GLOBAL ENVIRONMENT OUTLOOK YEAR BOOK 2006

GEO YEAR BOOK

An Overview of Our Changing Environment 2006

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Preface

It was the French novelist, Victor Hugo, who said: “There is nothing so powerful as an idea whose time has come”. That idea is the role of nature and natural capital in overcoming poverty and underpinning the wealth of nations.

2005 has witnessed unprecedented interest in the economics of the environment and the goods and services that nature provides. The wealth of nature was emphasized by, among others, the Millennium Ecosystem Assessment (MA), the findings of the Millennium Project – the initiative of the Secretary-General designed to inform the review of the Millennium Development Goals (MDGs) – and the 2005 World Summit.

The message emerging from these different processes, quite clearly, is this: targeted investments in the environment and in the restoration of damaged and degraded ecosystems have enormous long- and short-term economic benefits. As the 2005 Overview of this GEO Year Book points out with regard to the findings of the MA, although many of the benefits that ecosystems provide do not pass through the formal market system, they are often among the most valuable to societies.

The MA findings also point out that the economic and public health costs associated with damage to ecosystem services can be substantial. This was clearly demonstrated in 2005 – for several regions of the world where the impact of diverse natural disasters were worsened because environmental buffers had been previously removed.

The Feature Focus this year elaborates on the environmental, socio-economic and public health impacts of energy-related air pollution. There are many reasons why air pollution needs to be addressed urgently – not only because of its huge toll on human health in areas where it originates but also because it is too often an uncontrolled and unwelcome export to neighbouring countries. Associated with the energy consumption that contributes to air pollution are increasing global concerns over climate change, and energy security and access. On the other side of the coin, cleaner energy technologies are now available but are not always being widely adopted. These issues will be discussed at the annual UNEP Global Ministerial Environment Forum (GMEF) in 2006. A key challenge will be to identify ways in which the global community can continue to meet the rising demand for energy without compromising energy needs – particularly those of the poor – and still address the negative impacts of energy-related emissions.

In the past, the goods and services delivered by nature have often been seen as free and available at little or no cost. This will have to change as these resources become increasingly scarce and society demands higher standards of environmental care. The chapter on Emerging Challenges addresses two topics of policy interest related to food security.

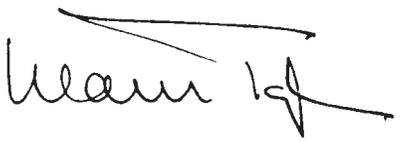
The first topic explores the issue of crop production in a changing climate. Global warming could seriously compromise the ability of the environment to meet food requirements in the future. Action is needed at the national and global level to ensure that we adapt as best we can to the changes that are already taking place, while addressing the root of the problem by reducing harmful greenhouse emissions in the future. The entry into force of the Kyoto Protocol earlier this year is a first historic step, but we still have a long way to go.

The second topic identifies environmental effects and best practices related to fish and shellfish farming in marine ecosystems. Caution, planning and good management is needed to ensure that current practices do not compromise the services provided by marine ecosystems in the future.

The GEO Indicators depict major developments and trends. They support the findings reported elsewhere in the Year Book that rising greenhouse gas emissions are resulting in ecosystem change, such as accelerating ice thickness losses of mountain glaciers, and that increasingly intense exploitation of fisheries stocks is leading to serious depletion.

However, the Indicators also show that there is hope. Where action has been taken, there are positive results. The global consumption of chlorofluorocarbons continues to decrease. The proportion of the Earth's surface affording some form of environmental protection to biodiversity continues to increase.

The GEO Year Book is intended to provide a bridge between science and policy. More than 140 experts were involved in preparing the sections of this Year Book. Previous volumes have stimulated calls for action – including by UNEP's Governing Council. I hope that you will find this edition both stimulating and informative. Your feedback is very welcome.



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

Source: Kevin Schafer/Still Pictures

Source: NASA/Still Pictures

2005 Overview

Source: Sean Sprague/Still Pictures

● GLOBAL ● AFRICA ● ASIA AND THE PACIFIC
● EUROPE ● LATIN AMERICA AND THE CARIBBEAN
● NORTH AMERICA ● WEST ASIA ● POLAR

Global

The linkages between environmental well-being, vulnerability and poverty emerged as a critical issue in 2005. Extreme weather events and new research and data were so dramatic that the year may prove a turning point in the urgency of our awareness and response.

In a year that brought compelling evidence for biodiversity loss, climate change and a host of other environmental threats, the global community showed signs of improved response. Major events such as the G-8 Summit in July and the 2005 World Summit in September reinforced the intent to act on environmental challenges and their links to development goals. In December the first Meeting of the Parties to the Kyoto Protocol produced a better than expected outcome. And at the year's close, at the sixth World Trade Organization Ministerial Conference, rich countries agreed to end export subsidies for cotton by the end of 2006 and for all agricultural products by 2013. By improving the incomes of poor farmers in poor countries, this should reduce the pressure to farm marginal land and clear forests.

CLIMATE CHANGE AND EXTREME EVENTS

The physical evidence for climate change continued to mount in 2005. It was one of the warmest years on record, second only to 1998, according to preliminary estimates from the US National Climatic Data Center (NOAA-NCDC 2005a).

There were also an unusually large number of extreme weather events (Box 1) – a development that most scientists agree is consistent with climate change. Heavy rainfall and floods persistently struck China, India, and Eastern Europe, causing considerable loss of life and serious economic damage. In the Americas, a record number of storms and hurricanes formed during the Atlantic season. Heat waves and severe droughts also plagued many parts of the world. In the Arctic, a stunning reduction in sea ice was observed during the northern summer by US experts (NSIDC-NASA 2005). The Munich Re Foundation, part of one of the world's

Box 1: A year of weather extremes

January
Drought across eastern and southern Africa and the Rockies in North America. Indonesia and Sri Lanka experience flooding. Costa Rica, Panama and Guyana have heavy rainfall and flooding that affects 200 000 people. Algeria has its heaviest snowfall in half a century.

February
Avalanches kill over 200 people in Kashmir after heavy snowfall. Heavy snow causes problems in Tajikistan, Iran and much of Europe, especially in the Balkans, as temperatures fall to record lows.

March
Ongoing drought causes a state of emergency in southern Brazil and food shortages in Eritrea. Flooding affects Algeria, Pakistan, Afghanistan, Madagascar and Angola, causing multiple deaths and injuries and displacing thousands.

April
Persistent drought affects eastern Africa, including Kenya, Ethiopia and Somalia. Drought and water shortages affect an estimated nine million people in Thailand.

May
Flooding displaces 25 000 people in Kenya and kills dozens in Ethiopia.

June
A heat wave continues in South Asia, with 400 deaths reported. Millions are affected by the worst flooding in China in 200 years. Hundreds die from thunderstorms in Afghanistan, rainfall in India and mudslides and flooding in Guatemala, El Salvador and Honduras.

July
Monsoon rain causes serious flooding in Mumbai, India, breaking the country's 95-year old record for the most rain in 24 hours, and leaving 1 500 people dead. Heat waves are recorded in the US, Europe and North Africa.

August
Hurricane Katrina becomes one of the most devastating disasters in US history after striking Louisiana and Mississippi. Typhoon Matsa displaces over one million people in Zhejiang, China. Droughts strike the Pacific Northwest, United Kingdom, France, and Spain, and exacerbate wildfires in Portugal.

September
Hurricane Rita causes severe damage in Texas and Louisiana in the US.

October
Hurricane Stan takes 2 000 lives in Guatemala, while Hurricane Wilma devastates Yucatan, Mexico, before striking Florida. With five further storms – Alpha to Epsilon – 2005 smashes all records for the Atlantic hurricane season. Northern China suffers from severe flooding that temporarily displaces 350 000 people. Hurricane Vince is the first hurricane ever to approach Europe, making landfall in Spain.

November
Tropical storm Delta hits the Canary Islands, the first ever tropical storm to strike the islands.

December
By 31 December, there were 27 tropical storms (six more than the previous record of 1933), and 14 hurricanes, breaking the 1969 record of 12 hurricanes.

Sources: WMO 2005, NOAA-NCDC 2005b, UN News Center 2005, BBC 2005a, BBC 2005b, BBC 2005c, Weather.com 2006

leading re-insurance companies, estimated that 2005 had witnessed the largest financial losses ever as a result of weather-related natural disasters, at more than US$200 billion (UN News Centre 2005).

A considerable amount of new research confirmed the need for urgent concern. In November, two *Science* papers analyzed ice cores whose trapped gas bubbles encased climate data stretching back 210 000 years further than previously available. The data showed that current levels of the greenhouse gases carbon dioxide, methane and nitrous oxide are the highest in 650 000 years (Siegenthaler and others 2005, Spahni and others 2005).

Several climate models found that extreme weather might become even worse than previously anticipated. Scientists at NASA's Goddard Institute for Space Studies released a study in *Science* that found that the Earth is absorbing more energy per square metre than it is radiating back to space. The study also found that the Earth's average global temperatures have not increased enough to account for this energy imbalance and it concludes that much of this energy imbalance has been stored in the ocean, with its full effect on the climate system still unrealized (Hansen and others 2005). Another study reported measurements, taken from ocean instruments moored along latitude 25N, suggesting that the "Atlantic conveyor" seems to be 30 per cent weaker than half a century ago. This system of currents carries warm surface tropical water in the Gulf Stream towards Western Europe, keeping the climate there warmer than it would otherwise be. The weakening may be linked to previously observed decreases in salinity and water density in the North Atlantic, as melting ice brings more fresh water into the ocean (Bryden and others 2005, UNEP 2005).

New data released in late 2005 also found that warming appears to be causing an increase in atmospheric water vapour (Soden 2005). Because water vapour is in itself a greenhouse factor, the results raised concerns about a positive feedback effect.

Decreased salinity and water density due to fresh water from melting ice could be weakening Atlantic currents.

Source: Klaus Andrews/Still Pictures

Other research suggested that sea-level rise is occurring at an increased rate (NASA 2005).

Perception, politics and the global response

There were signs in 2005 that concern over climate change was gradually translating into public interest and political action. At the corporate level, surveys showed many businesses in the US and elsewhere taking an increasing interest in the risks and opportunities resulting from climate change (Carbon Disclosure Project 2005). Many local and regional authorities in the US and other countries also emerged in 2005 as serious advocates for action (see North America section).

At the international level, the World Conference on Disaster Reduction in Kobe in January 2005 produced a strong statement of intent from governments, setting out concrete steps to reduce risk and vulnerability to natural disasters through early warning systems and other mechanisms (ISDR 2005).

The Kyoto Protocol entered into force in February 2005. By September, 156 nations had ratified. The Protocol commits most industrialized countries and countries with economies in transition to reduce their greenhouse gas emissions by an average of five per cent for the period 2008–2012 compared with 1990 levels. The most recent (year 2003) data suggests that while some progress had been made, a considerable effort would be required over the remaining years by Parties to meet their targets (UNFCCC 2005).

The first Meeting of Parties to the Kyoto Protocol, at its December 2005 meeting, adopted decisions on the outstanding operational details of the Kyoto Protocol, including a package of decisions known as the Marrakesh Accords. These include guidelines for how the Protocol will function,

such as those relating to the flexible mechanisms intended to help parties reach their emissions targets in a cost-effective way and a compliance mechanism (IISD 2005).

The December conference also took decisions to consider commitments for post-2012 through two tracks. On one track, the Kyoto Protocol and its carbon trading markets will continue beyond 2012. Negotiations on future commitments for industrialized country Parties to the Kyoto Protocol must be completed in time to ensure that there is no gap between the first and second round of commitments. A broader review of the Kyoto Protocol will also take place. On the other track, a "non-binding" global dialogue that includes the US has been initiated under the United Nations Framework Convention on Climate Change, to discuss the long-term future of multilateral climate change efforts (IISD 2005).

One emerging feature of multilateral and regional discussions in 2005 was a renewed commitment to developing and sharing new technology. The US, Australia, China, India, Japan, and South Korea, announced a regional technology-focused pact to help combat climate change (see Asia and the Pacific section). The European Union launched the Emissions Trading Scheme designed to help EU member states trade in the right to emit greenhouse gases – a cost-effective way to achieve the targets set out under the Kyoto Protocol. Seventeen countries joined the multi-country Methane to Markets partnership, an initiative encouraging cost-effective methane recovery and use as a clean energy source.

ENERGY CRISIS

Climate change, development and energy issues are closely connected. In 2005, the oil price crisis made its presence felt around the world. Public debate and consumer concern peaked at the end of August as oil prices briefly hit US$70 per barrel before dropping again later in the year, while still remaining around double the level of just two years earlier. The crisis was blamed on rising global demand, particularly from China and India, but extreme weather events and global security concerns also played a significant part.

Box 2: Life on the edge

Small Island Developing States (SIDS) are in the front line when it comes to experiencing the effects of climate change and inadequate development strategies. This was the conclusion of the *Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States* that was adopted alongside the *Mauritius Declaration* during the January 2005 Mauritius International Meeting for the 10-year Review of the Barbados Programme of Action.

A new analysis of the vulnerability of natural environments, developed by more than 300 experts, was presented at the meeting. The Environmental Vulnerability Index (EVI) combines 50 different indicators relating to climate change, biodiversity, water resources, agriculture and fisheries, desertification, exposure to natural disasters and human health aspects. Out of the 47 SIDS covered, 34 fell into the Highly or Extremely Vulnerable categories, while none were considered Resilient (Figure).

Some SIDS delegates tried to convince others that their "special case" status should extend to the multilateral trading system. The outcome agreements did not provide for a new SIDS category in this system, but they did offer to support efforts to integrate SIDS fully into the multilateral trading system.

The SIDS undertook to strengthen the International Strategy for Disaster Reduction and related regional mechanisms as facilities to improve national disaster mitigation.

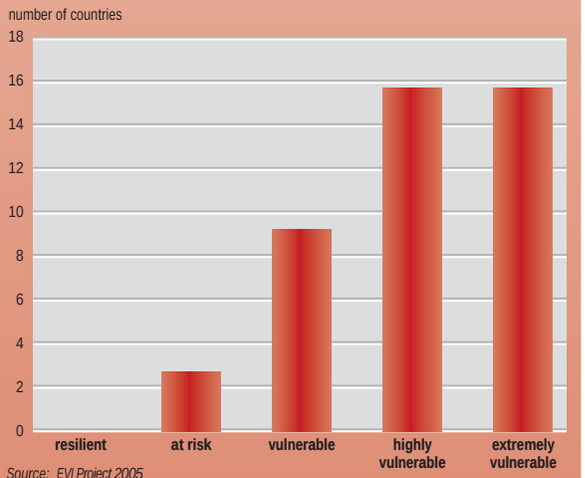
The United Nations Development Programme launched its SIDS Resilience Building Facility and SIDS University Consortium, both of which will seek to fund and build technical expertise for SIDS to reduce their vulnerability.

Sources: United Nations 2005a, ISDR 2005, EVI Project 2005

Seychelles.

Source: Dr. Justin Gerlach/Alliance for Zero Extinction

Environmental Vulnerability Index (EVI) for SIDS



Source: EVI Project 2005

Oil rig off the coast of England.

Source: Paul Glendell/Still Pictures

The oil price rises reflect a broader emerging concern about meeting the burgeoning global demand for energy. Estimates suggest energy demand will increase more than 50 per cent between 2005 and 2030 (IEA 2005). In 2004 alone, global demand rose by 4.3 per cent – the highest increase in percentage terms in two decades. In China, it shot up by a massive 15 per cent (BP 2005). Balancing energy supply with demand in a sustainable way without stifling economic growth will prove a major challenge in the context of global warming and the need to reduce emissions.

The growing energy crisis emerged as a serious public and policy issue in 2005. A number of bilateral and regional energy and renewable energy agreements were launched. Debates over the role of various forms of renewable energy also surfaced. Several governments including Australia, Brazil, China, the UK, and the US publicly contemplated the nuclear energy option, sparking heated debates. The World Bank and regional development banks came under pressure from environmental groups to shift lending towards renewables such as wind, solar and biomass. Attention also turned to "clean coal technology" and the capture and storage of carbon produced by fossil fuels. An Intergovernmental Panel on Climate Change (IPCC) report found that carbon capture and storage has the potential to reduce the overall costs of combating climate change (IPCC 2005).

Within the United Nations system, the interagency coordinating mechanism, UN-Energy, argued that the lack of modern fuels and electricity in developing countries locks people into poverty and damages both ecosystems and human health (UN-Energy 2005) (see Feature Focus section).

Global corporations also contributed to the debate. While some lauded renewables as the way of the future, Exxon Mobil Chairman Lee Raymond suggested that the focus should be on "how to find and produce enough conventional energy to support global economic activity and prosperity" (Exxon 2005).

POVERTY AND ENVIRONMENTAL DEGRADATION

Environmental sustainability plays a critical role in global efforts to eradicate poverty. This relationship was underlined in 2005 as several major scientific studies highlighted the science behind the linkages among environmental degradation, poverty and human security, and proposed policy responses.

The Millennium Ecosystem Assessment

Ecosystem services are the benefits that people obtain from ecosystems. This concept is the cornerstone of the Millennium Ecosystem Assessment (MA), the largest-ever international assessment of the world's ecosystems and the consequences of ecosystem change for human well-being. The MA involved more than 1 300 experts from 95 countries, and released its first findings in March 2005. It set out to survey changes in ecosystems, and to identify options and priorities for action to improve ecosystem management and contribute to human well-being and poverty eradication (MA 2005a).

Humans depend on ecosystem services for their well-being. Ecosystem services range from the provision of food, water, timber, fibre and genetic resources to the regulation of water quality, waste treatment, soil formation, pollination, and nutrient cycling, as well as cultural services such as recreation and aesthetic enjoyment.

Approximately 60 per cent of the ecosystem services examined in the MA were found to be degraded or used unsustainably. In particular, at least 25 per cent of commercially important fish stocks are over-harvested, and up to 25 per cent of global fresh water use exceeds long-term accessible supplies (MA 2005a). On the other hand, a few ecosystem services were found to have been enhanced in the past 50 years, in particular involving food: crops, livestock and aquaculture. The MA emphasized, however, that an increase in one ecosystem service often causes degradation in other services. For example, increasing food production through greater application of fertilizers often degrades water quality; expanding the area of cultivated land often results in biodiversity loss.

At the same time, the degradation in ecosystems and their services, caused by human activities, has also given rise to unprecedented transformations in ecosystems and losses of biodiversity. The MA found that

Ecosystems, such as this wetland in Botswana, provide many services that are vital to human well-being.

Source: Paul Springett/Still Pictures

Box 3: A new approach to preventing extinctions

A groundbreaking new study from the Alliance for Zero Extinction (AZE) provides a highly targeted approach to reducing the harrowing toll of wildlife extinctions. AZE is a grouping of 52 leading non-governmental organizations.

The study identifies 595 key sites in the world that are crucial to the survival of at least one endangered or critically endangered species. Species were chosen from the categories that have been globally assessed by the IUCN Red List – birds, mammals, amphibians, conifers and three clades of reptiles. Chosen sites have a definable boundary so as to be a practical conservation unit.

These sites are the homes, breeding or key feeding sites of a total of 794 endangered species, termed "trigger" species since they are decisive to identifying a site. Some sites house more than one species – Haiti's Massif de la Hotte has 13. The countries with the most sites are Mexico (62), Colombia (48), Brazil (39), Peru (31) and Indonesia (29).

Just over half the trigger species are amphibians – a change from the historical pattern where more than half of extinct species were birds. There is also a shift in the location of threats – a very high proportion of historical extinctions were on islands; today the largest share of endangered species on AZE's list are in mainland mountains.

The sites face more-than-average pressures from human population, land use and infrastructure. Only 34 per cent of the sites are fully contained within a gazetted protected area, while 43 per cent currently lack any legal protection.

The trigger species represent only a small proportion of those under threat worldwide, but the 595 sites represent valuable targets for a global network of protected areas. 508 of the 595 sites are in developing countries where assistance will often be needed. Median annual management costs would be US$220 000 – on that basis, all the sites in developing countries could be protected for around US$113 million per year.

Sources: Ricketts and others 2005, AZE 2005

Philautus ocularis, a trigger species.

Source: Don Church/Alliance for Zero Extinction

more land was converted to cropland in the 30 years between 1950 and 1980, than in the 150 years between 1700 and 1850. More than a third of the world's coral reefs and mangroves have been destroyed or degraded in the last few decades of the 20th century. With medium certainty, the MA concluded that human activity in recent centuries has increased the rate of species extinction by up to 1 000 times above the natural background rate, and today, as much as 30 per cent of mammal, bird and amphibian species are threatened with extinction.

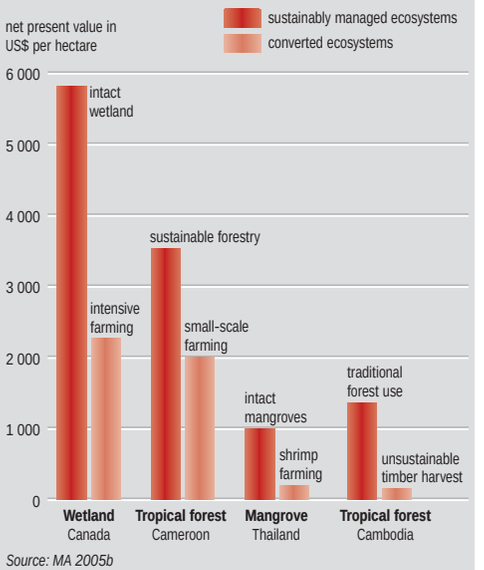
Ecosystem services, poverty and human well-being. The MA found that degradation of ecosystem services often harms the world's poorest people most, and in some cases, is the principal cause of poverty. Inadequate water, sanitation and hygiene cause diseases among half of the urban population of Africa, Asia, and Latin America and the Caribbean, with approximately 1.7 million deaths annually worldwide. Dryland ecosystems are home to one third of the world's population, but have the lowest levels of human well-being as measured by indicators such as per capita GDP and infant mortality. Desertification and low water availability threaten millions of livelihoods (MA 2005a).

Degradation of some ecosystem services is sometimes traded off with gains in other services, but many decisions taken often do not take full account of the value of services lost. Many of the benefits ecosystems provide to societies – such as water purification, flood regulation and provision of aesthetic benefits – do not pass through the formal market system although they are often among the most valuable. For example, Muthurajawela Marsh, a coastal peat bog in Sri Lanka of only 3 100 hectares, provides an estimated US$5 million in annual benefits through its role in local flood control. The MA also found the economic benefits of sustainably managed ecosystems to be higher than those of ecosystem conversion in locations as diverse as Canada, Cameroon and Thailand (Figure 1). However, private (market) incentives for conversion remain strong, compared to social (non-marketed) benefits of sustainable management (MA 2005a).

The MA therefore concluded that degradation of ecosystem services poses a significant barrier to the achievement of the Millennium Development Goals (MDGs). Socio-economic policy changes will play an important role in achieving the MDGs, but many of the MDGs and associated targets are unlikely to be achieved without sound management of ecosystems. This is particularly so for the goals related to hunger, disease, child mortality and environmental sustainability.

Scenarios and solutions. The MA describes four scenarios, which explore possible futures for ecosystems and human well-being. Under all four scenarios, the pressures on ecosystems are projected to continue growing during the first half of this century. The most important drivers of changes in ecosystems in the coming decades include habitat transformation, overexploitation, invasive alien species, pollution, and anthropogenic climate change. With continued growth in the consumption of ecosystem services, the MA scenarios project that food security will not be achieved even by 2050, that services from fresh water resources will continue to deteriorate, and that biodiversity will continue to be lost (MA 2005a).

Figure 1: Economic benefits under alternative management practices



Source: MA 2005b

The MA urges significant changes in policies, institutions and practices to mitigate the negative consequences of ecosystem change. One proposal is to integrate ecosystem management goals within broader development planning frameworks, such as the Poverty Reduction Strategies prepared by developing countries for the World Bank. The elimination of subsidies that promote excessive use of ecosystem services can also produce net benefits, if accompanied by compensatory mechanisms for affected poor people. Mechanisms such as ecolabelling that promote sustainability through consumer choices are encouraged.

The MA also identified a number of principles to improve decision-making processes, including use of the best available information, giving consideration to marketed and non-marketed ecosystem services, stakeholder participation, and regular monitoring and evaluation.

While the MA synthesized a large amount of existing knowledge, it also identified gaps in knowledge and monitoring: for instance, on land degradation in drylands, non-marketed ecosystem services and non-linear ecosystem changes. Significant advances are needed in models linking ecological and social processes (MA 2005a).

The United Nations 2005 World Summit addressed most major environmental issues.

Source: Julie Jacobson/Associated Press

2005 World Summit

Key poverty, development and environment issues were taken up during the UN 2005 World Summit held in New York in September – the largest gathering of world leaders in history. The Summit produced the *2005 World Summit Outcome* document that embodies the integration of conservation and development-related goals. It addresses most major environmental issues, including biodiversity, climate change, integrated water resources management, sustainable consumption and production, disaster reduction, forestry, chemicals and hazardous wastes, and oceans and seas (United Nations 2005b).

The Outcome endorses the MDGs, which include the goal of ensuring environmental sustainability (MDG 7). Countries also pledged to adopt (by 2006) and implement comprehensive national development strategies to achieve the MDGs.

On biodiversity, the Outcome endorses the goal of agreeing on an international regime

Box 4: Looking toward the International Year of Deserts and Desertification 2006

The United Nations has designated 2006 as the International Year of Deserts and Desertification. Over 250 million people are directly affected by desertification, and one billion in over 100 countries are at risk. Designating a year of desertification is expected to raise public awareness and contribute to protecting biological diversity and the indigenous and local communities affected.

The Desertification Synthesis report of the Millennium Ecosystem Assessment notes that drylands occupy 41 per cent of the global land mass and are home to a third of all people. Local communities play a central role in preventing desertification, and their ability to integrate land and water management is critical in this respect. The central role of communities is recognized by the United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD). By the end of 2005, over 80 national action programmes to address desertification from the local to national levels had been developed under the convention.

The seventh Conference of the Parties (COP) to the UNCCD, which took place in Kenya in October 2005, took an important decision to ensure that funding from the international community will be available for projects related to land degradation. The COP adopted a Memorandum of Understanding with the Global Environment Facility (GEF), finalizing its agreement with the GEF to serve as the financial mechanism of the UNCCD.

Sources: MA 2005c, UNCCD 2005

The Namib Desert, Namibia.

Source: Frans Lemmens/Still Pictures

2005 Overview

JANUARY

1 January The Emissions Trading Scheme enters into force in Europe, to help the region meet its Kyoto Protocol targets.

6 January UN Secretary-General Kofi Annan launches a US$977 million flash appeal for emergency aid – by far the largest ever for a natural disaster – at the Special ASEAN Leaders' Meeting on the Aftermath of the Earthquake and Tsunami.

10–14 January The Mauritius Strategy for the Further Implementation of the Programme of Action on the Sustainable Development of Small Island Developing States is adopted. It addresses climate change and sea-level rise, natural and environmental disasters, and biodiversity among many environmental and other issues.

18–22 January The UN World Conference on Disaster Reduction in Kobe adopts the *Hyogo Framework for Action 2005–2015*, and the *Hyogo Declaration*.

30–31 January The African Union adopts a Non-Aggression and Common Defence Pact to deal with threats to peace, security and stability on the continent, which will help reduce negative environmental impacts of refugee movements.

18 February The US Environmental Protection Agency establishes an official safety standard for the toxic chemical perchlorate, used in rocket fuel and explosives and blamed for widespread contamination of drinking water, especially near many military sites.

28 February China adopts a renewable energy law, establishing a target of ten per cent renewable energy share for 2020.

MARCH

15 March The US enacts the Clean Air Mercury Rule, limiting mercury emissions from new and existing coal-fired power plants and creating a market-based cap-and-trade programme that will permanently cap utility mercury emissions by the year 2018.

Ron Giling/Still Pictures

18 March The first-ever G-8 meeting of Environment and Development Ministers agrees to combat illegal logging and address the impact of climate change on African development.

11–22 April The 13th session of the UN Commission on Sustainable Development recommends a range of policy options and follow-up decisions on water, sanitation and human settlements.

Jeremy Woodhouse/WWF/Still Pictures

19 April UNEP names seven Champions of the Earth: Sheila Watt-Cloutier; the late Sheikh Zayed Bin Sultan Al-Nahyan; Julia Carabias Lillo; the King and people of Bhutan; President Thabo Mbeki and the people of South Africa; His All Holiness Ecumenical Patriarch Bartholomew; and Zhou Qiang and the All-China Youth Federation.

MAY

2–6 May First Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants adopts decisions needed to set Convention implementation in motion.

4 May UNEP's OzonAction Programme wins the US Environmental Protection Agency's 2005 Stratospheric Ozone Protection Award.

20–24 June The International Whaling Commission's 57th Annual Meeting rejects attempts by pro-whaling nations to remove the existing Southern Ocean Whale Sanctuary and to ease restrictions on certain types of whaling.

30 June The Central American Commission on Environment and Development Council of Ministers inaugurates the Regional Institute for Biodiversity to promote sustainable uses of biodiversity and provide information for drafting public policies.

JULY

5 July Donor countries agree to finance a feasibility study for the project to construct the 'Bahrain channel' linking the Red Sea to the Dead Sea, to prevent the Dead Sea from drying up.

6–8 July The G-8 Summit in Gleneagles agrees to increase debt relief and to boost aid to Africa by US$25 billion annually by 2010, to help the region meet the Millennium Development Goals.

20 July 39 new species are added to Canada's list of wildlife species at risk protected under the Species at Risk Act. This is the second group of species added to the list since the Act was proclaimed in 2003.

29 August Category 4 Hurricane Katrina makes landfall in New Orleans.

SEPTEMBER

14–16 September The UN 2005 World Summit in New York sets out a platform for action on issues ranging from terrorism to poverty, and UN reform to environmental issues.

Ron Giling/Still Pictures

21–23 September 5th Ibero-American Forum of Ministers of the Environment in Colon, Panama stresses the importance of water management and conservation, as well as the creation of an Ibero-American cooperation programme on meteorology and climatic research.

Werner H. Muller/Still Pictures

NOVEMBER

8–15 November The ninth Conference of the Parties to the Ramsar Convention on Wetlands adopt the Kampala Declaration, emphasizing the need to arrest continuing loss and degradation of wetland ecosystems.

10–12 November The Second International Conference on Arctic Research Planning prepares plans to guide international cooperation in Arctic research over the next 10 to 15 years.

13 November A chemical plant of the Jilin Petrochemical Company under the China National Petroleum Corp explodes, sending about 100 tonnes of pollutants containing benzene into the Songhua River in Northeast China. Severe water pollution compels cities along the river to suspend water extraction from the river for various periods.

13 November Agreement is reached on the European Union's policy on Registration, Evaluation, Authorization and Restriction of Chemicals, which shifts the burden of proof of safety to industry. New processes will be started to phase out certain chemicals in favour of environmentally superior alternatives. If all goes well, a final decision is expected in late 2006 and entry into force in early 2007.

20–25 November The eighth Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals adds several new species requiring protection to its appendices.

31 January–4 February First African Ministerial Conference on Housing and Urban Development adopts an "enhanced framework" to achieve sustainable cities and towns in Africa.

FEBRUARY

4–5 February Central Africa's political leaders sign treaty aimed at protecting the African rainforest. The first regional conservation agreement of its kind in Africa, the treaty establishes trust funds to ensure sustained funding for implementation.

Mark Edwards/Still Pictures

16 February Third Earth Observation Summit held in Brussels, endorses a 10-year implementation plan establishing a Global Earth Observation System of Systems that could dramatically improve understanding of the Earth's natural systems.

16 February The Kyoto Protocol enters into force.

24–29 March Asia Pacific Ministerial Conference on Environment and Development, with participants from 52 countries, stresses green growth and adopts a 2006–2010 implementation strategy.

31 March–1 April At the First Meeting of the Andean Community Council of Ministers of Environment and Sustainable Development, in Paracas, Peru, environment ministers draw up a regional environmental agenda.

APRIL

4–8 April The 20th session of the Governing Council of UN-HABITAT adopts decisions ranging from post-conflict, natural and human-made disasters assessment and reconstruction, to support for the Millennium Development Goals.

Harmut Schwarzbach/Still Pictures

5 April The Canadian government and the country's automobile industry sign a landmark agreement that commits automobile manufacturers to voluntarily reduce greenhouse gas emissions from new vehicles.

4 May New Zealand introduces a carbon tax, to come into effect in April 2007. Believed to be the first of its kind, the tax will add to the costs of electricity, petrol and other fuels depending on their environmental effects.

argus/Still Pictures

24 May The Commission for Environmental Protection of North America releases its annual Taking Stock report, showing total releases of 43.4 million kg of lead to the environment in the region.

JUNE

5 June World Environment Day spotlights 'Green Cities' with numerous events around the world focused on the environmental challenges of rapid urbanization.

5 June 158 US mayors sign a Climate Protection Agreement that commits them to strive to meet or exceed targets that would apply to the US under the Kyoto Protocol (seven per cent emissions reduction from the 1990 level by 2012).

Kelvin Aitken/Still Pictures

AUGUST

4 August Researchers at the Mexican Academy of Science use strains of the *Rhizobium etli* bacteria to create a new type of agricultural biofertilizer that is up to 15 times more economical than common chemical fertilizers.

8 August The US administration signs its first national energy plan in more than a decade. Along with extensive tax breaks, subsidies and loan guarantees to the fossil fuel industry, it also contains policies and tax incentives for renewable energy, and incentives for nuclear energy development, cleaner coal-fired plants, and increased energy conservation.

Roger Braithwaite/Still Pictures

16–19 August At the Greenland Dialogue on Climate Change in Ilulissat, north of the Arctic Circle, environment ministers from more than 20 nations tour rapidly-shrinking ice fields and hold informal talks about action on climate change.

27 September European Commission includes the airline industry in the Emissions Trading Scheme of the European Union, effective from 2008.

OCTOBER

8 October A magnitude 7.6 earthquake strikes Pakistan, India, and Afghanistan. The reported death toll reaches around 80 000. More than 2.5 million people are left without shelter.

Ton Koene/Still Pictures

17–28 October The seventh session of the Conference of the Parties to the UN Convention to Combat Desertification adopts a Memorandum of Understanding with the Global Environment Facility (GEF), finalizing its agreement with the GEF to serve as the financial mechanism of the CCD.

Paul Springett/Still Pictures

DECEMBER

28 November–9 December Despite fears of derailment, the eleventh Conference of Parties to the UN Framework Convention on Climate Change and First Meeting of Parties to the Kyoto Protocol end successfully.

Pascale Simard/Still Pictures

11 December Europe's worst peacetime fire at the Buncefield oil depot near London, as 20 out of 26 storage tanks catch fire. 43 people are injured and more than 2 000 evacuated. The heat of the fire drives smoke particles high into the sky, with pollution reaching above 2 750 metres, and the cloud stretching from East Anglia to the Salisbury Plain.

13–18 December At the sixth World Trade Organization Ministerial Conference in Hong Kong, China, developed countries agree to end export subsidies in agriculture by 2013, and for cotton by 2006. By improving poor farmers' incomes, this will reduce pressures to clear forest and farm marginal land.

21 December The contentious Arctic National Wildlife Refuge oil drilling provision is removed from a US defence spending bill to ensure the bill's passage, but the issue is likely to be raised again in 2006.

to promote fair and equitable sharing of benefits arising from the use of genetic resources. The Outcome highlights the need to act with "resolve and urgency" to address the many challenges faced in tackling climate change, promoting clean energy, meeting energy needs and achieving sustainable development. The need to create a worldwide early warning system for natural hazards is also supported, and an agreement to speed up the transfer of affordable and cleaner energy efficiency and conservation technologies to developing countries "on favourable terms" was articulated.

Other events held alongside the World Summit also addressed poverty-environment issues and launched new initiatives from governments, intergovernmental organizations and civil society. The Forum for Energy Ministers of Africa announced a goal of ensuring that at least 50 per cent of Africa's poor have access to sustainable modern energy services and technologies by 2015 (UNEP and UNDP 2005). The Swedish Government declared that it would target an estimated US$150 million in 2006 to invest in environmental protection for the poor in developing countries (UNEP and UNDP 2005). Meanwhile, former US President Bill Clinton's Global Initiative generated nearly US$1.3 billion in funding commitments to tackle problems of climate change, poverty, governance and security (Barber 2005).

LOOKING AHEAD

The year 2005 highlighted – perhaps more forcefully than ever before – the ever-growing environmental challenges created by humanity for biological diversity, the Earth's ecosystems and the climate. The response must continue to grow in scope, and international cooperation must continue to deepen, if the world is to confront the situation in a timely way.

In 2006, the international community will have a number of opportunities to demonstrate its commitment to tackling these growing challenges. The eighth Conference of Parties to the Convention on Biological Diversity and third Meeting of the Parties to the Cartagena Protocol on Biosafety will take place in March. These will provide an opportunity to push for further implementation of both agreements and to respond clearly and constructively to the findings of the Millennium Ecosystem Assessment. A series of meetings focused on chemicals management also offer opportunities for progress in 2006. Finally, the Commission on Sustainable Development, scheduled for May, begins a two-year focus on energy that should provide a much-needed forum for multilateral discussions.

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Africa

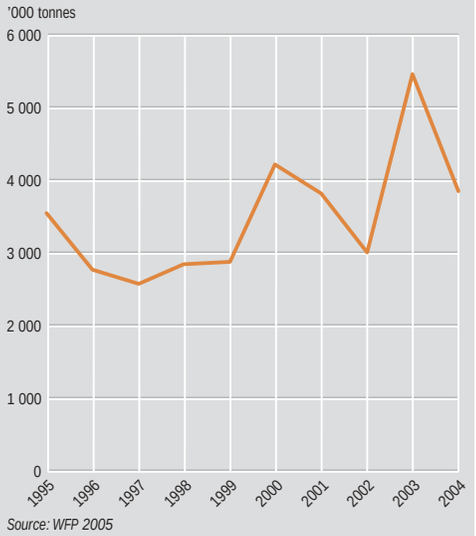
2005 saw efforts to ensure that Africa enters the mainstream of the global economy, helped by full debt cancellation for 14 countries in the region. The region still faces widespread food shortages, but groundbreaking initiatives on land management and great ape conservation brought hopes of real change.

FOOD SECURITY

Africa experienced widespread food shortages in 2005. In Niger, 3.6 million people were faced with starvation (Gosline 2005). By December, some 27 other countries were facing food emergencies (FAO/GIEWS 2005). In southern Africa ten million people suffered food shortages, 22 million in central Africa, and ten million in Ethiopia alone (Banton 2005). The region's food insecurity was largely attributed to droughts and pests, exacerbated by poverty, conflict, refugee situations and soil degradation.

In the Sahel region, particularly Mauritania, Niger, Mali and Burkina Faso, food shortages were due to a combination of drought and crop destruction by locusts in 2004. Drought continued to affect much of southern Africa. Only South Africa was able to produce a surplus of the staple food, maize. The rest of the sub-region had a deficit of 3.1 million tonnes as of August 2005 (SADC 2005).

Figure 1: Food aid trends in Africa for the period 1995–2004



Source: WFP 2005

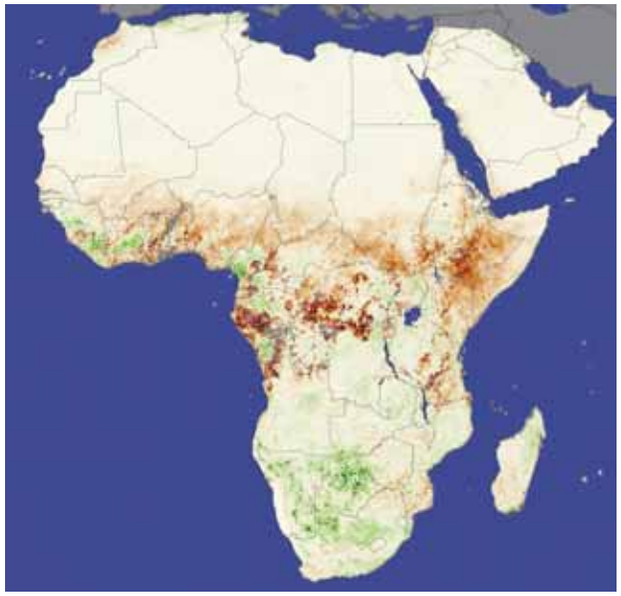
Maize crop in Swaziland stunted by drought.
Source: Neil Cooper/Still Pictures

Drought also affected East Africa, causing food shortages from Tanzania to the Horn of Africa, which is in its sixth year of severe drought (Geotimes 2005).

The region's food shortages were worsened by poverty and the inability of individuals and countries to produce or buy sufficient food. The number of people living on less than US$1 per day in the region is estimated at 313 million (UNDP 2005). Many farmers cannot afford the fertilizers, pesticides, and improved seeds and farming methods needed to increase agricultural productivity. As a result, the need for food aid has generally been increasing in Africa save for some good rainfall seasons (Figure 1).

Despite widespread food shortages, there has been concern in Africa about accepting genetically modified (GM) food aid, on the grounds that the technology has not been fully tested for environmental or health effects. Of the world's 81 million hectares under GM crops, Africa accounts for only 0.6 per cent, most of that in South Africa (Planet Ark 2005).

Drought affected areas in Africa in 2005.
Source: NASA



However, there is wide acknowledgement that GM technology has the potential to improve yields and quality of food crops, resistance to pests and diseases, and adaptation to environmental stresses such as heat, drought and salinity.

Conflict contributed to food insecurity in the Darfur region of Sudan, Somalia, the Democratic Republic of the Congo and Liberia. In Darfur alone, as many as 2.1 million conflict-affected people were dependent on food aid in June 2005 (USAID 2005), while in Somalia one million people – affected by several years of drought, floods, and recurrent civil unrest – continued to require humanitarian assistance (FEWSNET 2005).

Poor soil fertility and soil erosion are also blamed for declining crop yields and per capita food production in much of sub-Saharan Africa (Box 1). About 65 per cent of Africa's population is affected by land degradation, and over three per cent of agricultural GDP is lost each year to soil and nutrient loss. "Land degradation marginalizes efforts to secure Africa's long-term food security, economic growth, rural land-use productivity, and ecosystem services," explains Warren Evans, World Bank Director of Environment (TerrAfrica 2005).

Unfavourable trade policies threaten food security as well as the livelihoods of farmers in Africa.

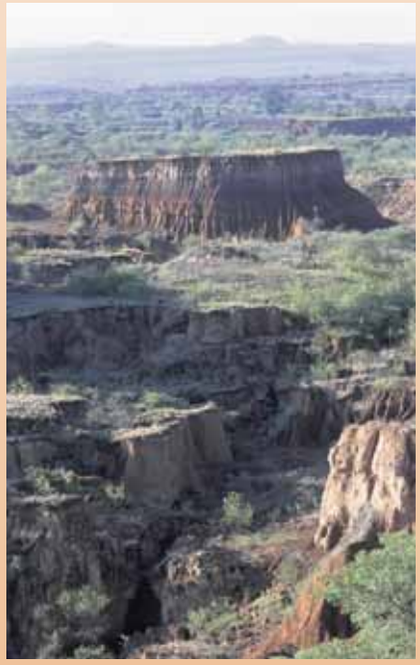
Source: Henning Cristoph/Still Pictures

Given the region's vulnerability to food insecurity, sub-regional famine early warning systems are in place to provide timely information on food supply, market prices and disaster preparedness. The region has

Box 1: Land degradation in Ethiopia's highlands

The highlands of Ethiopia occupy approximately 45 per cent of the country's total land area, and house over 85 per cent of the population and 75 per cent of livestock. Yet these crucial lands are among the most severely eroded areas in the world. Advanced deforestation and land degradation under increasing demographic pressure are the major causes. Some 50 per cent of the land area is significantly eroded, 25 per cent seriously eroded and five per cent has lost the ability to produce food. Highland soils are losing depth at an estimated average rate of four mm per year, far outstripping the rate of soil formation estimated to average no more than 0.25 mm per year in Africa. The effective soil depth in Ethiopia is estimated at 20 to 59 cm. If losses continue unabated, the highlands could lose nearly all their top soil in the next 100 to 150 years.

Source: FAO 2005



Massive soil erosion in southern Ethiopia.

Source: Mark Edwards/Still Pictures

Villagers in Ethiopia using stones to create terraces, a technique to prevent soil erosion.

Source: Neil Cooper/Still Pictures

Box 2: A new alliance to combat land degradation in Africa

TerrAfrica – a new partnership to increase sustainable land management throughout Africa – was launched in October at the 7th session of the UN Convention to Combat Desertification in Nairobi. The initiative is a coalition involving African governments, the New Partnership for Africa's Development (NEPAD), and many international, regional, governmental, civil society, and scientific organizations, working together with farmers and communities.

The strategic goal is to improve collective efforts to promote and support sustainable land management, and to increase the scope and scale of financing. The means include:

- building African-owned coalitions and strategic partnerships at global and regional levels in support of country level activities;
- developing, mobilizing, and harmonizing investments at sub-regional, country and local levels;
- generating stronger analysis and research;
- harmonizing systems to monitor and evaluate land management; and
- advocating sustainable land management and its mainstreaming into development strategies, financing, and policy dialogues at all levels.

TerrAfrica aims to galvanize an investment of at least US$4 billion over a 12-year period. It will also contribute to NEPAD's goals of increasing agricultural productivity by six per cent per year and allocating at least ten per cent of national budgets to agriculture, and to the Millennium Development Goals for environmental sustainability and developing global partnerships for development.

Source: Both Ends 2005

also put in place Africa's Strategic Plan of Action for Agriculture and Food Security Promotion, which is complemented by sub-regional initiatives (SADC 2004).

THE G-8 SUMMIT AND AFRICA

There have also been international efforts to alleviate poverty in Africa while at the same time ensuring food security.

Leaders of the world's eight richest nations (the G-8), meeting in Gleneagles, Scotland, agreed to double aid to the region, increasing it by US$25 billion per year by 2010. This is part of an overall increase of US$50 billion for all developing countries. The G-8 summit also agreed to cancel 100 per cent of the multilateral debts of the Highly Indebted Poor Countries (HIPC), including 14 countries in the region – Benin, Burkina Faso, Ethiopia, Ghana, Madagascar, Mali, Mauritania, Mozambique, Niger, Rwanda, Senegal, Tanzania, Uganda and Zambia (Deen 2005). G-8 leaders agreed to extend the HIPC initiative by two years. This would allow a further ten countries to qualify for debt relief in excess of US$30 billion – Burundi, Cameroon, Chad, Democratic Republic of the Congo, The Gambia, Guinea, Guinea-Bissau, Malawi, Sao Tome Principe and Sierra Leone (World Bank 2005). A special package of debt cancellation for Nigeria worth around US$17 billion was also endorsed (World Bank 2005).

It is hoped that some of the resources thus freed will support improved food production and land management, agricultural extension and research into appropriate and sustainable farming technologies.

MILLENNIUM SUMMIT +5 AND AFRICA

The Millennium Summit +5 welcomed the substantial progress Africa has made in recent years, particularly in meeting its Millennium Development Goals (MDGs). Among other successes, 14 countries are on track to get all children to school by 2015. Eight countries are on track in reversing the spread of HIV/AIDS, 13 countries are on target in reducing poverty, and 11 countries are on track in providing safe water to rural communities (ECA 2005).

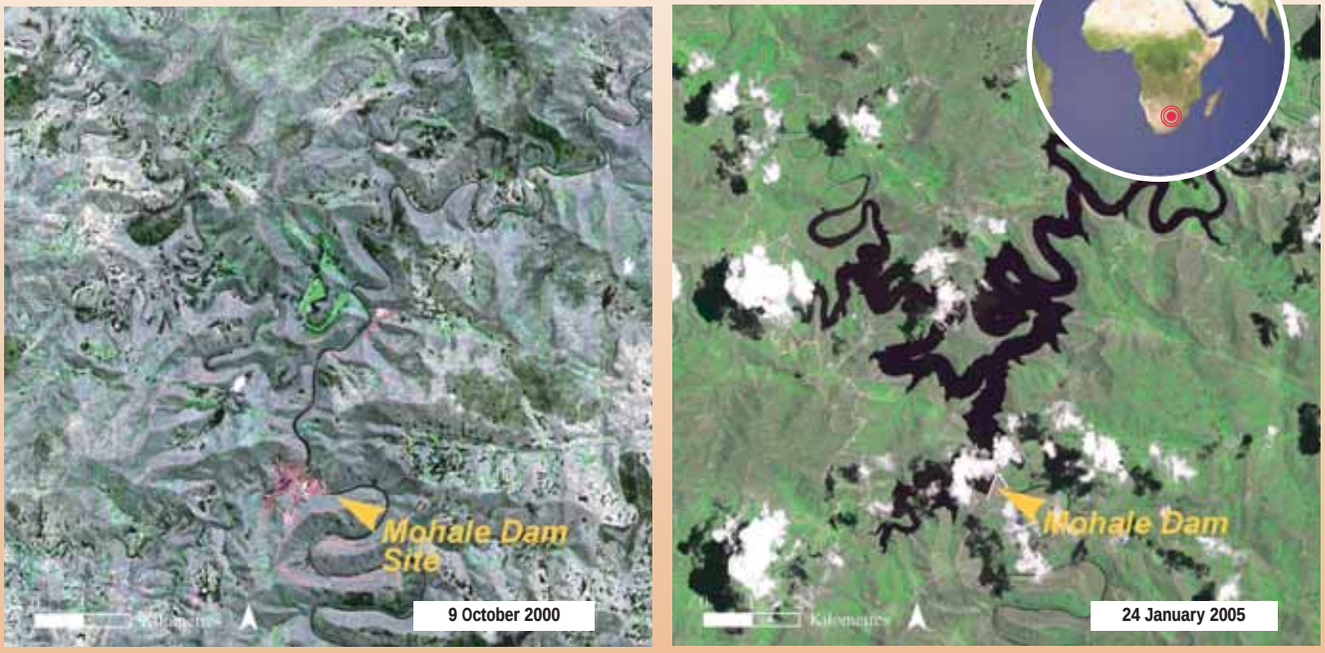
The summit resolved to strengthen cooperation with the New Partnership for Africa's Development (NEPAD) by mobilizing external financial resources and facilitating approval of NEPAD programmes by multilateral financial institutions, as well as by supplementing the efforts of African countries to increase agricultural productivity in a sustainable way, as part of an African Green Revolution.

A Green Revolution in Africa, focussed on environmentally sustainable improvements in crop, land and water management methods, and on crop varieties more adapted to Africa's environmental challenges, would boost the region's food security and the economies of its member states. Since low

Box 3: Lesotho highlands water project

The Lesotho Highlands Water Project, a partnership between the governments of Lesotho and South Africa, is Africa's largest ever water transfer project and the largest ongoing bi-national construction project on the continent. It is designed to divert water from Lesotho to the urban and industrial Gauteng region in South Africa (including Johannesburg) through a series of dams and tunnels blasted through the Maloti Mountains. Gauteng province needs more water than its main source, the Vaal River, can provide. At the same time the dam will promote the development of irrigation in Lesotho. The first three major dams in the six-dam scheme directly affected around 5 000 people. The satellite images show how water rapidly filled the newly completed Mohale Dam, a rock-fill dam with a wall height of 145 metres.

Sources: Pottinger 2005, LHWP 2005, USGS 2005



Source: USGS 2005

yields are one of the major reasons why African farmers clear wildlife habitat for farming, it would also reduce the loss of biodiversity (Box 4) through habitat loss and fragmentation.

CONCLUSION

Although many countries in Africa are making progress towards meeting the MDGs, efforts need to be accelerated and sustained. A key challenge is ensuring food security for all, while improving the sustainability of agricultural practices and reducing the loss of precious biodiversity.

Box 4: Great apes: global strategy and declaration

Africa is the home of two of the three genera and three of the four species of great apes, all of which are under severe threat of extinction in the wild. The new *World Atlas of Great Apes and their Conservation* – the most comprehensive compendium of information about great apes ever compiled – provides an alarming assessment of their status. The major threats include bushmeat trade, and habitat loss and fragmentation through rampant deforestation. Disease is worsening the situation dramatically: Ebola fever is advancing through gorilla and chimpanzee heartlands, killing up to 90 per cent of populations where it passes.

To remedy the situation the Great Apes Survival Project (GRASP) was set up in 2002, bringing together governmental and intergovernmental, UN institutional, non-governmental, and scientific foundations, local community and private sector interests. Its goal is to inform policy makers, to mobilize and pool resources for action to halt the decline of great ape populations.

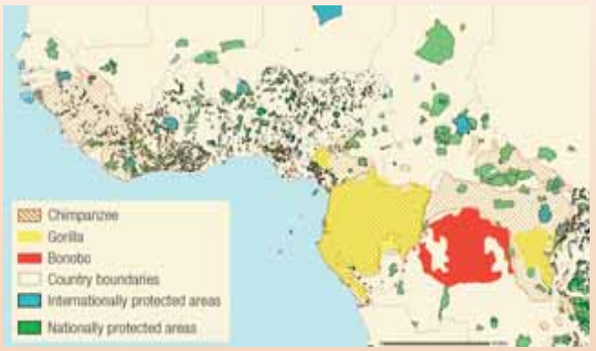
The first GRASP Council Meeting, and the first Intergovernmental Meeting on Great Apes and the Great Apes Survival Project, were held in September in Kinshasa. Participants adopted an ambitious global strategy for the survival of great apes and conservation of their habitats.

The strategy involves, among other things:

- encouraging and resourcing the 23 range states in preparing and implementing national conservation plans and expanding protected areas;
- collating and coordinating existing projects and initiatives, so as to identify gaps and set priorities;
- making sure that interactions with humans are mutually positive and sustainable;
- identifying and supporting income-generating initiatives to benefit communities living in and around great ape habitat and protected areas;
- researching and monitoring of ape habitats and populations;
- eliminating illegal transboundary traffic;
- encouraging compliance with, and enforcement of, international conventions and national laws; and
- promoting education and awareness about great apes.

Sixteen range states, along with many international and national institutions and non-governmental organizations, signed the *Kinshasa Declaration on Great Apes*, affirming political will at the highest level. They pledged to ensure the long term future for all great apes and their habitat, to reduce the current loss of great ape populations by 2010, and to secure the future of all species and subspecies of great apes in the wild by 2015.

Sources: Caldecott and Miles 2005, UNEP 2005



Distribution of great apes in Africa.

Source: Caldecott and Miles 2005

Western lowland gorillas, found in the tropical rainforests of Central Africa, are endangered due to loss of habitat and demand for bushmeat.

Source: Martin Harvey/Still Pictures

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Asia and the Pacific

Despite rising oil prices, the impact of severe natural disasters and the threat of bird flu, the region made significant progress towards achieving the Millennium Development Goals. Environmental sustainability was further integrated into overall economic planning in the region.

The latest available data show that the Asia and Pacific region has made significant progress towards some of the Millennium Development Goals (MDGs), but development and progress are uneven among sub-regions (United Nations 2005a).

Dramatic progress has been made in eradicating extreme poverty. The number of people living on less than US$1 a day dropped by nearly 250 million from 1990 to 2001 mainly due to sustained growth in China and acceleration of the economy in India (United Nations 2005a). However, progress has been slow on reducing malnutrition, especially in South Asia, where half the children (aged 0-5 years) are malnourished (United Nations 2005a).

Some progress has also been achieved in meeting Goal 7, ensuring environmental sustainability. The most impressive gains in safe sources of drinking water were made in South Asia, boosted primarily by increased access in India (Figure 1). Progress was also made in improving energy efficiency and access to clean technology and fuels in Eastern Asia and Southern Asia, although energy efficiency continued to decline in Southeast Asia (Figure 2). The number of urban slum dwellers continued to increase in the region (Figure 3).

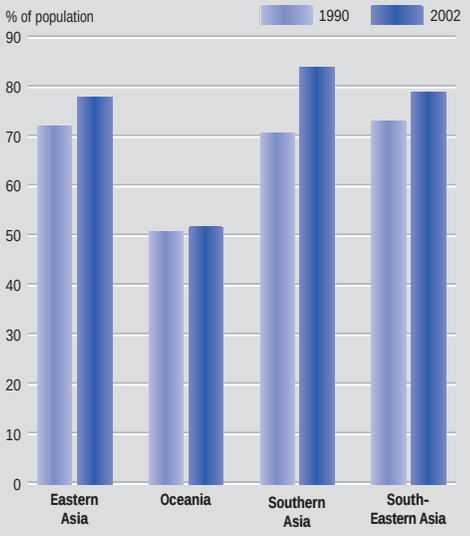
DISASTERS OLD AND NEW

The 2004 Indian Ocean Tsunami, which took 226 435 lives and caused over US$10 billion worth of damage to the region, resulted in a concerted international relief effort through 2005. More than US$4 billion was committed towards rehabilitation efforts and the establishment of the Indian Ocean Tsunami Early Warning System (IOTWS) (UNDP 2005, UNEP 2005a, Relief Web 2005). This system, paralleling one that is already in place for the Pacific, will involve a new network of earthquake and tidal sensors, speedy communications, alarm networks and disaster preparedness training in vulnerable regions. In June, UNESCO's Intergovernmental Oceanographic Commission (IOC) adopted a resolution to create the IOTWS, which is targeted to become operational during 2006 (IOC 2005).

Recovery efforts have gained momentum in tsunami-ravaged Banda Aceh, Indonesia.

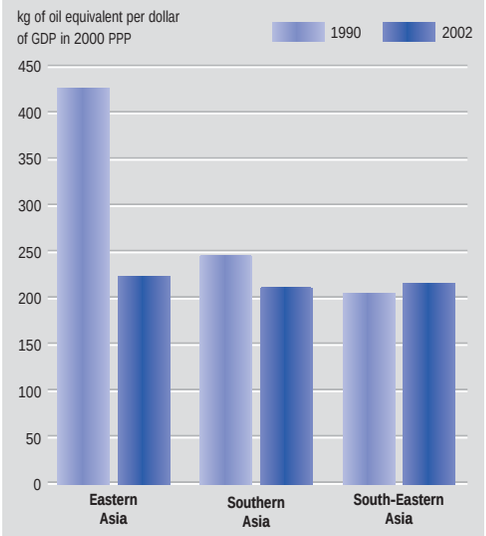
Source: Dita Alangkara/Associated Press

Figure 1: Access to safe drinking water



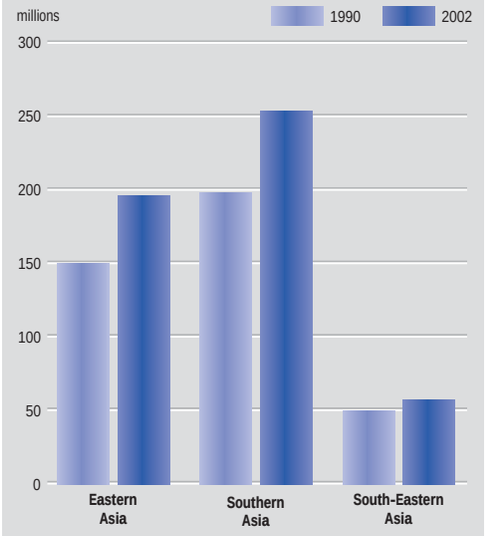
Source: United Nations 2005a

Figure 2: Energy per unit of GDP



Source: United Nations 2005a

Figure 3: Number of urban slum dwellers



Source: United Nations 2005a

In October, an earthquake measuring 7.6 on the Richter scale struck in the border regions of Pakistan and India (Box 2).

ATMOSPHERE AND CLIMATE

Increased economic development has led to rapid urbanization in the Asia and Pacific countries. The region now holds about 58 per cent of total world population and 45 per cent of the world's urban population. Between 1980 and 2002, the region's urban population more than doubled from 646 million to 1 333 million (GEO Data Portal based on United Nations 2005b).

Rapid urbanization and industrialization, and the associated increase in fossil fuel use, have intensified urban air pollution in the Asia-Pacific region (Box 2 of Feature Focus, page 43) and increased the region's contribution to greenhouse gas emissions. In 1990 the region produced 435 million tonnes (eight per cent) more CO_2 than North America. By 2002, the disparity had grown to 2 628 million tonnes (41 per cent more) (Figure 4).

Developing countries, including China, India and the Republic of Korea are not bound by the Kyoto Protocol to any emission reduction targets, while another country in the region, Australia, has not ratified. Therefore, it was significant when, in July 2005, these four countries joined with the US and Japan to launch a New Asia-Pacific Partnership on Clean Development and Climate (US State Department 2005). The US and China are the first and second largest national emitters of carbon dioxide in the world, while India and Japan are fourth and fifth (Earthtrends 2005).

The partnership does not have any quantitative emission targets, but aims to promote and create an enabling environment for development, diffusion, deployment and transfer of existing and emerging cleaner technologies and practices. These will relate to energy efficiency, clean coal, liquefied natural gas, carbon capture and storage, combined heat and power, methane capture and use, civilian nuclear power, geothermal power, hydropower, wind power, solar power,

Urbanization in Asia and the Pacific has intensified the deterioration in urban air quality.

Source: UNEP/Still Pictures

Box 1: Avian Influenza

Poultry being inspected for Avian Influenza, China.

Source: Xinhua/Still Pictures

The current outbreak of Avian Influenza H5N1 (bird flu), which originated in Southeast Asia, is spreading to other parts of the world primarily through migratory bird routes. Its major impact so far, however, remains in Southeast Asia. By 31 December there had been been 142 laboratory-confirmed human cases in five countries (Vietnam, Cambodia,Thailand, Indonesia and China) over the past two years. Of these, 74 people have died.

Though small in absolute numbers, this is the largest number of severe cases of avian influenza in humans on record. This and the 50 per cent human fatality rate have raised fears of a highly lethal pandemic, should the virus mutate to a form that allows ready human-to-human transmission. Not all experts agree that such a mutation is imminent or likely in the particular case of H5N1, but all agree that greater preparedness to prevent and to deal with pandemics is essential.

The outbreak among poultry is also the most severe and widespread on record. The virus is easily transmitted both in crowded factory farms, and in the less hygienic conditions of backyard farming and urban informal marketing. Ducks, which in Asia move between backyards and paddy fields where contact with wild birds is easy, present a particular problem.

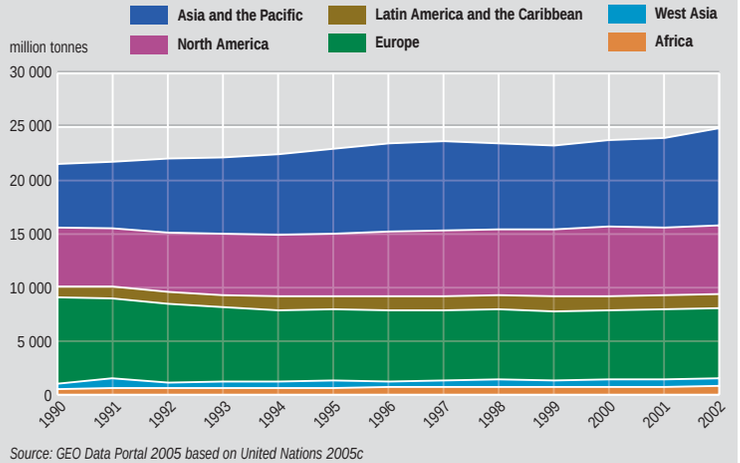
The primary economic impact thus far has been on poultry production and trade. By mid-November more than 150 million poultry had been slaughtered and China was planning to vaccinate its entire flock of over 14 billion birds. By late 2005, economic losses were estimated at US$10 billion and rising. The socio-economic impact of lost flocks and vaccination costs is grave – especially for the low-income backyard farmers who make up the majority of producers.

The environmental impacts have yet to be ascertained. Significant culls of domestic birds may stimulate shifts in agricultural production away from poultry to mammals or grains, and from small-scale poultry farming to large scale commercial operations able to afford increased bio-security costs. Loss of income to small scale farmers may trigger efforts to farm more intensively and on more marginal soils, risking lowered water quality and increased rates of soil erosion.

In November 2005, the Food and Agriculture Organization and the World Organization for Animal Health jointly proposed a global strategy for controlling avian influenza, involving capacity building for disease monitoring, control and policy development. Also in November, an international meeting hosted by WHO identified a global response strategy ranging from control at source in birds, through surveillance, rapid containment, vaccine production and preparedness of health services for pandemics.

Sources: WHO 2005a, WHO 2005b, WHO 2005c, Normile 2005, MacKenzie 2005, McLeod and others 2005, FAO 2005

Figure 4: Carbon dioxide emissions by region



Source: GEO Data Portal 2005 based on United Nations 2005c

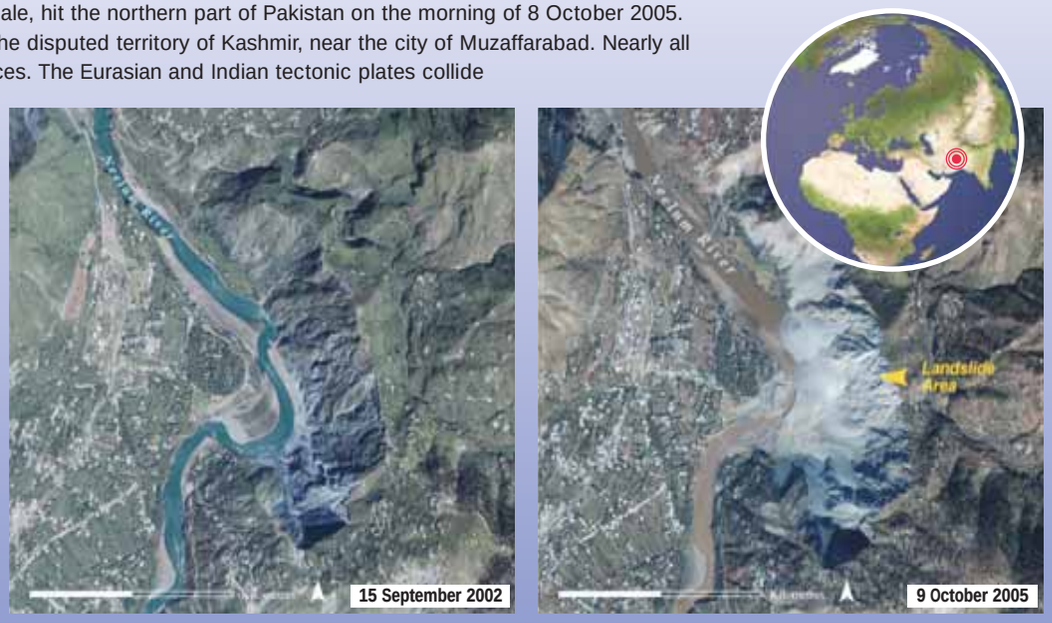
Box 2: Pakistan earthquake

A devastating earthquake, measuring 7.6 on the Richter scale, hit the northern part of Pakistan on the morning of 8 October 2005. The epicentre was in the Pakistan-administered region of the disputed territory of Kashmir, near the city of Muzaffarabad. Nearly all mountains that flank the city have collapsed in several places. The Eurasian and Indian tectonic plates collide in this region, causing earthquakes.

Most of the casualties were in Pakistan where the official death toll has topped 79 000, higher than the 30–60 000 toll of the massive 1935 Quetta earthquake. India has confirmed 1 300 deaths. The toll is expected to continue to rise through the harsh winter.

The right image captures a landslide in Makhri, a village on the northern outskirts of Muzaffarabad, on 9 October 2005. The western face of the mountain has collapsed, sending a cascade of white-grey rock into the Neelum River. The blue waters seen on 15 September 2002 (left) have turned brown with the dirt from landslides upstream. The landslide forced the Neelum to shift its course. The damage to the city is not visible, even in this detailed image, but the media report that the city has nearly been destroyed.

Sources: Ambraseys and Bilham 2003, Bilham 2005, NASA 2005, USGS 2005

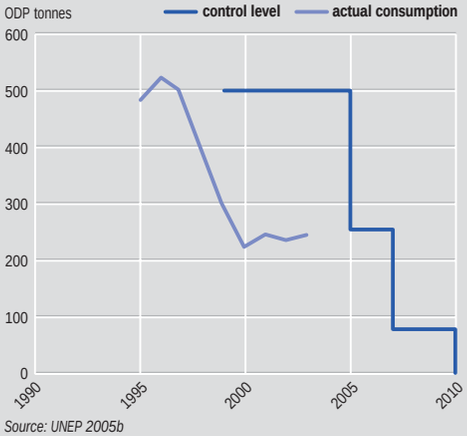


Source: NASA 2005

and other renewables, rural/village energy systems, advanced transportation, and so on.

The region is also progressing ahead of target in reducing its consumption of ozone depleting substances (ODS), with funding from the UN Multilateral Fund for the Implementation of the Montreal Protocol and other sources, and technical assistance from UNEP (Figure 5).

Figure 5: Progress reducing ODS consumption in Asia and the Pacific



Source: UNEP 2005b

NEW REGIONAL INITIATIVES

There are encouraging signs that developing Asia is taking environmental sustainability very seriously, and at earlier stages of development than occurred in the West.

China, the largest and fastest growing developing-country economy in the world, has adopted the concept of the "circular economy". The idea is to cut use of basic materials dramatically, by boosting recycling and re-use – one facility's waste, including energy, water and materials, becomes another facility's input. In the circular economy, all economic activities pursue low resource exploitation, maximum efficiency in using materials and energy, and low waste generation. Comprehensive legislation, policy and technology innovation mechanisms will be introduced to promote the circular economy.

The Government of China has set the following key targets for 2010 (China State Council 2005) using 2003 indicators as the baseline:

- Resource productivity per tonne of energy, iron and other resources increased by 25 per cent.
- Energy consumption per unit of GDP decreased by 18 per cent.
- Average water use efficiency for agricultural irrigation improved by up to 50 per cent.
- Reuse rate of industrial solid waste raised above 60 per cent.
- Recycle and reuse rate for major renewable resources increased by 65 per cent.
- Final industrial solid waste disposal limited to about 4 500 million tonnes.

Materials recycling in China.

Source: Associated Press

Box 3: A new family of mammals

A new mammal family was created – the first in over 30 years – to accommodate the discovery in Central Laos of a new species of rodent, *Laonastes aenigmamus*, The rat was discovered in the Khammouan Limestone Biodiversity Conservation Area in May 2005. The Laotian rock rat, or Kha-nyou as it is known locally, is not related to any other species of rodent, and the new family Laonastidae, was created to accommodate it. The last new mammal family was created in 1974 with the discovery of the bumblebee bat in Thailand.

Source: Jenkins and others 2005

The Laotian rock rat.

Source: R.J. Timmins/ Wildlife Conservation Society/Associated Press

Box 4: Major river pollution incident in northeast China

A chemical plant explosion on 13 November 2005 in Jilin Province, in northeast China, severely polluted one of China's biggest rivers, the Songhua River. Experts estimate that around 100 tonnes of pollutants containing benzene flowed into the river, causing water supplies to be cut for millions of people in cities along the river for various periods. Harbin, a city of more than three million residents, stopped drawing water from the Songhua River for four days after the incident.

On 14 November 2005, one monitoring station near the chemical plant confirmed that the content of nitrobenzene in the polluted water exceeded the national safe standard by 100 times.

The polluted water is expected to flow into the Heilongjiang River (called the Amur River in Russia) on the Sino-Russian border. China and Russia are working closely to minimize the potential impact of pollution on Russia, including intensifying monitoring and water quality control measures.

Sources: SEPA 2005, Xinhuanet 2005a, Xinhuanet 2005b

Japan is promoting a similar initiative known as the 3Rs (Reducing waste, Reusing products, and Recycling resources). A ministerial conference was held in April 2005 in Tokyo to launch the initiative globally. Japan's key national targets for 2010 include improving GDP per unit of material input by 39 per cent (compared with the base year of 2000), improving the proportion of re-used and recycled material in material input from ten per cent to 14 per cent, and reducing the amount of waste that needs to be disposed off from 56 million tonnes to 28 million tonnes (Koike 2005).

At regional level, the Fifth Ministerial Conference on Environment and Development in Asia and the Pacific was held in Seoul, Republic of Korea, in March 2005, with the theme of achieving environmentally sustainable economic growth. The 52 countries endorsed environmentally sustainable economic growth as the way for the future (UNESCAP 2005). The meeting issued a comprehensive Ministerial Declaration on Environment and Development, created a Regional Implementation Plan for Sustainable Development in Asia and the Pacific, and established the Seoul Initiative Network on Green Growth, as a policy forum and capacity-building mechanism for sustainable development in the region (UNESCAP 2005).

CHALLENGES FOR THE FUTURE

The sheer size and population of Asia and the Pacific, coupled with extremely rapid economic growth, means that environmental pressures and problems will tend to increase unless vigorous and effective policies are in place. There are encouraging signs that this is under way.

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Europe

European consumption, wastes and land use practices are putting great pressure on the regional and global environment. Current policy approaches are improving the situation, but environmental and social impacts and costs are not yet adequately addressed and accounted for.

EUROPE'S ECOLOGICAL FOOTPRINT

Consumption patterns in Europe continue to have negative impacts on ecosystems within Europe and beyond, according to the new five-year State of the Environment Report of the European Environment Agency (EEA 2005a). Water supplies, soils, biodiversity, air quality and climate are listed among the most threatened resources. The report stresses that the price of goods and services that Europeans consume seldom account for the full environmental and social costs of their production, distribution, use and disposal (EEA 2005a).

Studies of overall resource demands, such as estimates of the region's ecological footprint (Box 1) suggest that European policy has not yet struck the right balance between economic growth, prosperity and protection of the environment (WWF 2005a, Van Vuuren and Bouwman 2005, EEA 2005a). The sheer size of Europe's ecological footprint should arouse concern among policy-makers and the public. The longer corrective action is postponed, the higher the investment that will be required in future, and the greater the risk that critical ecosystems will be damaged beyond recovery (WWF 2005a).

WASTE

Waste generated in Europe translates into serious pressures on the local and global environment and on human health. Wastes range from hazardous chemicals and obsolete pesticides, to municipal waste water and sludge, packaging, electronic and nuclear waste, greenhouse gas emissions and oil spills.

On average each EU citizen is currently responsible, directly or indirectly, for the generation of some 172 kg of packaging waste a year. Waste loads have generally increased in line with private consumption, as reflected in GDP (EEA 2005a). In Southern- Central and Eastern Europe waste generation has also increased, but more slowly, in line with slower economic growth (UNDP and others 2004, OECD 2004).

Source: Philippe Hays/Still Pictures

Source: Peter Frischmuth/Still Pictures

Source: Peter Frischmuth/Still Pictures

Discarded appliances, packaging, and wastewater are just some of the many forms of waste in Europe.

Box 1: Europe's ecological footprint

The ecological footprint of a country or region is the total area required to produce the food and fibre it consumes, to absorb its waste, and to provide space for its infrastructure. The European Union (EU) hosts only seven per cent of the world population, but its footprint in 2001 was 20 per cent of the planet's biological production capacity (or bio-capacity – nature's ability to renew depleted resources).

The ecological footprint of a European is just under half that of a North American – yet it remains the second largest regional footprint in the world. Within Europe, Western Europe's ecological deficit (footprint minus bio-capacity) is the most serious (Table), but new EU member countries in Central Europe are coming close, while Eastern Europe still has more space to manoeuvre. In the southern and eastern parts of this sub-region, the footprint per person dropped by 23 per cent between 1991 and 2001, due to recession following the collapse of the Soviet Union.

Since the expanded EU (EU-25) already exceeds its bio-capacity, its resource consumption and waste levels can continue to rise only by importing more natural resources from other regions and shifting more wastes towards the rest of the world or to the global commons. Sustainable consumption and waste patterns can be fostered by pricing policies that incorporate environmental costs, and by encouraging innovations in, for example, renewable energy, food production, nature management and human mobility. Such approaches could eventually change behaviour and reduce the environmental deficit of Western Europe and avoid a future deficit in other parts of Europe.

Ecological footprints for Europe's sub-regions

	Total ecological footprint in 2001 (global ha/person)	Total bio-capacity in 2001 (global ha/person)	Ecological deficit in 2001 (global ha/person)	Ecological footprint change per capita (% change 1991–2001)	Bio-capacity change per capita (% change 1991–2001)
Western Europe*	5.1	2.1	3.0	+5	–7
EU-25**	4.9	2.1	2.8	+3	–7
Central and Eastern Europe*	3.8	4.2	–0.4	–23	0

*Source: *WWF 2004, ** WWF 2005a*

Governments across the region have drawn up waste management plans and legislation to improve the situation (OECD 2004, EEA 2005a). A 2005 review of the EU Packaging and Packaging Waste Directive of 1994 (Box 2) showed that in most countries consumers and suppliers made good progress in recycling and recovering packaging waste. The EU target of recycling 25 per cent of packaging waste in 2001 was significantly exceeded in 2002: 54 per cent was recycled in the 15 countries that were then members of the EU (EU-15). But producers are much slower in reducing their generation of packaging waste in the first place. Only the United Kingdom managed to actually reduce (and Austria to stabilize) the generation of packaging waste since 1997 (EEA 2005b).

Fast-growing amounts of plastics waste are of particular concern (Table 1). One reason is that recycling of plastics waste is more difficult than glass or paper, because plastics usually require labelling and careful sorting before they can be recycled. However, innovative technologies are being developed to use mixed plastics waste (Box 3).

The greatest challenge remains to reduce waste volumes in the first place by reducing materials intensity (EEA 2005a). Savings in materials would be greater if fiscal rules were changed and prices reflected their full environmental costs (EEA 2005a). Materials are usually less taxed and regulated than labour, and so improvement in materials productivity has lagged behind labour productivity. In Eastern Europe materials intensity has increased as labour-, material- and waste-intensive industry relocates from Western Europe where these factors are more costly.

In Central and especially Eastern Europe, funds for investments in eco-efficient technology are scarce (OECD 2004). For waste greenhouse gases, the EU Emissions Trading Scheme (ETS) is expected to improve the situation by allowing emitting industries to fulfil their obligations by joint implementation with other countries. The ETS came into force in January 2005 to help the European region meet its Kyoto targets.

LAND MANAGEMENT

Today only 15 to 25 per cent of Europe's land remains as traditional farmland of high conservation value. Most is located in eastern and southern Europe, and much of it is becoming too fragmented for many species to survive (EEA and UNEP 2004, EEA 2005a). Enormous pressure on Europe's landscapes and biodiversity continues, caused by unsound agricultural practices and expanding land uptake for housing, services, recreation, industry, and transport infrastructure (GLOBIO 3 2005, Blue Plan 2005, EEA 2005a).

Road networks expanded in Western Europe by some 365 000 km between 1990 and 1999, 200 000 km in Central Europe (1990–2001) and 105 000 km in Eastern Europe (1992–2001) (GEO Data Portal based on World Bank 2005). Although conventional rail and inland waterways cause less pressure

Box 2: The EU's Packaging and Packaging Waste Directive

The first priority of the 1994 Directive was the *prevention* of packaging waste. However, specific targets were set only for *recycling* and *recovery*. To achieve these targets member countries introduced producer responsibility, established packaging recycling companies, and improved collection and recycling systems. These measures have promoted a market for recycled products, and led to the pricing of packaging waste and strong increases in recycling.

New recycling targets for 2008 have been almost doubled. However, only a few countries are on track to achieve them. With no overall cap in place, packaging waste generation increased by ten per cent in the EU-15 between 1997 and 2002, in close line with the 12.6 per cent growth in GDP. Thus, while the Directive more than met its *recycling* and *recovery* targets, it failed to achieve its first priority, namely waste *prevention*.

Economic instruments, where used, do seem to affect behaviour. For example, landfill taxes in Austria, Denmark, Ireland, Italy and the United Kingdom, and charging people for plastic bags in supermarkets in Denmark and Ireland (and in France, from late 2005 onwards) are cost-effective ways of changing behaviour.

Sources: CEC 1994, EEA 2005a, EEA 2005b

Table 1: Plastics waste in the EU-15, Norway and Switzerland

Consumption	Per capita consumption of plastics increased by almost 50 per cent from 64 kg per year in 1990 to 95 kg in 2002.
Recycling	Recycling of plastics waste more than doubled, from seven per cent in 1990 to 15 per cent in 2002, but this remains much lower than the 54 per cent average in 2002 for total packaging waste.
Disposal*	In 2002, disposal still accounted for 62 per cent of the treatment of plastics waste, compared to 40 per cent for total packaging waste.

** Note: Disposal is considered "the least ideal" way to get rid of plastics waste, and includes open dumps, sanitary landfills and deep-well geological disposal. It does not include composting or incineration.*

Sources: ETCW 2004, EEA 2005a

Box 3: Ukraine's roof-tile revolution

Plastic roof tiles made from recycled materials in Ukraine.

Source: Britanica

When the Soviet Union collapsed in the early 1990s, many heavy industries in Ukraine closed down, increasing unemployment and poverty. Housing was a particular problem, with many existing houses roofed with crumbling sheets of asbestos. Since then the transition to a market economy has increased incomes and fuelled demand for new and better housing. A joint venture company, Britanica JV, responded to this demand by making roof tiles from recycled plastic.

To avoid the costs of sorting plastic waste, researchers in Ukraine developed a process for large-scale manufacture of good quality plastic from mixed plastics waste. The new product is strong, light, durable and fully waterproof – ideal for roof tiles. At the same time the venture is helping to ease pressure on landfills.

The tiles are already in use throughout Ukraine. The UK is expected to start imports as soon as building regulation approval is obtained.

Source: The World Challenge 2005

Source: argus/Still Pictures

Source: Vilarino-UNEP/Still Pictures

Source: Paul Glendell/Still Pictures

Source: argus/Still Pictures

Extreme weather events in 2005 caused drought, forest fires and flooding in Europe.

on landscapes and biodiversity, EU investments focus on high-speed rail and motorway networks through transport corridors, even in Southern-central and Eastern Europe (EEA 2004a).

2005 demonstrated once again that unsound management of soils, forests, rivers and groundwater also leaves ecosystems and societies more susceptible to extreme weather (Box 4). Better adapted and more integrated land and water planning and management could prevent some of the high social and economic costs incurred (CEC and JRC 2005, EEA 2005c, GFMC 2005, WWF 2005b, WWF 2005c).

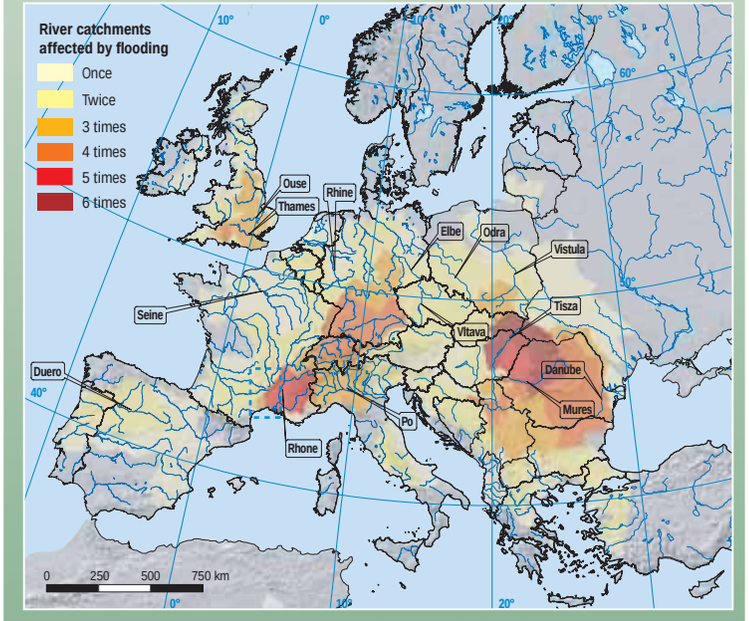
Europe has many regional, national and sub-national land use policies and programmes in place, such as the EU Birds and Habitat directives, the integrated UNECE Pan-European Biological Diversity and Landscape Strategy, the Natura-2000 and Emerald Networks, and the EU Water Framework Directive.

Box 4: Extreme weather events in Europe

The most serious drought in the Iberian Peninsula in 60 years occurred in 2005, reducing overall EU cereal yields by an estimated ten per cent. The drought also triggered forest fires, killing 15 people and destroying 180 000 hectares of forest and farmland in Portugal alone. Meanwhile, torrential rains flooded areas that were recurrently hit between 1998 and 2002 (Figure). The 2005 floods killed at least 70 people. Damages in the Alps alone were estimated at US$2 000 million.

Extreme weather is not the only cause of such events. Canalization of rivers, draining of wetlands, clearing forests and sealing soils to cater for housing and industrial development in vulnerable floodplains – all increase the risk of flooding. Crop failures may result from excess dependence on (or inefficient) irrigation, as well as lack of rain.

Sources: CEC and JRC 2005, EEA 2005c, GFMC 2005, Planet Ark 2005, WWF 2005b, WWF 2005c



Recurrent flood events in Europe between 1998 and 2002. The 2005 floods occurred more or less in the same regions.

Source: EEA 2005c

Box 5: Oil discharges in European waters

Increasing production, consumption and waste means an increase in marine transport – with increasing risks of major oil spill accidents. In addition, routine shipping operations (by all types of ships including merchant ships, fishing and tourist vessels) result in roughly three times more oil discharges than the amount released during accidental spills. For seas surrounding the European Union almost 3 000 illegal oil dumping incidents are reported every year – around half of them in the Mediterranean. It is believed, however, that this only represents a small percentage of the actual incidents.

Despite international, regional seas and domestic conventions and legislation, oil dumping at sea remains a major unsolved and uncontrolled environmental problem. It is hoped that the recently proposed EU Marine Strategy Directive will improve the situation through measures including better monitoring.

Oil spills can be easily detected and monitored with remote sensing techniques. The map below shows 1 400 oil spills detected in the Mediterranean from 2 240 radar images in 2002, the last complete dataset available. The areas off north Africa show few spills, but this may be because they are less thoroughly covered by satellite monitoring.

Sources: EU 2005, JRC 2005, Kluser and others 2005, Oceana 2003

Oil spills detected in the Mediterranean Sea.

Source: JRC 2005

However, many of Europe's landscapes and species continue to deteriorate (EEA 2005a), with massive costs in lost biodiversity and ecosystem services (OECD 2005a). The challenge is to design incentives to conserve nature and disincentives against damage, through legal instruments and economic tools such as tradable environmental permits.

Production of bio-fuel is another growing form of land use that may have drastic negative impacts on Europe's landscapes, food production and biodiversity (Box 6). The EU has set a target that bio-fuel should form 5.75 per cent of road transport energy use by 2010 (CEC 2004). Growing the required bio-fuel crops on EU territory would take between four and 13 per cent of its total agricultural area.

More research is needed to find bio-fuel crop combinations with low requirements in land area and production intensity, such as adding woody biomass to the arable crops that currently dominate the market (EEA 2004b, EEA 2005d).

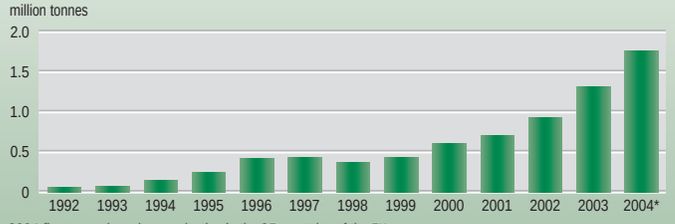
CONCLUSION

Despite a wide range of policy responses, the ecological footprint in large parts of Europe remains too high. Progress in recycling is offset by increasing consumption and waste generation, while inadequate land management and planning continues to threaten ecosystems and societies. A new approach is needed, putting more emphasis on improving the effectiveness of environmental policies (CEC 2005, EEA 2005e, EEAC 2005, OECD 2005b). Policy actions in key sectors need to reinforce one another. Incorporating environmental costs and benefits in prices of goods and services can influence behaviour, raise resource efficiency and reduce environmental damage. Finally, the costs of policy action need to be carefully weighed against the costs of postponement or inaction.

Box 6: Does bio-fuel threaten high nature-value farmland and biodiversity?

The EU aims to increase the use of bio-fuels in transport. Bio-fuel consumption is still low in Europe (0.45 per cent of EU-15 road transport energy consumption in 2002), but production (mainly bio-diesel) is growing rapidly (Figure). Germany and France are the biggest producers, followed by Italy and recently the Czech Republic. Current bio-diesel processing capacity is about 56 per cent higher than actual production.

Bio-fuel production in the EU, 1992–2004



2004 figures are based on production in the 25 countries of the EU

Source: EurObserv'ER 2005

Preliminary analysis by the European Environment Agency indicates that Europe's biomass potential could be developed without additional pressures on biodiversity, soil and water resources. However, this would require careful planning at all levels of decision making. The potential for achieving mutual benefits between biomass production and nature conservation needs to be further explored.

Sources: EEA 2004b and EEA 2005d

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Latin America and the Caribbean

In a year of contrasts, the regional economy continued to grow but also suffered damage from a series of natural disasters. Efforts for better environmental management continued, but changes are taking place at a faster pace and with deeper effects.

WATER MANAGEMENT

The Latin America and the Caribbean region is very rich in water resources. However, the demand for water is growing in some areas, including northern Mexico, Central America and the Andes, while the management of drinking water and effluents poses a problem in many cities.

An estimated 75 million people in the region (seven per cent of the urban population and 39 per cent of the rural population) do not have access to water of acceptable quality. Sixty per cent of urban and rural households do not have regular water supply. Some 116 million people (13 per cent of the urban population and 52 per cent of the rural population) do not have access to sanitation services (IDB 2004).

Collecting drinking water, Guatemala.
Source: Sean Sprague/Still Pictures

In Mexico, where the Fourth World Water Forum will be held in March 2006, around 70 per cent of the water extracted is used for irrigation, livestock production, and aquaculture. Most of the water – 64 per cent – is from surface water sources. Overexploitation of aquifers is also a problem. In 2004, 104 aquifers (16 per cent of all aquifers) were considered overexploited, compared to 32 in 1975. In 2005, about 35 million people in Mexico were living in conditions of "water stress", with 1 700 m^3 of water or less per person annually, and another 24 million are in danger of being in a similar situation (CNA 2005).

Widespread privatization of water services has led to social unrest over rising prices in many areas, but alternative approaches have tried to tackle the problem. For example, the *Agua para Todos* (Water for All) programme in Cochabamba, Bolivia, provides engineering design, building material, training and micro-credit loans to local communities to build, manage and own their own sustainable water distribution system, thus greatly reducing the cost of water. *Agua para Todos* received the 2005 International Seed Award from UNEP, IUCN and UNDP, which is aimed to inspire, support and develop locally driven entrepreneurial partnerships (IUCN and others 2005).

EXTREME CLIMATE EVENTS

2005 was a year of climatic extremes. The first disaster struck early in January in Guyana, as torrential rains, the heaviest recorded since 1888, forced thousands of people from their homes in Georgetown

Water levels in the central reaches of the Amazon River, at Manaus, Brazil, approached the lowest in 100 years.
Source: Luiz Vasconcelos/Interfoto/Associated Press

(IFRC 2005). The drought that took place in central and south-eastern Amazonia is believed to be the worst in 40 years. The Amazon River approached the lowest level recorded in the past 100 years in its central reach, at Manaus (CPTEC 2005). Drought also hit the Pantanal and southern Cerrado eco-regions in Paraguay, and the Chaco thorn forest in Argentina.

The tropical storm season in Mesoamerica and the Caribbean was especially severe. Hurricane Stan, in late September and early October, impacted heavily the southern coasts of Mexico (including the Yucatan

peninsula) and was one of the most devastating events since Hurricane Mitch struck the region in 1998 (Box 1). More than 1 000 deaths were recorded in the region. Hurricane Wilma inflicted serious damage on infrastructure, especially tourism infrastructure, in the Yucatan peninsula in Mexico (NOAA 2005a).

PROTECTED AREA SYSTEMS

There are at least 4 437 terrestrial and marine protected sites in Latin America and the Caribbean, covering an area of more than 350 million hectares (Chape and others 2005). However, hotspot zones and different eco-regions are not adequately or equally covered in this system of protected areas.

A new study of global hotspots rich in bird biodiversity found that six of the nine hotspots with the highest number of bird species are in the Latin America and Caribbean region (Orme and others 2005). The Andes is the richest, with 2 139 species, and the Amazon basin is second with 961 species. Others are the Guyana Highlands (877 species), the Atlantic

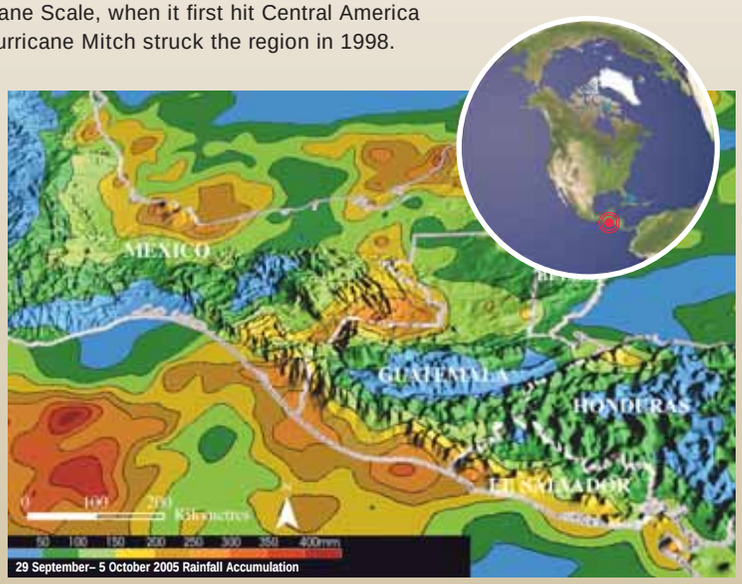
Box 1: Floods in Central America

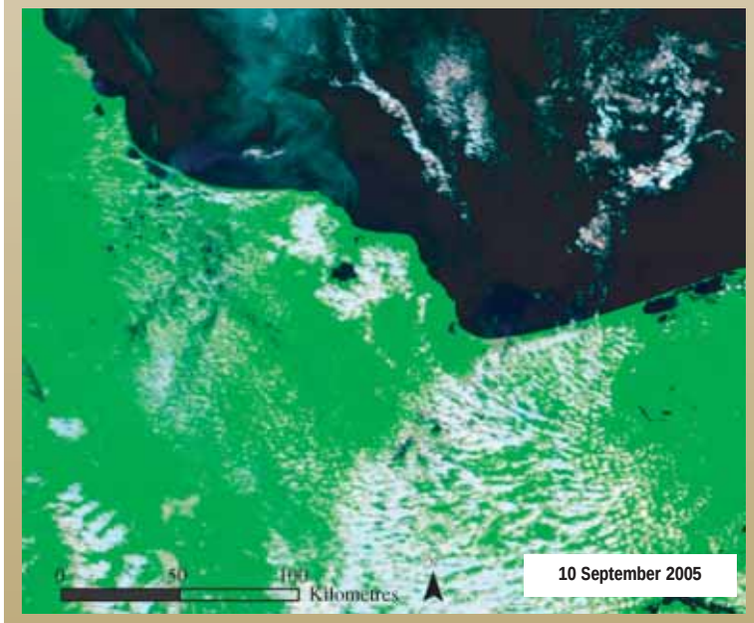
Hurricane Stan was category 1, the lowest rung of the Saffir/Simpson Hurricane Scale, when it first hit Central America in early October. Yet Stan proved to be one of the most devastating since Hurricane Mitch struck the region in 1998. Stan dropped heavy rains on parts of Central America for several days in October 2005 triggering deadly floods. Between 1 000 and 2 000 people died across the region as flash floods and mudslides hit portions of Costa Rica, El Salvador, Guatemala, Honduras, Mexico and Nicaragua. Thousands of people were forced out of their homes. Roads and bridges throughout the affected areas were damaged.

In the map (right), topography is overlaid with data showing rainfall accumulation from Hurricane Stan during seven days, from 29 September to 5 October 2005.

The pair of satellite images (below) shows flooding caused by Stan, in the upper left quadrant of the rainfall map. The image on the left – taken on 10 September before Stan hit – shows wetlands surrounding the confluence of the Grijalva and Usumacinta Rivers in Mexico's Tabasco state. In the image on the right taken on 10 October, the rivers are more clearly defined, expanded with floodwaters. These images show water as black or dark blue. Clouds range from white to pale blue, and vegetation is bright green.

Sources: NASA 2005, NOAA 2005b





Source: NASA 2005

forest in Brazil (733 species), the Mato Grosso plains (687 species) and the mountain areas of Panama and Costa Rica (621 species). Several endemic and threatened species are also found in many of these areas.

However, the study shows that there is no strong correlation between hotspots based on species richness, on level of endemism, or on the number of threatened species. It concludes that a mixture of measures is needed to select priority areas, but if only one is chosen, hotspots with endemic species provide the best single focus for conservation, capturing a high proportion of species richness and threatened species (Orme and others 2005).

In Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay, less than ten per cent of the total area is protected, covering 40 of the 75 existing terrestrial eco-regions. At least 21 of these eco-regions are shared by two or more countries and therefore require coordinated biodiversity conservation strategies. The Andean Community of Nations has put forward a strategy for coordination in the Andean region (Soutullo and Gudynas 2005).

Some progress was made in protecting biodiversity in 2005. In Ecuador, the Sangay National Park was withdrawn from UNESCO's list of World Heritage Sites in Danger (UNESCO 2005). Peru conferred protected status to 2.7 million hectares in the Amazonian region of Alto Purus, which is also an indigenous reserve. This park is home to 86 species of mammals and 510 species of birds, and is an important link in creating a network of reserves in the Peruvian, Bolivian and Brazilian Amazon areas (WWF 2005).

Progress was also made in protecting the marine environment, through the creation of new marine and coastal protected areas. In Chile, two new marine sanctuaries were created stretching a nautical mile (1 852 m) around the Choros and Damas Islands and Chañaral Island. These new areas protect species such as the bottle-nosed dolphin, the Humboldt penguin, the southern sea otter and the marine otter. The Pygmy Beaked whale (*Mesoplodon peruvianus*),

Box 2: Five new bird species discovered

Latin America and the Caribbean is already the richest region in bird species, with more than 3 300 recorded species. Yet, new species are still being discovered – at least five new bird species were identified in 2005.

Two new species of the Tapaculos family were discovered in Colombia. *Scytalopus stilesi* is found in the cloud forests of the Cordillera Central of the Andes. It is estimated that 63 per cent of the original habitat has been lost. *Scytalopus rodriguezi* or the Upper Magdalena Tapaculo is distributed along the Cordillera Central and in the Magdalena valley in Colombia. A third species of the same family, *Scytalopus pachecoi*, was identified in southern Brazil and in the area adjacent to north Argentina, in primary and secondary forests.

A new species of the parrot (Psittacidae) family was also discovered. The sulphur-breasted parakeet (*Aratinga pintoi*) was found in the northern margin of the lower Amazon River in the state of Para, Brazil. Finally, in the outskirts of the city of Iquitos, in the Allpahuayo-Mishana National Reserve in the Peruvian Amazon, a new species of the gnatcatcher, *Polioptila clementsi*, was discovered.

Sources: BirdLife International 2004, Cuervo and others 2005, Krabbe and others 2005, Natchigall Mauricio 2005, Silveira and others 2005, Whitney and Alonso 2005

Sulphur-breasted parakeet (*Aratinga pintoi*).

Source: Eduardo Parentoni Brettas/American Ornithologists' Union and The Auk

Box 3: Deforestation

Deforestation due to indiscriminate logging, expansion of agricultural areas and fires remains the most serious threat to biodiversity in Latin America. Satellite images in September 2005 recorded more than 73 000 fires in the forests of Bolivia, Brazil, Peru and Paraguay.

Deforestation is greatly facilitated by the building of new roads. A recent study examined a limited area of 546 000 km^2 in the Amazon, and found almost 21 000 km of illegal highways, some of them breaching protected areas and indigenous reserves.

The highest absolute loss of forests is taking place in Brazil, which lost an average of 2.3 million hectares per year between 1990 and 2000, followed by Mexico with 631 000 hectares. The Brazilian Amazonia reported a loss of 2.7 million hectares between August 2003 and July 2004 – the second largest loss since 1995. However, significant action against illegal deforestation by federal agencies in Brazil reduced the rate of deforestation dramatically by over 30 per cent, to less than 1.9 million hectares between August 2004 and July 2005.

Sources: PROARCO 2005, Souza and others 2005, FAO 2005, GPTIDA 2005, MMA 2005

Satellite image showing fires in the southeastern Amazon rainforest and the more savanna-like region along the perimeter. Active fires are marked with red dots.

Source: MODIS Land Rapid Response Team at NASA Goddard Space Flight Center

Humpback whale calf, breaching.

Source: Doug Cheeseman/Still Pictures

Box 4: Sustainability in border zones

A new initiative in the western Amazon region, along the border zone shared by Brazil, Peru and Bolivia, aims at promoting regional integration in conservation and development. This initiative, called MAP for the states of Madre de Dios in Peru, Acre in Brazil and Pando in Bolivia, covers 207 million hectares around the Acre River.

Environmental pressures in the area include deforestation driven by the expansion of export-led cattle breeding and agriculture, and the construction of highways, bridges and hydroelectric dams.

The MAP initiative proposes measures to control the burning of forests and pastures, as well as for forest conservation and support for its sustainable use.

The initiative was launched by civil society organizations in 2000. Participation in its annual meetings grew from an initial 25 people to 1 200 participants in 2005, along with local governments and other regional development institutions. In 2004, the presidents of Brazil, Bolivia and Peru recognized the importance of the initiative and committed themselves to cooperating in the prevention of illegal logging and trade of wood along the border regions.

Sources: Chávez and others 2005, Brown and others 2005, MAP 2004

a species discovered in 1991, is also found in this area (Leviathan 2005).

A corridor of marine protected areas, covering important transit areas for cetaceans, was established in Panama in 2005 (UNESCO 2005). Meanwhile, UNESCO recognized as a World Heritage Site a group of nine protected areas in the Gulf of California, which includes 244 islands, islets and coastal areas in Mexico (IUCN 2005). New initiatives to protect humpback whales, found in the Pacific Ocean coasts close to Costa Rica, Panama and Colombia, include coordinated efforts by Panama and Colombia to protect breeding sites in the Las Perlas Archipelago.

The International Maritime Organization (IMO) designated the waters that surround the Galapagos Islands in Ecuador as a "particularly sensitive sea area". This measure will allow improved international assistance in the event of an environmental accident (IMO 2005).

CONCLUSION

While there have been important improvements in protecting biodiversity, the continuing pressures of development and habitat loss are severe. It is essential to reduce human vulnerability and to stabilize ecosystems. There is a growing need to tackle these issues with a regional approach and perspective, and to further strengthen environmental policies.

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North America

In addition to their human toll, Hurricanes Katrina and Rita damaged oil refineries and exacerbated US energy insecurity. New policies in the US and Canada provided incentives for energy efficiency and renewable energy, while continuing to support the oil and gas industries.

NEW CLIMATE AND ENERGY PLANS

North America represents five per cent of world population, but in the most recent figures available, it accounts for 25 per cent of total world primary energy consumption. North Americans emit more carbon dioxide (CO_2) per capita than any other region – almost 20 metric tonnes of CO_2 per person according to the latest figures, compared to 7.9 tonnes in Europe and just over one tonne in Africa (2002 figures from GEO Data Portal 2005 based on United Nations 2005). 2005 saw new actions to curb greenhouse gas (GHG) emissions, though these were considered insufficient by many observers.

Canada's new climate change plan

After the Kyoto Protocol came into force in February 2005, Canada produced a new plan to meet its targets. The plan enhances incentives for renewable energy and energy efficiency, outlines strategies to reduce vehicle emissions and promotes individual action. It will place mandatory caps on the emission intensity of sectors responsible for major GHG emissions, and will provide government funds to purchase emission reductions domestically and internationally through the Kyoto Protocol's market-based mechanisms. The plan anticipates reductions of about 270 million tonnes of carbon dioxide equivalent (Government of Canada 2005a, Pew Center on Global Climate Change 2005a). Critics claim that the means are inadequate to achieve the targets; there are no timelines; and there is too much onus on individuals, while targets for big business are too low (Greenpeace 2005, SLDF 2005).

US Energy Bill

In August 2005, the US administration signed its first national energy plan in more than a decade. The plan contains policies and tax incentives for renewable energy, as well as incentives for nuclear energy development, cleaner coal-fired plants, increased energy conservation, and energy-efficient cars, buildings and appliances (The White House 2005a). It will extend daylight-saving time by one month in 2007 to save energy (Wilson 2005). Critics claim the plan is directed at energy supply and will not reduce energy demand. They note the omission of mandatory controls on fossil-fuel consumption and GHG emissions, and failure to raise vehicle fuel efficiency standards, as well as continued tax breaks, subsidies, and loan guarantees to the fossil fuel industry (Foss 2005, Hebert 2005, Wilson 2005).

Hurricane Katrina (Box 2) prompted the US government to direct its departments and agencies as well as citizens to conserve fuel, curtail non-essential travel, and to make use of carpooling, public transportation, and telecommuting (The White House 2005b and 2005c). Such gestures are new to an administration whose focus has been on boosting energy supplies rather than reducing demand.

It is still too early to analyze the lasting effect of higher prices on consumer patterns of energy use, although the media reported significant declines in sales of heavy cars and increased sales in smaller efficient Japanese vehicles (McClellan 2005). In 2002, the North American transport sector was responsible for 39 per cent of the region's total energy consumption and the total amount of energy used by the sector rose by 30 per cent over the past two decades (GEO Data Portal 2005 based on IEA 2004).

Canada's agreement on vehicle emissions

In April 2005, the Government of Canada and the Canadian automobile industry signed a landmark agreement on climate change action. The industry voluntarily agreed to reduce GHG emissions from new vehicles. The goal is to reduce total annual GHG emissions from light-duty vehicles down to a target of 5.3 million tonnes by 2010. The industry will offer and promote a wide variety of fuel-saving vehicle technologies including hybrid power trains,

Box 1: States mandate energy efficiency and emissions reductions

In the absence of US ratification of the Kyoto Protocol, many US states joined a remarkable process of policy formulation to increase energy efficiency and lower greenhouse gas (GHG) emissions at the state level. The movement began in the early 1990s but has expanded and intensified in the past decade (Rabe 2002). Among the actions mandated by a number of state governments in 2005 are new or stronger appliance efficiency standards for products not covered by existing federal standards, and the promotion of energy efficiency and renewable energy investments. Some states have set targets to achieve emission reductions – including California's aggressive new targets equivalent to returning to year 2000 GHG emissions levels by 2010 and to 1990 levels by 2020. Other state-level policies include improved energy efficiency for public buildings and facilities, and the adoption of improved standards for motor vehicle GHG emissions. These new policies promise to reduce GHG emissions by millions of tonnes a year and to save billions of dollars in reduced energy costs (Pew Center for Global Climate Change 2005b).

At the city level, 158 US mayors signed a Climate Protection Agreement that commits them to strive to meet or exceed targets that would apply to the US under the Kyoto Protocol (seven per cent emission reduction from the 1990 level by 2012). They joined 164 other mayors who had already signed onto the agreement (US Mayors 2005).

Box 2: Hurricane season

Hurricane Katrina was one of the worst natural disasters in US history, causing one of the largest displacements of people – officially some 374 000 evacuees were in shelters on 12 September, with many more in relatives' homes (Grier 2005). The final death toll was 1 312 (FEMA 2005). The most costly natural disaster in US history, Katrina caused estimated economic losses of more than US$100 billion (HIIC 2005) and the US government pledged at least US$60 billion in reconstruction aid (The White House 2005d).

As it passed over the Gulf of Mexico during the last week of August 2005, Hurricane Katrina grew to category 5 on the Saffir-Simpson scale. At landfall, it was a strong category 4 hurricane and one of the most powerful to hit the northern Gulf Coast in 50 years. The Gulf of Mexico's exceptionally warm water helped to fuel its intensity (Webster and others 2005).

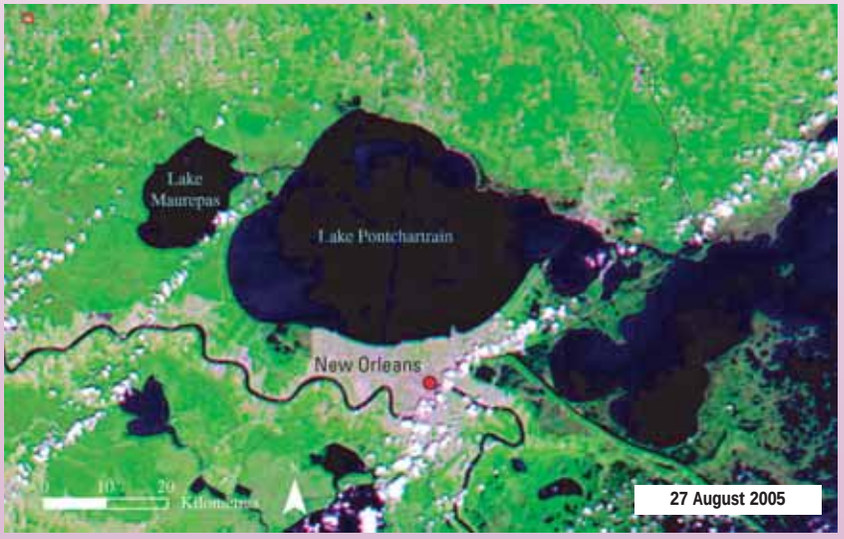
One of the factors contributing to Katrina's disastrous impact was the large number of people living in harm's way. Between 1980 and 2003, total US coastal population increased by 28 per cent (Crossett and others 2004). By 2003, more than 45 million people resided permanently on hurricane-prone coastlines (NSTC 2003).

Protective structures and the availability of flood insurance have encouraged people to settle in flood-prone areas such as New Orleans (Brun and others 1997, Bruce and others 1999). However, breaks in the levees separating New Orleans from surrounding lakes exacerbated the loss of life and property damage (NCDC 2005). In the 1990s, the US initiated a new strategy to encourage non-structural approaches to flood prevention, such as resettlement projects and wetland restoration (Changnon and Easterling 2000), but in the early 2000s federal investment in flood control and wetland restoration was reduced. This may have contributed to the severity of the hurricane's impact (Blumenthal 2005), which may also have been exacerbated by the loss of marshes that buffer the coast from storm surges (America's Wetland 2005). Between 1990 and 2000, Louisiana lost wetlands at a rate of about 6 194 hectares per year, exposing low-lying areas to major storms (US Army Corps of Engineers 2004).

The hurricane damaged or temporarily shut down oil wells in the Gulf of Mexico and coastal oil refineries, and led to a significant rise in the price of oil. About one quarter of US oil production comes from the Gulf of Mexico, where ten per cent of the nation's refining capacity is located (Worldwatch Institute 2005).

The environmental effects of Hurricane Katrina have yet to be fully tallied. The floodwaters were contaminated with oil, gas, hazardous waste, toxic chemicals, and sewage from spills and damaged containers and pipes. At least 44 oil spills discharged more than 26 million litres of oil into streams, lakes and surrounding wetlands (Benfield and others 2005, USCG 2005). Katrina affected at least three Superfund (hazardous waste) sites located near low-income communities in New Orleans. Many such communities lacked adequate emergency preparedness plans (Benfield and others 2005). The hurricane also devastated natural coastal habitat, islands, marshes, forests, and coastal and marine wildlife species. These impacts will seriously affect the Gulf of Mexico's fishery industry, valued at almost US$700 million per year (USINFO 2005).

Hurricane Rita struck along the Louisiana-Texas border three weeks after Katrina, causing mass evacuations but relatively minor damage. In October, Hurricane Wilma hit the lowest pressure ever recorded in the Atlantic basin. Wilma caused the deaths of 26 people in the US (FEMA 2005) and caused damage in Mexico. These weather events made the 2005 Atlantic season the most active in recorded history for both hurricanes and tropical storms (Bernard 2005). They also helped to stimulate a national media debate about the role of humans in climate change, the warming trend in the planet's oceans, and the increased duration and severity of hurricanes (Begley 2005, Kluger 2005).



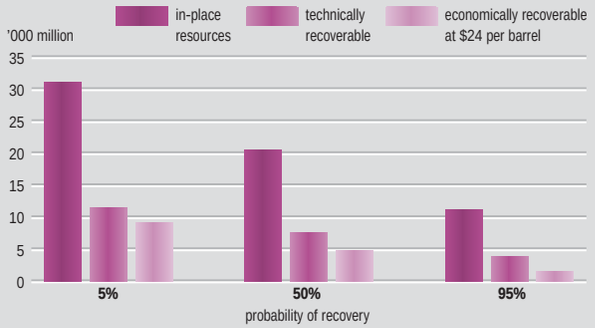
Taken on 30 August 2005, the lower image shows much of New Orleans under water in the wake of Hurricane Katrina. Lake Pontchartrain and Lake Maurepas have nearly blended into a single body of water, separated only by a narrow strip of land. The upper image, taken three days earlier, shows the city still intact between the lake shore and the river. Water is clearly visible against the land. Water is black or dark blue where it is coloured with mud, vegetation is bright green, and clouds are light blue and white.

Source: Jeff Schmaltz/ MODIS Land Rapid Response Team at NASA Goddard Space Flight Center

Figure 1: Map of the US Arctic National Wildlife Refuge (ANWR) and the National Petroleum Reserve (NPRA) in Alaska

Source: FWS 2001

Figure 2: Estimated thousand millions of barrels of oil in the Arctic Refuge's 1002 area



Source: FWS 2001

cylinder deactivation technology, and advanced diesel technology (Government of Canada 2005b).

ARCTIC DRILLING STILL IN THE BALANCE

The 7.7 million hectares US Arctic National Wildlife Refuge in Alaska (ANWR, Figure 1) is one of North America's and the world's most pristine and diverse Arctic and sub-Arctic ecosystems (FWS 2001). It is the home of muskoxen, polar bears, snow geese and other migratory birds, and large herds of barren-ground caribou (IISD 2005, MSNBC 2005). In March 2005, just over 600 000 hectares along the coastal plain, known as Section 1002, was designated for potential oil production as part of a US plan to reduce dependency on foreign oil. (The US imports about 60 per cent of the oil it consumes). A 1998 assessment predicted that there was a 50 per cent chance that a total of some 7 700 million barrels of mean crude oil might be *technically* recoverable in total from Section 1002. But at a price of US$24 a barrel only around 5 000 million would be *economically* recoverable – equivalent to only eight to nine month's of US oil consumption (FWS 2001). Figure 2 shows estimates of the number of barrels of oil in section 1002 of the Refuge under various assumptions.

Drilling in ANWR has been the source of much debate. While proponents claim that only a very small area will be *directly* affected, many environmentalists and scientists contend that it would have major detrimental impacts on the ecosystem, and that energy efficiency initiatives could save far more oil than is economically recoverable from the area over a 50-year period (UCSUSA 2002). A drilling provision was removed from a US defence spending bill in late December, but the issue is likely to come up again in 2006.

In September 2005, Canada informed the US government that if it allowed drilling in the Refuge, it would violate the 1987 Canada-United States Agreement on the Conservation of the Porcupine Caribou Herd. Canada claims drilling would have a devastating impact on the Porcupine Caribou as well as on the Gwich'in indigenous people, whose livelihoods and culture rely heavily on the herd (Government of Canada 2005c).

Caribou in the Arctic National Wildlife Refuge.

Source: US Fish and Wildlife Service

Box 3: Youth-at-risk clean up the Anacostia River

The Anacostia River, which runs into Washington D.C., is one of the most polluted rivers in the US. The US Environmental Protection Agency reports that every year, some 7 500 million litres of raw sewage is dumped into the Anacostia (NRDC 2002). Anacostia is also the name of a black D.C. neighbourhood known for poverty, drugs, and violent crime (Bradley 2005).

The Earth Conservation Corps (ECC), an innovative youth programme to restore the Anacostia River, aims to put local youth-at-risk on the path to a better future. Each year the ECC enrols 20 young people who commit themselves to doing 1 700 hours of environmental work a year in exchange for a small living allowance. If they fulfill their commitment, they receive a US$5 000 scholarship (ECC 2005). Since 1989, ECC has graduated more than 300 young people.

Programme participant.

Source: Earth Conservation Corps Youth Media Arts Department

One of the first ECC projects was the removal of nearly 5 000 tyres dumped in the river. The ECC also returned the Bald Eagle to the nation's capital after a 50-year absence. With help from the US Fish and Wildlife Service, ECC youth built the young eagles a nest, fed them fish with a rope and pulley, and monitored their activities for months. Between 1994 and 1998, 16 eagles were released to the environment (ECC 2005).

US CORAL REEFS ARE IN DECLINE

In August 2005, the US National Oceanic and Atmospheric Administration (NOAA) reported a serious decline in coral reef ecosystems in US waters over the past five years. The decline is attributed to a wide array of threats, including overfishing, climate change, marine diseases, land-based pollution, storms, and grounded ships (Sheer 2005).

In over three-quarters of the areas studied, NOAA found that climate change was a moderate or high threat to coral reef ecosystems (NOAA 2005). Global warming was directly implicated in the die-off of reefs in Guam, in the North Pacific. Coral reefs are important to marine ecosystems as well as the US economy since they provide nutrients and habitat for marine wildlife and protect shorelines from erosion (Sheer 2005).

CHALLENGES AHEAD

Energy is likely to remain the focus of environmental policies in 2006. With weather experts suggesting that hurricane frequency and intensity may continue, the national debate in the US over greenhouse emissions is likely to intensify.

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West Asia

Despite improvements in environmental policies, priorities and management, population growth, urbanization and pollution continue to be major challenges in West Asia.

The West Asia region is in social, economic and political transition. In 2005, the region saw rapid economic growth and urbanization, fuelled by rising oil prices and capital inflows. The emerging trends of democratization and public participation in environmental management have brought improvements. However, the security situation continues to have major negative impacts on economic, social and environmental conditions (ESCWA 2005, World Bank 2005).

CONTRIBUTIONS TO CLIMATE CHANGE

Emissions of the major greenhouse gas (GHG) carbon dioxide (CO_2) continued to rise in West Asia – the latest available data show that per capita emissions increased by 22 per cent between 1990 and 2002 (GEO Data Portal 2005 based on United Nations 2005a) (Figure 1). Only four of the 12 countries in the region have completed GHG inventory reports (Bahrain, Jordan, Lebanon and Yemen). None have taken any measures to reduce emissions so far.

The sharp rise in energy and fossil fuel consumption in the Gulf Region (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates) is due to both accelerated economic growth and extreme climatic conditions (high temperatures and aridity), which require widespread use of air conditioning and energy-rich processes for desalination of sea-water. As a result, it has become one of the highest per capita commercial energy consumers in the world and GHG emissions have risen. However, these rates may decline as more oil companies adopt zero emission flaming technologies. Expansion in the use of natural gas in power and desalination plants will also help to limit emissions of some GHGs.

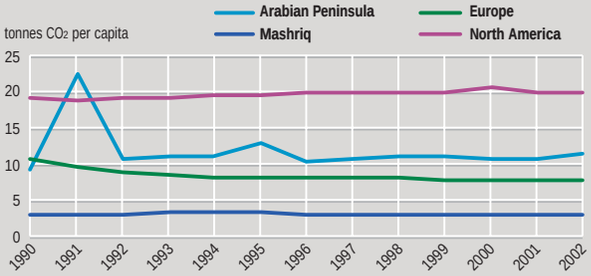
The potential impact of climate change on West Asia has not been fully examined. It could possibly increase temperatures and aggravate the region's vulnerability to extreme events and natural disasters. These include drought, food shortages, flash floods, dust storms (Box 1), lightning strikes and pest infestations. Sea-level rise could also cause inundation of low-lying coastal areas (IPCC 2001, UNEP 2003).

Decreased water availability and food production (especially if there is a shortage of

Flash flooding in Jeddah, Saudi Arabia.

Source: Associated Press

Figure 1: Per capita carbon dioxide emissions in selected regions, 1990–2002



Note: Arabian Peninsula figures include emissions due to oil production and flaring. The spike for 1991 is related to burning oil wells during the Gulf War.
Source: GEO Data Portal 2005 based on United Nations 2005a

Box 1: Dust and sand storms

Dust and sand storms are among the most significant weather phenomena in the West Asia region. They have widespread adverse effects on natural ecosystems, the economy, and the quality of life. In many areas, they act as carriers of various types of pollutants, especially heavy metals (ROPME 2004).

The incidence of dust storms has increased in recent years. This may reflect the degradation of terrestrial ecosystems, climate change, damage associated with conflicts and wars, industrial and agricultural activities, mining of sand and gravel, stripping of vegetation cover and overgrazing (UNEP 2003, World Bank 2005).

Satellite observations have indicated that most storm-generated particulate matter comes from exposed desert surfaces or abandoned croplands. Remote sensing observations in April, May and August 2005 showed a series of large dust storms spreading across northern Syria, Jordan, Iraq and Saudi Arabia. Other observations made in the area show advancing sand storms over Baghdad and Kuwait (NASA 2005).

Fine dust from the region can spread worldwide. Deposits of black powdery dusts on the Japanese sea coast in 2003 were attributed to incomplete combustion of oil flares burning in Iraq and the frequent sandstorms in the area. The carbon-bearing particles may have been transported as cloud nuclei from Iraq to Japan (Tazaki and others 2004).

Dust storm in western Iraq, April 2005.

Source: Gunnery Sgt. Shannon Arledge/Associated Press/USMC

water for irrigation) would lead to indirect impacts on human health associated with nutritional and hygiene issues (IPCC 2001). Climate change may also have negative health effects, mainly through heat stress and possible increases in vector-borne and water-borne diseases.

THE CHALLENGE OF URBANIZATION

Urbanization in West Asia has proceeded very rapidly, presenting massive challenges to future prosperity and the fight to achieve the Millennium Development Goals (MDGs). Among the problems are the sheer physical scale of growth, massive infrastructure needs, the plight of the urban poor, pollution of the environment and degradation of the coastal areas.

West Asia's total population increased from 36 million in 1970 to 118 million in 2005. The total urban population in the region went up from 16 million in 1970 to 75 million in 2005 (GEO Data Portal based on United Nations 2005b). Urban growth rates were much more rapid in the Arabian peninsula, where the urban population increased from 38 per cent of the total in 1970, to 63 per cent by 2005. In the same period, the urban share in the Mashriq sub-region (Iraq, Jordan, Lebanon, the Occupied Palestinian Territories and Syria) increased from 52 per cent to 65 per cent (GEO Data Portal based on United Nations 2004). By 2030, the urban population in West Asia is projected to reach 143 million (Figure 2).

The concentration of population in urban areas has resulted in increased air pollution, inadequate solid waste collection and disposal, toxic and hazardous waste problems, poor or non-existent sanitation facilities and degradation of urban environments (UNEP 2003, World Bank 2005).

Cities such as Sana'a, Damascus (Box 2), Baghdad and Manama among other major

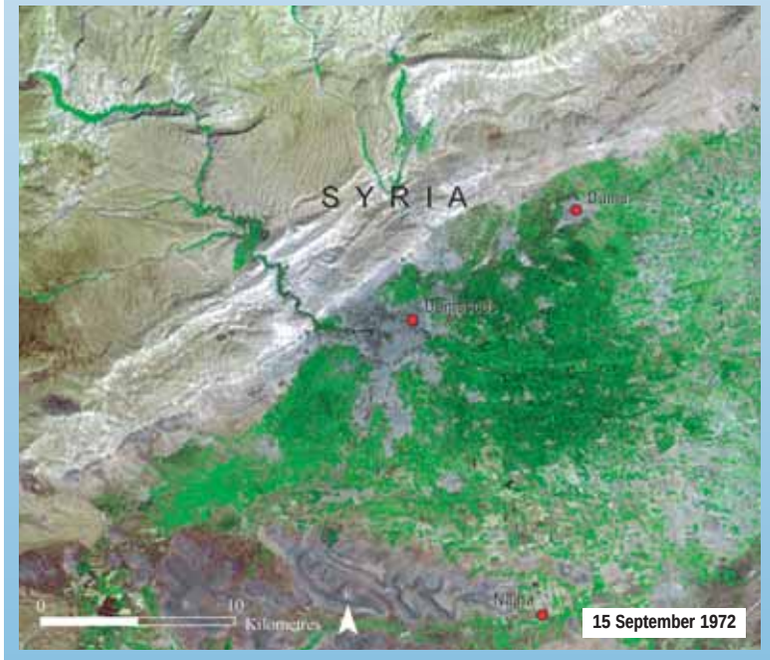
Box 2: Urbanization of Damascus

Damascus, the capital city of Syria, is one of the oldest continuously inhabited cities in the world. In the last half century it has experienced rapid growth, seeing its population grow from 367 000 in 1950 to more than six times that number, 2.3 million, in 2005 – an average growth rate of 3.4 per cent a year.

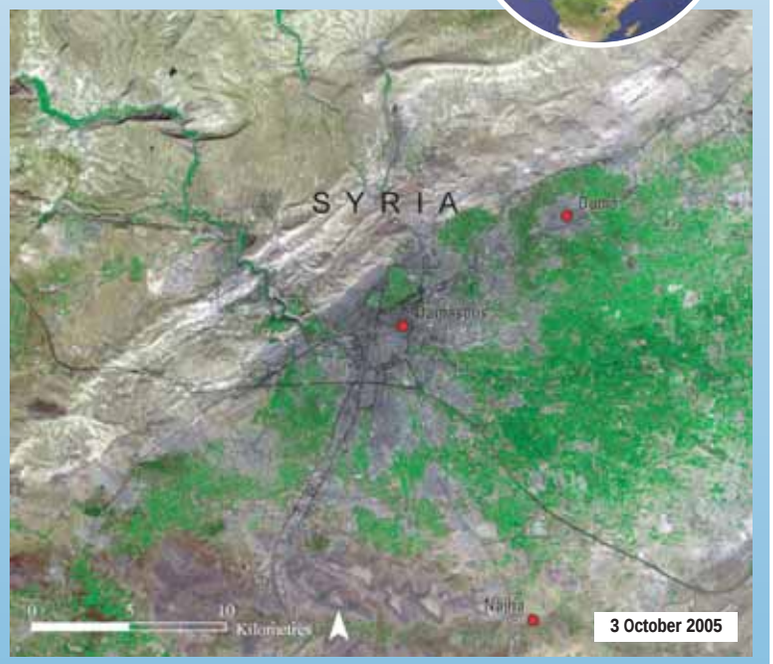
Most of this increase occurred in informal settlements at the edge of, or just outside the city's boundaries, where land is more affordable. For the most part, migrants settle on agricultural land that is not included in development plans. These areas have high population densities and a range of problems including environmental degradation, poor health and sanitation, crime, hazardous/chaotic building methods, unemployment and poverty. Today, it is estimated that 40 per cent of the population of Damascus live in informal settlements.

The fast growth rate of Damascus has resulted in the expansion of the city at the expense of rural areas, resulting in clearance of forested land to cater for demand of land for urban development. The two images show how Damascus has rapidly urbanized by contrasting the area coved by urban areas in 1972 and 2005. The grey colour on these images represents area covered by urban development, while the green parts show vegetation cover, which has been shrinking due to clearance of land for urbanization.

Sources: United Nations 2004, UMPASR 2005, UN-Habitat 2005

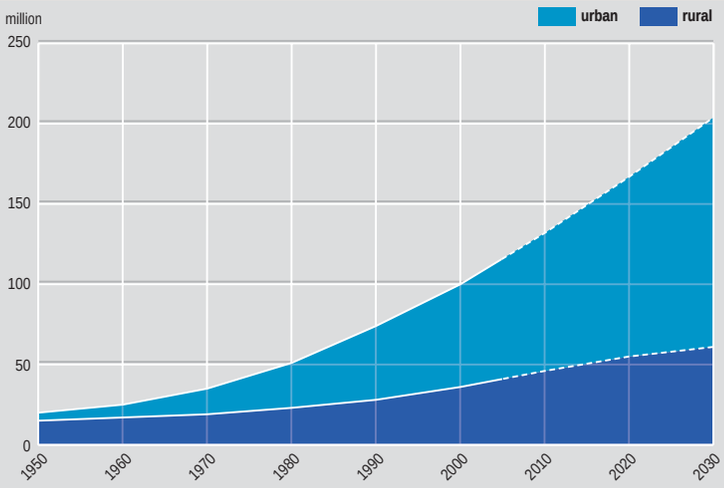


Source: UNEP/GRID 2005



Source: USGS 2005

Figure 2: Urban and rural population in West Asia, 1950–2030



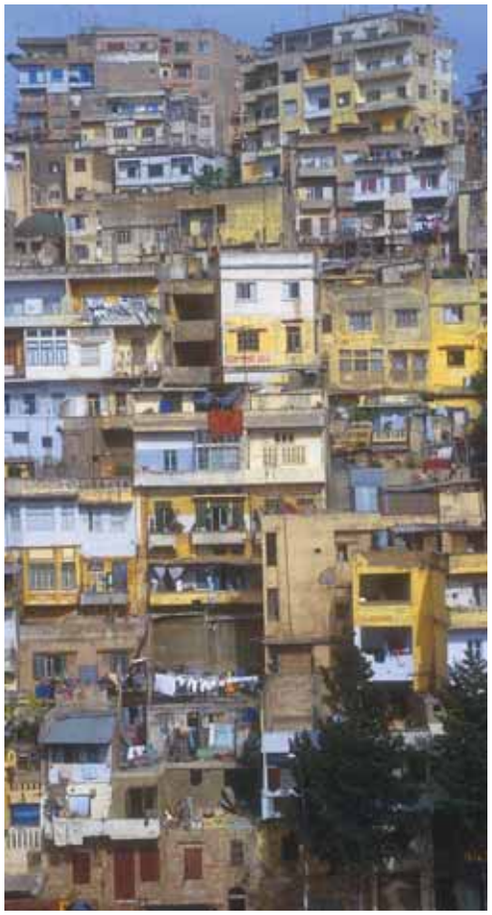
Source: GEO Data Portal 2005 based on United Nations 2005b

Air pollution in many West Asian cities like Baghdad is on the rise.

Source: Shehzad Noorani/Still Pictures

Rapid urbanization in West Asia has resulted in poor housing conditions as seen in this neighbourhood in Tripoli, Lebanon.

Source: Jean-Leo Dugast/Still Pictures



cities in West Asia suffer air pollution levels that sometimes exceed WHO guidelines (UNEP 2003, Meslmani 2004, Meslmani and others 2005). Although few West Asian countries monitor air pollution levels systematically, available data and reports indicate that the main sources include industrial processes, inappropriate disposal of solid and hazardous waste, vehicle emissions and the burning of oil in electric power production.

Waste management is a serious problem in the region. In some countries, municipalities face problems in finding new landfill sites (Box 3) since the existing ones have reached their limit, resulting in air, soil and water pollution (El-Khatib 2005). Although some of the Gulf Cooperation Council (GCC) countries have placed recycling at the top of their waste management priorities, the low cost of landfill and the availability of land (usually old quarries) in most of these countries render recycling programmes difficult. There are no recycling targets, and the only comprehensive form of recycling available within the GCC countries is for paper and cartons (Alhumoud 2005).

Box 3: Green Award for Bahrain industrial landfill site

The Hafira Industrial Landfill Site in Bahrain has become an example for the design and operation of hazardous waste landfills in similar geographical locations. The Bahrain Directorate of Environmental Control, Public Commission for the Protection of Marine Resources, Environment and Wildlife recently won a Green Apple Award from the UK's Green Organization for the landfill site. The project has also been chosen by UNEP in the preparation of a set of guidelines for the design and operation of a waste landfill in hyper-arid areas.

The project contributes to sustainable and integrated waste management in Bahrain, by making it possible for companies to stop storing industrial and hazardous wastes on their own sites.

The landfill site, completed at a cost of US$1.2 million, is designated as a Class II landfill with three disposal cells and three evaporation ponds for treating the landfill leachate and liquid industrial waste, and two boreholes to monitor ground water pollution. Since the project started in February 2001, the landfill site has accommodated around 51 499 m^3 of industrial waste. Fees from the waste generators have paid the construction cost and by May 2005 the project had accrued a profit of US$1.7 million.

Source: Ahmed 2005

Box 4: Sustainable development plan for Bubiyan Island

Bubiyan Island is located in Kuwait, in the northwestern corner of the ROPME Sea Area. A unique network of tidal channels in the northern part of the 888 km² island encompasses regionally important salt marsh wetlands. In 2003, the Kuwait government decided to develop an environmentally driven Master Plan for the island.

The Kuwait Institute for Scientific Research (KISR) conducted a comprehensive baseline environmental field inventory programme of the island's ecosystems. Over 75 interpretive thematic and constraint maps were created and considered by the planning team and decision makers. The study demonstrated that Bubiyan Island has a unique significance for terrestrial and marine biodiversity.

The sustainable development plan for the island is unique to the region because it uses a comprehensive environmental baseline study as the basis for master planning and long-term national policies. It incorporates contributions of many stakeholders in government and non-governmental organizations. KISR is also involved in the follow-up development of comprehensive resource conservation and management plans.

Source: Omer 2005

Box 5: Champion of the Earth

The late President of the United Arab Emirates (UAE), Sheikh Zayed bin Sultan Al Nahyan, posthumously received the UNEP *Champions of the Earth* Award in April 2005 for his outstanding work in preserving the environment.

Sheikh Zayed oversaw the planting of over 150 million trees in the UAE in an effort to stem the encroachment of sand onto agricultural land and urban areas.

To protect the country's fauna, Sheikh Zayed banned hunting more than a quarter of a century ago. He created the island reserve of Sir Bani Yas, a sanctuary for endangered species such as the Arabian Oryx and the sand gazelle. The Dorcas Gazelle, the symbol of Abu Dhabi, was declared a protected species, and special programmes were started to increase its population. Other species such as the rare Arabian Leopard, the ibex and the dugong also received special protection.

The Arabian Oryx have benefited from the efforts of Sheikh Zayed.

Source: Roland Seitre/Still Pictures

Sheikh Zayed had previously won other prestigious environment-related awards, including a gold medal from the Food and Agriculture Organization, for his agricultural development efforts. In 1997, he won the World Wide Fund for Nature's highest award, the Gold Panda – the first time that a Head of State was so honoured.

"On land and in the sea, our forefathers lived and survived in this environment. They were able to do so only because they recognized the need to conserve it, to take from it only what they needed to live, and to preserve it for succeeding generations. With God's will, we shall continue to work to protect our environment and our wildlife, as did our forefathers before us. It is a duty, and, if we fail, our children, rightly, will reproach us for squandering an essential part of their inheritance, and of our heritage."

- Sheikh Zayed, speech on UAE's first Environment Day, 1998

Sources: UNEP 2005, UAE Interact 2005

Another problem facing some West Asia countries is contamination of coastal areas due to reclamation, land filling, or discharge of industrial effluents from coastal factories such as those north of the Sitra industrial zone in Bahrain (ROPME 2004). Hotspots on Lebanon's public beaches were found to be "highly polluted" in a recent study (Environment and Development 2005).

CHALLENGES FOR THE FUTURE

With the prevailing atmosphere of reform in the region, there is more effective public participation in addressing the legacy of environmental problems. West Asia is now entering another development boom, with several mega projects already in the pipeline. If not well planned, such development could have significant environmental impacts in the region.

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Polar

Evidence of accelerating climate change in both Polar Regions, including notable shrinking of Arctic sea ice, continued to accumulate while current and planned expansion of commercial exploitation in both regions raised concerns for sustainability.

CLIMATE CHANGE

Evidence continued to strengthen in 2005 that Arctic temperatures are rising more rapidly than the global average, and that the rate of increase may accelerate due to feedback mechanisms.

In the northern hemisphere, the highest increases over average temperatures occurred in northwest North America and the northern Far East of Russia. In the Yukon Territory and Alaska, summer temperatures reached record highs in 2004 and were above normal in 2005. Alaska and Yukon also experienced record high areas of burned forest in 2004 and near record high areas in 2005 – a total for the two years of about 65 000 km^2, which comprises 25 to 30 per cent of all forested land and an area roughly the size of Ireland or of Sri Lanka. Forest fires of similar size burned large portions of Siberia in 2002 and 2003 (Juday 2005).

There were new findings this year on feedback mechanisms that could stoke global warming:

- In western Siberia, a massive peat bog of nearly one million km^2 in area, has begun to melt over the past three or four years. This will release huge amounts of the greenhouse gas methane into the atmosphere, which in turn will result in further climate warming. Estimates put the amount of methane frozen in the Siberian peat bog at 70 billion tonnes – one quarter of all the methane stored in land, worldwide (Pearce 2005).
- A study in Alaska found that 95 per cent of the recent increases in summer temperatures in the region are attributable to increases in the length of the snow-free period (about 2.5 days per decade since the 1960s) (Beringer and others 2005, Chapin and others 2005). This leads to warming because the darker, snow-free land reflects less of the sun's radiation than the light-coloured snow. The warmer summers promote increased growth and expansion of shrubs, which also have an overall warming influence.

There was a record reduction in summer Arctic sea ice in 2005 (Box 1). Experts predict that if current trends continue, the Arctic Ocean will be completely ice-free by the end of this century.

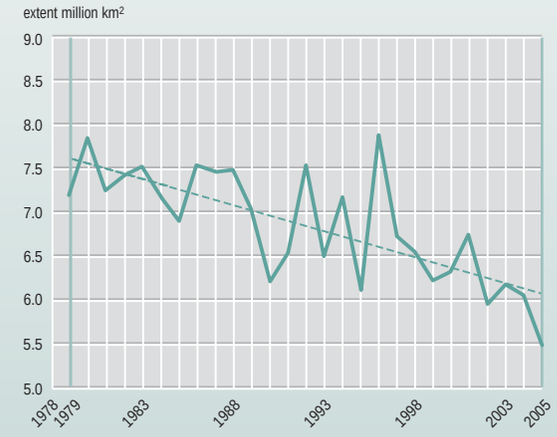
Box 1: Melting of Arctic sea ice accelerates

Sea ice has long been considered a key indicator and agent of climate change. The Arctic Climate Impact Assessment report concluded that Arctic summer sea ice extent has decreased by nearly 27 per cent in the past 50 years due, at least in part, to warming temperatures. In the past 30 years, Arctic sea ice loss has accelerated by 20 per cent compared with previous rates. In the past two decades, sea ice thickness also has decreased at a rate of seven to nine per cent per decade.

Climate models predict that if current warming trends continue, the Arctic Ocean could be ice-free during the summer by the end of this century.
The Figure on the right depicts the decline in sea ice extent from 1978–2005, as measured through satellite imagery. The September trend from 1979 to 2005, shown with a dashed line in the Figure, is a decline of more than eight per cent per decade.

Sources: ACIA 2005, Johannessen and others 2004

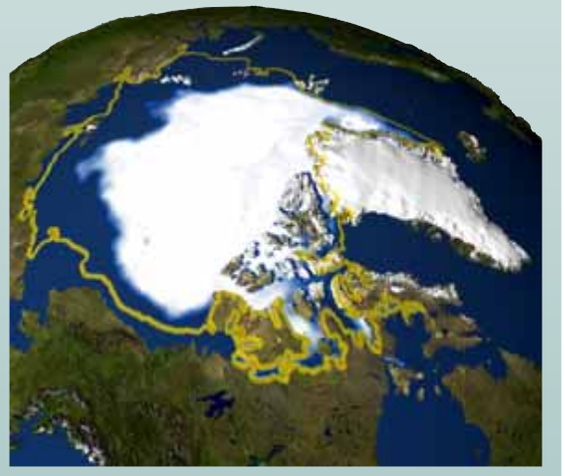
Trend in extent of September ice in the Arctic Ocean, 1978–2005



Source: NSIDC 2005

Sea ice extent minimum over the Arctic Ocean in September 1979.

Source: NASA Goddard Space Flight Center



Sea ice extent minimum over the Arctic Ocean in September 2005. The yellow line is the average of sea ice extent from 1979 to 2004.

In the Antarctic, by contrast, there has been only a slight decline in the extent of sea ice between 1973 and 2004. This may be due to oceanographic and sea ice dynamics which differ from those in the Arctic (Flato and Boer 2001). A recent study indicates that the Antarctic's response to climate change is only being delayed and that a marked reduction in the extent of sea ice is likely later this century (Goosse and Renssen 2005).

Future changes in the extent of Antarctic sea ice cover may adversely impact krill, the small crustaceans that form the base of the Antarctic marine food chain. The extent and duration of Antarctic sea ice influences both krill recruitment (the proportion that survives to maturity) and spawning (Siegel and Loeb 1995). Although adult krill can withstand long periods of starvation, juveniles cannot and sea ice production is vital to their survival because their primary food source is algae that live in the sea ice (Arrigo and Thomas 2004). A decline in krill will affect other species, including seabirds. Reduction in three seabird species and in penguin nests in some sub-Antarctic Islands have already been observed, and studies show a correlation among sea ice, availability of krill, and numbers of breeding pairs of birds (Woehler and others 2001).

Polar terrestrial and ocean ecosystems will be affected dramatically by the reduction in sea ice and significant global impacts are predicted. The projected changes will impact surface energy and moisture budgets in the Polar Regions and will affect atmospheric and oceanic circulation (ACIA 2005, Johannessen and others 2004).

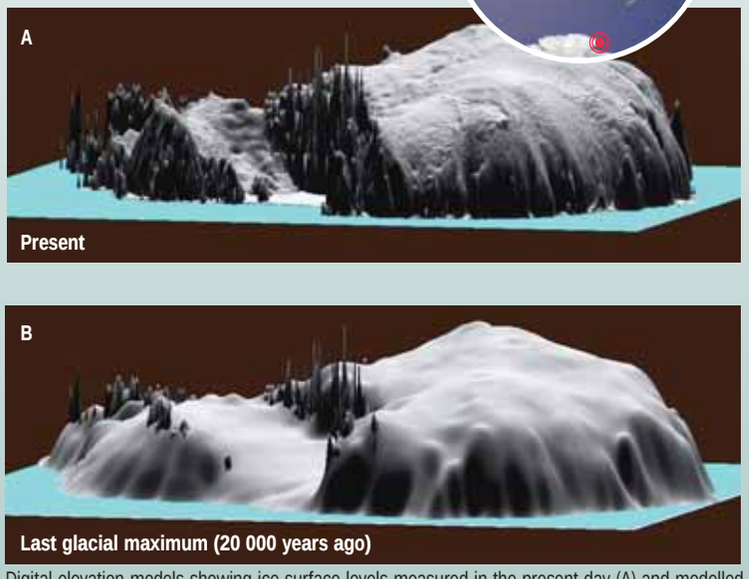
Attention also focused in 2005 on the large stores of freshwater ice in the Antarctic and Greenland ice sheets. Changes in the mass balances of these ice sheets would have global consequences, such as changes in sea level and salinity. Meltwaters from polar ice sheets – mainly the Greenland Ice Sheet – have been making a small contribution to sea level rise of 1–2 mm per year over the past century (Alley and others 2005). Concerns have also been raised about the recent acceleration of melting and breakdown along the margins of the West Antarctic Ice Sheet (Box 2), which are disintegrating at an unprecedented rate in some areas (Shepherd 2004).

Environmental changes also directly affect the lives of Arctic residents, especially indigenous peoples (ACIA 2005). According to local observations changes on the land and sea related to the warming Arctic climate are already affecting indigenous

Box 2: New evidence questions stability of the West Antarctic Ice Sheet

Antarctica is made up of two giant ice sheets: the West Antarctic Ice Sheet (WAIS) and the East Antarctic Ice Sheet (EAIS). Together, they account for 91 per cent of total global ice and 80 per cent of the world's freshwater. Changes in the mass balance of the Antarctic ice sheets could have huge influences on changes in sea level. At present, the EAIS is getting thicker while the WAIS is getting thinner, effectively balancing each other out. The Intergovernmental Panel on Climate Change's 2001 assessment concluded that the collapse of the WAIS was unlikely during the 21st century. Although there are many uncertainties, some experts now think that a full collapse of the WAIS is conceivable in this century. Such an event could raise global sea levels by 5–6 metres. Changes have been observed on the edges of the WAIS. In the past ten years, three ice shelves have collapsed along the Antarctic Peninsula, causing an unprecedented dumping of glacial ice into the ocean. Pine Island and Thwaites Glaciers around the Amundsen Sea are releasing more than 100 km² of ice each year.

Sources: Bindschadler 1998, Casassa 2003, IPCC 2001, Oppenheimer and Alley 2004, USGS 2005a



Digital elevation models showing ice surface levels measured in the present day (A) and modelled for the last glacial maximum (B). The West Antarctic Ice Sheet (on the left side of each image) has lost two-thirds of its mass since the last glacial maximum.

Note: Vertical scale is exaggerated by about 500 times. Dark needle shapes are mountain peaks.

Source: Bindschadler 1998

Krill, at the base of the Antarctic food chain, are adversely impacted by a reduction in Antarctic sea.

Source: I Everson/WWI/Still Pictures

Box 3: “We watch the weather and notice changes”

Reindeer herding in the Sakha Republic, Russian Federation.

Source: Tero Mustonen/Snowchange

Lakes are flooding the banks. Small rivers become larger. On grazing grounds I come across unknown plants. There are many dwarf willows growing on the tundra. We use them for bonfires. When I was a kid we had to search hard for the willows. Today, I don’t need to look hard at all. New fish species can be observed in the Kolyma River. Marine species are showing up. We used to migrate north slowly to reach the sea. Now we reach it very fast because of the mosquitoes that bother the reindeer. We observe new streams and very little ice on the sea. We are observing lots of single polar bears wandering along the shore that used to hibernate. Four cyclones in the fall and lots of snow. Very difficult to ensure enough food for the reindeer.

- Slava Kemlil, reindeer herder and leader of Nutendli, a Chukchi settlement along the Kolyma River in the Sakha Republic, Yakutia, Russian Federation, speaking at the Snowchange Conference in Anchorage, Alaska.

Source: Mustonen 2005

peoples – for example, travel conditions and the availability of water (Box 3).

INCREASING COMMERCIAL EXPLOITATION

As global energy demand increases, so does pressure to explore and develop the estimated 25 per cent of global undiscovered energy resources that may reside in the Arctic (USGS 2005b). The past year saw an increase in oil and gas related activities, and in planning and preparations for expanded development in several areas of the Arctic. These developments bring economic opportunities to parts of the Arctic, but also impacts and risks to the environment and to Arctic residents. Changes in sea ice are opening opportunities for development, transportation and settlement, and at the same time increasing political awareness of the need for measures to conserve coastal and marine ecosystems (Box 4).

In the Antarctic, the number of tourists landing on continental Antarctica continued its sharp rise. From 1992–1993 to 2004–2005 there was an increase of 308 per cent in the number of ship-borne tourists visiting Antarctica (UNGA 2005). This increase is accompanied by increased diversification of tourist activities, including high-risk adventure tourism. The increased numbers and diversification bring new management challenges.

Antarctic marine harvesting is dominated by two fisheries, krill and toothfish (often marketed as Chilean Sea Bass), managed under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). Notwithstanding efforts under CCAMLR, concerns about the sustainability of the fishery for toothfish have continued, in relation to both target fish stocks, seabirds and other species caught

Box 4: Some Arctic oil and gas issues

Barents Sea. The lifting of an embargo on offshore hydrocarbon exploration in the Norwegian Barents Sea in 2004 has renewed activity there. Regulation of exploration is an important political issue. Debate in 2005 focused on environmental protection and establishing areas free of oil development. In Russia five companies were selected as finalists in the joint development of the Shtokman gas field, in the Barents Sea. This field is estimated to hold twice the known gas reserves of Canada.

Mackenzie Delta and Pipeline. In Canada debate continues about developing hydrocarbon reserves in the Mackenzie Delta and constructing a 1 220-kilometre pipeline to link with existing pipelines supplying southern Canada and the US. Primary issues include ensuring local economic benefits (especially to indigenous peoples), and cumulative environmental effects.

Alaska Beaufort Sea Coast. Since the start of the Prudhoe Bay oil field development in 1969, facilities and infrastructure have expanded to about 260 000 hectares, producing a total of 15 billion barrels of oil and bringing economic development to the region. Studies show that caribou have shifted their calving grounds away from the oilfields. In December 2005, after intense lobbying and political wrangling, the latest in a series of measures to open the coastal plain of the Arctic National Wildlife Refuge to hydrocarbon exploration was withdrawn (see North America section).

Sources: Ahlenius and others 2005, Bellona Foundation 2005, Cameron and others 2005, Cizek and Montgomery 2005, Griffith and others 2002, Mackenzie Gas Project 2005, NRC 2003, Petroleum Economist 2005, USGS 2005b

Box 5: Ozone depletion continues

The Antarctic ozone hole in 2005 was one of the deepest and largest recorded. The ozone layer over the Arctic is not pierced by a hole as in the Antarctic, but in the winter of 2004–2005 it was the thinnest on record. Despite the success of the Montreal Protocol in markedly reducing ozone-depleting substances like chlorofluorocarbons, recovery of the ozone layer is expected to take another half century. Recent studies have shown that climate change is partly responsible for the slow recovery in the Arctic. Changes in the atmosphere linked to climate change have boosted the formation of clouds high within the Arctic ozone layer, providing conditions conducive to the chemical reactions that break down ozone. The Polar Regions, and the Antarctic in particular, are more susceptible to ozone depletion than other latitudes because of the cold atmospheric temperatures. Arctic ozone depletion has been observed since 1990 and a hole in the stratosphere over Antarctica has appeared annually for the past 30 years. Increased surface UV-B levels have been measured in both regions.

Sources: BAS 2005, Rozema and others 2005, University of Cambridge 2005

Box 6: Addressing environmental emergencies

The Protocol on Environmental Protection to the Antarctic Treaty 1991 (the Madrid Protocol) designates Antarctica as "a natural reserve, devoted to peace and science" (Article 2). In June 2005, at the Antarctic Treaty Consultative Meeting XXVIII in Stockholm, a 6th Annex to the Protocol was adopted addressing *Liability Arising from Environmental Emergencies*. This was the outcome of 13 years of negotiations on liability rules in the event of environmental emergencies in the region and was the first new legal instrument adopted under the Antarctic Treaty System since 1991. The Annex outlines guidelines regarding preventive measures, contingency plans, response actions, as well as liabilities for environmental emergencies. The Protocol's five other Annexes address environmental impact assessments, conservation of flora and fauna, waste disposal and management, prevention of marine pollution, and protected areas and management. The Protocol and its Annexes create rules and guidelines that work together to comprehensively protect the Antarctic environment and its associated ecosystems.

Source: ATS 2005

inadvertently. For the 2004–2005 season, 14 074 tonnes of toothfish were harvested in the authorised fishery within the CCAMLR Area – a further 8 511 tonnes were reportedly caught outside the boundaries (CCAMLR 2005a). An additional 3 023 tonnes of toothfish were estimated to have been caught through Illegal, Unregulated and Unreported (IUU) fishing within the Area (CCAMLR 2005b). There are some indications that IUU fishing within the CCAMLR Area may have decreased recently, although it is too early to determine whether this is a genuine or enduring change.

Krill fishing reached a peak of over 500 000 tonnes per year in the early 1980s, then declined in the 1990s due to processing problems and changes in markets and subsidies. The fishery has now started to increase rapidly (Clark and Hemmings 2001). Annual catches are increasing steeply. By September 2005, the 2004–2005 harvest was already 124 535 tonnes with several months of the period still to run, compared with 102 202 tonnes in 2003–2004 (CCAMLR 2005a). Notifications of intention to harvest krill in the 2005–2006 season total 245 000 tonnes.

CONCLUSIONS

The Polar Regions continue to send us signals on impacts from climate change and how the environment is responding to those changes. Issues concerning ice and snow are increasingly making the headlines as we realize the importance of ice to the planet and its ecosystems. Increased commercial pressures on the Polar Regions bring with them increased threats to ecosystems and, in the Arctic, increased challenges for the sustainability of local economies and ways of life.

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feature focus

Energy and Air Pollution

Source: Hartmut Schwarzbach/Still Pictures

● DEFINING THE ENERGY AND AIR POLLUTION CHALLENGE ● INDOOR AIR POLLUTION FROM SOLID FUELS ● URBAN OUTDOOR AIR POLLUTION ● LONG-RANGE TRANSPORT OF AIR POLLUTION ● DEALING WITH AIR POLLUTION ● CONCLUSIONS

Energy and Air Pollution

Changes in the way the world produces and uses energy have become important for a number of compelling reasons, including the negative impacts of indoor, outdoor and transboundary air pollution on human health and the environment.

The future of the world's energy supply made headlines once again in 2005, as conventional energy prices skyrocketed. In 2004, the increase in crude oil prices resulted from higher demand in developing economies and continuing growth in industrialized economies. This growth in demand stabilized in the second quarter of 2005 as consumers and industry reduced oil consumption in response to higher prices (IEA 2005a). However, hurricanes in the Gulf of Mexico disrupted US supply lines and crude oil prices soared to a record high of US$70 a barrel in August 2005.

These events highlighted – once again – the risks of the world's dependency on fossil fuels, which currently meet around 80 per cent of global energy needs (Figure 1) (IEA 2005b).

According to the International Energy Agency (IEA), if existing energy policies continue, the world's energy needs will be almost 60 per cent higher in 2030 than in 2004. Arguably, this increase in demand could be met from present known fossil fuel reserves (IEA 2004a). From a supply point of view, oil, gas and especially coal could therefore continue to dominate the global energy mix for the foreseeable future, unless we reconsider the environmental implications of this fossil fuel dependency.

Alternatively, we could see major changes in global energy patterns driven by concerns about energy security, access, and the negative externalities of current patterns of energy use – particularly climate change and the health impacts associated with air pollution.

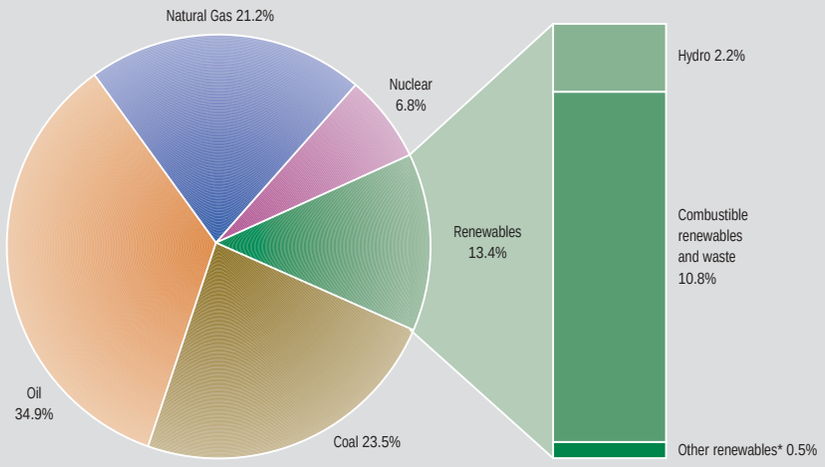
There is already some action in this direction. The Johannesburg Plan of Implementation, agreed at the World Summit on Sustainable Development in 2002, includes commitments to diversify energy supply and to increase substantially the global share of renewable energy sources; to improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources; and to establish domestic programmes for energy efficiency, among other things. The International Action Programme agreed at the International Conference for Renewable Energies in Bonn, in 2004, lists over 200 commitments and actions to promote more sustainable forms of energy by governments and others (Renewables 2004). Policies for renewable energy exist in at least 45 countries worldwide, and at least 43 countries had a national target for renewable energy supply by mid-2005 (REN21 2005).

Additional action is still needed to stem the growth in energy consumption and to develop efficient technologies and energy

Skyrocketing oil prices caused some people to rethink their car dependency.

Source: Matt York/Associated Press

Figure 1: World total primary energy supply by fuel source, 2002



**Other Renewables: Geothermal, Wind, Solar, Tide. Totals in graphs might not add up due to rounding.*

Source: IEA 2004b

sources that are less polluting than fossil fuels. The IEA estimates that energy investments from 2003 to 2030 will total around US$16 trillion, or US$568 billion per year (IEA 2002a). If today's policies continue to over-emphasize fossil fuel investments, the world could be further 'locked' into unsustainable energy patterns, as energy investments have a lifetime of 30–50 years.

DEFINING THE ENERGY AND AIR POLLUTION CHALLENGE

Whereas energy consumption in developed countries has continued to grow and currently accounts for 70 per cent of the world energy demand, two-thirds of future growth is expected to take place in developing countries (IEA 2002a). Much of this growth will be to satisfy basic energy needs. Roughly 54 per cent of the population in developing countries still lack access to modern, high quality energy sources and fuels, relying on traditional fuels such as wood, dung and agricultural residues for cooking and heating (UN Statistics Division 2005). At least 1 600 million people lack access to electricity in their homes (Smith and others 2004).

If the anticipated growth in energy demand is met with our current energy mix, the risks range from adverse effects on ecosystem and human health, through severe economic hardship as prices continue to increase, to implications for national and human security.

The challenge today is therefore to increase energy efficiency, and meet the rising demand by urgently promoting forms of energy that reduce or eliminate harmful emissions, without compromising energy needs – particularly those of the poor.

Improved access to energy services is among the necessary ingredients of economic growth, including the eradication of extreme poverty and hunger as called for in the Millennium Development Goals (Table 1). Modern energy services can help meet the basic human needs of nutrition, warmth, and lighting as well as reduce the burden of time-consuming domestic labour – all of which also contribute to improvements in areas such as education and public health.

Source: Rustam Vania

Energy services also contribute to industrial growth, enhanced productivity and access to global markets and trade. Access to modern fuels and electricity are particularly important to promote gender equality as women and young girls disproportionately shoulder the

Table 1: Energy and the Millennium Development Goals

MDG	Energy Linkages
1 Eradicate extreme poverty and hunger	Energy inputs such as electricity and fuels are essential to generate jobs, industrial activities, transportation, commerce, micro-enterprises and agriculture outputs. Most staple foods must be processed, conserved and cooked, requiring heat from various fuels.
2 Achieve universal primary education	Electricity is needed for homes and schools. After dusk study requires illumination. Many children, especially girls, do not attend primary schools because they must carry wood and water to meet family subsistence needs.
3 Promote gender equality and empower women	Lack of access to modern fuels and electricity contributes to gender inequality. Women are responsible for most household cooking and water boiling activities. This takes time away from other productive activities as well as from educational and social participation. Access to modern fuels eases women's domestic burden and allows them to pursue educational, economic and other opportunities.
4 Reduce child mortality	Diseases caused by unboiled water, and respiratory illness caused by the effects of indoor air pollution from traditional fuels and stoves, directly contribute to infant and child disease and mortality.
5 Improve maternal health	Women are disproportionately affected by indoor air pollution. Lack of electricity in health clinics, illumination for night time births, and the daily drudgery and physical burden of fuel collection and transport all contribute to poor maternal health conditions, especially in rural areas.
6 Combat HIV/AIDS, malaria and other diseases	Electricity for communications such as radio and television can spread important public health information to combat deadly diseases. Health care facilities, doctors and nurses, all require the services that electricity provides (such as illumination, refrigeration and sterilization) to deliver effective health services.
7 Ensure environmental sustainability	Energy production, distribution and consumption have many adverse effects on the local, regional and global environment. These include indoor, local and regional air pollution, land degradation, acidification of land and water, and climate change. Cleaner, more efficient energy systems are needed to address all of these effects and to contribute to environmental sustainability.
8 Develop a global partnership for development	The 2002 World Summit for Sustainable Development called for partnerships between public entities, development agencies, civil society and the private sector to support sustainable development, including the delivery of affordable, reliable and environmentally sustainable energy services.

Source: UNDP 2004a

Source: Rustam Vania

burden of lack of modern energy services for household use (UNDP 2005).

Many of the impacts of air pollution are global (Box 1). Pollution can travel great distances and cause damage to human health and flora and fauna; acid rain; eutrophication of fresh water; and global and regional climate change. In some cases, the people who are worst affected by the negative impacts of energy-related emissions are the poorest, who have contributed the least towards them.

To steer the world to safer patterns of production and use, decisive national and global policies are needed. These must be aimed at expanding access to energy services for the poor (including the use of cleaner fossil fuel and biomass technologies); controlling the growth in per capita energy demand through improved efficiency; and encouraging the use and further development of more sustainable energy technologies.

The energy and air pollution link

Emissions from fossil fuel and biomass burning account for most energy-related air pollution in most parts of the world. Energy-related emissions are released through the entire spectrum of energy activities, from upstream emissions during fossil fuel extraction and production to end-use emissions from fossil fuels burned for transport, heating, cooking and the like.

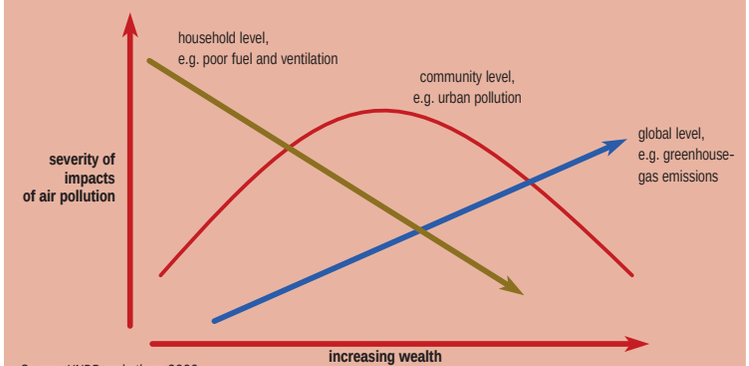
A wide range of gaseous and particulate compounds have adverse impacts and can be considered air pollutants – including particulate matter (PM), tropospheric (surface) ozone (O_3), nitrogen dioxide (NO_2) and nitric oxide (NO) (together known as nitrogen oxides or NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), harmful levels of carbon dioxide (CO_2), organic compounds and metals. Particulates are further defined by their diameter – smaller particulates of diameters less than ten micrometres (µm) (called PM_{10}) and 2.5 µm ($PM_{2.5}$) can

Box 1: The shifting burden of air pollution

Efforts to deal with local air pollution often simply transfer the pollution elsewhere. For instance, higher smoke stacks to deal with stationary sources can mitigate the local problem to some extent, but transform it into a larger regional problem, depending on the lifetime of an air pollutant in the atmosphere. Experience has shown that displacement solutions like these are not sustainable in the long run.

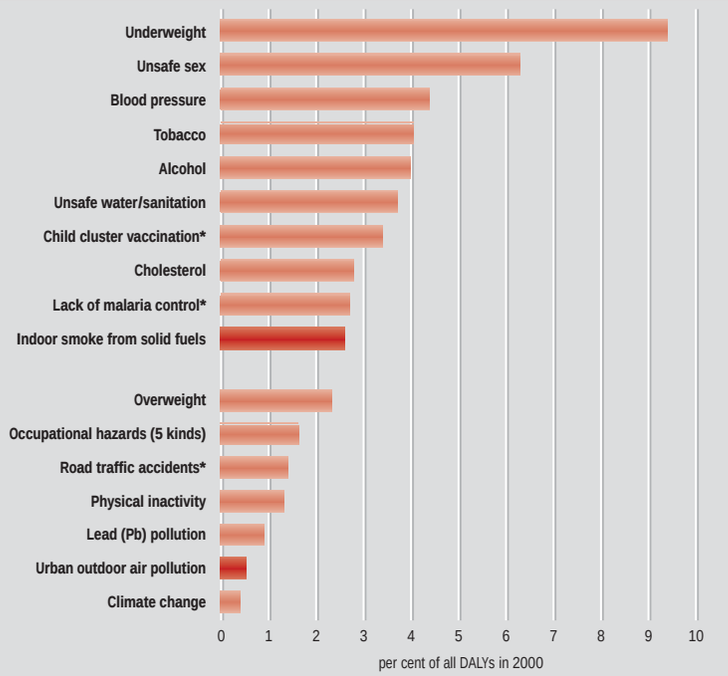
For the world's poorest populations, the most detrimental impacts of air pollution stem from indoor sources – mainly the burning of simple solid fuels such as dung, crop residues or wood. For more developed economies, outdoor pollution in urban areas is the major problem. At the highest level of development, local and national effects may be greatly reduced, but serious impacts still persist from emissions to wider regions or the globe, through climate change for example. This historical process, called the 'environmental risk transition', is shown in a generalized form in the Figure, and is well supported by global data on environmental health risks (Smith and Ezzati 2005).

The environmental risk transition



Source: UNDP and others 2000

Figure 2: Global burden of disease from top ten risk factors plus selected other risk factors



**DALYs - Disability-Adjusted Life Years. One DALY is equal to the loss of one year of healthy life.*

*Source: Those marked * are based on outcomes in the Global Burden of Disease database of the World Health Organization (Smith and Ezzati 2005). The remaining estimates are from the Comparative Risk Assessment managed by WHO (WHO 2002b).*

penetrate deeper into the human lung and do more health damage.

These compounds have a range of harmful local, regional and global impacts. Climate change, often described as one of the biggest global challenges facing humankind today, has received considerable global attention from policy makers, scientists and the media. Whilst not the focus of this section, which deals with energy-related indoor, outdoor and transboundary air pollution, the fundamental energy sector transformation needed to reduce carbon dioxide and other greenhouse emissions overlaps in many ways with the measures needed to address air pollution problems.

Globally, indoor air pollution levels from solid fuel use are higher than outdoor air pollution. For example, typical levels of PM_{10} in homes using biomass energy range from 300 to 3 000 micrograms per cubic metre (µg/m3) (WHO 2002a), whereas even the most polluted cities rarely exceed 150 µg/m3 (Box 2). For comparison, the US Environmental Protection Agency's (US EPA) annual air pollution guideline for PM_{10} is 50 µg/m3, and the EU guideline is 40 µg/m3.

The WHO, in a large-scale risk assessment that combined the results of many studies, compared the global burden of illness and premature death from major risk factors, including outdoor air pollution, tobacco smoking, unsafe water and sanitation and others. The results indicated that indoor air pollution from solid fuel use is the tenth major health risk in the world in terms of potentially preventable lost life-years (Figure 2), and may be responsible for 0.8–2.4 million premature deaths each year worldwide (Smith and others 2004). In developing countries, indoor smoke from solid fuels is estimated to be the fourth leading high mortality health risk (WHO 2002b). Urban air pollution, meanwhile, is

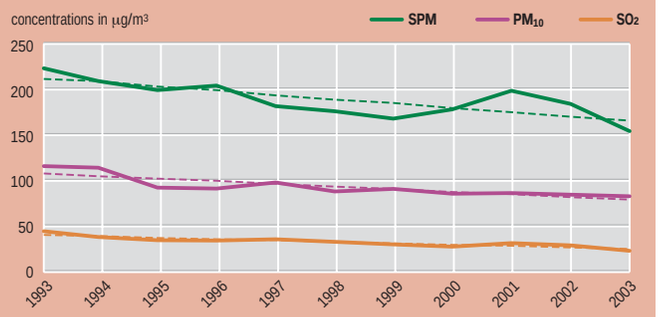
Box 2: Urban air pollution in Asia

Asia has 58 per cent of the global population and half of the world's cities with a population of ten million people or more (the so-called mega-cities). Over the last four decades, the total urban population in Asia has increased almost four-fold, from 340 million in 1960 to 1 329 million in 2002 (UN-Habitat 2004, UNPD 2005). Growing energy consumption in industry, transport and the domestic sector have presented a challenge for air quality management.

Although most Asian cities have been able to reduce levels of SO_2 to safe levels (Figure 1), NO_2 levels are gradually increasing. Suspended Particulate Matter (SPM) and PM_{10} levels have been reduced in almost all Asian cities, but in most cities they continue to exceed the EU and the US Environmental Protection Agency's ambient air quality guidelines of 40 µg/m3 and 50 µg/m3 respectively (Kong Ha 2005) (Figure 2).

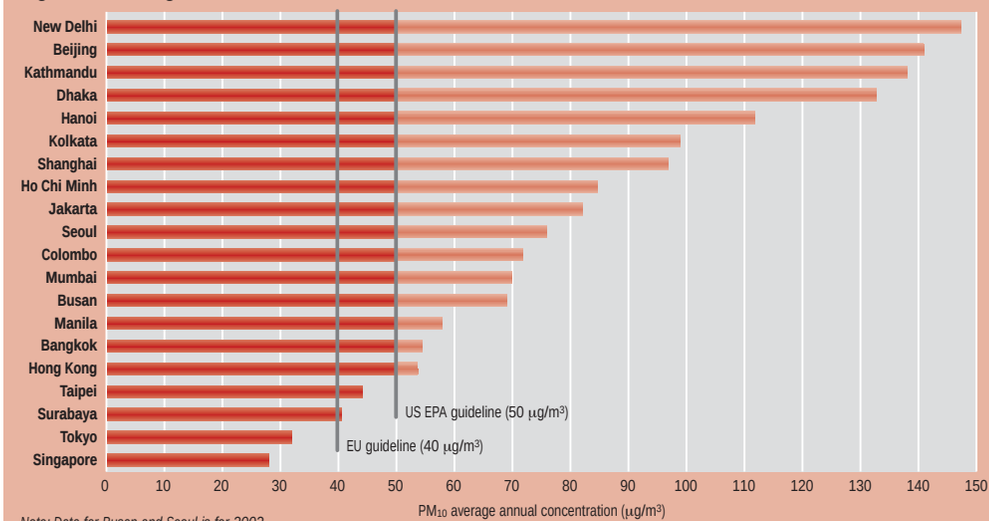
SO_2 and NO_x emissions are of particular concern in China, where rapid industrial development and growing energy demands have increased air pollution. The main reasons for these high levels of urban air pollution are the widespread use of coal for power generation and home heating, and the increase in the number of automobiles (Figure 3).

Figure 1: Trends of aggregated annual averages of SPM, PM_{10} and SO_2 for Asian cities (1993–2003)



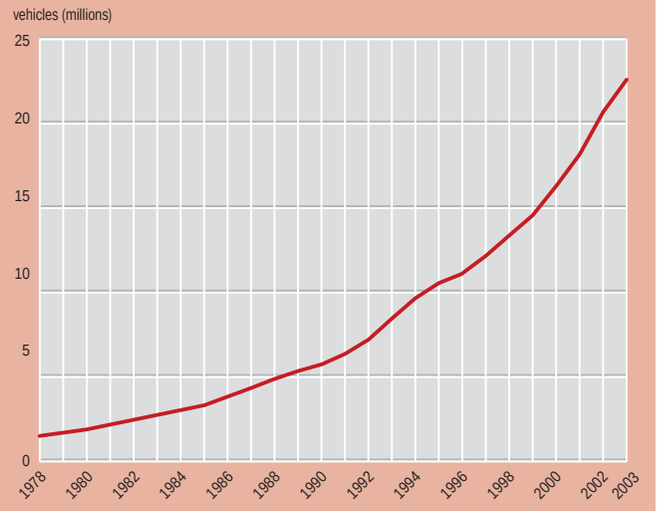
Source: CAI-Asia and APMA 2004

Figure 2: Average annual PM_{10} concentrations in selected Asian cities in 2003



Note: Data for Busan and Seoul is for 2002
Source: CAI-Asia and APMA 2004

Figure 3: Growth in number of vehicles in China



Source: Liu and Diamond 2005

estimated to be responsible for approximately 800 000 premature deaths every year (Cohen and others 2004).

Despite these high figures, the negative impacts of these air pollutants have received little attention in many parts of the world for a variety of reasons, including insufficient information on the status of the damaging pollutants and their impacts, the costs to the economy of corrective action, and the fact that the affected populations are primarily the poor. Several dangerous pollutants such as ozone, benzene and small particulates are not monitored regularly in many countries. For instance, PM_{10} and ozone levels are measured regularly only in a few cities in the developing world (Molina and others 2004, Cohen and others 2004). Although a wide variety of technologies are available for monitoring air pollutants, economic and skill-related problems limit their use in many regions.

INDOOR AIR POLLUTION FROM SOLID FUELS

Traditional biomass fuels such as wood, charcoal, crop residues and animal dung remain the most common sources of household energy in most of the developing world. They account for about a third of all energy consumption in developing countries as a whole, and nearly 90 per cent in some of the least developed countries (Kartha and Larson 2000). Coal is still used in many households, particularly in China.

Traditionally, these solid fuels have been burned with poor combustion efficiency under poorly ventilated conditions, such as the three-stone fire inside a hut. This has resulted in a host of problems, including damage to human health from indoor air pollution (Figure 3), pressure on natural ecosystems from fuel gathering, and excessive time spent on fuel collection by the poor at the expense of time for income generation, education, childcare and so on.

In many developing countries, gender-ascribed roles entrenched within the social and cultural fabric mean that women and girls are often responsible for fuel collection and cooking. Women may spend as much as three to seven hours per day by the cooking fire, exposed to smoke, often with young children nearby (ESMAP 2004). The potential health impacts of health-damaging pollutants from burning solid fuels are compounded by the constant proximity of the users to the source.

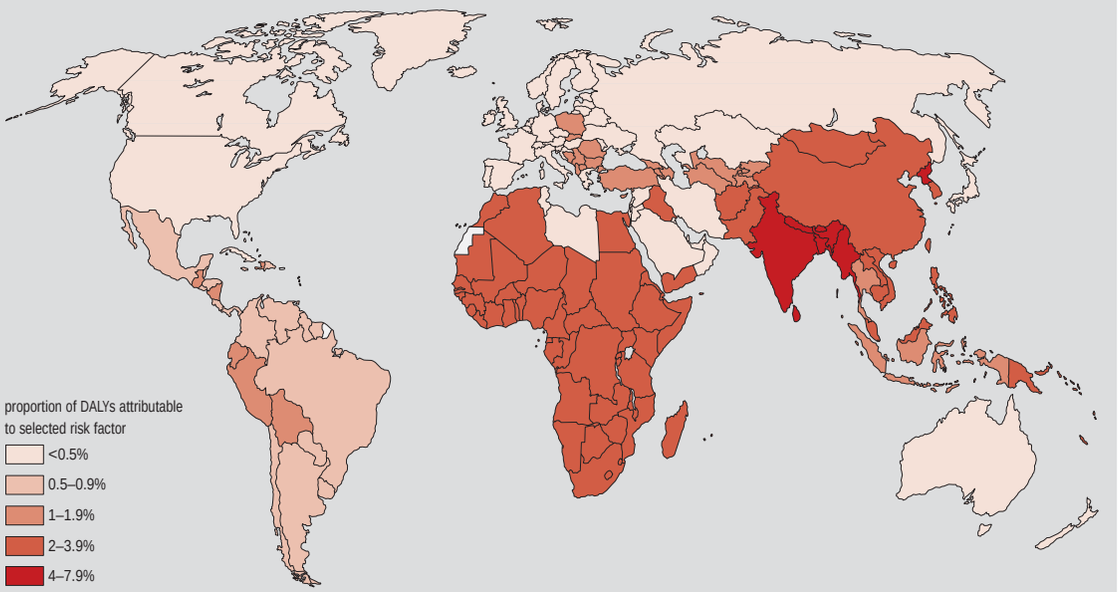
It is possible to burn biomass (wood and agricultural residues) quite cleanly, producing mostly carbon dioxide and water, but such conditions are difficult to achieve with small-scale inexpensive stoves. Studies in India and China, for example, show that the percentage of fuel carbon fully burned to carbon dioxide is typically only 90 per cent, with some fuel/stove combinations only achieving 80 per cent. The remaining 10 to 20 per cent is diverted into products of incomplete combustion — primarily carbon monoxide, but including benzene, 1,3-butadiene, formaldehyde, polyaromatic hydrocarbons, and many other compounds posing health hazards (Smith and others 2000). Household coal use can present additional hazards because of the intrinsic toxic contaminants in some coals, including sulphur, arsenic, fluorine, mercury, and selenium. Combined with the low energy efficiency of burning devices, the result is large emissions per unit of useful energy delivered.

The best indicator of the health hazard of combustion smoke is thought to be small particles, which contain many chemicals. Since the mid-1980s, many epidemiological studies have examined a range of health effects from indoor air pollution due to solid fuel use. Various health effects have been found, including:

- acute lower respiratory infections in young children, the primary cause of childhood mortality worldwide and the disease responsible for the most lost life years in the world. Indoor air pollution seems to play an important role, although the main risk factor is malnutrition;
- chronic obstructive pulmonary disease, such as chronic bronchitis and emphysema, particularly in adult women who have cooked over unvented solid fuel stoves for many years; and
- lung cancer, mainly from coal smoke.

It seems that young children are twice as likely to contract acute lower respiratory infections and women are three times more

Figure 3: Burden of disease attributable to indoor air pollution



Note: DALYs – Disability-Adjusted Life Years. One DALY is equal to the loss of one year of healthy life.
Source: WHO 2002b

The use of energy efficient biogas stoves like this one could improve indoor air quality emissions.

Source: Andy Eames/Associated Press

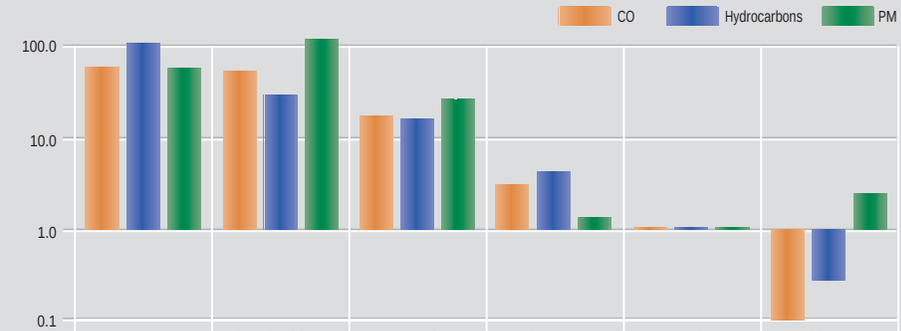
likely to suffer from chronic bronchitis if exposed to indoor air pollution from solid fuels (Smith and others 2004). Effects probably occur in men and school-age children as well (although both these groups typically spend less time inside the home) but few studies have been conducted. There is also growing evidence of other health effects from indoor air pollution – including tuberculosis, cataracts, several other cancers, low birth-weight, stillbirth, and heart disease.

Amongst the most convincing health studies are those that document an improvement in health associated with a reduction in pollution levels. Two studies conducted in south China showed a significant reduction in lung cancer and chronic obstructive pulmonary disease due to the introduction of improved coal stoves in the late 1970s (Lan and others 2002, Chapman and others 2005).

As development progresses, households tend to move to cleaner fuels (**Figure 4**). This process of moving up the so-called energy ladder is a slow one and households often shift only selected cooking tasks to cleaner but more expensive fuels at first. The recent increase in crude oil prices and the reduction of fuel subsidies for the poor in countries such as Indonesia and India could force households back down the energy ladder, to more use of biomass fuels.

It is perhaps surprising that biomass stoves contribute to global warming even when the biomass is harvested as a renewable resource and carbon dioxide emissions from the combustion process are offset by the absorption of carbon dioxide during re-growth. One reason is that biomass, particularly wood, is not always harvested renewably, from sources that re-grow. Another is that some products of incomplete combustion – particularly methane and black carbon particles – are even more powerful greenhouse pollutants than carbon dioxide, and therefore have higher global warming potential. Thus, although biomass fuel used on traditional stoves can sometimes be *carbon* neutral, the process is not *greenhouse gas* (GHG) neutral unless the biomass fuel is burnt efficiently and completely.

Figure 4: The energy ladder: relative pollutant emissions per meal with LPG* set to 1.0



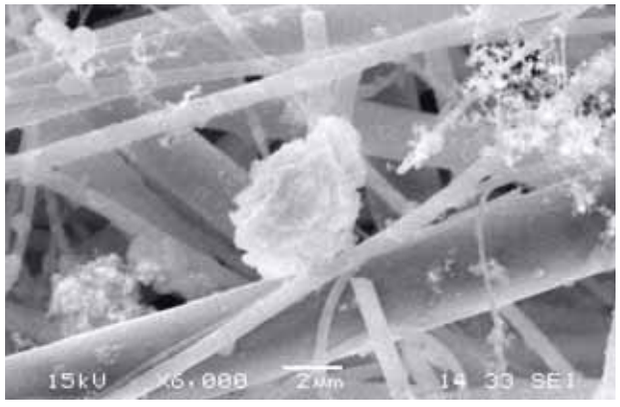
	Dung	Crop Residues	Wood	Kerosene	LPG	Biogas
Carbon monoxide (CO)	64	60	19	3.1	1.0	0.1
Hydrocarbons	115	32	17	4.2	1.0	0.3
Particulate Matter (PM)	63	124	26	1.3	1.0	2.5

**LPG – Liquefied Petroleum Gas*

Source: Smith and others 2005

Scanning electron micrograph of ultrafine suspended particle ($PM_{2.5}$).

Source: J. Sepulveda/INE-SEMARNAT



Urban air pollution has serious implications for human health and environmental quality.

Source: Binsyo Yoshida/UNEP/Still Pictures

Depending on assumptions and global warming potentials of the different pollutants involved, improving biomass stoves can achieve a double benefit in the form of lower GHG emissions and reduced ill-health. Even shifting to clean-burning fossil fuels could be considered a GHG-reduction measure in places where wood is not harvested renewably, because it reduces emissions of methane and black carbon, as well as of CO_2 (Smith and others 2000).

This is not to say that the growing risk of global climate change is due to the stoves of the poor. To blunt global warming, it is the world's use of fossil fuels that needs to be addressed. However, investments in better energy technologies for the poor offer the possibility of substantial and important benefits aside from GHG reductions, including reduced health risks, saving of women's time, reduced resource consumption, and other local benefits.

URBAN OUTDOOR AIR POLLUTION

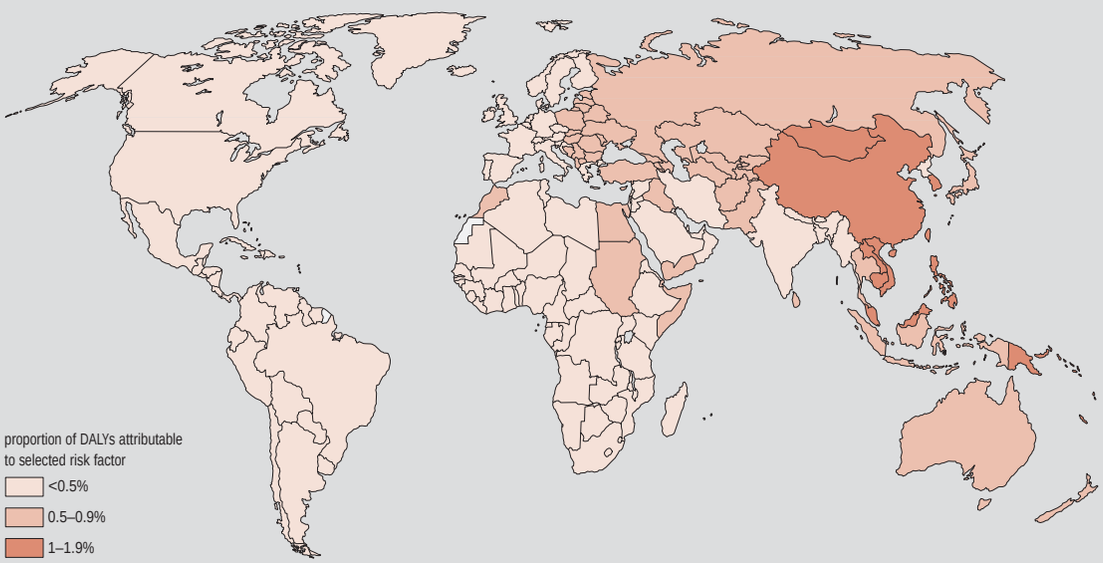
Almost half of the world's population presently lives in urban areas (UNPD 2004). Energy is needed in cities for lighting, transportation, industrial processes, and various household uses (such as cooking, heating, cooling and ventilation). Along with urbanization comes an increase in the concentration of economic activities and, since these activities rely heavily on the combustion of fossil fuels, associated increase in outdoor air pollution and its negative impacts (Figure 5). In many regions of the world, outdoor air pollution problems are aggravated by rapid economic development and industrialization, and a lag in adopting pollution control strategies.

Of the 800 000 premature deaths attributed to urban air pollution every year, about 65 per cent occur in the developing countries of Asia (Cohen and others 2004) (Box 2). Air pollution from transport and industry contributes to an increased risk of death from cardiopulmonary causes; increased risk of respiratory symptoms; an increased incidence of lung cancer in people with long-term exposure; and adverse outcomes in pregnancy, such as premature birth and low birth weight (Krzyzanowski and others 2005). As with indoor air pollution, the type of pollutant, intensity of exposure and the age and health of the individual exposed determine the severity of the impacts.

A growing body of evidence indicates that small particulates are associated with an increased mortality risk. Accordingly, attention has focused on exhaust from diesel engines, which contains finer particulates than gasoline. Moreover, these particulates contain polyaromatic hydrocarbons (PAHs), which are potent carcinogens and mutagens. Although the impact increases with the exposure level, WHO guidelines have been revised to reflect that there is no safe level of particulates – they have negative health impacts on humans no matter how low the concentration in the atmosphere (WHO 2000).

Trends towards higher levels of urban air pollution around the world have been addressed in the more developed economies by more efficient technology and pollution control policies. The level of development also influences the sources of pollution, the ambient levels and the 'pollution mix' in a particular urban area. For example, in higher-

Figure 5: Burden of disease attributable to urban air pollution



Note: DALYs – Disability-Adjusted Life Years. One DALY is equal to the loss of one year of healthy life.
Source: WHO 2002b

income cities, air pollution is dominated by finer particles and photochemical smog – mainly from the transport sector. In lower income cities particulate matter, sulphur dioxide from coal and other fossil fuel burning, and suspended dust from disturbed land, unpaved roads and construction are more common (Molina and others 2004).

The level of development also determines the transport mix in a city. Poorer countries have fewer cars, but more two- and three-wheeled vehicles with dirtier two-stroke engines, and older fleets of vehicles with inefficient or badly maintained engines, and no or poorly functioning emission control devices. In richer countries, vehicle technologies are more efficient and less polluting, but the number of vehicles is higher.

Urban planning – or lack thereof – can determine how well a city manages rising energy demands from transport and industry. Some cities are more services-oriented, while others may have a concentration of industries nearby, contributing to air pollution. Historic and social-cultural reasons often explain the differences – and often also determine factors such as the early creation of an underground transport system, or bicycle lanes to encourage more sustainable forms of transport. Investments in reliable public transport can help rein in urban pollution levels.

Geographical and demographic factors have an important role to play. For instance, the location of a city is an important factor (enclosed basin versus open plain; sea level versus high altitude where the lower level of oxygen affects combustion; latitude with corresponding differences in radiation levels for photochemical pollution). The size and shape of a city; meteorological and climate conditions (for instance, temperature, wind speed and the existence of thermal inversions); number of inhabitants per square kilometre (hence emission density); and the seasonal distribution of the emissions are also important. For instance, in China, cities often suffer from lack of sufficient wind for the quick dispersion of air pollution. Mexico City, Athens, Los Angeles and Kathmandu are disadvantaged because of local topographical conditions.

Mexico City's geographical situation causes air pollution to be trapped over the city.

Source: Julio Etchart/Still Pictures

Regulatory policies have a key role to play in controlling energy demand and in reducing emissions. Setting and enforcing emission standards for all sources and fuel quality standards are essential to control emissions, and they also influence the choice of technology. For instance, better quality fuel is crucial for the success of after-treatment devices for vehicles, such as catalytic converters or particle traps.

Improved public transportation can help to address urban air pollution.

Source: Jochen Tack/Still Pictures

Economic policies, particularly those relating to energy, can have a significant impact on the level of outdoor air pollution. Subsidizing the price of diesel fuel relative to gasoline stimulates the use of more diesel vehicles, resulting in a rise in particulate levels. The relative price of cleaner options like natural gas influence choices made by industries (**Box 3**). Economic policies that force users to internalize the costs of air pollution can often provide important incentives for good practice.

In the case of industrial pollution, end-of-pipe technologies like scrubbers and filters have helped reduce emissions of certain pollutants. However, the only long-term solution is to attack the problem at its root by improving energy and materials efficiency and cycles and switching to sustainable energy sources.

LONG-RANGE TRANSPORT OF AIR POLLUTION

Long-range air pollution, sometimes referred to as transboundary air pollution, was recognized in the 1960s when scientists demonstrated the relationship between sulphur emissions in Europe and the acidification of Scandinavian lakes (UNECE 2005). Many studies have since confirmed that nitrogen, particulates, acidifying gases, heavy metals, and organic pollutants travel in the atmosphere for thousands of kilometres within and across national borders, interacting with each other and forming secondary pollutants before being deposited.

One of the defining early activities of European environmental regulation, under the

Box 3: Conversion to natural gas in Santiago de Chile

A shift to natural gas in Santiago, Chile, resulted in a drastic decrease in particulate (PM_{10}) and SO_2 emissions from industrial sources that had previously relied on fuel oil and wood. PM_{10} concentrations fell from an annual average of 42 µg/m^3 in 1997, the year the change took place, to 34 µg/m^3 in 2002 (CONAMA 2004).

However, this gain may be reversed by uncertainty in the supply of natural gas. The shift to natural gas was facilitated by the building of a pipeline in 1997 to bring natural gas from Argentina, and by convenient pricing and stronger emission regulations in Chile. Similar polices to keep prices of natural gas low in Argentina, however, increased domestic demand. Since production levels remained constant, supplies to Chile were restricted in 2004. Industries moved back to burning fuel oil during the periods of interrupted gas supply.

With the future of natural gas availability uncertain, some large industries in Chile are considering switching to clean coal technologies. Although these technologies are capable of complying with environmental regulations, emission levels will be higher than with natural gas.

Box 4: Preventing acid rain in Europe – a success story

The first evidence of extensive ecological damage from long-range acid deposition came from the acidification of Scandinavian lakes and rivers in the 1960s and 1970s, which eliminated fish stocks in thousands of lakes, and from the impact of acid rain on forests in central Europe. This resulted in the UNECE Convention on Long-Range Transboundary Air Pollution.

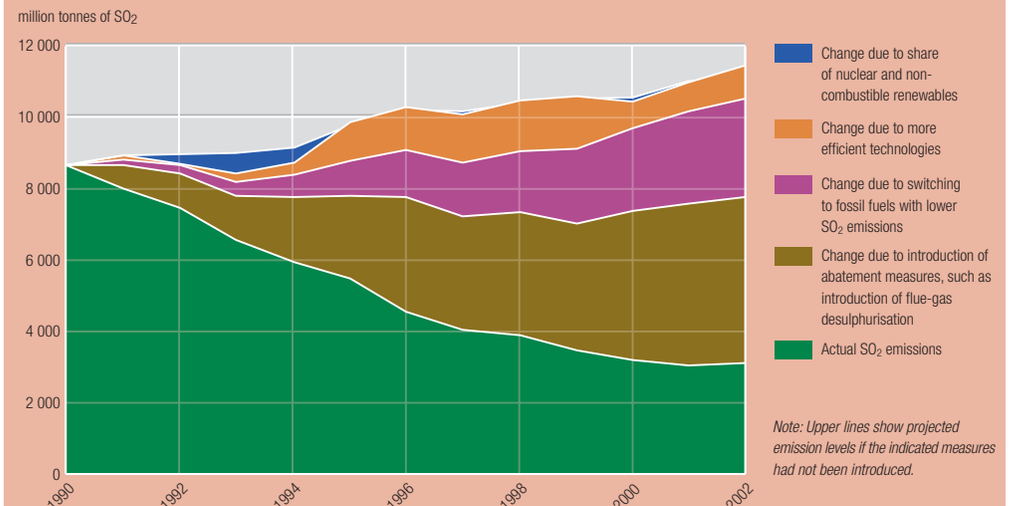
Under the Convention, a Protocol was adopted in the mid-1980s on reducing sulphur emissions in Europe by at least 30 per cent. Several other Protocols have been adopted since, targeting further sulphur reductions, nitrogen oxides and ozone. The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone took an integrated approach to manage all three environmental problems. Protocols on heavy metals and persistent organic pollutants (POPs) have followed.

As a result, many large fossil-fuel burning power stations in Europe, the major sources of sulphur dioxide, have introduced flue-gas desulphurization equipment to remove the gas from stack emissions. Others have converted to burning coal or oil with lower sulphur content, or to natural gas (**Figure**). Sulphur dioxide emissions across Europe have fallen by two-thirds since 1980. Based on current projections, they will halve again by 2012, by which time they will be lower than at any time since 1900.

The success rate has been lower with nitrogen oxides, emitted mainly by road transport. However, emissions of NO_x are down by more than a quarter compared to 1990 levels as a result of the introduction of catalytic converters in cars. Overall, emissions of acidifying gases have decreased across Europe by more than a third, and by greater than a half in industry and power generation (EEA 2005a).

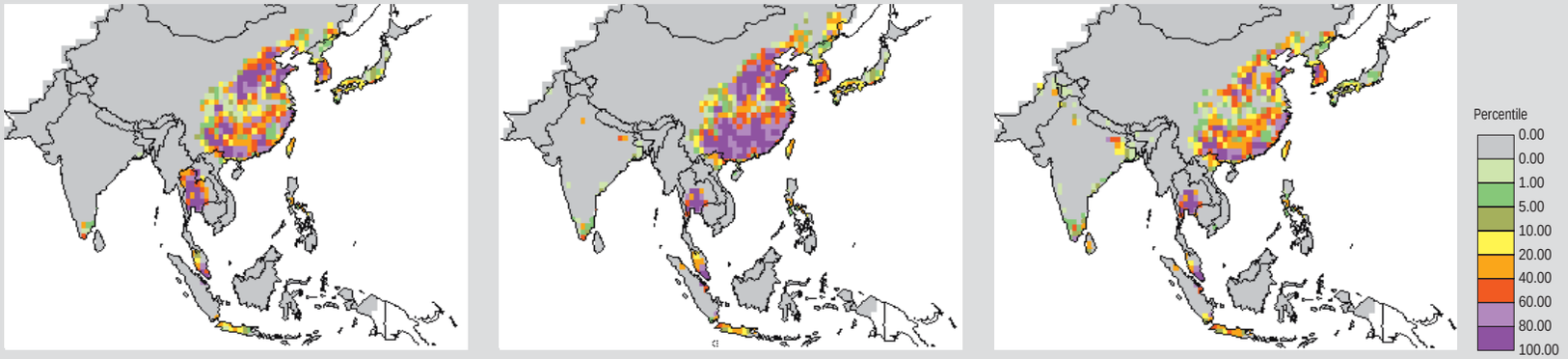
Despite these stringent requirements, roughly ten per cent of European ecosystems still receive acid deposition above their critical loads. Even if reductions are achieved to lower than sustainable levels, these ecosystems could take decades or centuries to recover (EEA 2005a), with some impacts being irreversible.

How sulphur dioxide emissions were reduced in the EU



Source: EEA 2005a

Figure 6: Acidification risks in Asia



Levels of acidification (percentile) over the sustainable level in Asia in 1995 (left), in 2030 under business-as-usual assumptions (centre) and with additional climate change policies (right).

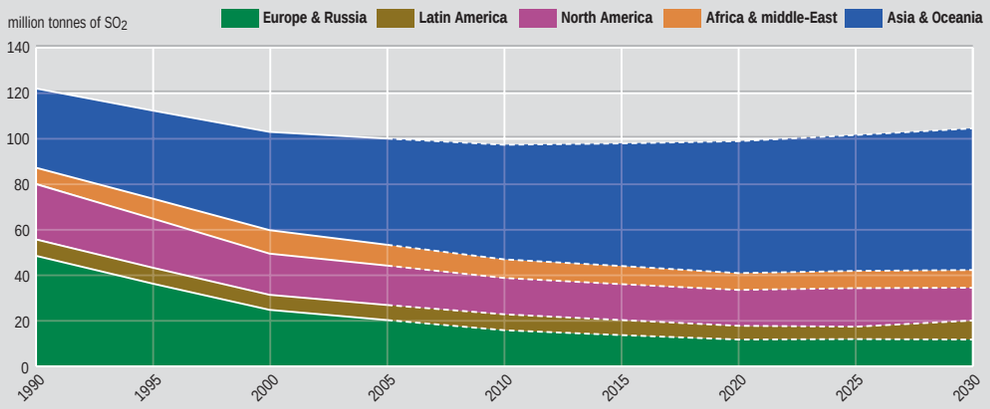
Source: RIVM 2005

United Nations Economic Commission for Europe (UNECE), was action on the sulphur emissions that contribute to acid rain (Box 4). Since then, there have been other national and regional efforts to address long-range pollution – for instance, the Association of Southeast Asian Nation's Agreement on Transboundary Haze Pollution, signed in 2002, the Malé Declaration on Control and Prevention of Air Pollution in South Asia, and the US EPA's Clean Air Interstate Rule issued in early 2005.

Studies indicate that sulphur-related acidification also affects parts of Asia (Figure 6). Sulphur dioxide emissions in the region are projected to increase substantially (Figure 7). Data availability to monitor the trends is improving, as the Acid Deposition Monitoring Network East Asia (EANET), formed in 1998 by 12 countries, has a monitoring programme in place since 2003.

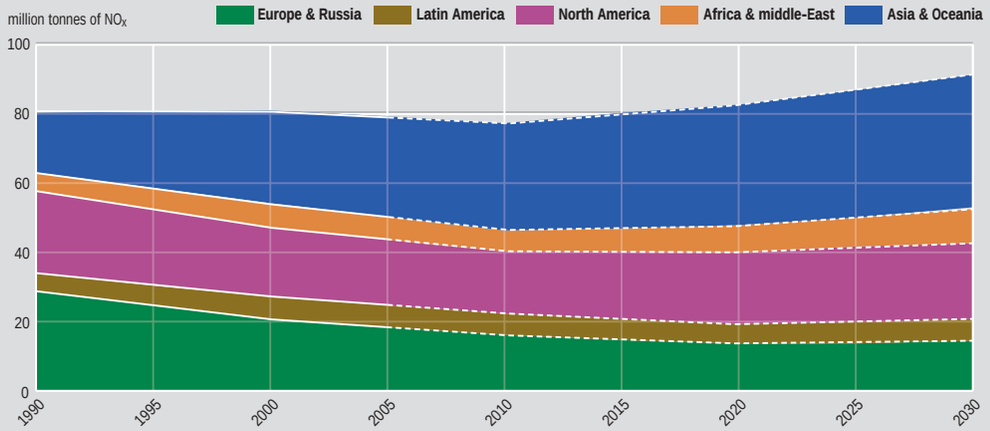
As anthropogenic emissions of nitrogen increased (Figure 8), it also emerged that the deposition of nitrogen compounds, including ammonia, causes problems such as eutrophication of freshwaters and marine and terrestrial ecosystems (see *GEO Year Book 2003*). Eutrophication is the consequence of excess input of nutrients into ecosystems. Common outcomes are excessive algal growth (or algal blooms) in surface waters, oxygen depletion, enhanced growth and dominance of some species that grow better with higher nitrogen conditions and reduced growth of others, resulting in

Figure 7: Global emissions of sulphur dioxide and projections



Source: Cofala and others 2005

Figure 8: Global emissions of nitrogen oxides and projections



Source: Cofala and others 2005

Box 5: The Atmospheric Brown Cloud

Since 1995 an international group of over 250 scientists has been collecting data over the Indian Ocean as part of the Indian Ocean Experiment (INDOEX). In spring 1999, scientists discovered a brownish pollution haze layer caused by aerosol (particulate) air pollution, or Atmospheric Brown Cloud (ABC) over the Indian Ocean. The formation of the haze layer is a seasonal phenomenon facilitated by an extended dry season, which prevents the removal of pollution from the atmosphere through rainfall.

Since this discovery, the impacts of aerosol pollution around the world have received considerable attention (Ramanathan and others 2002). Aerosols reduce the amount of sunlight that can reach the Earth's surface, with significant impacts on terrestrial and marine ecosystems. Preliminary assessments of the impact of the ABC, commissioned by UNEP in 2001, identified potential direct and indirect impacts, including regional and global climate change and impacts on ecosystems, the water cycle, agriculture and human health (UNEP and C4 2002).

The 'dimming' effect of aerosols on sunlight causes 'global cooling' – and therefore reduces the impact of global warming. Exactly how much aerosols counteract global warming is still being investigated, but this finding implies that studies on global warming that have not taken the aerosol cooling into account have underestimated the extent of global warming. The 'benefit' of this global cooling will progressively decline as the influence of the short-lived aerosols is gradually overwhelmed by the countervailing influence of the long-lived greenhouse gases.

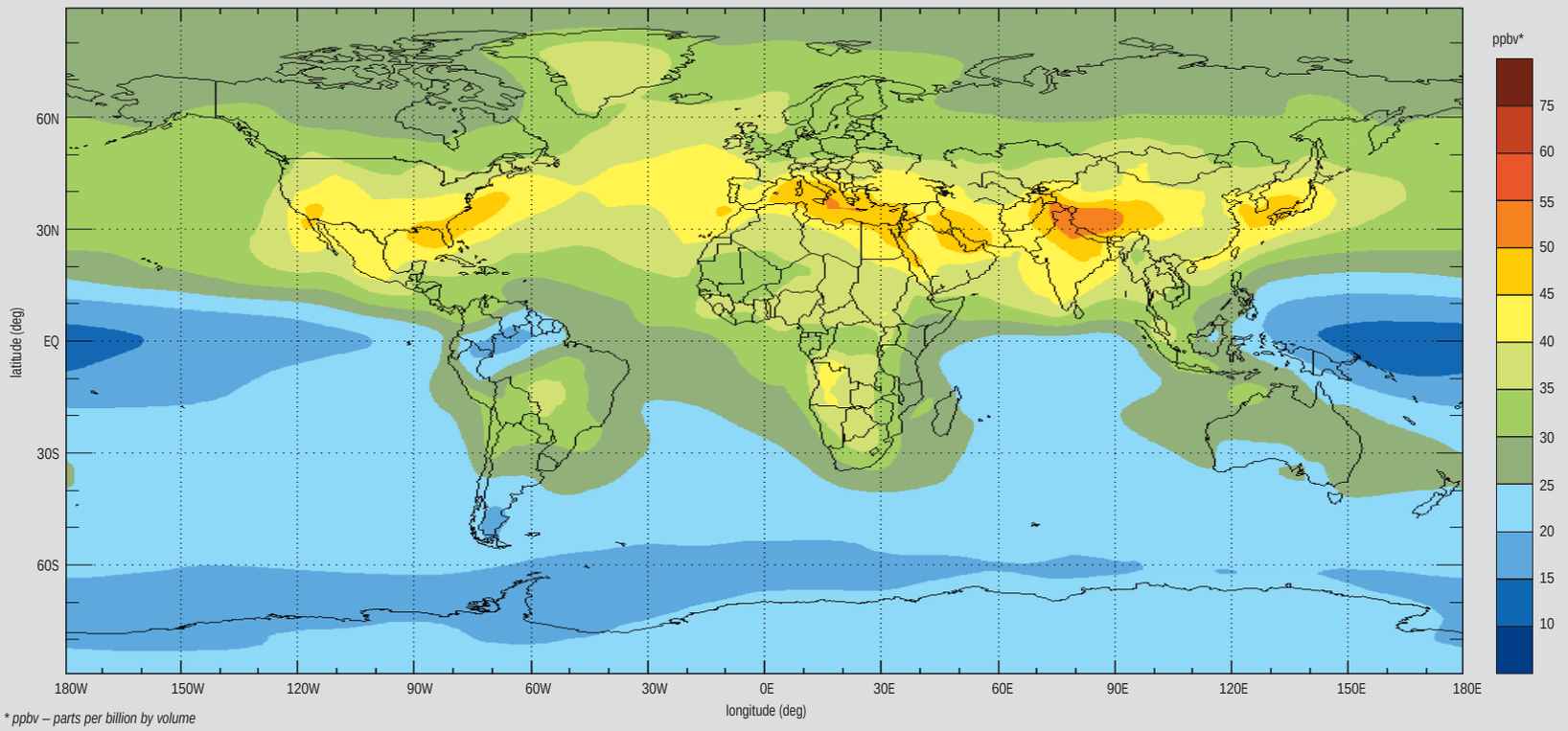
Based on the scientific review of the initial assessment, UNEP has established an international scientific team to assess the impacts of ABC on health, agriculture, water budgets, and climate change. Aerosol observatory stations have been established and capacity building activities such as training have been initiated.

ecosystem imbalance and a decline in species richness. In Europe and North America, forests are growing faster now than earlier this century, and at least part of that increase has been attributed to increased atmospheric nitrogen inputs (Matson and others 2002).

Other energy related air pollutants that pose long-range problems include mercury from coal burning and persistent organic pollutants (POPs), including dioxins, which are produced when biomass, waste containing chlorine and wood treated with pentachlorophenol (PCP) are burnt. POPs, which do not degrade easily, can travel long distances through air and water. They accumulate in the bodies of humans and animals, interfering with the hormone system and neurological development.

Recently there has been growing concern over the hemispheric-scale transport of pollutants, including black carbon particles (Box 5), and tropospheric ozone (Figure 9).

Figure 9: Annual average of surface ozone in 2000



** ppbv – parts per billion by volume*

Source: Dentener and others 2005

Renewable energy, including wind power, accounted for 13 per cent of the total primary world energy supply in 2002.

Source: Yuki Ishii/UNEP/Still Pictures

DEALING WITH AIR POLLUTION

Concerns for energy security, rising energy demand and costs, human health and the environment – particularly climate change – have all created a new impetus for change in the energy sector. This has resulted in policies to control demand, improve efficiency, and to promote sustainable energy options including improved fossil fuel technologies and renewable energy sources.

Increasing energy efficiency may be the most effective way to curb air pollution in the short term. Improved energy efficiency offers several win-win options for better air quality, reduced greenhouse gas emissions, improved energy security, and financial savings. This is especially so in areas where air pollution represents a major threat to public health but non-fossil fuel technologies are either not available or not feasible; and also where large existing investments in fossil fuel based infrastructure do not allow a short-term transition to renewable energy sources.

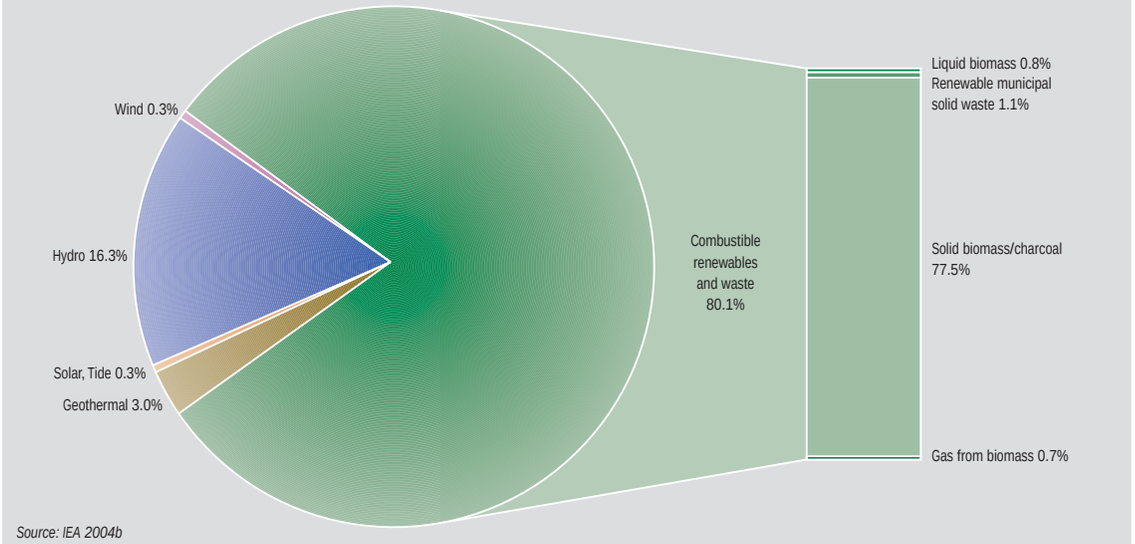
Widespread political support for renewable energy has already led to impressive technological advances and dramatic cost reductions (Salwin 2004). Renewable energy sources, which contributed over 13 per cent of the total primary world energy supply in 2002 (Figure 10), have the potential to contribute to more than just energy supply.

The costs of energy output (for instance, per kWh) of renewable energy sources do not adequately capture a number of other important benefits to society.

For instance, the modular nature of renewable technologies like windmills and solar arrays makes them particularly suitable for rural areas in developing countries that are off-grid. They could enable developing countries to 'leapfrog' over unsustainable fossil-fuel technologies, providing cleaner and more sustainable options. Renewables could also contribute to the employment and investment opportunities arising from continued rapid market growth. If factors such as environment, jobs and security are taken into account, renewable energy prices are already competitive with fossil technologies in many contexts (IEA 2002b).

Renewable technologies are most likely to succeed in off-grid rural areas if they meet multiple needs such as energy for cooking, heating, electricity, water supply, irrigational use and other livelihood uses. Micro and mini hydropower, for instance, has been successful in many parts of the world in providing rural electricity, and also other needs such as agro-processing and cottage industries. The construction of 150 micro hydropower plants

Figure 10: World renewable energy supply, 2002



Source: IEA 2004b

Geothermal power plant, Iceland.
Source: Jose Roig Vallespir/UNEP/Still Pictures

(total capacity of about two MW) in Nepal provided access to electricity to 15 000 rural families while allowing for income generating activities (UNDP 2004b).

A number of technologies to convert bioenergy to more convenient forms such as gases, liquids or electricity are now becoming commercially viable. Anaerobic digestion (without air), steam turbine technologies, and biofuels such as ethanol are already commercial and widespread. Gasification technologies, which produce a combustible gas from biomass, provide a clean fuel that can be burned directly for cooking or heating, or used in secondary conversion devices such as internal combustion engines for producing electricity.

Biogas, produced by anaerobic digestion of readily available biomass resources, such as dung, can be highly viable in rural areas. A biogas programme started in Nepal in 1992 has resulted in over 110 000 household plants, with 20 000 additional plants being installed each year by private companies (Acharya and others 2005). Some 95 per cent of the plants are still operational. Key factors in the success of the programme include a uniform technical design for easy replication; quality control and monitoring of production; installation and after-sales services tied with incentives for private companies; and financial support for end-users, through a subsidy of US$70–150 per household biogas plant plus easy access to financing through micro-credit schemes (Pandey 2004).

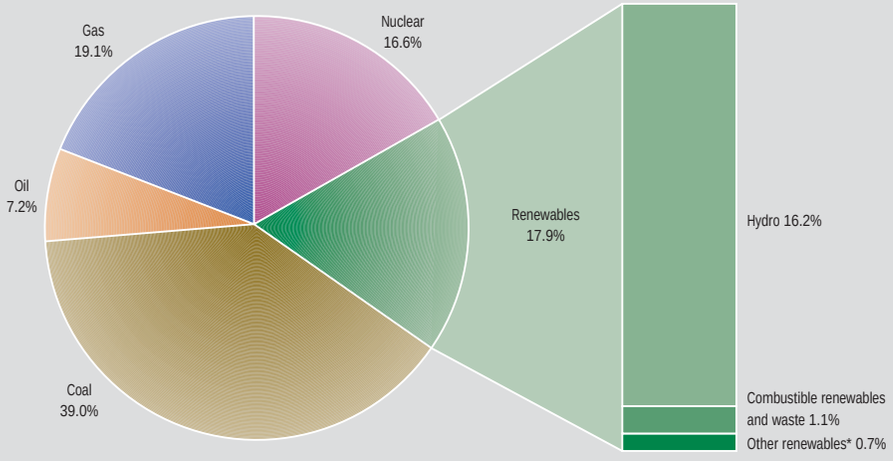
Industry and power sector

In the power and industry sector, many cleaner technologies are already mature and commercially available, like low-NO_x burners, staged combustion, reburning and fluidized bed burners (Heinsohn and others 1999). Fabric filters and electrostatic precipitators can reduce particulate emissions by up to 99 per cent (US EPA 2003a and US EPA 2003b). Flue gas desulphurization systems can capture up to 98 per cent of SO_x (US EPA 2003c), while Selective Catalytic Reduction can cut NO_x emissions by 90 per cent (US EPA 2003d).

Energy savings in the power and industry sector are also achievable through the use of Combined Heat and Power (CHP), or cogeneration. In conventional electricity generation a considerable percentage of the heat content of the fuel is dissipated to the environment, typically 55 to 65 per cent for conventional Rankine Cycle, and 40 to 50 per cent for Combined Cycle plants (Korobitsyn 2000). The concept of CHP is to use part of this wasted heat in industrial processes or district heating. However, awareness and incentives are needed to promote the use of CHP by industries. In the Netherlands, for instance, the government provides free expertise to help industries install CHP.

Technologies currently being promoted to deal with greenhouse gas emissions present

Figure 11: World electricity production by fuel source, 2001



**Other Renewables: Geothermal, Wind, Solar, Tide. Totals in graphs might not add up due to rounding.*
Source: IEA 2004a

further opportunities for co-benefits in controlling local air pollution while dealing with climate change. These include clean coal technologies and 'carbon capture' (removing emissions directly from industrial or utility plant exhausts and storing them in secure reservoirs such as deep saline aquifers). Nuclear energy has been promoted afresh in recent years as a solution to reduce greenhouse gas emissions from power utilities, but the three primary concerns of reactor safety, waste transport and disposal, and nuclear proliferation remain.

The increased cost competitiveness of renewables comes at an advantageous time, because there is a huge and growing demand for new capacity for power utilities, and for millions of systems to serve the 1 600 million people currently without electricity. Renewable sources already make a substantial contribution to global electricity production (Figure 11), although hydro accounts for more than 90 per cent of this. Existing renewable electricity capacity worldwide, excluding large hydro, totalled 160 GW in 2004. Small hydro and wind power account for two-thirds of this capacity (REN21 2005).

Grid-connected solar photovoltaic (PV) is the fastest growing energy technology in the world in terms of per cent growth: installed capacity grew by 60 per cent annually from 2000–2004 (REN21 2005). Although the costs are still high on a kilowatt-hour basis, PV technology is also cost-competitive for a range of off-grid applications ranging from telecommunications to remote village power. PV technologies have dropped in price to between one-third and one-fifth their cost in 1980 (Salwin 2004).

Geothermal technology is mostly used for power generation, though its use for space heating is becoming increasingly important. Oceans offer various energy sources: tidal forces, ocean currents, wave power and thermal gradients can all be captured to produce electricity, and these are starting to be deployed. Ocean energy systems need a relatively extended research and development effort, but full-scale prototypes have been constructed.

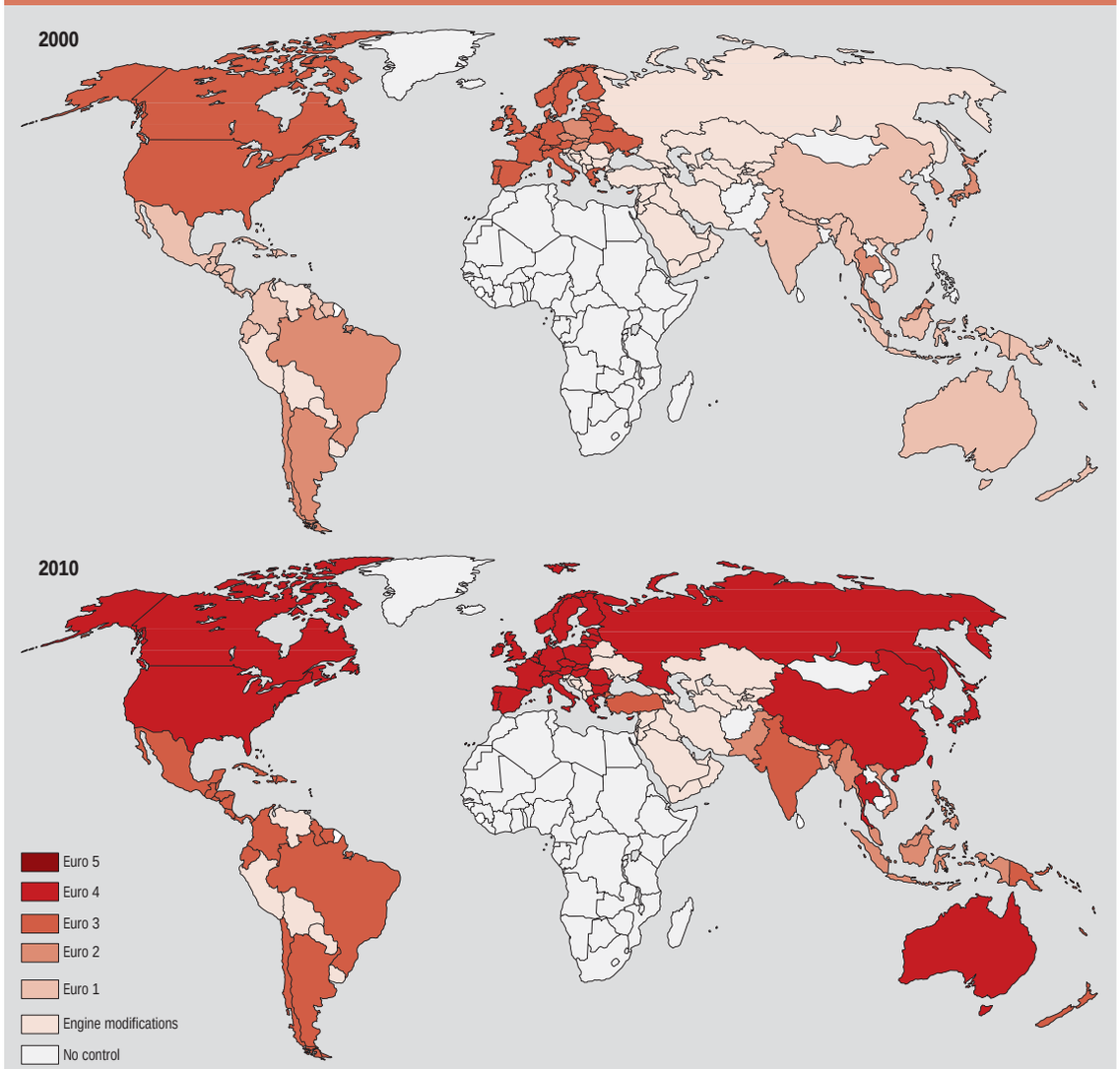
Transport

Improvements in emission standards of vehicles and in fuel quality have brought down urban air pollution levels in many developed countries. Tightening of vehicle emission standards have led to improvements of vehicle technology (such as the use of modern material for lighter cars, engine technology, end-of-pipe solutions such as catalytic converters and soot traps, and more recently, the development of 'hybrid' cars).

In Europe, progressively stringent 'Euro' standards specify limits for vehicular emissions of CO, HC, NO_x and particles. Euro 5 standards for personal cars and light duty vehicles were adopted in late 2005, and the more stringent Euro 6 standards for heavy duty vehicles are currently being discussed. These could result in a 50–90 per cent reduction for particulates and NO_x in bigger vehicles, and up to a 40 per cent reduction in NO_x emissions in personal cars (EEA 2005b).

Acute urban air pollution problems are also leading to tougher measures in developing countries, including the adoption of vehicular standards (Figure 12). In

Figure 12: Emission standards for gasoline vehicles around the world, equivalent to Euro standards



Sources: Cofala and others 2005, ADB 2005, AECC 2005, DieselNet 2005

Leaded gasoline is still used in some parts of the world, however efforts to phase out its use are ongoing.

Source: Permdhai Vesmaporn/UNEP/Still Pictures

addition, cities like Delhi and Bangkok have shifted vehicle fleets to cleaner fuels such as compressed natural gas (CNG) or liquefied petroleum gas (LPG), with substantial benefits for air quality.

The presence of lead in transport-related emissions continues to be a challenge in some parts of the world. Lead additives are still used in some countries in Africa, the Middle East and South America. The Dakar Declaration, adopted by representatives of 28 sub-Saharan countries in June 2001, agreed to phase out leaded gasoline in these countries by the end of 2005 – a goal that has been met. Twelve other African countries with refining capacity have also committed to phase out lead.

The phase-out of leaded gasoline is but a first step in developing a more comprehensive approach to management of transport-related air pollution. Further steps would include improving fuel quality and developing new fuel specifications, including lowering of sulphur levels; upgrading the quality of vehicles and tightening emission controls; establishing baseline inventories of key pollutants and health effects; and developing an appropriate public information or awareness campaign.

As the world transport fleet is still growing steadily, with high rates of growth in China, India and elsewhere, it is important to adopt fuel-saving and clean technologies soon so that the world is not saddled with large numbers of cars with unnecessarily poor performance in future years.

Hybrid electric vehicles (HEVs), which could help reduce emissions by as much as 50 per cent, present considerable opportunities. HEV's have been available to the public since 1997 in Japan. The first cars typically increased the efficiency from 11 km per litre (km/l) to 17 km/l, while recent models have improved to 20–22 km/l. Various governments have introduced tax incentives to stimulate sales of hybrid cars. With the recent energy price hike acting as further stimulus, the market for hybrid cars is expanding.

Recently, there has been much interest in biofuels such as ethanol and biodiesel – fuels made from biomass that can be used as alternatives for transport. Production of biofuels exceeded 33 billion litres in 2004 – about three per cent of the 1 200 billion litres of gasoline consumed globally. Ethanol provided 44 per cent of all non-diesel motor vehicle fuel consumed in Brazil in 2004, and was being blended with 30 per cent of all gasoline sold in the US (REN21 2005).

Gasoline/electric hybrid engine.

Source: Atsushi Tsukada/Associated Press

Biodiesel, extracted from oil seed crops such as jatropha, rape and soy, is often blended with diesel in concentrations of 10–15 per cent to reduce exhaust emissions. However, the environmental and social impacts of large-scale plantations for biodiesel and ethanol must be taken into account in policy making.

Many OECD countries and a growing number of developing countries also have active hydrogen and fuel cell research and development programmes, with aggregate public funding worldwide now running at about US$1 billion a year. The largest programmes are in the US, Japan and the European Union. Three major multilateral initiatives were launched in 2003: the International Partnership for the Hydrogen Economy (IPHE), set up at the instigation of the US administration and including 12 OECD countries, the European Commission and Brazil, China, India and Russia; the Hydrogen and Fuel Cell Technology Platform set up by the European Commission; and the IEA Hydrogen Coordination Group, aimed to enhance coordination of the public research and development programmes and policies of IEA member countries.

Household sector

Indoor air pollution requires viable, cost-effective interventions that can reduce exposures and improve health. Although awareness has been growing, indoor air pollution from household solid fuel use has not been a major issue on the global agenda in terms of international, bilateral, or national development assistance.

Rather than focusing on health-damaging pollution, improved stove and fuel subsidy programmes in the past have been mainly directed toward reducing pressures on forests, improving the efficiency of crop residue utilization, alleviating fuel poverty in urban slums, and reducing the need for gathering fuel. As a result, there is relatively little knowledge available about the ways that indoor air quality could be promoted in large-scale sustainable efforts.

Well-designed stoves with chimneys reduce air pollution in kitchens substantially, but unfortunately produce more modest reductions in actual human exposures because the smoke is still released in the vicinity of the household. The methods used in the past for reducing fuel use in stoves sometimes actually increased emissions, although good design can achieve both goals.

Previous programmes focused mostly on the design of the stove. A broader focus on the design and ventilation of the whole kitchen could provide multiple benefits, for example by including a raised platform for cooking and food preparation, thereby improving ergonomics, safety, and hygiene.

There is still need for improved engineering of stoves to achieve efficiency and health objectives, as well as meet local cooking needs and cost constraints. In addition, lifetimes of many improved stoves have been quite short, reducing their value and reputation. Use of stronger materials can increase lifetimes, help maintain performance, improve acceptability, and result in overall lower social costs considering all factors.

Improved fuels such as LPG produce fewer emissions than biomass fuels, but are more expensive. Where populations can afford them, for example in peri-urban areas where households already pay for biomass fuels, partnerships between governments, non-governmental organizations and the private sector can improve the reliability of LPG supply and lower the initial cost of buying stove and cylinders. Kerosene tends to be cheaper than LPG but may be associated with a higher risk of injuries, and must be burned in better-quality and well-maintained stoves to be adequately clean.

Non-toxic and clean-burning dimethyl ether (DME, sometimes called ‘synthetic LPG’) shows promise as a clean non-toxic fuel that can meet the same markets now served by LPG. A significant industry has developed in China to produce it from coal, although it

Sudanese woman using a new LPG stove.
Source: Liz Bates/Practical Action

Solar and wind energy are promising options for rural areas that are not connected to the electricity supply grid.

Source: Hartmut Schwarzbach/Still Pictures

could also be made from biomass. Other gaseous and liquid fuels made from biomass or coal show possibilities for providing clean, efficient fuels to households in some parts of the world, but more research is needed to establish the technology, economy, and safety of these fuel cycles (Larson and Yang 2004).

Where the geographical location is suitable, solar thermal technologies such as solar cookers and water heaters are available for residential uses. For many applications these technologies are now mature, and recent cost reductions have brought them into the competitive range. However, even in areas with sufficient solar radiation such as South Africa, solar cookers can only replace approximately 40 per cent of a household's energy needs (GTZ and DME 2004). Commercial applications of solar thermal electric technologies which could generate in the range of a few kilowatts to hundreds of megawatts are technically feasible though not yet economically competitive.

More efficient household appliances can reduce emissions, but they are usually more expensive and the majority of consumers buy the cheaper, but less efficient ones. Under these circumstances, economies of scale in production cannot kick in, and so prices remain high. Policies requiring manufacturers to provide efficiency information have proved successful. For instance, efficiency ratings for refrigerators in Thailand, which gave consumers information on average energy consumption and savings on electricity, resulted in total savings of 1 992 GWh of energy and avoided 1.5 million tonnes of CO_2 emissions during 1995–2004 (EGAT 2000). Information on thermal characteristics is also valuable for prospective homeowners – buyers can make better decisions if they know the energy efficiency of the house they are thinking of buying.

CONCLUSIONS

Energy use, development, air pollution, human and ecosystem health are all inextricably interrelated. Access to energy is essential for development, but energy generated by the combustion of fossil fuels and biomass often results in air pollution, with negative impacts on human and ecosystem health. The impacts of indoor and urban outdoor air pollution warrant urgent action (Box 6). The good news is that clean technology is now largely available to provide access to energy, without compromising public and ecosystem health.

To achieve a more sustainable energy future we need political will and leadership at national, regional and global levels; global cooperation, particularly on technology transfer; and economic resources. More efficient technologies and measures to promote more efficient use of energy by consumers can help reduce the demand for energy, while new energy technologies can have longer-term benefits by reducing the negative impacts at source.

Specific tools to control air pollution include standards, enforcement and monitoring. National and regional air quality standards are needed to establish tolerable levels of pollutants. A wider range of air pollutants need to be monitored to measure exposure levels, and also the success of abatement measures. Emission standards for mobile and stationary sources and for fuel quality improve air quality, and at the same time provide an essential impetus for improvements in technology.

Clearly defined national and regional targets related to air quality could help in ensuring progress. For instance, the United Nations Millennium Project calls on countries to adopt a target to halve, by 2015, the number of people without effective access to modern cooking fuels, and make improved cookstoves widely available (Millennium Project 2005).

Awareness and access to information are essential tools for cleaner air. Consistent education and awareness programmes are needed to warn of the health impacts of pollution, and possible preventive measures. Like water and sanitation, indoor air pollution can be made a focus of primary health care programmes. With a consistent health focus, over time people will better understand the risks they and their children are exposed to, and this will enable them to make better decisions about fuel use.

In urban areas, pollution alerts are an important tool in warning the public of days with high pollution levels. Such alerts are given out in several parts of the US, Europe and also in some cities in Mexico.

Participation of affected people and user groups is essential for success. Programmes to design and introduce more efficient stoves in the past often had limited participation from women, the main user group. Stoves were often rejected because they did not cater to user needs. This can be overcome through improved participation of women early in the design of stoves, and in designing programmes to promote cleaner fuels.

Local entrepreneurship should be encouraged in the promotion and introduction of new technologies. Involvement of women in sales and promotion of stoves, for

Box 6: Pricing benefits of air pollution abatement

Economists are constantly refining methods to evaluate the costs of air pollution – and hence the benefits of abatement measures – due to impacts such as mortality and morbidity among humans; damage to ecosystems, agriculture and materials; and visibility impairments.

The widely used 'damage function' approach, for instance, measures the impact of abatement measures on human health using epidemiological studies and information on real or projected changes in ambient air pollutant concentrations resulting from abatement measures and population exposure levels. The impacts are then calculated as economic benefits that could be achieved from saved medical costs and productivity gains, and from people's own willingness to pay to obtain these benefits. These are generally conservative estimates, as they monetize only some of the benefits of improved human health. Some equally important impacts, such as personal pain and suffering, and loss of uncompensated labour (such as child care) are not adequately captured.

In a national-level study, the US Environment Protection Agency (US EPA), for example, projected the benefits of the Clean Air Act from 1990 to 2010 to be around US$690 billion. Of this, US$610 billion came from reduced mortality risks, US$49 billion from reduced morbidity, and the rest from ecological and welfare effects (US EPA 1999). These figures represent the health benefits of reductions in several air pollutants, including PM_{10} and ozone, to the whole country.

No such studies have been carried out at the national level in developing countries, but some studies have been carried out in specific cities. One study in Mexico City estimated that a ten per cent reduction in ozone and PM_{10} levels would bring annual economic benefits of US$1 billion and US$1.4 billion respectively when considering society's willingness to pay, and US$493 million and US$158 million when only productivity losses and medical costs are considered (World Bank 2000). Willingness to pay estimates are usually higher since they take into account all the changes in people's welfare, not only medical costs and productivity losses. Another study in Santiago, Chile, assessed the benefits of compliance with standards set in the Santiago Decontamination Plan at US$4 billion over a period of 15 years (DICTUC 2000).

In both the US EPA and Santiago studies, the cost-benefit ratios were remarkably similar: the benefits were six times higher than the costs. Considerable uncertainty about benefits still exists, but in the majority of cases it is likely that the benefits of reducing air pollution would be higher than the costs in these studies.

Studies also show that the actual costs of measures may be less than the predicted costs. This was the case of air pollution measures taken in the UK (Watkiss and others 2004). Policy makers do not need to wait for local data and local studies to confirm the negative impacts of air pollution on human health before taking action. Studies are often transferable after being adjusted for pollution characteristics and demography. For instance, poorer people are more vulnerable to air pollution, and therefore background mortality figures will be higher. Children, older people, and those with existing respiratory illnesses are also more vulnerable.

example, could become an agent of change in itself by providing women with income-earning and entrepreneurial opportunities outside the home.

Economic policies send important signals to producers and consumers. For instance, access to micro-credit and innovative fuel and technology subsidies are essential to encourage the use of cleaner fossil fuels like kerosene and LPG. Examples of economic instruments to deal with outdoor pollution include the recent move in Europe to shift from taxing labour to taxing energy use to better reflect its external costs, and the congestion tax in central London. Investments in highly efficient, service-oriented and clean public transport followed by incentives for its use are another effective measure in controlling urban pollution.

Collaboration across different ministries (dealing with health, housing, energy, for instance) and sectors is required to deal with both indoor and outdoor pollution, because while the benefits may not seem large in one sector, they are significant when combined. The cooperation of different ministries is also required to implement measures such as better urban planning to minimize travel needs, and improving building laws and standards to promote energy efficiency.

Investments in scientific and technological research on indoor and outdoor pollution need scaling up. For instance, further work is needed to:

- develop reliable clean-burning biomass stoves using pellets, blowers, secondary combustion, and other means to use biomass cleanly;
- improve fuel quality;
- study the environmental impacts of using biodiesel and ethanol in transport; and
- understand the impacts of long-range transport of pollutants.

Harnessing co-benefits through measures that reduce the negative impacts of air pollution and of global warming, while ensuring energy security, offer considerable potential. Measures that offer substantial social co-benefits, such as the provision of better household energy technologies to the poor, can be prioritized.

Easily achievable goals that can result in a considerable reduction of impacts can be given priority for quick results – such as removing toxics like lead and sulphur from fossil fuels, and phasing out household use of poisonous coals contaminated with toxic elements such as fluorine and arsenic.

Long-term solutions to air pollution from energy sources will often require radical changes in the way we use and generate energy. Renewable energy technologies already show considerable promise, but in order to become commercially competitive they need the policy and system support that fossil fuel-based systems have received over the last century. Further policy support is needed to accelerate technology development, boost markets, and provide economic incentives to offset start-up costs (Salwin 2004).

The growth in modern non-hydropower renewable energy over the past decade has taken place mostly in six countries: Denmark, Germany, India, Japan, Spain, and the US. These countries have pursued policies to

create a demand for these technologies, including access to the electric grid at attractive prices; low-cost financing; tax incentives and other subsidies; standards; education and stakeholder involvement (Salwin 2004). Although the form of this support will clearly vary from technology to technology and from country to country, depending on the overall policy framework in place, it is an essential ingredient in the widespread increase in renewable energy use.

Finally, the present time is ripe for change, when we have seen peaks in extreme weather events and in energy prices. An increasing number of polices have already been adopted to support renewables, and many companies in the energy industry have recognized that the future is 'beyond petroleum'. International cooperation to promote research and development, mobilize investment, create markets or share experiences could form a powerful tool to strike while the iron is hot.

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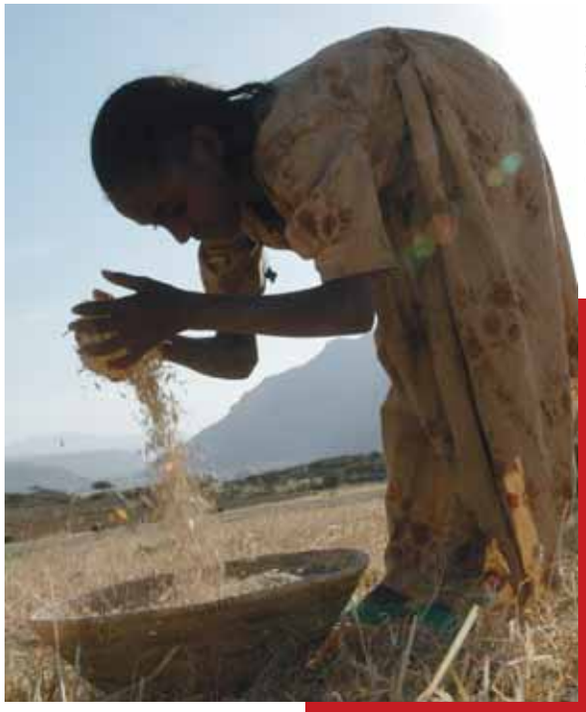


Source: Sean Sprague/Still Pictures

Source: Mark Edwards/Still Pictures

Emerging Challenges – New Findings

Source: WorldFish Center

- CROP PRODUCTION IN A CHANGING CLIMATE
- FISH AND SHELLFISH FARMING IN MARINE ECOSYSTEMS

Crop Production in a Changing Climate

The agriculture sector highlights perhaps more clearly than any other the extent and severity of potential impacts of climate change on food production, food security, lost livelihoods, environmental damage and environmental migration. A "Green Planet Revolution" in crops and agricultural technology can help reduce emissions, limit damage and increase our adaptability to change.

One of the great achievements of the 20th century was the successful expansion of food production to keep pace with growing demand caused by growing populations and rising incomes. The Food and Agriculture Organization (FAO) estimates that as these two factors continue to push demand upwards, the world will require about 50 per cent more food by 2030, compared to 1998 (FAO 2005a). Climate change will be an important factor in determining whether this can be achieved.

The most recent assessment by the Intergovernmental Panel on Climate Change (IPCC) projected that global average surface temperature would increase by between 1.4 to 5.8°C over the period 1990 to 2100, while sea-levels could rise by between nine and 88 centimetres (IPCC 2001a). Temperatures have already increased by 0.6°C over the 20th century, and most of this warming is attributable to human activities (IPCC 2001a).

The rise in temperatures will influence crop yields by

- shifting optimal crop growing zones;
- changing patterns of precipitation (quantity and variability) and potential evapotranspiration;
- reducing winter storage of moisture in snow and glacier areas;
- shifting the habitats of crop pests and diseases;
- affecting crop yields through the effects of carbon dioxide and temperature; and
- reducing cropland through sea-level rise and vulnerability to flooding.

The overall impact of these effects will vary by elevation, soil type, crop and other local factors. This variability, along with the uncertainties of very long-term climate forecasting, especially at the regional level, makes discussion of the effects of climate change on crop production tentative at best. Generalizations can usually only indicate ranges of possible scenarios.

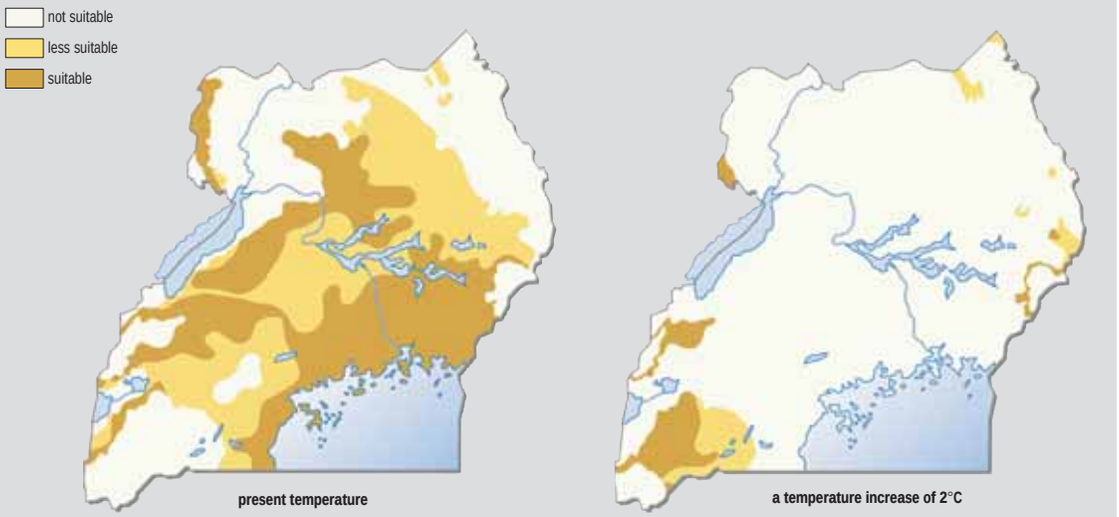
Overall, there may be benefits for agriculture in many temperate zones, where the length of the growing period will increase, costs of overwintering livestock will fall, crop yields may improve and forests may grow faster. For many tropical zones, the overall picture looks more negative: there may be increased rainfall variability, increased incidence of extreme weather events, and reduced crop yields. Improvements in crops, techniques of cultivation, and soil and water management may be able to compensate, but increasing food production in these zones will be made that much harder (FAO 2002).

Shifting growth zones: As a result of rising temperatures, the zones where individual crops do better due to certain climactic conditions are likely to shift polewards and to higher elevations. This will result in a loss of food production and export revenue for some countries in the tropics. For example, coffee is the first, second or third largest export crop for 26 mostly poor countries in Africa and Central America. Yet coffee is sensitive to changes in average temperatures. In Uganda, a warming of only 2°C would massively cut back the land area that is suitable for coffee (GRID 2002) (Figure 1).

In northerly latitudes, global warming may expand the potential production areas northwards – most extensively in Canada and Russia (Epstein and Mills 2005). However, soil types in the new climactic zones may not always be suitable for intensive agriculture as currently practiced in the main producer countries (STOA 1998).

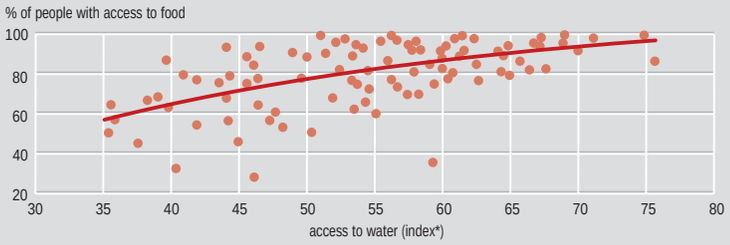
Precipitation changes: Precipitation patterns are likely to change in many parts of the world as a result of global warming.

Figure 1: Global warming could shrink Uganda's coffee growing areas



Source: GRID 2002

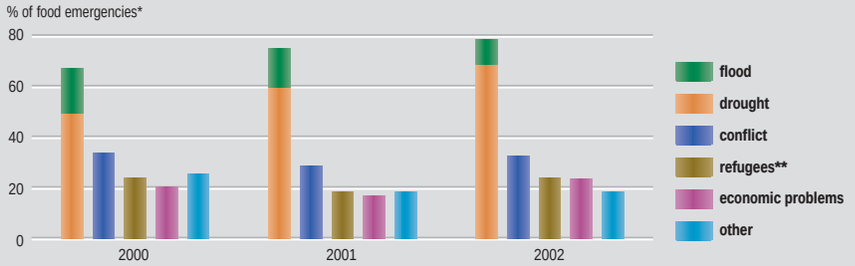
Figure 2: Access to water and food security



** A composite indicator that incorporates measures of water resources (from rainfall, river flow and aquifer recharge), access, environmental issues (water quality) and pressure on resources.*

Source: FAO 2005a

Figure 3: Causes of food emergencies in developing countries



** Total exceeds 100% because of multiple causes and cited for many emergencies*
*** Includes internally displaced people*

Source: FAO 2005a

According to the IPCC, globally averaged annual precipitation is projected to increase during the 21st century, though some regions will experience a decline. In areas where an increase is projected, larger year-to-year variations are likely (IPCC 2001a). Water stress during flowering, pollination and grain-filling stages is known to depress yields in maize, soybean, wheat and sorghum (Epstein and Mills 2005).

Changes in precipitation and increased evapotranspiration could lead to further water shortages and affect water quality in some regions of the world. Access to water is a key factor in ensuring food security (Figure 2). Agriculture, which accounts for almost 70 per cent of global water use and up to 95 per cent in Asia and West Asia, will be severely impacted by water stress (FAO 2005a).

Temperate zones may benefit from an extended growing season.

Source: NRSC/Still Pictures

Precipitation changes will also affect soil moisture. A recent analysis of 15 global climate models found certain predictions consistently across all the models. Drier soils caused by increased evaporation due to warming were expected in Southwest USA, Mexico, Central America, the Mediterranean, Australia and Southern Africa in every season. Much of the Amazon and West Africa would experience drier soils in June, July and August, while the Asian monsoon region would experience drier soils in December, January and February. Predictions of wetter soils were highly consistent across the models only for Northern middle and high latitudes, and only during non-growing seasons. The study concluded that global warming could cause an overall reduction in global food production potential due to lack of soil moisture (Wang 2005).

Precipitation changes will also affect streamflow and the availability of irrigation. In regions where irrigation depends on melting snow, as in much of South Asia, the retreat of glaciers and reduction in snowfall could have grave consequences for water availability in summer (Barnett and others 2005).

Effects of rainfall variability: Climate change will further exacerbate the frequency and magnitude of droughts in Central Asia, Northern and Southern Africa, the Middle East, the Mediterranean region, and Australia (IPPC 2001b). The increase in the frequency and intensity of extreme weather events – including droughts, storms and floods – could result in crop damage and land degradation (IPCC 2001a). Droughts and floods already rank as the single most common cause of severe food shortages in developing countries (FAO 2005a) (Figure 3).

Climate-driven changes in the abundance and distribution of insects, weeds, and pathogens could also affect food productivity (Box 1).

Box 1: Climate change and pests

Warming trends will increase the abundance, growth rate, and geographic range of many key crop insect pests. Depending on shifting precipitation patterns, warming may also stimulate microbial pathogens.

Bean beetle larvae.

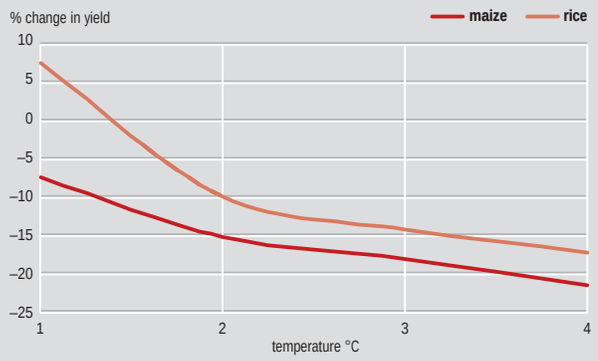
Source: Kent Wood/Still Pictures

The effects of climate change on crop pests are already being felt in some areas. Some global examples:

- Reduced incidence of frosts led to an increase in the tropical grass webworm in northern New Zealand, causing severe damage to pasture grasses.
- Citrus canker, a highly contagious bacterial disease favouring heat and heavy rain, has spread by hurricane to citrus crops throughout Florida in the US.
- Bean leaf beetles, which damage soybean crops by spreading bean pod mottle virus, have migrated from the southern US to the central and northern midwest.

Sources: Willoughby and Barnes 2002, Wildlife Trust 2005, Epstein and Mills 2005, Pritchard and Amthor 2005

Figure 4: Maize and rice yields versus temperature increase in the tropics averaged across 13 crop modelling studies



Note: All studies assumed an increase in precipitation. CO_2 direct effects were included in all studies.
Source: Easterling and Apps 2005

Effects of temperature changes: Crop yields vary considerably according to temperature (Figure 4). Rice yields can decline with even moderate warming, because rice is grown under conditions close to maximum temperature tolerances (Fischer and others 2002a, IPCC 2001b). A recent study on the effects of global warming on rice yields in the Philippines found that yields declined by ten per cent for each 1°C increase in mean daily minimum (night-time) temperature in the growing season (Peng and others 2004).

Carbon dioxide effects: The increase in carbon dioxide concentrations in the atmosphere could increase the net productivity of many crops as a result of carbon 'fertilization', which results in increased photosynthesis. This effect varies between crops. It has a positive fertilizing effect on some crops, known as C3 crops. These include the major cereals of Europe and Asia – wheat and rice. On the other hand, C4 crops such as maize, sorghum, sugarcane, and millet do not respond well to carbon dioxide. Since some C3 weeds may respond well, the effect would be to depress C4 yields. C4 crops are the major food staples of tropical African and Latin American agriculture (IPCC 2001a).

Recent research on test crops of maize, wheat, soybeans and rice grown under realistic conditions in China, Japan and the US reveals that the fertilization boost from rising carbon dioxide levels in the field may only be about half its theoretical optimum, blunted by environmental stresses such as high ground-level ozone concentrations (Ainsworth and Long 2005, Rogers and others 2004).

Loss of land to sea-level rise: Some of the world's most densely populated areas could lose fertile arable land, especially in low-lying delta areas such as those of the Nile, the Mekong and the Ganges-Brahmaputra. A one metre sea-level rise, for example, could result in the loss of 5 800 km^2 in the lower Nile delta, affecting 15 per cent of Egypt's habitable land (Nicholls 1994). In Bangladesh, a one metre rise could flood almost 30 000 km^2, affecting over 13 per cent of the population, while in Vietnam 40 000 km^2 could be lost affecting 23 per cent of the population (Table 1) (IPCC 2001b). Even where land is not flooded, soil quality may decline due to salinization of soils and groundwater sources and increased risk of tidal surges.

Table 1: Potential land loss to different amounts of sea-level rise in selected Asian countries

Country	Assumed sea-level rise cm	Potential land loss km^2	Potential land loss per cent	Population exposed by 2050 millions	Population exposed by 2050 per cent
Bangladesh	45	15 668	11	12.1	5
Bangladesh	100	29 846	21	32.8	13.5
India	100	5 763	0.4	12.7	0.8
Indonesia	60	34 000	2	3.1	1.1
Vietnam	100	40 000	12.1	26.9	23.1

Note: Different studies assumed different amounts of sea-level rise.

Source: IPCC 2001b adapted to 2050 population projections from United Nations 2005

IMPACT ON GLOBAL FOOD PRODUCTION

Determining the net effect of these complex changes on global agricultural capacity is difficult at best. Where negative effects are expected, it is important to remember that they are negative effects on production *potential*. In many regions, appropriate improvements in crop varieties, and in crop, soil and water management techniques, will continue to increase yields and more than compensate for the depressing effects of global warming. Hence major prospective studies do not expect global-level food shortages, and conclude that climate change is likely to slow the expected increase of world food production only slightly, if at all, at least in the first half of this century (Bruinsma 2003).

However, even though world agricultural production today broadly meets world demand, food insecurity is still widespread because it is individual families and countries that have to buy or produce the crops they need. Even when global food production appears adequate, effects at local and country level can increase food insecurity. Moreover, in negatively affected areas, the losses in production potential will have the effect of "raising the bar" for future yield improvements – whereas previous research and development efforts produced equivalent yield improvements, in future a proportion of the effort will be needed simply to maintain current levels of production.

The International Institute for Applied Systems Analysis (IIASA) has made a thorough study of how production potential might change with climate change (Fischer and others 2002a, b and c). The agro-ecological zones methodology was used, comparing the growing requirements of major crops with data on soils, slopes and changing rainfall and temperatures. Looking at the effect of a 3ºC temperature rise on the areas, the study found that with rainfall levels unchanged, there would be a very small global gain of one per cent in land suitable for growing rainfed wheat, rice or maize. Increased rainfall levels (expected due to global warming) would raise this to a 4-5 per cent gain. However, the great majority of the

potential cropland increases lie in sparsely populated areas of Canada and Russia and would depend on the cultivation of northerly lands that at present lie uncultivated.

CLIMATE CHANGE AND GLOBAL INEQUITIES

Climate change will affect production potential differently in different parts of the world. In broad terms it is likely to deepen global inequities. While some developed countries in middle and especially northerly latitudes may make net gains, many developing countries in the tropics may suffer increased climate-related difficulties and increased variability of rainfall (Fischer and others 2002b).

The IIASA study suggests that, taken as a whole, developing countries might lose 11 per cent of currently suitable land for rainfed cereals (Fischer and others 2002b). Not all developing areas will lose out. Given a 3°C temperature rise and unchanged rainfall, China would make net gains in potential rainfed cereal land, as would Central Asia and West Asia. But there would be very significant losses of 31 per cent in Southern Africa and 20 per cent in South America, with losses ranging from 11 per cent to 13.5 per cent in the rest of sub-Saharan Africa, and in Central America, South and South-East Asia (Figure 5).

Projected losses increase progressively as temperatures increase. Increased rainfall improves the situation for some regions, but worsens it for others, with the overall loss in developing countries remaining at the same level. Calculated at country level under the Hadley Centre's CM2 climate model, 38 developing countries, with a projected year 2080 population of 3 300 million, would lose more than 5 per cent of their rainfed cereal production, losing a total potential production of 273 million tonnes. Figure 6 shows country-level gains and losses under another Hadley climate model, CM3-A1F1.

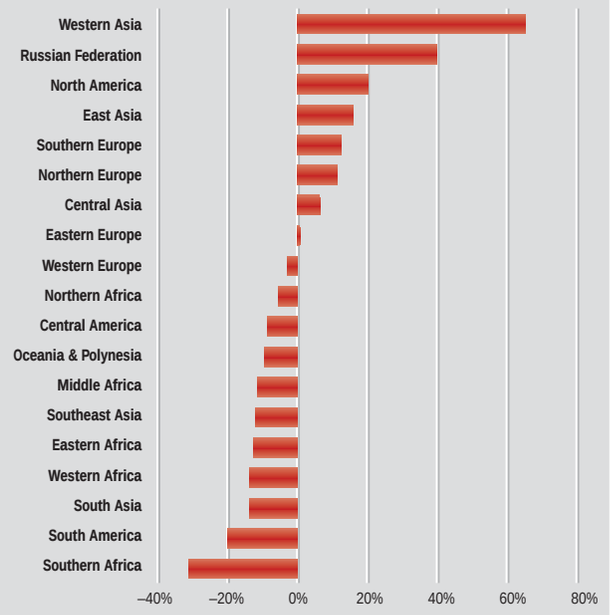
IMPACTS ON FOOD SECURITY

Because global warming will hit hardest in already poor regions, especially Africa, climate change is likely to increase the numbers suffering from food insecurity and malnourishment. IIASA has estimated that the numbers of malnourished – 815 million in 2000–2002 (FAO 2005b) – could increase by an additional 75 million at concentrations of 600 parts of carbon dioxide per million, and even more if levels go beyond that (Fischer and others 2002a and c).

Low-income, food-deficit countries often lack the financial resources to import food to fill gaps in supply (Bruinsma 2003, United Nations 2005, FAO 2005c). Food security and export revenues are already threatened in some developing countries due to a combination of climatic and socio-economic factors, and a downward trend in global agricultural commodity prices. Africa – where per capita food production has declined since the 1960s – is likely to face even greater difficulties in a warmer world.

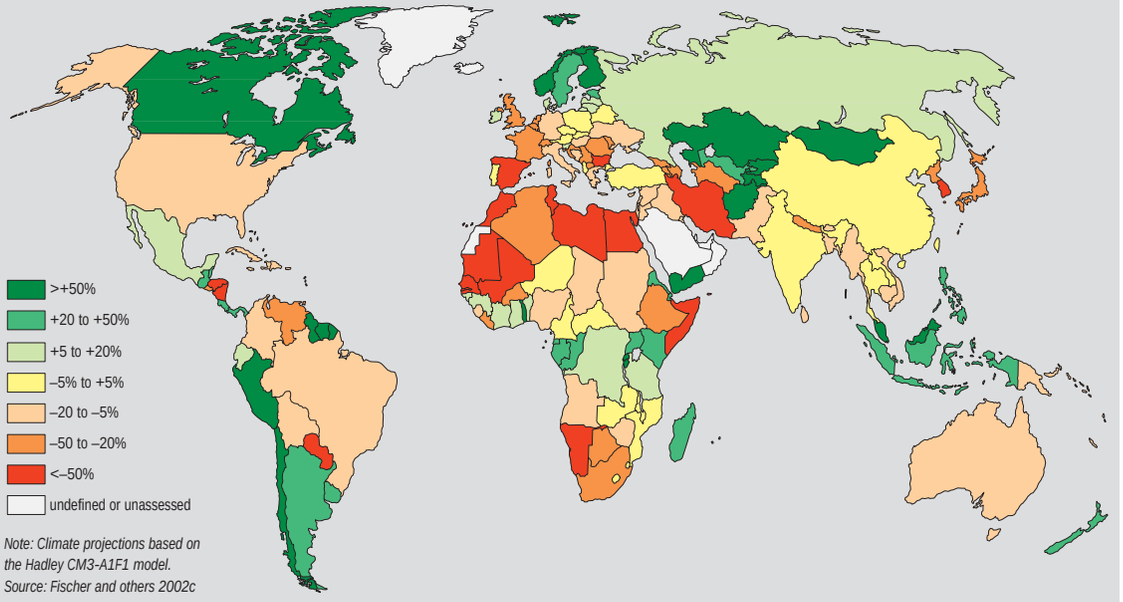
Through sea-level rise and changing cropland areas, global warming will not just reduce potential food production. It will destroy livelihoods and give rise to large numbers of environmental refugees who will head for cities, for other countries, or for unopened territories. In much of sub-Saharan Africa, Central and South America, and South East Asia, where unused land reserves still exist under forest cover, many farming families displaced by climate change or flooding may try to find new land. In such cases, deforestation rates could increase and encroachment on and poaching in national parks and other areas crucial for biodiversity would grow.

Figure 5: Gains and losses in rainfed cereal potential, by region, for a 3°C temperature rise



Source: Fischer and others 2002b

Figure 6: Projected percentage gains and losses in rainfed cereal production potential, by 2080



Note: Climate projections based on the Hadley CM3-A1F1 model.
Source: Fischer and others 2002c

LOOKING AHEAD

The impact of climate change on agriculture production is a serious concern to those working to meet the food demands of a growing human population, as well as those working to preserve natural ecosystems and the services they provide.

As data and research accumulate, the negative effects of climate change on potential food production for many regions of the developing world are being clarified. At the very least, these effects will raise the bar that technological innovation has to "jump". As the suitable ranges for different crops shift, farmers in many parts of the world will also be faced with difficult decisions about what crops to grow, and there will be mistakes and failures of adaptation.

Natural ecosystems may have even greater difficulty adapting to climate change, since natural plant species move more slowly than human introductions. Since natural ecosystems provide many services to agriculture – including water regulation, pollination, pest control, genetic resources for new crop varieties and cultivars – this will also rebound on food production, as well as on other services such as biodiversity conservation, leisure and aesthetic pleasure.

The most effective solution to limiting the impacts of climate change on food production is, of course, to mitigate climate change by reducing greenhouse gas emissions and increasing carbon sinks. This will be a vast undertaking affecting almost every sector of human activity. The agricultural sector itself can contribute significantly. The planting of high-yield varieties as part of the Green Revolution saved an estimated 170 million hectares of forest from cropping in Africa, Latin America and Asia between 1970 and 1990 – saving the equivalent of two to three years of total global carbon emissions (Gregory and others 2005). Converting to conservation agriculture with no tillage could reduce fossil fuel use in mechanized ploughing by 50 per cent and also lock up 0.1 to 1 tonne of carbon per hectare per year (FAO 2002). Agroforestry can increase the presence of trees in arable land and pasture, increasing carbon uptake.

The agriculture sector's emissions of methane can be reduced by changing cultivation methods in paddy fields, and by using feed additives that increase livestock digestion efficiency. Biogas plants can use methane from dung for energy generation. Nitrous oxide emissions from nitrogenous fertilizers can be reduced by changing the way the fertilizers are applied (Epstein and Mills 2005).

Some degree of climate change is inevitable irrespective of any action taken to control greenhouse gas emissions, so adaptive policies are also required (Box 2). We will need what could be called a 'Green Planet Revolution' in crops and agricultural technology. Development of crops better suited to changing environmental conditions will need to be prioritized by national and international breeding and genetic modification programmes (Box 3).

Increased irrigation for double and triple cropping will be needed where renewable water supplies suffice. However, many areas where potential rainfed cereal land may be reduced are also areas facing significant or critical water shortages (FAO 2005a) – especially North Africa and South Asia. Here, water conservation techniques and methods to improve irrigation efficiency will be needed. These include rainwater harvesting and storage, crop varieties that need less water

Intercropping could help conserve soil moisture.

Source: Mark Edwards/Still Pictures

Box 2: Agricultural technology and policy options for climate change

Measures to reduce agriculture's greenhouse gas emissions and increase carbon uptake

- Removal of subsidies and introduction of environmental taxes on fossil fuel energy based inputs.
- Improvement of fertilizer use efficiency.
- Improved management of livestock and crop waste to reduce methane.
- Use of livestock and crop wastes for biofuel.
- Development of rice varieties emitting less methane.
- Restoration of degraded lands.
- Expansion of agroforestry and reforestation.

Measures to promote adaptation to climate change

- Sustainable production of bio-fuels for other sectors, for instance transport.
- Development and distribution of crop varieties resistant to drought, storms and floods, higher temperatures, salinity and emerging pests and pathogens.
- Improvement of water use efficiency through:
  - no-till/conservation agriculture in rainfed areas; and
  - appropriate water pricing, management and technology in irrigated areas.
- Promotion of agroforestry to increase ecosystem resilience and maintain biodiversity.
- Maintenance of livestock mobility in pastoral areas subject to drought.

Measures to reduce food insecurity

- Reduction of rural and urban poverty.
- Improvement of roads and communications in disaster-prone areas.
- Removal of agricultural export subsidies that limit markets for poor farmers.
- Slowing of rapid population growth rates.
- Development of early-warning and storm-forecasting systems.
- Preparedness plans for relief and rehabilitation.
- Introduction of flood- and storm-resistant and salt-tolerant crops.
- Introduction of land use systems to stabilize slopes and reduce the risk of soil erosion and mudslides.
- Building of homes, livestock shelters and food stores above likely flood levels.

Source: FAO 2002

and the use of drip irrigation methods, which deliver the water when and where it is most needed. Moisture-conserving methods such as minimum tillage agriculture and sustainable agricultural practices such as windbreaks, agroforestry, intercropping, and relay cropping can help maintain soil moisture (FAO 2005a).

Agricultural policies at the national level that reward good practices, such as the use of integrated pest management, could provide farmers incentives for change. Information networks that provide early warning of seasonal changes or extreme events could minimize losses by providing farmers crucial information on what kind of seeds to plant, and when, to reduce risks. Such early warning networks already exist in some parts of the world. For instance, the US National Oceanic and Atmospheric Administration (NOAA) has set up a series of Regional Outlook Forums across Africa, Latin America and the Caribbean, and southeast Asia, bringing together national and international meteorologists to produce consensus-based seasonal forecasts (DFID 2004).

Box 3: The potential of biotechnology

The Green Revolution was based on the breeding of new high-yielding crop varieties. We will need a new generation of varieties adapted to changes induced by global warming. Breeding will continue to be important, but gene technology will help to speed up the process. This process can be expensive, and vulnerable countries will require international assistance, for example through the Consultative Group on International Agricultural Research network of agricultural research centres. Many of the conditions we can expect in the future are already problems for marginal areas: drought, heat stress, salinity, pests and pathogens.

Genetic modification experiments on rice.
Source: Joerg Boethling/Still Pictures

Drought and temperature are two forms of stress resistance particularly relevant to climate change. A number of studies have demonstrated that genetic modifications to crops can increase drought tolerance. Breeding and genetic modification for heat resistance will also be essential. However, caution should be exercised to minimize potential socio-economic, health and environmental impacts of introducing genetically modified crops.

Sources: Cheikh and others 2000, FAO 2004, Pilon-Smits and others 1995, Drennen and others 1993, Kishor and others 1995, Hinderhofer and others 1998

However, the scale and depth of expected changes may be too great in some countries for national measures to suffice, so increased levels of technical support and aid may be required.

All told, climate change will present a vast range of challenges to agriculture and its ability to feed and provide livelihoods for human populations. As well as working to limit the extent of climate change, constant adaptations will be required.

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Fish and Shellfish Farming in Marine Ecosystems

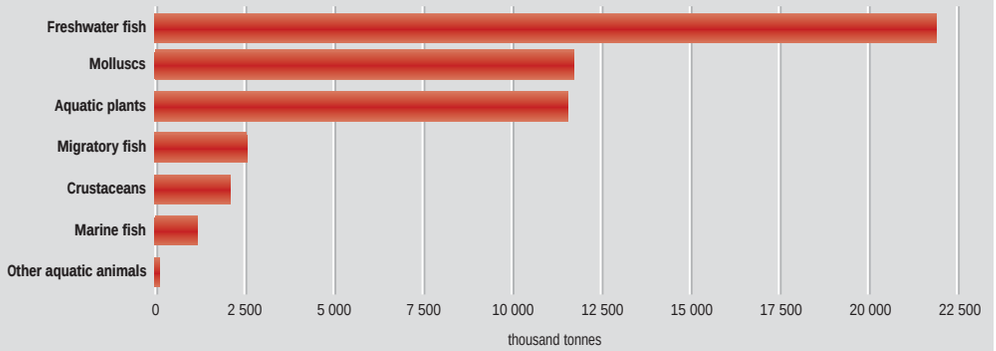
With marine capture fisheries stagnant, marine fish farming can supply rising demand, but sustainable practices must reduce current levels of environmental damage.

Due to population growth and rising incomes, consumption of fish more than tripled from 1961 to 2001, rising from 28 to 96 million tonnes. Much of the increase was fuelled by consumption in developing countries (IFPRI and WorldFish Center 2003). With three-quarters of the world's wild fish stocks fully or overexploited, a number of countries are turning to fish farms to meet the rising demand for fish and shellfish.

Aquaculture, dominated by freshwater species (Figure 1), has grown at an average annual rate of nine per cent since 1970, compared with three per cent for livestock meat and one per cent for captured fish over the same period. Nearly one-third of the fish consumed by humans is now produced by fish farms, with China, India and other Asian countries accounting for 87 per cent of global aquaculture production by weight (IFPRI and WorldFish Center 2003).

Africa is the only continent where per capita fish supplies have barely changed in recent decades – from 10.3 kg per person in 1973, to 10.5 kg in 2002 (FAO 2005a). However,

Figure 1: World aquaculture production, 2002



Source: FAO 2004

African aquaculture could increase dramatically. At a summit held in Nigeria in August 2005, leaders of 25 African nations signed a resolution calling for rapid investment in fish farms as a means to reduce poverty and hunger (von Bubnoff 2005).

Farming of marine species – or mariculture – is growing rapidly. Across the globe, from Chile to China and Scotland to South Africa, farming of salmon, shrimp, mussels, oysters and clams is increasingly common. Atlantic cod farms have recently opened in Iceland and Norway. Sea bream and sea bass are increasingly cultivated in the Mediterranean. In Mexico, Spain and Australia, farms now fatten wild-caught tuna. In the waters off the coast of the Northeastern United States, pilot studies are underway to farm halibut, haddock, flounder and other species.

While mariculture has the potential to supplement the world's supply of edible protein, current practices often create significant environmental problems and even reduce the overall supply of fish protein.

Fertilizer, undigested feed, biological waste and veterinary drugs used in mariculture are released into the oceans and surrounding waterways. Farms create conditions for the spread of disease and parasites and, through

Salmon farm.

Source: Jim Wark/Still Pictures

Nearly one-third of fish consumed by humans is now produced in fish farms.

Source: Schafer & Hill/Still Pictures

the escape of farmed fish, introduce invasive species. Through competition for food or habitat, these exotic species threaten native species or alter entire ecosystems. Coastal farming, particularly for shrimp, has destroyed thousands of hectares of mangrove forests, which filter water, reduce erosion, serve as critical hatcheries for fish, and protect coastal communities from storms and floods (IFPRI and WorldFish Center 2003).

Several mariculture systems are in use or under development in Asia, Africa, Europe and the Americas. They include net pens in coastal and offshore areas, ocean ranching, non-feeding or extractive culture and intensive shrimp farming. Each system offers food production benefits but also has the potential to create environmental damage – both of which can be improved through effective policy responses.

MARINE NET-PEN REARING

There are two main types of net-pen mariculture. One type involves rearing fish in enclosed nets from small juveniles to adults. Fish are fed, given drugs to control disease, and harvested. The second type involves fattening ocean-caught fish in enclosed nets by supplying large amounts of feed for several weeks to months before harvest.

The use of net pens has increased dramatically in recent years as a means of rearing large numbers of salmon, tunas, and other commercially valuable fishes. Salmon net-pen operations can be found extensively in Scotland, Ireland, Norway, Chile, Canada and the US while net-pen rearing of tuna, sea bass and sea bream has boomed in the waters off Spain, Greece, and Italy. In Asia, sea bass and grouper net-pen rearing is common.

Net pen rearing in the US.
Source: Kevin J. Kilmer/Associated Press

This is a capital-intensive industry with far-reaching consequences for the environment and for the economics of competitive capture-based fisheries in rural regions (FAO 2004).

Environmental consequences

There are several potentially serious environmental consequences of net-pen rearing.

Waste from cages damages bottom-dwelling plants and animals, reducing biodiversity. Concentrating large amounts of fish in small areas can lead to disease outbreaks. Viral and bacterial diseases, as well as parasites, can then be transmitted to wild fish. Data from Ireland, Scotland, Norway and Canada suggests that net-pen rearing is linked to outbreaks of deadly sea lice in wild salmon (Naylor and Burke 2005). To control outbreaks, some farmers use antibiotics and parasiticides. Along with uneaten feed and fish faeces, these chemicals foul local waters. As a result of pharmaceutical discharge, resistant strains of infectious organisms emerge.

Net-pen operators often kill or aggressively deter predators such as herons, seals, sea lions and killer whales through tactics such as sirens. Salmon farms are believed to interrupt the migration of wild salmon and the movement of killer whales in Europe and North America (World Fisheries Trust 2002). In these regions, interbreeding with escaped fish can also reduce fitness of wild fish.

Toward best practices

Net-pen farming can be modified to better protect the environment as well as improve economic output. Farmers can apply a "systems approach" by raising ecologically complementary species together, a practice known as polyculture. One example is to breed algae, filter feeding bivalves and fin fishes together to reduce feeding waste and nutrient loading and increase the overall accumulation of edible protein (Box 1).

Evaluating ocean currents and water circulation – which effect how coastal zones can assimilate organic matter from farms – can cut down accumulating organic wastes. Training farm workers in feeding practices can also reduce feed losses. (Soto and Norambuena 2004).

Farmers can reduce the density of fishes in pens, which, along with water re-circulation systems or rotation of cultured stocks, could reduce disease outbreaks. Technological advances in vaccination and breeding for immunity can be applied to reduce use of pharmaceuticals. Finally, designing flexibility

Box 1: Two ways of reducing waste

Polyculture

Many mariculture operations create undigested feed and faeces, which can pollute waters and, over time, destroy habitat and disrupt marine food chains. One organism's waste, however, is another organism's food. This is the idea behind polyculture, or integrated aquaculture, which involves growing two or more "crops" together for a balanced ecosystem approach.

Long practised in freshwater fish farms, polyculture can also be applied to marine operations. In Sungo Bay in Northern China, nitrogen excreted by the two billion scallops produced there each year is used to cultivate kelp. A Canadian pilot project in the Bay of Fundy shows that kelps and mussels grow faster when cultivated near salmon. Researchers also found that kelps, mussels and salmon can be grown together safely and economically, and are working on policies that would allow for commercial-scale operations.

Greener feeds

Paradoxically, raising some farmed fish species requires more fish biomass than those species produce. This is due to the high levels of fish meal and fish oil in aquaculture feeds. Production of a single kilogram of carnivorous marine fish such as cod or seabass typically uses two to five kilograms of processed wild-caught fish.

Efforts are underway to develop substitutes for fish-derived feeds using oilseeds, soybeans, meat by-products and microbial proteins. Chinese researchers are creating a protein supplement based on yeast. However, feed substitutes have yet to match the nutritional value of fish meal and oil. This has led some environmentalists to conclude that plant-eaters such as carp are one of the few sustainable aquaculture crops.

Sources: AquaNet 2003, Ecological Society of America 2001, World Fisheries Trust 2002, World Resources Institute 2001

and diversity into the types of fish produced can act as insurance against environmental changes in the coastal zone from climate-induced alterations in sea temperatures and other environmental factors.

Clams growing inside a cage, feed on suspended detritus before being harvested.

Source: WorldFish Center

OCEAN RANCHING

In ocean ranching, young fish are reared in captivity, released into the open ocean and later harvested as part of the "wild" fishery. Ranchers often release fry in staggering numbers. North American hatcheries, for example, release over five thousand million juvenile salmon each year (World Fisheries Trust 2002). Commonly used species include salmon as well as smelt, pike, abalones and flatfishes such as sole, flounder, and halibut.

Ocean ranching is commonly practiced in China and Japan. Japan, for example, releases more than 70 species each year in its coastal waters, ten of which are ranched on a large scale (Arnason 2001). Ocean ranching requires a relatively moderate capital investment, is practised largely in rural or remote regions, and uses native species.

Environmental consequences

Ocean ranching can deplete wild fish through increased competition for food and habitat. Ranch fish such as salmon, which return in large numbers for harvest, can attract predators such as fishes, birds and sea lions – animals who can then fall prey to other predators or to fisheries operators who may kill or deter them. There are also concerns over reduced genetic diversity, due to interbreeding. The overall effect is a disruption of the food chain and, in some cases, a decline in genetic biodiversity and in endangered wild stocks.

Methods for harvesting fish bring additional consequences. Bottom trawling or powerful vacuums disturb or damage the seabed, destroying critical marine habitats and nursery grounds. Trawling also stirs up seafloor sediments, which can clog fish and mollusc gills (Thorne-Miller 1999).

Toward best practices

Harmful environmental effects can be reduced by spreading the release of ranch fish over longer periods, establishing non-harvest conservation areas and exclusive harvest zones, and using fish such as salmon that exhibit homing instincts at specified times in their life history – a practice that can avoid harmful capture methods such as trawling or line capture which can net endangered species (FAO 1995). Capture methods that minimize physical disturbance to the environment should be strongly encouraged.

EXTRACTIVE AQUACULTURE

Oysters, clams, mussels, and scallops feed on phytoplankton and suspended detritus while seaweeds feed on nutrients dissolved in seawater. These species can be raised without supplemental feed, a practice called extractive aquaculture. This method of farming entails "planting" mollusc larvae or "seed" directly on the bottom of tidal flats or suspending the larvae from floating rafts, trays or mesh bags. Molluscs can also be hung in racks or placed on platforms anchored by sticks or posts.

Nearly 12 million tonnes of molluscs were produced in 2002, comprising 23 per cent of global animal aquaculture products (FAO 2004). Extractive aquaculture is extensively conducted in coastal waters, particularly off the shores of Asian, North American and European countries. Molluscs are often farmed in waters near urban areas, where discharge of nitrogen and other nutrients fuels the production of plankton. This, in turn, provides a source of food for molluscs, which also can help control eutrophication.

Environmental consequences

Molluscs could reduce nitrogen and other nutrients in the oceans – thus improving water quality. However, densely planted farms can result in the accumulation of faeces on bottom sediment below farming rafts and ropes, leading to oxygen-starved dead zones (Furuya 2003). Sediment can also change seafloor habitat and encourage growth of pollution-tolerant species (World Fisheries Trust 2002).

Mollusc farming can also introduce exotic species. For example, the widely cultured Japanese or Pacific oyster is now common in the wild on almost all Northern Hemisphere coasts. Non-native molluscs become competitors, predators, disease vectors, and parasites of wild native species (Naylor and others 2001).

Mangrove forests are removed to make way for shrimp farming in Thailand.

Source: Cyril Ruoso/Still Pictures

Toward best practices

Some environmental degradation can be avoided with sound planning. Farms should be sited in areas with adequate circulation along the ocean bottom to prevent dead zone formation. The density of molluscs "planted" also should be determined according to the environmental carrying capacity, so as to avoid robbing the food supply of other plankton-consuming species.

It is possible to establish sustainable mariculture systems by integrating finfish or shrimp production with mollusc and seaweed production, since molluscs and seaweeds remove food particles and dissolved nutrients produced by the fish or shrimp (Naylor and others 2000, McVey and others 2002, Neori and others 2004) (Box 1).

INTENSIVE SHRIMP FARMING

Shrimp are raised, fed and harvested in shallow coastal ponds, mainly in tropical countries such as Thailand, Ecuador and Indonesia. Shrimp farming has boomed as an industry. In 2000, global production totalled 1.3 million tonnes with a market value of over US$7 billion (FAO 2003). Approximately 80 per cent of farmed shrimp is produced in Asian countries – China alone produced 493 000 tonnes in 2003 (FAO 2005b). Much of the shrimp is exported to developed nations.

According to the degree of intervention, shrimp farming is classified as extensive, semi-intensive or intensive. Intensive farming implies increased stocking density, higher inputs of antibiotics, nutritional additives and probiotics, as a means of achieving extremely high productivity, all of these leading to greater generation of wastes. (Naylor and others 2000).

Environmental consequences

It has been estimated that a shrimp's assimilating efficiency of nitrogen from feed is around 22 per cent (Briggs and Funge-Smith 1994), while the remaining nitrogen is discharged into the water. The enormous quantity of faeces and feed waste resulting from intensive shrimp farming has resulted in the pollution of canal water, eutrophication of coastal areas, and the spread of human disease. Shrimp farming has degraded salt marshes and freshwater wetlands and threatened coral reefs and seagrass beds.

Pond construction has also damaged mangrove forests, one of the world's most threatened habitats. Shrimp aquaculture development is a major cause of recent mangrove loss in countries such as Thailand, and it has been estimated that it may be responsible for as much as 38 per cent of mangrove loss globally (Environmental Justice Foundation 2004). Destruction of mangroves has left coastal areas exposed to erosion and flooding, altered natural drainage patterns, increased salt intrusion and removed critical habitats for many aquatic and terrestrial species (Environmental Justice Foundation 2004).

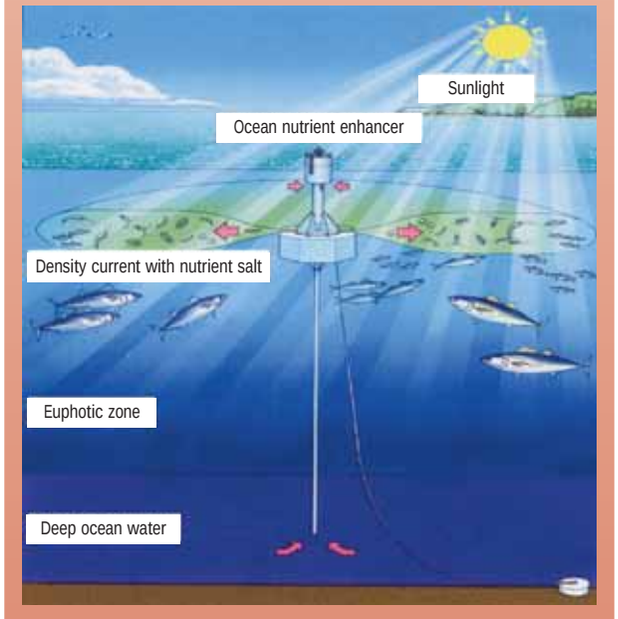
Box 2: Artificial upwelling for enhancing biological productivity

Nutrients and light significantly influence ocean productivity. However, there is a constant nutrient limitation near the water's surface where light penetrates, which is the area where photosynthesis can occur – an area called the euphotic zone. Increase the supply of nutrients to the euphotic zone and phytoplankton production improves. This, in turn, boosts production of fish.

In some oceanic areas, such as the west coast of South America, nutrient-rich deep water regularly rises into the euphotic zone. This is called upwelling. While upwelling occurs in only 0.2 per cent of the ocean's area, about 20 per cent of global capture fisheries products are obtained in upwelling areas.

Can new fishing grounds be created by delivering more nutrients to the ocean surface? Japanese scientists are conducting an artificial upwelling experiment to find out. A floating ocean nutrient enhancer dubbed Takumi (meaning "reclaiming the sea") is moored in Sagami Bay in central Japan. Since July 2003, Takumi has continually pumped nutrient-rich seawater from a depth of 200 metres. It is mixed with water pulled from a depth of five metres to adjust density, then discharged into the bay. While the impact on fish production is under study, stock enhancements are predicted.

Takumi currently uses a diesel engine for pumping, but cleaner energy sources such as solar power may be applicable.



Schematic view of Takumi, an ocean nutrient enhancer in Sagami Bay, Japan.

Source: Takahashi 2001, Ouchi and Ohmura 2004

Toward best practices

Many Asian countries are rapidly developing policies to preserve mangrove forests while enabling sustainable shrimp culture. For example, the Southeast Asian Fisheries Development Center has developed guidelines that suggest limiting ponds' proximity to the coastline and reducing the amount of mangrove forests used for farming (SEAFDEC 2004).

Other attempts are being made to reduce pollution from shrimp farms. In Thailand, the government supports a project where effluent is treated extensively by removing sludge and using biological filtration before being returned to the ocean. Additionally, pathogen-free and pathogen-resistant shrimp larvae and broodstock have been developed in an effort to reduce the use of drugs and other chemicals in shrimp ponds (Moss and others 2005).

REALIZING A SUSTAINABLE BLUE REVOLUTION

Fish provide more than 2.6 billion people with 20 per cent of their intake of animal protein (FAO 2004). With wild fish stocks fully exploited – and the human population rising – mariculture can provide an important dietary staple to a hungry planet.

If guided by sustainable principles, and supported by effective policies, mariculture's adverse effects on biodiversity can be blunted. Sustainable principles can:

- minimize multiple stresses, including better control of land pollutants discharged into the coastal zone, to make mariculture more economically and ecologically viable;
- promote integrated fish farming systems that reduce waste and use the most regionally appropriate species;
- provide access to best practice information, such as strategies for pollution prevention or disease control, to decision makers and practitioners; and
- encourage adaptive management to allow for local, regional or global changes in the environment and the economy.

Sustainable policies to mitigate environmental damage caused by mariculture include (World Fisheries Trust 2002):

- **feed changes.** Reformulate feed to include less animal protein so as to reduce phosphorus and nitrogen waste;
- **waste reduction.** Eliminate or contain effluent from farmed species and make more efficient use of feeds;
- **seedstock protection.** Reduce use of wild fry or larvae as seed for cultured species;
- **chemical use.** Reduce use of chemicals and antibiotics;
- **disease transmission.** Promote management practices that reduce stress on farmed species and guard against escapes; and
- **exotic species.** Broaden use of native species and promote recovery of exotic species escapes.

To protect biodiversity in the world's oceans – and the food supplies they support – sustainable wild fisheries management practices should accompany mariculture development, including the establishment of a no-fishing marine reserve system. Mariculture regulation should be comprehensive, addressing proper siting of operations to minimize environmental impacts as well as long-term rights and responsibilities should any environmental damage occur. Permissions to establish operations should be also legally rigorous to ensure that parties granted rights are held accountable for environmental or ecological problems and that the operation cannot be implicated in any illegal, unregulated or unreported fishing activity. The offshore oil and gas industry – which has a long history of successes and failures regarding siting, operations and remediation – could provide valuable lessons for the burgeoning ocean fish farming industry.

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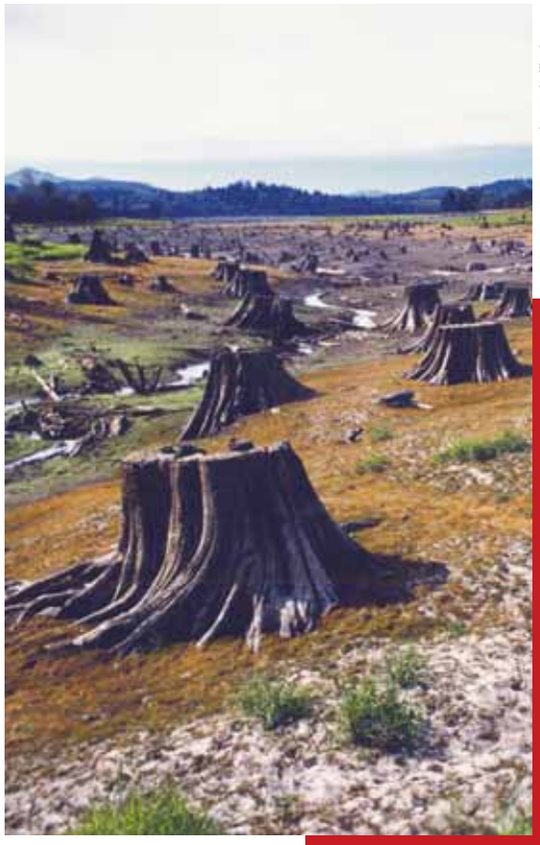


Source: Steven Poe/UNEP/Still Pictures

Source: Roland Seitre/Still Pictures

GEO Indicators

Source: Clyde H. Smith/Still Pictures

● ATMOSPHERE ● DISASTERS CAUSED BY NATURAL HAZARDS ● FORESTS ● BIODIVERSITY ● COASTAL AND MARINE AREAS ● FRESHWATER ● URBAN AREAS ● GLOBAL ENVIRONMENTAL GOVERNANCE

GEO Indicators

The core set of GEO Indicators present global headline trends in selected environmental issues. Together, they present a snapshot of humanity's progress in sustainably managing our planetary habitat.

Continued efforts in the area of environmental monitoring, surveying and remote sensing, data compilation and verification, capacity building and international cooperation are modestly improving the overall data situation. However, there are persisting data gaps and shortcomings that make it impossible to show a comprehensive and regular set of indicators for all issues. Current gaps include data about waste disposal and its management, land degradation and urban air pollution. Each year we include a range of available indicators, particularly including any that have been updated or which shed new light on key trends. Indicators on forest cover and glacier mass change have been reinstated, while new ones are included for threatened bird species and the number of new organizations adopting the ISO 14001 standard on environmental management.

Indicators which are currently used to monitor progress under the Millennium Development Goals (MDGs) are marked as such in the headings. Most indicators are presented comprehensively for major regions and the world as a whole, based on the GEO regional classification. Latest available data are used in all cases.

All the indicators can be accessed from http://geodata.grid.unep.ch, the GEO Data Portal, which provides more background information and many more data sets.

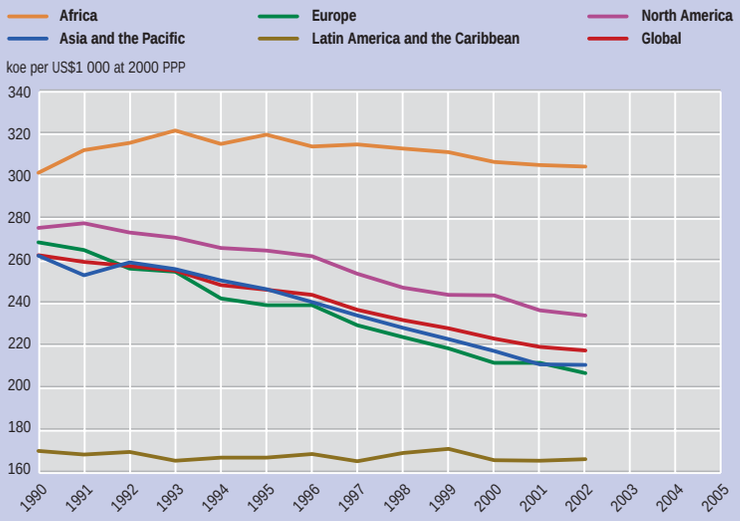
Theme: **ATMOSPHERE** Issues: **Climate change, stratospheric ozone depletion**

Indicator: **Energy use per unit of GDP**

MDG indicator no. 27 under Target 9, Goal 7

Energy intensity – the amount of energy used per unit of GDP – indicates progress in the efficiency of energy use in producing economic output. Changes in the ratio over time also reflect changes in the structure of the economy (for example shifts between agriculture, industry and services).

On the whole, the ratio has been decreasing in most regions, indicating that the overall efficiency of energy use is improving.



no data for West Asia

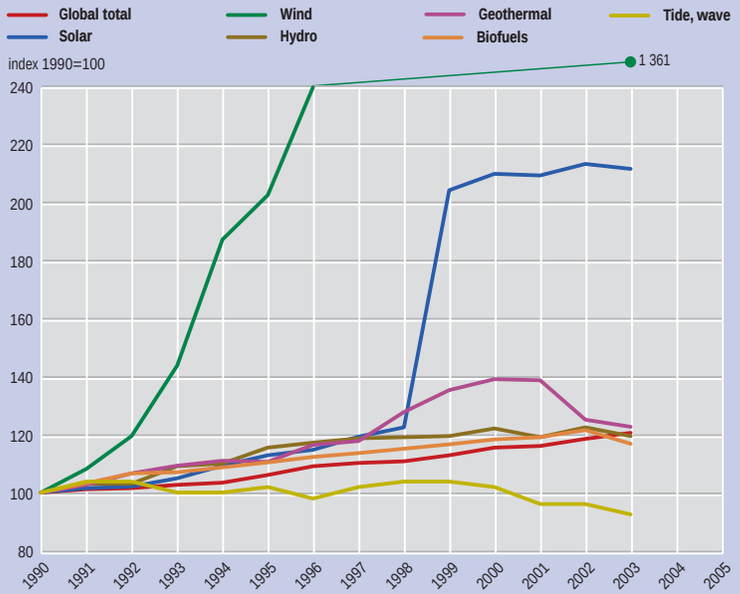
Unit of measurement: Kilogram of oil equivalent (koe) per US$1 000 of GDP converted from national currencies using purchasing power parity (PPP) conversion factors for 2000.

Definition: Energy use is calculated by the International Energy Agency as the production of primary energy, plus energy imports, minus energy exports, minus energy delivered to international marine bunkers, and plus or minus stock changes that happened during the year..

Source: GEO Data Portal, compiled from UNSD 2005

Indicator: **Renewable energy supply index**

Among the renewables, only wind energy saw a small increase compared to previous years. However, as wind energy made up the major proportion of renewables, the global index has continued to show a positive trend. During the 1990s, the share of renewable energy in total energy use increased very slowly, from 12.9 per cent to 13.5 per cent. Since then the share has decreased slightly, down to 13.2 per cent in 2003, due to the continued strong increase in overall energy use.



Unit of measurement: None (index).

Definition: Renewable energy data refer to Total Primary Energy Supply, originally expressed in million tonnes of oil equivalent, for all the countries of the world from 1990 to 2003.

Source: GEO Data Portal, compiled from IEA 2005

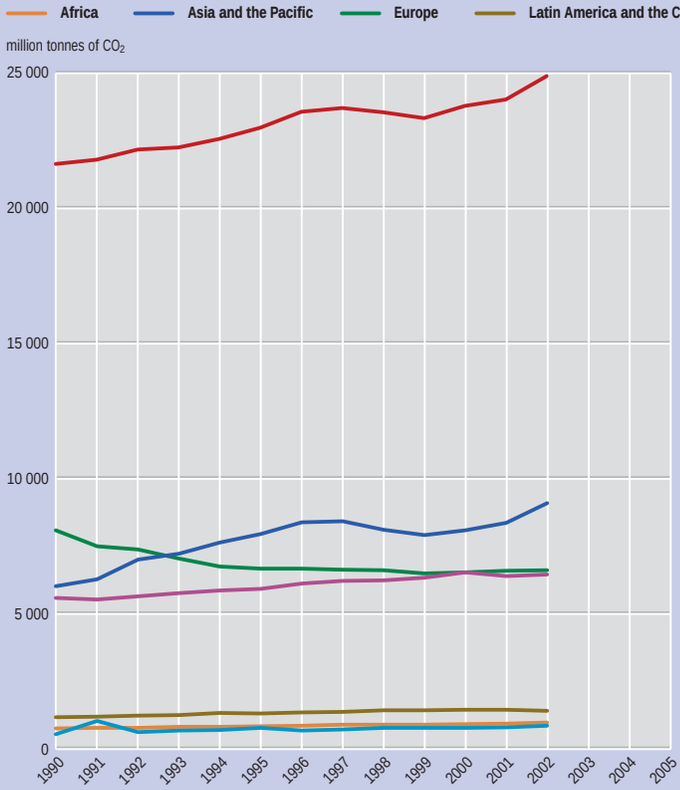
Theme: **ATMOSPHERE** Issues: **Climate change, stratospheric ozone depletion**

Indicator: **Carbon dioxide emissions, total and per capita**

MDG indicator no. 28a under Target 9, Goal 7

Carbon dioxide emissions continue to rise as world consumption of fossil fuels increases. For 2002, the latest year for which comprehensive data are available, global carbon dioxide emissions were estimated to have reached almost 25 billion tonnes, 3.6 per cent more than the year before. Only the Latin America and the Caribbean region showed a decrease during 2002, of 2.4 per cent. Large increases were noted for the Asia and the Pacific and West Asia regions, 8.8 and 8.9 per cent respectively.

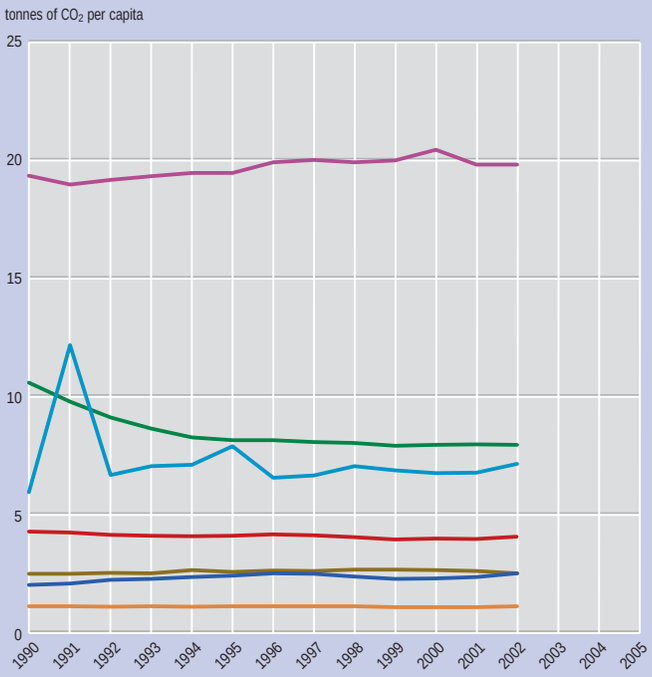
Globally, annual average emissions per capita have been fairly stable since 1990. For 2002, this figure was up to 3.93 tonnes from 3.85 tonnes in 2001.



Unit of measurement: Million tonnes.

Definition: Emission of CO_2 is the total amount emitted as a consequence of human production and consumption.

Sources: GEO Data Portal, compiled from UNFCCC 2005 and Marland and others 2005



Unit of measurement: Tonnes per capita.

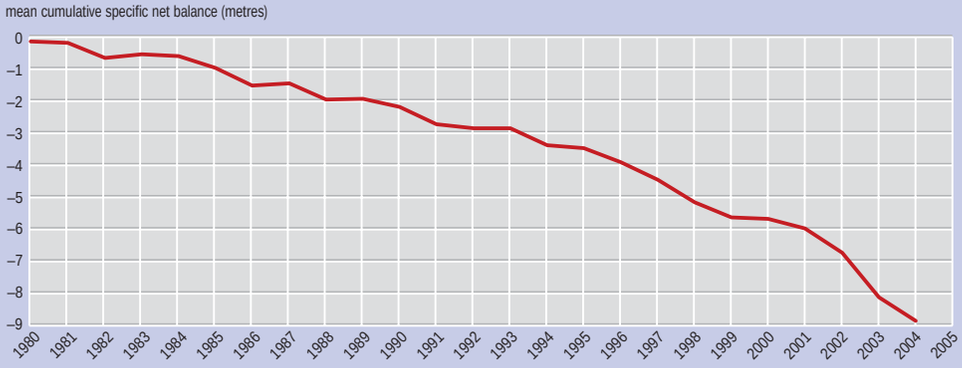
Definition: Emissions of CO_2 per capita is the total amount emitted by a region divided by the region's population.

Additional source: GEO Data Portal, compiled from UN Population Division 2005

The global and regional data are compiled from national data submitted to the United Nations Framework Convention on Climate Change (UNFCCC) by countries listed in its Annex 1, and from estimated country data from the Carbon Dioxide Information Analysis Center (CDIAC) for the rest of the world. National reporting to UNFCCC covers all sources of anthropogenic emissions as well as carbon sinks. In the estimates of the CDIAC, the calculated country emissions of CO_2 include emissions from consumption of solid, liquid and gas fuels; cement production; and gas flaring.

Indicator: **Mountain glacier mass balance**

The average ice thickness of mountain glaciers which are being monitored has been reducing by a few tens of centimetres per year since 1980. The total decrease during 1980–2004 was about nine metres. The global average decrease for 2003 has been estimated at 1.2 metres – the highest value recorded in recent decades. The decrease for 2004 has been estimated at 0.73 metre, which is the second highest record during that period (WGMS 2005a). The current trend is consistent with accelerated global warming. The acceleration in worldwide glacier disappearance has become more and more obvious during the past two decades (WGMS 2005b). The overall retreat of glaciers during the 20th century was in the order of several kilometres for larger glaciers, and hundreds of metres for smaller ones. On realistic projections of future warming, almost complete de-glaciation of many mountain ranges could occur within decades, leaving ice only on the highest peaks and in glaciers that are still thick (WGMS 2005c).



Unit of measurement: Metres.

Definition: Mountain glacier mass balance represents the annual change in thickness for a representative set of 30 major glaciers in nine mountain regions of the world. Mass balance is calculated by dividing the volume of the glacier (expressed in m^3) by area (expressed in m^2). Reliable time-series data are only available for a limited set of glaciers. The mean is strongly influenced by the large proportion of Alpine and Scandinavian glaciers. Thus, the data reflect regional climatic variability but also marked differences in the sensitivity of the observed glaciers.

Source: GEO Data Portal, compiled from WGMS 2005a

Indicator: **Consumption of CFC*, HCFC and MeBr**

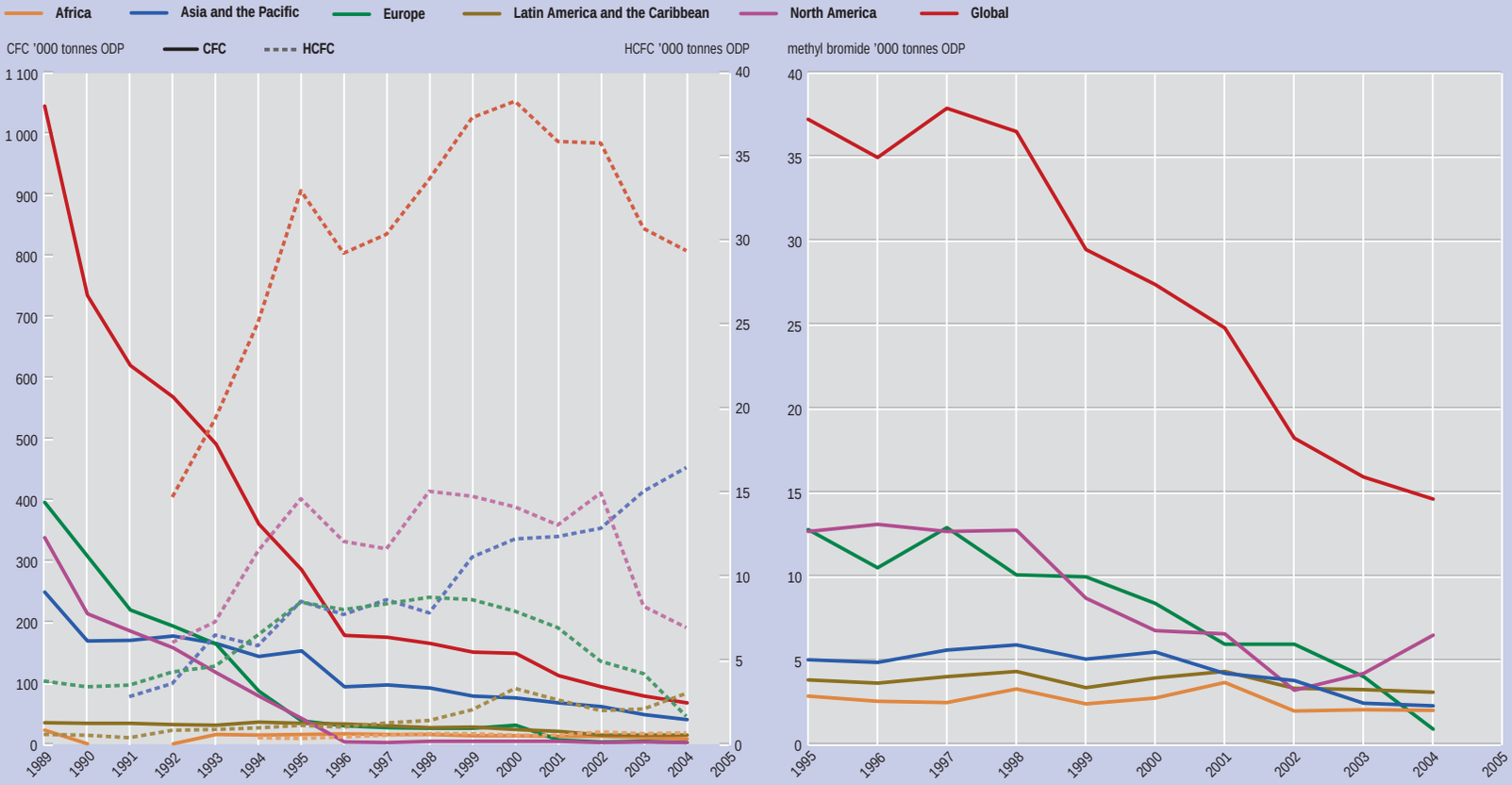
**MDG indicator no. 27b under Target 9, Goal 7*

Stratospheric ozone depletion is caused primarily by increases in concentrations of reactive chlorine and bromine compounds, produced by degradation of anthropogenic ozone depleting substances (ODS). The international process that started in 1985 with the Vienna Convention ended production of most chlorofluorocarbons (CFCs), but led to increased use of hydrochlorofluorocarbons (HCFCs), and the production of a wide range of other chemicals (hydrofluorocarbons, perfluorocarbons and others) (IPCC 2005). HCFCs are much less ozone depleting than CFCs, but they have a significant higher global warming potential.

The use of CFCs has been further decreasing in all regions, and for 2004 stands at 65 000 tonnes for the world, as expressed in Ozone Depleting Potential (ODP). The use of substitute compounds within the group of HCFCs has also been decreasing since the year 2000, and for 2004 was at the level of 29 000 ODP tonnes (UNEP 2005a).

The use of methyl bromide has declined steadily since the mid-1990s. In 2004, it amounted to 15 000 ODP tonnes, with only the North America region showing an increase in that year. Under the Montreal Protocol, developed countries have agreed to a gradual phase-out of methyl bromide between 1999 and the end of 2004, and developing countries between 2002 and 2015. To allow for "critical use" mainly in the agricultural and food-processing sectors, several developed countries have received exemptions to the phase-out, amounting to 853.8 metric tonnes in 2006 (UNEP 2005a).

The ozone layer is expected to begin to recover in coming decades due to declining ODS concentrations, assuming full compliance with the Montreal Protocol (IPCC 2005). However, the ozone hole over the Antarctic in 2005 was still almost the size it was in 2000 and 2003, the two record years when it was the largest, as one would expect from recent levels of chlorine and bromine in the atmosphere. Observed changes in the stratosphere, related to higher concentrations of greenhouse gases (GHGs), could delay the expected recovery of the ozone layer (WMO 2005).



Insufficient data for West Asia

Unit of measurement: Tonnes of ozone-depleting potential.

Definitions: Consumption of CFCs, HCFCs and methyl bromide is defined as production plus imports minus exports of controlled substances, as reported to the Secretariat of the Montreal Protocol by parties.

Ozone-depleting potential (ODP) is the ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11. Thus, the ODP of CFC-11 is defined as 1.0. The five CFCs included are CFC-11, CFC-12, CFC-113, CFC-114 and CFC-115.

The **HCFCs to be phased out** are HCFC-22, HCFC-123, HCFC-124, HCFC-133a, HCFC-141b, HCFC-142b, HCFC-225ca and HCFC-225cb.

Methyl bromide, MeBr or CH_3Br, is to be phased out by 2005 in developed countries and by 2015 in developing countries (except for critical use). In 2004, 11 developed countries which faced a year-end deadline for phasing out methyl bromide were granted limited 'critical use exemptions'.

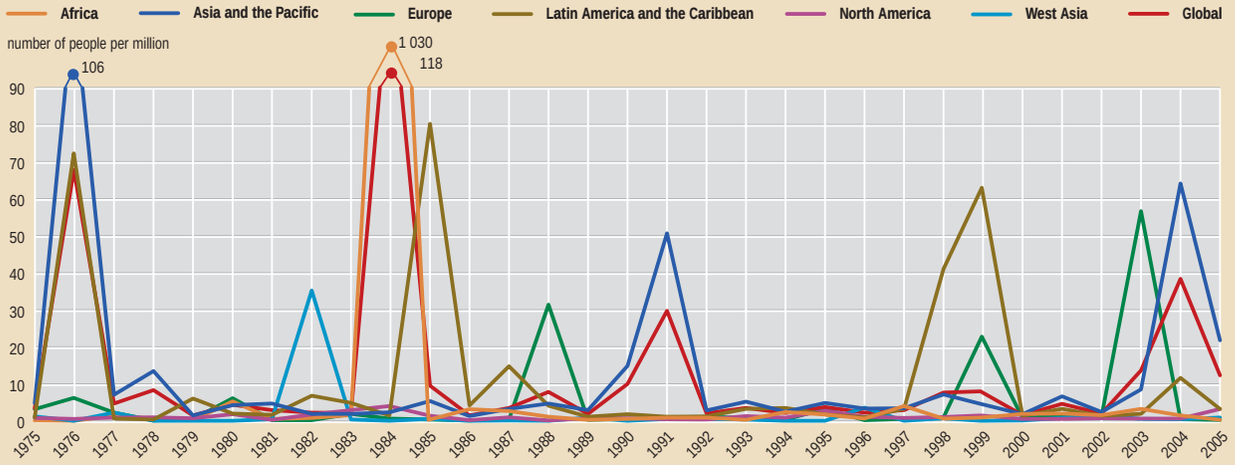
Source: GEO Data Portal, compiled from UNEP 2005b

Theme: **DISASTERS CAUSED BY NATURAL HAZARDS** Issue: **Human vulnerability to extreme natural events**

Indicator: **Number of people killed by natural disasters**

**MDG indicator no. 27b under Target 9, Goal 7*

The year 2004 ended with one of the biggest disasters in recent times – the tsunami in the Indian Ocean. The reported death toll of this disaster is 226 435 (CRED 2005), while about ten times that number were injured, homeless or otherwise affected, and massive damage was incurred by infrastructure, housing and ecosystems. **In total, 241 400 people were reportedly killed in 2004 due to natural hazards.** The year 2005 again saw several major disasters, including the earthquake in Pakistan and many related to typhoons (in Asia) and hurricanes (in the Caribbean and North America).



Unit of measurement: Number of people killed per million of total population.

Definitions: Number of people killed by natural disasters includes people who are confirmed as dead, missing and presumed dead. A **disaster** is defined as a situation or event which overwhelms local capacity necessitating a request to national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering. Natural disasters include earthquakes, volcanic eruptions, droughts, extreme temperatures, insect infestations, floods, landslides, wave/surges, wild fires and wind storms.

Source: GEO Data Portal, compiled from CRED 2005

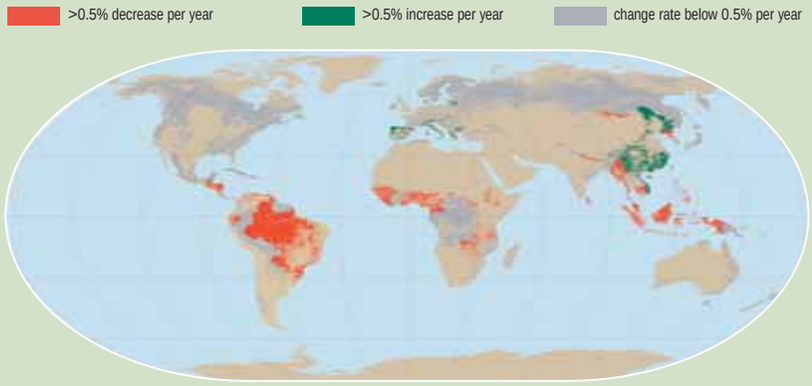
Theme: **FORESTS** Issue: **Deforestation**

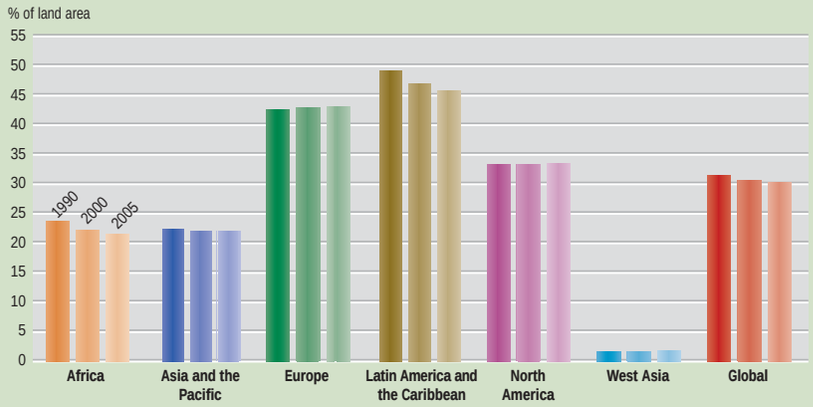
Indicator: **Proportion of land area covered by forest**

MDG indicator no. 25 under Target 9, Goal 7

Global deforestation, mainly through conversion of forests to agricultural land, continues at an alarmingly high rate – about 13 million hectares per year. At the same time, forest planting, landscape restoration and natural expansion of forests – mostly in the Northern hemisphere – have significantly reduced the net loss of forest area. The net loss in forest cover in the period 2000–2005 (deforestation minus reforestation) is estimated at 7.3 million hectares per year – an area about the size of Sierra Leone or Panama. Globally, the forest cover area in 2005 is estimated at 30.2 per cent of total land area, down from 30.5 per cent in 2000 and 31.2 per cent in 1990. The pace of forest loss seems to have decreased slightly, and some regions show a stabilization or net gain.

Although the Latin America and Caribbean region still has the largest proportion of forest area, the decrease here is significant: from 49.2 per cent cover in 1990 to 45.8 per cent in 2005. Africa also shows a continued net loss of forest area with 21.4 per cent in 2005, compared to 23.6 per cent in 1990. Forest areas in Europe and North America continued to expand modestly in this period, while the Asia and Pacific and West Asia regions showed relatively little change.





Unit of measurement: Per cent.

Definition: Forest includes natural forests and forest plantations, and refers to land with more than 10 per cent tree cover and area of more than 0.5 hectares. The term includes forests used for purposes of production, protection, multiple use or conservation, as well as forest stands on agricultural lands (for instance, windbreaks and shelterbelts of trees with a width of more than 20 metres).

Source: GEO Data portal, compiled from FAO 2005a

Indicator: **Ratio of area protected to maintain biological diversity to surface area**

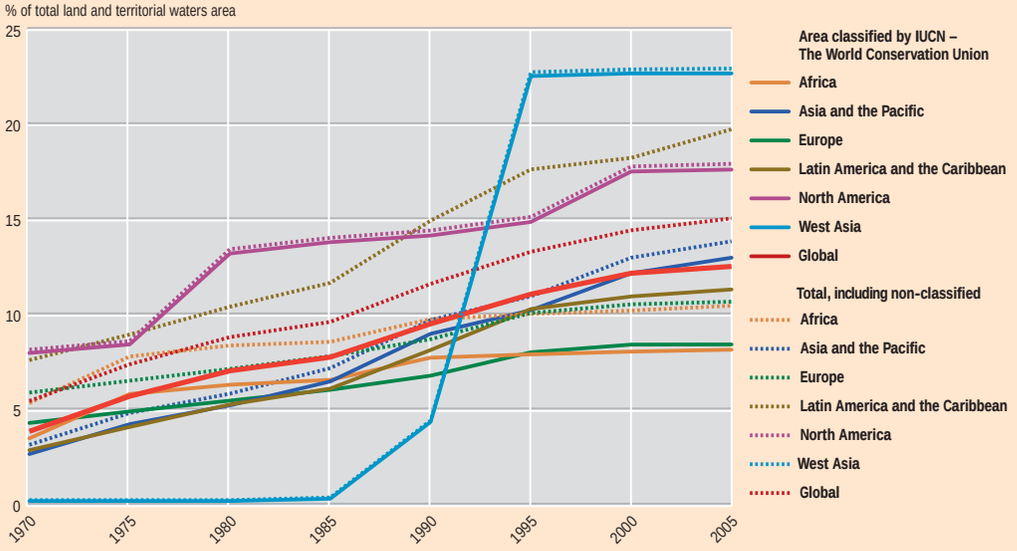
MDG indicator no. 26 under Target 9, Goal 7

There are now over 117 000 protected areas worldwide, taking into account both those classified under any of the six IUCN management categories I to VI (see below), and those not classified. This amounts to 15 per cent of the total territorial surface of the Earth, when including all land area and territorial sea area up to the 12 nautical miles limit.

At the global level, 17 per cent of the protected areas are currently not classified under the IUCN scheme. Several regions have a significant proportion of non-IUCN classified protected areas, most notably Latin America and the Caribbean.

The overall trend in the total surface of protected areas has been steadily upward during the last decades in all regions of the world, but has been levelling off somewhat since 2000. The sudden increase for West Asia is related to the establishment of a single large protected area in 1994 in Saudi Arabia. The total number and area of marine protected areas is relatively very modest, with about 4 000 sites, covering 0.5 per cent of the ocean surface (Chape and others 2005).

It should be noted that several shortcomings persist in data on protected areas. For example, the trends depicted here exclude protected areas for which no starting data was known.



Unit of measurement: Per cent.

Definitions: A **protected area** is land and/or sea dedicated to protection and maintenance of biological diversity, and of natural and associated cultural resources.

The six **IUCN management categories** are Strict Nature Reserve (Ia); Wilderness Area (Ib); National Park (II); Natural Monument (III); Habitat/Species Management Area (IV); Protected Landscape/Seascape (V); Managed Resource Protected Area (VI).

Source: GEO Data Portal, compiled from IUCN 2005

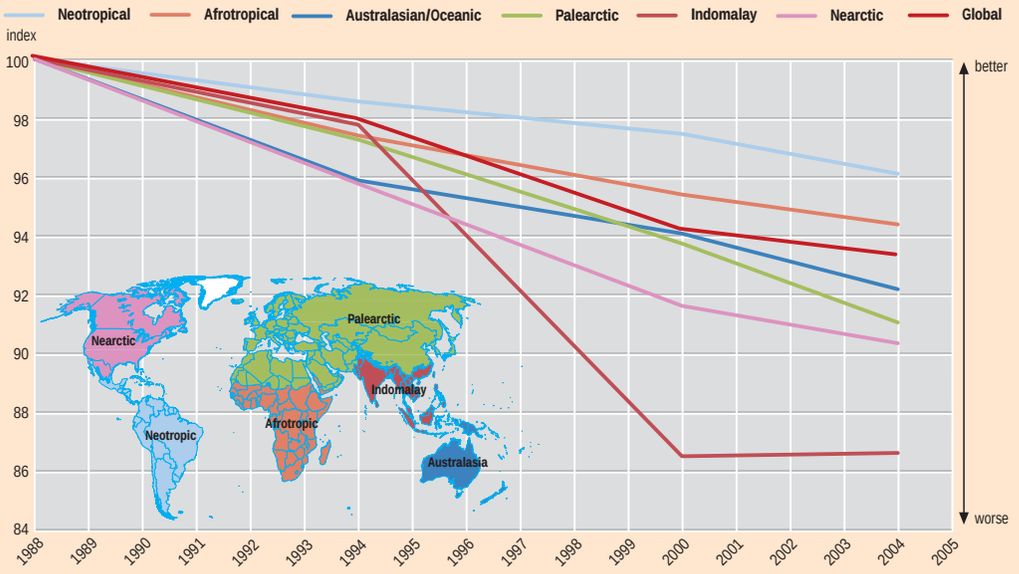
Indicator: **Red List Index for birds**

The IUCN Red List is widely recognized as an authoritative and objective system for classifying species by their risk of extinction, with threat status categories ranging from Least Concern to Extinct. Four complete bird species assessments have been conducted between 1988 and 2004.

Red List Indices (RLIs) use information from the IUCN Red List to illustrate net changes in the overall threat status of sets of species, based on their population, range size and trends. They provide a measure of the rate at which species in a particular group increase or decrease in threat status, for example from vulnerable to endangered. Falling RLI values indicate increases in overall threat status over time – that is, proportionally more species becoming more threatened.

The RLI for the world's birds shows that that their overall threat status has deteriorated steadily since 1988, in all ecosystems and biogeographic realms.

Declines were particularly steep in the Indomalay realm during the 1990s, as a result of intensifying destruction of lowland forests in the Sundaic lowlands of Sumatera and Kalimantan in Indonesia. A preliminary RLI for amphibians for 1980–2004 shows similar rates of decline as for birds, with the steepest declines in the Neotropical and Australasian/Oceanic realms (Butchart and others 2005).



Unit of measurement: None (index).

Definition: The **Red List Index** for birds measures whether the conservation status of a group of species is getting better or worse. RLIs are calculated from the number of species in each Red List category, and the number changing categories between the assessments as a result of genuine improvement or deterioration in threat status (any category changes owing to improved knowledge or revised taxonomy are excluded). The RLI illustrates the relative rate at which species in a particular group change in overall threat status (that is, projected relative extinction risk), as quantified by Red List categories, over periods of around five years. Four species assessments have taken place up to date (1988, 1994, 2000 and 2004). At present, suitable data are available only for birds (Butchart and others 2004).

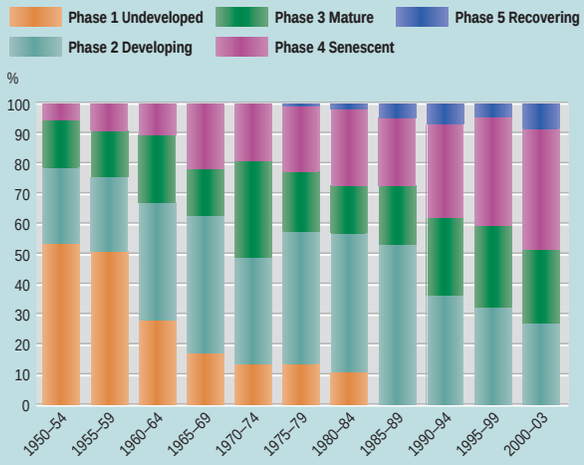
Source: GEO Data Portal, compiled from IUCN 2005

Theme: **COASTAL AND MARINE AREAS** Issue: **Unsustainable use of living marine resources**

Indicator: **World fisheries stocks and marine capture**

Over the last decades, there has been continuing exploitation and depletion of fisheries stocks. Undeveloped fish reserves have disappeared altogether since the mid-1980s. During the last decades, there has been a continued decline in fish resources in the 'developing' phase, and an increase of those in the depleted or over-exploited ('senescent') phase, somewhat offset by the emergence of resources in the 'recovering' phase.

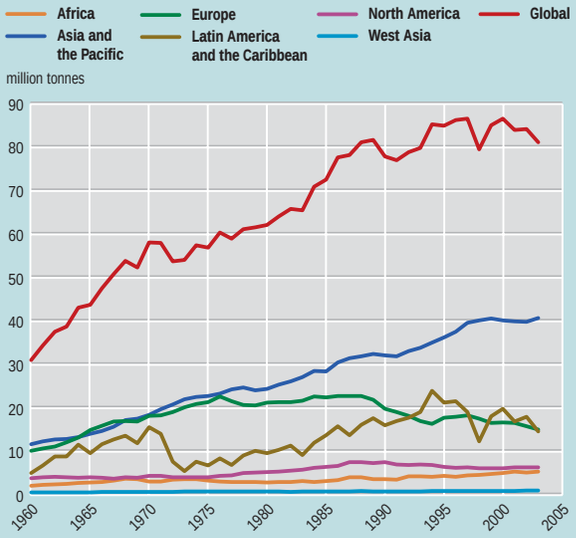
Global harvests from marine fisheries have been above 80 million tonnes per year since the latter half of the 1980s, with peaks of 87 million tonnes in 1997 and 2000. Since then, the total world catch of marine fish, crustaceans and molluscs has declined, with a reported total quantity of about 81 million tonnes for 2003, the latest year for which comprehensive data are available. The decrease is mostly related to declines in fishing zones in the Southeast and Northwest Pacific oceans (FAO 2004).



Unit of measurement: Per cent.

Definition: World fisheries stocks gives the percentage of major marine fishery resources in various phases of fishery development. The development of fisheries on the world's main marine fishery resources since 1950 was chronicled using an initial methodology based on four phases: Undeveloped, Developing, Mature and Senescent. The present analysis also distinguishes fish resources recovering following a senescent phase from those developing for the first time, thus adding a new fifth phase termed Recovering. The top 200 species items for all FAO marine statistical areas, referred to here as "resources" were selected for analysis on the basis of average annual landings over the whole time period 1950–2003.

Source: GEO Data Portal, compiled from FAO 2004



Unit of measurement: Tonnes.

Definition: Marine capture is the nominal catch of fish, crustaceans and molluscs in marine areas. The harvest from mariculture, aquaculture and other kinds of fish farming is excluded. Catches are expressed in live weight – the weight of the organisms at the time of capture. Although the statistics probably reflect general trends reliably, the annual figures involve some uncertainty.

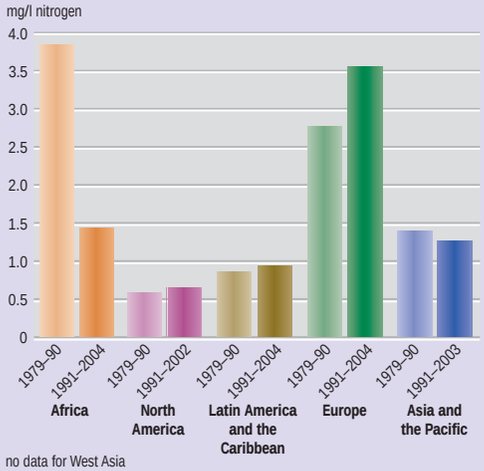
Source: GEO Data Portal, compiled from FAO 2005b

Theme: **FRESHWATER** Issue: **Water quality**

Indicator: **Levels of nitrogen and BOD in rivers, lakes and groundwater**

In water, nitrogen (N) occurs as nitrates (NO_3-N) and nitrites (NO_2-N). These are naturally occurring ions that are part of the nitrogen cycle. High levels of nitrogen can result in a deterioration of water quality. In most countries, nitrate levels in drinking water derived from surface water do not exceed ten milligrammes per litre (mg/l), although nitrate levels in well water often exceed 50 mg/l. Nitrite levels are normally lower, less than a few milligrams per litre (WHO 2004). Although the data among regions are not fully comparable in terms of time periods, the overall level of nitrogen seems to be declining in Africa and the Asia and Pacific regions, but rising in others when compared with the 1979–1990 period.

Biological Oxygen Demand (BOD) gives an indication of the amount of organic matter present in water bodies. A certain level of BOD is always detected in water bodies, usually around two mg/l of oxygen, while higher levels of BOD could imply that the water is contaminated with bacteria and thus poses a risk to human health. Compared with the 1979–1990 period, the average BOD level has increased during recent years in Africa and Latin America and the Caribbean, decreased in North America and Europe, and remained the same in the Asia and the Pacific region.



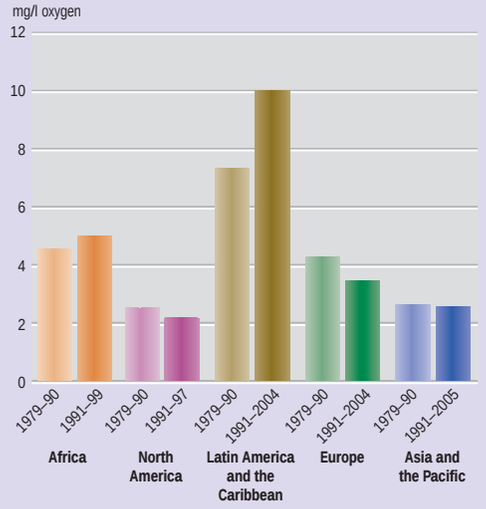
no data for West Asia

Unit of measurement: Milligrammes per litre (mg/l).

Definitions: Surface waters include rivers and lakes. **Nitrate** is the principal form of combined nitrogen found in natural waters. **Total nitrogen** is usually calculated as the sum of particulate nitrogen (which does not pass a 0.45 μm filter) and the resultant dissolved nitrate.

Nitrogen and BOD data are derived from the GEMS/Water Programme database. The figures should be used with caution: the existing database is fairly sparse in regions such as Africa and parts of Latin America and the Caribbean.

Source: GEO Data Portal, compiled from UNEP/GEMS-Water 2005



no data for West Asia

Unit of measurement: Milligrammes per litre (mg/l).

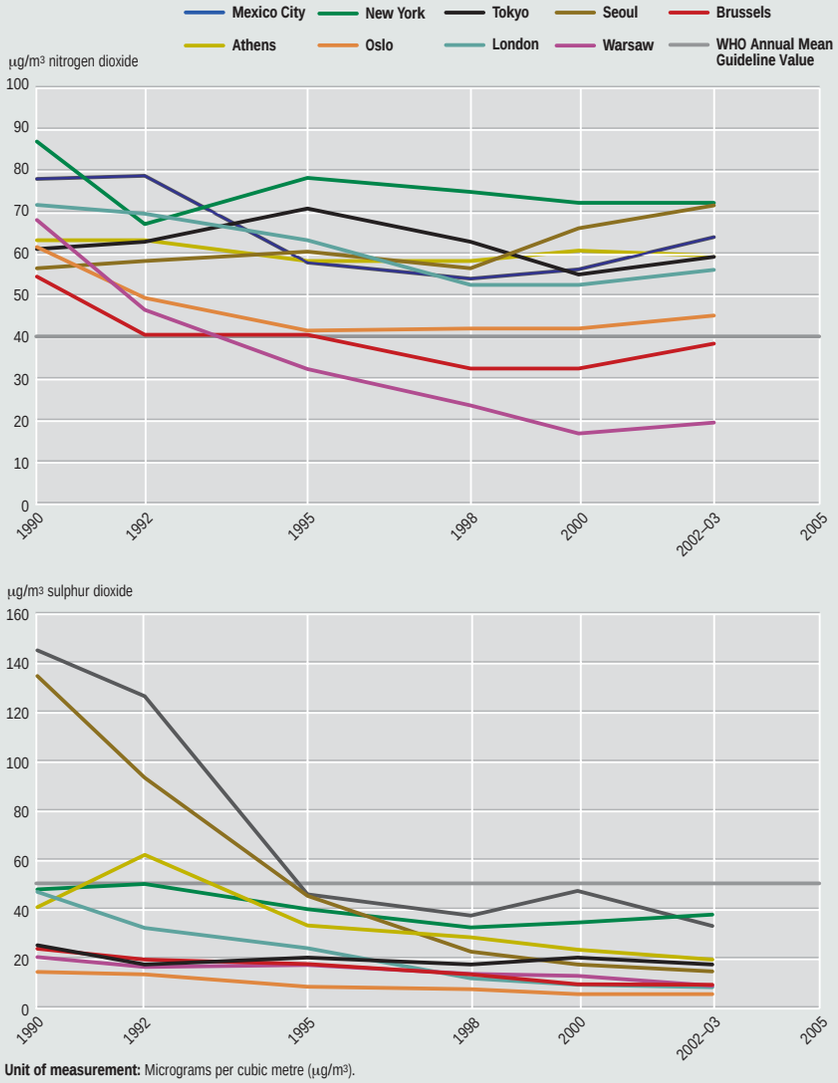
Definition: Biological oxygen demand (BOD) measures the level of organic material in a water body, based on the fact that microorganisms use the oxygen dissolved in water to decompose organic matter in polluted water through a biochemical process, which produces the carbon they need to survive.

Source: GEO Data Portal, compiled from UNEP/GEMS-Water 2005

Theme: **URBAN AREAS** Issue: **Urban air quality**

Indicator: **Concentrations of sulphur dioxide and nitrogen oxides**

Current trends in urbanization, private transport and industrial development in many parts of the world continue to raise concerns about urban air quality and the impacts on human health. Although comprehensive international data on urban concentrations of sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), ground-level ozone and toxic chemicals are not available, recent information for selected cities from the OECD indicates that **levels of SO_2 have decreased substantially since the early 1990s, and are remaining below guideline values set by** WHO. The levels of NO_2 show a more variable picture. Many cities still have concentrations above the WHO guideline, and some have been rising again in recent years (OECD 2005).



Unit of measurement: Micrograms per cubic metre (µg/m³).

Definition: The data provide an indication of trends in ambient air quality in cities. The use of the data is limited because often only one measurement site is available for trend purposes, and in some cities the number of trend sites will change significantly from one year to the next. Caution is needed when interpreting these data, especially because of the large differences in the number of monitoring sites used in calculating citywide averages. Sometimes monitoring is carried out only at sites where there is a severe problem, leading to a bias towards higher concentrations.

Source: GEO Data Portal, compiled from OECD 2005

Theme: **GLOBAL ENVIRONMENTAL GOVERNANCE**

Indicator: **Number of parties to multilateral environmental agreements**

The continuing increase in the number of ratifications of major multilateral environmental agreements (MEAs) shows the growing commitment of countries and regions to address global environmental issues. **At the end of 2005, 78 per cent of the potential participants had become parties to 13 major MEAs when taken together** (Table). In particular, there have been significant increases in the number of Parties to the relatively recent Kyoto Protocol to the UN Framework Convention on Climate Change and the two conventions related to chemicals – the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC) and the Stockholm Convention on Persistent Organic Pollutants (POPs). The Kyoto Protocol entered into force in February 2005. The PIC and POPs agreements entered into force in 2004. By now, a number of MEAs are approaching the maximum number of Parties, including the Vienna Convention and Montreal Protocol on Substances that Deplete the Ozone Layer ("Ozone"), the UN Convention to Combat Desertification (UNCCD), the Convention Concerning the Protection of the World Cultural and Natural Heritage ("World Heritage"), and the Convention on Biological Diversity.

Convention on Biological Diversity (CBD): http://www.biodiv.org/world/parties.asp

Convention on the Conservation of Migratory Species of Wild Animals (CMS): http://www.cms.int/about/part_lst.htm

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): http://www.cites.org/eng/disc/parties/index.shtml

Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage): http://whc.unesco.org/en/statesparties/

Kyoto Protocol to the UN Framework Convention on Climate Change (Kyoto): http://unfccc.int/essential_background/kyoto_protocol/status_of_ratification/items/2613.php

Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer (Ozone): http://www.unep.ch/ozone/ratif.Shtml

Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar): http://www.ramsar.org/key_cp_e.htm

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC): http://www.pic.int/en/ViewPage.asp?id=265

Stockholm Convention on Persistent Organic Pollutants (POPs): http://www.pops.int/documents/signature/signstatus.htm

UN Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification Particularly in Africa (UNCCD): http://www.unccd.int/convention/ratif/doeif.php

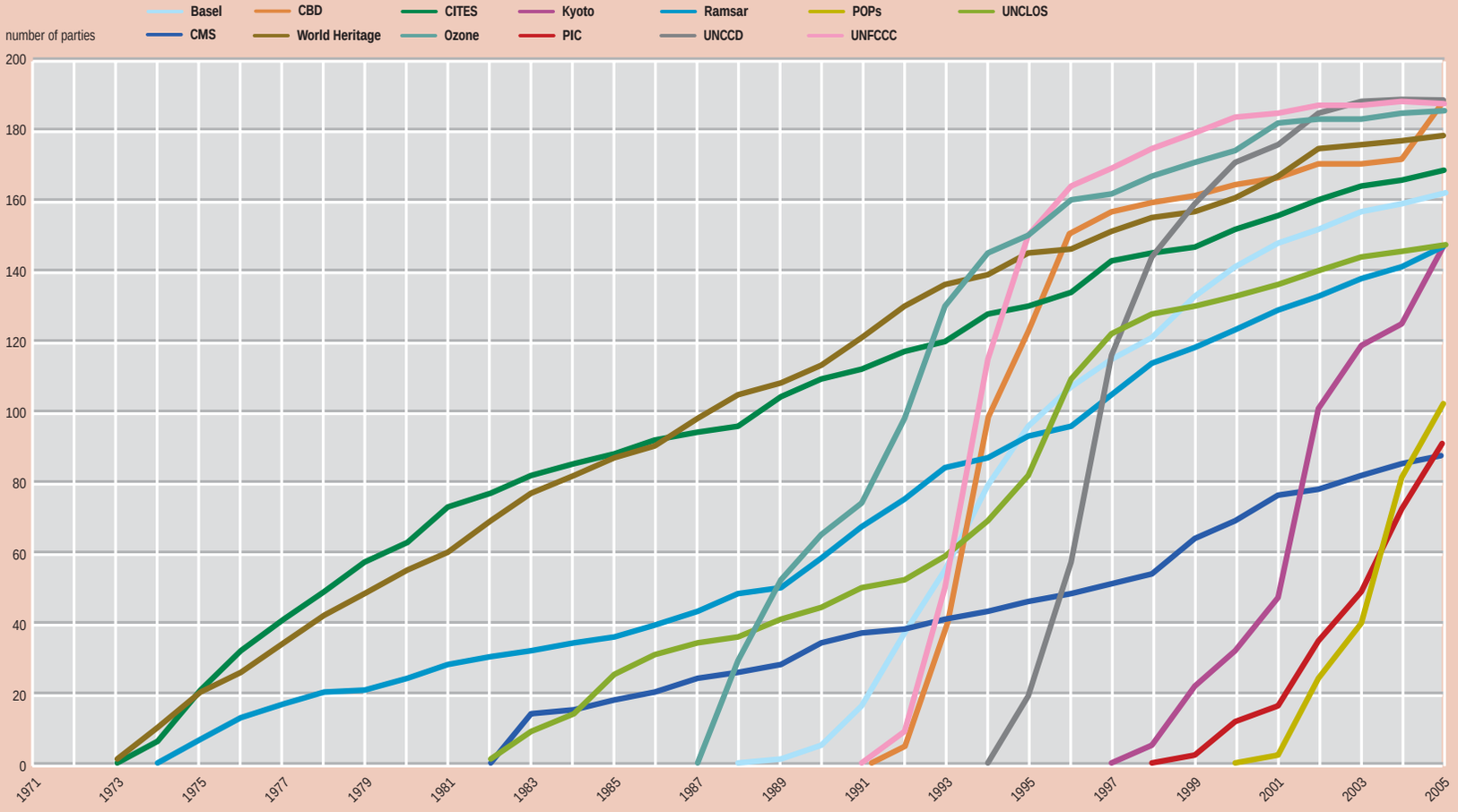
UN Convention on the Law of the Sea (UNCLOS): http://www.un.org/Depts/los/reference_files/chronological_lists_of_ratifications.htm#The United Nations Convention on the Law of the Sea

UN Framework Convention on Climate Change (UNFCCC): http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel): http://www.basel.int/ratif/frsetmain.php

Number of parties to multilateral environmental agreements, 2005

	Basel	CBD	CITES	CMS	Heritage	Ozone	PIC	POPs	Ramsar	UNCCD	UNCLOS	UNFCCC	Kyoto	Total	Potential	% (total/ potential)
Africa (53)	42	52	52	31	46	52	29	29	42	53	39	52	35	554	689	80
Asia + Pacfic (45)	33	45	31	9	40	43	17	23	26	45	33	44	37	426	585	73
Europe (49)	46	46	45	37	48	46	26	25	46	46	38	47	38	534	637	84
LAC (34)	30	32	32	8	32	33	14	19	26	33	27	33	30	349	442	79
North America (2)	1	1	2	0	2	2	1	1	2	2	1	2	1	18	26	69
West Asia (12)	10	10	7	3	11	10	5	6	4	10	9	10	7	102	156	65
Global (195)	162	186	169	88	179	186	92	103	146	189	147	188	148	1 983	2 535	78



Unit of measurement: Number of parties.

Definition: Number of parties to Multilateral Environmental Agreements is the number of countries and political and/or economic integration organizations, which have deposited their instrument of ratification, accession, acceptance or approval of each of the 13 multilateral environmental agreements (MEAs) listed on the left. The list also includes secretariats' Web pages where status of ratification is shown.

Source: GEO Data Portal, compiled from MEA secretariats (see above)

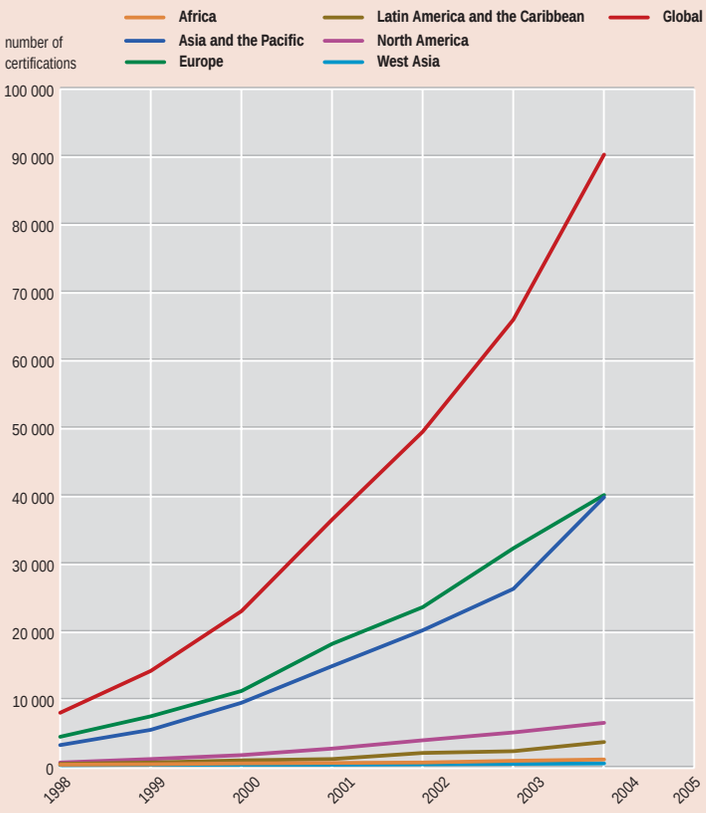
Theme: **GLOBAL ENVIRONMENTAL GOVERNANCE** Issues: **International environmental initiatives**

Indicator: **Number of certifications of the ISO 14001 standard**

The International Organization for Standardization (ISO) 14001 standard, first published in 1996, specifies the actual requirements for an environmental management system in organizations (companies and institutions), with the goal of minimizing harmful effects on the environment and achieving continual improvement of its environmental performance.

ISO 14001 is the only environmental management standard that can currently be certified by an external certification authority. However, it does not itself state specific environmental performance criteria: certifications only give an indication of the extent to which an organization conforms to its own stated environmental policy (ISO 2005a).

For 2004, the total number of organizations with the ISO 14001 certification stood at 90 569 (in 127 countries), up from 66 070 (in 113 countries) in 2003, a 37 per cent increase. The European and Asia and the Pacific regions account for 88 per cent of the world figure. All regions have shown significant increases since the start of the certification process, with average annual increases of around 50–70 per cent. The numbers in West Asia and Africa are still relatively low (230 and 818 certificates in 2004 respectively) (ISO 2005b).



Unit of measurement: Number of certifications

Definitions: Number of certifications of ISO 14001 standards gives the number of organizations (enterprises, institutions) that have received the ISO 14001certificate.

ISO 14000 is a series of international standards on environmental management, providing a framework for the development of an environmental management system and supporting audit programme.

ISO 14001 is the cornerstone standard of the series, and specifies a framework of control for an Environmental Management System against which an organization can be certified by a third party. It applies to those environmental aspects over which the organization has control.

The standard is applicable to any organization that wishes to:

- implement, maintain and improve an environmental management system;
- assure itself of its conformance with its own stated environmental policy (those policy commitments of course must be made);
- demonstrate conformance;
- ensure compliance with environmental laws and regulations;
- seek certification of its environmental management system by an external third party organization; and
- make a self-determination of conformance.

ISO performs the 14001 survey annually by requesting certification data from a variety of sources, including national standards institutes, accreditation and certification bodies and regional databases. The survey does not pretend to academic rigour in its compilation, to scientific accuracy in its results, nor to being exhaustive, and so a degree of caution is advised in interpreting the data.

Source: GEO Data Portal, compiled from ISO 2005b

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Acronyms and abbreviations

ABC	atmospheric brown cloud
ANWR	Arctic National Wildlife Refuge
AZE	Alliance for Zero Extinction
Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
BOD	biological oxygen demand
CBD	Convention on Biological Diversity
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CDIAC	Carbon Dioxide Information Analysis Center
CFCs	chlorofluorocarbons
CHP	combined heat and power
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
DALY	disability-adjusted life years
DME	dimethyl ether
EAIS	East Antarctic Ice Sheet
EANET	Acid Deposition Monitoring Network East Asia
ECC	Environmental Conservation Corps
EEA	European Environment Agency
ETS	Emissions Trading Scheme (of the EU)
EU	European Union
EVI	Environmental Vulnerability Index
FAO	Food and Agriculture Organization of the United Nations
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEMS	Global Environment Monitoring System
GEO	Global Environment Outlook (of UNEP)
GHG	greenhouse gas
GM	genetically modified
GRASP	Great Apes Survival Project
GRID	Global Resource Information Database
HCFCs	hydrochloroflourocarbons
HEVs	hybrid electric vehicles
HIPC	Highly Indebted Poor Countries
HIV/AIDS	human immunodeficiency virus/acquired immunodeficiency syndrome
IEA	International Energy Agency
ILO	International Labour Organization
IIASA	International Institute for Applied Systems Analysis
IMO	International Maritime Organization
INDOEX	Indian Ocean Experiment
IOC	Intergovernmental Oceanographic Commission
IOTWS	Tsunami Warning and Mitigation System for the Indian Ocean
IPCC	Intergovernmental Panel on Climate Change
IPHE	International Partnership for the Hydrogen Economy
ISO	International Organization for Standardization
IUCN	World Conservation Union
IUU	Illegal, Unregulated and Unreported (fishing)
KISR	Kuwait Institute for Scientific Research
koe	kilogram of oil equivalent
Kyoto Protocol	Kyoto Protocol to the UN Framework Convention on Climate Change
LPG	liquefied petroleum gas
MA	Millennium Ecosystem Assessment
Madrid Protocol	The Protocol on Environmental Protection to the Antarctic Treaty 1991
MAP	Madre de Dios (Peru), Acre (Brazil) and Pando (Bolivia)
MDGs	Millennium Development Goals
MEA	Multilateral Environmental Agreement
MeBr	methyl bromide
N	nitrogen
NASA	National Aeronautics and Space Administration (of the United States)
NEPAD	New Partnership for Africa's Development
NO	nitric oxide
NO_2	nitrogen dioxide, nitrites
NO_3	nitrates
NOAA	National Oceanic and Atmospheric Administration (of the United States)
NO_x	nitrogen oxides
NPRA	National Petroleum Reserve in Alaska
O_3	ozone
ODP	ozone depleting potential
ODS	ozone depleting substance
OECD	Organization for Economic Cooperation and Development
PAHs	polyaromatic hydrocarbons
PCP	pentachlorophenol
PIC	Prior Informed Consent
PM	particulate matter
POPs	persistent organic pollutants
PPP	purchasing power parity
PV	photovoltaic
Ramsar Convention	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
RLIs	Red List Indices
Rotterdam Convention	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
SIDS	Small Island Developing State(s)
SO_2	sulphur dioxide
SPM	suspended particulate matter
Stockholm Convention	Stockholm Convention on Persistent Organic Pollutants
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USEPA	United States Environmental Protection Agency
USGS	United States Geological Service
UV	ultraviolet
WAIS	West Antarctic Ice Sheet
WHO	World Health Organization
World Bank	International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA)
World Heritage Convention	Convention Concerning the Protection of the World Cultural and Natural Heritage
WWF	World Wide Fund for Nature

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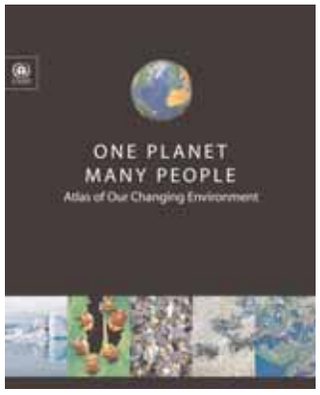

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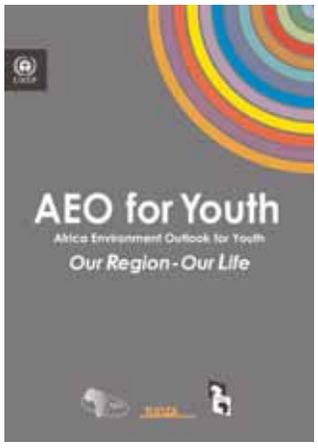

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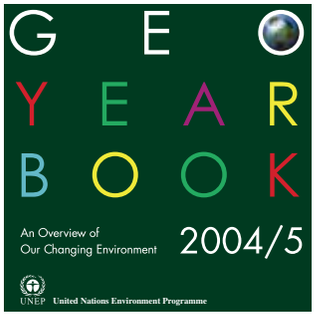

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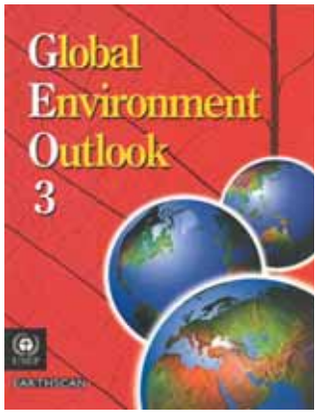

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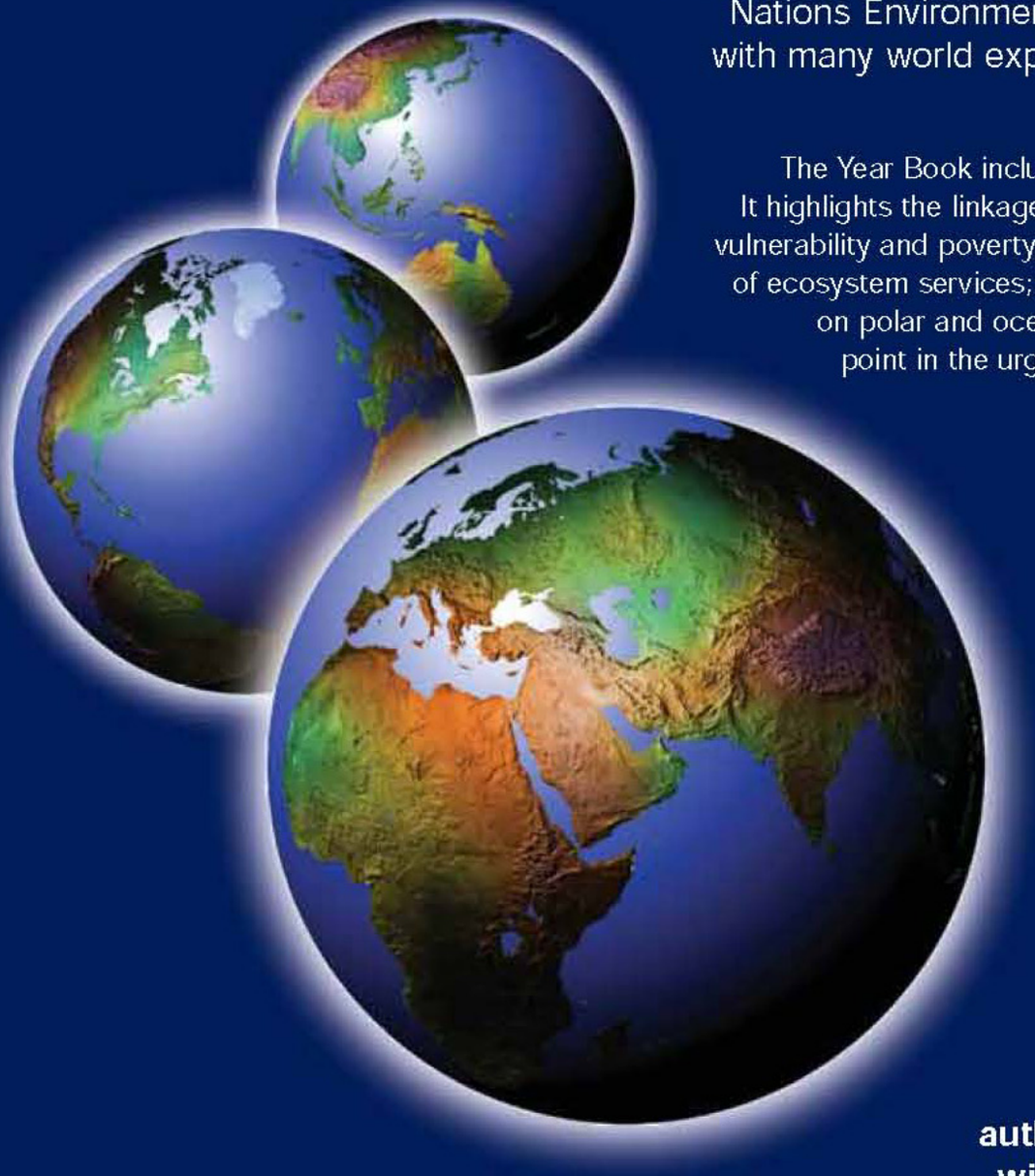

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