for example, ownership of public irrigation systems has been transferred to 386 Water User Associations resulting in a dramatic improvement in cost recovery, system maintenance, yield and water use efficiency (Saleth and Dinar 1999).

Industry also uses large amounts of water. In South America, it is estimated that annual industrial withdrawals reach 15 km^3 with 80 per cent of this demand coming from Argentina and Brazil alone (ACAA 2001). In Brazil, virtually all the country's electricity comes from hydropower. The mining sector, especially in Chile and Peru, requires increasing quantities of water. For some regions such as the Andes, this may well lead to the need to import water in the near future. In Venezuela and Trinidad and Tobago, the petroleum sector is an important consumer.

The demand for water for domestic use is also on the increase. However, inequity among users, even in water-rich countries, is rampant. Many of the poor in both rural areas and urban communities have neither access to clean water nor sanitation services (WWC 2000). In 1995, 27 per cent of the population had

Water availability in 2000 (1 000 m^3 per capita/year)



Map shows water availability measured in terms of 1 000 m^3 per capita/ year

Source: compiled from UNDP, UNEP, World Bank and WRI 2000 and United Nations Population Division 2001

'In 1998, Hurricane Mitch caused US$58 million of damage in Honduras alone. The devastation included the destruction of 85 000 latrines and 1 683 rural water mains. As a result, 75 per cent of the population — about 4.5 million people — lost access to drinking water. Devastation such as that caused by Hurricane Mitch may last for months or even years.' —
WHO and UNICEF 2000

either no domestic water supply or no easy access to it. In the same year, 41 per cent of the water was untreated and 31 per cent of the population had no sewage services (PAHO 1998). By 2000, 85 per cent of the population had an improved water supply and 78 per cent had improved sanitation coverage — but this still meant that 78 million people had no access to improved water supply and 117 million had no access to improved sanitation services (WHO and UNICEF 2000). Large disparities also exist between rural and urban areas. Natural disasters provide an additional, unexpected factor that can seriously undermine efforts to improve water and sanitation services.

Attempts have been made to improve water supply and sanitation in many urban areas and to set tariffs that reflect the real value of water. Although the efficiency of privatization and the use of economic instruments such as water pricing remain highly contentious (WWC 2000), some countries, such as Jamaica, have started using economic instruments (UNECLAC 2000).

Limited information on water utility infrastructure and operation is a major constraint in government efforts to improve regulations related to the urban water sector. While the role of governments has shifted from provider of a water service to regulator representing the public, many governments still do not have sufficient information on water utility operation, and this limits their regulatory functions. Although the rate of technological change in the water sector is generally slower than in other sectors, the need to transfer technology is critical to efforts to save water and introduce improved control strategies.

To increase the efficiency of the sanitation sector, as well as to attract capital, national and international initiatives have been suggested, including the creation of local or regional markets such as the Guarani Aquifer project (see box on page 169). In Brazil, there have been notable advances in legislation, especially with a 1997 federal law that put in place a national water resources policy and established a national water resources management system.

The Tegucigalpa Model: water supply for peri-urban settlements

Community participation, a cost-sharing and cost-recovery system, hygiene education and training have contributed to improving water supply and sanitation in many peri-urban communities in the Honduran capital of Tegucigalpa. Rapid urbanization over the past 20 years increased Tegucigalpa's population to 850 000, with more than half of the people living in 225 peri-urban communities. Surface water is almost non-existent, and groundwater is often too deep and polluted. The provision of basic services such as water and sewage systems is difficult and costly.

The programme on water supply for peri-urban settlements, which is a partnership involving UNICEF, with the National Autonomous Water and Sewage Authority (SANAA) Executive Unit for Settlements in Development (UEBD) and communities, provided water supply to 150 000 people in 80 communities and sanitation coverage to about 5 000 in four communities between 1987 and 1996. One of the strengths of the programme is community participation and investment. The community has to provide labour and construction materials, contribute financially through water tariffs and recover the full investment cost. The community must establish a Water Board to collect tariffs, administer the water system and take care of the operation and simple maintenance activities. A cost-sharing and cost-recovery system exists and this includes the use of a revolving fund: the community's contribution is about 40 per cent of the cost of the water system, while SANAA and UNICEF contribute 25 per cent and 35 per cent respectively.

Source: UNCSD 1999

Water quality

Water pollution problems in Latin America and the Caribbean did not become a serious issue until the 1970s. Over the past 30 years, however, there has been a significant decrease in the quality of surface water and groundwater. Agriculture and the release of untreated urban and industrial sewage have become the major sources of pollution.

The excessive use of fertilizers in agriculture has enhanced algal growth and eutrophication in lakes, dams and coastal lagoons. Rising levels of nitrates have been observed in rivers, including the Amazon and the Orinoco, as well as in underground sources in the region. In Costa Rica, levels of nitrates approaching or surpassing international guidelines

The Guarani Aquifer System

The Guarani Aquifer System is one of the world's largest aquifers, covering about 1.2 million km^2 in the southeast of South America. The permanent reserves of the system in Brazil are conservatively estimated at about 48 000 km^3 with an annual recharge of 160 km^3. Groundwater extraction of about 20 per cent of current annual recharge rates would be enough to supply 300 litres per day per capita to 360 million inhabitants.

Argentina, Brazil, Paraguay and Uruguay are working together to develop an integrated plan for the protection and sustainable management of the system under a project funded by the Global Environment Facility and the World Bank — the Project for Environmental Protection and Sustainable Development of the Guarani Aquifer System. The Organization of American States, other international donors and agencies are also participating. Success would be an important step towards ensuring long-term availability of freshwater and aquifer resources for people in these countries.

have been found in both metropolitan and rural sources (Observatorio del Desarrollo 2001).

Untreated sewage from urban centres remains a major cause of pollution. In the region as a whole, only about 13 per cent of collected sewage receives any kind of treatment (PAHO 1998). Increasing pollution from urban run-off and the release of untreated sewage into water bodies serving urban areas has added to the difficulties of meeting the increasing demand for water in cities, especially those located in areas such as Lima and Mexico City where water is scarce (WWC 2000).

Industrial activities, and the resulting pollution, have contributed substantially to water quality problems. Animal waste from tanneries, slaughterhouses and meat packing plants, for example, pollutes aquifers with coliform bacteria (WWC 2000).

Another water quality problem that is becoming more prevalent, especially in the Caribbean, is the salinization of water in coastal areas due to overextraction. This is particularly severe given the rising demand for water in the Caribbean, mainly to service the tourism industry (UNEP 1999).

Institutional and legal frameworks

In most countries, water resources continue to be managed on a sectoral basis with little integration either between sectors or with other environmental management procedures. Such an approach ignores vital interactions with much wider ecosystems and other functions, and ecological services related to water. There has been a trend towards transferring water services from the public to the private sector during the past decade and to decentralizing legal and administrative responsibilities. As a result, laws and regulations designed to protect freshwater resources are often lacking or poorly enforced (WWC 2000).

References: Chapter 2, freshwater, Latin America and the Caribbean

ACAA (2001). *Usos e Impactos* Atlas Continental del Agua en America http://www.atlaslatinoamerica.org/usos_impac/amer_sur.htm

CATHALAC (1999). *Vision on Water, Life and the Environment for the 21st Century. Regional Consultations. Central America and Caribbean.* Panama City, Water Centre for the Humid Tropics of Latin America and the Caribbean (CATHALAC).

FAOSTAT (2001). FAOSTAT Statistical Database. Food and Agriculture Organization http://www.fao.org/ [Geo-2-068]

GWP (2000). *Water for the 21st Century: Vision to Action – South America.* Stockholm, Global Water Partnership South American Technical Advisory Committee

Observatorio del Desarrollo (2001). El agua en Costa Rica: abundante pero vulnerable *Boletín Información para la Toma de Decisiones*, Año 3, No. 6, Abril-Mayo

PAHO (1998). *Health in the Americas. Volume I, PAHO Scientific Publication No. 569*. Washington DC, Pan American Health Organization

Saleth, R.M. and Dinar, A. (1999). *Water Challenge and Institutional Response (A Cross-Country Perspective), Policy Research Working Paper 2045.* Washington DC, World Bank Development Research Group Rural Development and Rural Development Department

UNCSD (1999). *The Tegucigalpa Model: Water Supply for Peri-urban Settlements.* United Nations Commission for Sustainable Development http://www.un.org/esa/sustdev/success/tegu_mod.htm

UNDP, UNEP, World Bank and WRI (2000). *World Resources 2000-2001*. Washington DC, World Resources Institute

UNECLAC (2000). *Water Utility Regulation: Issues and Options for Latin America and the Caribbean*. ECLAC, LC/R. 2032. Santiago de Chile, United Nations Economic Commission for Latin America and the Caribbean

UNEP (1999). *Caribbean Environment Outlook.* Nairobi, United Nations Environment Programme

WHO and UNICEF (2000). *Global Water Supply and Sanitation Assessment 2000 Report*. Geneva and New York, World Health Organization and United Nations Children's Fund http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm

World Bank (1999). *Annual Review – Environment Matters,* Washington DC, World Bank

World Bank (2001). *World Development Indicators 2001*. Washington DC, World Bank http://www.worldbank.org/data/wdi2001/pdfs/tab3_8.pdf [Geo-2-024]

WWC (1999). *Vision on Water, Life and the Environment for the 21st Century. Regional Consultations: North America.* Marseille, World Water Council

WWC (2000). *Water in the Americas for the Twenty First Century, Roundtable Meeting of the Americas, July 26-28 2000, Final Report,* Montreal, World Water Council

North America

North America holds about 13 per cent of the world's renewable freshwater (excluding glaciers and ice caps). At the end of the 1990s, North Americans used 1 693 cubic metres of water per person per year (Gleick 1998), more than in any other region. In the United States, recent conservation measures have led to declines in consumption: during 1980–95, water withdrawals declined by nearly 10 per cent while the population increased by 16 per cent (Solley, Pierce and Perlman 1998). In Canada, on the other hand, water withdrawal increased by 80 per cent during 1972–91 while the population grew by 3 per cent (EC 2001a).

Although point source water pollution has been reduced in the United States since the 1970s, non-point sources, such as agricultural run-off and urban storm drainage, have grown causing serious pollution problems. Nutrient enrichment problems are of particular concern.

Most of the continent's (unfrozen) freshwater resources lie in groundwater. Groundwater contamination and declining aquifer levels are now priority issues (Rogers 1996, EC 1999a).

Thirty years ago, one of the gravest issues facing North America's freshwater resources was the precarious state of the Great Lakes Basin. The clean-up effort is a notable story of cooperation among nations and local users.

Health risks from groundwater pollution

A number of recent reports of localized well contamination have alerted the public to the health risks associated with contaminated groundwater (EC 1999a). In May 2000, for example, seven Canadians died and more than 2 000 became sick in Walkerton, Ontario, from *E. coli* contamination in the town's water supply. Livestock manure was one of the factors implicated in the accident, exacerbated by others such as infrastructure failure, high-risk well location, human error and extreme rainfall (ECO 2000).

The tragedy alerted the Canadian provinces to the need to correct serious drinking water problems related to contaminants from animal waste entering groundwater supplies and, in the case of some, to the roles played by earlier budget cuts, staff reductions and greater reliance on municipalities for regulating environmental services (Gallon 2000).

Groundwater

By the mid-1990s, groundwater was supplying up to 50 per cent of the North American population and more than 90 per cent of rural dwellers (EPA 1998, Statistics Canada 2000).

The many hazardous compounds used in industry and agriculture are now threatening groundwater quality. Contaminants from non-point sources are present in many shallow wells throughout large regions of North America (Moody 1996). Agriculture is the worst offender, with artificial fertilizer use in the region increasing from 15 to 22.25 million tonnes a year over the past 30 years (IIFA 2001).

Although nitrogen contamination rarely exceeds levels of potential health risk, it is a chronic problem for the population in the Prairie Provinces that rely on wells for water, and it affects groundwater to some extent in 49 US states (OECD 1996, Statistics Canada 2000). Consumed in high concentrations, nitrates can cause infant methaemoglobinaemia or blue-baby syndrome (Sampat 2000).

During 1993–95, low concentrations of pesticides were also detected in shallow groundwater in 54.4 per cent of US sites tested. Although concentrations of pesticides rarely exceed drinking water standards, some scientists suggest that their combined effects on health and the environment are not adequately assessed (Kolpin, Barbash and Gilliom 1998).

Underground storage tanks containing, for example, petroleum products, acids, chemicals and industrial solvents, are leading sources of groundwater contamination (Sampat 2000). The tanks are often inappropriate containers for these substances or have been improperly installed. In 1998, more than 100 000 petroleum tanks in the United States were found to be leaking. State Underground Tank Remediation Funds have helped clean-up many US sites (US EPA 1998).

Septic tank systems, the largest source of waste discharged to the land, contain many organic contaminants and are suspected to be one of the key sources of rural well contamination. Between one-third and one-half of US septic systems may be operating poorly (Moody 1996).

The long-term availability of groundwater in arid agricultural regions is a priority issue. In general, groundwater levels stopped declining during the 1980s but depletion of stored groundwater still accounted for about 10 per cent of all freshwater withdrawals in the United States in the mid-1990s (OECD 1996). Agriculture relied on groundwater resources for 62 per cent of its irrigated farmland in 1990 (OECD 1996, Sampat 2000).

During the late 1980s and early 1990s, all US states enacted groundwater legislation (TFGRR 1993,

Gobert 1997). The Canadian federal government has initiated new national legislation on the environment, trade and groundwater issues (EC 1999a). Although groundwater management has traditionally focused on surface and groundwater separately, interactions between them have direct effects on water quality and availability, and on the health of wetlands, riparian ecology and aquatic ecosystems in general (Cosgrove and Rijsberman 2000).

Great Lakes water quality

The Great Lakes basin is one of the Earth's largest freshwater systems, containing 18 per cent of the world's fresh surface water (EC 2001a). Less than 1 per cent of the water is renewed annually by precipitation, surface water run-off and groundwater inflow.

Over the years, the lakes have been subject to a polluting mix of effluents due to inadequate sewage treatment, fertilizer and wastewater effluent. By the early 1970s, beaches were smothered with algae and water was unfit for drinking unless extensively purified. Lake Erie suffered from excess phosphorus, algal blooms and serious declines in fish populations. Aboriginal communities were the most affected. Newspaper headlines in 1970 declared that 'Lake Erie is Dead' (EC 1999b, EC 2001c).

Other clues pointed to more insidious problems. In the early 1970s, eggshells of the double-crested cormorant, which is high on the aquatic foodchain and subject to the effects of bioaccumulation, were some 30 per cent thinner than normal (EC 1999b). Some species of bird populations crashed.

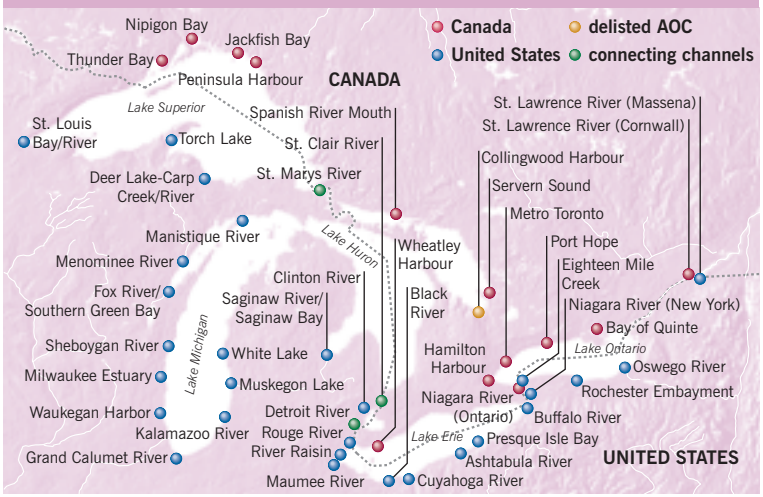
The International Joint Commission (IJC) released a report on the pollution problem in the lower Great Lakes in 1970. The IJC, an independent organization of Canadian and US representatives, has been in charge of assessing water quantity and quality along the boundary between Canada and the United States since 1909 (IJC 2000a). The report led to the 1972 signing of the Great Lakes Water Quality Agreement (GLWQA) and the beginning of concerted efforts to restore water quality. In 1978, the GLWQA was renewed to introduce the ecosystem approach and to address persistent chemical discharges (IJC 1989).

In 1987, targets or strategies for phosphorus load reductions, airborne pollutants, pollution from land-based activities and the problems of contaminated sediment and groundwater were set. Remedial Action Plans (RAPs) were developed to clean up 43 areas of concern (see map).

Municipal phosphorus loadings to Lakes Erie and Ontario have been reduced by almost 80 per cent since the early 1970s, slowing algal growth and decreasing the extent of oxygen depletion in bottom waters. Once thought 'dead', Lake Erie now has the world's largest walleye fishery (EC 1999b, EC 2001c).

Discharge of a number of persistent toxic chemicals was also reduced. Since the late 1980s, government regulations achieved an 82 per cent reduction in chlorinated toxic substances discharged from pulp-and-paper mills. Since 1972, there has been an overall reduction of 71 per cent in the use, generation and release of seven priority toxic chemicals and a significant reduction in chemical spills (EC 1999b, EC 2000, EC 2001c).

Areas of concern (AOC) in the Great Lakes



In 1987, Remedial Action Plans were developed to clean up 43 areas of concern in the Great Lakes basin in both Canada and the United States

Source: EC 2000

DDE and PCB residues, once exceptionally high in cormorant eggs in the Great Lakes basin, decreased by as much as 91 per cent and 78 per cent respectively between the early 1970s and 1998 (EC 2001b). Cormorant populations are breeding successfully again and other bird populations are increasing (EC 1998, EC 1999b).

Rapid urban and industrial development, however, continued to cause environmental damage to the watershed during the 1990s. Sediment contamination in harbours and river mouths threatened to contaminate fish and posed problems related to dredging and sediment disposal (IJC 1997). Evidence revealed that pollutants carried in the air settle on the

lakes, contributing significantly to water pollution (US EPA 1997). Up to 96 per cent of PCBs in the Great Lakes come from the atmosphere (Bandemehr and Hoff 1998). The Great Lakes Binational Toxics Strategy was launched in 1997 to eliminate these chemical contaminants (BNS 1999, EC 2000b).

Although exposure to persistent toxic contaminants has decreased, some studies show that children of mothers who ate large quantities of Great Lakes fish had development problems (Health Canada 1997). Recent IJC reports warn of slow progress with some problems, such as the clean-up of sediments containing persistent toxic chemicals and exotic invasive species (IJC 2000b).

The Great Lakes will face other environmental challenges in the future. Global warming could lower lake levels by a metre or more by the middle of this century, causing severe economic, environmental and social impacts. Water shortages throughout North America may also increase pressure to divert or remove water in bulk from the lakes, threatening the sustainable use of surface and groundwater resources (IJC 2000c, IPCC 2001).

References: Chapter 2, freshwater, North America

Bandemehr, A. and Hoff, R. (1998). *Monitoring Air Toxics: The Integrated Atmospheric Deposition Network of the Great Lakes* (unpublished report to the CEC Secretariat). Montreal, Commission for Environmental Cooperation

BNS (1999). *The Great Lakes Binational Toxics Strategy*. Binational Toxics Strategy http://www.epa.gov/glnpo/p2/bns.html [Geo-2-129]

Cosgrove, William J. and Rijsberman, Frank R. (2000). *World Water Vision: Making Water Everybody's Business*. World Water Council. London, Earthscan

EC (1998). Toxic Contaminants in the Environment: Persistent Organochlorines. *Environment Canada National Environmental Indicator Series, State of the Environment Reporting Program*. 98-1

EC (1999a). *Groundwater — Nature's Hidden Treasure: Freshwater Series A-5*. Environment Canada, Minister of Public Works and Government Services http://www.ec.gc.ca/water/en/info/pubs/FS/e_FSA5.htm [Geo-2-130]

EC (1999b). *Rising to the Challenge: Celebrating the 25th Anniversary of the Great Lakes Water Quality Agreement*. Ottawa, Environment Canada

EC (2000a). *Binational Remedial Action Plans (RAPs)*. Environment Canada http://www.on.ec.gc.ca/glimr/raps/intro.html [Geo-2-131]

EC (2001a). *The Management of Water*. Environment Canada http://www.ec.gc.ca/water/index.htm

EC (2001b). *Tracking Key Environmental Issues*. Environment Canada http://www.ec.gc.ca/TKEI/air_water/watr_qual_e.cfm [Geo-2-132]

EC (2001c). *Great Lakes Water Quality Agreement*. Environment Canada http://www.ijc.org/agree/quality.html [Geo-2-134]

ECO (2000). *Changing Perspectives: Annual Report 1999/2000*. Toronto, Environmental Commissioner of Ontario

Gallon, Gary (2000). The Real Walkerton Villain. *The Globe and Mail*, 20 December 2000

Gleick, P.H. (1998). *The World's Water 1998-1999*. Washington DC, Island Press

Gobert, Christopher (1997). Groundwater Contamination: A Look at the Federal Provisions. *The Compleat Lawyer.* Spring 1997 http://www.abanet.org/genpractice/lawyer/complete/98julschneid.html [Geo-2-135]

Health Canada (1997). *State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes Basin*. Ottawa, Minister of Public Works and Government Services

IIFA (2001). *Fertilizer Nutrient Consumption, by Region, 1970/71 to 1998/99*. International Industry Fertilizer Association http://www.fertilizer.org/ifa/ab_act_position3.asp [Geo-2-136]

IJC (1989). *Great Lakes Water Quality Agreement of 1978*. International Joint Commission http://www.ijc.org/agree/quality.html [Geo-2-137]

IJC (1997). *Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin*. International Joint Commission http://www.ijc.org/boards/wqb/sedrem.html [Geo-2-138]

IJC (2000a). *International Joint Commission: United States and Canada* http://www.ijc.org/agree/water.html [Geo-2-139]

IJC (2000b). *Open Letter to Great Lakes Leaders and the Great Lakes Community*. Washington DC and Ottawa, International Joint Commission

IJC (2000c). *Protection of the Waters of the Great Lakes: Final Report to the Governments of Canada and the United States.* International Joint Commission http://www.ijc.org/boards/cde/finalreport/finalreport.html [Geo-2-140]

IPCC (2001b). *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom, and New York, United States, Cambridge University Press

Kolpin, Dana W., Barbash, Jack E. and Gilliom, Robert J. (1998). Occurrence of Pesticides in Shallow Ground Water of the United States: Initial Results from the National Water-Quality Assessment Program. *Environmental Science and Technology*. 32, 1998 http://water.wr.usgs.gov/pnsp/ja/est32/ [Geo-2-141]

Moody, David W. (1996). *Sources and Extent of Groundwater Contamination*. North Carolina Cooperative Extension Service, Publication Number: AG-441-4 http://www.p2pays.org/ref/01/00065.htm [Geo-2-142]

OECD (1996). *Environmental Performance Reviews: United States*. Paris, Organization for Economic Cooperation and Development

Rogers, Peter (1996). *America's Water: Federal Roles and Responsibilities*. Cambridge, Massachusetts, MIT Press

Sampat, Payal (2000). Groundwater Shock: The Polluting of the World's Major Freshwater Stores. *World Watch*. 13, 1, 13-22

Solley, Wayne B., Pierce, Robert R. and Perlman, Howard A. (1998). *Estimated Use of Water in the United States in 1995*. US Department of Interior, US Geological Survey http://water.usgs.gov/watuse/pdf1995/html/ [Geo-2-143]

Statistics Canada (2000). *Human Activity and the Environment 2000*. Ottawa, Minister of Industry

TFGRR (1993). *Groundwater Issues and Research in Canada: a report prepared for the Canadian Geoscience Council*. Task Force on Groundwater Resources Research http://wlapwww.gov.bc.ca/wat/gws/gissues.html [Geo-2-145]

US EPA (1997). *Deposition of Air Pollutants to the Great Waters: Second Report to Congress*. EPA-453/R-977-011. Research Triangle Park, North Carolina, US Environmental Protection Agency

US EPA (1998). *National Water Quality Inventory: 1998 Report to Congress*. US Environmental Protection Agency http://www.epa.gov/305b/98report/98summary.html [Geo-2-144]

Freshwater: West Asia

The Arabian Peninsula is characterized by an arid climate with annual rainfall of less than 100 mm. There are no reliable surface water supplies. The sub-region depends entirely on groundwater and desalination plants to meet its water requirements. Large increases in demand have placed the meagre resources available under increasing pressure. The Mashriq sub-region is mostly arid and semi-arid. About 70 per cent of the sub-region receives less than 250 mm of rain a year. The Mashriq has two shared rivers originating outside the area, the Euphrates and Tigris, and many smaller ones. Agreements or understandings about how to share these water resources have been reached among Arab countries but agreements over the Euphrates are yet to materialize between Iraq and Syria on one side and Turkey on the other.

Increasing water demand

The major cause of the increasing demand for water is rapid population growth. The region's population increased from 37.3 million in 1972 to 97.7 million in 2000 (United Nations Population Division 2001). A high annual population growth rate of more than 3 per cent in the Mashriq sub-region has seen the annual per capita share of available water resources decreasing from 6 057 m^3 in 1950 (Khouri 2000) to 1 574 m^3 in 2000 (see box above) .

Domestic water demand has also been rising due to an increase in per capita consumption. In many countries, water rationing is used to limit demand. For example, Jordan restricts water supplies in Amman to only three days a week. In Damascus, water can be used for less than 12 hours a day.

Agriculture is the main user of water in West Asia, accounting for nearly 82 per cent of the total water consumed compared to 10 per cent and 8 per cent for the domestic and industrial sectors, respectively. In the Arabian Peninsula, agriculture utilizes about 86 per cent of the available water resources, and about 80 per cent in the Mashriq (Khouri 2000). To satisfy water demand, especially for irrigation, groundwater abstraction has increased dramatically during the past three decades.

In the Gulf Cooperation Council (GCC) countries, the total annual water supply increased from 6 km^3 in 1980 to 26 km^3 in 1995, with 85 per cent of the water used for agricultural purposes (Zubari 1997). In 1995, the GCC countries had water resources equivalent to 466 m^3/year per capita and a per capita water use of 1 020 m^3/year, producing an average annual water deficit of about 554 m^3 per capita, provided mainly by mining groundwater reserves (Zubari 1997).

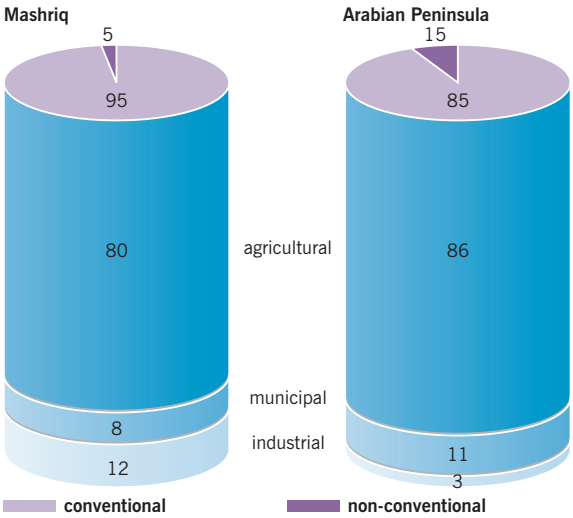
The water stress index in West Asia (expressed as a percentage of water used to available water resources) is more than 100 per cent in five of the seven countries in the Arabian Peninsula, and is critical in the remaining two. These countries have already exhausted their renewable water resources and are now exploiting non-renewable reserves. In the Mashriq, except in Jordan, the water stress index is lower (see table above). While per capita water resources in 9 of the 12 countries in West Asia are below 1 000 m^3/year, they are also below 500 m^3/year

Water stress index: West Asia

	Mashriq	*Arabian Peninsula*	*West Asia region*
population (millions, 2000)	50.7	47.0	97.7
available water (km^3/year)	79.9	15.3	95.2
water used (km^3/year)	66.5	29.6	96.1
water stress index (%)	**83.3**	**>100**	**>100**
per capita available (m^3/year)	1574	326	974

Source: ACSAD 2000 and United Nations Population Division 2001

Water uses in West Asia



Origins and uses of water resources in the West Asian sub-regions; the Arabian Peninsular depends mainly on groundwater, the Mashriq countries on surface water — but both use most of their water in agriculture

Source: Khouri 2000

Available water resources in West Asia (million m^3/year)

	Mashriq	*Arabian Peninsula*	*West Asia region*
surface water	68 131	6 835	74 966
groundwater	8 135	6 240	14 375
desalination	58	1 850	1 908
agricultural drainage reuse	3 550	392	3 942
total	**79 873**	**15 318**	**95 191**

Source: Khouri 2000

in seven countries. The overall value of the water stress index for West Asia is more than 100 per cent (see table on page 173).

Over the past three decades, the adoption of food self-sufficiency policies has encouraged agricultural expansion. Governments offered subsidies and incentives which resulted in a large-scale expansion of farming, increasing water demand which was satisfied mainly by mining deep aquifers. Furthermore, unregulated pumping, absence or minimal irrigation water tariffs, lack of enforcement measures against unlawful drilling, poor irrigation practices and lack of farmer awareness have resulted in excessive water usage.

Intensive agriculture and heavy application of agrochemicals have also contributed to the contamination of water resources. For example, the concentration of nitrates in Gaza's tap water exceeds WHO guidelines (10 mg/litre) and nitrate concentrations are increasing at a rate of 0.2-1.0 mg/litre per year in the country's coastal wells. Adherence to WHO standards would place half of these coastal wells off limits as drinking water (PNA 2000).

Water use for irrigation in West Asia

Subsidies and incentives have led to a large expansion of the private agricultural sector in West Asia, and to the extension of supplementary irrigation into some rainfed farming areas. For example, the total irrigated area in Syria has nearly doubled over the past three decades, increasing from 625 000 ha (10.9 per cent of arable land) in 1972 to 1 186 000 ha (25.2 per cent of arable land) in 1999 (FAOSTAT 2001). In Iraq, the percentage of irrigated land increased from 30.3 per cent in 1972 to 67.8 per cent in 1999 (FAOSTAT 2001). Irrigation efficiency — the percentage of water that actually reaches the crop — does not exceed 50 per cent in the region, and sometimes falls as low as 30 per cent, leading to high water losses (ACSAD 1997).

The water used in wheat farming in Saudi Arabia during 1980-95 was about 254 km^3 (Al-Qunaibet 1997), equivalent to 13 per cent of the country's total fossil groundwater reserves of 1 919 km^3 (Al Alawi and Razzak 1994).

Overexploitation of groundwater

Excessive use of groundwater has resulted in sharp declines in groundwater levels and quality deterioration due to seawater intrusion. For instance, in Saudi Arabia water levels declined by more than 70 metres in the Umm Er Radhuma aquifer during 1978-84, and this decline was accompanied by a salinity increase of more than 1 000 mg/litre (Al-Mahmood 1987). In the United Arab Emirates, excessive groundwater pumping has created cones of depression 50-100 km in diameter in several areas. These cones have caused groundwater levels to fall, shallow wells to dry up, and saltwater intrusion. Groundwater salinity in most areas of the Syrian and Jordanian steppe has increased to several thousand milligrammes per litre. overexploitation of coastal aquifers in the coastal zone of Lebanon has caused seawater intrusion with a subsequent rise from 340 to 22 000 mg/litre in some wells near Beirut (UNESCWA 1999).

Water quality

Water quality degradation is often a consequence of both water scarcity and overexploitation. Water quantity and quality are both major issues in the Mashriq countries. Effluent, agrochemicals and industrial discharges have seriously affected aquatic life, causing public health hazards. Discharge from tanneries into the Barada River in Syria has caused levels of biological oxygen demand (BOD) to increase 23-fold above normal (World Bank 1995). Close to Homs, in Syria, the winter BOD levels of the Orontes River are 100 times higher than where the river enters the country from Lebanon.

Health impacts due to poor water quality are a major concern. Water-borne diseases, especially diarrhoea, are second only to respiratory diseases as a cause of mortality and morbidity among children in the region (World Bank 1995).

Policy developments

West Asia is developing policies to increase both water supply and conservation. In Jordan, priority is given to the sustainability of water resources without mining groundwater resources; the country is constructing dams and facilities to store all available water resources (Al-Weshah 2000). Many countries

have started to invest in more efficient irrigation technology. Improvements in irrigation efficiency in the Jordan Valley increased average yields for vegetables from 8.3 tonnes per hectare in 1973 to 18.2 tonnes per hectare in 1986 (World Bank 1995). Wastewater reuse is another important conservation tool for non-potable uses, including irrigation, and for reducing environmental degradation and improving public health. Reuse of treated wastewater has increased in Mashriq countries from zero in 1973 to about 51 million m^3/year in 1991 (Sarraf 1997). But comprehensive water policies to manage water resources are still lacking in many countries.

The problem of water scarcity and quality deterioration in the region is attributed to:

- fragmentation and weakness of water authorities, leading to inefficient water management and to conflicts over use between different sectors;
- rapid and unplanned urbanization, including rural to urban migration;
- political and military conflicts negatively affecting the development of the water sector;
- escalating sectoral water demands;
- food self-sufficiency policies;
- poor irrigation practices;
- lack of sanitation causing pollution; and
- lack of mechanisms for strengthening water legislation and enforcement procedures.

Lack of hydrographic data is a serious issue. Most studies are based on short record data or even on educated guesses.

In the past three decades, water authorities in the region have concentrated their efforts on supply augmentation and, to a lesser extent, on demand management and conservation. Although their effectiveness is not yet proven, programmes related to demand management, conservation and protection have been implemented in both sub-regions. These programmes include the reduction of fuel and agricultural subsidies, metering of groundwater wells, future plans for an irrigation water tariff, subsidies for modern irrigation techniques, and public awareness campaigns.

In the GCC countries, these policies have been only partially successful in alleviating water scarcity caused by increasing demand and food self-sufficiency policies. In fact, the food self-sufficiency policies of the past three decades have not been successful. The deficit in food production is growing and is aggravated by the scarcity of land and water resources that are already overexploited. Water security will become one of the major constraints to further development in the region in the next 30 years unless there are major changes to agricultural and water policies.

References: Chapter 2, freshwater, West Asia

ACSAD (1997). *Water resources and their utilization in the Arab world, 2nd Water Resources Seminar*. Conference held in Kuwait, 8-10 March 1997

ACSAD (2000). *Alternative Policy Study: Water Resource Management in West Asia*. Nairobi, United Nations Environment Programme http://www.grida.no/geo2000/aps-wasia/index.htm [Geo-2-146]

Al-Alawi, Jamil and Abdul Razzak, M. (1994). Water in the Arabian Peninsula: Problems and Perspectives. In Peter Rogers and Peter Lydon (eds.). *Water in the Arab World: Perspectives and Prognoses.* Cambridge, Massachusetts, Harvard University Press

Al-Mahmood, M.J. (1987). *Hydrogeology of Al-Hassa Oasis.* M.Sc. Thesis, Geology Department, College of Graduate Studies, King Fahd University of Petroleum and Minerals, Saudi Arabia

Al-Qunaibet, M.H. (1997). Water Security in the Kingdom of Saudi Arabia. In Al-Zubari, W. and Mohammed Al-Sofi (eds.). *Proceedings of the 3rd Gulf Water Conference,* 8-13 March 1997, Muscat

Al-Weshah, R. (2000). *Hydrology of Wadi Systems in Jordan*. Damascus, Arab Network on Wadi Hydrology, ACSAD/ UNESCO

FAOSTAT (2001). FAOSTAT Statistical Database. Food and Agriculture Organization http://www.fao.org/ [Geo-2-068]

Khouri, J. (2000). *Sustainable Management of Wadi Systems in the Arid and Semi Arid zones of the Arab Region*. International Conference on Wadi Hydrology. Conference held in Sharm El-Sheikh, Egypt, 21-23 November 2000

PNA (2000). *State of Environment, Palestine*. Jerusalem, Ministry of Environmental Affairs, Palestine National Authority

Sarraf, S. (1997). Water Resources of the Arab Countries: A Review. In ACSAD, *Water resources and their utilization in the Arab world, 2nd Water Resources Seminar*. Conference held in Kuwait, 8-10 March 1997

UNESCWA (1999). *Updating the Assessment of Water Resources in ESCWA Member States, ESCWA/ ENR/ 1999/ WG.1/7*. Beirut, United Nations Economic and Social Commission for West Asia

United Nations Population Division (2001). *World Population Prospects 1950-2050 (The 2000 Revision)*. New York, United Nations www.un.org/esa/population/publications/wpp2000/wpp2000h.pdf

World Bank (1995). *Towards Sustainable Development: an Environmental Strategy for the Middle East and North Africa Region*. Washington DC, World Bank

Zubari, W.K. (1997). *Towards the Establishment of a Total Water Cycle Management and Re-use Program in the GCC Countries.* The 7th Regional Meeting of the Arab International Hydrological Programme Committee, 8-12 September 1997, Rabat, Morocco

Freshwater: the Polar Regions

Arctic

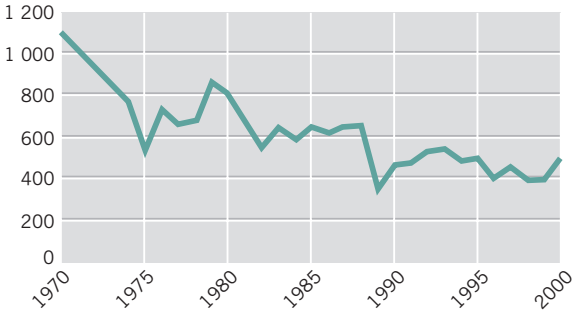
The Arctic holds much of the world's freshwater supply and its landscape is dominated by freshwater systems. The two main permanent ice fields are the ice pack of the Arctic Ocean (8 million km^2) and the Greenland ice cap (1.7 million km^2), which together hold 10 per cent of the world's freshwater. The Greenland ice cap produces about 300 km^3 of icebergs a year. The Arctic has several of the world's largest rivers. They pour 4 200 km^3 of freshwater into the Arctic Ocean annually along with about 221 million tonnes of sediment (Crane and Galasso 1999, AMAP 1997).

Low temperatures, low nutrient, short light availability and a brief growing season limit the primary productivity of Arctic freshwater systems. This in turn restricts the animal life that can be supported. Nevertheless, the river systems are heavily populated by several fish species such as the Arctic charr, and the North Atlantic and Pink salmon. In recent years, the overall warming trend plus increased recreational and commercial fisheries use have put pressure on these populations. Accidental introduction of alien species and increased fish farming is another source of concern (Bernes 1996). Eutrophication is a recent problem in several lakes in Scandinavia where human settlements have raised nutrient levels.

Northbound rivers are major pathways of pollutants from sources far inland, especially in the Russian Federation. In the spring, these contaminants are deposited into the freshwater systems and eventually into the marine environment and can be transported thousands of kilometres from their sources via the Arctic's marine circulation patterns. Contaminants include chemicals from agricultural, industrial and petroleum production, radionuclides from nuclear testing and military activities, and water soluble salts (Crane and Galasso 1999). The Arctic countries adopted a circumpolar Regional Programme of Action for Protection of the Arctic Marine Environment against Land-based Activities (based on the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities) as well as National Programmes of Action in some countries, including the Russian Federation. These instruments are too recent to assess long-term effectiveness (PAME 1998).

Opposition to damming is strong in the Nordic countries. During 1975-2001, the Cree people fought the government of Quebec over environmental damage to their lands. In a surprise move in October 2001, however, the Cree reversed their stand and signed an agreement in principle to allow the government of Quebec to build another large power development project on the Eastmain-Rupert river system in exchange for a cash settlement. In 2000, a hydroelectric power project that would have flooded an important wetland was rejected (Arctic Bulletin

The decline of Barrow's Goldeneye



The decline of Barrow's Goldeneye, *Bucefala islandica*, at Lake Myvatyn, Iceland, measured by numbers of males in the spring

Source: CAFF 2001

Major river systems in the Arctic

Catchment area of the Arctic Ocean, showing major rivers with their annual discharges in cubic kilometres

Source: CAFF 2001

2001). In 2001, Iceland's National Planning Agency rejected plans for a hydroelectric power project that would have dammed two of the three main rivers flowing from Europe's largest glacier and destroyed a vast wilderness.

Since the 1970s, surface air temperatures appear to have increased on average 1.5°C per decade over continental Siberia and western portions of North America, both of which are major sources of freshwater into the Arctic basin. The opposite trend is occurring in Greenland and Canada's eastern Arctic where there is a negative trend of –1°C per decade (AMAP 1997). The warming trend has resulted in thawing of the continuous permafrost in Alaska and northern Russia (Morison and others 2000, IPCC 2001).

Arctic countries have partially responded to threats to their freshwater systems by establishing protected areas and designating important wetland areas under the Convention on Wetlands of International Importance. Nearly half the protected area in the Arctic is the Greenland ice cap and glaciers which store freshwater.

Antarctic

Although the Antarctic ice cap is the world's largest body of freshwater, there are also seasonal streams and rivers, and numerous lakes and ponds in Antarctica. Other sources of freshwater are captured in the glaciers that occur in many coastal Antarctic regions. All these freshwater features are potentially threatened by pollution, including contaminates introduced by Antarctic scientists and tourists.

Freshwater lakes are found mainly in the coastal regions, on many of the sub-Antarctic Islands, and in the rare ice-free areas. Many are exposed to potential contamination from human activities. Observations at selected lakes, however, show that contamination resulting from research activities and station operations is generally near or below detection levels. In the Larsemann Hills of East Antarctica, trace metal concentrations appear to be higher in lakes situated in the vicinity of stations than those further away. The concentration levels still complied with drinking water standards (Gasparon and Burgess 2000). It is expected that the Protocol on Environmental Protection to the Antarctic Treaty will minimize the impacts of human activities on these lakes.

In 1970, observations revealed the existence of large lakes under the ice sheet in the central regions of the continent. Lake Vostok, which is about 220 km long, 70 km wide and holds about 2 000 km^3 of water, is the largest of the approximately 70 sub-glacial lakes known today (Dowdeswell and Siegert 1999). The global significance of sub-glacial lakes is that they have not been exposed to the atmosphere for the past 500 000 years and therefore maintain a unique archive of the past environment. There are also indications that Lake Vostok could contain viable micro-organisms (Karl and others 1999, Priscu and others 1999). A number of technologies for entering the lake without contaminating it are being considered (Russian Federation 2001).

References: Chapter 2, freshwater, the Polar Regions

Arctic Bulletin (2001). *WWF Arctic Programme* No. 3.01, Oslo

AMAP (1977). *Arctic Pollution Issues: A State of the Arctic Environment Report.* Arctic Council Arctic Monitoring and Assessment Programme, Oslo

Bernes, C. (1996). *The Nordic Arctic Environment – Unspoilt, Exploited, Polluted?* Nordic Council of Ministers, Copenhagen

CAFF (2001). *Arctic Flora and Fauna: Status and Conservation.* Conservation of Arctic Flora and Fauna. Helsinki, Edita

Crane, K. and Galasso, J.L. (1999). *Arctic Environmental Atlas.* Office of Naval Research, Naval Research Laboratory, Washington DC

Dowdeswell, J.A. and Siegert, M.J. (1999). The dimensions and topographic setting of Antarctic subglacial lakes and implications for large-scale water storage beneath continental sheets. *Geological Society of America Bulletin* 111, 2

Gasparon, M. and Burgess, J.S. (2000). Human impacts in Antarctica trace-element geochemistry of freshwater lakes in the Larsemann Hills, East Antarctica. *Environmental Geology* 39 (9), 963–76

IPCC (2001). *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom, and New York, United States, Cambridge University Press

Karl, D.M., Bird, D.F., Bjorkman, K., Houlihan, T., Shackelford, R. and Tupas, L. (1999). Microorganisms in the accreted ice of Lake Vostok, Antarctica. *Science* 286 (5447), 2144–47

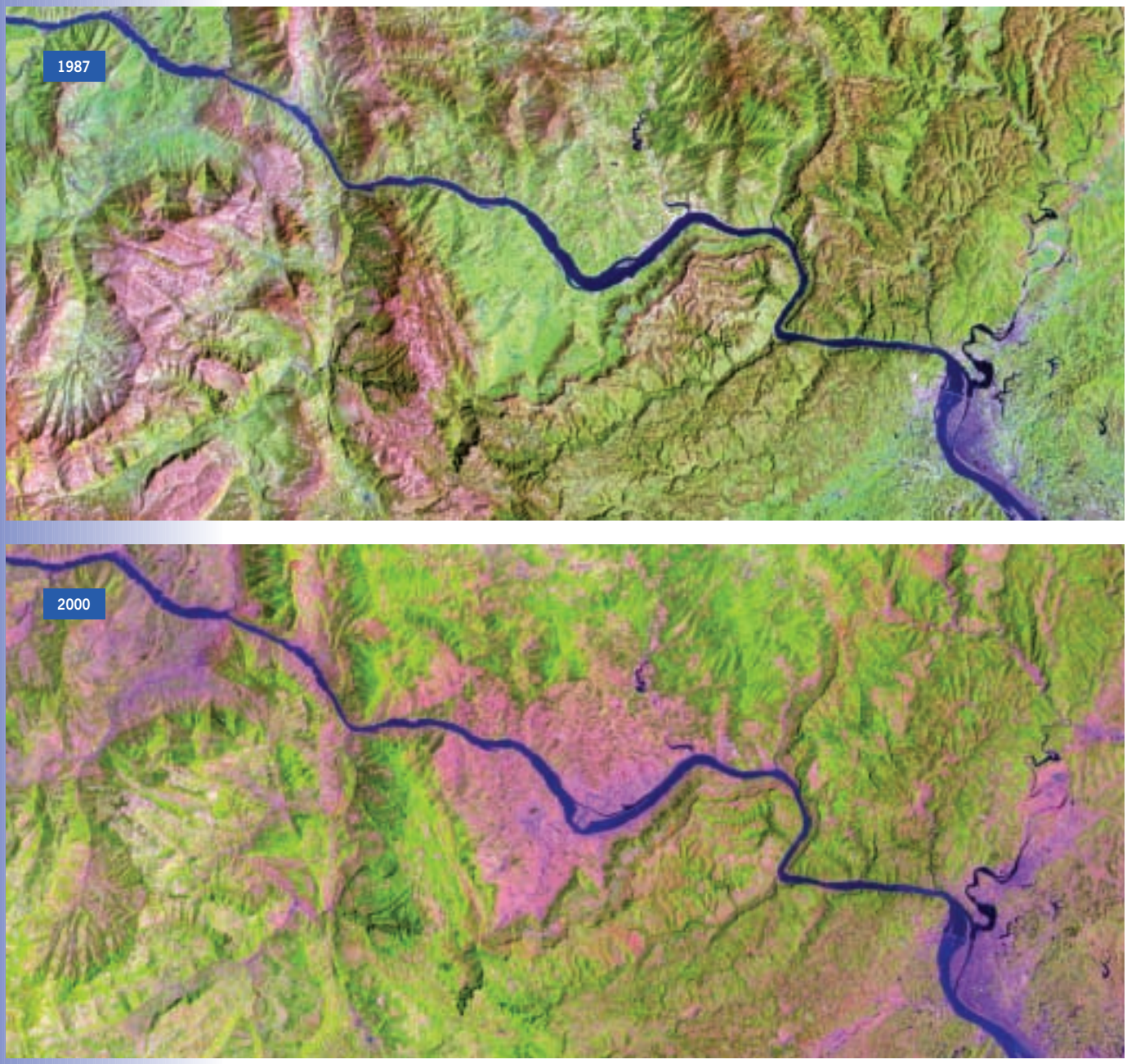
Morison, J., Aagaard, K. and Steele, M. (2000). Recent Environmental Changes in the Arctic: a review. *Arctic (Arctic Journal of the Arctic Institute of North America)* 53, 4, December 2000

PAME (1998). *Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-Based Activities.* Arctic Council Programme for the Protection of the Arctic Marine Environment

Priscu, J.C., Adams, E.E., Lyons, W.B., Voytek, M.A., Mogk, D.W., Brown, R.L., McKay, C.P., Takacs, C.D., Welch, K.A., Wolf, C.F., Kirshtein, J.D., and Avci, R. (1999). Geomicrobiology of subglacial ice above Lake Vostok, Antarctica. *Science* 286 (5447), 2141–44

Russian Federation (2001). *Expert Conclusions for the Project 'Justification and development of the ecologically clean technology for penetrating the subglacial Lake Vostok'.* Working Paper 29, 4th Antarctic Treaty Consultative Meeting, 9-20 July 2001, St. Petersburg

OUR CHANGING ENVIRONMENT: Three Gorges dam, China



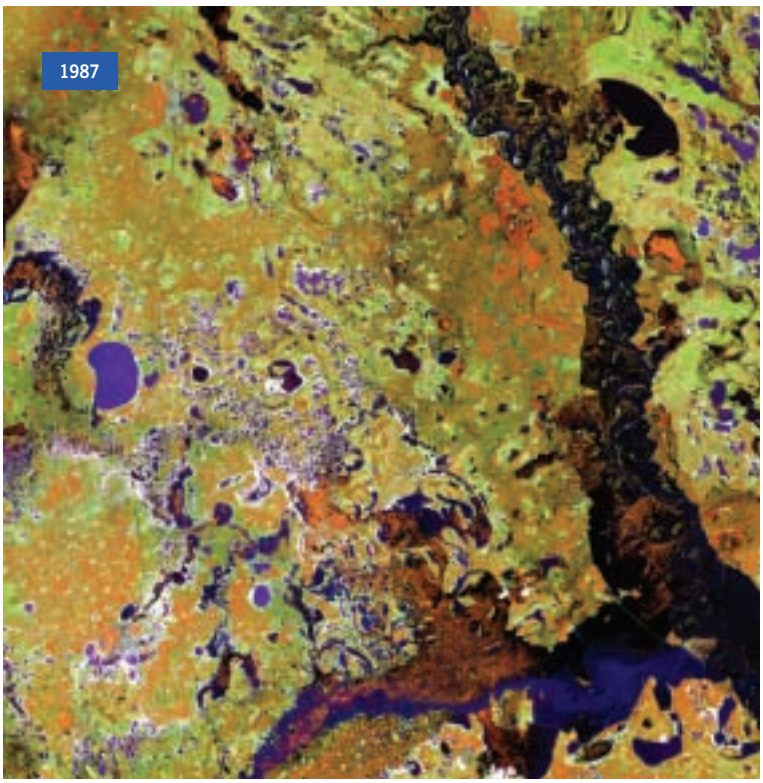
The Three Gorges Dam is located northwest of Yichang city in Hubei Province, China, a sub-tropical region that supports evergreen and deciduous mixed forest.

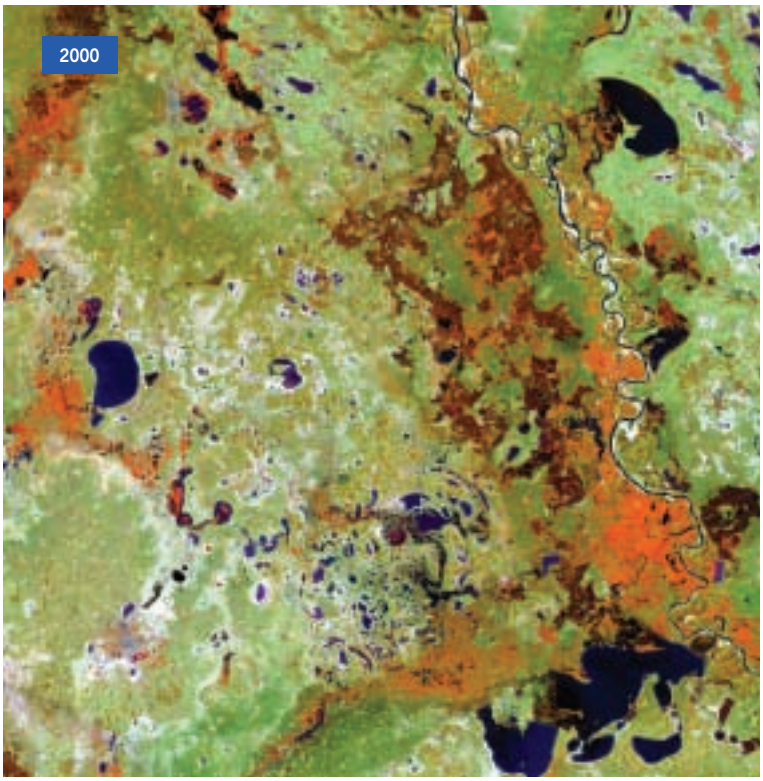
In the images, vegetation appears natural green, water bodies blue, bare land pink and built-up areas bluish-violet.

The images show the great changes that have taken place to farmland and to the original bush forest. In the area round the Three Gorges dam (dead centre of both images), a formerly vegetated area has been largely replaced by a man-made landscape. Soil erosion in this area has been intensified, as can be seen in the year 2000 image.

Imagery and text: China National Environmental Monitoring Centre

OUR CHANGING ENVIRONMENT: Jilin Province, China





Nenjiang plain is located in the northeast of China, in the semi-arid mid-temperate zone. The plain is nowhere more than 100 metres above sea level. Much of the region consists of wetlands which are important for protecting biodiversity and marshland resources. The images show the vast marshland zone to the east of Baicheng City in Jinlin Province. Water bodies appear blue-black. The large area of water on the lower right of the image is Yueliangpao. The two images show how marshland has been lost and replaced by farmland, which appears red in the image. also indicated the loss of biodiversity in this region. Land salinization is beginning to occur along the banks of the river (white areas).

Imagery and text: China National Environmental Monitoring Centre