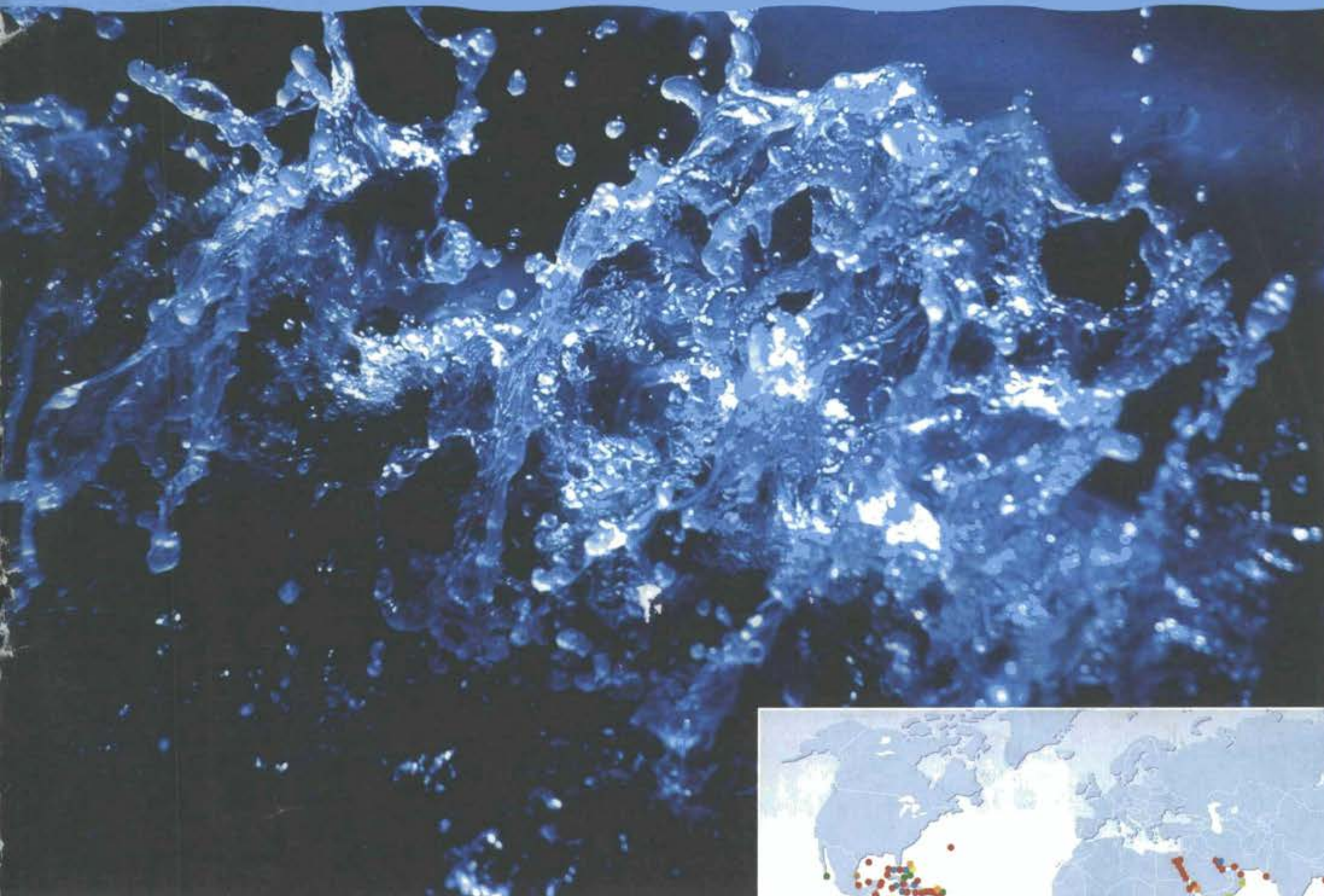


Vital **Water** Graphics

An Overview of the State of
the World's Fresh and Marine Waters

UNEP

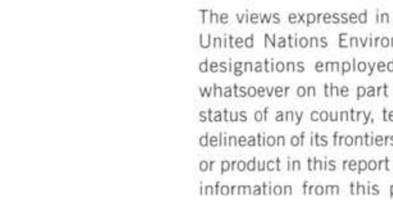
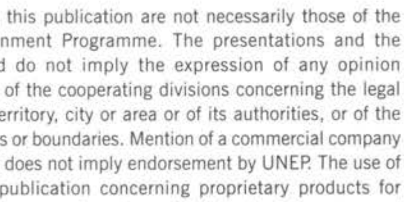
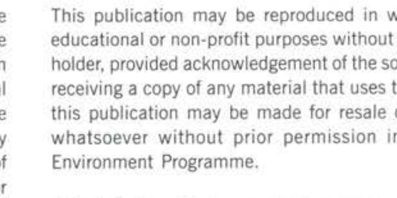
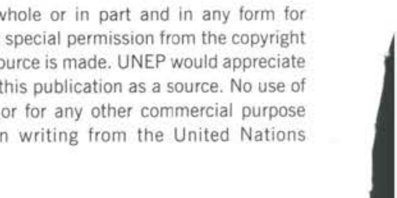
About This Report

The United Nations Environment Programme (UNEP) has been at the forefront of assessing and monitoring global water resources and presenting information on their use and management for the past 30 years. UNEP, in collaboration with partners and collaborating centres, collates and analyses water resource data on a global basis. Despite a concerted effort to create a comprehensive database on global water use, however, there remain many gaps in the information available. Several projects and programmes are working to fill these gaps. Among them are the Global International Waters Assessment (GIWA), the Global Programme of Action for the Protection of the Marine Environment from Land Based Activities (GPA/LBA), and the Global Environment Monitoring System Freshwater Quality Programme (UNEP-GEMS/Water), as well as many other programmes dealing with fresh and coastal/marine waters within other United Nations agencies and partners. The current situation reveals that, while there is significant information on most aspects of water resources in Europe and North America, there are glaring gaps in some of the available data for Africa, South America and parts of Asia, particularly in water quality and quantity.

As was the case with its earlier publication on *Vital Climate Graphics*, UNEP has compiled this report in order to provide an easily accessible resource on the state of the world's waters. The goal of this publication is to produce a clear overview, through a set of graphics, maps and other illustrations, of the state of the world's fresh and marine waters. It also illustrates the causes, effects, trends and threats facing our water sources, with examples of areas of major concern and future scenarios for the use and management of fresh, coastal and marine waters.

It is hoped that this information will assist water users and professionals to make better decisions in order to protect our water resources for future generations.

Further graphics and links to relevant websites on topics presented in this publication are available on the accompanying CD-ROM or at www.unep.org/vitalwater.

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ISBN: 92-807-2236-0

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Foreword

By Klaus Töpfer
United Nations Under-Secretary General and
Executive Director, United Nations Environment Programme

Water-related problems having been recognised as the most immediate and serious threats to humankind. The new UNEP Water Policy and Strategy – which itself is part of a broader restructuring of UNEP that has taken the organisation away from addressing issues sectorally – recognises this need. At its core lie three components: assessment, management and co-ordination of actions. UNEP has long been involved in the field of fresh and marine water and has developed a number of programmes over the years. These, updated and revitalised, are being combined with newer programmes, such as the Global International Waters Assessment (GIWA) and Global Programme of Action to Protect the Marine Environment From Land-Based Activities (GPA), to produce an integrated, comprehensive and dynamic approach to priority water issues.

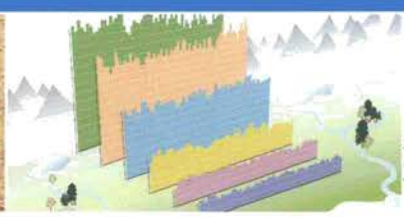
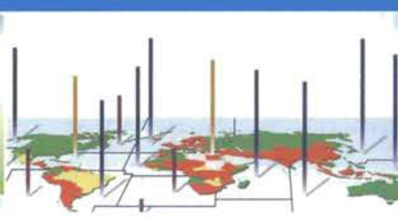
One of the goals of the new UNEP Water Policy and Strategy is to identify and promote the tools that will address the critical water issues facing humanity. Many already exist. New technologies and water management demands can improve efficiency in irrigation and encourage cleaner production in industry. The harmonisation of water policies with land and forestry policies can improve soil and water conservation and halt land degradation. International co-operation, especially among countries sharing water resources, can address the transboundary nature of many water issues.

Vital Water Graphics is a valuable and timely addition to existing assessments of the state of the world's water resources. It focuses on our most 'vital' and pressing water issues – issues that will determine the very future of life on Earth.

A total of 40 graphics, together with accompanying texts and maps, highlight how the quantity, quality and availability of fresh and marine waters play a major role in determining levels and patterns of poverty, land degradation, pollution, sanitation, health, and rural and urban development around the world.

It also documents water trends in our fast changing environment, with examples from the past two decades revealing present trends and providing potential scenarios for the future. By recounting the latest chapter in the history of our fresh and marine water resources, the publication demonstrates how rapidly these are being depleted and polluted – and how urgently we must work for their conservation.

By providing a clear synthesis between water usage and social, economic and environmental factors, *Vital Water Graphics* will contribute through UNEP's Water Policy and Strategy to the achievement of the relevant goals (coastal, marine and freshwater) of its implementation plan of the World Summit on Sustainable Development. We know that this document will provide valuable messages for the public and the media, as well as being an effective tool for decision-making in water use and management during the years to come.


Vital **Water** Graphics

An Overview of the State of
the World's Fresh and Marine Waters

Executive Summary

Published 10 years after the Rio Summit of 1992, *Vital Water Graphics* focuses on the critical issues of water quantity, quality and availability – issues that are vital to the quality of life on Earth. The assessment of global water resources and the provision of early warnings on water issues are enshrined in the mandate, vision and mission of the United Nations Environment Programme. UNEP, UN agencies, and collaborating centres and partners monitor and analyse water resources on a global scale. This partnership enables a wider involvement in assessing the status of the implementation of Chapters 17 and 18 of Agenda 21, which address coastal and marine waters and freshwater, respectively.

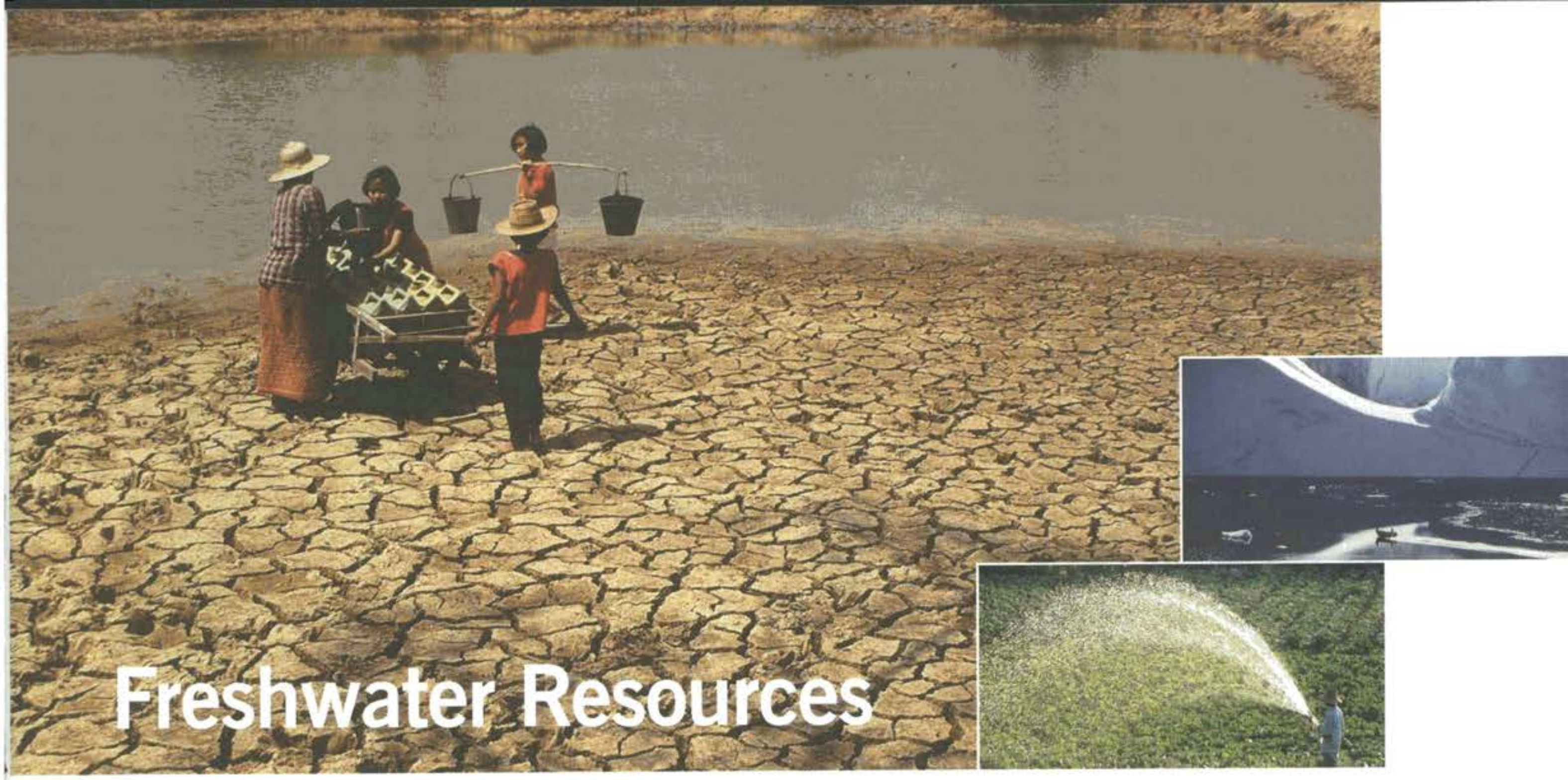
Highlights from assessment activities over the past two decades, which are used to establish present and future water trends, reveal that:

1. Freshwater resources are unevenly distributed, with much of the water located far from human populations. Many of the world's largest river basins run through thinly populated regions. There are an estimated 263 major international river basins in the world, covering ~231 059 898 km^2 or 45.3% of the Earth's land surface area (excluding Antarctica).
2. Groundwater represents about 90% of the world's readily available freshwater resources, and some 1.5 billion people depend upon groundwater for their drinking water.
3. Agricultural water use accounts for about 75% of total global consumption, mainly through crop irrigation, while industrial use accounts for about 20%, and the remaining 5% is used for domestic purposes.
4. It is estimated that two out of every three people will live in water-stressed areas by the year 2025. In Africa alone, it is estimated that 25 countries will be experiencing water stress (below 1,700 m^3 per capita per year) by 2025. Today, 450 million people in 29 countries suffer from water shortages.
5. Clean water supplies and sanitation remain major problems in many parts of the world, with 20% of the global population lacking access to safe drinking water. Water-borne diseases from faecal pollution of surface waters continue to be a major cause of illness in developing countries. Polluted water is estimated to affect the health of 1.2 billion people, and contributes to the death of 15 million children annually.

A wide variety of human activities also affect the coastal and marine environment. Population pressures, increasing demands for space and resources, and poor economic performances can all undermine the sustainable use of our oceans and coastal areas. Serious problems affecting the quality and use of these ecosystems include:

1. Alteration and destruction of habitats and ecosystems. Estimates show that almost 50% of the world's coasts are threatened by development-related activities.
2. Severe eutrophication has been discovered in several enclosed or semi-enclosed seas. It is estimated that about 80% of marine pollution originates from land-based sources and activities.
3. In marine fisheries, most areas are producing significantly lower yields than in the past. Substantial increases are never again likely to be recorded for global fish catches. In contrast, inland and marine aquaculture production is increasing and now contributes 30% of the total global fish yield.
4. Impacts of climate change may include a significant rise in the level of the world's oceans. This will cause some low-lying coastal areas to become completely submerged, and increase human vulnerability in other areas. Because they are highly dependent upon marine resources, small island developing states (SIDS) are especially vulnerable, due to both the effects of sea level rise and to changes in marine ecosystems.

UNEP is involved in promoting Integrated Coastal Management (ICM) through a broad variety of initiatives, as a way of resolving current and future problems at a local/ecosystem-based level. Through its different assessment activities, UNEP focuses on highlighting key areas to promote policy recommendations.



Freshwater Resources

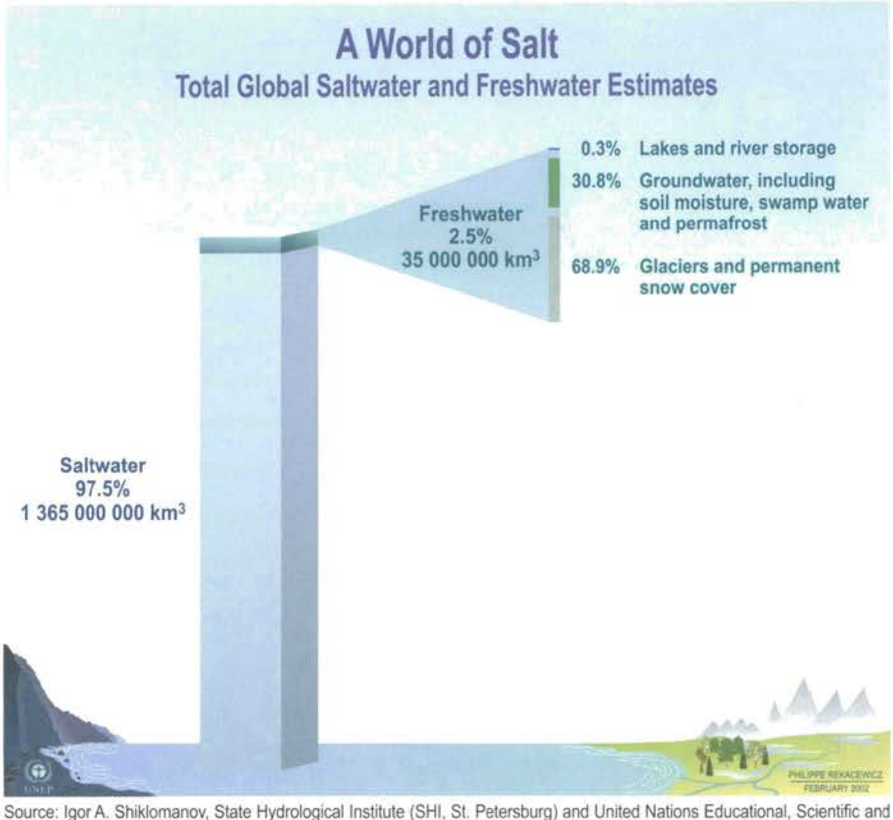
Over the past decade, efforts based on Agenda 21's freshwater management guidelines in Chapter 18, which address the protection of the quality and supply of freshwater and the application of integrated approaches for the development, management and use of water resources, have focused on the following areas:

- Integrated water resources development and management;
- Water resources assessment;
- Protection of water resources, water quality and aquatic ecosystems;
- Drinking-water supply and sanitation;
- Water and sustainable urban development;
- Water for sustainable food production and rural development; and
- The impact of climate change on water resources.

Estimates of global water resources based on several different calculation methods have produced varied estimates. Shiklomanov in Gleick (1993) estimated that:

- The total volume of water on Earth is ~1.4 billion km^3.
- The volume of freshwater resources is ~35 million km^3, or about 2.5% of the total volume.
- Of these freshwater resources, ~24 million km^3 or 68.9% is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions.
- Some 8 million km^3 or 30.8% is stored underground in the form of groundwater (shallow and deep groundwater basins up to 2 000 metres, soil moisture, swamp water and permafrost). This constitutes about 97% of all the freshwater that is potentially available for human use.
- Freshwater lakes and rivers contain an estimated 105 000 km^3 or ~0.3% of the world's freshwater.
- The total usable freshwater supply for ecosystems and humans is ~200 000 km^3 of water, which is < 1% of all freshwater resources, and only 0.01% of all the water on Earth (Gleick, 1993; Shiklomanov, 1999).

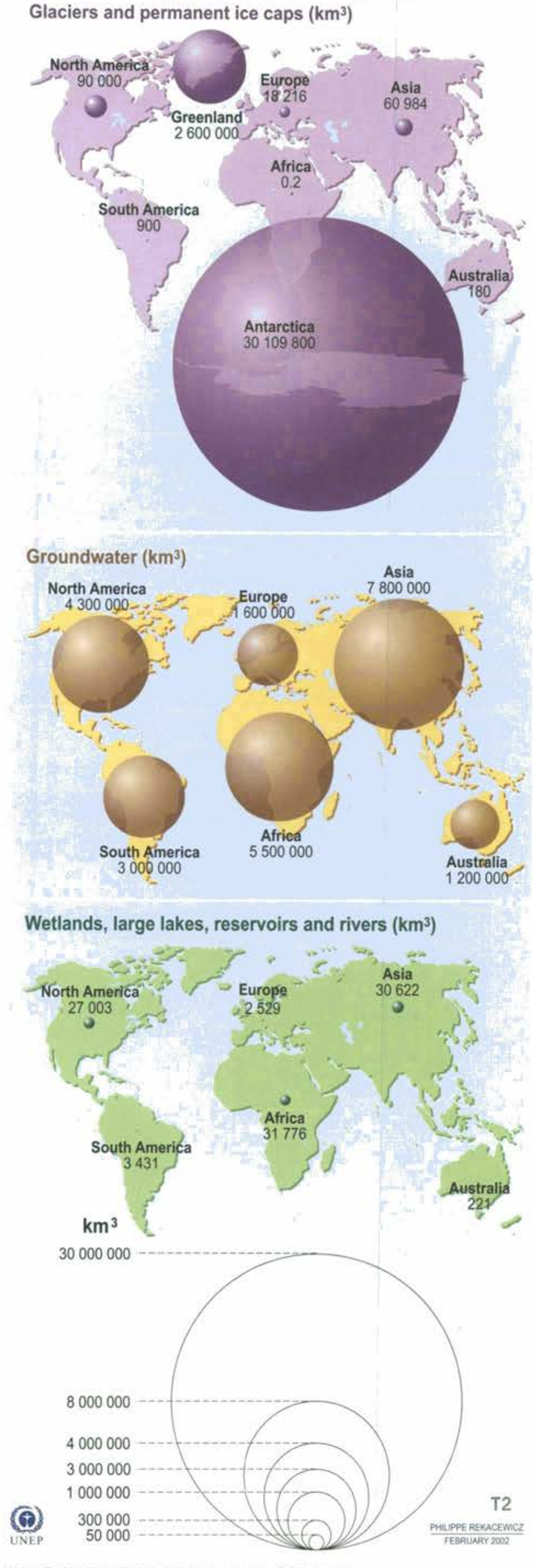
T1



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Global Freshwater Resources

Quantity and Distribution by Region



Note: Estimates refer to standing volumes of freshwater.

Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999; World Meteorological Organisation (WMO); International Council of Scientific Unions (ICSU); World Glacier Monitoring Service (WGMS); United States Geological Survey (USGS).

Glaciers and icecaps cover about 10% of the world's landmass. These are concentrated in Greenland and Antarctica and contain ~70% of the world's freshwater. Unfortunately, most of these resources are located far from human habitation and are not readily accessible for human use.

According to the United States Geological Survey (USGS), 96% of the world's frozen freshwater is at the South and North poles, with the remaining 4% spread over 550 000 km² of glaciers and mountainous icecaps measuring about 180 000 km³ (UNEP, 1992; Untersteiner, 1975; WGMS, 1998, 2002).

Groundwater is by far the most abundant and readily available source of freshwater, followed by lakes, reservoirs, rivers and wetlands:

- Groundwater represents over 90% of the world's readily available freshwater resource (Boswinkel, 2000). About 1.5 billion people depend upon groundwater for their drinking water supply (WRI, UNEP, UNDP, World Bank, 1998).
- The amount of groundwater withdrawn annually is roughly estimated at ~600-700 km³, representing about 20% of global water withdrawals (WMO, 1997).
- A comprehensive picture of the quantity of groundwater withdrawn and consumed annually around the world does not exist.

Most **freshwater lakes** are located at high altitudes, with nearly 50% of the world's lakes in Canada alone. Many lakes, especially those in arid regions, become salty through evaporation, which concentrates the inflowing salts. The Caspian Sea, the Dead Sea, and the Great Salt Lake are among the world's major salt lakes.

Rivers form a hydrological mosaic, with an estimated 263 international river basins covering 45.3% (~231 059 898 km²) of the land surface area of the Earth, excluding Antarctica (UNEP, Oregon State University et al., in preparation). The total volume of water in the world's rivers is estimated at 2 115 km³ (Groombridge and Jenkins, 1998).

Major River Basins of the World

North America
1 Yukon
2 Mackenzie
3 Nelson
4 Mississippi
5 St. Lawrence

South America
6 Amazon
7 Paraná

Europe
25 Danube

Africa and West Asia
8 Niger
9 Lake Chad Basin
10 Congo
11 Nile
12 Zambezi
26 Orange
24 Euphrates and Tigris

Asia and Australia
13 Volga
14 Ob
15 Yenisey
16 Lena
17 Kolyma
18 Amur
19 Ganges and Brahmaputra
20 Yangtze
21 Murray Darling
22 Huang He
23 Indus

Source: United Nations Environment Programme (UNEP); World Conservation Monitoring Centre (WCMC); World Resources Institute (WRI); American Association for the Advancement of Science (AAAS); *Atlas of Population and Environment*, 2001.

Reservoirs are artificial lakes, produced by constructing physical barriers across flowing rivers, which allow the water to pool and be used for various purposes. The volume of water stored in reservoirs worldwide is estimated at 4 286 km³ (Groombridge and Jenkins, 1998).

Wetlands include swamps, bogs, marshes, mires, lagoons and floodplains. The 10 largest wetlands in the world by area are: West Siberian Lowlands (780 000-1 000 000 km²), Amazon River (800 000 km²), Hudson Bay Lowlands (200 000-320 000 km²), Pantanal (140 000-200 000 km²), Upper Nile River (50 000-90 000 km²), Chari-Logone River (90 000 km²), Hudson Bay Lowlands in the South Pacific (69 000 km²), Congo River (40 000-80 000 km²), Upper Mackenzie River (60 000 km²), and North America prairie potholes (40 000 km²) (Pidwiny, 1999).

The total global area of wetlands is estimated at ~2 900 000 km² (Groombridge and Jenkins, 1998). Most wetlands range in depth from 0-2 metres. Estimating the average depth of permanent wetlands at about one metre, the global volume of wetlands could range between 2 300 km³ and 2 900 km³.

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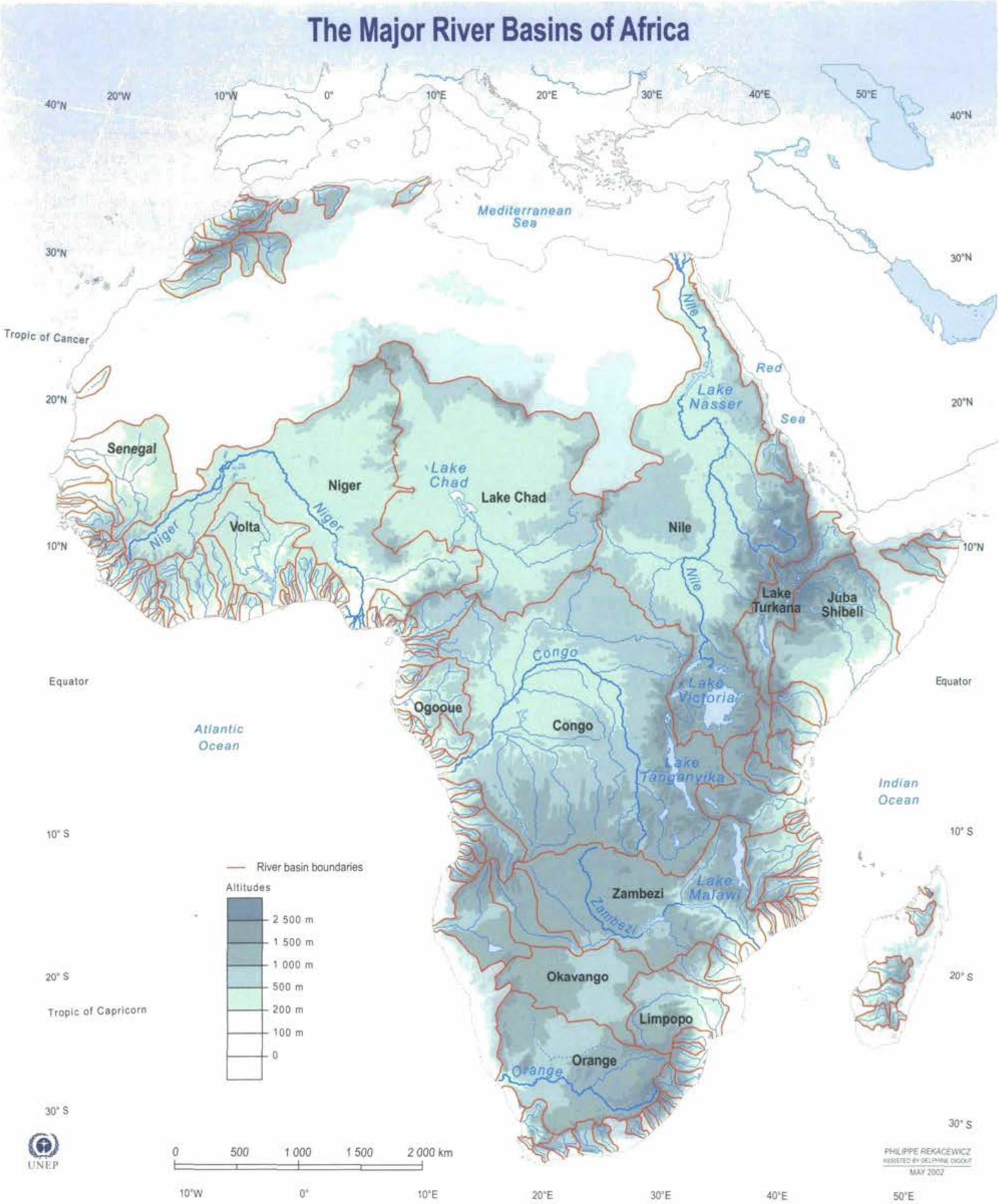
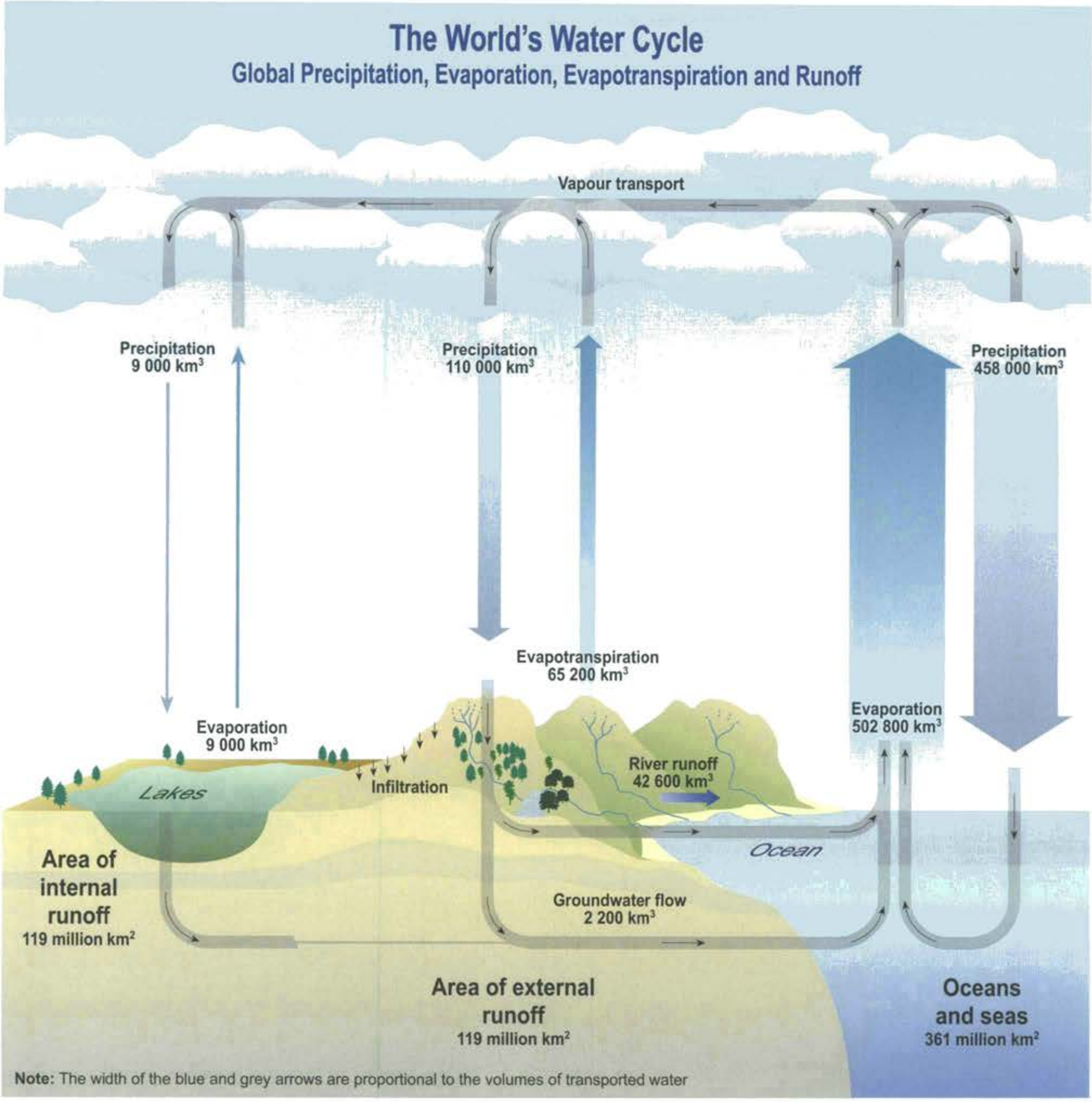
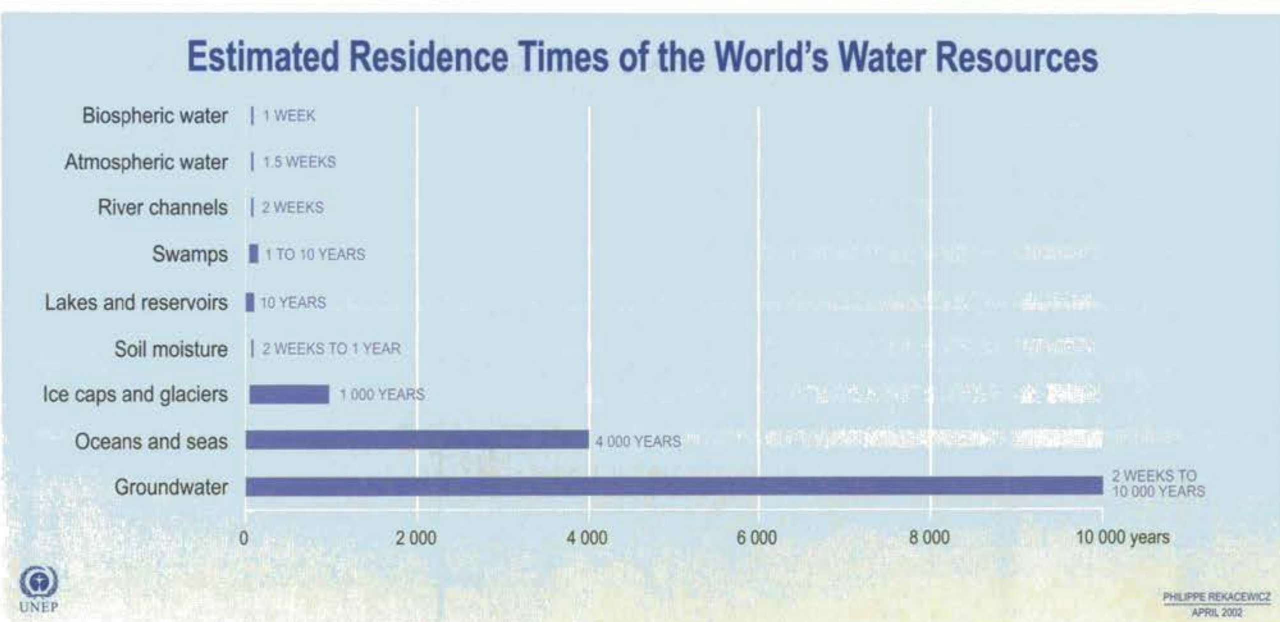


Source: Aaron T. Wolf et al., 1999; Revenga et al., *Watersheds of the World*, World Resources Institute (WRI), Washington DC, 1998; Philippe Rekacewicz, *Atlas de poche*, Livre de poche, Librairie générale française, Paris, 1996 (revised in 2001).





Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999; Max Planck, Institute for Meteorology, Hamburg, 1994; Freeze, Allen, John, Cherry, *Groundwater*, Prentice-Hall: Engle wood Cliffs NJ, 1979.

Water is transported in different forms within the **hydrological cycle** or 'water cycle'. Shiklomanov in Gleick (1993) estimates that each year about 502 800 km^3 of water evaporates over the oceans and seas, 90% of which (458 000 km^3) returns directly to the oceans through precipitation, while the remainder (44 800 km^3) falls over land.

With evapo-transpiration totalling about 74 200 km^3, the total volume in the terrestrial hydrological cycle is about 119 000 km^3. About 35% of this, or 44 800 km^3, is returned to the oceans as run-off from rivers, groundwater and glaciers. A considerable portion of river flow and groundwater percolation never reaches the ocean, having evaporated in internal runoff areas or inland basins lacking an outlet to the ocean. However, some groundwater that bypasses the river systems reaches the oceans. Annually the hydrological cycle circulates nearly 577 000 km^3 of water (Gleick, 1993).

Because much of the world's surface water is far from concentrations of human settlements, not all of it is readily usable.

- It is estimated that the freshwater available for human consumption varies between 12 500 km^3 and 14 000 km^3 each year (Hinrichsen et al., 1998; Jackson et al., 2001).
- Many countries in Africa, the Middle East, Western Asia, and some Eastern European countries have lower than average quantities of freshwater resources available to their populations.
- Due to rapid population growth, the potential water availability of Earth's population decreased from 12 900 m^3 per capita per year in 1970 to 9 000 m^3 in 1990, and to less than 7 000 m^3 in 2000 (Clarke, 1991; Jackson et al., 2001; Shiklomanov, 1999).
- In densely populated parts of Asia, Africa and Central and Southern Europe, current per capita water availability is between 1 200 m^3 and 5 000 m^3 per year (Shiklomanov, 1999).
- The global availability of freshwater is projected to drop to 5 100 m^3 per capita per year by 2025. This amount would be enough to meet individual human needs if it were distributed equally among the world's population (Shiklomanov, 1999).
- It is estimated that 3 billion people will be in the water scarcity category of 1 700 m^3 per capita per year by 2025 (UNEP, 2002).

The uneven distribution of freshwater creates major problems of access and availability. For example:

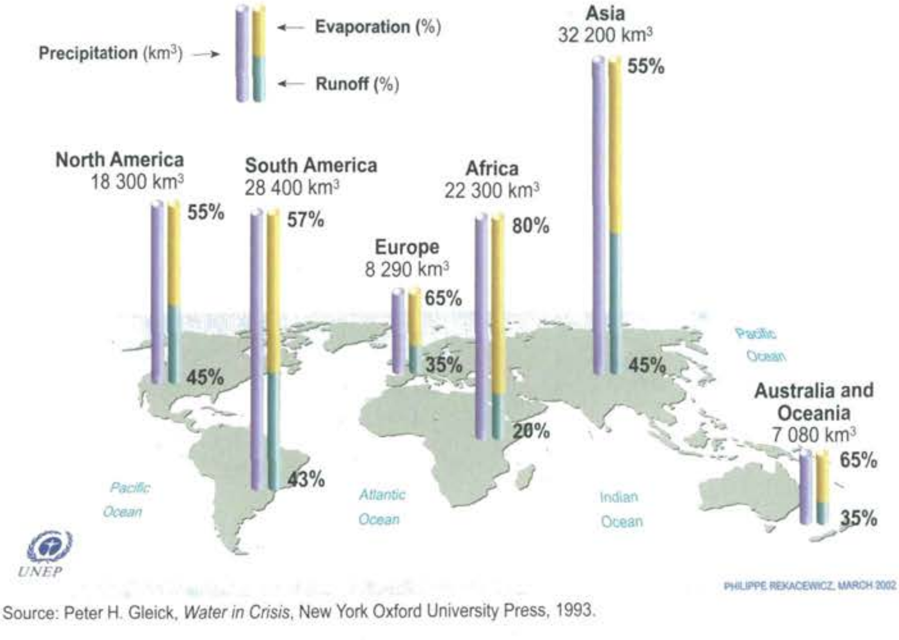
- Asia and the Middle East are estimated to have 60% of the world's population (~3 674 000 000 people in 2000), but only 36% of its river runoff – much of which is confined to the short monsoon season (Graphic Maps, 2001; Shiklomanov, 1999).
- South America, by contrast, has an estimated 6% of the global population (~342 000 000 people in 2000) and 26% of its runoff (Graphic Maps, 2001; Shiklomanov, 1999).

These examples do not take into account groundwater abstraction.

River runoff is cyclical in nature, with alternating cycles of wet and dry years. Significant deviations from average values differ in duration and magnitude. For example, 1940-44, 1965-68 and 1977-79 are clearly low periods in terms of total runoff from the world's rivers. During these periods, the runoff was estimated at 1 600-2 900 km^3 below the average value. By contrast, 1926-27, 1949-52 and 1973-75 saw much greater levels of river runoff (Shiklomanov, 1999). The last two decades have witnessed increasing runoff in South America and decreasing runoff in Africa.

T6

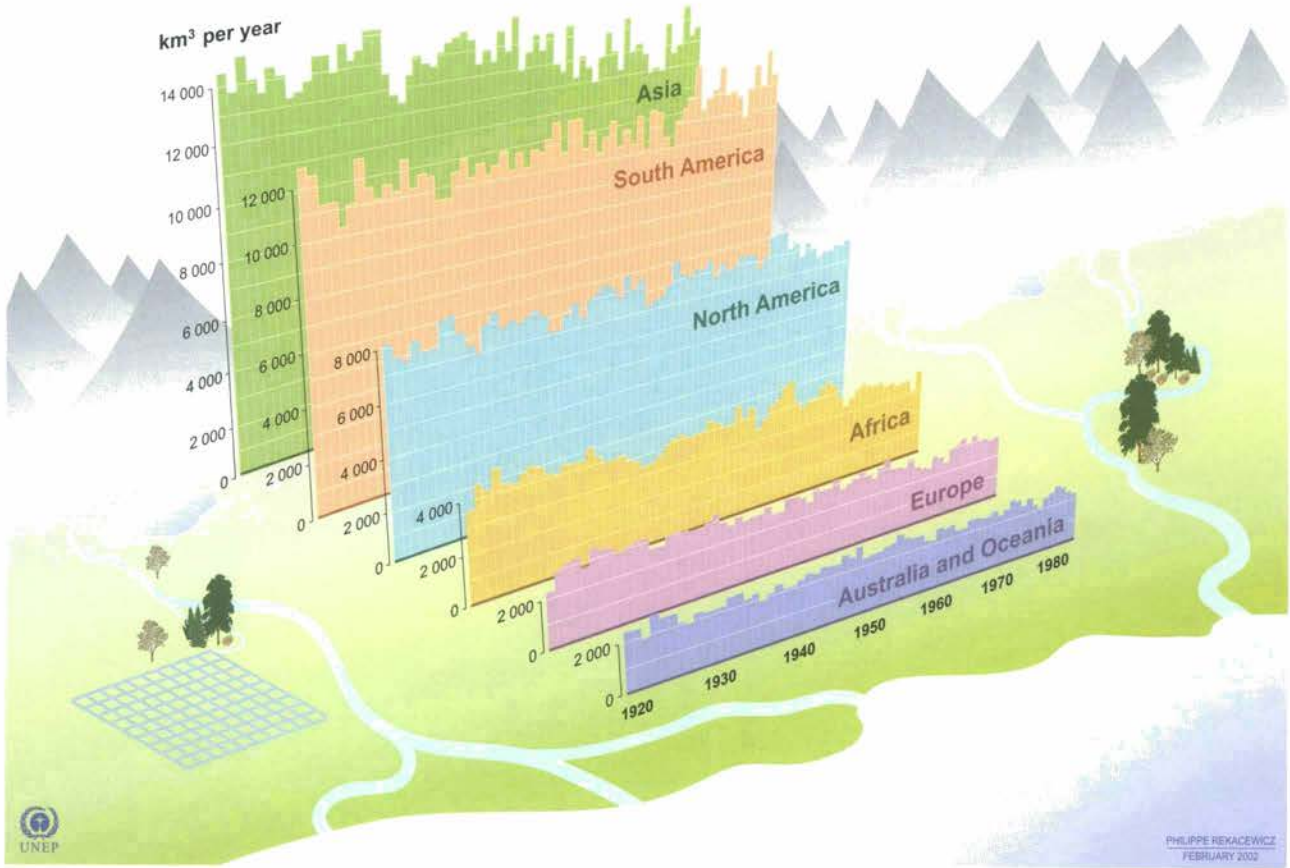
The World's Surface Water
Precipitation, Evaporation and Runoff by Region



Source: Peter H. Gleick, *Water in Crisis*, New York Oxford University Press, 1993.

River Runoff through the 20th Century
Average Annual Volumes by Continent, 1921-1985

T7



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

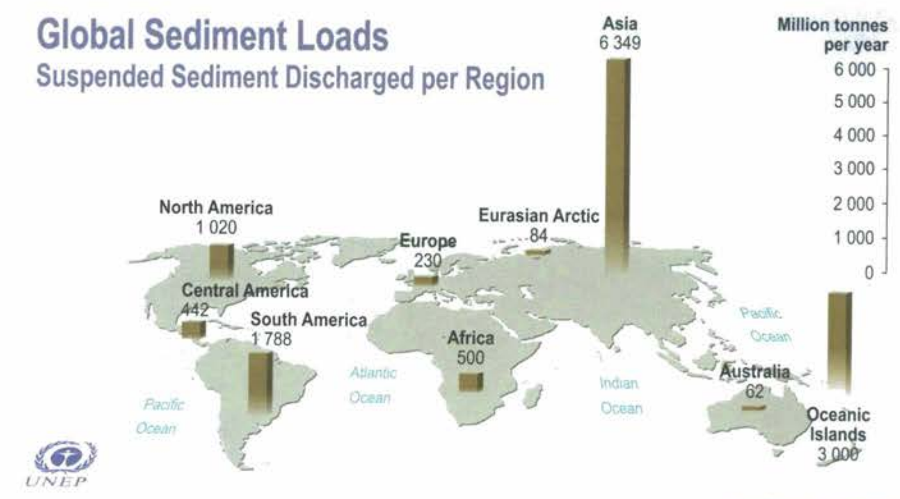
Tropical regions typically exhibit greater river runoff volumes. The Amazon carries 15% of all the water returning to the world's oceans, while the Congo-Zaire basin carries 33% of the river flow in Africa. Arid and semi-arid regions, which make up an estimated 40% of the world's land, have only 2% of its runoff (Gleick, 1993).

Water quality information is required for sustainable water resource management. Land-based activities can affect water chemistry through pollution, and play a role in transporting sediments in rivers. Sediments carry many types of pollutants from point and non-point sources, the quantity of which depends on the general land use and activities in the drainage basin of origin.

Asia exhibits the largest runoff volumes and, therefore, the highest levels of **sediment discharge**. Due to their high precipitation, the Oceanic Islands have disproportionately high suspended sediment loads (Gleick, 1993).

Global Sediment Loads
Suspended Sediment Discharged per Region

T8



Source: Peter H. Gleick, *Water in Crisis*, New York Oxford University Press, 1993.

Results collected and analysed by the Global Environmental Monitoring System on Water (GEMS/Water) over the last two decades **for biological oxygen demand (BOD)**, alkalinity, nitrates and phosphates are indicative of efforts undertaken in various parts of the world to assess freshwater quality.

BOD is an indicator of the organic pollution of freshwater. In comparing the past two decades, rivers in Europe and Australasia show a statistically significant reduction in BOD concentrations. Although the reduction is not particularly large, it is indicative of positive trends. There was no change in the assessed results for North America, although there was a tighter data distribution, indicating the data available for 1991-2000 is less variable than for previous periods.

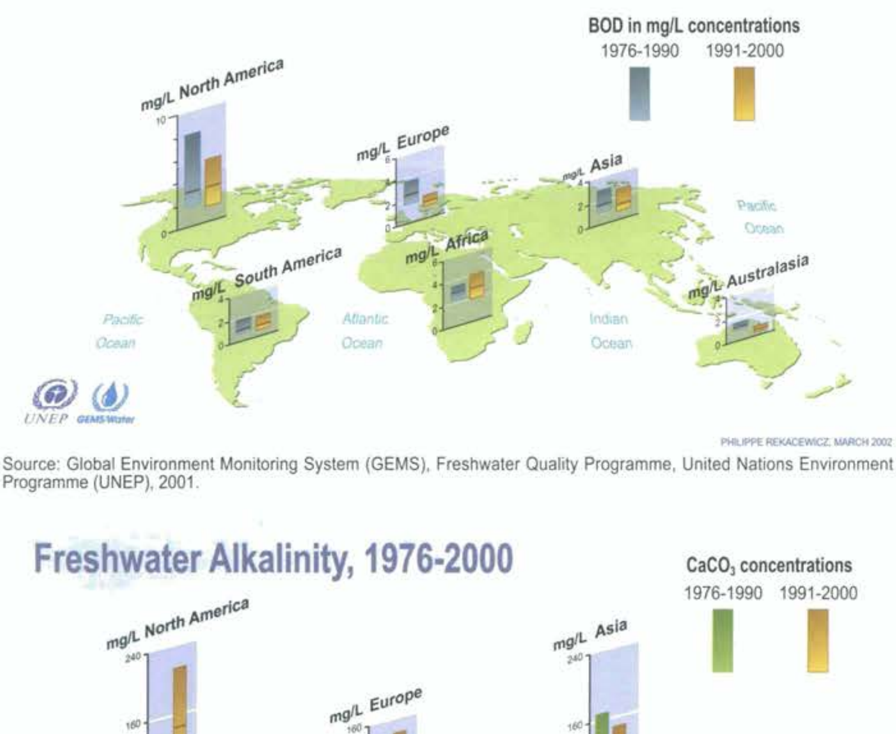
Alkalinity (as $CaCO_3$) was analysed for all sampling stations available at the continental level. Concentrations remained reasonably steady between the two decades for Africa, Asia, South America and Australasia. Significant increases in alkalinity concentrations were noted for European and North American rivers, which may indicate a shift towards reduced acidic impacts at the continental scale.

Examination of the outflow stations in 82 monitored river basins indicated a decrease in bicarbonate concentrations between the two decades in the northern latitudes, including North America, Europe and Asia.

For the period 1976-1990, European rivers displayed the highest concentrations of calcium at the continental level. Concentrations varied from between 2 mg per litre and 50 mg litre for major rivers. Comparing the two decades, observations of surface water showed an increase in calcium concentrations in the Laurentian shield region of North America, and in the rivers of the North Central European region.

Biological Oxygen Demand (BOD), 1976-2000

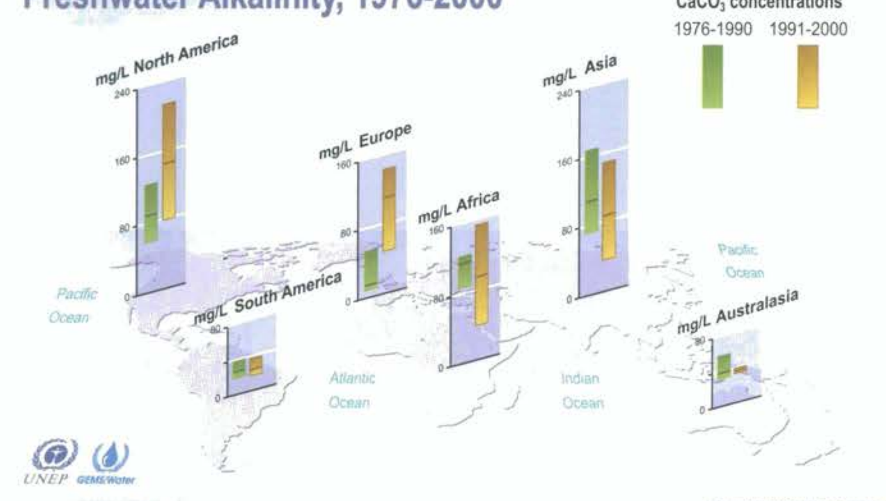
T9



Source: Global Environment Monitoring System (GEMS), Freshwater Quality Programme, United Nations Environment Programme (UNEP), 2001.

Freshwater Alkalinity, 1976-2000

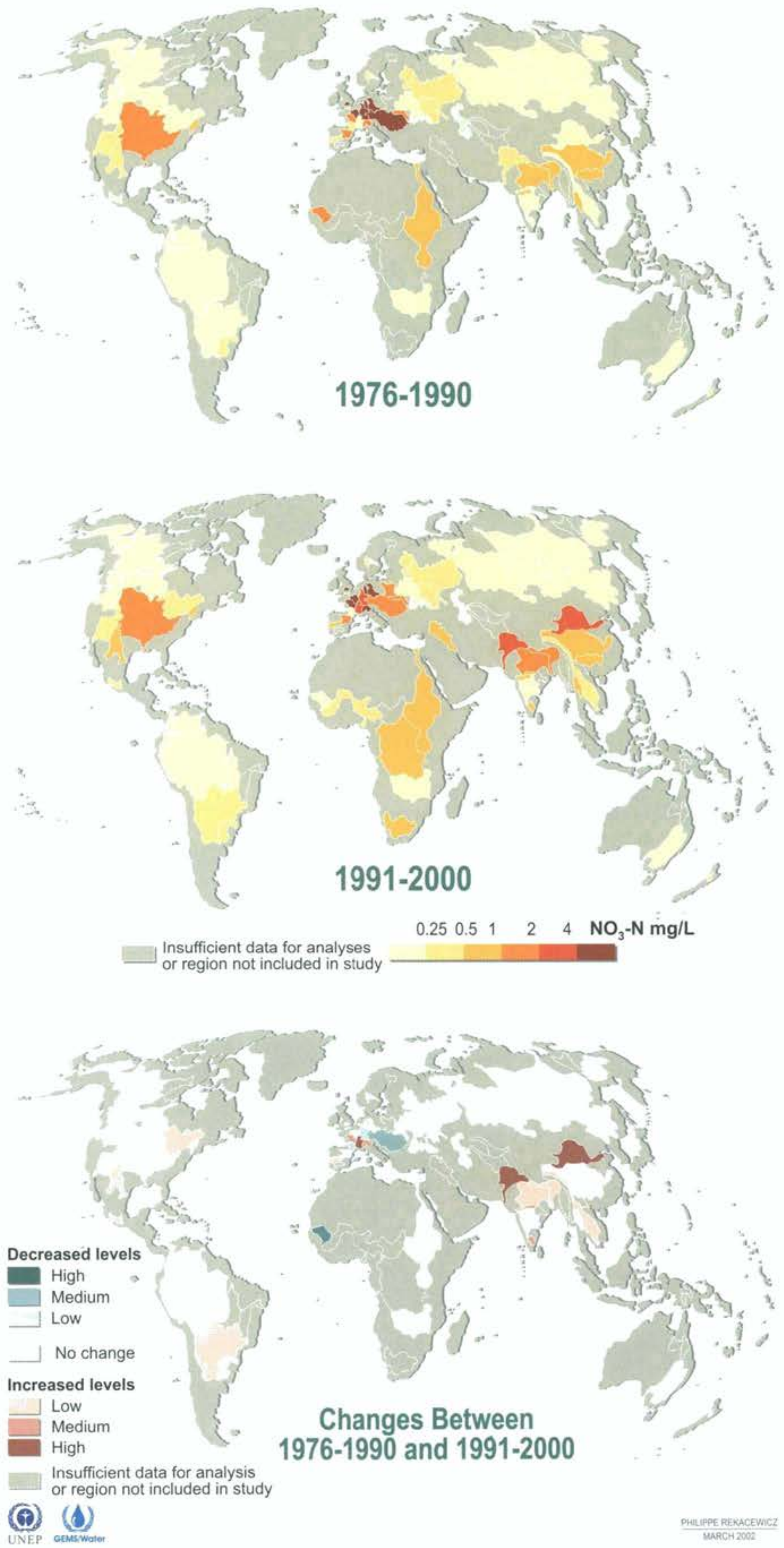
T9



Source: Global Environment Monitoring System (GEMS), Freshwater Quality Programme, United Nations Environment Programme (UNEP), 2001.

Global Average Nitrate Levels
Concentrations at Major River Mouths

T10



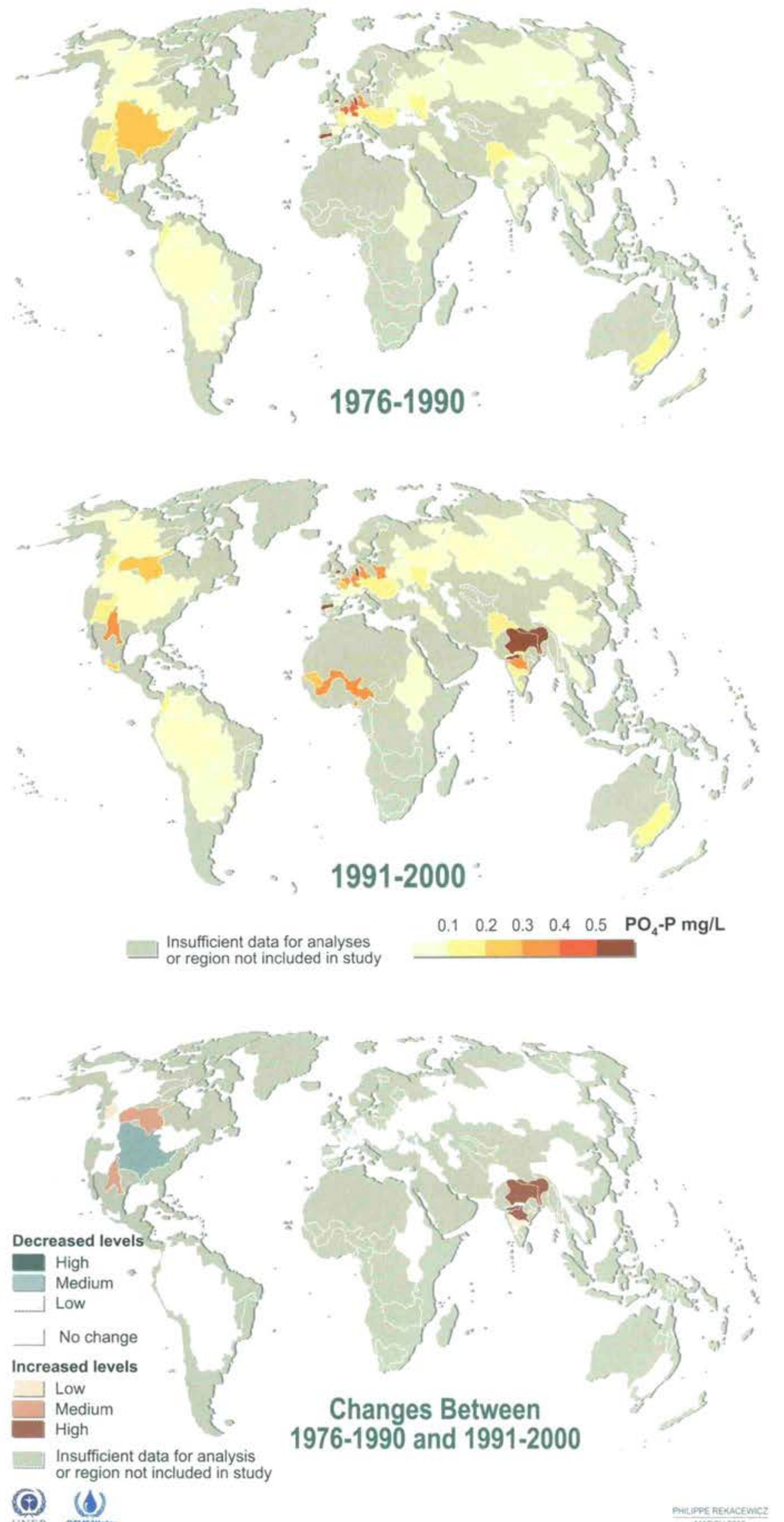
Considering the data for all the rivers at the continental level, there has been little change in **nitrate (NO_3–N) concentrations** between the two decades under comparison. Changes in the median value were not statistically significant. European rivers showed the highest nitrate loads transported to the marine environment. Comparing data from the two decades, North American and European rivers have remained fairly stable, while major river basins in South Central and Southeast Asia have recorded higher nitrate concentrations.

Source: United Nations Environment Programme (UNEP) - Global Environment Monitoring System (GEMS) Water Programme, 2001; National Water Research Institute Environment Canada, Ontario, 2001.

Global Dissolved Phosphate Levels

Concentrations at Major River Mouths

A comparison of the major watersheds between the two decades showed that Northern Europe and North America had lower **phosphate concentrations**, while the Ganges and Brahmaputra watersheds in South Central Asia had higher concentrations. Nutrient control programmes in municipal and agricultural activities may be key factors in the observed reductions in phosphate concentrations.



Source: United Nations Environment Programme (UNEP) - Global Environment Monitoring System (GEMS) Water Programme, 2001; National Water Research Institute Environment Canada, Ontario, 2001.

Global International Water Assessment (GIWA) Case Studies

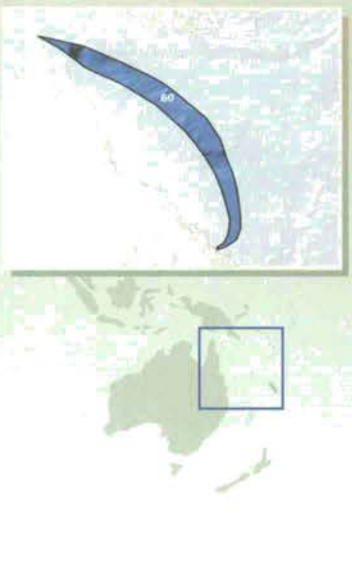
http://www.giwa.net/

Black Sea

- **Introduction:** The catchment area is ~ 2.5 million km^2 with a population of ~ 162 million, of which the urban population accounts for 60%.
- **Freshwater shortages** are a problem, although not yet catastrophic. Industry accounts for 50% of freshwater use, irrigation for 12-40%, and domestic use for ~ 28%. Increasing pollution in river basins and rising salinity are also exacerbating water shortages.
- **Pollution** from industries, municipal waste and oil spills is affecting groundwater, the seas and rivers through eutrophication.
- **Unsustainable exploitation of fisheries**: In the past 30 years, pollution has devastated the fishing industry. Total catches fell from ~ 750 000 tons in 1986 to ~ 284 000 tons in 1992.
- **Habitat and community modification and loss:** Ecosystems have drastically changed as a result of the increasing eutrophication of water bodies.
- **Socio-economic impacts** include the decreasing amenity value of coastal areas for tourism and recreation, losses in agriculture, and rising unemployment.

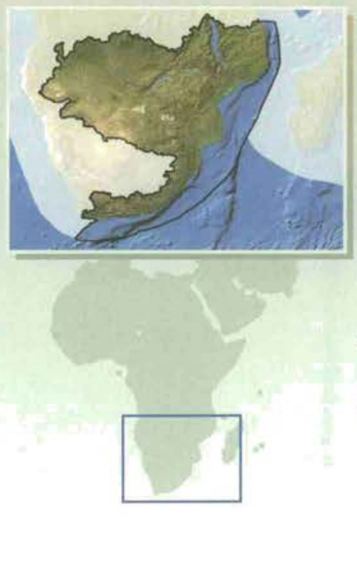
Amazon

- **Introduction:** The sub region 40b measures 6 869 km^2 and is shared by six countries.
- **Freshwater shortages**: The high rate of deforestation in southeastern Brazil is altering the water cycle and increasing problems of freshwater availability.
- **Pollution** caused by chemical and suspended solids – emanating from agricultural wastes and mercury contamination respectively – is of growing concern.
- **Habitat and community modification** is the priority concern, with management desperately required to address large-scale extension impacts.
- **Over-exploitation of fisheries:** The region's fisheries have a potential catch of 200 000 - 1 million tonnes/year with > 200 exploitable species. However, consumption is based on only a few dozen species and these are already threatened by over-exploitation.
- **Socio-economic impacts** include minor water shortages, growing pollution in urban centres, and increasing social and health problems in the suburbs of Amazon cities.



Great Barrier Reef

- **Introduction:** Bordered on the east by the GBR Marine Park World Heritage Area, the sub-region extends north across the Torres Strait to Bramble Cay and the Australia-Papua New Guinea territorial border, west to the PNG-Indonesia border, and south to the tip of Cape York, Australia.
- **Pollution:** Eutrophication, chemical pollution and suspended solids from the catchments, rivers, wetlands and estuaries are causing moderate impacts in the region. In some areas, the impacts are considered severe.
- **Habitat and community modification:** Loss or modification of ecosystems is a severe problem locally, notably in marshlands and riparian belts. Overall, the impacts are considered moderate.
- **Unsustainable exploitation of fisheries and other living resources:** Over-exploitation, excessive by-catches, discards and destructive fishing techniques (benthic trawling) are severe problems, particularly when targeting sharks, mackerel, lobster and shrimps/prawns.
- **Global climate change** is a major threat, particularly the impact of ocean sea surface temperature increases on coral reefs.



Agulhas Current

- **Introduction:** There are eight river basins in the sub region, forming a network of transboundary water systems, including a 5,000 km coastline off the Mozambique and South African continental shelves. The Zambezi catchment area covers ~ 1 434 680 km^2 and supports 38.4 million people – about 70% of the region's population.
- **Freshwater shortages** are the primary concern due to excessive water abstraction and increasing pollution of supplies. Irrigation accounts for 60% of local freshwater use. Streamflow in the Zambezi River has declined by over 50% in the last three decades, due to the construction of three large dams.
- **Unsustainable exploitation of fisheries**, particularly tuna and shrimps in marine waters, is severe and likely to escalate to critical levels by the year 2020.
- **Pollution** is not a critical concern at the present, although some hotspots have been reported in the mining and industrial zones of major cities.
- **Socio-economic impacts** include escalating poverty, food insecurity and mortality due to waterborne diseases and rural-rural/rural-urban migration. The major root causes are declining agricultural productivity and fishery harvests, and habitat losses and modification.

There are several hundred relevant assessments and access points for meta-data catalogues and holdings, providing a substantial basis on which to build a comprehensive global assessment of international water issues and problems. The **Global International Waters Assessment (GIWA)** is an example of a comprehensive strategic assessment designed to identify priorities for remedial and mitigatory actions in international waters.

The GIWA geographical framework divides the world into a series of areas, based upon environmental, biogeographical and geopolitical factors. These encompass major causes and effects of environmental problems associated with each transboundary water area, whether river basin, groundwater, lake or sea. A total of 66 sub-regions were identified as the basic units of assessment, and grouped into nine regions for assessment purposes (GEF Unit/UNEP, 1998).

T12

Global International Water Assessment Tools
for Better Monitoring of the World's Water Resources

The GIWA Assessment Methodology

«Transboundary Diagnostic Analysis»

Scoping and Scaling
Identifying Issues

- Environmental impact
- Socio-economic impact

↓

Detailed Impact Assessment
Assessing Situations

- Environmental impact assessment
- Socio-economic impact assessment

↓

Causal Chain Analysis
Constructing the Causal Chain

- By following the most significant successive causes of environmental degradation, a causal chain is constructed to discover the root causes of the problems.

↓

Policy Option Analysis

- The evaluation of alternative scenarios follows various projections developed on the basis of actions to address the societal root causes of environmental degradation. These analyses consider methods for evaluating the environmental impacts of various options for water use, before weighing the costs of measures designed to modify unsustainable developments.

↓

Better action in the field

UNEP

GIWA's Five Major Concerns

Freshwater shortages

- Reduction of stream flows
- Lowering of water tables
- Pollution of existing water supplies

Pollution

- Microbiological pollution, eutrophication
- Chemical pollution
- Suspended solids, solid waste
- Thermal pollution
- Radionuclides
- Spills

Habitat and community modification

- Loss of ecosystems or ecotones
- Modification of ecosystems or ecotones

Unsustainable exploitation of fisheries and other living resources

- Inappropriate harvesting practices
- Resource/habitat changes
- Habitat alteration or destruction
- Decreased viability of stock through contamination or disease
- Reduction of biodiversity

Global change

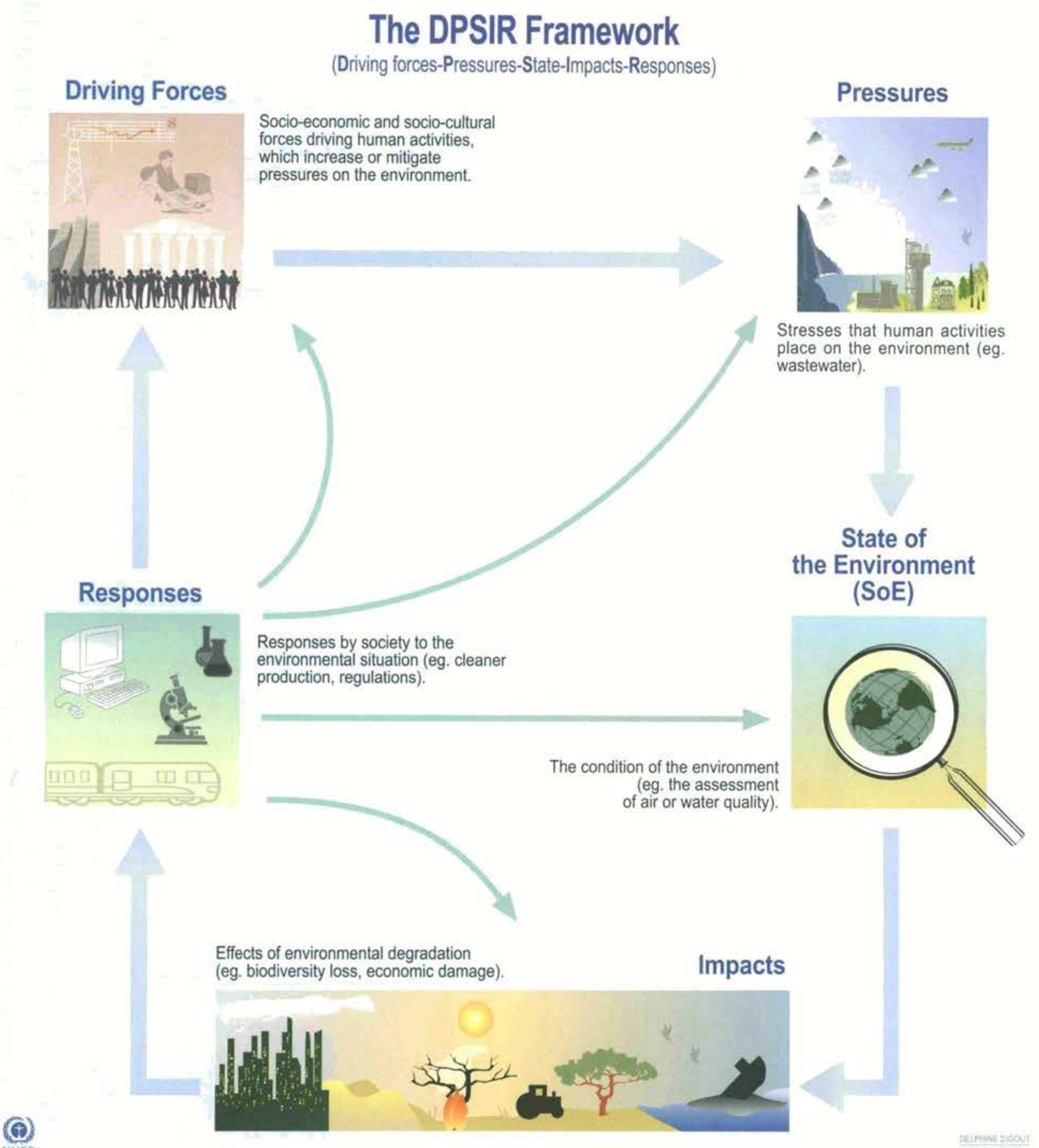
- Changes in hydrological cycles
- Rising sea levels
- Increased UV-B radiation as a result of ozone depletion
- Changes in ocean carbon dioxide source/sink function

Source: Global International Water Assessment (GIWA), 2001.

GIWA's assessment tools for monitoring the world's water resources, incorporating **five major environmental concerns** and application of the **DPSIR framework**, are now beginning to yield results of practical use for management decisions.

The **DPSIR framework** is used in many assessments, eg. in GIWA.

T13



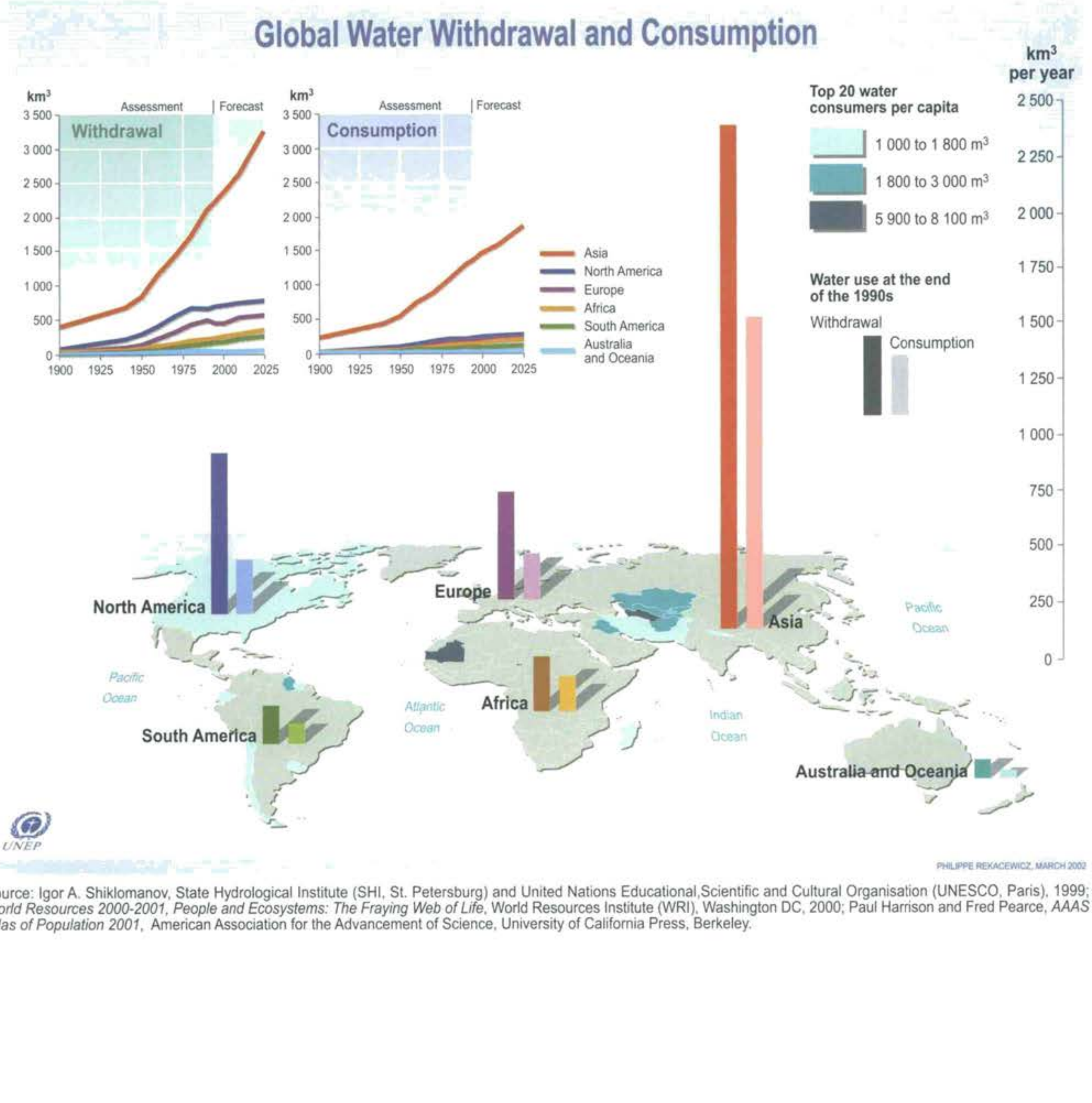
Source: Global International Water Assessment (GIWA), 2001; European Environment Agency (EEA), Copenhagen.

Water Use and Management

Freshwater use by continents is partly based on several socio-economic development factors, including population, physiography, and climatic characteristics.

- Annual global freshwater withdrawal has grown from 3 790 km^3 (of which consumption accounted for 2 070 km^3 or 61%) in 1995, to ~4 430 km^3 (of which consumption accounted for 2 304 km^3 or 52%) in 2000 (Shiklomanov, 1999).
- In 2000, about 57% of the world's freshwater withdrawal, and 70% of its consumption, took place in Asia, where the world's major irrigated lands are located (UNESCO, 1999).
- In the future, annual global water withdrawal is expected to grow by about 10-12% every 10 years, reaching approximately 5 240 km^3 (or an increase of 1.38 times since 1995) by 2025. Water consumption is expected to grow at a slower rate of 1.33 times (UNESCO, 1999).
- In the coming decades, the most intensive growth of water withdrawal is expected to occur in Africa and South America (increasing by 1.5-1.6 times), while the smallest growth will take place in Europe and North America (1.2 times) (Harrison and Pearce, 2001; Shiklomanov, 1999; UNESCO, 1999).

T14



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999; *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000; Paul Harrison and Fred Pearce, *AAAS Atlas of Population 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.

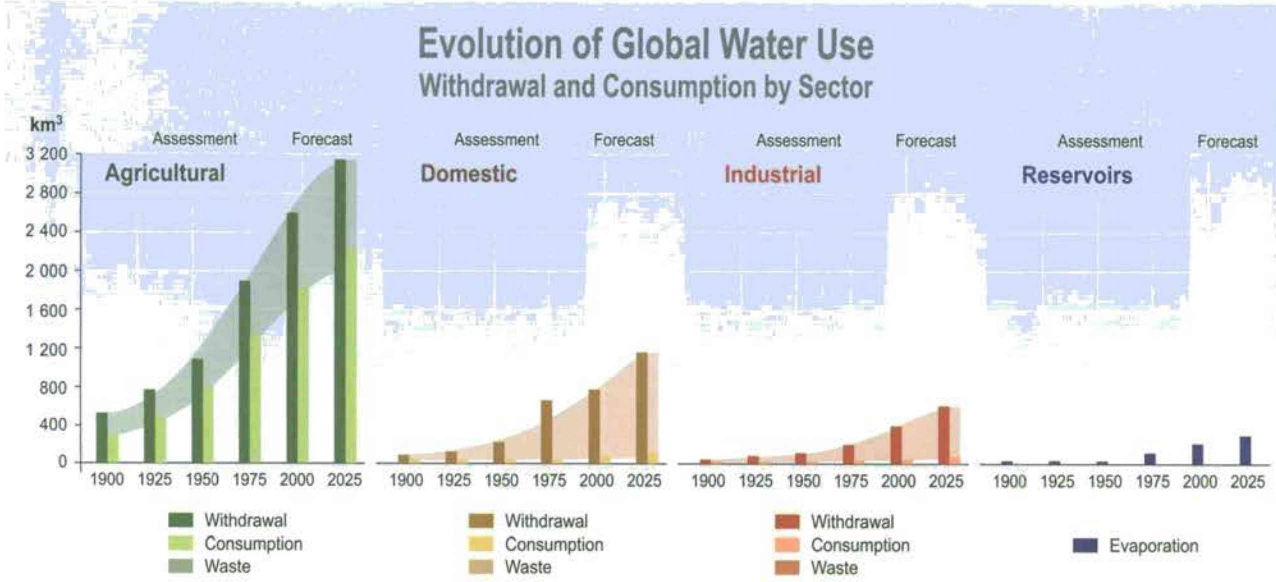
The **agricultural sector** is by far the biggest user of freshwater:

- In the United States, agriculture accounts for some 49% of the total freshwater use, with 80% of this volume being used for irrigation (Shiklomanov, 1999).
- In Africa and Asia, an estimated 85-90% of all the freshwater used is for agriculture (Shiklomanov, 1999).
- According to estimates for the year 2000, agriculture accounted for 67% of the world's total freshwater withdrawal, and 86% of its consumption (UNESCO, 2000).
- By 2025, agriculture is expected to increase its water requirements by 1.2 times, industry by 1.5 times, and domestic consumption by 1.8 times (Shiklomanov, 1999).
- The world's irrigation areas totalled approximately 253 million hectares in 1995. By 2010, they are expected to reach about 290 million hectares, and by 2025 about 330 million hectares (Shiklomanov, 1999).
- By the year 2000, an estimated 15% of the world's cultivated lands were irrigated for food crops, accounting for almost half of the value of global crop production (UNESCO, 1999).

In the **industrial sector**, the biggest share of freshwater is stored in reservoirs and dams for electrical power generation and irrigation. However, the volume of water evaporated from reservoirs is estimated to exceed the combined freshwater needs of industry and domestic consumption. This greatly contributes to water losses around the world, especially in the hot tropical regions (UNESCO, 1999).

Industrial uses account for about 20% of global freshwater withdrawals. Of this, 57-69% is used for hydropower and nuclear power generation, 30-40% for industrial processes, and 0.5-3% for thermal power generation (Shiklomanov, 1999).

T15



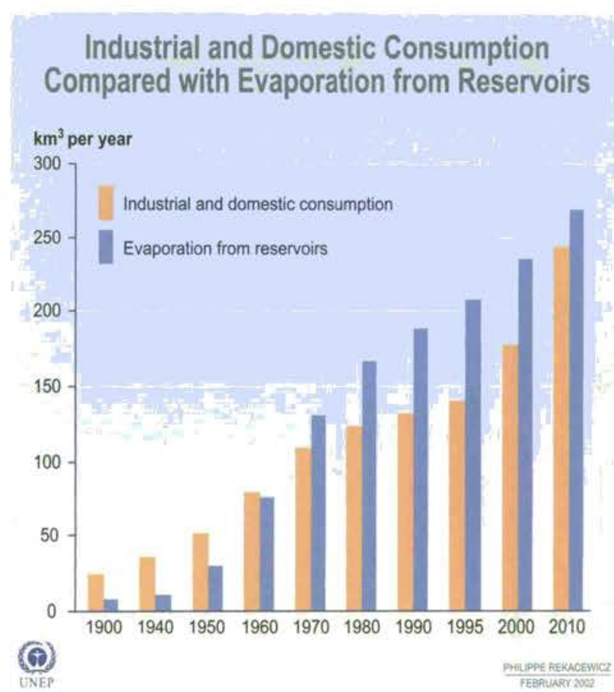
UNEP

Note: Domestic water consumption in developed countries (500-800 litres per person per day) is about six times greater than in developing countries (60-150 litres per person per day).

PHILIPPE REKACEWICZ FEBRUARY 2002

Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999.

T15



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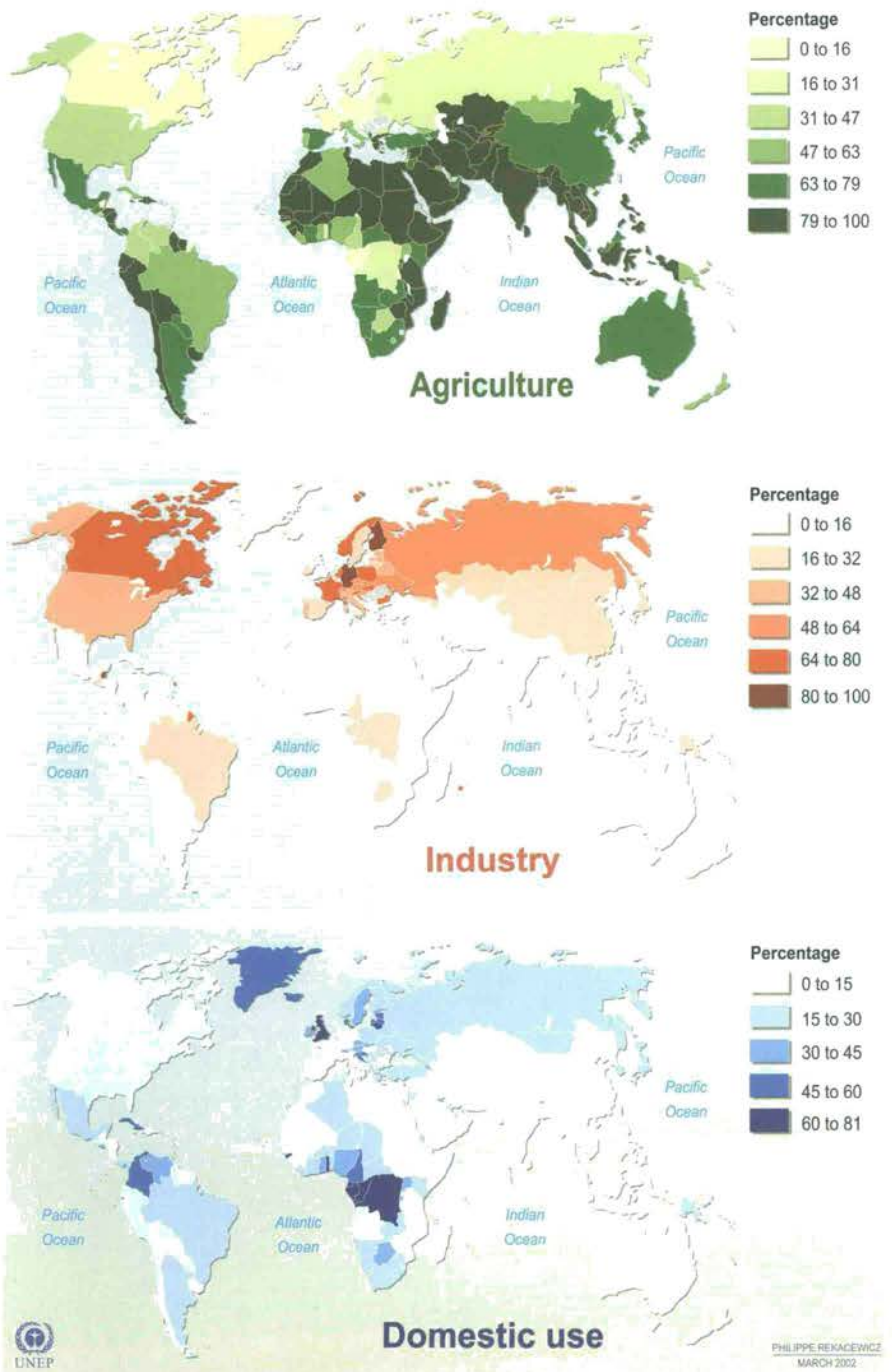
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Domestic water use is related to the quantity of water available to populations in cities and towns.

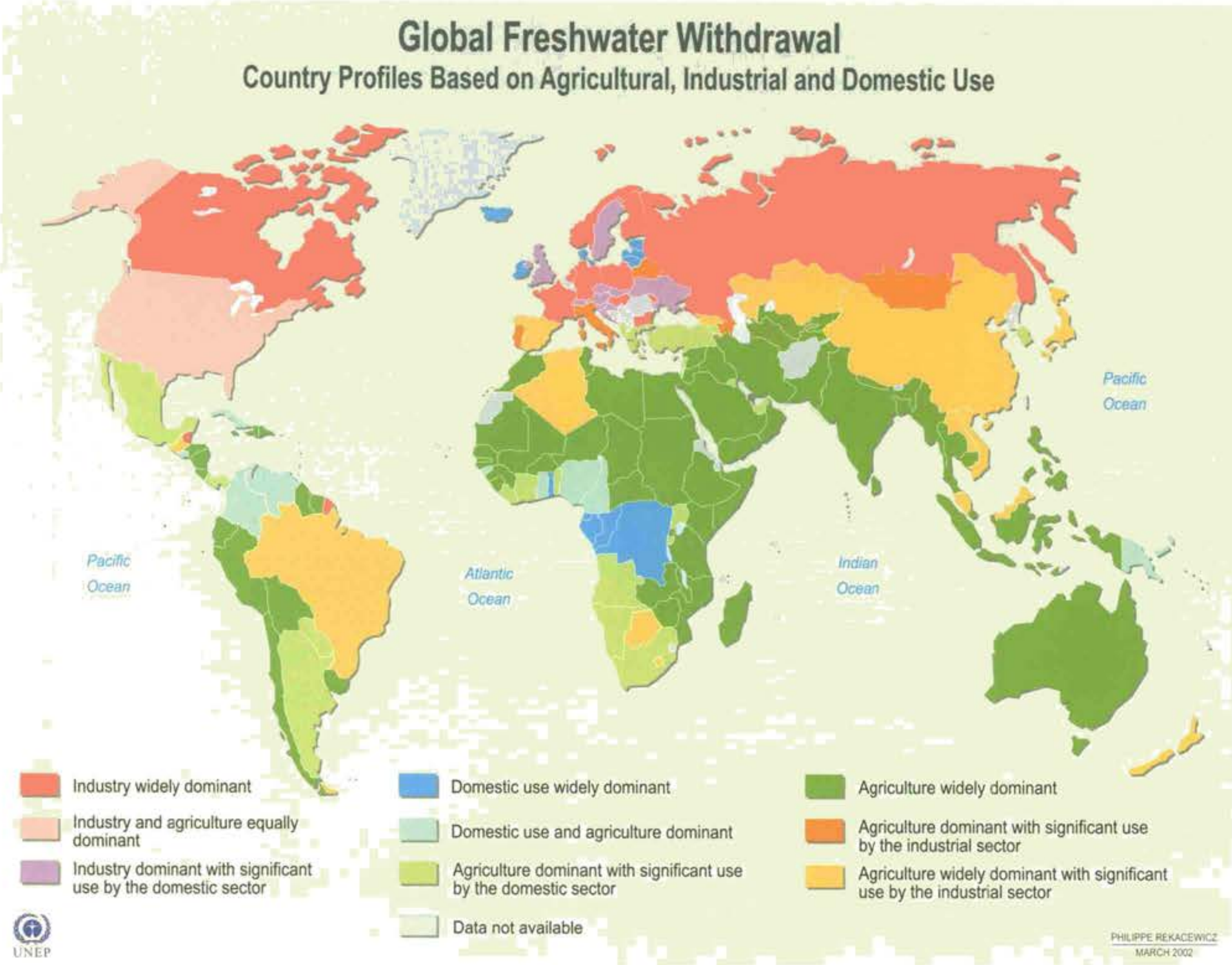
- People in developed countries on average consume about 10 times more water daily than those in developing countries. It is estimated that the average person in developed countries uses 500-800 litres per day (300 m^3 per year), compared to 60-150 litres per day (20 m^3 per year) in developing countries (UNESCO, 2000).
- In large cities with a centralised water supply and an efficient canalisation system, domestic consumption does not usually represent more than 5-10% of the total water withdrawal (intake) (UNESCO, 2000).
- Water withdrawal in large cities is estimated at 300-600 litres per person per day, while small cities have a water withdrawal of ~100-150 litres, and consumption can reach 40-60% of the total water intake (UNESCO, 2000).
- In developing countries in Asia, Africa and Latin America, public water withdrawal represents just 50-100 litres per person per day. In regions with insufficient water resources, this figure may be as low as 20-60 litres per day (UNESCO, 2000).

T16

Freshwater Withdrawal by Sector in 2000



Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

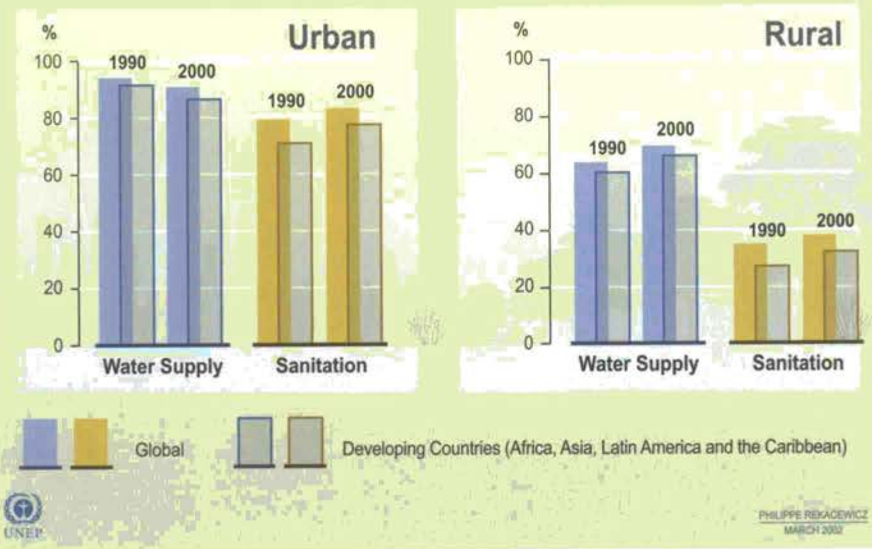


Source: Based on data from Table FW1 in *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

Managing water resources using an integrated river basin management approach is the most sustainable way of ensuring ecosystem integrity. In this respect, there is a need to consider the economic value of freshwater ecosystems, including their fisheries, wildlife habitats, recreation and natural flood control benefits.

T18

Water Supply and Sanitation Coverage



Source : *Global Water Supply and Sanitation Assessment 2000 Report*, World Health Organisation (WHO) and United Nations International Children's Emergency Fund (UNICEF), 2000.

The **supply** of safe drinking water and the provision of **sanitation** are management issues that raise concerns of inequitable service provision, particularly in developing countries. Although several successful initiatives have been launched to supply safe drinking water to urban populations, efforts continue to fall short of the required targets for sustainable development. In developing countries, water delivery systems are plagued by leakages, illegal connections and vandalism, while precious water resources are squandered through greed and mismanagement. The World Bank recently estimated that US $600 billion is required to repair and improve the world's water delivery systems (UNCSD, 1999).

During the 1990s, the greatest reduction in per capita water supply was in Africa (by 2.8 times), Asia (by two times), and Latin America and the Caribbean (by 1.7 times). The water supplies available to European populations for that period decreased only by 16% (WHO/UNICEF, 2000).

The lack of access to safe drinking water and sanitation is directly related to poverty, and in many cases to the inability of governments to finance satisfactory water and sanitation systems. The direct and indirect human costs of these failings are enormous, including widespread health problems, heavy labour (particularly for women, who are forced to travel long distances to obtain water for their families), and severe limitations for economic development (Gleick, 1995). Improved water and sanitation facilities, on the other hand, bring valuable benefits for both social and economic development and poverty alleviation (WHO/UNICEF 2000).

Water Supply Highlights, from *The Global Water Supply and Sanitation Assessment 2000*

- The percentage of people served with some form of improved water supply rose from 79% (4.1 billion people) in 1990 to 82% (4.9 billion) in 2000. Between 1990 and 2000, approximately 816 million additional people gained access to water supplies – an improvement of 3%.
- Two of every five Africans lack access to an improved water supply. Throughout Africa, rural water services lag far behind urban services.
- During the 1990s, rural water supply percentage coverage increased while urban coverage decreased – although the number of people who lack access to water supplies remained about the same.
- In Africa, Asia, Latin America and the Caribbean, nearly 1 billion people in rural areas have no access to improved water supplies.
- To achieve the 2015 targets in Africa, Asia, Latin America and the Caribbean, water supplies will have to reach an additional 1.5 billion people.

Source: WHO/UNICEF, 2000.

Sanitation Highlights, from *The Global Water Supply and Sanitation Assessment 2000*

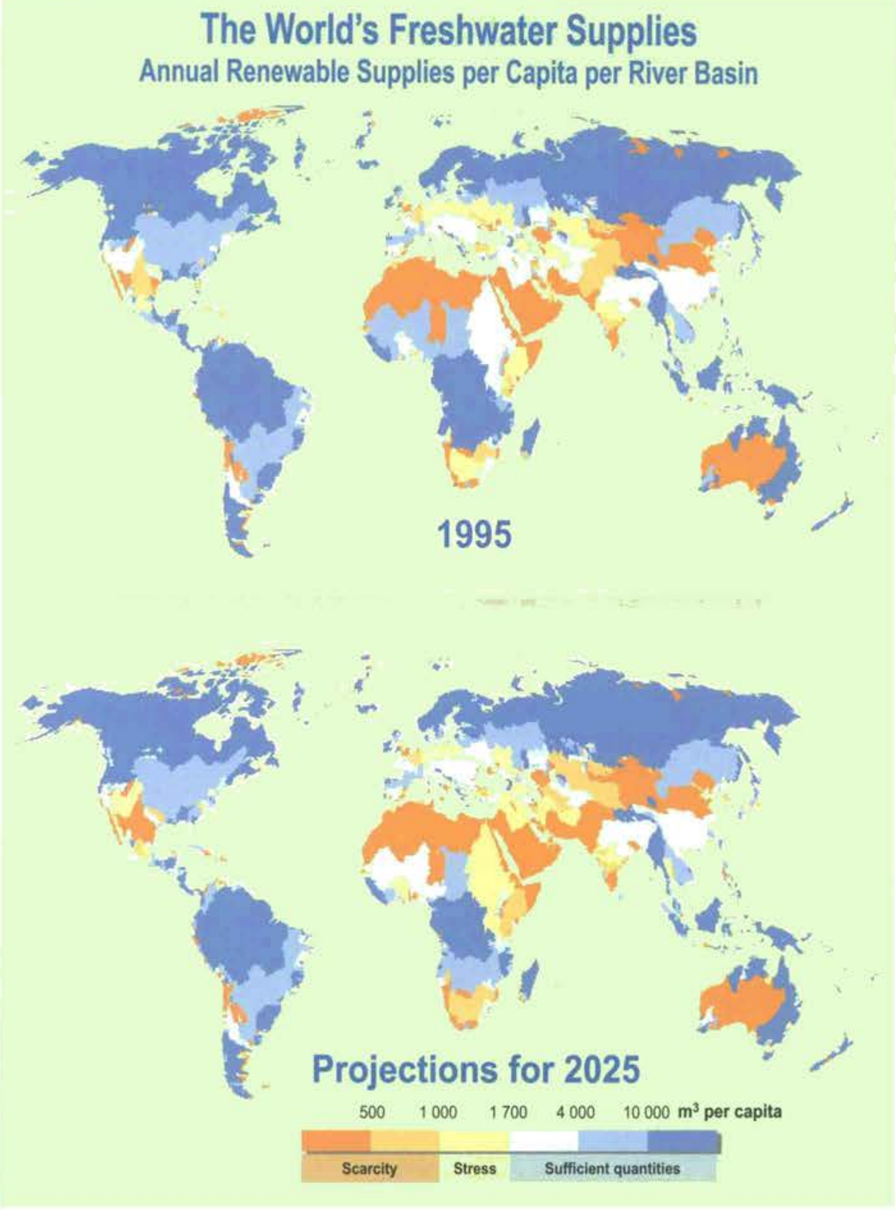
- The proportion of people with access to excreta disposal facilities increased from 55% (2.9 billion people) in 1990 to 60% (3.6 billion) in 2000. Between 1990 and 2000, approximately 747 million additional people gained access to sanitation facilities – although the number of people who lack access to sanitation services remained roughly the same.
- At the beginning of 2000, two-fifths of the world's population (2.4 billion people) lacked access to improved sanitation facilities. The majority of these people live in Asia and Africa, where fewer than half of all Asians have access to improved sanitation.
- Sanitation coverage in rural areas is less than half of that in urban locations, even though 80% of those lacking adequate sanitation (2 billion people) live in rural areas – some 1.3 billion in China and India alone.
- In Africa, Asia, Latin America and the Caribbean, nearly 2 billion people in rural areas have no access to improved sanitation facilities.
- To achieve 2015 sanitation targets in Africa, Asia, Latin America and the Caribbean, an additional 2.2 billion people will have to be provided with sanitation facilities.
- Polluted water is estimated to affect the health of more than 1.2 billion people, and to contribute to the death of an average 15 million children every year. In 1994, WHO estimated the number of people without access to clean drinking water at 1.3 billion. By 2000, nearly 1.2 billion people lacked access to clean water, while 2.4 billion lacked access to adequate sanitation services.

Source: WHO/UNICEF, 2000.

Problems Related to Freshwater Resources

Although the absolute quantities of freshwater on Earth have remained approximately the same, the uneven distribution of water and human settlement continues to create growing problems of **freshwater availability and accessibility**.

T19



	m³ per capita per year		m³ per capita per year		m³ per capita per year
North America		**Europe**		**Asia and Australia**	
1 Yukon	1 249 832	25 Danube	2 519	13 Volga	4 260
2 Mackenzie	408 243			14 Ob	14 937
3 Nelson	15 167	**Africa and West Asia**		15 Yenisey	79 083
4 Mississippi	8 973	8 Niger	4 076	16 Lena	161 359
5 St. Lawrence	9 095	9 Lake Chad Basin	7 922	17 Kolyma	722 456
		10 Congo	22 752	18 Amur	4 917
South America		11 Nile	2 207	19 Ganges and Brahmaputra	-
6 Amazon	273 767	12 Zambezi	-	20 Yangtze	2 265
7 Paraná	8 025	26 Orange	1 050	21 Murray Darling	-
		24 Euphrates and Tigris	2 189	22 Huang He	361
				23 Indus	830

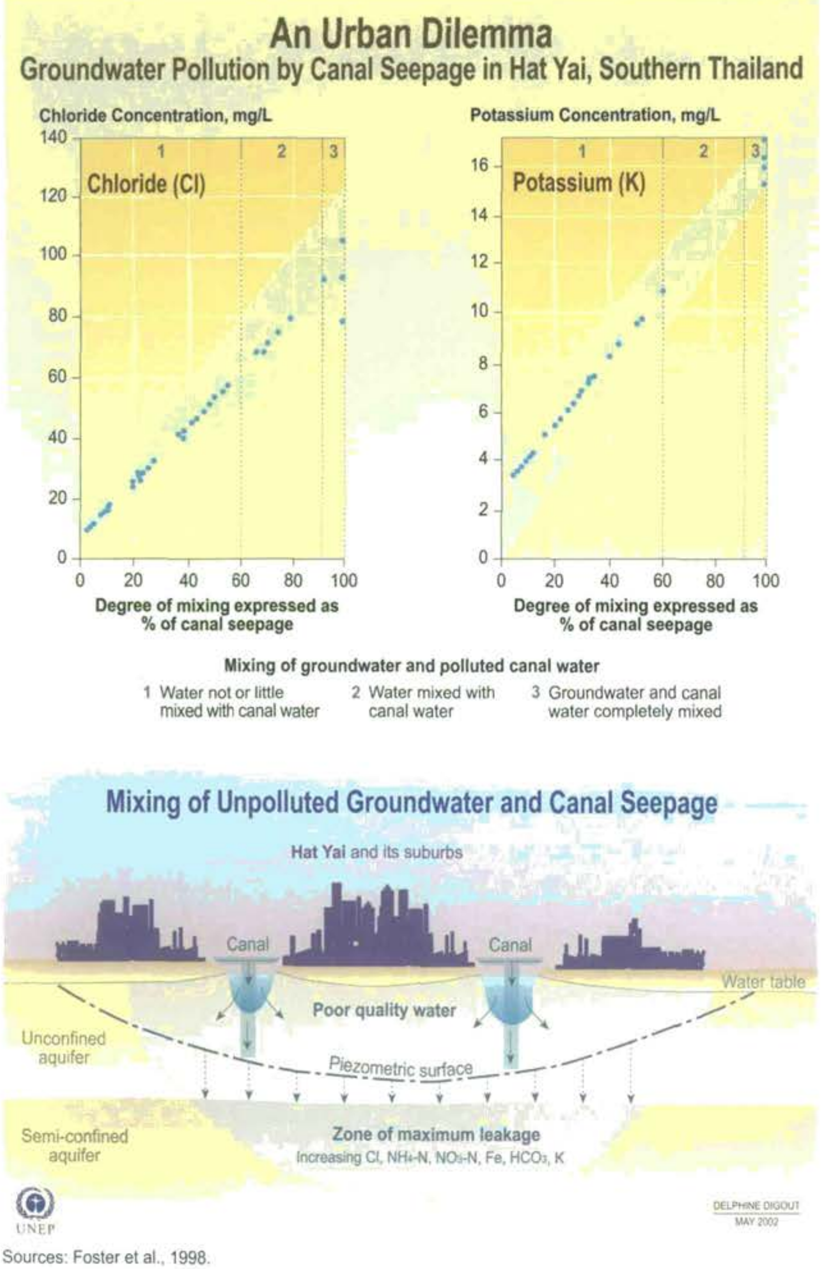
Source: Revenga et al. 2000, from *Pilot Analysis of Global Ecosystems: Freshwater Systems.*

In areas where surface water is not readily available (located far away from areas of need), groundwater is the primary water source. Groundwater aquifers supply an estimated 20% of the global population living in arid and semi-arid regions. Despite their widespread presence, groundwater aquifers in arid areas receive only limited and/or seasonal recharge – making such aquifers susceptible to rapid depletion. The Northern Sahara Basin Aquifer, for example, was exploited at almost twice its replenishment rate during the 1990s, causing many of its springs to stop flowing (Jackson et al., 2001). The rapid shift of populations to urban areas is causing ever-greater demands on groundwater resources, particularly in the developing world.

Where cities are located above productive aquifers and are far from surface water supplies, groundwater is usually the primary freshwater source. It is primarily exploited through hand-dug wells or drilled boreholes (Foster et al., 1998). Although urban aquifers meet the growing water demands of several major cities today (Merida, Madras, Bangkok, Hat Yai, Santa Cruz, Dakar), major problems are being caused by unregulated groundwater exploitation, and the disposal of solid and liquid wastes above or into these aquifers. A growing number of large urban centre aquifers are facing pollution from organic chemicals, pesticides, nitrates, heavy metals and waterborne pathogens.

The level of water and wastewater service provision can also radically alter aquifer replenishment mechanisms, affecting not only the dynamic equilibrium between increased recharge availability and pumped withdrawals, but also the magnitude of the pollutant load and the rate of aquifer contamination. All these problems occur to a certain degree in towns and cities, depending upon their type of groundwater supply.

T20



Sources: Foster et al., 1998.

Cities With Groundwater Problems

- **Hat Yai**, Thailand: Mixing of unpolluted regional groundwater and canal seepage has occurred in this busy border city. It was discovered that the most polluted urban groundwater has high chloride concentrations, indicating that canal water seepage has occurred at groundwater abstraction points and where downward leakage is greatest.
- **Merida**, Yucatan Peninsula, Mexico: With no main sewerage system, the majority of Merida's wastewater is disposed of directly to the ground via septic tanks, soak-aways, and cesspits. The fissured nature of the local limestone means that water movement to the water table is frequently rapid, and the vadose zone provides virtually no attenuation capacity because the aperture of the fissures is many times larger than the size of pathogenic micro-organisms. Not surprisingly, the shallow aquifer has been grossly contaminated, with fecal coliforms (FC) typically in the range of 1 000-4 000 per 100 ml. The permitted concentration set by WHO for drinking water is <1 per 100 ml.
- **Santa Cruz**, Bolivia: This low-rise, relatively low-density, but fast-growing city derives its water supply from wellfields within the city limits, which extract from deep semi-confined alluvial aquifers. Although groundwater in the deeper aquifer, below 100 metres, is of excellent quality, the uppermost aquifer above 45 metres has begun to show substantial deterioration, with elevated nitrate and chloride concentrations under the more densely populated districts. These are caused by effluent disposal to the ground, mainly from on site sanitation units. This urban recharge is drawn downwards in response to pumping from the deeper semi-confined aquifers. Dissolved oxygen in the urban recharge is low, being consumed as the carbon in the organic load is oxidized to carbon dioxide, which, in turn, reacts with carbonate minerals in the aquifer matrix to produce bicarbonate. The oxidation of the high organic load also mobilises naturally occurring manganese from the aquifer matrix, and some of the production boreholes in the main wellfield have started to show concentrations above 0.5 mg per litre, leading to taste and laundry problems.

Source: Lawrence et al., 1997.

It is estimated that water pollution/contamination denies close to 1.3 billion people (~ 20% of the global population in 2000) access to clean water supplies. In 1986, WHO reported that there were 250 million new cases of waterborne diseases each year, causing the deaths of nearly 3.5 million people. An estimated 4.2 billion cases of waterborne diseases are reported each year, with diarrhoea accounting for 4 billion of the total (Cosgrove and Rijsberman, 2000; Revenga et al., 2000).

Some 460 million people – more than 8% of the world's population – live in countries using so much of their freshwater resources that they can be considered highly water **stressed** (UNCSD, 1999; WMO 1997). A further 25% of the population lives in countries approaching a position of serious water stress (WMO, 1997).

Definitions of Water Stress and Scarcity

An area is experiencing **water stress** when annual water supplies drop below 1 700 m^3 per person. When annual water supplies drop below 1 000 m^3 per person, the population faces **water scarcity**.

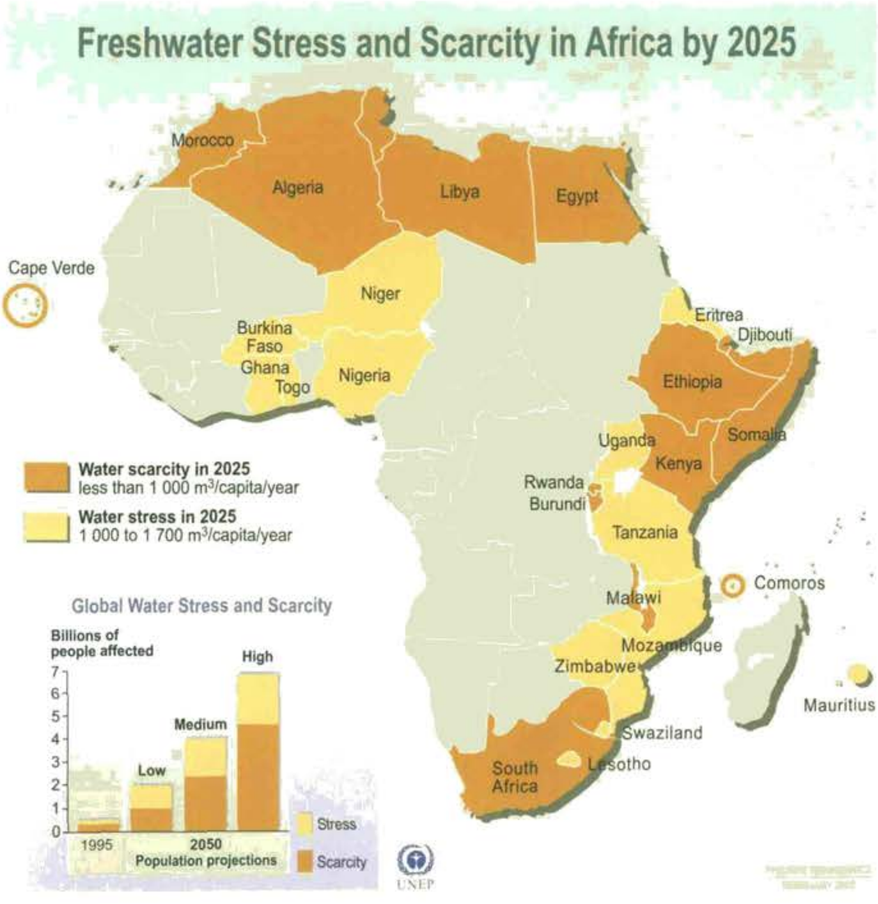
Sources: UNPD, UNEP, World Bank, and WRI, 2000.

Water scarcity occurs when the amount of water withdrawn from lakes, rivers or groundwater is so great that water supplies are no longer adequate to satisfy all human or ecosystem requirements, resulting in increased competition between water users and demands.

According to Population Action International, based upon the UN Medium Population Projections of 1998, more than 2.8 billion people in 48 countries will face water stress or scarcity conditions by 2025. Of these countries, 40 are in West Asia, North Africa or Sub-Saharan Africa. Over the next two decades, population increases and growing demands are projected to push all the West Asian countries into water scarcity conditions. By 2050, the number of countries facing water stress or scarcity could rise to 54, with their combined population being 4 billion people – about 40% of the projected global population of 9.4 billion (Gardner-Outlaw and Engleman, 1997; UNFPA, 1997).

- Many African countries, with a population of nearly 200 million people, are facing serious water shortages. By the year 2025, it is estimated that nearly 230 million Africans will be facing water scarcity, and 460 million will live in water-stressed countries (Falkenmark, 1989).
- Today 31 countries, accounting for less than 8% of the world's population, face chronic freshwater shortages. Among the countries likely to run short of water in the next 25 years are Ethiopia, India, Kenya, Nigeria and Peru. Parts of other large countries (eg. China) already face chronic water problems (Hinrichsen et al., 1998; Tibbetts, 2000).
- Bahrain, Kuwait, Saudi Arabia and the United Arab Emirates have resorted to the desalinisation of seawater from the Gulf. Bahrain has virtually no freshwater (Riviere, 1989). Three-quarters of Saudi Arabia's freshwater comes from fossil groundwater, which is reportedly being depleted at an average of 5.2 km^3 per year (Postel, 1997).

T21



Source: United Nations Economic Commission for Africa (UNECA), Addis Ababa; Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999; Population Action International.

Water has been associated with **conflicts** between several neighbouring countries. In Africa, Central Asia, West Asia and the Americas, some countries are arguing fiercely over access to rivers and inland seas, and confrontations could arise as water shortages grow (Gleick, 2000).

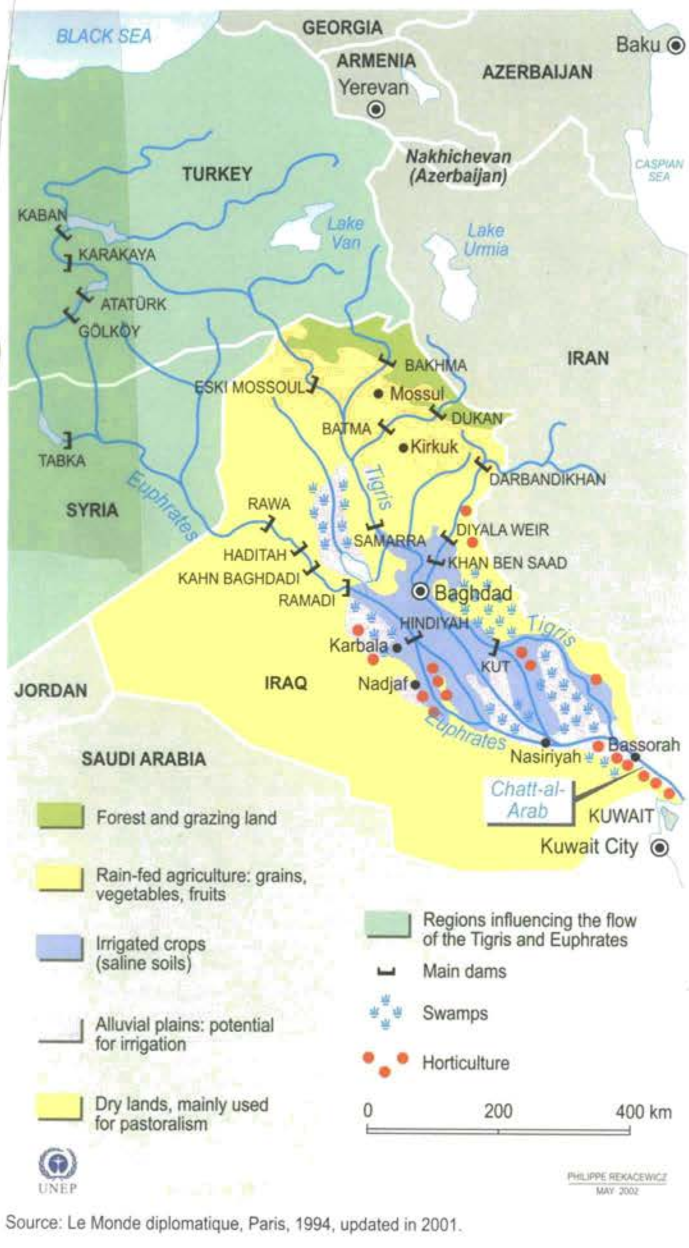
Countries currently or potentially involved in international disputes over access to river water and aquifers include:

- Turkey, Syria and Iraq (the Tigris and Euphrates rivers);
- Israel, Jordan, Syria and Palestine (the Jordan River and the aquifers of the Golan Heights);
- India and Pakistan (the Punjab rivers);
- India and Bangladesh (the Ganges and Brahmaputra rivers);
- China, Indochina and Thailand (the Mekong River);
- Tajikistan, Kyrghyzstan and Uzbekistan (the Oxus and Jaxartes rivers);
- Ethiopia, Sudan and East African riparian countries, including Kenya, Tanzania, Rwanda, Burundi, Uganda and Egypt (the Nile River) (Gleick, 2000; Villers, 1999).

T22

Turning the Tides

Regulation of the Tigris and Euphrates Rivers



Source: Le Monde diplomatique, Paris, 1994, updated in 2001.

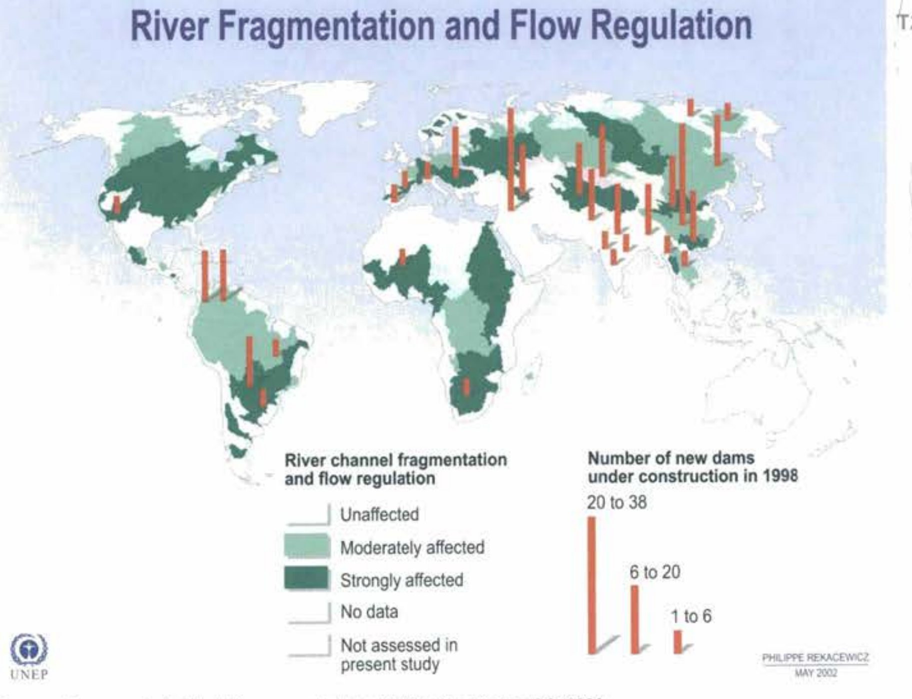
Freshwater ecosystem alterations have been carried out by man through much of modern history, with the intensity of modifications increasing in the early to mid-1900s. Common waterway modifications – such as the construction of dams and irrigation channels, inter-basin connections and water transfers – can impact on the hydrology of freshwater systems, disconnect rivers from floodplains and wetlands, and decrease water velocity in riverine systems. This, in turn, can affect the seasonal flow and sediment transport of rivers downstream, impacting on fish migrations and changing the composition of riparian ecosystems. Exotic species often thrive at the expense of indigenous ones, leading to an unquantifiable loss in freshwater biodiversity and inland fishery resources (Revenga et al., 2000).

The construction of **large dams** – defined as those with walls at least 15 metres high – has increased significantly over the past 50 years. The average height of new dams, estimated at 30-34 metres from 1940-1990, increased to about 45 metres in the 1990s, due largely to construction trends in Asia. The average area and volume of freshwater reservoirs have also steadily increased, rising to about 50 km^2 between 1945 and1970, declining through the 1980s to 17 km^2, and increasing again in the 1990s to about 23 km^2 (WCD, 2000).

By 1997, there were more than 45 000 large dams worldwide, 22 100 of them in China. Other nations with many large dams include the United States (with 6 390 large dams), India (with more than 4 000), and Spain and Japan (with 1 000-1 200 each) (WCD, 2000).

The countries with the greatest number of large dams under construction, in order of significance, are Turkey, China, Japan, Iraq, Iran, Greece, Romania and Spain, and countries in the Parana basin in South America. The river basins with the most large dams under construction are the Yangtze with 38, the Tigris and Euphrates, with 19 each, and the Danube, with 11 (Revenga et al., 2000).

Damming and flood control can have negative impacts, such as declining fish catches, loss of freshwater biodiversity, increases in the frequency and severity of floods, loss of soil nutrients on floodplains, and increases in diseases such as schistosomiasis and malaria. In Egypt, for example, the massive Aswan Dam has caused the fertile Nile Delta to shrink, with 30 of 47 commercially exploited fish species becoming economically or biologically extinct. On the Mississippi River, the rising frequency and severity of flooding – attributed to local flood control structures – have reduced the river's ability to support native flora and fauna. And a dramatic increase in floods on the Rhine River has been attributed to increased urbanisation, engineering, and the walling off of the river from its floodplain (Revenga et al., 1998).



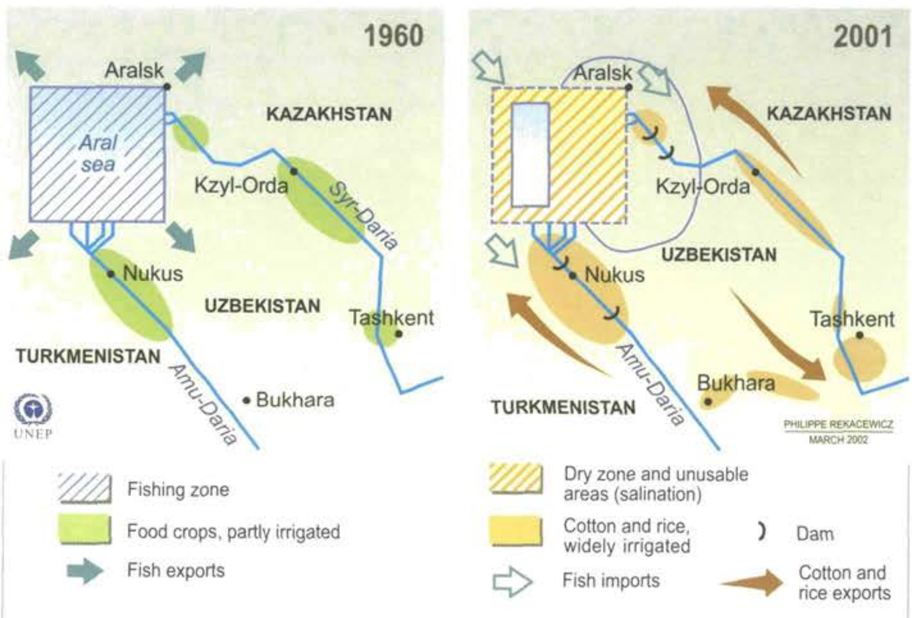
Source: Revenga et al., World Resources Institute (WRI), Washington DC, 2000.

River fragmentation - the interruption of a river's natural flow by dams, inter-basin transfers or water withdrawal - is an indicator of the degree to which rivers have been modified by man (Ward and Stanford, 1989, and Dynesius and Nilsson, 1994, as cited in Revenga et al., 2000). A fragmentation analysis carried out by the University of Umea and the World Resources Institute showed that, of 227 rivers assessed, 37% were strongly affected by fragmentation and altered flows, 23% were moderately affected, and 40% were unaffected.

- Strongly or moderately fragmented systems accounted for nearly 90% of the total water volume flowing through the rivers analysed.
- Strongly fragmented river systems are defined as "rivers with less than a quarter of their main channel remaining without dams, where the largest tributary has at least one dam, as well as rivers where the annual flow pattern has changed substantially." Fragmented rivers are only considered unaffected if their main channel has no dams or, if their tributaries have been dammed, the total river discharge has only declined by less than 2% (Revenga et al., 2000).
- The combined length of rivers altered for shipping increased from less than 9 000 km in 1900 to more than 500 000 km in 1997 (Naiman et al., 1995, as cited in Revenga et al., 2000).
- The only remaining large free-flowing rivers in the world are found in the tundra regions of North America and Russia, and in smaller coastal basins in Africa and Latin America.
- Considerable parts of large rivers in the tropics, such as the Amazon, the Orinoco and the Congo, remain basically unaffected. China's Yangtze River will become strongly affected with the completion of the Three Gorges dam project (Revenga et al., 2000).

The last three decades have seen several inland ecosystems (eg. the Aral Sea, Lake Chad, the Mesopotamian Marshlands) decline in size and function.

T24 **The Shrinking of the Aral Sea: Socio-Economic Impacts**

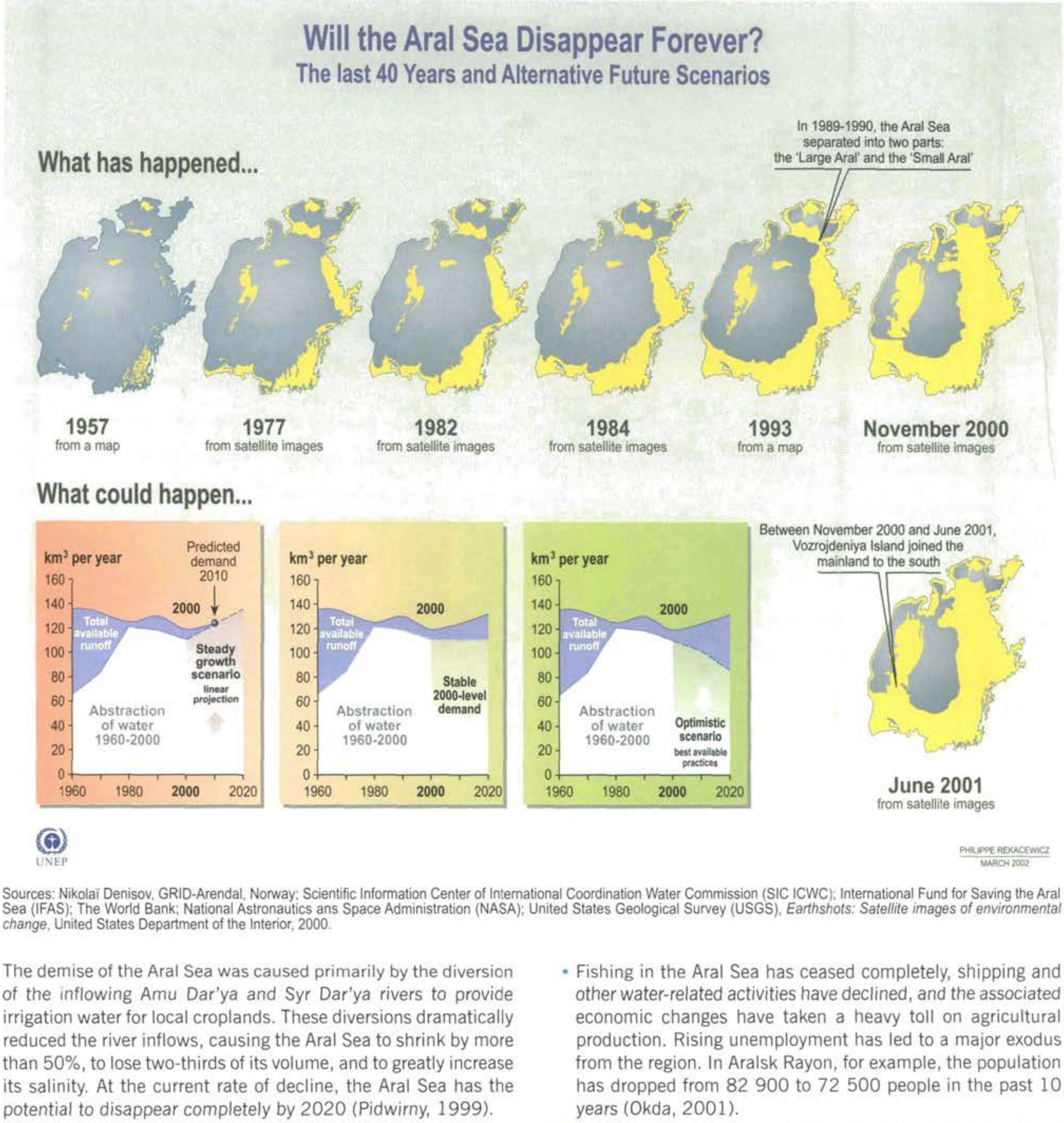


Source: Philippe Rekacewicz, *An Assassinated Sea*, in Histoire-Géographie, initiation économique, page 333, Classe de Troisième, Hatier, Paris, 1993 (data updated in 2002); *L'état du Monde*, 1992 and 2001 editions, La Découverte, Paris.

The Aral Sea: A shrinking regional resource

Over the past 30 years, the Aral Sea in the former Soviet Union has shrunk to less than half of its original size. The reduction in the quantity and quality of water in the Aral Sea basin, and the resulting spread of toxic dusts, has caused an ecological and socio-economical disaster in the region (Pidwirny, 1999).

T25



Sources: Nikolaï Denisov, GRID-Arendal, Norway; Scientific Information Center of International Coordination Water Commission (SIC ICWC); International Fund for Saving the Aral Sea (IFAS); The World Bank; National Astronautics ans Space Administration (NASA); United States Geological Survey (USGS), *Earthshots: Satellite images of environmental change*, United States Department of the Interior, 2000.

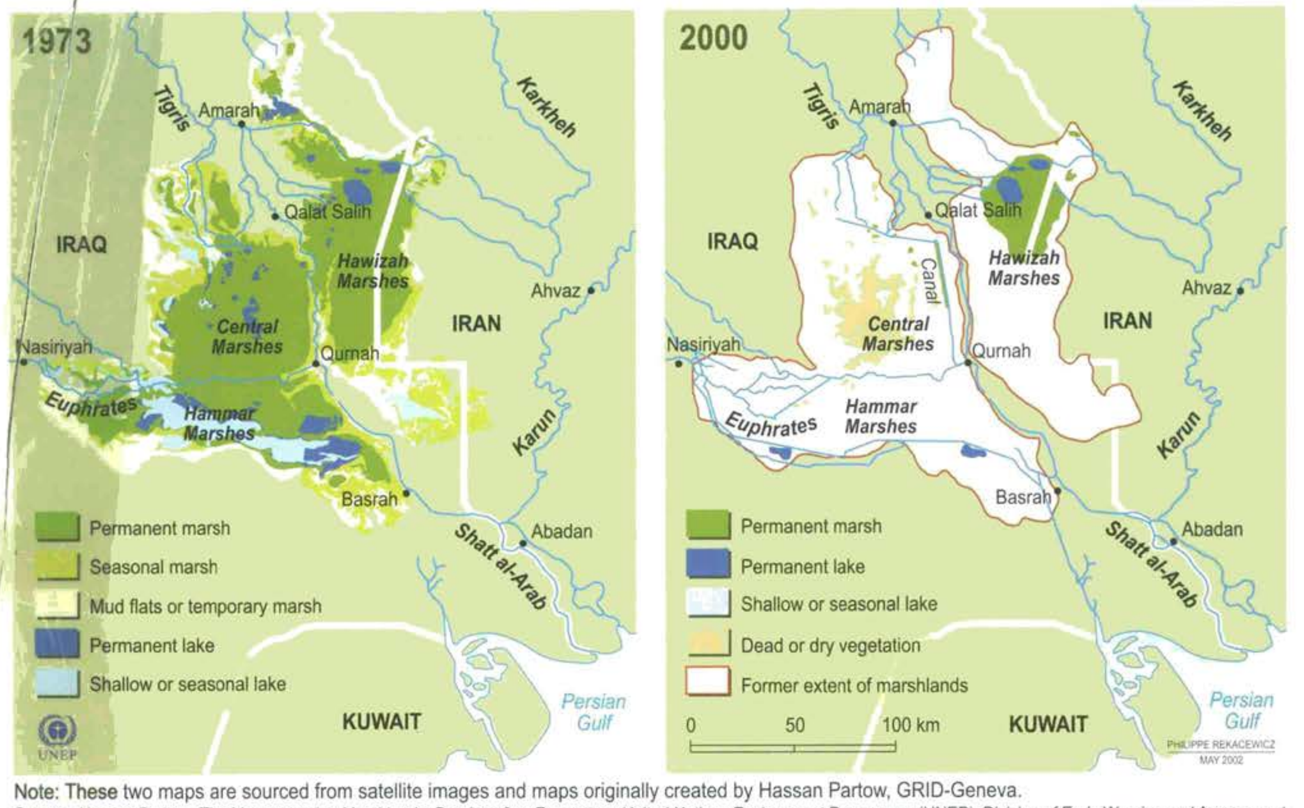
The demise of the Aral Sea was caused primarily by the diversion of the inflowing Amu Dar'ya and Syr Dar'ya rivers to provide irrigation water for local croplands. These diversions dramatically reduced the river inflows, causing the Aral Sea to shrink by more than 50%, to lose two-thirds of its volume, and to greatly increase its salinity. At the current rate of decline, the Aral Sea has the potential to disappear completely by 2020 (Pidwirny, 1999).

- In 1963, the surface of the Aral Sea measured 66 100 km², with an average depth of 16 metres and a maximum depth of 68 metres. The salt content was 1%. During the 1960s, upstream irrigation schemes for growing rice and cotton consumed 90% of the natural flow of water from the Tian Shan Mountains.
- By 1987, 27 000 km² of former sea bottom had become dry land. About 60% of the Aral Sea's volume had been lost, its depth had declined by 14 metres, and its salt concentration had doubled.
- Today, about 200 000 tonnes of salt and sand are carried by the wind from the Aral Sea region every day, and dumped within a 300 km radius. The salt pollution is decreasing the area available for agriculture, destroying pastures, and creating a shortage of forage for domestic animals. The number of domestic animals in the region has become so low that the government has issued a decree to reduce their slaughter for food.
- Fishing in the Aral Sea has ceased completely, shipping and other water-related activities have declined, and the associated economic changes have taken a heavy toll on agricultural production. Rising unemployment has led to a major exodus from the region. In Aralsk Rayon, for example, the population has dropped from 82 900 to 72 500 people in the past 10 years (Okda, 2001).
- The quality of drinking water has continued to decline due to increasing salinity, bacteriological contamination, and the presence of pesticides and heavy metals.
- Diseases like anaemia, cancer and tuberculosis, and the presence of allergies, are on the rise. The incidence of typhoid fever, viral hepatitis, tuberculosis and throat cancer is three times the national average in some areas (DLR, 2002; LEAD, 1997; Okda, 2001).

Recently steps have been taken to change this disastrous state, through the International Fund for Saving the Aral Sea (UNEP, GRID-Arendal, IFAS, 1997). If all steps are adhered to, a substantial recovery might be achieved within 20 years, although it is doubtful that the Aral Sea will ever be restored to the conditions that existed before the large-scale diversion of its inflowing rivers.

From Wetlands to Dry Lands

The Destruction of the Mesopotamian Marshlands



Note: These two maps are sourced from satellite images and maps originally created by Hassan Partow, GRID-Geneva.
Source: Hassan Partow, *The Mesopotamian Marshlands: Demise of an Ecosystem*, United Nations Environment Programme (UNEP), Division of Early Warning and Assessment (DEWA), 2001.

Wetlands remain a grossly underestimated asset in many parts of the world. Because of their erroneous reputation as unproductive ecosystems or hazardous places, many governments still encourage the conversion of wetlands to more productive land uses. In recent years, however, people are coming to understand and appreciate the multitude of vital environmental functions that wetlands perform.

The value of these environmental services to humankind is immense. Costanza et al. (1998) estimated the global value of wetlands at nearly US $5 trillion a year, based on their ecosystem functions as flood regulators, waste treatment plants, wildlife habitats, and areas of fisheries production and recreation. Another estimate put the value of one hectare of wetland at US $15 000 (Holmes, 1997).

The Mesopotamian Marshlands: From wetlands to dry lands

The Mesopotamian Marshlands in the Tigris and Euphrates river basins were devastated by damming and river channelisation during the late 1980s. Satellite images taken in 1973-76 revealed that the wetlands were more or less intact. By 2000, however, most of the dense marsh vegetation had been replaced by vegetation on moist-to-dry soil.

- Massive drainage works in southern Iraq in the late 1980s and early 1990s, together with major upstream damming, caused the loss of more than 9 000 km^2 of wetlands and lakes from the vast and ecologically vital marshlands.
- Only minor and fragmented parcels remain today of the marshlands, which once covered an area of 15 000-20 000 km^2. At least 7 600 km^2 of primary wetlands (excluding seasonal and temporary flooded areas) were lost between 1973 and 2000, with most of the change occurring between 1991 and 1995.
- The central and Al Hammar marshlands have been completely destroyed, with 97% and 94% of their respective cover transformed into bare land and salt crusts. Less than a third of the transboundary Hawr Al Hawizeh/Al Azim marshland remains today.
- The water filtering role of the marshland has ceased and the Saddam River discharges polluted agricultural drainage directly into the Shatt-al-Basrah Canal, before emptying into the Gulf at Umm Qasr via the Khawr al-Zubair. The seawater around Warbah Island on the Iraq-Kuwait border has become less saline and more polluted, with potentially harmful impacts on local fish resources (Partow, 2001).
- The entire Marsh Arab community has suffered serious social and economic upheaval as a result of the marshlands' destruction. About 40 000 Marsh Arabs were forced to flee to southwest Iran because of this natural disaster, combined with the 1991-93 armed conflicts (AMAR, 2001; UNCHR, 1996).
- The impact on marsh wildlife and biodiversity has been catastrophic, with the probable extinction of the endemic smooth-coated otter, and the disappearance of the African Darter and the Sacred Ibis from the Middle East. A further 66 bird species existing in the marshlands in internationally significant numbers are now at risk. A wide range of migratory aquatic species have been affected – including the penaied shrimp, which migrates between the Arabian Gulf and nursery grounds in the marshlands – with serious economic consequences for coastal fisheries in the northern Gulf.
- The disappearance of the marshlands will doubtless have a significant impact on the regional micro-climate, with an anticipated reduced cooling effect from the wetlands and lakes (Partow, 2001).

Lake Chad: A conspiracy of climate change and crops

Straddling the borders of Chad, Niger and Cameroon in West Africa, Lake Chad has been a source of freshwater for irrigation projects in all these countries. Maps drawn from a series of satellite images show a dramatic decrease in the size of the lake over the past 30 years. Since 1963, the lake has shrunk to nearly a twentieth of its original size, due both to climatic changes and to high demands for agricultural water. Since 1963, the surface area of Lake Chad has decreased from approximately 25 000 km^2 to 1 350 km^2 (*Scientific American*, 2001).

- Between June 1966 and January 1973, the surface area of Lake Chad shrunk from 22 772 km^2 to 15 400 km^2.
- In 1982, the lake's surface area was estimated to be about 2 276 km^2. In February 1994, Meteosat images were used to measure it at just 1 756 Km^2 .
- Between 1953 and 1979, irrigation had only a modest impact on the Lake Chad ecosystem. Between 1983 and 1994, however, irrigation water use increased four-fold.
- About 50% of the decrease in the lake's size since the 1960s is attributed to human water use, with the remainder attributed to shifting climate patterns.
- Invasive plant species currently cover about 50% of the remaining surface of Lake Chad.

Research carried out over the past 40 years indicates that the main factors in the shrinking of the lake have been:

- Major overgrazing in the region (Coe and Foley, 2001), resulting in the loss of vegetation and serious deforestation, contributing to a drier climate;
- Large and unsustainable irrigation projects built by Niger, Nigeria, Cameroon and Chad, which have diverted water from both the lake and the Chari and Logone rivers.

A 'Win - Win' Solution: Using Constructed Wetlands for Wastewater Treatment, Habitat Creation and Food Production

Constructed Wetlands (CWs) use the natural processes involving wetland vegetation, soils and associated microorganisms to assist in treating wastewater. They are designed to take advantage of many of the processes that occur in natural wetlands, in a more controlled environment.

Constructed Wetlands fall into two general categories: Subsurface Flow Systems (SFS) and Freewater Surface Systems (FSS). SFS systems are applied to improve water quality, while FSS systems maximise wetland habitat values and reuse opportunities, while also improving water quality.

Benefits of using Constructed Wetlands:

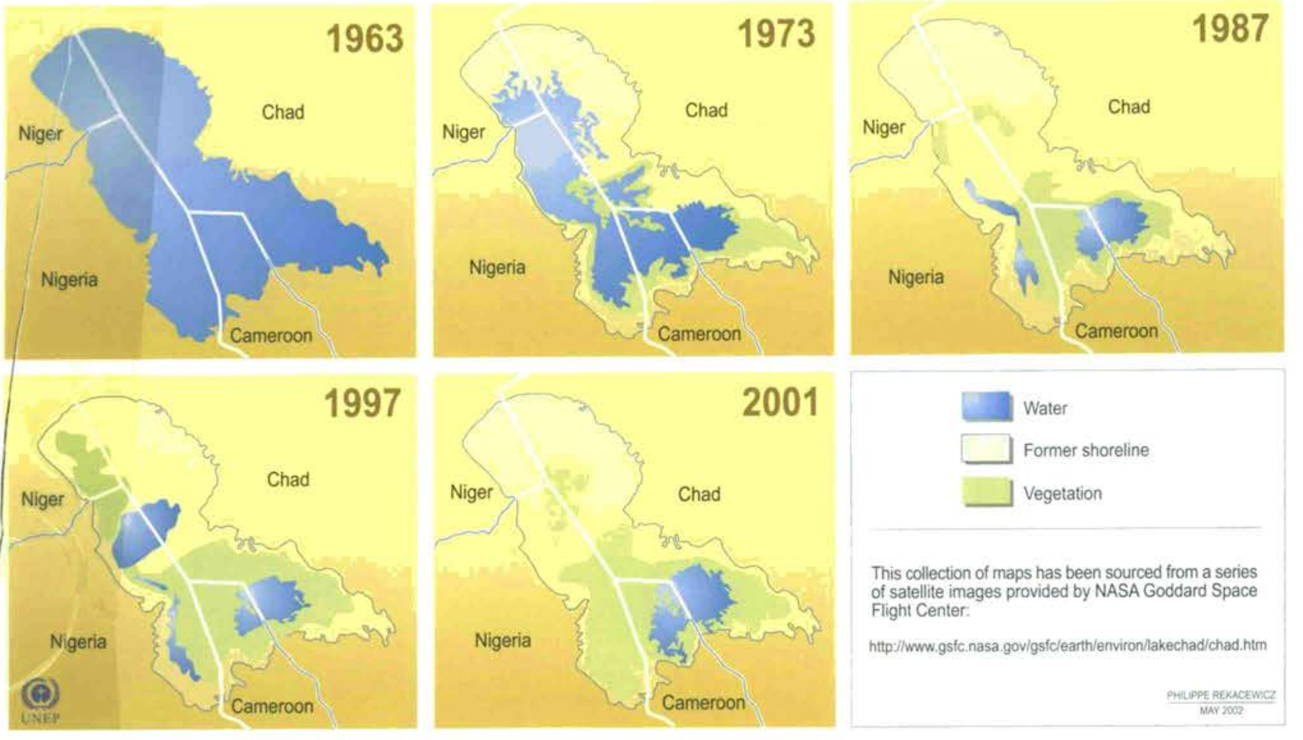
- Constructed Wetlands are an effective, environmentally friendly means of treating liquid and solid waste. Research in France in the 1980s, for example, indicated that Reed Bed Filters (SFS) designed to treat waste from 100-250 people were highly effective in improving water quality.
- CWs are effective at reducing loads of BOD/COD, nitrogen, phosphorus and suspended solids by up to 98%. However, despite the suitability of climate in developing countries, the spread of wetlands in such areas has been "depressingly slow" (Denny et al., 1997).
- In recent years, there has been a tendency to construct more SFS-type wetlands, which are believed to be more effective in treating wastes.
- Despite current usage patterns, tropical and subtropical climates hold the greatest potential for wetland use. Cold climates cause problems because of both icing and thaw. The annual production of papyrus in tropical conditions, for example, can exceed 100 tonnes per ha per year. The foliage can be sustainably cropped, while the papyrus stems can be used for matting and thatching roofs. Water that has passed through the wetland can be used to irrigate crops and/or introduce to fishponds. In this final stage, the remaining nitrates and phosphates stimulate the growth of phytoplankton – the favourite food of Tilapia, a freshwater food fish becoming increasingly popular in Europe.
- CWs require little maintenance, and remain effective after more than 10 years of use.
- CWs could bring major economic benefits to developing countries through the provision of biomass and aquaculture. Such wetland systems can yield a significant profit for local communities, and might be a powerful tool for breaking the poverty cycle.
- In developed countries, CWs can provide a valuable habitat for wildlife and a natural tourist attraction. Slimbridge in the UK has become a popular venue for viewing birds, amphibians such as frogs, newts and toads, and insects such as dragonflies. Its wetlands are also used to treat all liquid waste produced on-site (up to 4 000 m^3 per day).

Source: Fujita Research, 1998.

T27

A Chronology of Change

Natural and Anthropogenic Factors Affecting Lake Chad

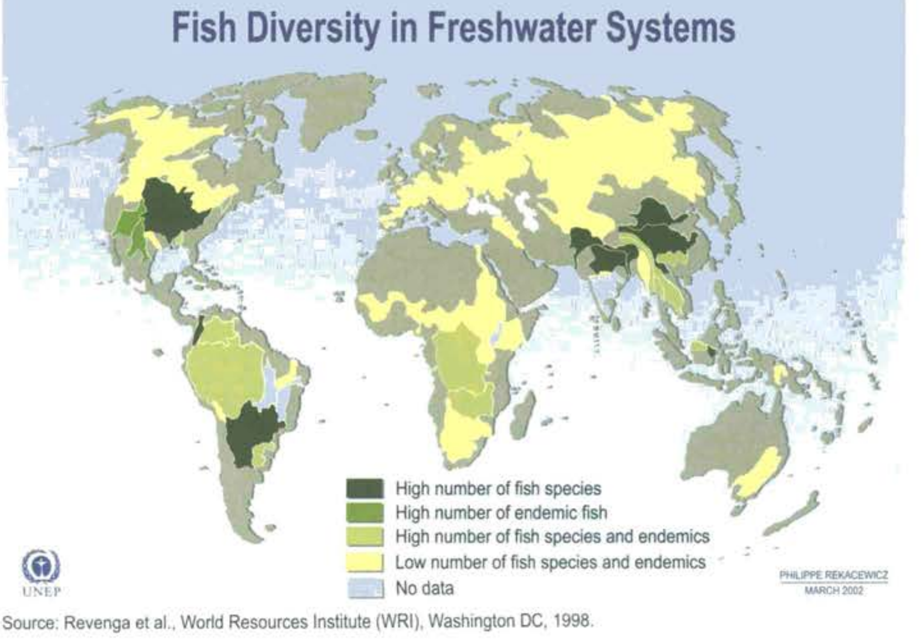


The changes in the lake have contributed to local lack of water, crop failures, livestock deaths, collapsed fisheries, soil salinity, and increasing poverty throughout the region.

Freshwater biodiversity: Although freshwater ecosystems such as rivers, lakes and wetlands occupy less than 2% of the Earth's total land surface, they provide a wide range of habitats for a significant proportion of the world's plant and animal species. Although many are yet to be discovered, the number of freshwater species worldwide is estimated at between 9 000 and 25 000 (Cosgrove and Rijsberman, 2000). This number is rapidly decreasing due to human interference.

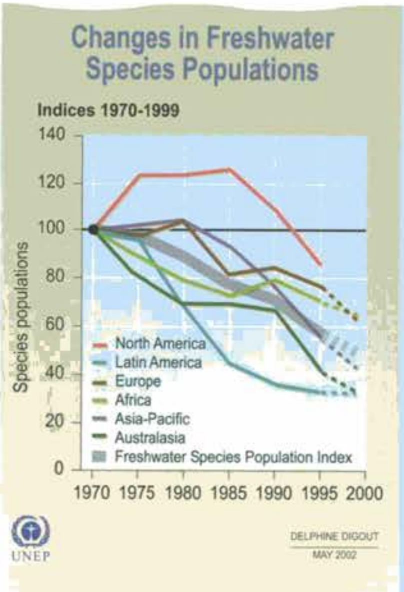
Physical alteration, habitat degradation, excessive water withdrawal and pollution have contributed directly or indirectly to the decline in freshwater species. Other factors that reduce freshwater biodiversity include the incursion of non-native species and the mismanagement of inland fisheries. Today, an estimated 20% of the world's freshwater fish are vulnerable, endangered or extinct (Revenga et al., 1998).

T29



Source: Revenga et al., World Resources Institute (WRI), Washington DC, 1998.

T28



Source: J. Loh (ed.), *Living Planet Report 2000*, World Wide Fund for Nature (WWF).

Freshwater Species Population Index

Between 1970 and 1999, the Freshwater Species Population Index fell by nearly 50%, which constitutes a very rapid decline in population indices.

The Freshwater Species Population Index measures the average change over time in the populations of some 194 species of freshwater birds, mammals, reptiles, amphibians and fish. The index represents the average of six regional indices, which measure freshwater species populations in Africa, Asia-Pacific, Australasia, Europe, Latin America and the Caribbean, and North America. There has been a much smaller decline over the past 30 years in the freshwater species of North America and Europe than those in the other regions. Much of the loss and degradation of freshwater ecosystems in the industrialised world took place prior to 1970.

The status of freshwater bird and mammal populations is better known than those of other groups. Waterfowl are among the most closely monitored of all wild species. Much less is known about population trends among freshwater fish and amphibians, although many biologists believe these to be among the most threatened classes of species in the world. Recent evidence suggests there has been a drastic decline in amphibian populations in many parts of the world since the 1950s.

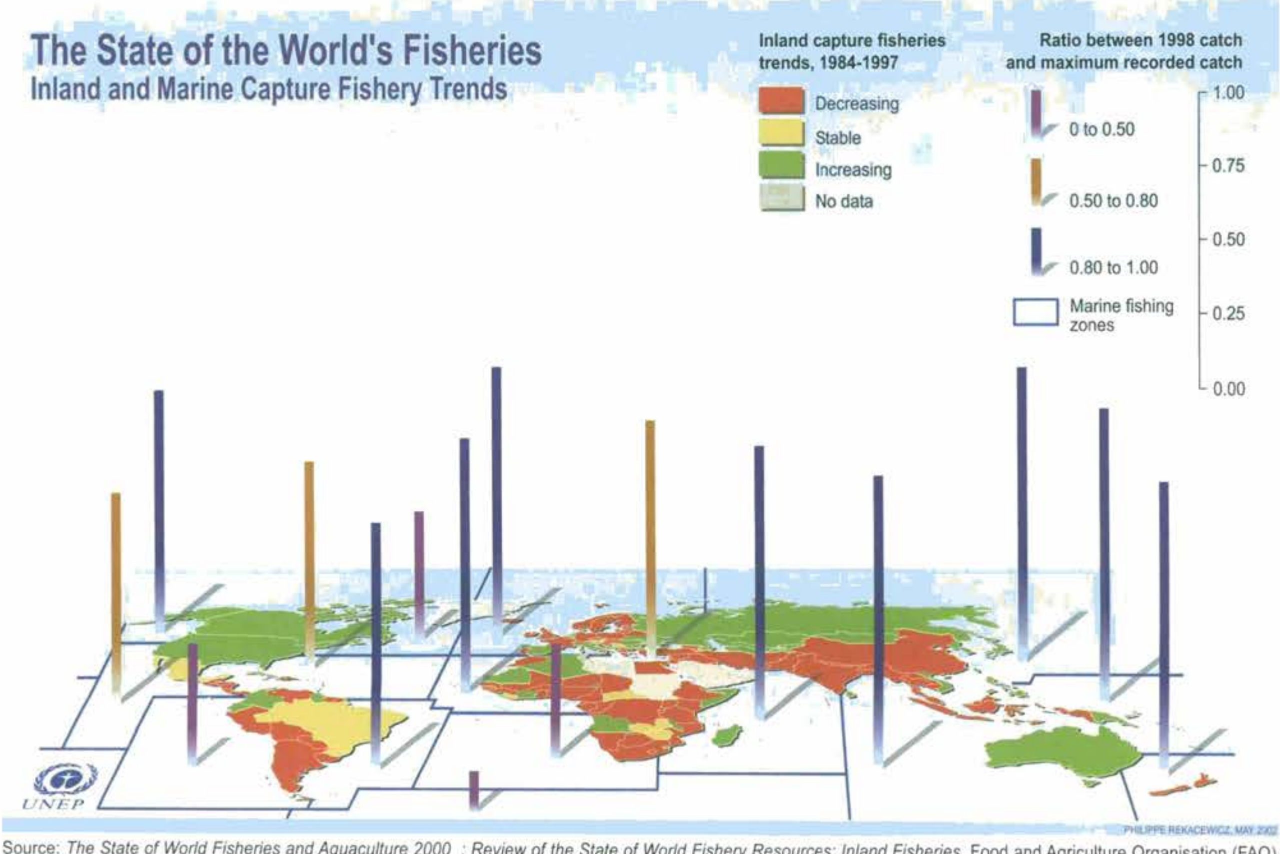
Source: Loh, 2000.

The harvest of freshwater fish is likely to increase either through **capture fisheries** or **aquaculture** (otherwise known as 'fish farming'). In many developing countries, freshwater fish provide a significant contribution to the diets of local communities.

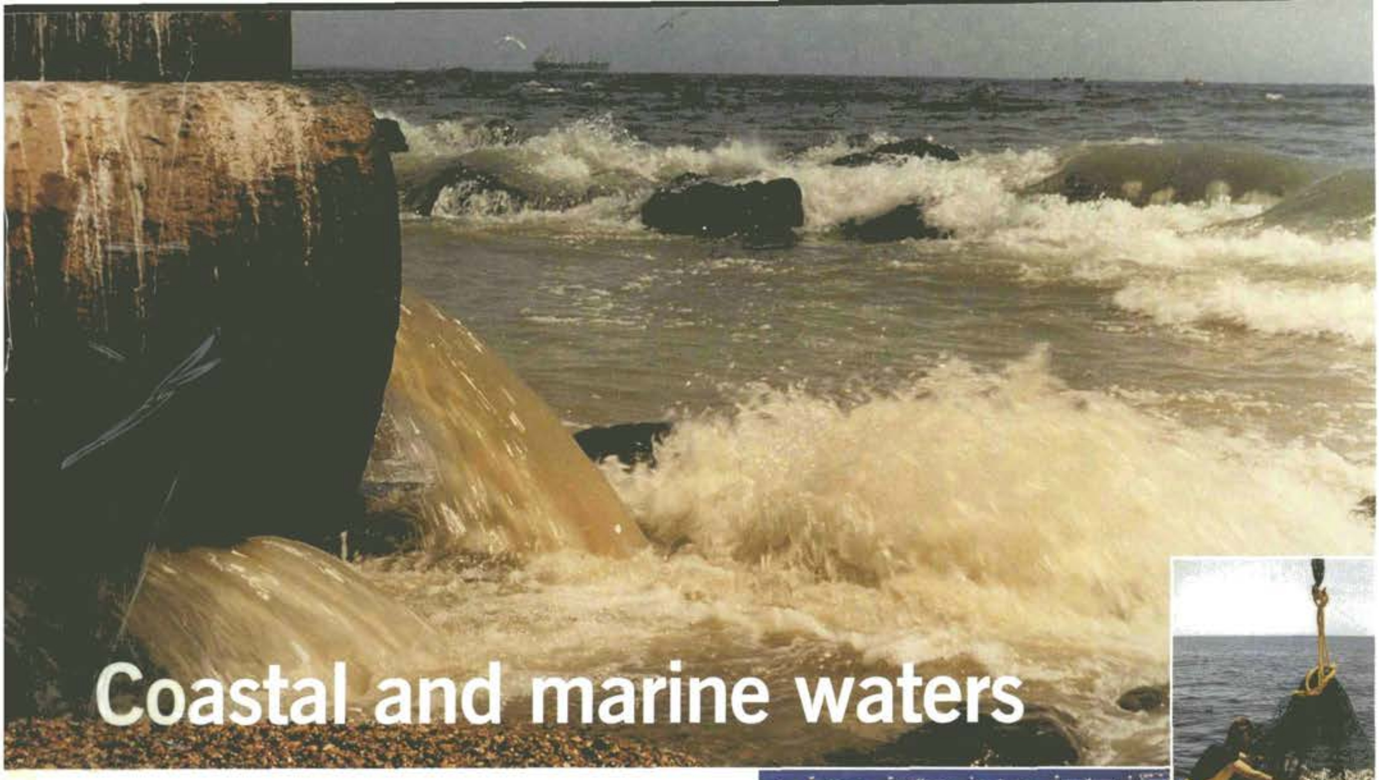
- "The introduction of the non-native Nile Perch to Africa's Lake Victoria in 1954, combined with pollution loading and increased water turbidity resulting from agriculture and industrial development, has greatly reduced indigenous fish populations. Kenya, for example, reported only 0.5% of its commercial fish catch as Nile Perch in 1976. Five years later, the proportion was 68%. Lake Victoria, the second largest lake in the world, has lost an estimated 200 different endemic cichlid species found nowhere else, while the remaining 150 are endangered. Two-thirds of the freshwater species introduced into the tropics worldwide have become established" (Revenga et al., 1998).
- In Africa and Asia, fish provide 21% and 28% of all animal protein, respectively (Revenga et al., 1998). The figures are more significant in landlocked countries, where data on the fish caught are often not formally recorded, and their importance is not fully known.
- In 1999, the reported fish production from inland waters totalled 28 million tonnes, with contributions of 8.2 and 19.8 million tonnes from capture fisheries and aquaculture, respectively. With major under-reporting from subsistence fisheries, these figures could be twice as high (FAO, 2000).

"The over-exploitation and mismanagement of fisheries, particularly when combined with other manmade stresses, can lead to the collapse of regional fish faunas. In many countries, aquaculture is rapidly increasing in response to declining natural fisheries, often exacerbating the degradation of inland and coastal ecosystems through habitat alteration, pollution and the introduction of alien species" (Revenga et al., 1998).

T30



Source: *The State of World Fisheries and Aquaculture 2000* ; *Review of the State of World Fishery Resources: Inland Fisheries*, Food and Agriculture Organisation (FAO), 1999, Rome.



Coastal and marine waters

Chapter 17 of Agenda 21 stresses the need for the protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas, as well as the protection, rational use and development of their living resources. The chapter covers the following programme areas:

- The integrated management and sustainable development of coastal areas, including exclusive economic zones;
- Marine environmental protection;
- The sustainable use and conservation of living marine resources of the high seas;
- The sustainable use and conservation of living marine resources under national jurisdiction;
- The addressing of critical uncertainties for the management of the marine environment and climate change;
- The strengthening of regional and international cooperation and coordination;
- The sustainable development of small islands.

A wide variety of human activities can affect the coastal and marine environment. Population pressure, increasing demands for space and resources, and poor economic performances can all undermine the sustainable use of our oceans and coastal areas. The most serious problems affecting the quality and use of these ecosystems are:

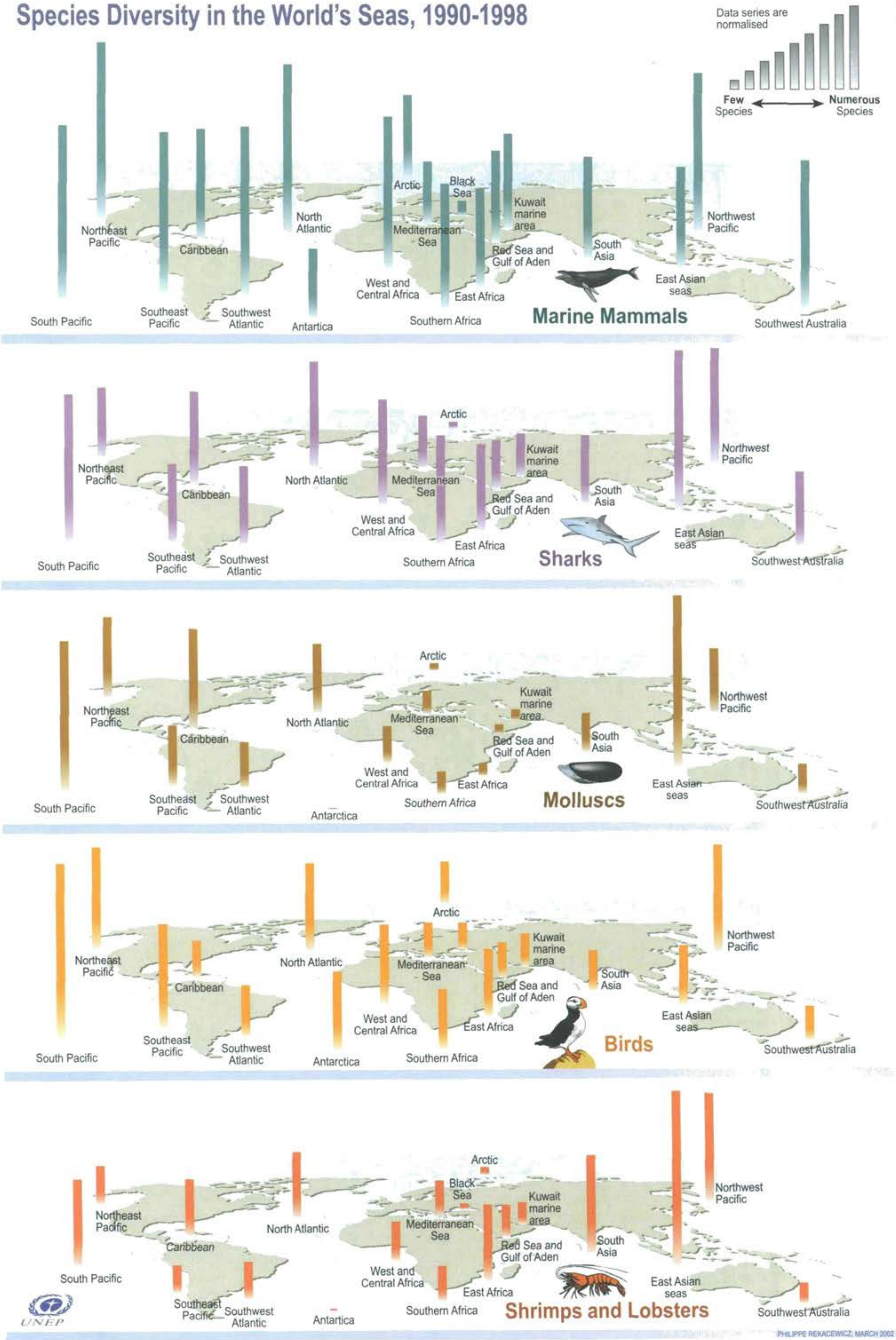
- The alteration and destruction of habitats and ecosystems;
- The effects of sewage on human health;
- Widespread and increasing eutrophication;
- The decline of living resources, such as fish stocks;
- Changes in sediment flows due to hydrological changes;
- The impacts of climate change, including rising sea levels (GESAMP, 2001b).

Coastal Zone Statistics for Countries Grouped by Region

	Length of Coast (km)	Area of Continental Shelf, <200m (1000 km²)	Territorial Sea, up to 12 nm for each country (1000 km²)	Exclusive Fishing Zone (1000 km²)
North America	398,835	5,107.5	3,484.1	X
Central America & Caribbean	73,703	806.6	1,050.0	197.2
South America	144,567	2,203.0	1,030.0	1,814.1
Europe	325,892	6,316.0	2,589.4	1,783.0
Middle East & North Africa	47,282	786.5	649.7	196.0
Sub Saharan Africa	63,124	987.0	871.9	3,111.1
Asia	288,459	5,515.4	5,730.9	249.5
Oceania	137,772	2,565.0	2,830.4	X
World	1,634,701	24,287.1	18,816.9	12,885.2

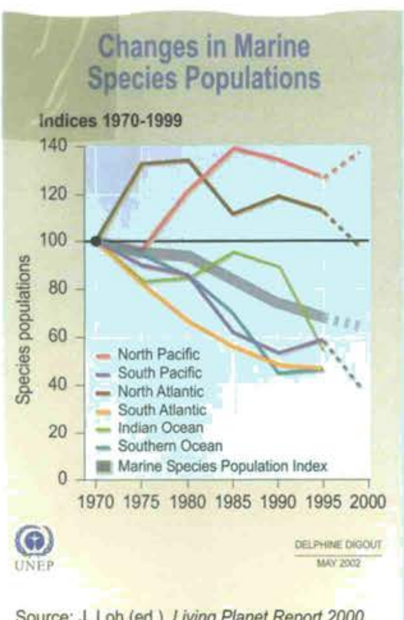
Source: Burke et al., 2001.

Species Diversity in the World's Seas, 1990-1998



Note: Data have been modified to show the species diversity of each region as a fraction of the most species rich region. The maximum number of marine mammals species in a region is 52, sharks 140, molluscs 1114, birds 115, and shrimps and lobsters 210.
Source: World Resources Institute (WRI), Washington DC, 1998, based on data from UNEP-WCMC.

T28



Source: J. Loh (ed.), *Living Planet Report 2000*, World Wide Fund for Nature (WWF).

Marine Species Population Index

Between 1970 and 1999, the Marine Species Population Index recorded a decline of about 35%.

The Marine Species Population Index provides an assessment of the average change over time in the populations of 217 species of marine mammals, birds, reptiles, and fish. The index represents the average value of six regional ocean indices. More pronounced declines are seen in the southern oceans, which is attributed to the fact that major losses and degradation of marine ecosystems in the industrialised world took place prior to 1970.

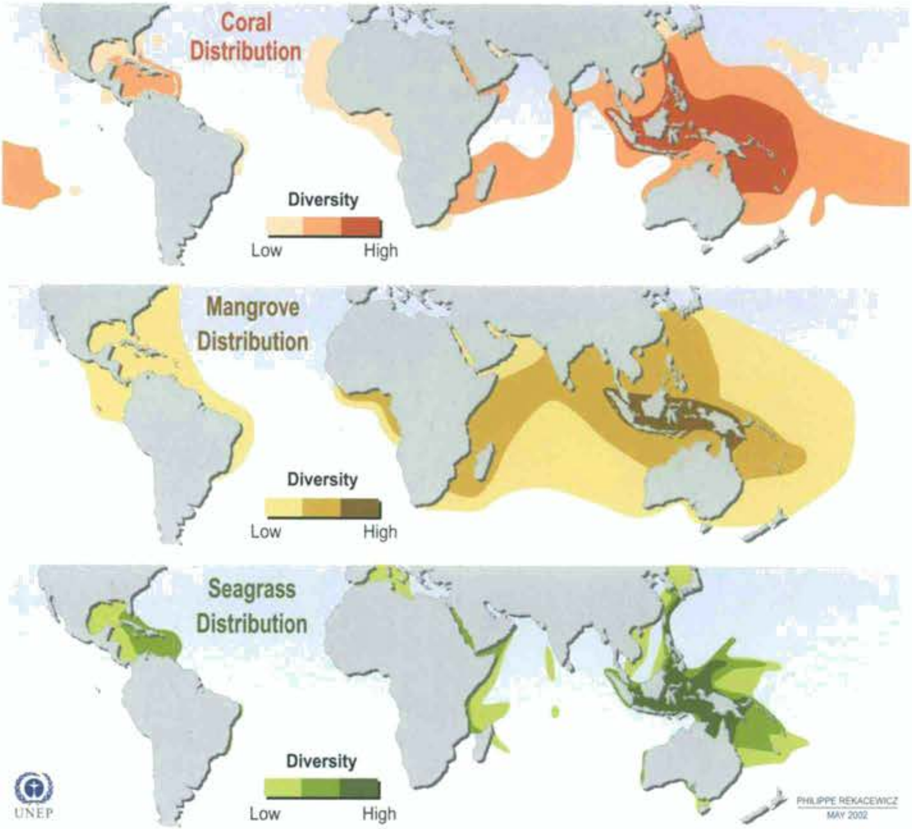
Marine species are generally more difficult to monitor than terrestrial ones. Assessments are therefore based primarily on fishery catches, and the monitoring of land breeding species (eg. turtles, birds and seals). However, these species are over-represented in the index, which should have a far greater proportion of invertebrate species.

Source: Loh, 2000.

Limited information is available on **species diversity** and the condition of coastal and marine ecosystems (Burke et al., 2001). There is growing evidence that many marine species are less widely distributed, and therefore more vulnerable to extinction, than previously thought (GESAMP, 2001a).

The protection and sustainable use of marine resources and biodiversity are governed by several international conventions, including the Convention on Biological Diversity (CBD). In this framework, sustainable use is defined as "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations" (CBD, 2001).

Global Distribution of Coral, Mangrove and Seagrass Diversity T32



Source: UNEP-WCMC, 2001.

There are two distinct regions in which **coral reefs** are primarily distributed: the Wider Caribbean (Atlantic Ocean) and the Indo-Pacific (from East Africa and the Red Sea to the Central Pacific Ocean).

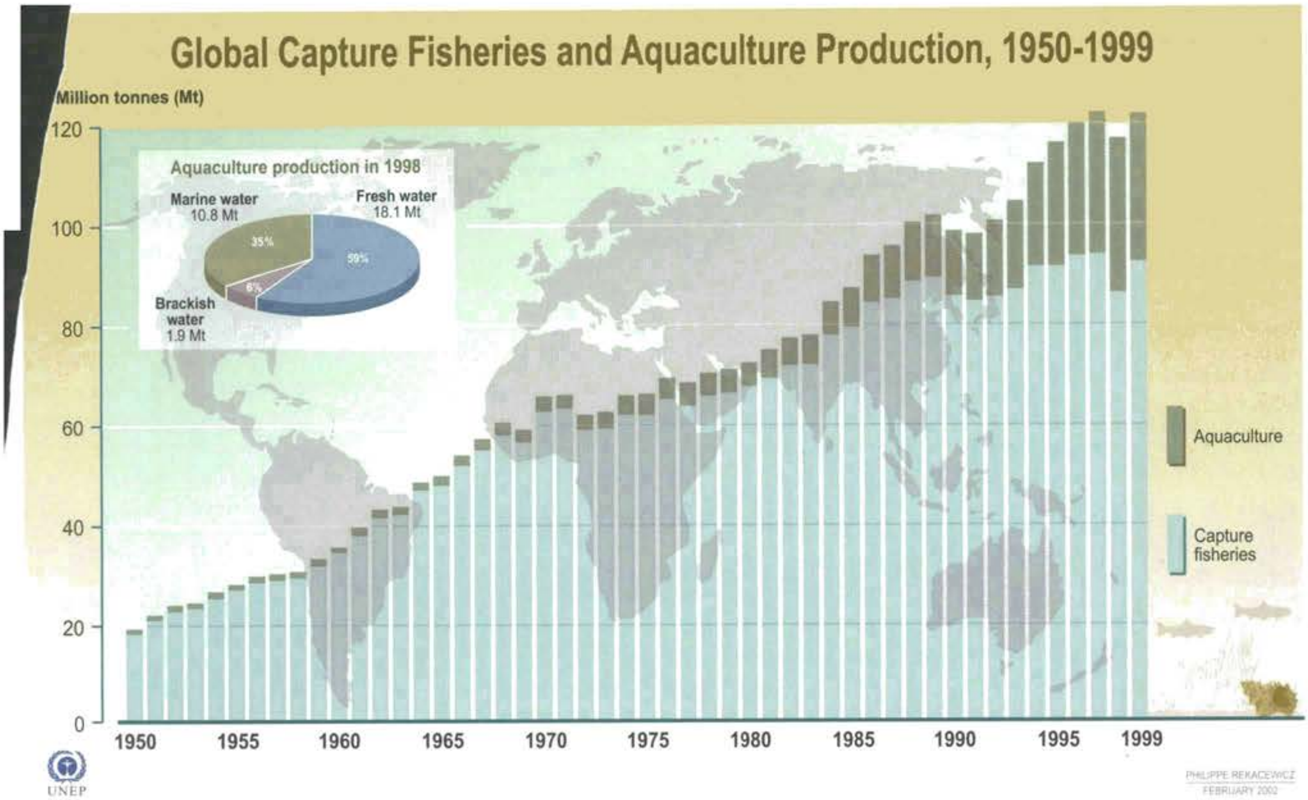
- The diversity of coral is far greater in the Indo-Pacific, particularly around Indonesia, the Philippines, and Papua New Guinea. Many other groups of marine fauna show similar patterns, with a much greater diversity in the Indo-Pacific region.
- Although they possess a smaller number of species the corals of the Atlantic are still unique, with few common species between the two regions (Spalding et al., 2001).

Mangrove forests cover less than 8% of the global coastline, and comprise of only a few species. Although their distribution is relatively homogenous, there are two distinct regions with completely different floras: the Indian Ocean and the Atlantic Ocean (West Africa and the Americas).

- Similar to corals, the region of greatest mangrove diversity is in Southeast Asia, particularly around the Indonesian Archipelago (Burke et al., 2001).
- Mangroves are vital for coastal protection, water purification, and for absorbing CO_2, and provide important breeding and nursing grounds for many commercially valuable fish species. Despite their importance, however, mangrove forests are experiencing increasing pressure from timber industries, as well as conversion to agriculture and aquaculture.

There are three distinct areas of **seagrass diversity** in the Pacific region: the Indo-Pacific (areas around Indonesia, Malaysia, and Papua New Guinea), the seas around Japan, and southwest Australia (Spalding et al., 2002).

- Seagrass beds cover less than 10% of the world's shallow coastal waters, but are important nursing grounds for commercial fish species. They also provide coastal protection and water purification, absorb CO_2, and stabilise sediments (Spalding et al., 2002).
- Seagrass ecosystems host a rich diversity of species, including threatened species such as dugongs and seahorses.
- Seagrass beds are under threat from dredging for harbours, ports and shipping lanes, fishing by benthic trawling, conversion to aquaculture, coastal pollution, and clearance for beaches and tourist facilities (Spalding et al., 2002).

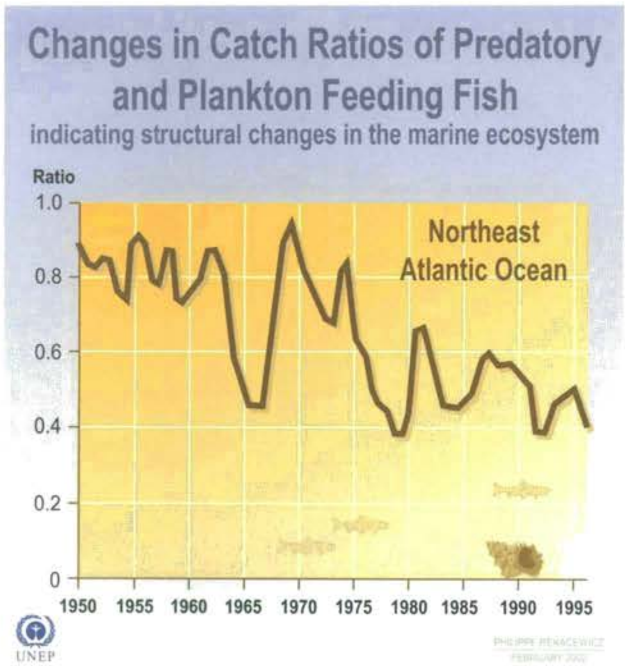


Source: *The State of World Fisheries and Aquaculture 2000*, Food and Agriculture Organisation of the United Nations (FAO).

The levelling off of the **global fisheries catch** reflects a growing decline in most major fishing areas. Today, most fishing areas are producing lower yields than in the past, and it is unlikely that substantial increases will ever again be possible (FAO, 2000).

Inland and marine aquaculture production grew by about 5% annually during the 1950s and 1960s, by about 8% per year during the 1970s and 1980s, and by some 10% per year during the 1990s (FAO, 2000). Most aquaculture is developed in freshwater environments, primarily in Asia. The development of inland aquaculture is seen as an important source of food security in Asia, particularly in land-locked countries.

T34



Source: John F. Caddy and Luca Garibaldi, *Apparent Changes in the Trophic Composition of Marine Harvests: the Perspective from the FAO Capture Database*, Ocean and Coastal Management 43(8-9), 2000.

Three-quarters of fish stocks are currently exploited to the maximum extent, if not excessively (FAO, 2000). This exploitation has had the following impacts:

- A growing variety of fishery products are being exploited. Commercial fishermen are targeting progressively smaller species at lower levels of the food chain as the main predator species are being depleted.
- Most of the world's main fishing areas are close to full exploitation. The Eastern Indian Ocean and the Western Central Pacific Ocean are the only areas that still show little sign of stress, and which exhibit a potential for continuing growth (FAO, 2000).
- The Northeast Atlantic Ocean continues to exhibit declining catches, as well as a shift towards fish at lower levels in the food chain. Indices developed to monitor changes suggest that continued heavy fishing may lead to irreversible **ecological change**.
- Rivers, lakes and wetlands, which account for less than 1% of the world's surface, but at least 8% of its fisheries production, are under mounting pressure from the growing human population (FAO, 2000).

According to the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), the crisis in capture fisheries stems from three main causes:

- Free and open access to fishing areas, particularly the high seas, which encourages over-fishing without concern for stock sustainability;
- Subsidies for fishing fleets, estimated at up to US $20 billion a year, which encourage unprofitable fishing;
- Non-compliance of seasonal closures of fisheries or fishing limits, which, although designed to conserve stocks, are countered by fishermen working harder during the periods when fishing is allowed.

Unless governments and the fishing industry take effective action, over-fishing and long-term declines in catches will invariably continue. At the moment, the major fisheries bodies and agreements are not particularly effective, with their members exhibiting little commitment to cooperating on the conservation of stocks and failing to fulfil previously made commitments (GESAMP, 2001a).

Aquaculture is having several detrimental long-term enviro tal impacts, among them:

- Increased releases of nutrients, pathogens and poter hazardous chemicals into coastal waters;
- Salinisation of groundwater and nutrient pollution of w ways, resulting from the creation of shrimp farms;
- The clearing of mangroves for shrimp farms. It is estima that 60% of all Asia's mangroves have been converted aquaculture farms (UNEP, 2002).

Besides the well-known economic value of fisheries, there ar several other **activities generating significant revenues** in coasta and marine areas. **Tourism** has become one of the world's fastes growing industries, providing a significant proportion of the GDPs of many developing countries. Small island states are particularly reliant on coastal and marine tourism. In the Caribbean, for example, the industry accounts for a quarter of the total economy, and a fifth of all jobs. However, the very areas that attract tourists are also coming under increasing pressure from the damage and pollution caused by tourist facilities and the supporting infrastructure (GESAMP, 2001a).

Benefits from Marine and Coastal Ecosystems and Activities

Coastal tourism

The volume of global tourist arrivals increased more than 20 times between 1950 and 1995, making tourism the world's fastest-growing industry. The present number of tourists is expected to double by 2010 – particularly in the Caribbean and Asia-Pacific regions, where much of the industry is concentrated in coastal areas.

$ 161 billion

Trade and shipping

Since the 1950s, the annual volume of shipping and seaborne trade has risen sixfold, to more than 5 billion tonnes of oil, dry bulk goods and other cargo. In 1995, there were 27,000 freighters over 1,000 tonnes in operation. Industrial countries account for 50% of the cargo loaded – and 75% of that unloaded.

$ 155 billion

Offshore oil and gas

Since gasoline was first used in California a century ago, the oil and natural gas industry has skyrocketed to meet soaring energy demands. Today, about 20% of the world's oil and natural gas comes from offshore drilling installations in the Middle East, the United States, Latin America, and the North Sea.

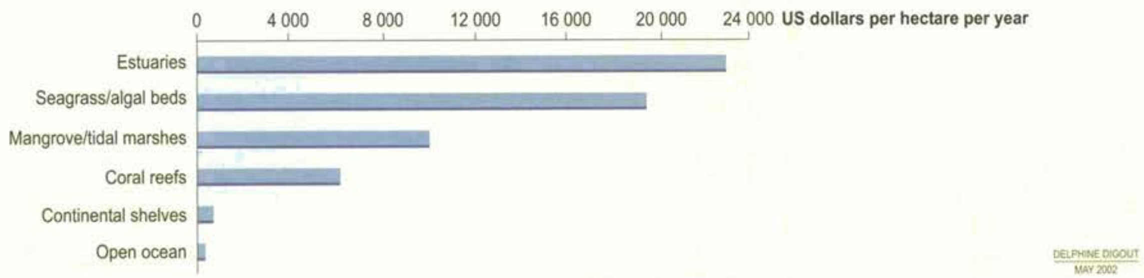
$ 132 billion

Fisheries

Between 1950 and 1997, global fish production from capture and culture fisheries grew from 20 million tonnes to 122 million tonnes, with the per capita supply doubling from 8 kg to 15 kg. Over 200 million people rely on fishing for their livelihoods, with more than 80% of all fish (by value) sold in industrial countries.

$ 80 billion

Estimated Mean Value of Marine Biomes



Source: Anne Platt McGinn, *The Health of Oceans*, Worldwatch paper 145, Worldwatch Institute, 1999, Washington DC (www.worldwatch.org) ; Costanza, R., et al, *The Value of the World's Ecosystem Services and Natural Capital*, Ecological Economics, 1998.

orld's oceans also provide for a major global **shipping** industry, h has recorded significant growth in recent years. Between 5 and 2020, the volume of international trade is expected to e, according to the National Oceanic and Atmospheric ninistration (NOAA), with up to 90% of it travelling by sea Ginn, 1999).

ining for sand, gravel, coral and minerals has been taking place shallow waters and continental shelves for decades. Offshore rilling now supplies a substantial proportion of the world's **oil nd natural gas**, and the offshore industry is expected to grow significantly in the coming years (Stark & Chew, 2001).

- Although marine products such as seafood, sand and oil have been valued for decades, it is only recently that we have begun to appreciate the **oceans' vital services** in maintaining ecological diversity and regulating climate.
- A recent calculation, based on more than 100 studies over the past two decades, suggests that ocean services are worth US $23 trillion a year – only slightly less than the world's total GNP.
- It is estimated that the seas and oceans provide two-thirds of the value of all the natural services provided by our natural environment (GESAMP, 2001a).
- Damage caused by the introduction of non-indigenous organisms to coastal and marine environments totals hundreds of millions of US dollars (GESAMP, 2001b).

Urgent Actions for Controlling Land-Based Activities

At the technical, management and policy levels, the most urgent actions for controlling land-based activities, in order to improve the quality of the marine environment, are:

- Preventing habitat destruction and the loss of biodiversity through education, combined with the development and enforcement of legal, institutional and economic measures appropriate to local circumstances;
- Establishing protected areas for habitats and sites of exceptional scenic beauty or cultural value;
- Devoting primary management attention to the control of pollution from sewage, nutrients (especially nitrogen) and sediment mobilisation;
- Designing national policies that take account of the economic value of environmental goods and services, and provide for the internalisation of environmental costs; and
- Integrating the management of coastal areas and associated watersheds.

Source: GESAMP, 2001b.

It has been estimated that about 80% of all **marine pollution** originates from land-based activites. It reaches the ocean directly, via rivers, or through atmospheric depositions.

- Inputs of nitrates to the North Sea, for example, have risen four-fold, and phosphate inputs eight-fold, since the 1970s, causing eutrophication and tides of toxic algae that have killed stocks in offshore fish farms (Harrison and Pearce, 2001).
- Severe eutrophication has been discovered in several enclosed or semi-enclosed seas (UNEP, 2002).
- Eutrophication has been linked to the formation of 'dead zones' on the ocean floor. One of the largest known 'dead zones' is found along the United States shoreline of the Gulf of Mexico, which receives large volumes of fertilizer from the Mississippi River system (Harrison and Pearce, 2001).
- The collapse of the Baltic Sea cod fishery in the early 1990s is blamed on oxygen loss in deep waters due to eutrophication, which interfered with the development of cod eggs.
- Eutrophication can also cause **Harmful Algal Blooms** (HABs), which can harm fish and shellfish, as well as the people who consume them. Some algae can cause negative effects when they appear in dense blooms, while others have potent neurotoxins and need not be present in large numbers.

Losses Caused to Fisheries and Aquaculture by Harmful Algal Blooms

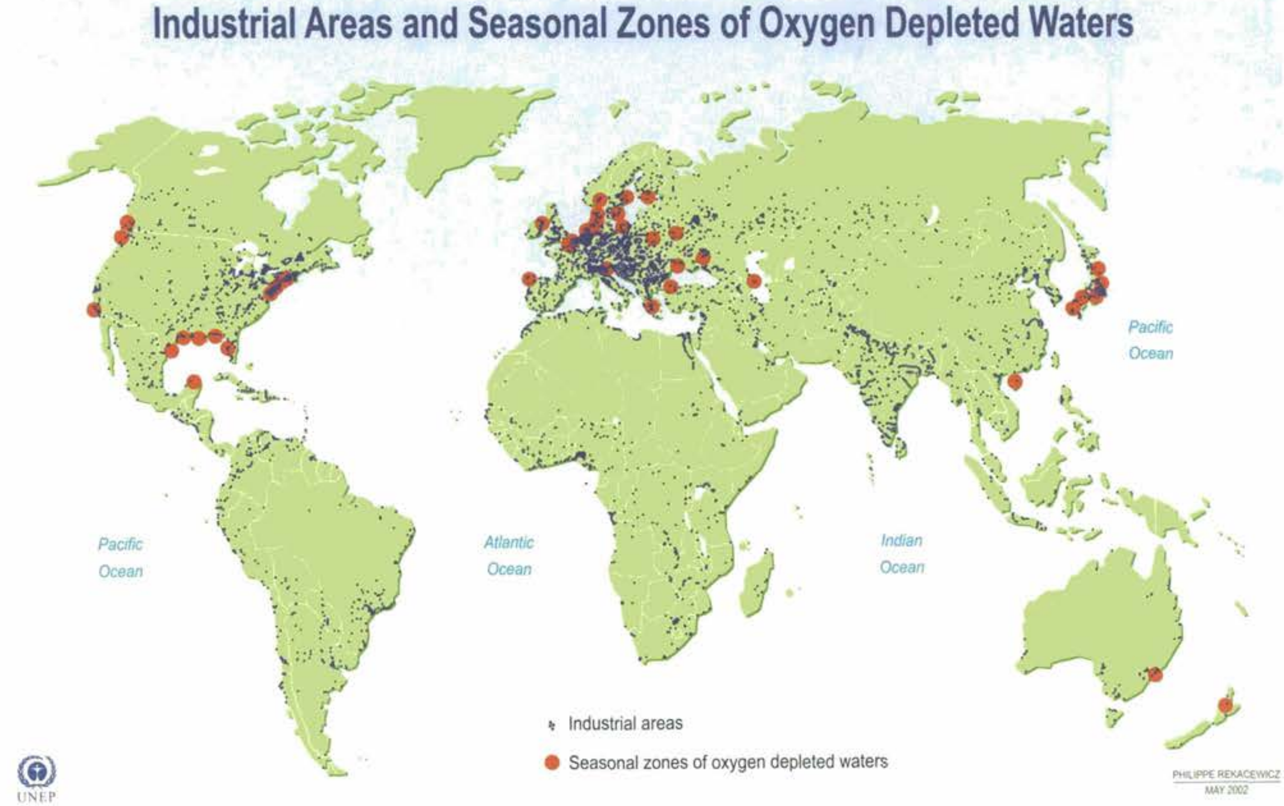
Date	Location	Species	Loss (Millions of US$)
1972	Japan	Yellowtails	47
1977	Japan	Yellowtails	20
1978	Japan	Yellowtails	22
1978	Korea	Oysters	4.6
1979	Maine, USA	Many species	2.8
1980	New England, USA	Many species	7
1981	Korea	Oysters	>60
1985	Long Island, NY USA	Scallops	2
1986	Chile	Red salmon	21
1987	Japan	Yellowtails	15
1988	Norway and Sweden	Salmon	5
1989	Norway	Salmon, rainbow trout	4.5
1989-1990	Puget Sound, WA USA	Salmon	4-5
1991	Washington State, USA	Oysters	15-20
1991-1992	Korea	Farm fish	133
1996	Texas, USA	Oysters	24
1998	Hong Kong	Farm fish	32

Source: *Vital Signs* 1999 in GESAMP, 2001a.

There is a strong link between areas with high densities of **industrial activity and zones of seasonally oxygen depleted waters**. In recent years, there has been an increasing focus on treating and reducing municipal and industrial wastes, and on reducing nitrogen levels in agricultural runoff. However, less attention has been paid to the continually increasing nitrogen emissions into the atmosphere. It is believed that between 10% and 70% of the fixed nitrogen input in many coastal regions is *currently delivered by rain and the fallout of nitrogen compounds* from the atmosphere. GESAMP recommends that atmospheric nitrogen must be included among the nutrient sources assessed as part of the management of coastal water quality. Political factors are also of major significance, as the primary causes of atmospheric anthropogenic nitrogen result from energy generation and transportation, and thus from society's economic and social activities (GESAMP, 2001b).

Industrial Areas and Seasonal Zones of Oxygen Depleted Waters

T36



Source: D. Malakoff, 1998, after R.J. Diaz and R.Rosenberg, 1995; ESRI,1990.

Physical alteration and destruction of habitats are now considered one of the most important threats to coastal areas. Half of the world's wetlands, and even more of its mangrove forests, have been lost over the past century to physical alterations, with accelerating social and economic development and poor-planning being major causes (UNEP, 2002).

There are currently about one billion people living in coastal urban areas. It is estimated that almost 50% of the world's coasts are threatened by development-related activities. The intense pressure on coastal ecosystems calls for preventive and protective action at all levels: local, national, regional and global.

Source: United Nations Environment Programme (UNEP).

The Case for Integrated Coastal Management

Integrated Coastal Management (ICM) is increasingly being recognised as an effective method for managing and protecting the marine and coastal environments and associated freshwater catchments. It merits wider application, both for resolving existing problems and for dealing effectively with new ones.

ICM incorporates and promotes the following actions:

- Promoting coordinated, cross-sectoral and holistic approaches to the management of environmental resources and amenities, taking full account of environmental, public health, economic, social and political considerations;
- Conducting environmental impact assessments, risk management, and cost-benefit analyses in all decision making processes, and incorporating the value of ecosystem services wherever possible;
- Seeking the active involvement and participation of all major stakeholders (local authorities, private sector and interested public) in the design and implementation of ICM;
- Conducting regular reviews of management systems and their implementation, and adjusting priorities, targets and methods where necessary; and
- Strengthening institutional capacities through training and retraining programmes.

If existing global and regional environmental agreements had been implemented as intended, coastal areas would not be in their current precarious state. In many countries, legislative frameworks to achieve national goals and implement multilateral agreements are weak and inadequately enforced.

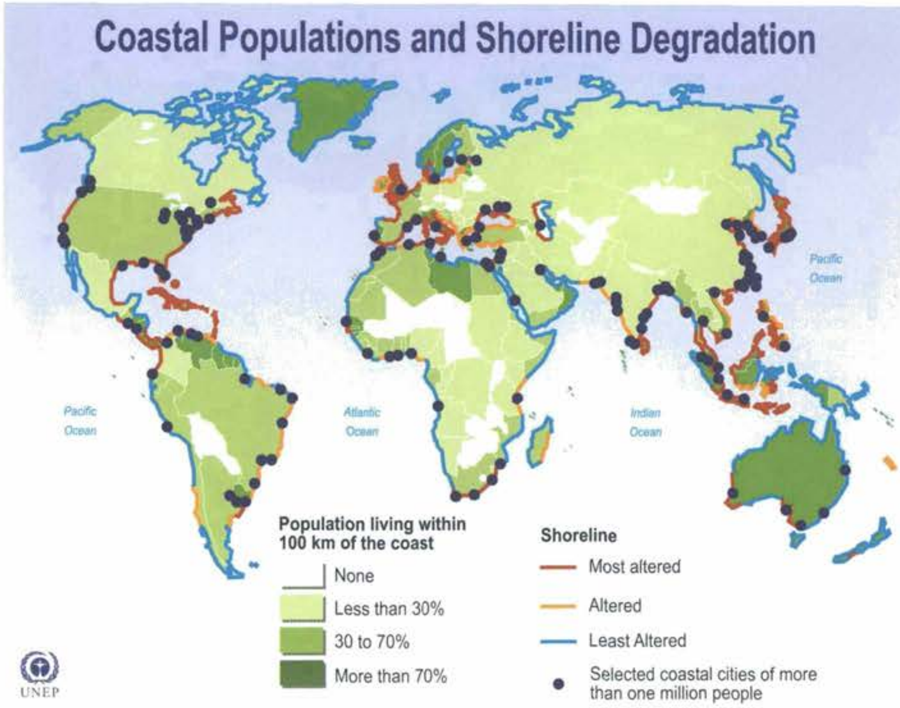
To address this situation, ICM recommends the following actions:

- Governments should adapt national legal instruments to conform to the provisions of internationally endorsed agreements;
- National and international attention should focus on compliance with existing international agreements rather than the development of new ones, unless they have compelling justification;
- Governments must adopt a consistent and coordinated approach in dealing with different international organisations and agreements;
- International bodies responsible for the implementation of global environmental agreements should improve the co-ordination of their secretariats and governing bodies to this end; and
- Further attention should be devoted at the regional level to harmonising national approaches and measures, and to cost-effective collaboration; the full potential of voluntary commitments and targets should be explored, including with the private sector; and further legally binding instruments should be developed.

The need for globally integrated freshwater, coastal and marine assessments facilitated the development of the Global International Waters Assessment (GIWA) together with a request from the UNEP Governing Council to conduct a feasibility study for the establishment of a regular process for assessing the state of the marine environment.

Source: GESAMP 2001a; UNEP, 2002.

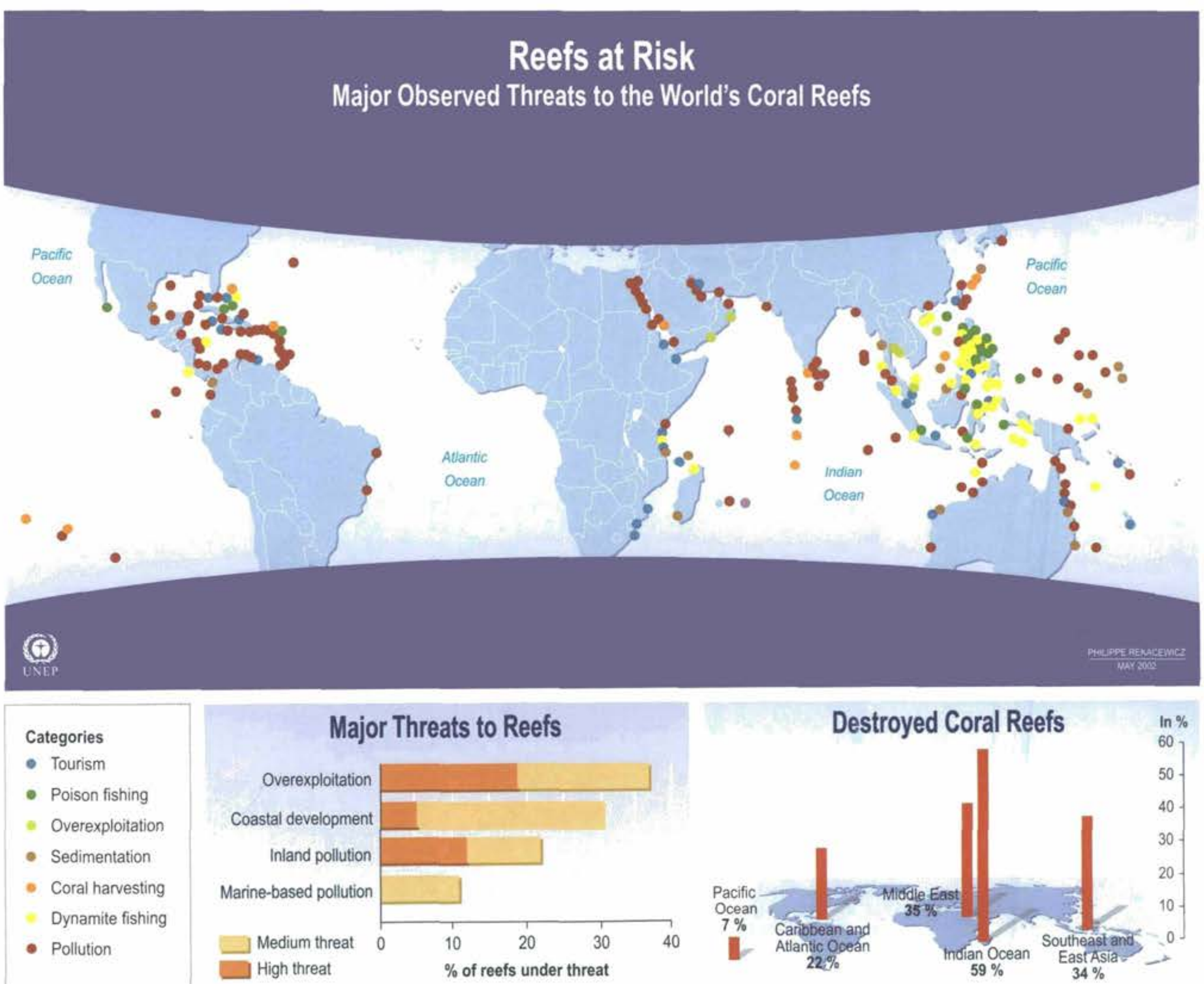
T38



Source: Burke et al., World Resources Institute, Washington DC, 2001; Paul Harrison and Fred Pearce, *AAAS Atlas of Population and Environment 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.

Unsurprisingly, the coastal areas with the greatest population densities are also those with the most **shoreline degradation**. The areas surrounding the Black Sea, the Mediterranean and Southern Asia have the highest proportion of altered land, while the coastal zones of the Arctic, Northeast Pacific, South Pacific, West and Central Africa, East Africa, the Red Sea/Gulf of Aden, and Kuwait have the highest proportions of least modified land.

T39



Source: Bryant et al., *Reefs at Risk: a Map-Based Indicator of Threats to the World's Coral Reefs*, World Resources Institute (WRI), Washington DC, 1998.

The **global warming** that the world is beginning to experience will likely have a major impact on coastal and marine environments.

- The sea has an enormous capacity to store heat. Warmer water, combined with anticipated changes in ocean currents, could have a devastating impact on marine ecosystems and biodiversity.
- One potential result could be a reduction in the upwelling of nutrients, which would in turn reduce productivity in key fishing areas.
- Decreased growth may also be seen in coral reefs, with high concentrations of CO_2 in the water impairing the deposition of limestone required for coral skeletons (UNEP, 2002).

A significant **sea level rise** is one of the major anticipated consequences of climate change. This will cause some low-lying coastal areas to become completely submerged, while others will increasingly face short-lived high-water levels. These anticipated changes could have a major impact on the lives of coastal populations. The small island developing states (SIDS) will be especially vulnerable to the effects of sea level rise, and to changes in marine ecosystems, because of their major dependence on marine resources (UNEP, 2002).

The extent of future sea level rise will depend on a multitude of factors, and is therefore extremely difficult to predict. While rising sea levels will be exacerbated by thermal expansion of the warming oceans, and the melting of land ice, they will be partially offset by increased precipitation over Antarctica (Met Office UK, 2001).

Feasibility of a Global Marine Assessment

At its 21st session in February 2001, the UNEP Governing Council (GC) adopted a decision to investigate the feasibility of a "Global Assessment of the State of the Marine Environment" (UNEP GC Decision 21/13).

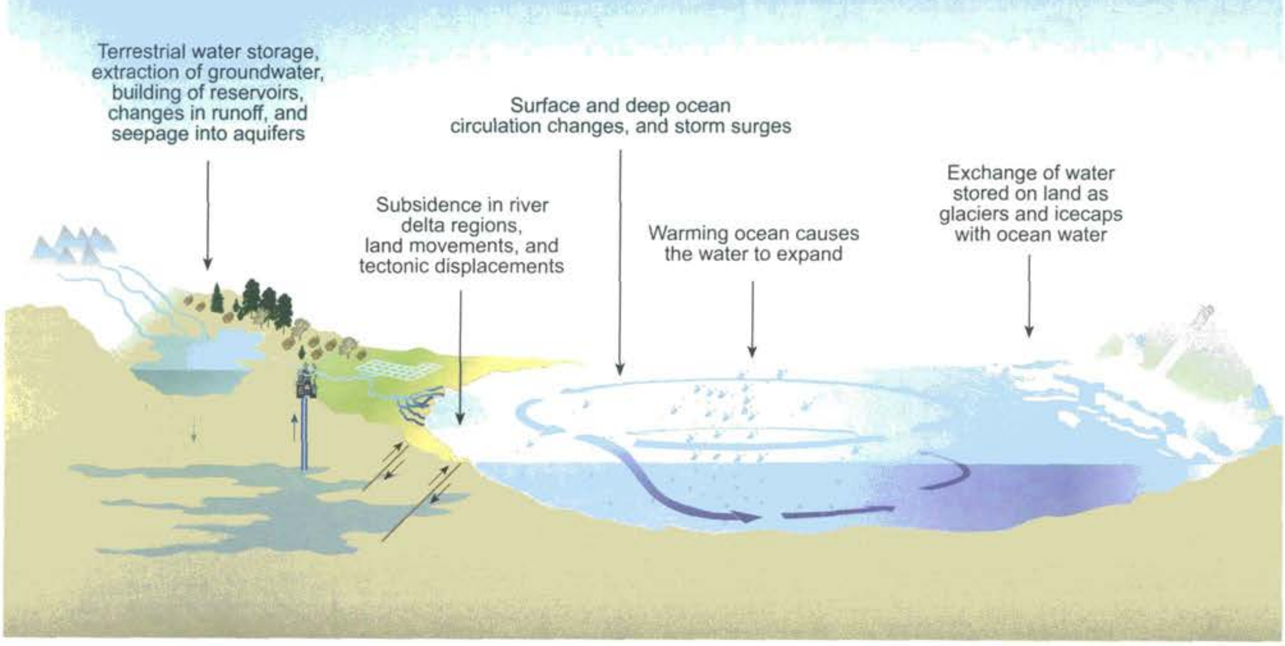
During two subsequent consultative meetings, it was recognised that a global marine assessment (GMA) was needed and feasible. The scope of an assessment process was outlined and it was agreed that GMA activities should include socio-economic considerations, together with the relevant work, approaches and experience of national, regional and global organisations. The global assessment component of the GMA process will guide the timing and facilitate the development of regional or thematic assessments on specific issues.

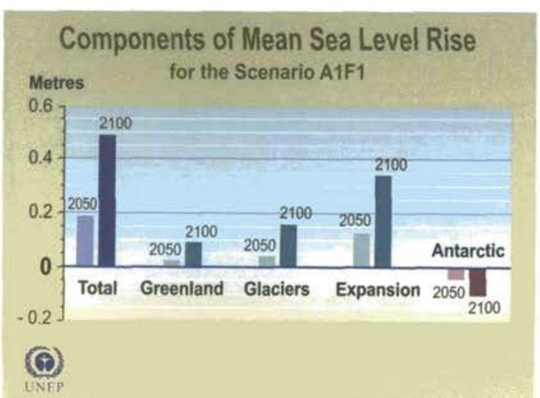
These recommendations and other suggestions, including institutional mechanisms and operational arrangements, will be presented and discussed at the UNEP Governing Council in February 2003. The first step in the GMA process will be to evaluate existing assessments of the state of the marine environment, and to identify the scope, status and timing of forthcoming assessment activities.

Source: www.unep.org/marineassessment

T40

What Causes the Sea Level to Change?





The A1 scenario family describes a future of rapid economic growth, a global population that peaks in the middle of the 21st century and then declines, and the rapid introduction of new and more efficient technologies. The major underlying themes are convergence among regions, capacity-building, and increased cultural and social interaction, with a substantial reduction in regional differences in per capita incomes. The A1 scenario family develops into three groups with alternative directions of technological change according to their energy systems: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance of both (A1B)

PHILIPPE REKACEWICZ
MARCH 2002

Source: David Griggs, in *Climate Change 2001*, Synthesis report, Contribution of working groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2001.

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This is a joint publication of the Division of Early Warning and Assessment (DEWA) and the Division of Environmental Policy Development and Law (DPDL) of the United Nations Environment Programme (UNEP), published as part of UNEP's global water policy and strategy. The publication was developed in close collaboration with the UNEP Centre, GRID-Arendal, in Norway.

Credits

Please quote: UNEP (2002), Vital Water Graphics - An Overview of the State of the World's Fresh and Marine Waters. UNEP, Nairobi, Kenya. ISBN: 92-807-2236-0

Text
Salif Diop, Patrick M'mayi, Dennis Lisbjerg.

Maps and Graphics
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Editor
Ralph Johnstone.

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Web Site Team
Eivind Holt, Brian Lucas, Teslin Seale.

Acknowledgements

Many people assisted in the compilation of data and provided useful comments and suggestions in the preparation of this publication: Johannes Akiwumi, Alex Alusa, Lauretta Burke, Amy Cassara, Marion Cheatle & the GEO team, Munyaradzi Chenje, Gerard Cunningham, Nikolai Denisov, Dominique Del Pietro, Andy Fraser, Ed Green, Pamela Green, Leo Heileman, Lawrence Hislop, Kelly Hodgson, Beth Ingraham, Bob Kakuyo, Grace Kamala, Bakary Kante, Johnathan Kool, Yumiko Kura, Christian Lambrechts, Brian Morris, Theuri Mwangi, Edith Mussukuya, Emmanuel Naah, Takehiro Nakamura, Nick Nuttall, Thierry de Oliveira, Joakim Palmqvist, Hassan Partow, Doug Percival, Marie Prchalova, Walter Rast, Elina Rautalahti-Miettinen, Carmen Revenga, Audrey Ringler, Richard Robarts, Megumi Seki, Igor Shiklomanov, Ashbindu Singh, David Smith, Anna Stabrawa, Thomas Tata, Sekou Toure, Dan Tunstall, Svein Tveitdal, Isabelle Vanderbeck, Ron Witt, Eric Wolanski, Kai Falck.

We apologise to anyone whose name may have been inadvertently omitted from this list.

Global freshwater consumption rose sixfold between 1900 and 1995 – more than twice the rate of population growth. About one third of the world's population already lives in countries considered to be 'water stressed' – that is, where consumption exceeds 10% of total supply. If present trends continue, two out of every three people on Earth will live in that condition by 2025.

Kofi Annan, in We The Peoples, 2000

Vital **Water** Graphics

An Overview of the State of the World's Fresh and Marine Waters

ISBN 92-807-2236-0

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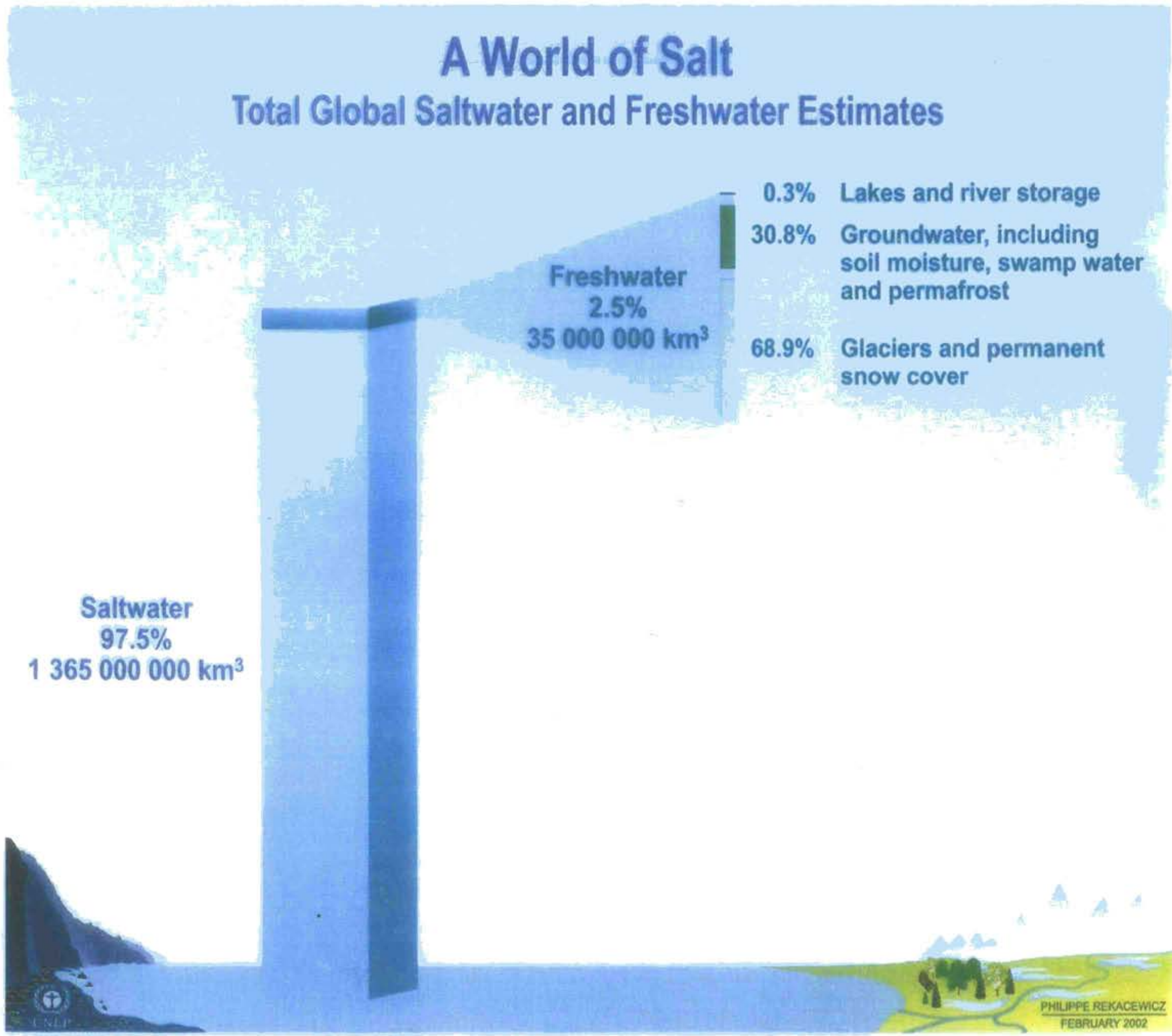
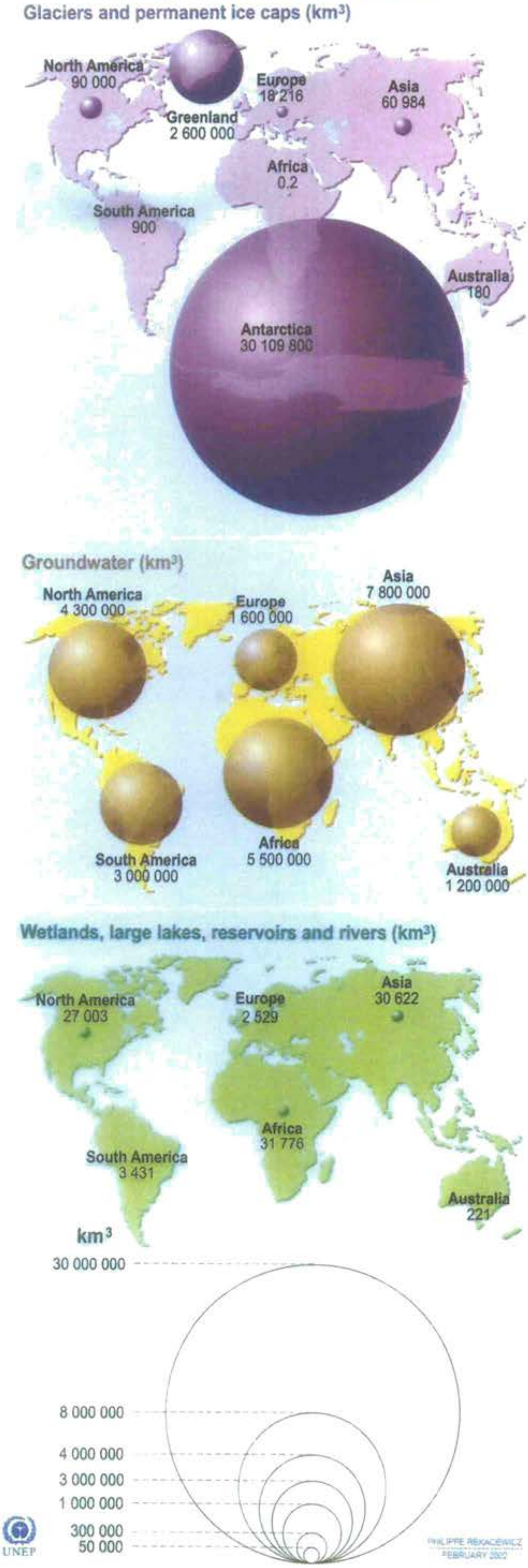


Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Global Freshwater Resources

Quantity and Distribution by Region



Note: Estimates refer to standing volumes of freshwater.

Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999; World Meteorological Organisation (WMO); International Council of Scientific Unions (ICSU); World Glacier Monitoring Service (WGMS); United States Geological Survey (USGS).

Major River Basins of the World

North America
1 Yukon
2 Mackenzie
3 Nelson
4 Mississippi
5 St. Lawrence

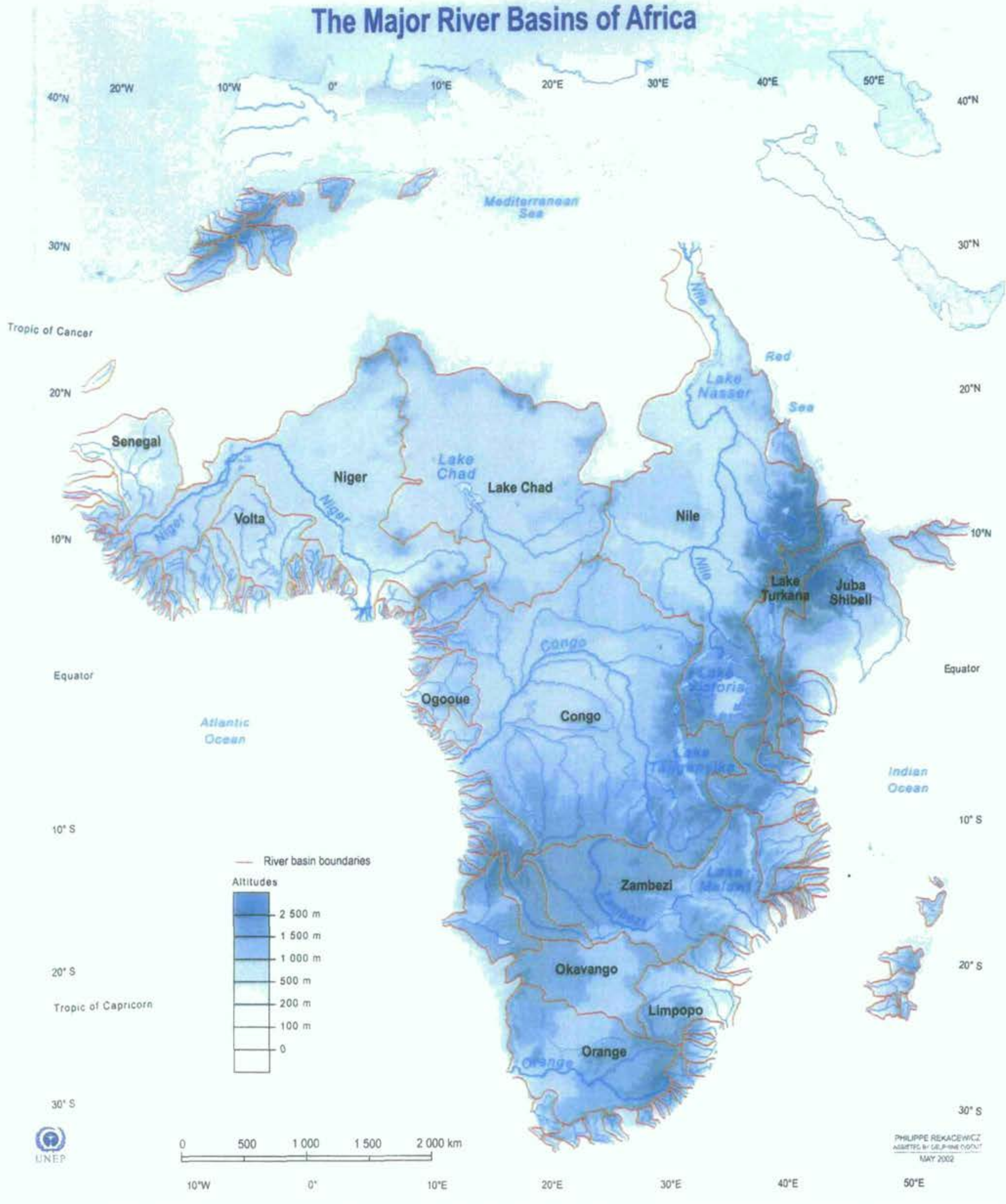
South America
6 Amazon
7 Paraná

Europe
25 Danube

Africa and West Asia
8 Niger
9 Lake Chad Basin
10 Congo
11 Nile
12 Zambezi
26 Orange
24 Euphrates and Tigris

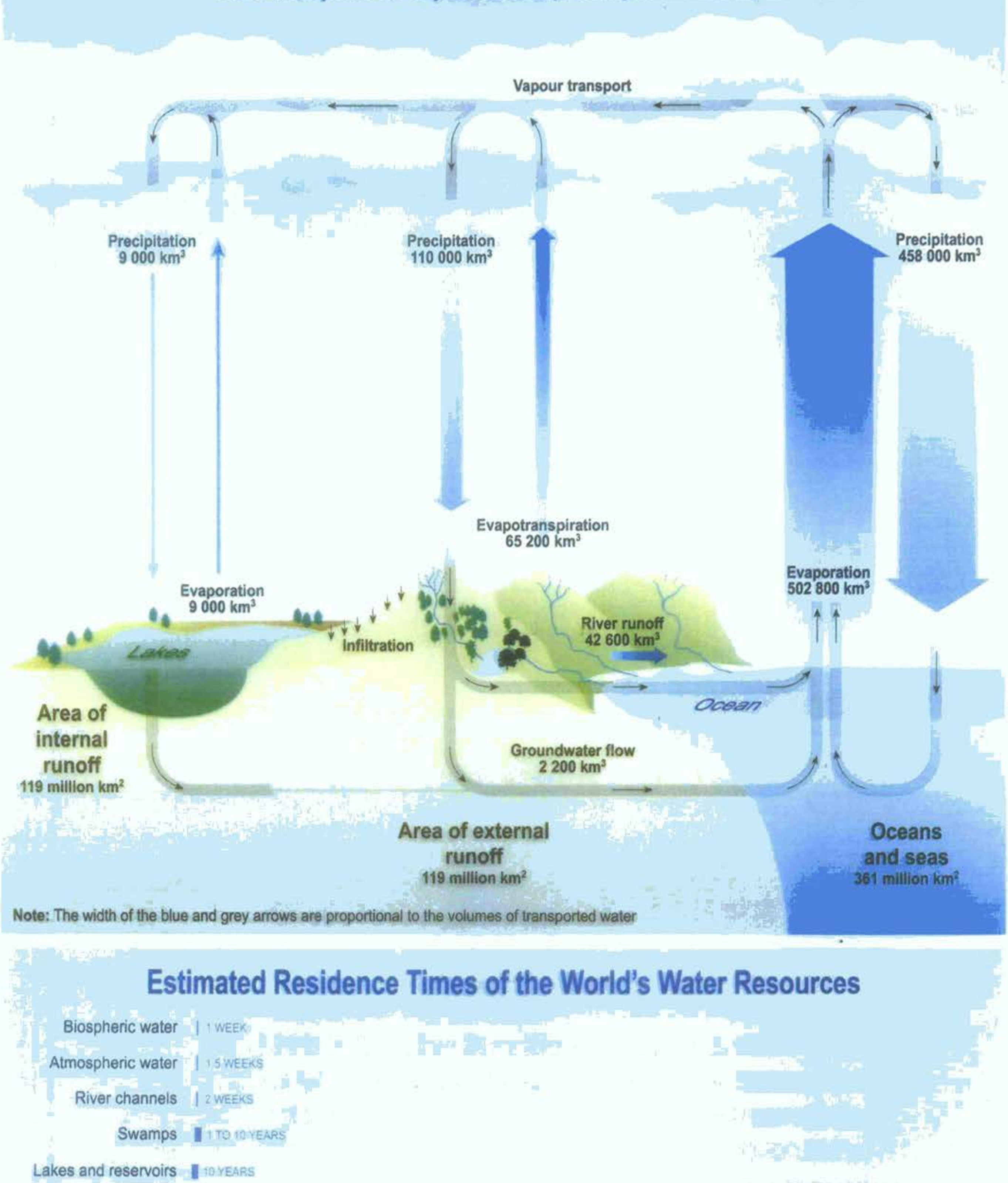
Asia and Australia
13 Volga
14 Ob
15 Yenisey
16 Lena
17 Kolyma
18 Amur
19 Ganges and Brahmaputra
20 Yangtze
21 Murray Darling
22 Huang He
23 Indus

Source: United Nations Environment Programme (UNEP); World Conservation Monitoring Centre (WCMC); World Resources Institute (WRI); American Association for the Advancement of Science (AAAS); *Atlas of Population and Environment*, 2001.

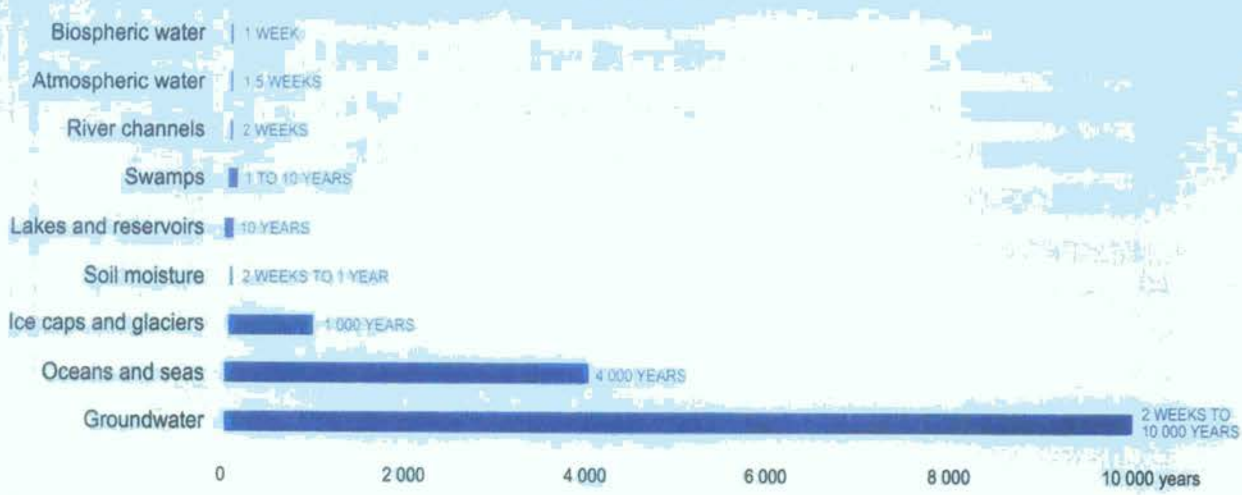


Source: Aaron T. Wolf et al., 1999; Revenga et al., *Watersheds of the World*, World Resources Institute (WRI), Washington DC, 1998; Philippe Rekacewicz, *Atlas de poche*, Livre de poche, Librairie générale française, Paris, 1996 (revised in 2001).

The World's Water Cycle
Global Precipitation, Evaporation, Evapotranspiration and Runoff



Estimated Residence Times of the World's Water Resources



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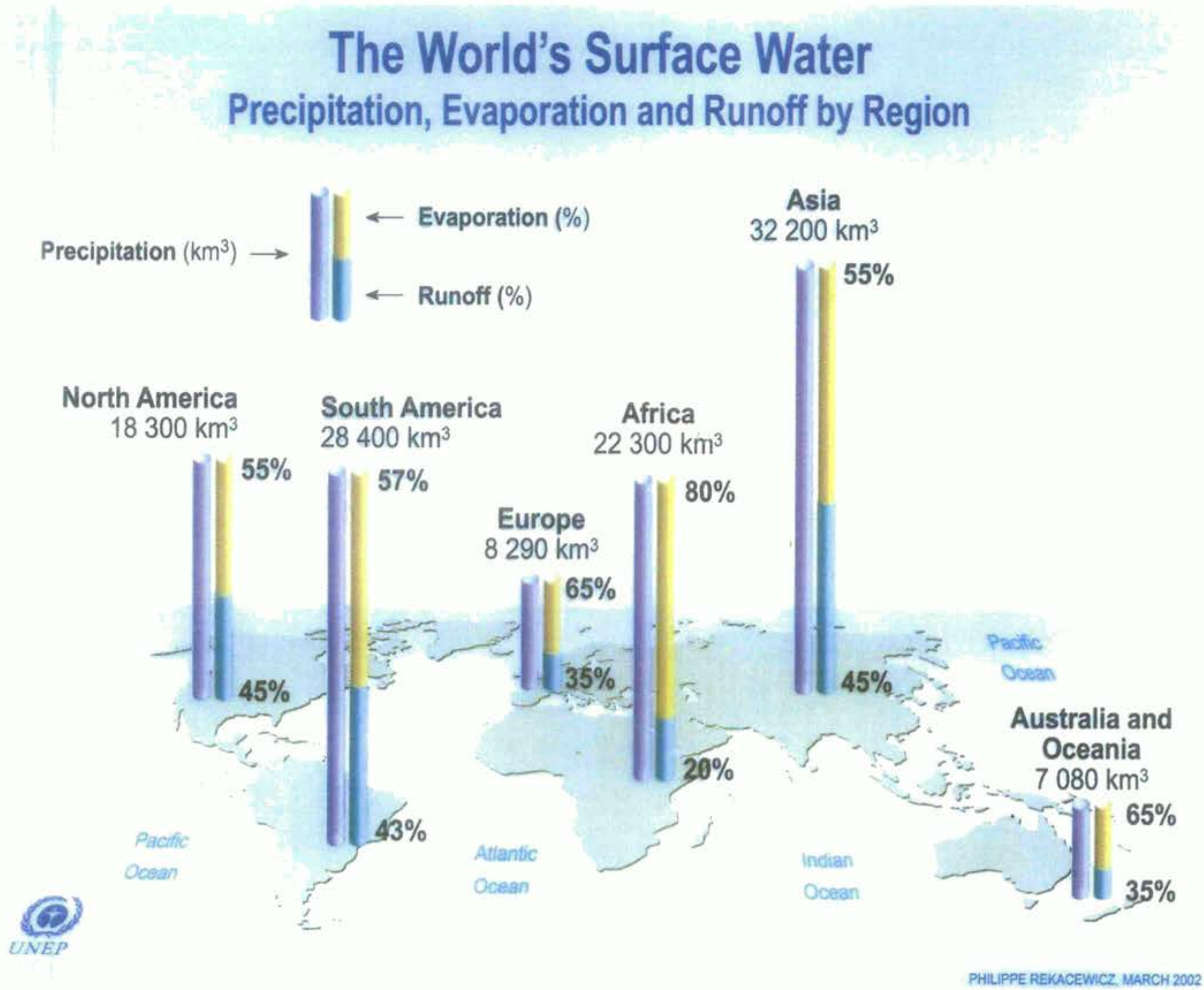
APRIL 2002

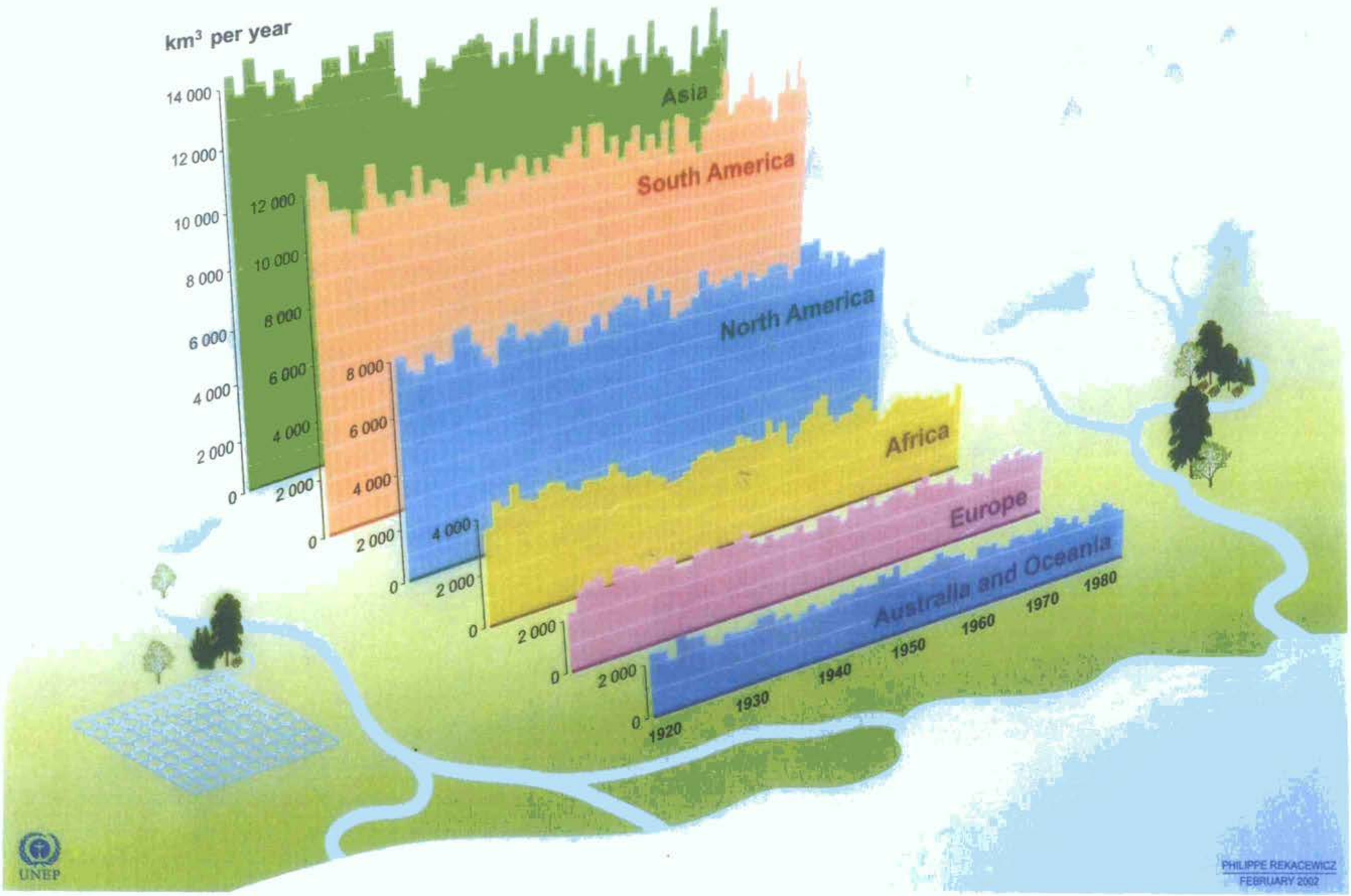
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999; Max Planck, Institute for Meteorology, Hamburg, 1994; Freeze, Allen, John, Cherry, *Groundwater*, Prentice-Hall: Engle wood Cliffs NJ, 1979.



Source: Peter H. Gleick, *Water in Crisis*, New York Oxford University Press, 1993.

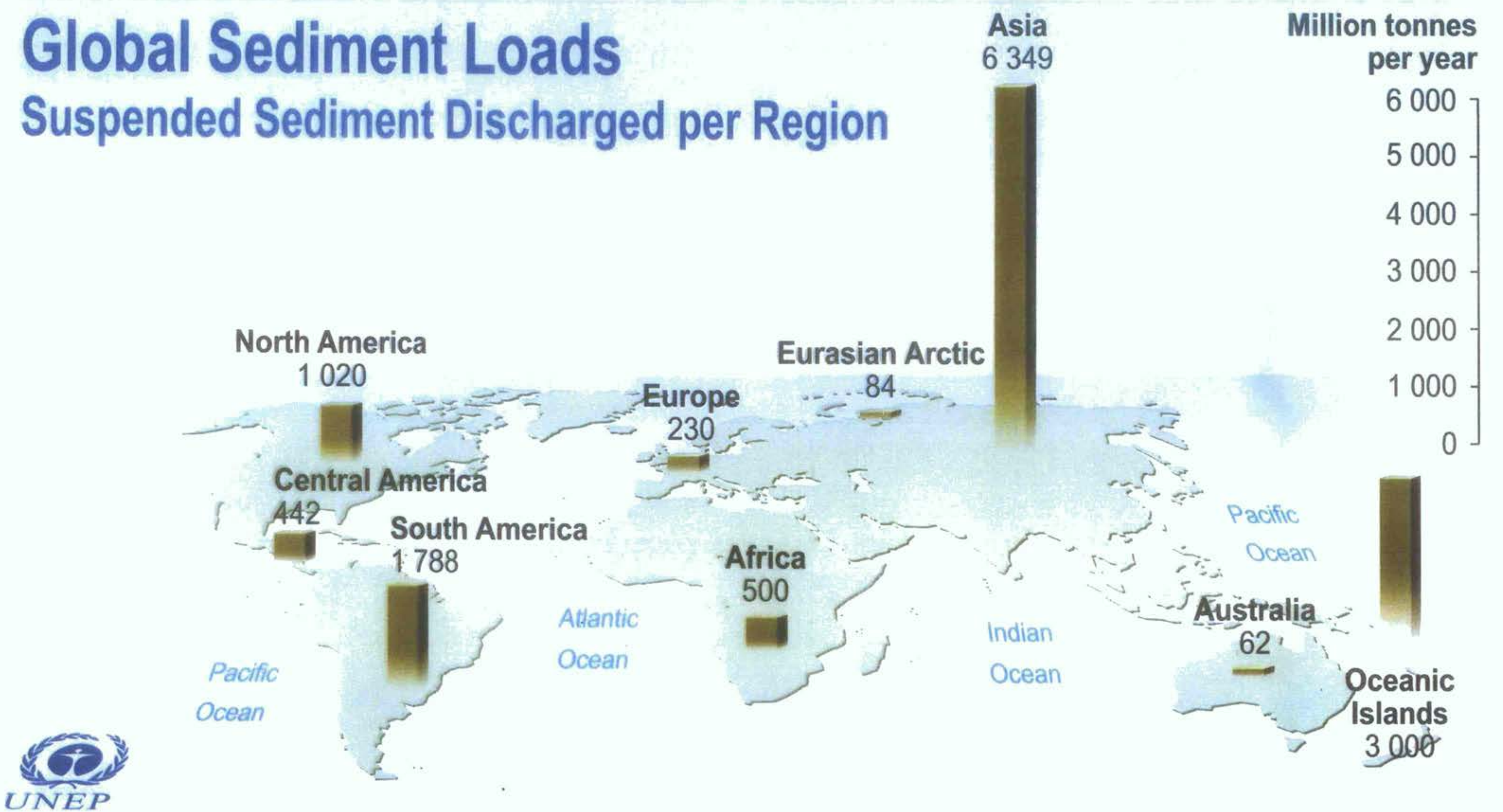
River Runoff through the 20th Century

Average Annual Volumes by Continent, 1921-1985



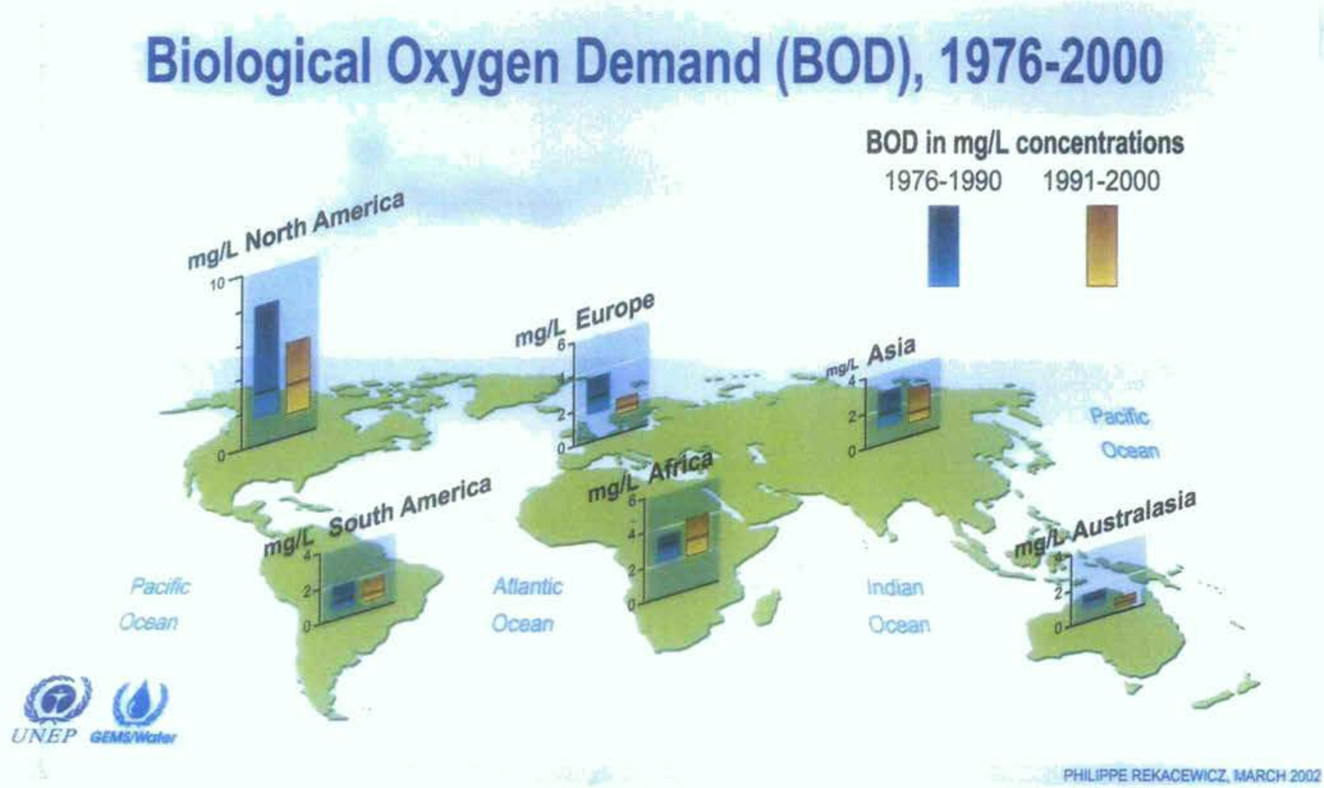
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Global Sediment Loads
Suspended Sediment Discharged per Region

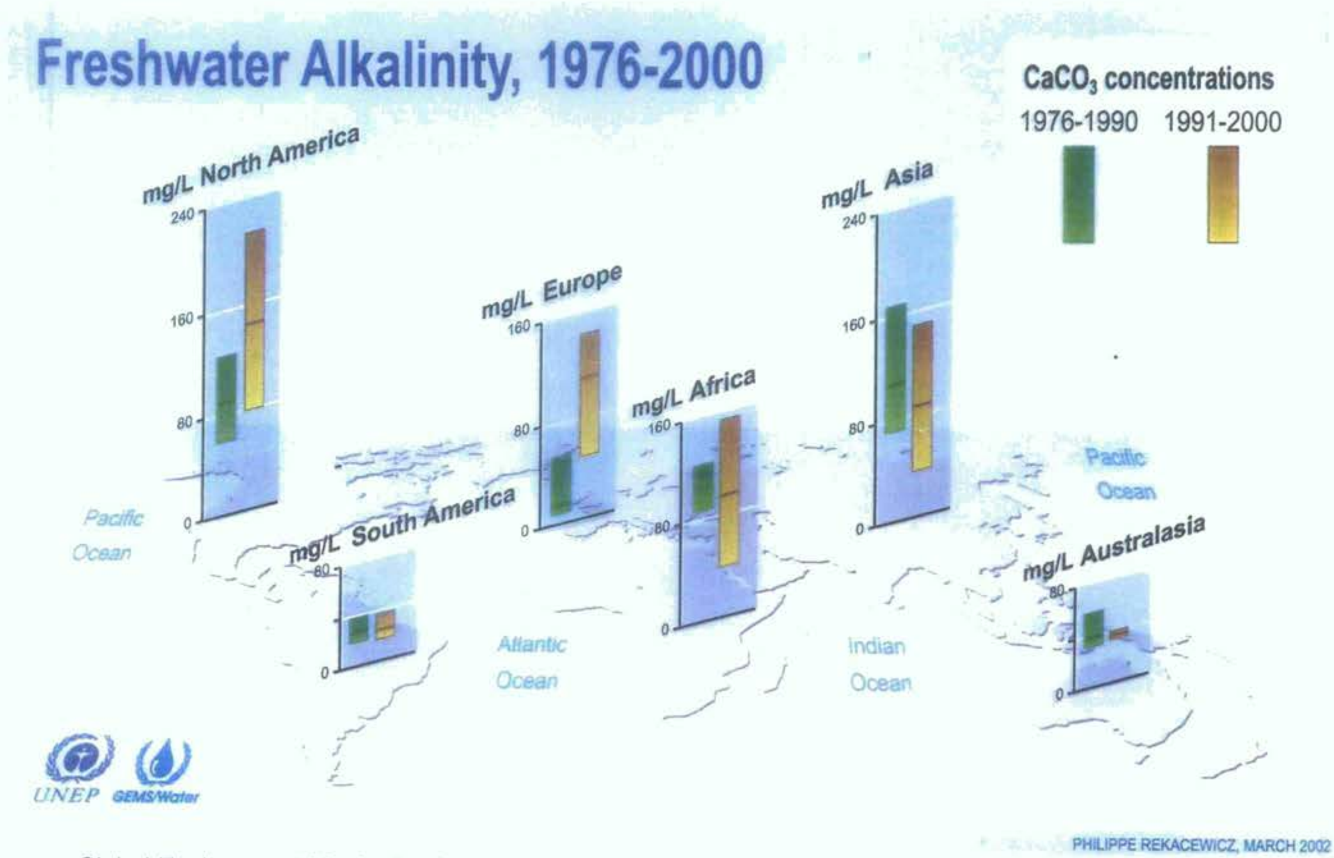


PHILIPPE REKACEWICZ, MARCH 2002

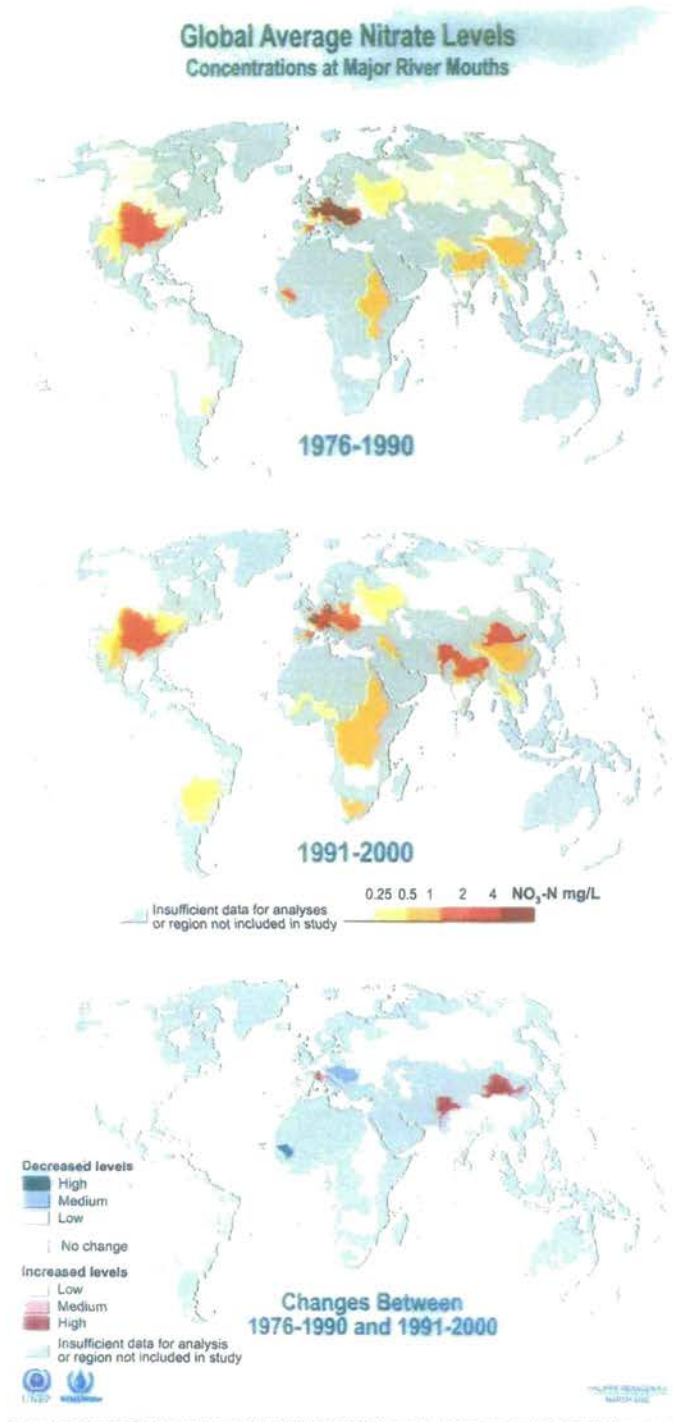
Source: Peter H. Gleick, *Water in Crisis*, New York Oxford University Press, 1993.



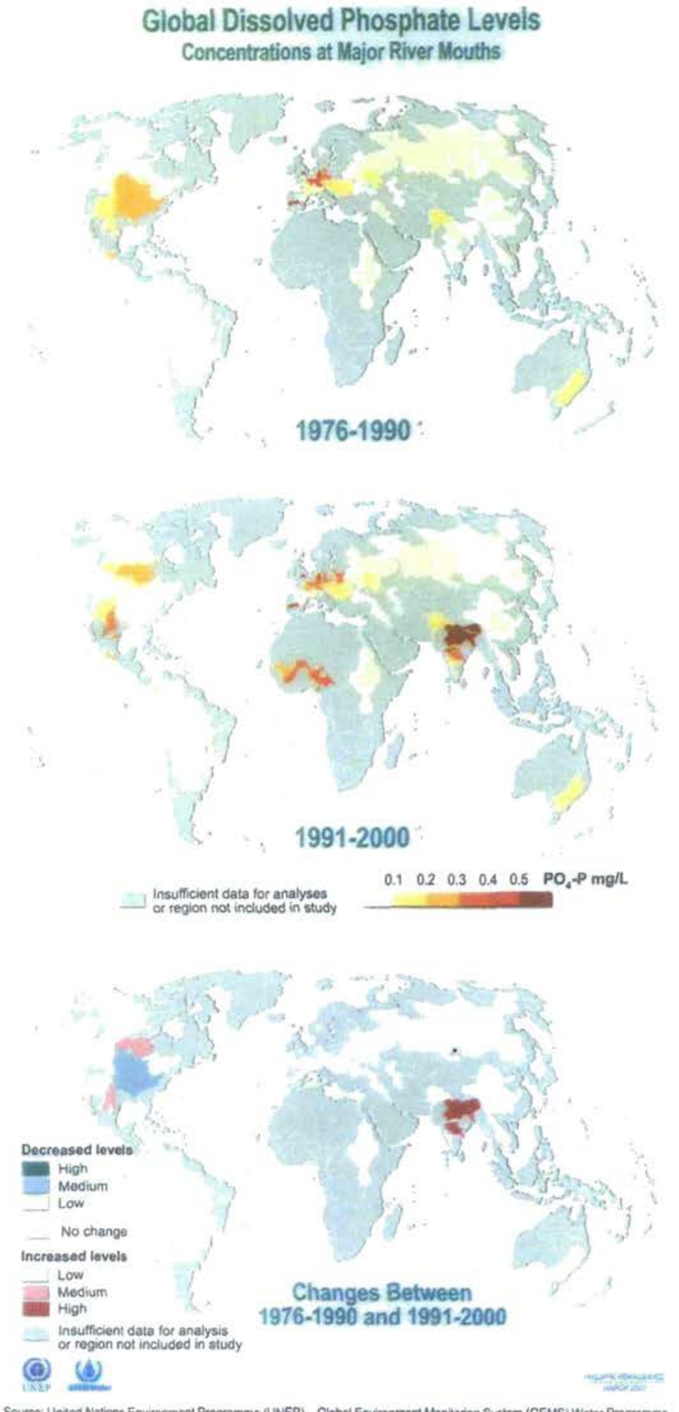
Source: Global Environment Monitoring System (GEMS), Freshwater Quality Programme, United Nations Environment Programme (UNEP), 2001.



Source: Global Environment Monitoring System (GEMS), Freshwater Quality Programme, United Nations Environment Programme (UNEP), 2001.



Source: United Nations Environment Programme (UNEP) - Global Environment Monitoring System (GEMS) Water Programme, 2001; National Water Research Institute Environment Canada, Ontario, 2001.

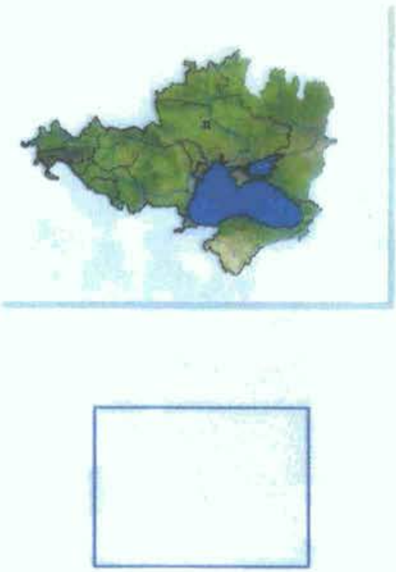


Source: United Nations Environment Programme (UNEP) - Global Environment Monitoring System (GEMS) Water Programme, 2001; National Water Research Institute Environment Canada, Ontario, 2001.

Global International Water Assessment (GIWA) Case Studies

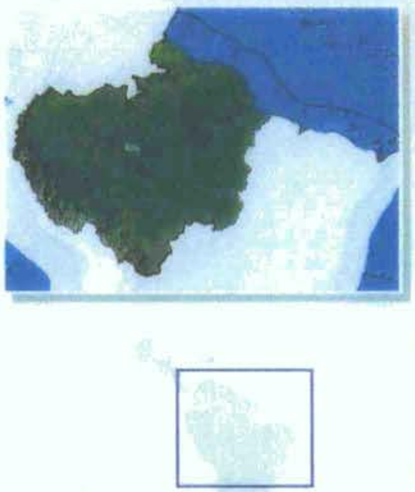
http://www.giwa.net/

Black Sea



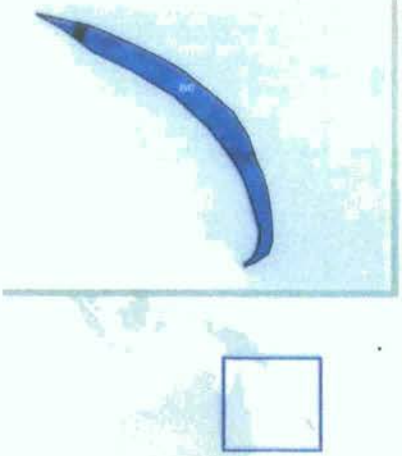
- **Introduction:** The catchment area is ~ 2.5 million km² with a population of ~ 162 million, of which the urban population accounts for 60%.
- **Freshwater shortages** are a problem, although not yet catastrophic. Industry accounts for 50% of freshwater use, irrigation for 12-40%, and domestic use for ~ 28%. Increasing pollution in river basins and rising salinity are also exacerbating water shortages.
- **Pollution** from industries, municipal waste and oil spills is affecting groundwater, the seas and rivers through eutrophication.
- **Unsustainable exploitation of fisheries:** In the past 30 years, pollution has devastated the fishing industry. Total catches fell from ~ 750 000 tons in 1986 to ~ 284 000 tons in 1992.
- **Habitat and community modification and loss:** Ecosystems have drastically changed as a result of the increasing eutrophication of water bodies.
- **Socio-economic impacts** include the decreasing amenity value of coastal areas for tourism and recreation, losses in agriculture, and rising unemployment.

Amazon



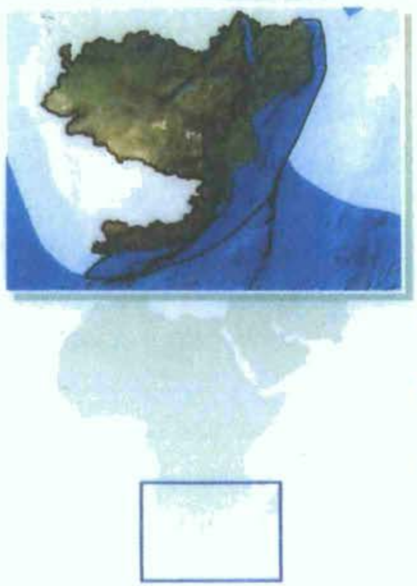
- **Introduction:** The sub region 40b measures 6 869 km² and is shared by six countries.
- **Freshwater shortages:** The high rate of deforestation in southeastern Brazil is altering the water cycle and increasing problems of freshwater availability.
- **Pollution** caused by chemical and suspended solids – emanating from agricultural wastes and mercury contamination respectively – is of growing concern.
- **Habitat and community modification** is the priority concern, with management desperately required to address large-scale extension impacts.
- **Over-exploitation of fisheries:** The region's fisheries have a potential catch of 200 000 - 1 million tonnes/year with > 200 exploitable species. However, consumption is based on only a few dozen species and these are already threatened by over-exploitation.
- **Socio-economic impacts** include minor water shortages, growing pollution in urban centres, and increasing social and health problems in the suburbs of Amazon cities.

Great Barrier Reef



- **Introduction:** Bordered on the east by the GBR Marine Park World Heritage Area, the sub-region extends north across the Torres Strait to Bramble Cay and the Australia-Papua New Guinea territorial border, west to the PNG-Indonesia border, and south to the tip of Cape York, Australia.
- **Pollution:** Eutrophication, chemical pollution and suspended solids from the catchments, rivers, wetlands and estuaries are causing moderate impacts in the region. In some areas, the impacts are considered severe.
- **Habitat and community modification:** Loss or modification of ecosystems is a severe problem locally, notably in marshlands and riparian belts. Overall, the impacts are considered moderate.
- **Unsustainable exploitation of fisheries and other living resources:** Over-exploitation, excessive by-catches, discards and destructive fishing techniques (benthic trawling) are severe problems, particularly when targeting sharks, mackerel, lobster and shrimps/prawns.
- **Global climate change** is a major threat, particularly the impact of ocean sea surface temperature increases on coral reefs.

Agulhas Current



- **Introduction:** There are eight river basins in the sub region, forming a network of transboundary water systems, including a 5,000 km coastline off the Mozambique and South African continental shelves. The Zambezi catchment area covers ~ 1 434 680 km² and supports 38.4 million people – about 70% of the region's population.
- **Freshwater shortages** are the primary concern due to excessive water abstraction and increasing pollution of supplies. Irrigation accounts for 60% of local freshwater use. Streamflow in the Zambezi River has declined by over 50% in the last three decades, due to the construction of three large dams.
- **Unsustainable exploitation of fisheries**, particularly tuna and shrimps in marine waters, is severe and likely to escalate to critical levels by the year 2020.
- **Pollution** is not a critical concern at the present, although some hotspots have been reported in the mining and industrial zones of major cities.
- **Socio-economic impacts** include escalating poverty, food insecurity and mortality due to waterborne diseases and rural-rural/rural-urban migration. The major root causes are declining agricultural productivity and fishery harvests, and habitat losses and modification.

Global International Water Assessment Tools
for Better Monitoring of the World's Water Resources

The GIWA Assessment Methodology

«Transboundary Diagnostic Analysis»

Scoping and Scaling
Identifying Issues

- Environmental impact
- Socio-economic impact

↓

Detailed Impact Assessment
Assessing Situations

- Environmental impact assessment
- Socio-economic impact assessment

↓

Causal Chain Analysis
Constructing the Causal Chain

- By following the most significant successive causes of environmental degradation, a causal chain is constructed to discover the root causes of the problems.

↓

Policy Option Analysis

- The evaluation of alternative scenarios follows various projections developed on the basis of actions to address the societal root causes of environmental degradation. These analyses consider methods for evaluating the environmental impacts of various options for water use, before weighing the costs of measures designed to modify unsustainable developments.

↓

Better action in the field

UNEP

Source: Global International Water Assessment (GIWA), 2001.

GIWA's Five Major Concerns

Freshwater shortages

- Reduction of stream flows
- Lowering of water tables
- Pollution of existing water supplies

Pollution

- Microbiological pollution, eutrophication
- Chemical pollution
- Suspended solids, solid waste
- Thermal pollution
- Radionuclides
- Spills

Habitat and community modification

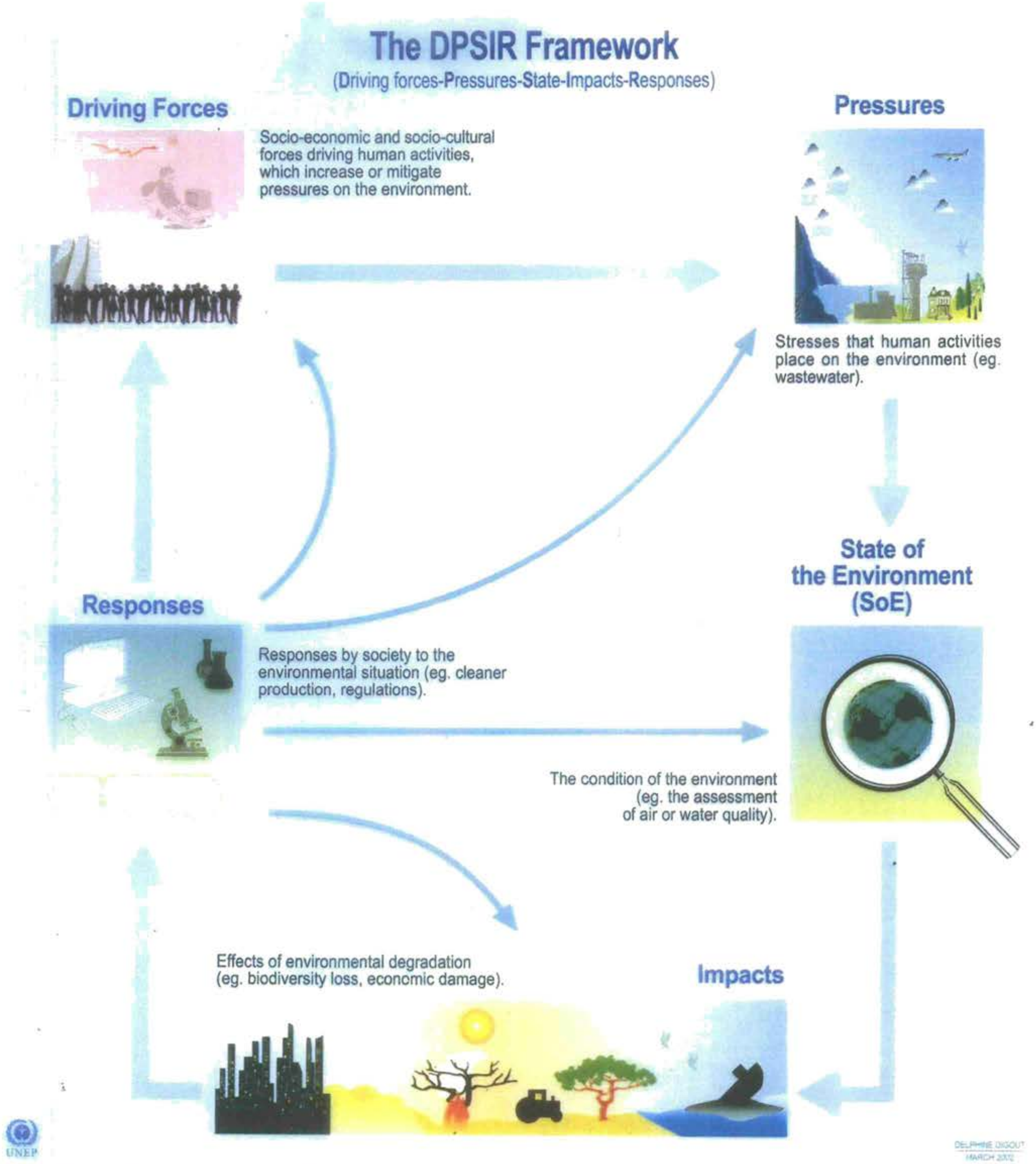
- Loss of ecosystems or ecotones
- Modification of ecosystems or ecotones

Unsustainable exploitation of fisheries and other living resources

- Inappropriate harvesting practices
- Resource/habitat changes
- Habitat alteration or destruction
- Decreased viability of stock through contamination or disease
- Reduction of biodiversity

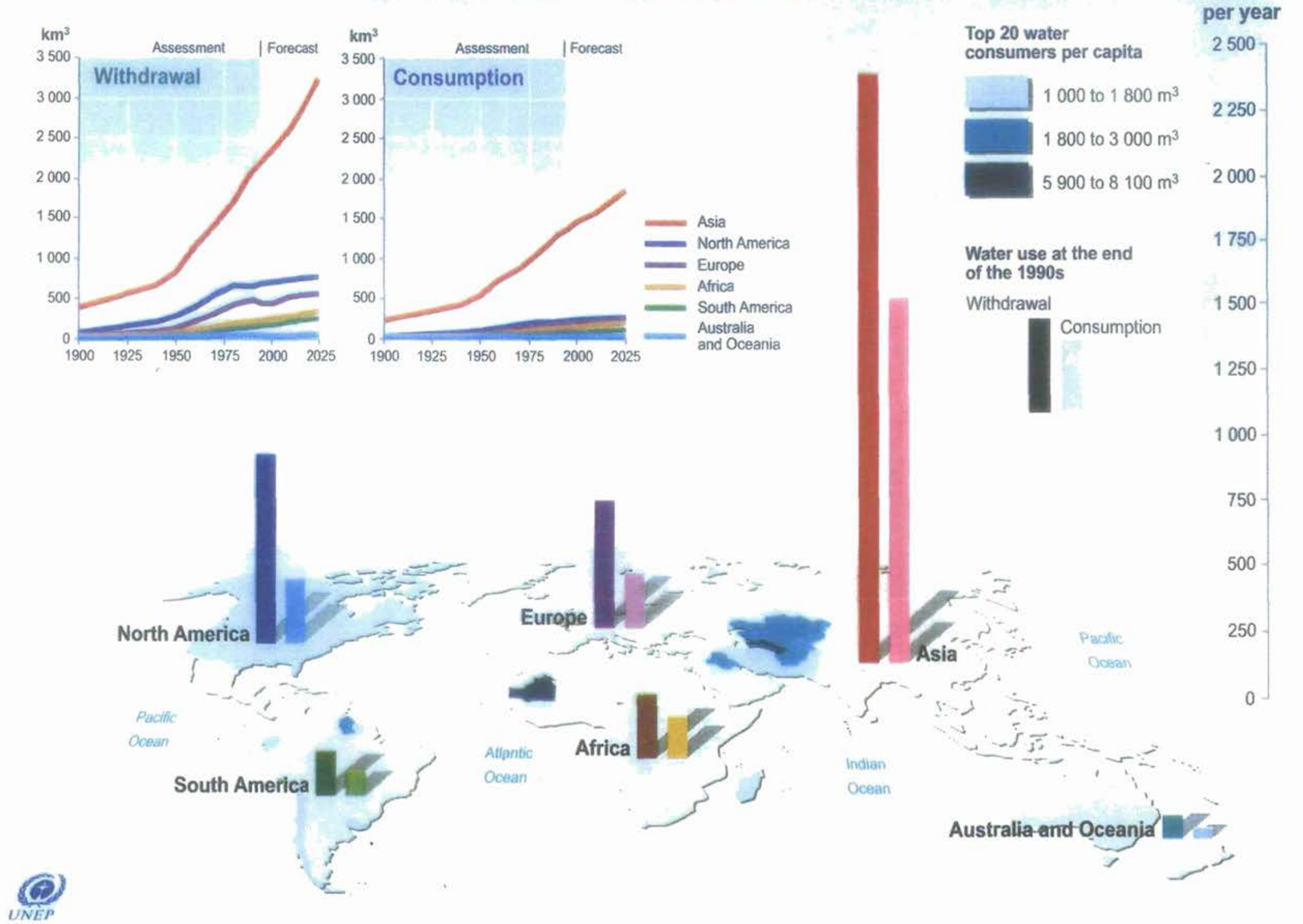
Global change

- Changes in hydrological cycles
- Rising sea levels
- Increased UV-B radiation as a result of ozone depletion
- Changes in ocean carbon dioxide source/sink function

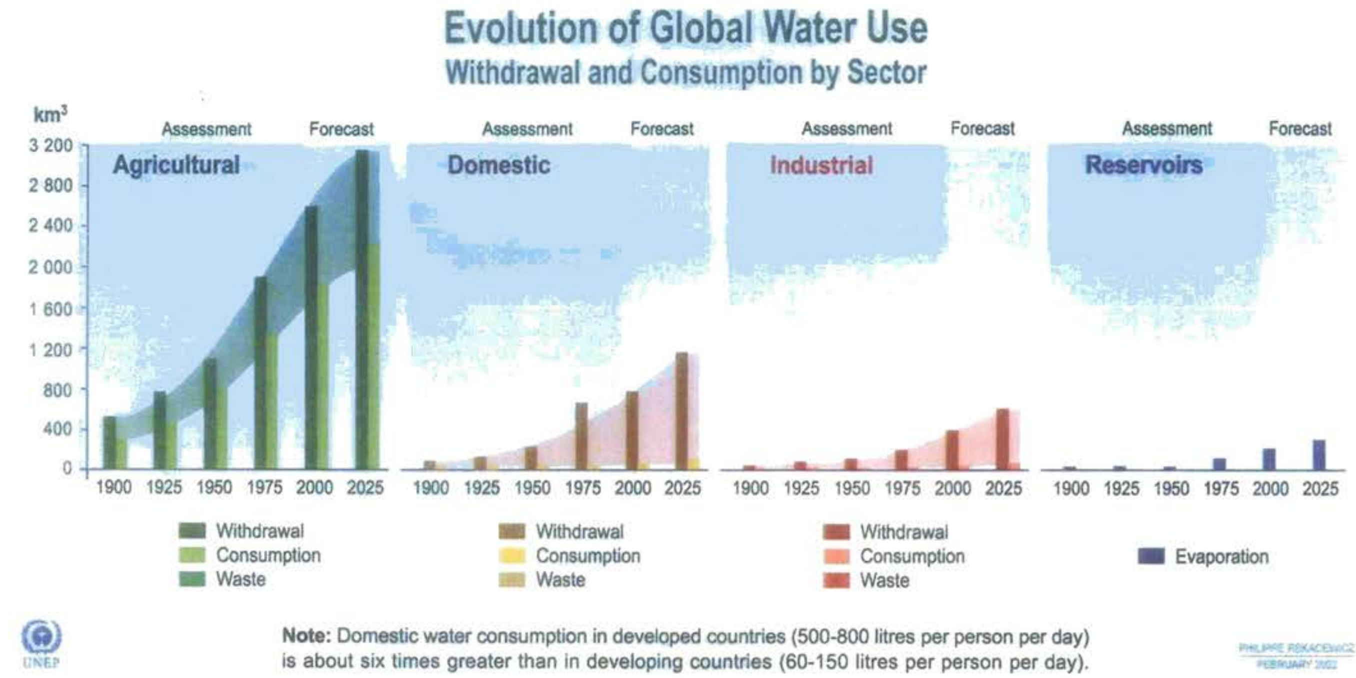


Source: Global International Water Assessment (GIWA), 2001; European Environment Agency (EEA), Copenhagen.

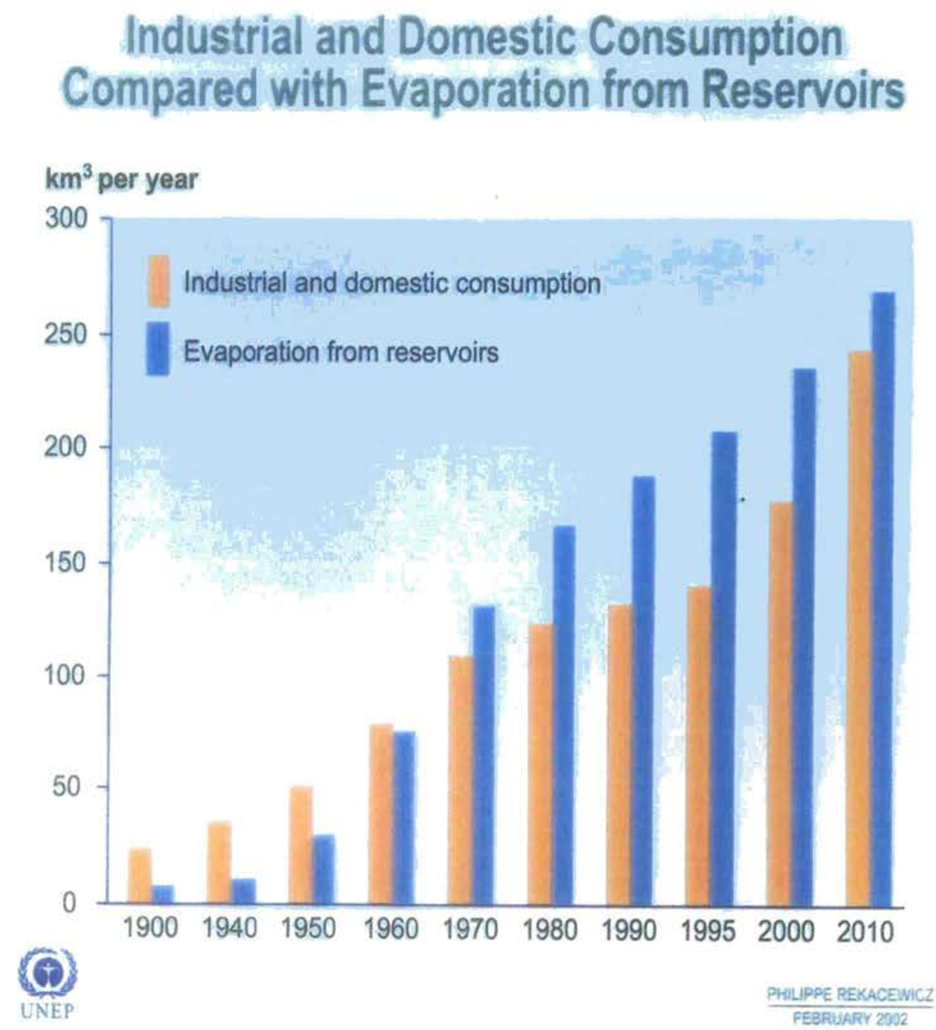
Global Water Withdrawal and Consumption



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999; *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000; Paul Harrison and Fred Pearce, *AAAS Atlas of Population 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.

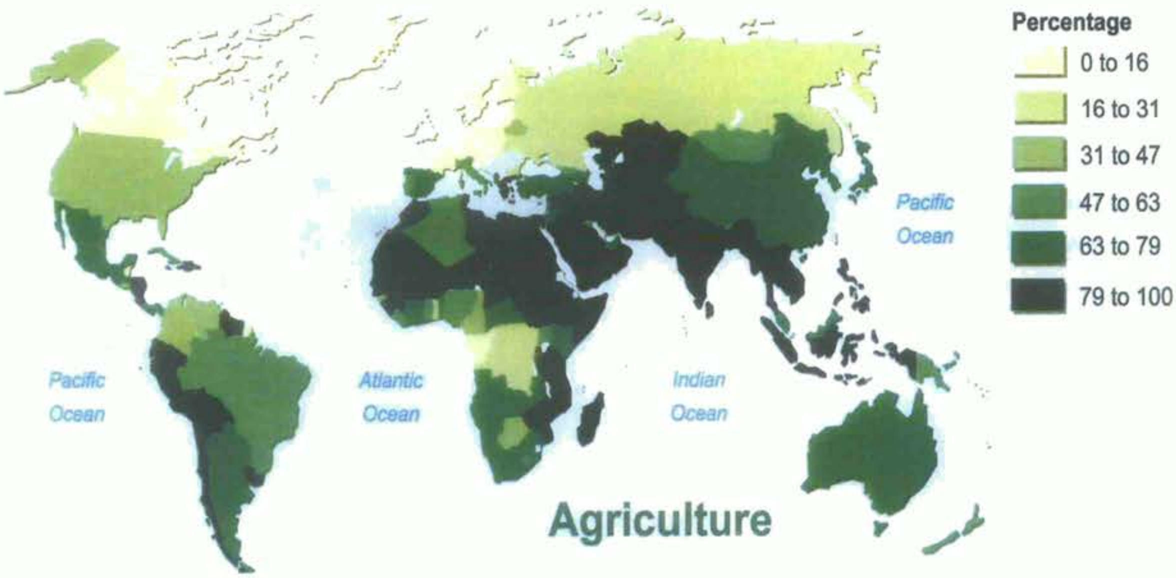


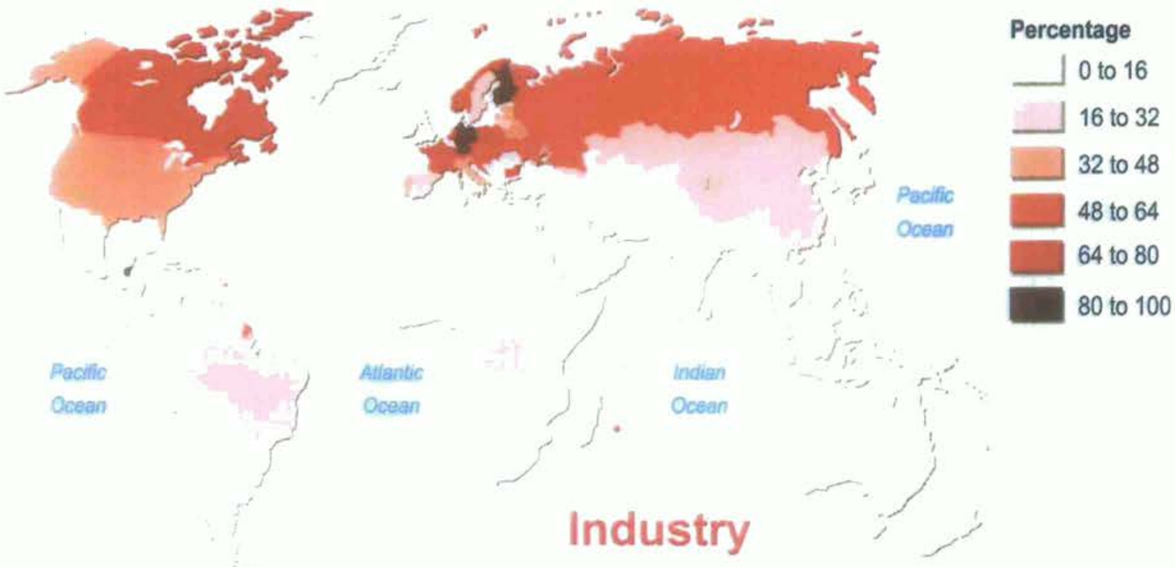
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999.

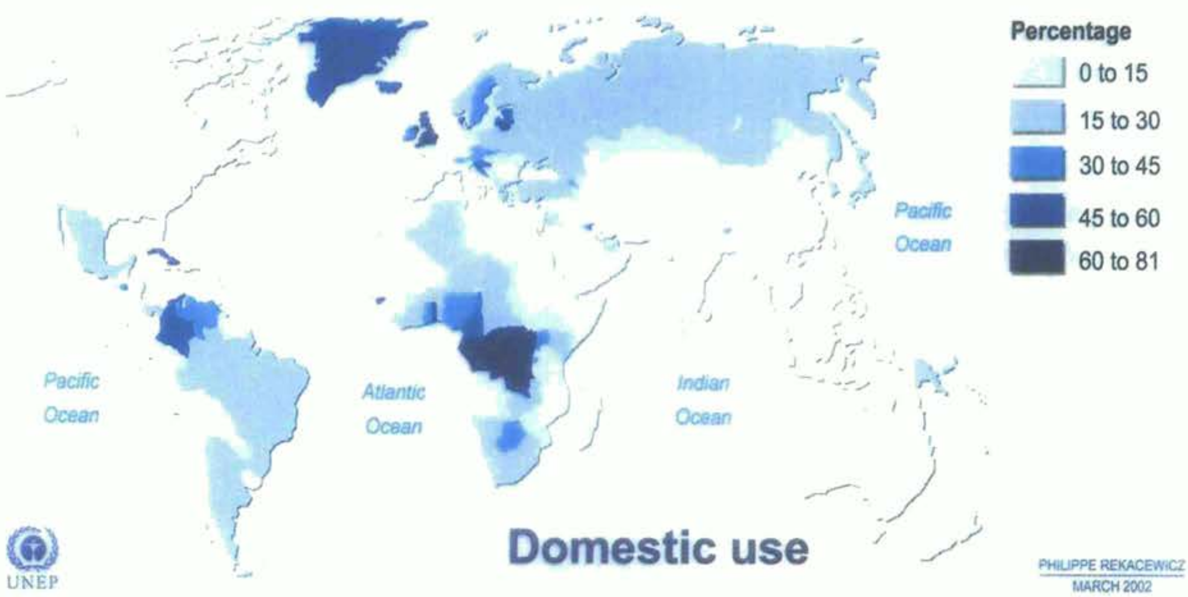


Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Freshwater Withdrawal by Sector in 2000



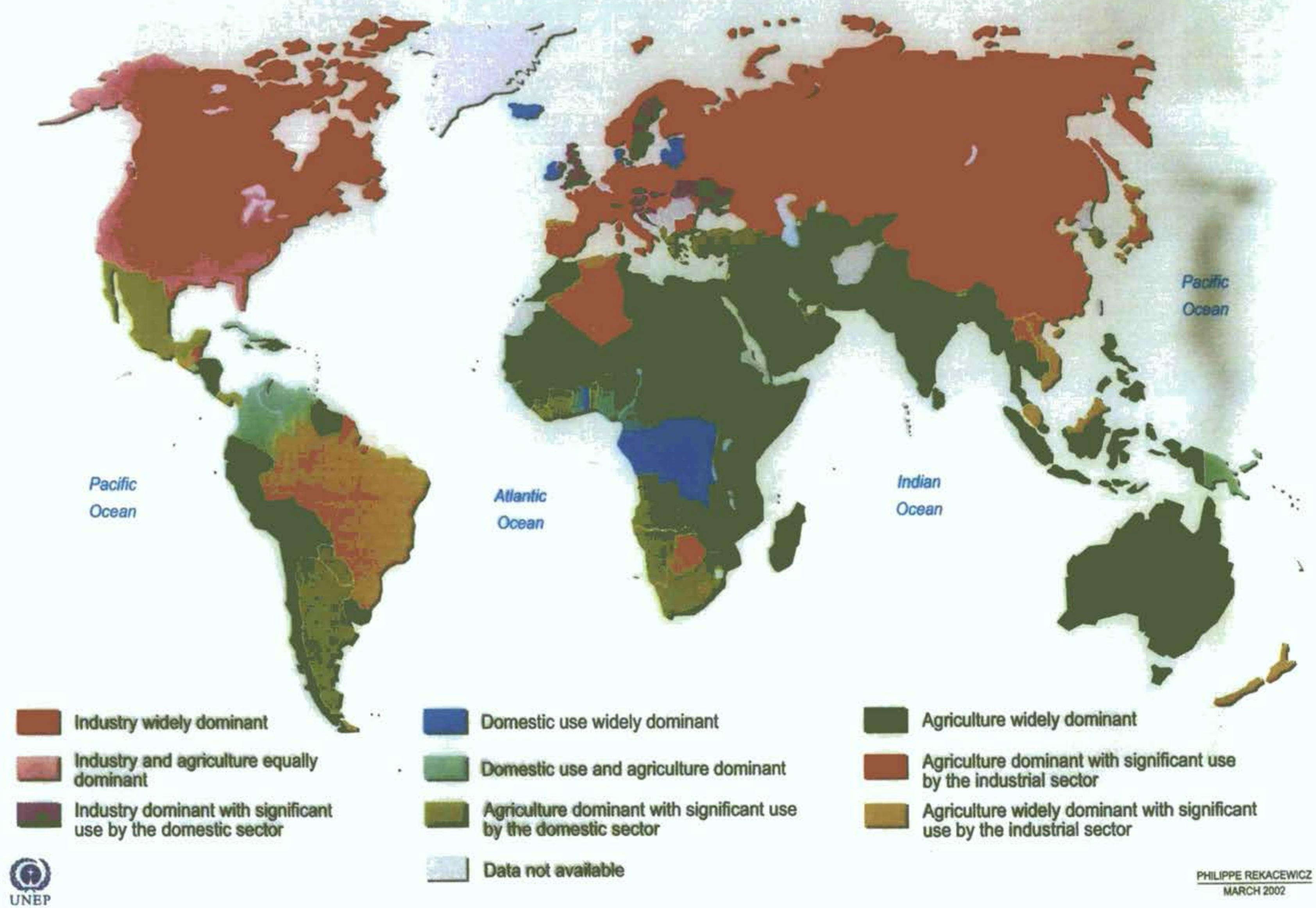




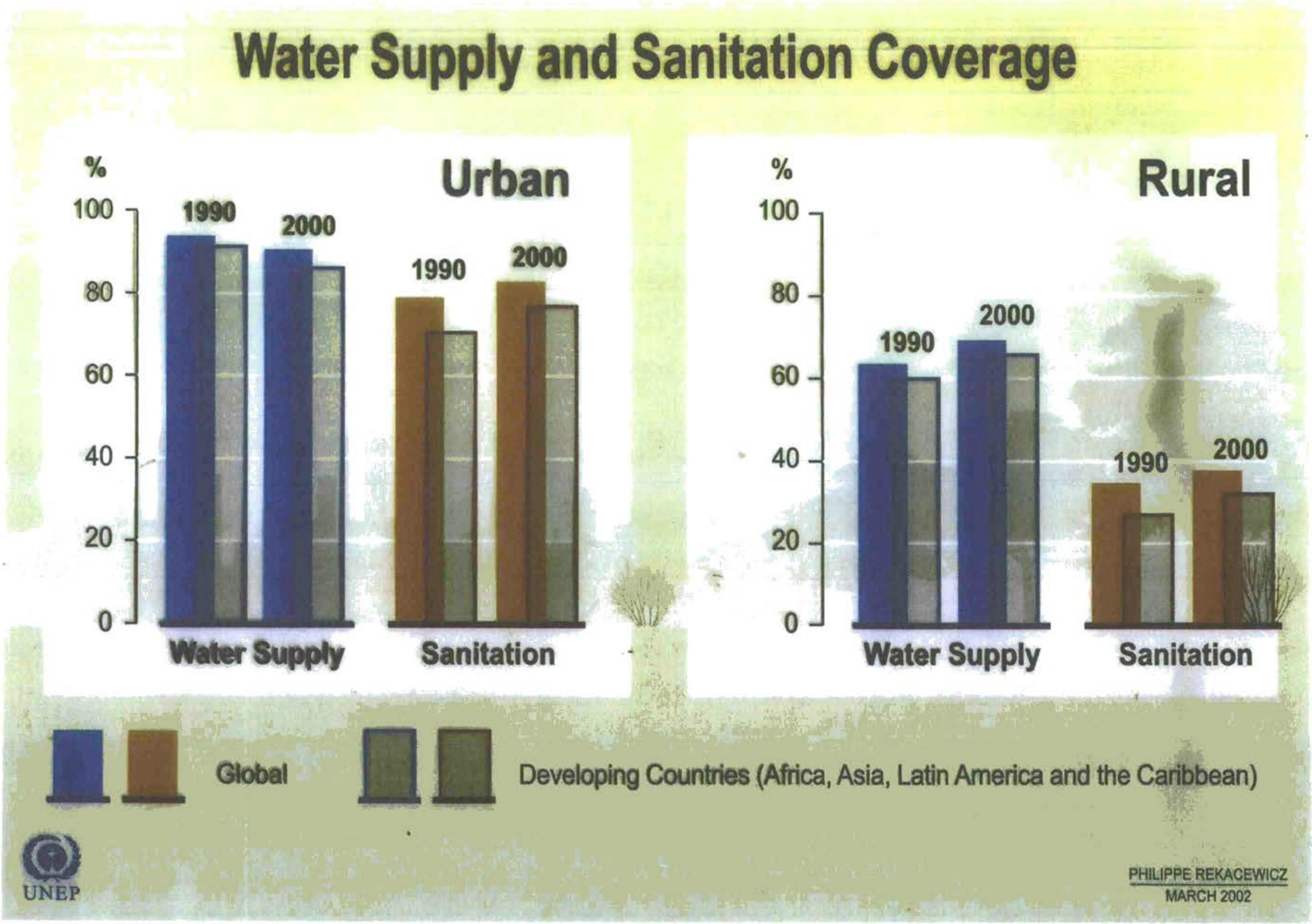
Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

Global Freshwater Withdrawal

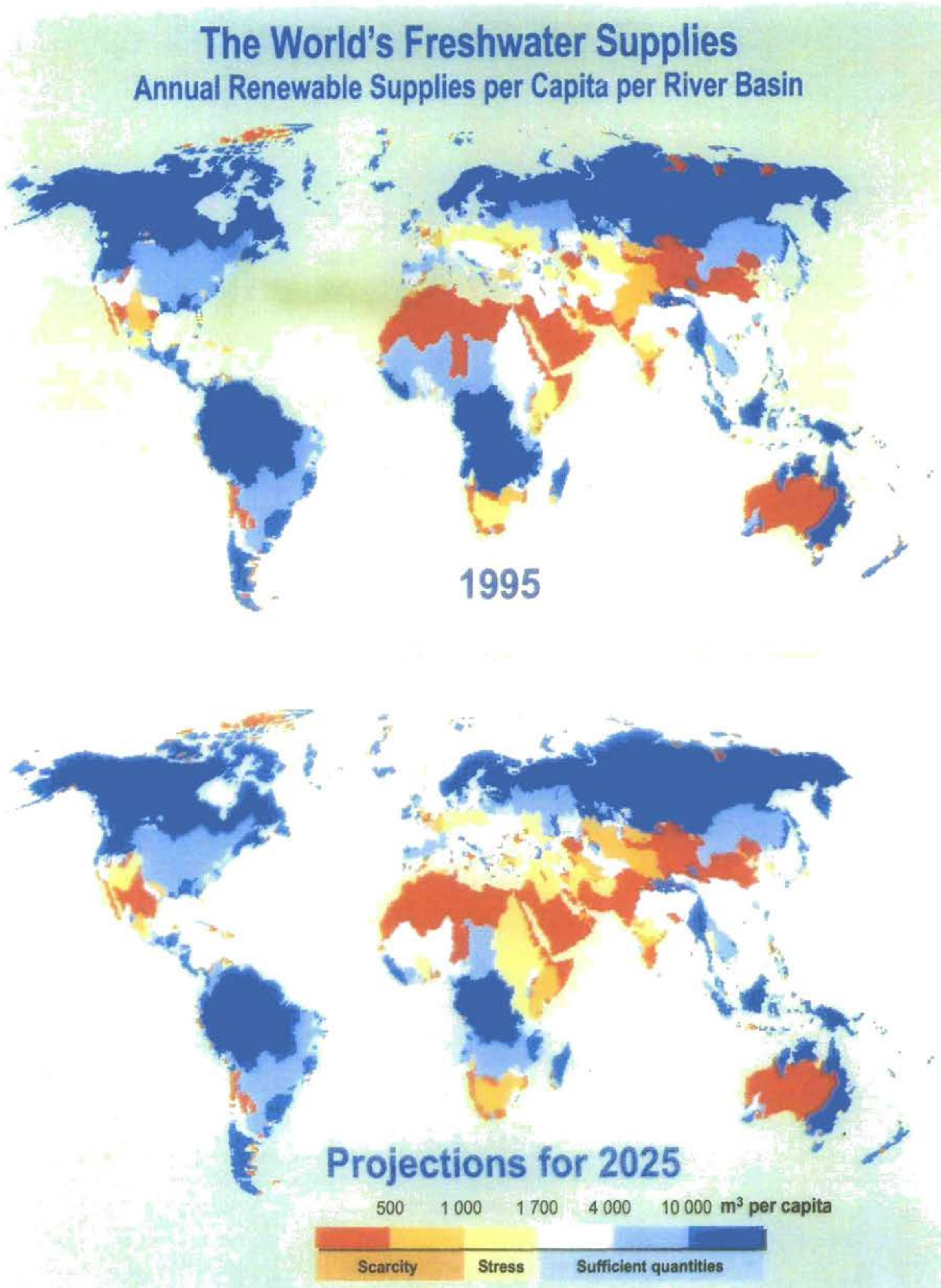
Country Profiles Based on Agricultural, Industrial and Domestic Use



Source: Based on data fromTable FW1 in *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.



Source : *Global Water Supply and Sanitation Assessment 2000 Report*, World Health Organisation (WHO) and United Nations International Children's Emergency Fund (UNICEF), 2000.

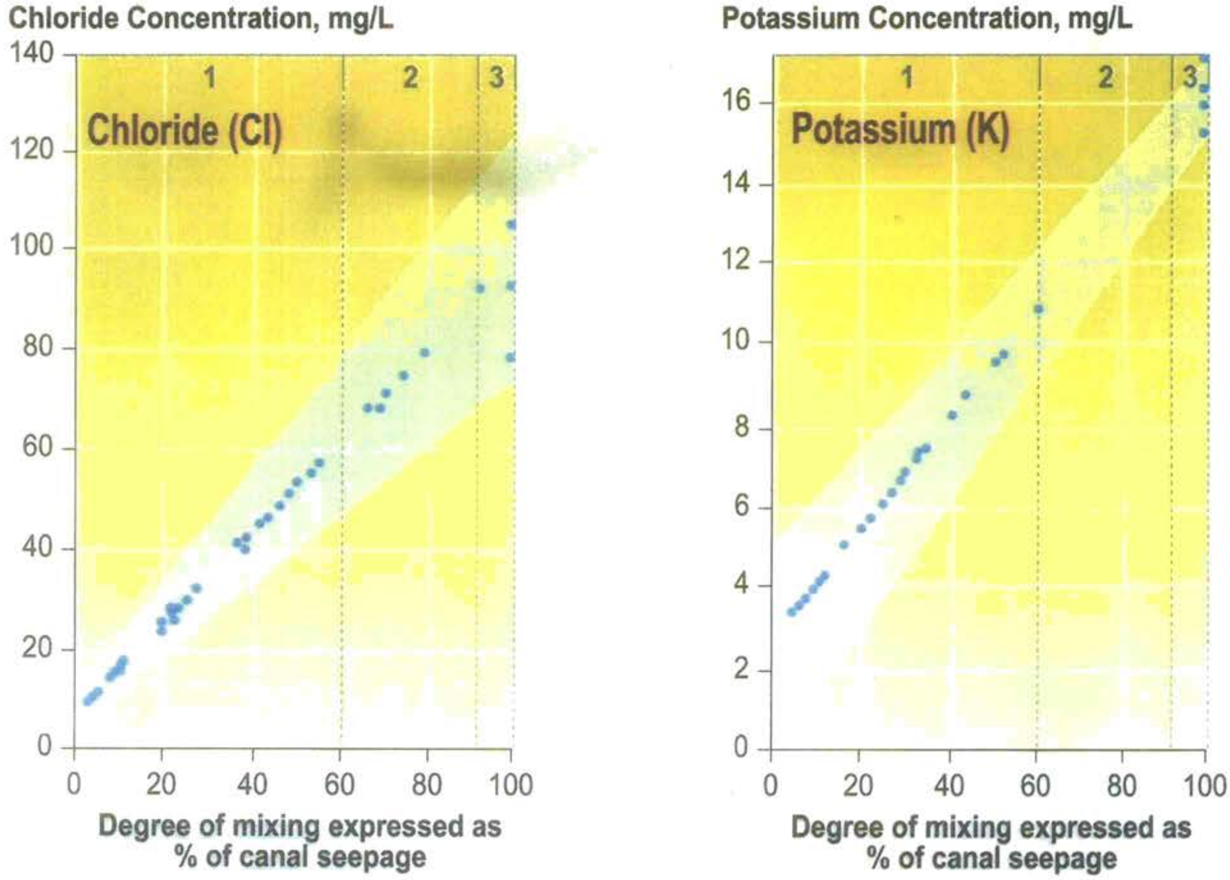


	m^3 per capita per year
North America	
1 Yukon	1 249 832
2 Mackenzie	408 243
3 Nelson	15 167
4 Mississippi	8 973
5 St. Lawrence	9 095
South America	
6 Amazon	273 767
7 Paraná	8 025
Europe	
25 Danube	2 519
Africa and West Asia	
8 Niger	4 076
9 Lake Chad Basin	7 922
10 Congo	22 752
11 Nile	2 207
12 Zambezi	-
26 Orange	1 050
24 Euphrates and Tigris	2 189
Asia and Australia	
13 Volga	4 260
14 Ob	14 937
15 Yenisey	79 083
16 Lena	161 359
17 Kolyma	722 456
18 Amur	4 917
19 Ganges and Brahmaputra	-
20 Yangtze	2 265
21 Murray Darling	-
22 Huang He	361
23 Indus	830

Source: Revenga et al. 2000, from *Pilot Analysis of Global Ecosystems: Freshwater Systems.*

An Urban Dilemma

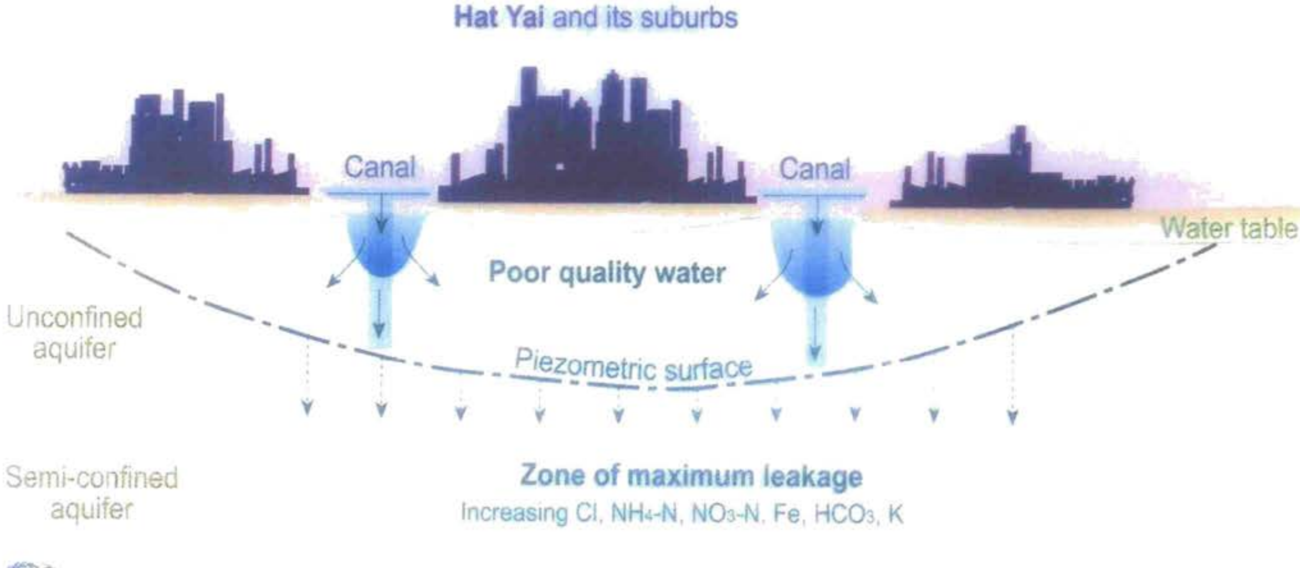
Groundwater Pollution by Canal Seepage in Hat Yai, Southern Thailand



Mixing of groundwater and polluted canal water

1 Water not or little mixed with canal water
2 Water mixed with canal water
3 Groundwater and canal water completely mixed

Mixing of Unpolluted Groundwater and Canal Seepage



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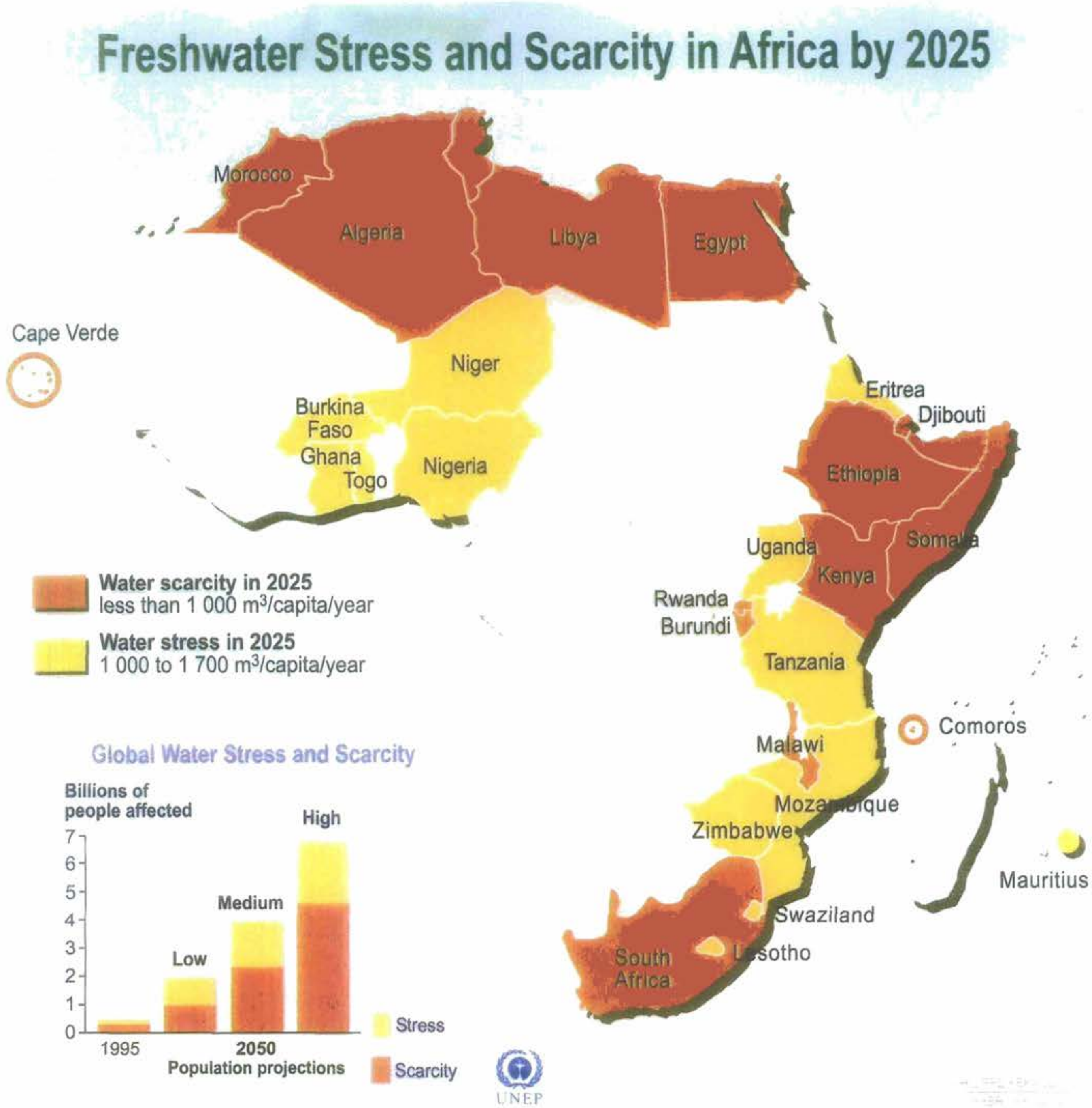
MAY 2002

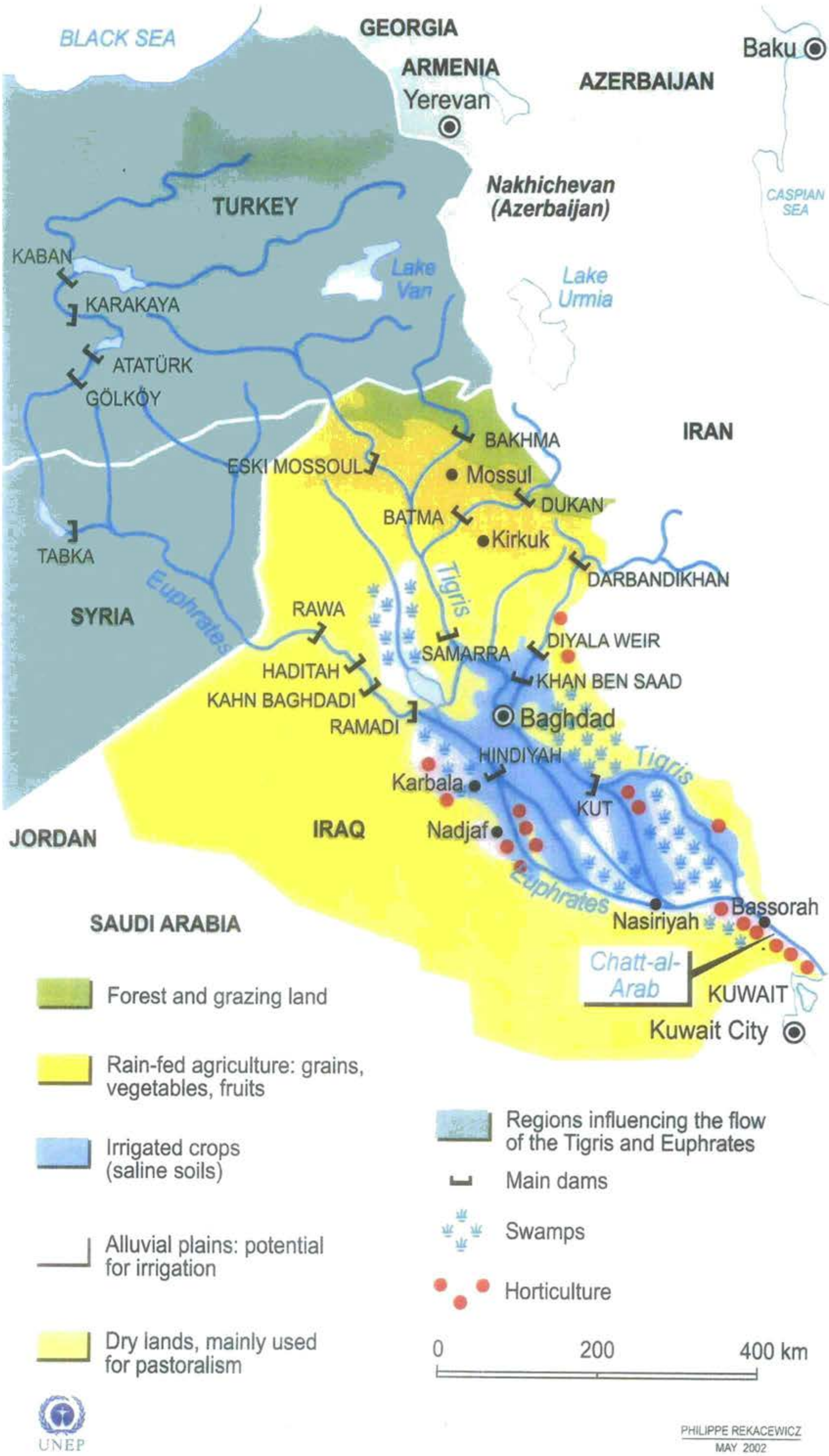
Sources: Foster et al., 1998.



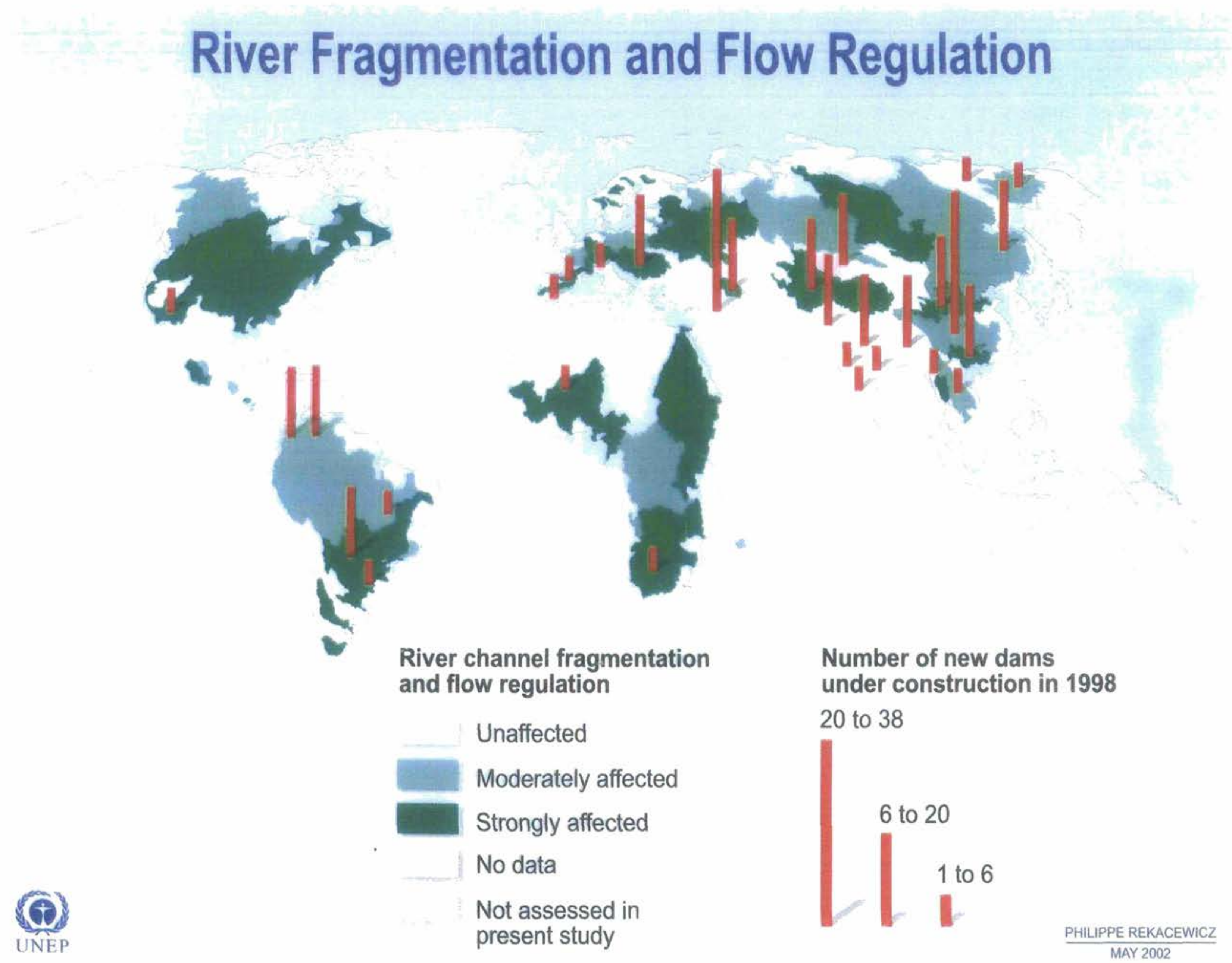
Source: United Nations Economic Commission for Africa (UNECA), Addis Ababa; Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999; Population Action International.

Turning the Tides

Regulation of the Tigris and Euphrates Rivers

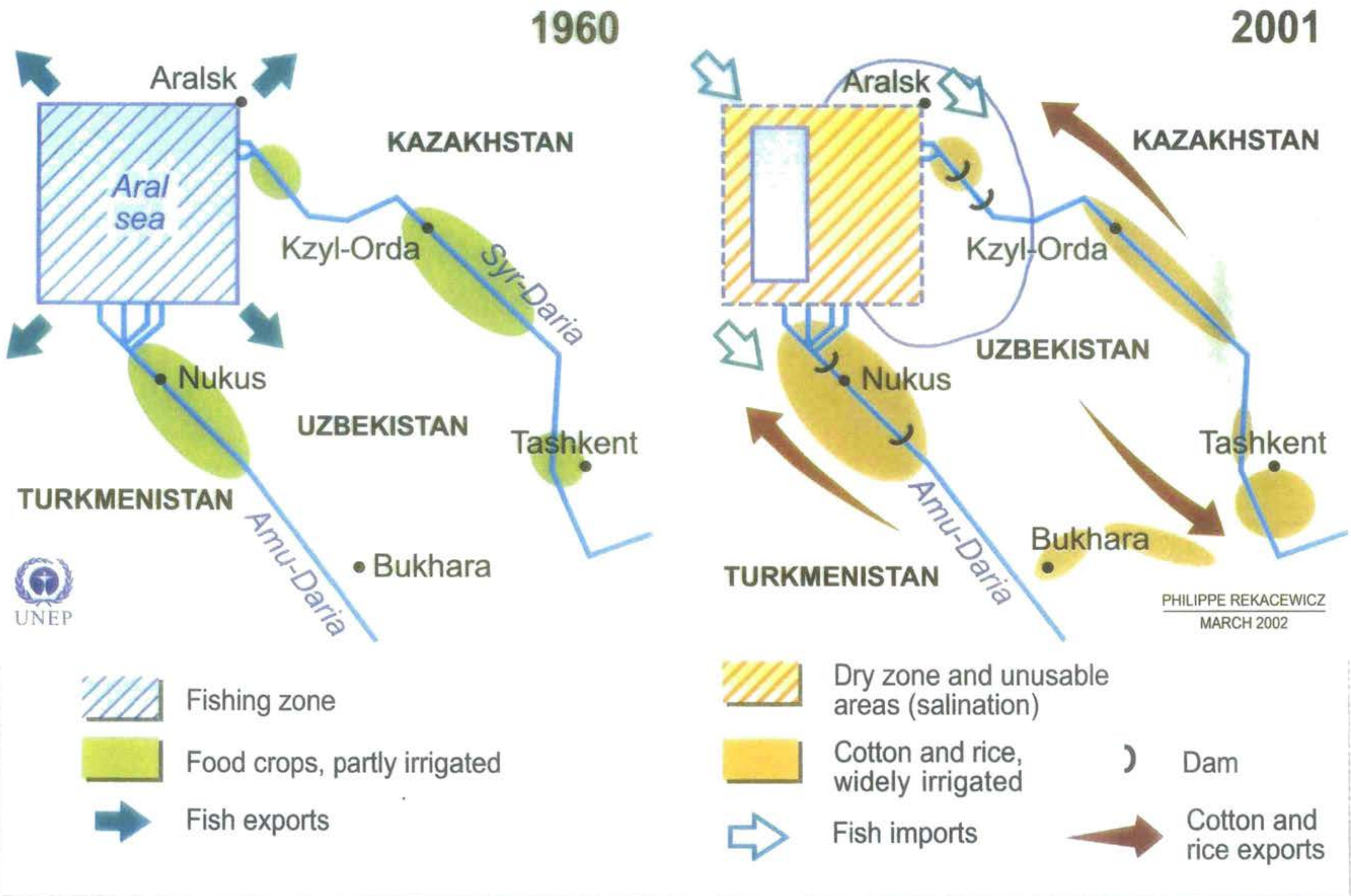


Source: Le Monde diplomatique, Paris, 1994, updated in 2001.



Source: Revenga et al., World Resources Institute (WRI), Washington DC, 2000.

The Shrinking of the Aral Sea: Socio-Economic Impacts



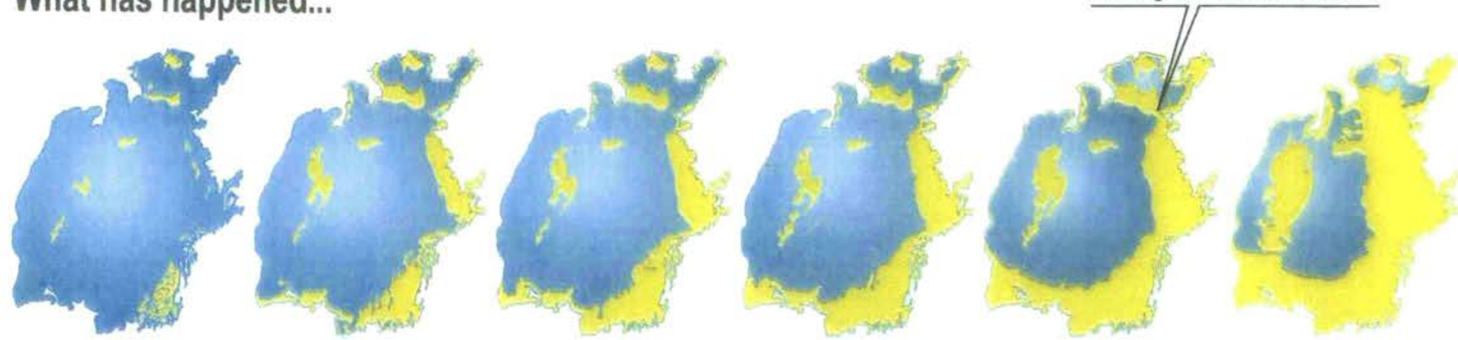
Source: Philippe Rekacewicz, *An Assassinated Sea*, in Histoire-Géographie, initiation économique, page 333, Classe de Troisième, Hatier, Paris, 1993 (data updated in 2002); *L'état du Monde*, 1992 and 2001 editions, La Découverte, Paris.

Will the Aral Sea Disappear Forever?

The last 40 Years and Alternative Future Scenarios

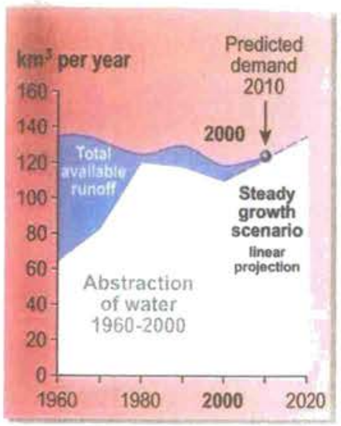
What has happened...

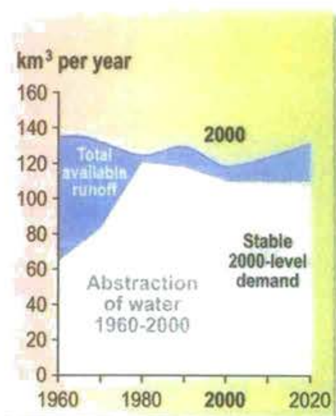
In 1989-1990, the Aral Sea separated into two parts: the 'Large Aral' and the 'Small Aral'

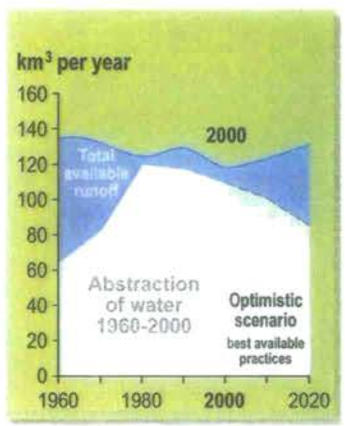


1957 from a map — **1977** from satellite images — **1982** from satellite images — **1984** from satellite images — **1993** from a map — **November 2000** from satellite images

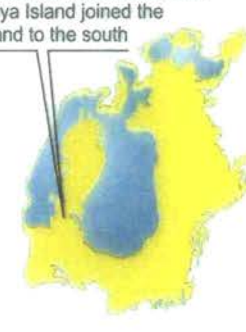
What could happen...







Between November 2000 and June 2001, Vozrojdeniya Island joined the mainland to the south



June 2001 from satellite images

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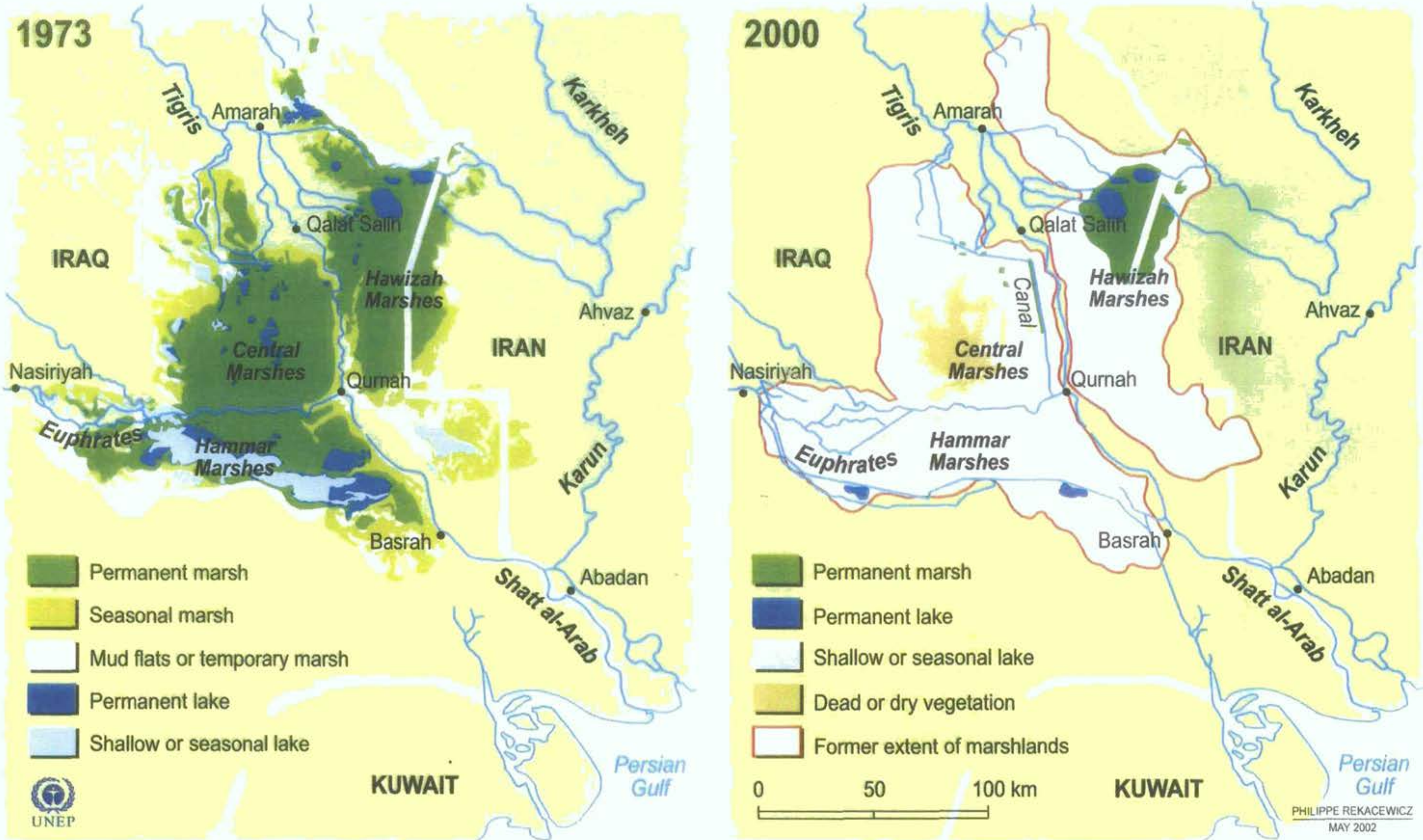
MARCH 2002

Sources: Nikolaï Denisov, GRID-Arendal, Norway; Scientific Information Center of International Coordination Water Commission (SIC ICWC); International Fund for Saving the Aral Sea (IFAS); The World Bank; National Astronautics ans Space Administration (NASA); United States Geological Survey (USGS), *Earthshots: Satellite images of environmental change*, United States Department of the Interior, 2000.

From Wetlands to Dry Lands

The Destruction of the Mesopotamian Marshlands

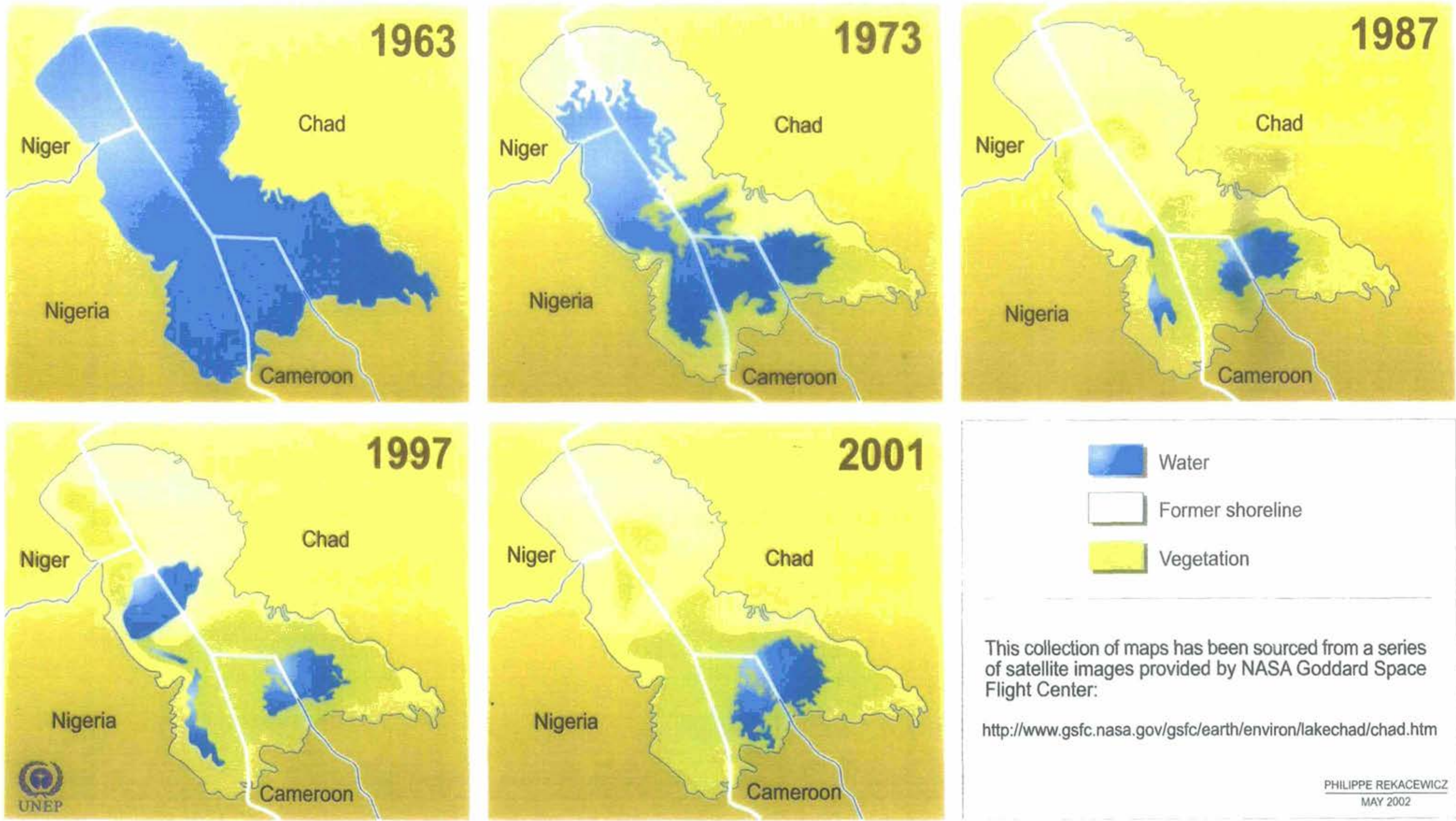


Note: These two maps are sourced from satellite images and maps originally created by Hassan Partow, GRID-Geneva.

Source: Hassan Partow, *The Mesopotamian Marshlands: Demise of an Ecosystem*, United Nations Environment Programme (UNEP), Division of Early Warning and Assessment (DEWA), 2001.

A Chronology of Change

Natural and Anthropogenic Factors Affecting Lake Chad



This collection of maps has been sourced from a series of satellite images provided by NASA Goddard Space Flight Center:

http://www.gsfc.nasa.gov/gsfc/earth/environ/lakechad/chad.htm

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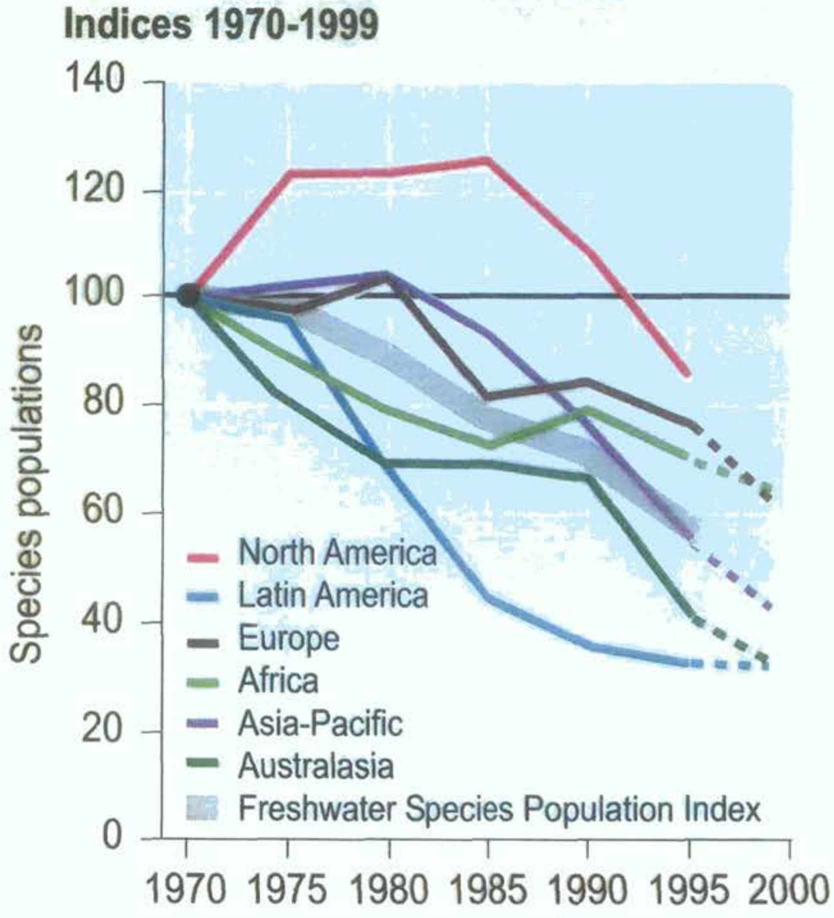
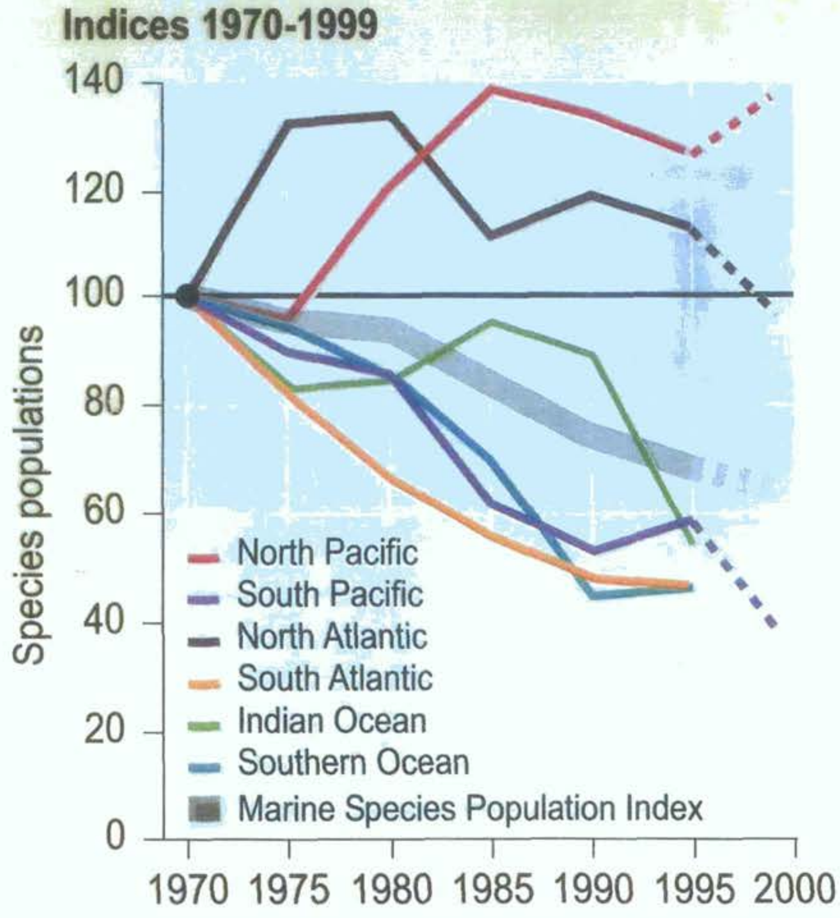
Changes in Freshwater Species Populations



Changes in Marine Species Populations



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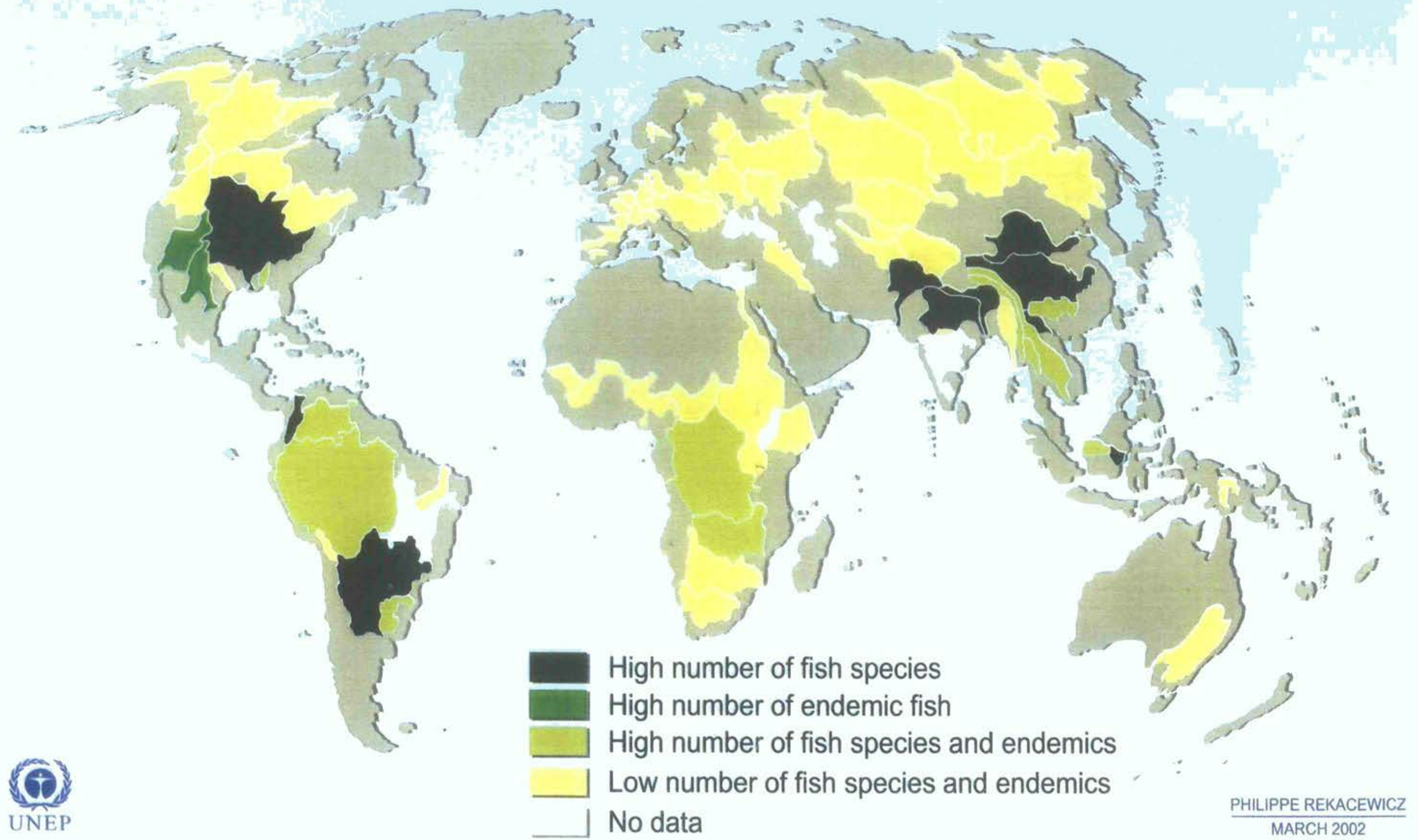
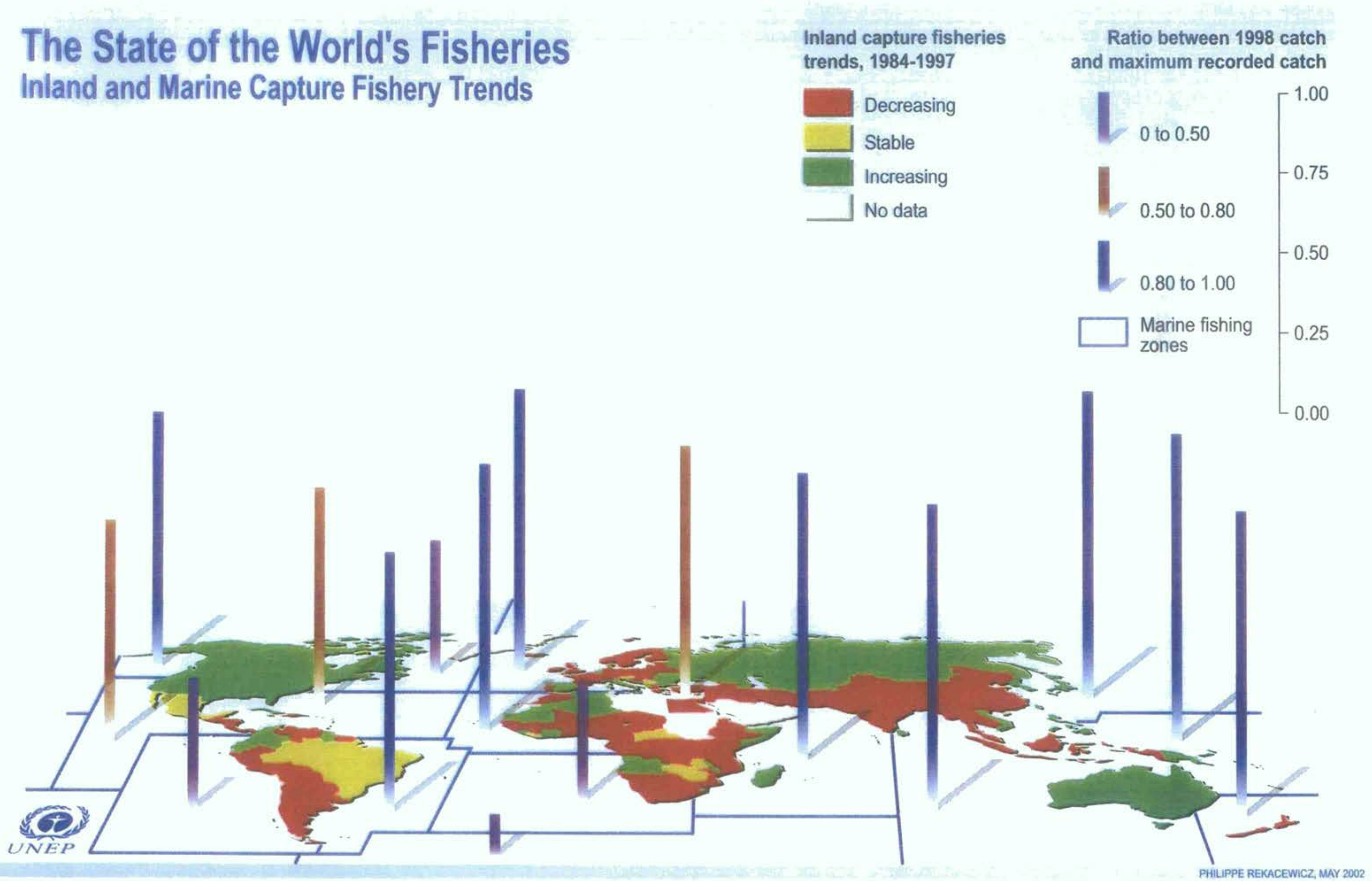
Source: J. Loh (ed.), *Living Planet Report 2000*, World Wide Fund for Nature (WWF)

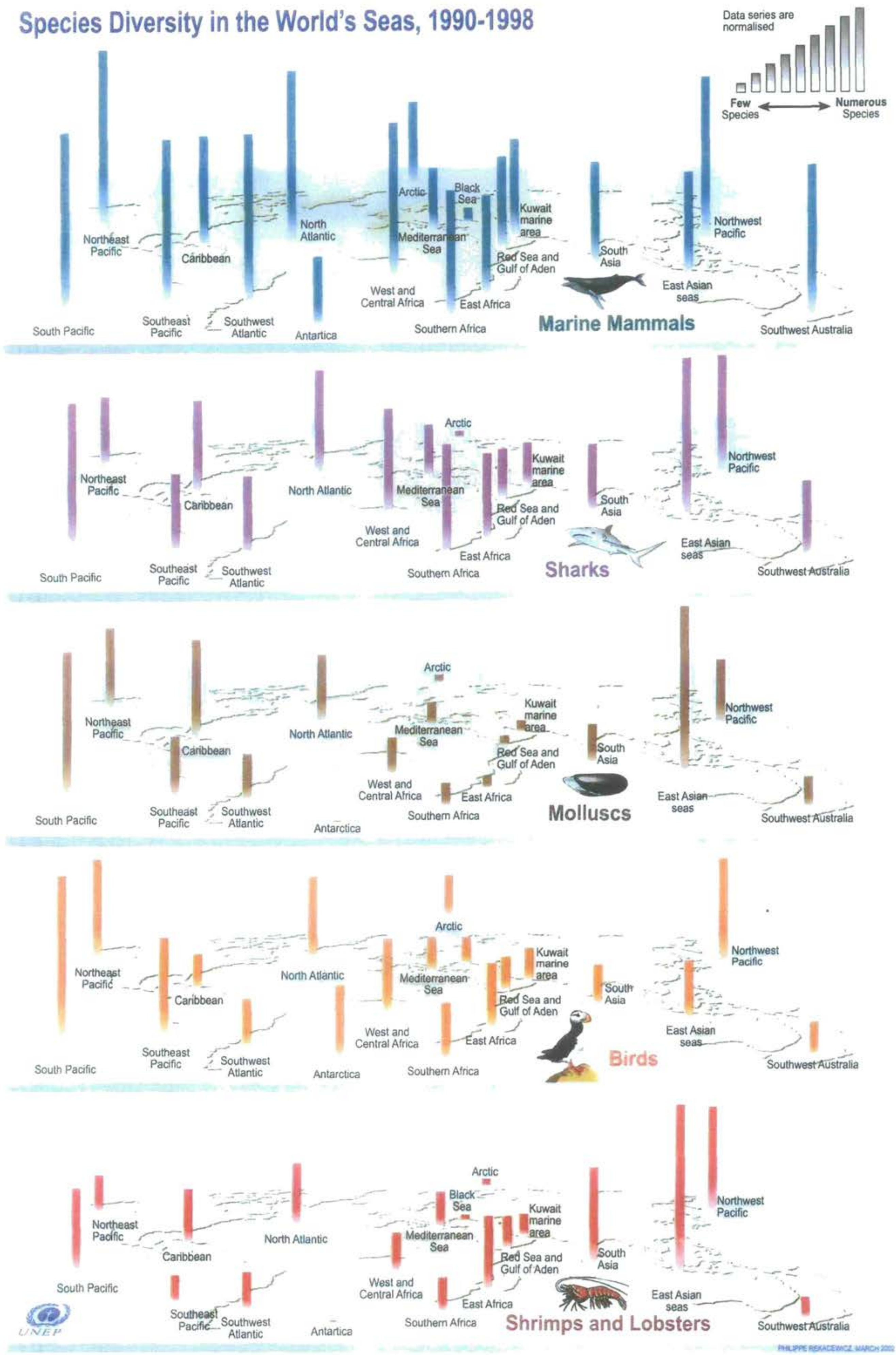
Fish Diversity in Freshwater Systems



Source: Revenga et al., World Resources Institute (WRI), Washington DC, 1998.

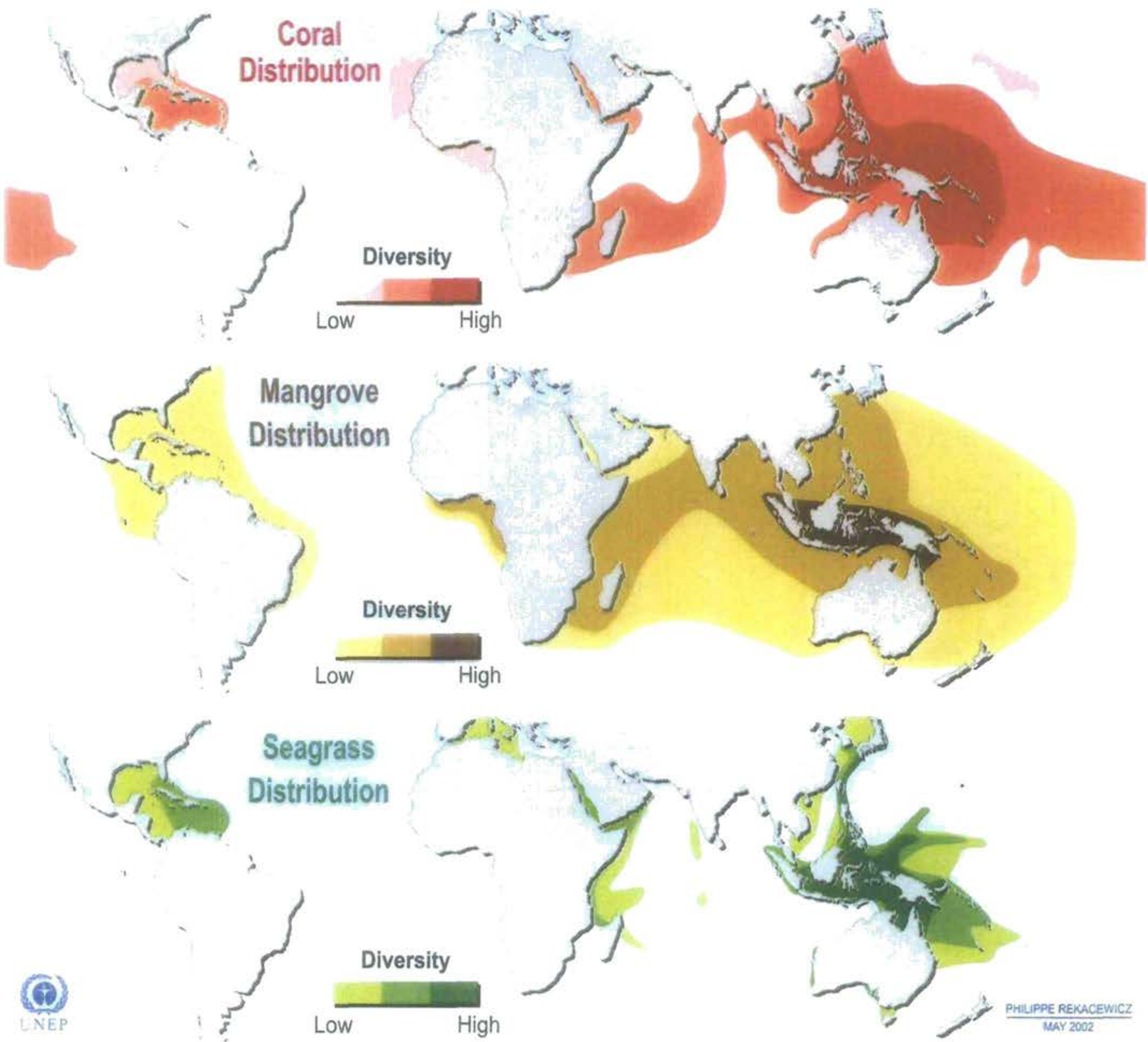


Source: *The State of World Fisheries and Aquaculture 2000* ; *Review of the State of World Fishery Resources: Inland Fisheries,* Food and Agriculture Organisation (FAO), 1999, Rome.

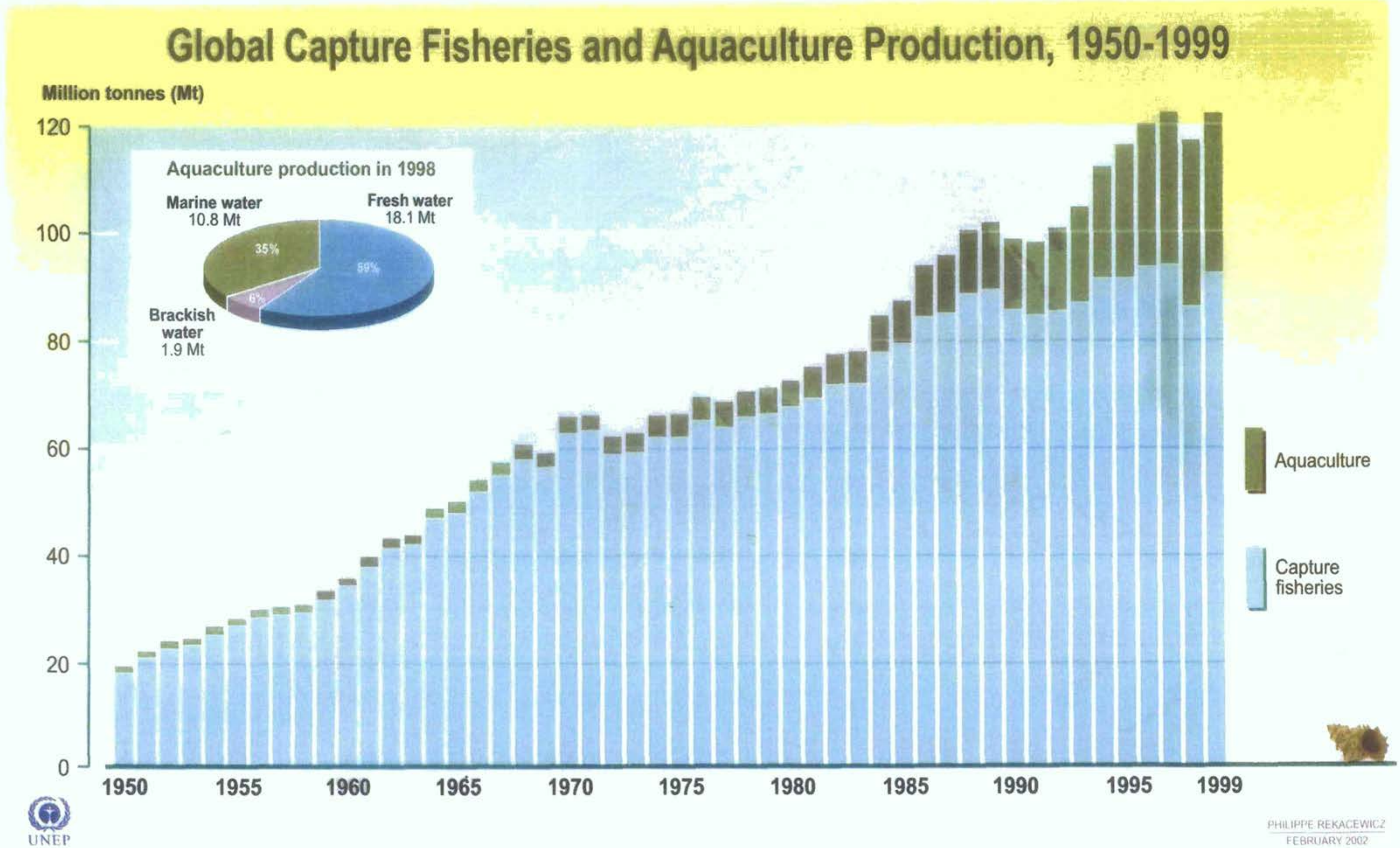


Note: Data have been modified to show the species diversity of each region as a fraction of the most species rich region. The maximum number of marine mammals species in a region is 52, sharks 140, molluscs 1114, birds 115, and shrimps and lobsters 210.
Source: World Resources Institute (WRI), Washington DC, 1998, based on data from UNEP-WCMC.

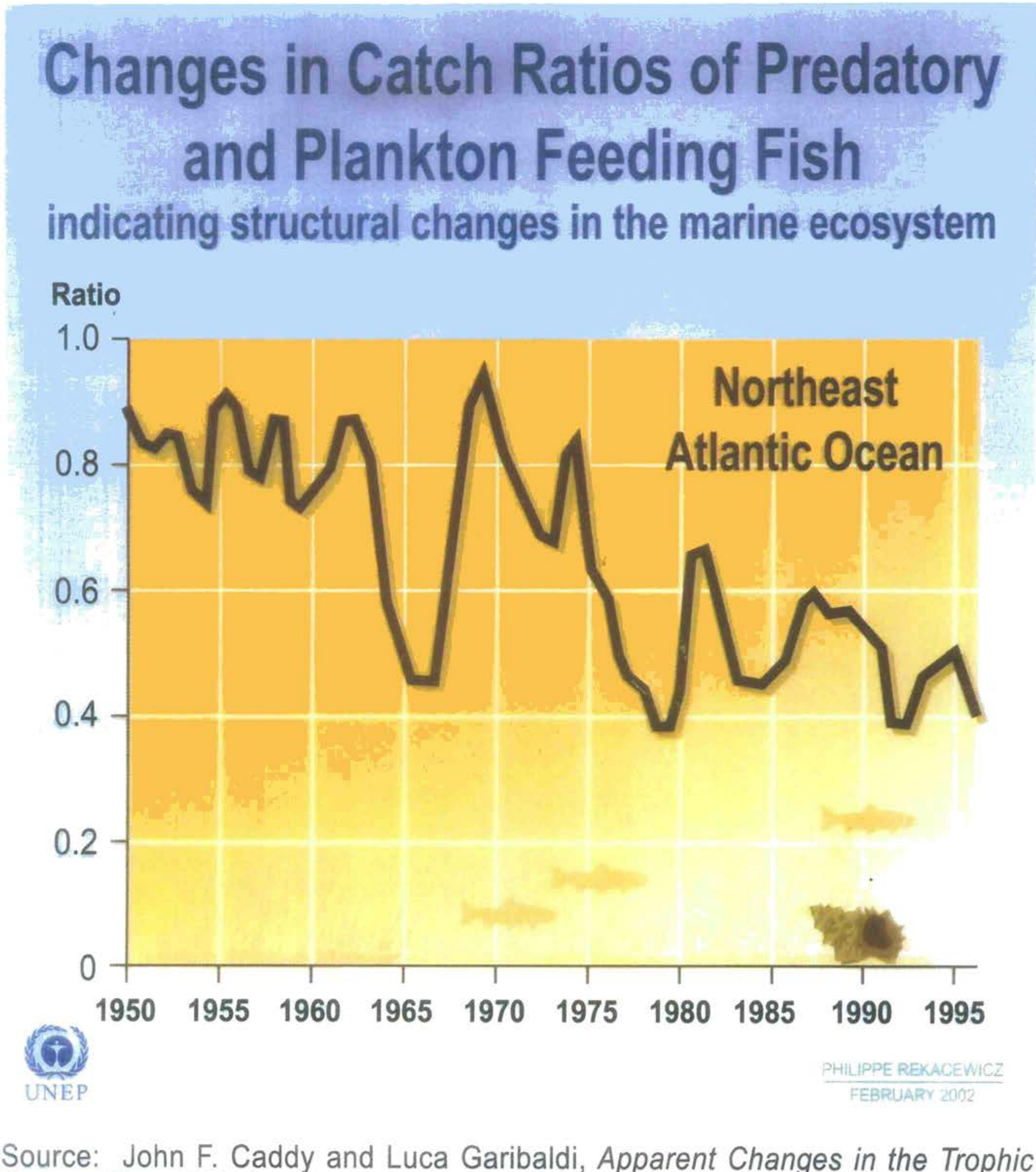
Global Distribution of Coral, Mangrove and Seagrass Diversity



Source: UNEP-WCMC, 2001.



Source: *The State of World Fisheries and Aquaculture 2000*, Food and Agriculture Organisation of the United Nations (FAO).



Source: John F. Caddy and Luca Garibaldi, *Apparent Changes in the Trophic Composition of Marine Harvests: the Perspective from the FAO Capture Database*, Ocean and Coastal Management 43(8-9), 2000.

Benefits from Marine and Coastal Ecosystems and Activities

Coastal tourism

The volume of global tourist arrivals increased more than 20 times between 1950 and 1995, making tourism the world's fastest-growing industry. The present number of tourists is expected to double by 2010 – particularly in the Caribbean and Asia-Pacific regions, where much of the industry is concentrated in coastal areas.

$ 161 billion

Trade and shipping

Since the 1950s, the annual volume of shipping and seaborne trade has risen sixfold, to more than 5 billion tonnes of oil, dry bulk goods and other cargo. In 1995, there were 27,000 freighters over 1,000 tonnes in operation. Industrial countries account for 50% of the cargo loaded – and 75% of that unloaded.

$ 155 billion

Offshore oil and gas

Since gasoline was first used in California a century ago, the oil and natural gas industry has skyrocketed to meet soaring energy demands. Today, about 20% of the world's oil and natural gas comes from offshore drilling installations in the Middle East, the United States, Latin America, and the North Sea.

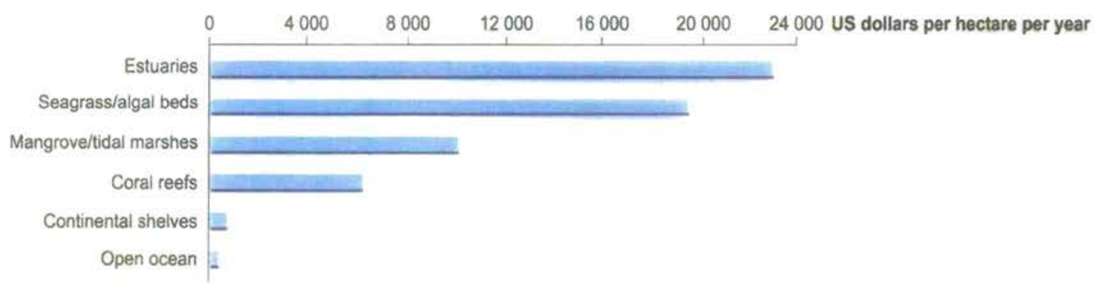
$ 132 billion

Fisheries

Between 1950 and 1997, global fish production from capture and culture fisheries grew from 20 million tonnes to 122 million tonnes, with the per capita supply doubling from 8 kg to 15 kg. Over 200 million people rely on fishing for their livelihoods, with more than 80% of all fish (by value) sold in industrial countries.

$ 80 billion

Estimated Mean Value of Marine Biomes

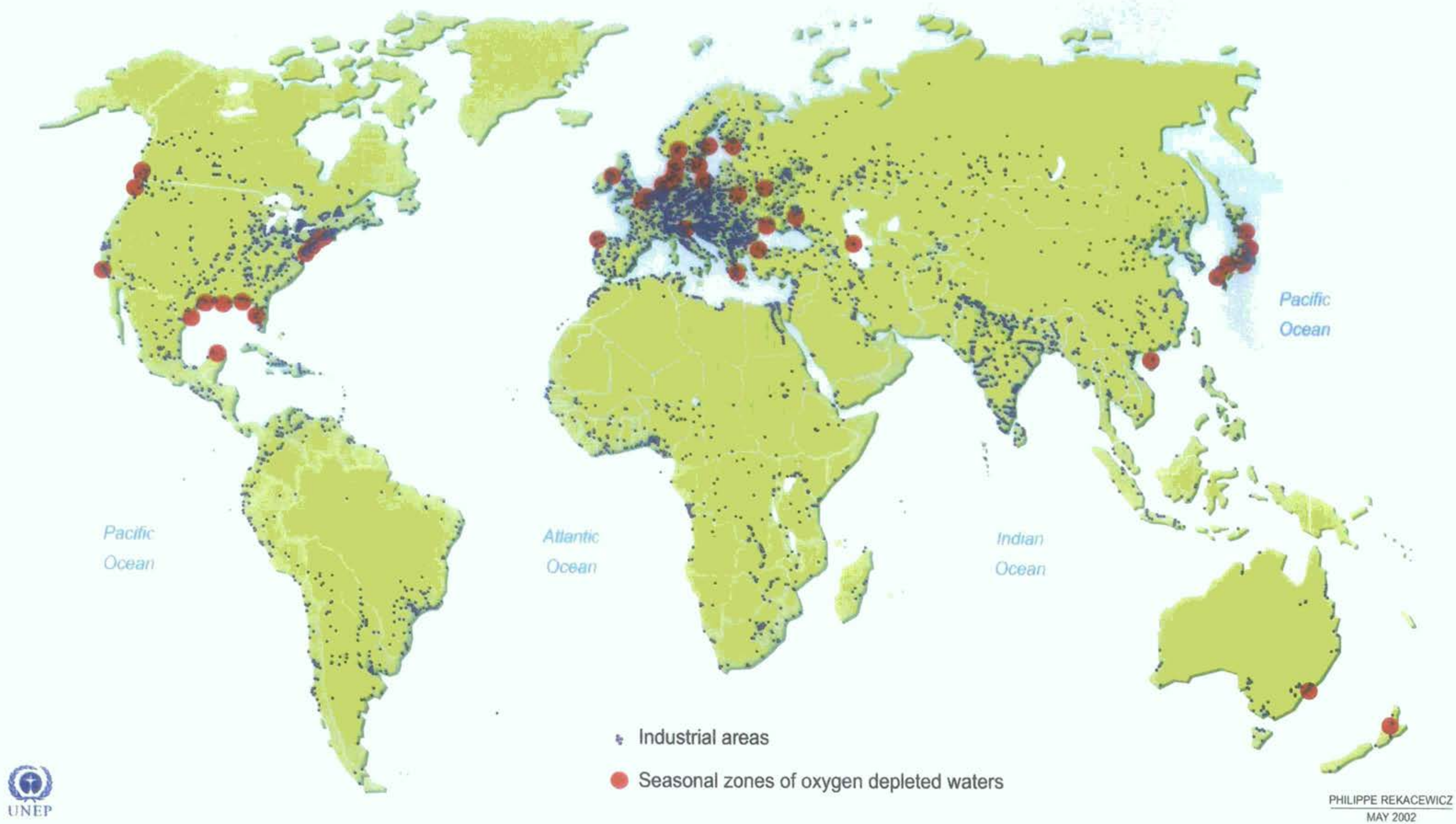


UNEP

DELPHINE DIGOUT
MAY 2002

Source: Anne Platt McGinn, *The Health of Oceans*, Worldwatch paper 145, Worldwatch Institute, 1999, Washington DC (www.worldwatch.org) ; Costanza, R., et al, *The Value of the World's Ecosystem Services and Natural Capital*, Ecological Economics, 1998.

Industrial Areas and Seasonal Zones of Oxygen Depleted Waters



Source: D. Malakoff, 1998, after R.J. Diaz and R.Rosenberg, 1995; ESRI,1990.

Human Actions Leading to Coastal Degradation

Cause of degradation	Estuaries	Inter-tidal Wetlands	Open Ocean
Drainage of coastal ecosystems for agriculture, deforestation, and mosquito control measures	Common and major cause of degradation	Present but not a major cause	Common and major cause of degradation
Dredging and channelisation for navigation and flood protection	Common and major cause of degradation	Common and major cause of degradation	Absent or uncommon
Solid waste disposal, road construction, and commercial, industrial or residential development	Common and major cause of degradation	Common and major cause of degradation	Present but not a major cause
Conversion for aquaculture	Common and major cause of degradation	Common and major cause of degradation	Common and major cause of degradation
Construction of dykes, dams and seawalls for flood and storm control, water supply and irrigation	Common and major cause of degradation	Common and major cause of degradation	Common and major cause of degradation
Discharge of pesticides, herbicides, domestic and industrial waste, agricultural runoff and sediment loads	Common and major cause of degradation	Common and major cause of degradation	Common and major cause of degradation
Mining of wetlands for peat, coal, gravel, phosphates, etc.	Present but not a major cause	Absent or uncommon	Present but not a major cause
Logging and shifting cultivation	Present but not a major cause	Common and major cause of degradation	Absent or uncommon
Fire	Present but not a major cause	Present but not a major cause	Absent or uncommon
Sedimentation of dams, deep channels and other structures	Common and major cause of degradation	Common and major cause of degradation	Common and major cause of degradation
Hydrological alteration by canals, roads and other structures	Common and major cause of degradation	Common and major cause of degradation	Common and major cause of degradation
Subsidence due to extraction of groundwater, oil, gas and other minerals	Common and major cause of degradation	Absent or uncommon	Present but not a major cause

- (large blue) Common and major cause of degradation
- (green) Present but not a major cause
- (small red) Absent or uncommon

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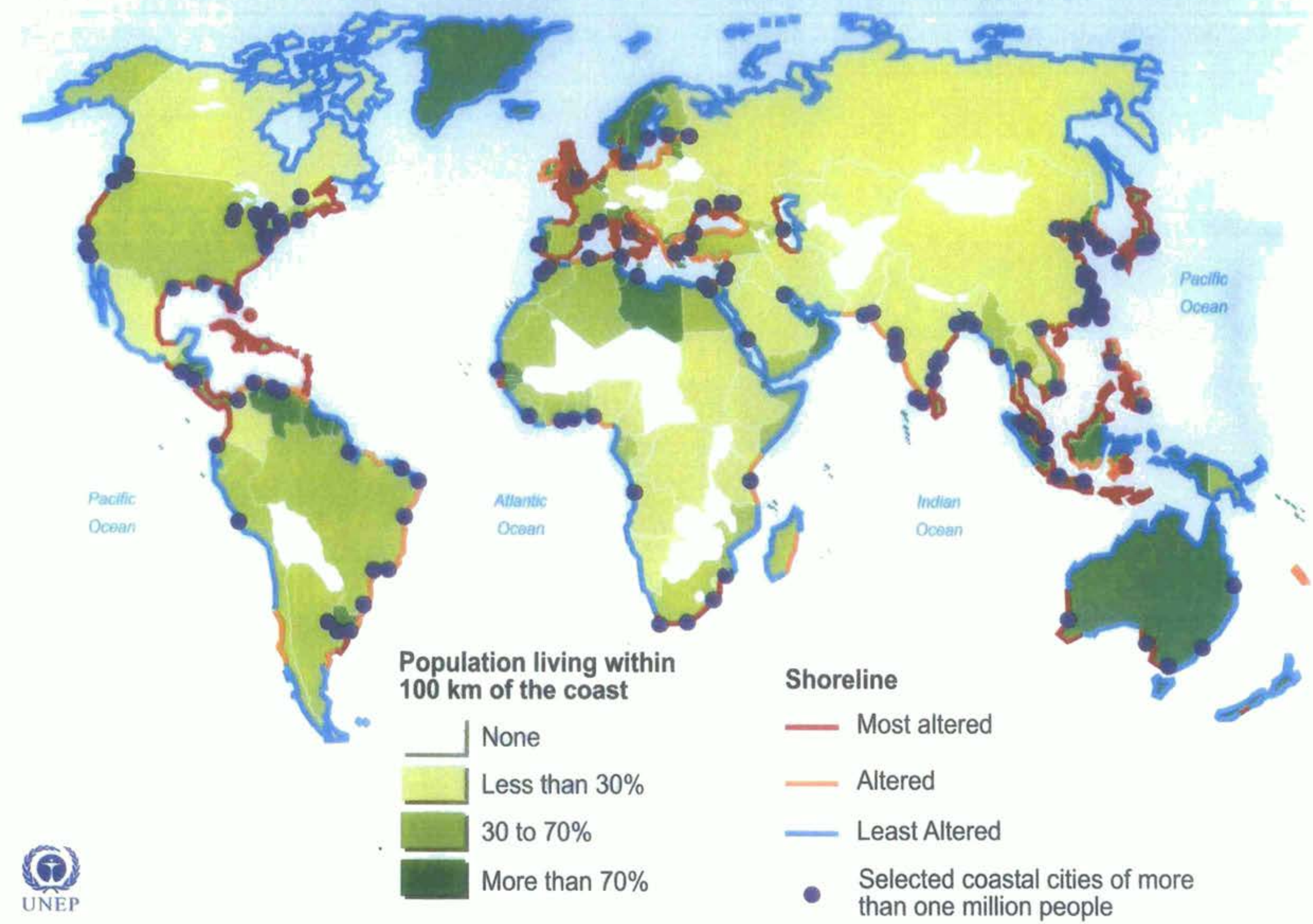
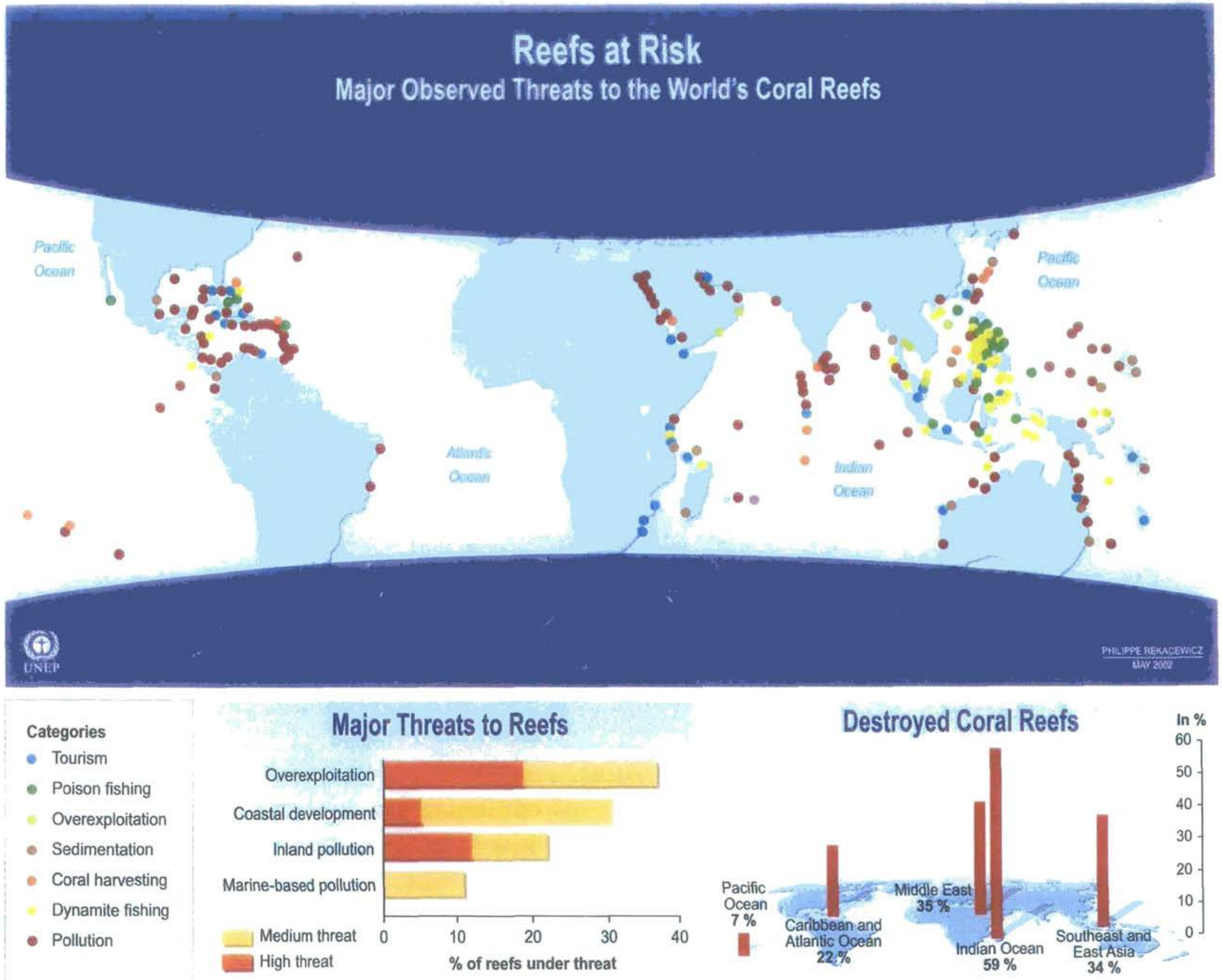
DELPHINE DIGOUT
APRIL 2002

Source: United Nations Environment Programme (UNEP).

Coastal Populations and Shoreline Degradation

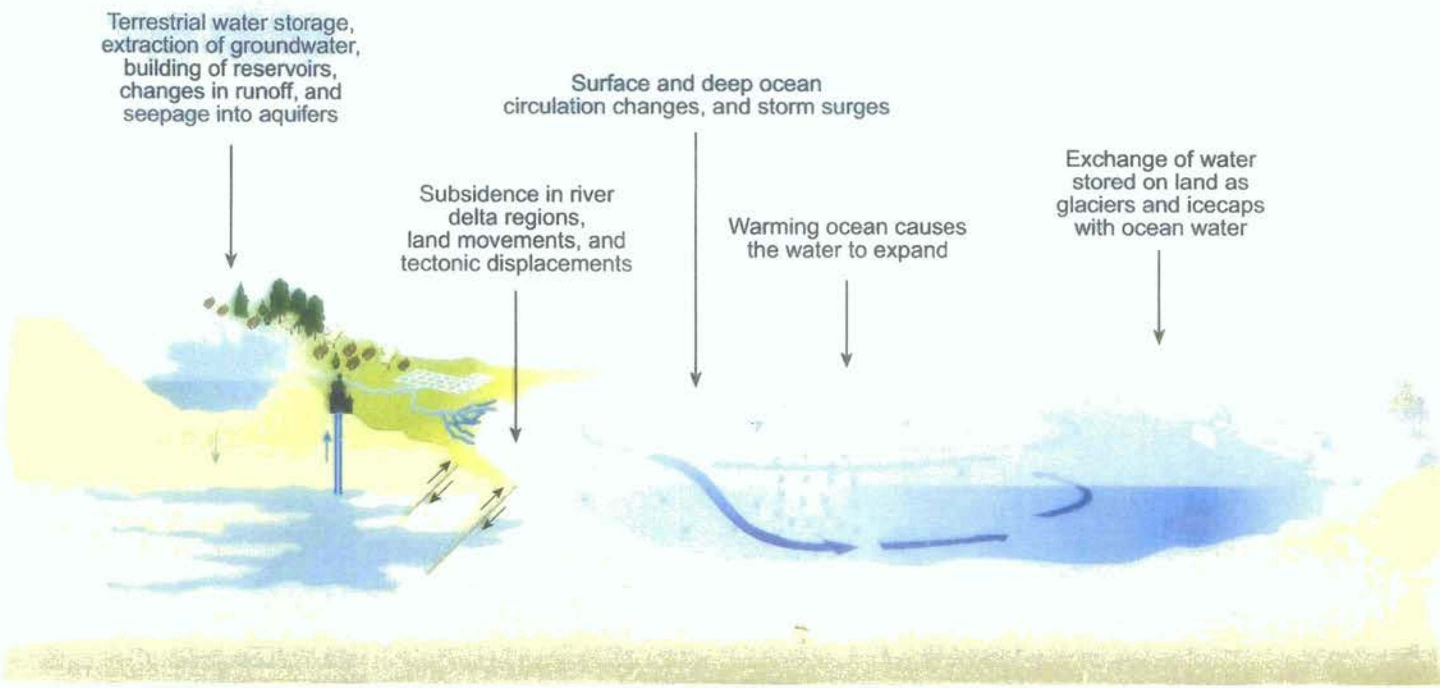


Source: Burke et al., World Resources Institute, Washington DC, 2001; Paul Harrison and Fred Pearce, *AAAS Atlas of Population and Environment 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.



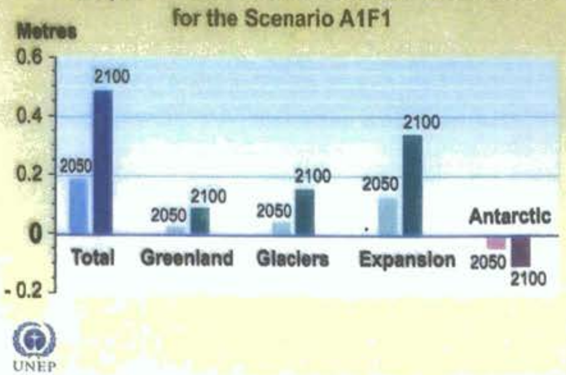
Source: Bryant et al., *Reefs at Risk: a Map-Based Indicator of Threats to the World's Coral Reefs*, World Resources Institute (WRI), Washington DC, 1998.

What Causes the Sea Level to Change?



Components of Mean Sea Level Rise

for the Scenario A1F1



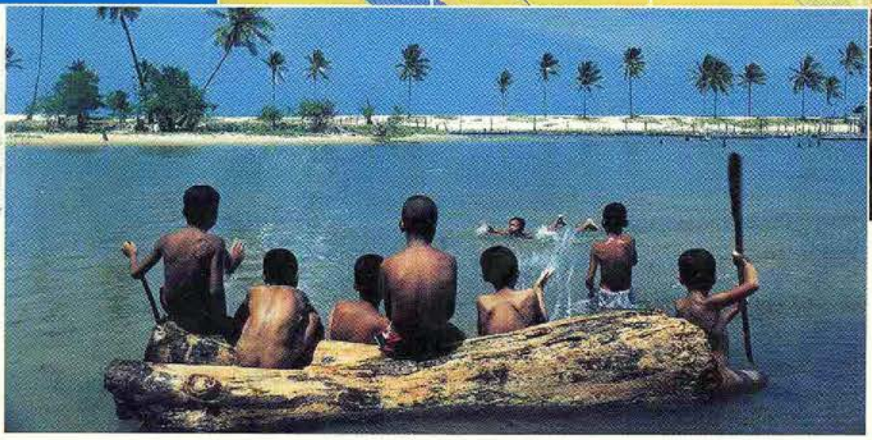
The A1 scenario family describes a future of rapid economic growth, a global population that peaks in the middle of the 21st century and then declines, and the rapid introduction of new and more efficient technologies. The major underlying themes are convergence among regions, capacity-building, and increased cultural and social interaction, with a substantial reduction in regional differences in per capita incomes. The A1 scenario family develops into three groups with alternative directions of technological change according to their energy systems: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance of both (A1B)

PHILIPPE REKACEWICZ
MARCH 2002

Source: David Griggs, in *Climate Change 2001*, Synthesis report, Contribution of working groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2001.

Global freshwater consumption rose sixfold between 1900 and 1995 – more than twice the rate of population growth. About one third of the world's population already lives in countries considered to be 'water stressed' – that is, where consumption exceeds 10% of total supply. If present trends continue, two out of every three people on Earth will live in that condition by 2025.

Kofi Annan, in We The Peoples, 2000



Vital **Water** Graphics

An Overview of the State of the World's Fresh and Marine Waters

ISBN 92-807-2236-0

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