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THE STATE OF THE WORLD ENVIRONMENT

May 1991

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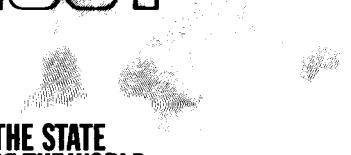

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CONTENTS

Page

PREFACE i

SUMMARY iii

PART I THE STATE OF THE ENVIRONMENT

Chapter 1 The Socio-economic Environment 1
Chapter 2. Environmental Quality 7

PART II. FOCUS ON: BIOLOGICAL DIVERSITY .....

Chapter 3. Biological Diversity 19

PART III. FOCUS ON: SHARED WATER RESOURCES

Chapter 4: Shared Water Resources 27

PART IV. FOCUS ON: MARINE ENVIRONMENT

Chapter 5: Marine Environment 35

References 45

PREFACE

One of the main functions assigned to the Governing Council of the United Nations Environment Programme by the General Assembly in resolution 2997 (XXVII) of 15 December 1972 is:

> *"To keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration by Governments."*

Accordingly, each year the United Nations Environment Programme issues a report on the state of the environment.

At its thirteenth session, the Governing Council of UNEP decided that the state-of-the-environment reports should alternate in successive years between a report on economic and social aspects of the environment and a report on environmental data and assessment (decision 13/9 D, para.2). Accordingly, UNEP published in 1988 a state-of-the-environment report dealing with the public and environment, and in 1989 a report on the state of the world environment which was an update of the 1987 report, but with in-depth treatment of two issues: greenhouse gases and climate, and hazardous waste (according to decision 14/9 B, para. 7, requesting the Executive Director to focus, in the state of the world environment reports, on specific subjects and/or geographical areas).

At its first special session in 1988, the Governing Council of UNEP decided that the topic of the state-of-the-environment report for 1990 should be children and the environment (decision SS.I/2). At its fifteenth session, the Governing Council approved the outline proposed by the Executive Director with some additional sections (decision 15/13 A, paras.2 and 6). By the same decision (para.7a), the Governing Council requested the Executive Director to continue to produce in odd years reports on the state of the environment along the lines of the 1989 report.

Accordingly, in 1990 UNEP published a state of the environme nt report dealing with children and the environment. As requested by the Governing Council, the report was prepared in co-operation with UNICEF.

The present report has been prepared in compliance with decision 15/13 A, para. 7a. It is an update of the 1989 state of the world environment report focusing on developments that have taken place since 1989. Three topics that are receiving world-wide attention have been selected for in-depth treatment. These are: (a) biological diversity; (b) shared water resources; and (c) the state of the marine environment.

In the preparation of this report we have relied on relevant information included in various reports published by UNEP, the 1990 report of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) on the state of the marine environment, assessments published by GEMS, and many recent publications by United Nations bodies, IGOs, NGOs

and scientific institutions. Two publications are of direct relevance to this report: the World Resources, 1990-1991 report prepared by the World Resources Institute in collaboration with UNEP and UNDP, and published by Oxford University Press in 1990; and UNEP's Environmental Data Report published by Blackwell in 1989.

On 16 January 1991, conflict erupted between Iraq and Kuwait. The Executive Director will report to the Governing Council in due time on the different environmental impacts of this war. The report will be issued as an addendum to his Introductory Report to the Governing Council.

Mostafa Kamal Tolba
Executive Director
United Nations Environment Programme

Nairobi, February 1991

SUMMARY

The world's population reached 5.3 billion in 1990 and is expected to grow by another one billion to reach 6.3 billion by 2000. About 93 per cent of this population growth will be in the developing countries. Although there has been marked progress in improving health conditions throughout the world in the 1980s, enormous gaps remain between the rich and poor in developed and developing countries, and especially between the two groups of countries.

Economic performance in the 1980s was erratic and has varied widely among countries and continents. In general, economic growth was much slower in the 1980s than in the 1970s. In the developing countries, external debt has escalated, prices for raw commodities have fallen, and adjustment policies have not functioned as expected. One-third of the population of the developing countries - some 1.2 billion people - live under the poverty line of $370/person/year. For these poor, structural adjustment has done virtually nothing. On the contrary, it has increased their plight. By the end of the 1980s, many Governments in the developing countries have remained pre-occupied with short-term economic and political crises. In their efforts to adjust, environmental and natural resource management and conservation have ranked extremely low on their priority lists. For many developing countries, the 1980s has been a lost decade, economically as well as environmentally.

Air pollution continues to be a major environmental problem in most countries. Although levels of sulphur dioxide, suspended particulate matter, nitrogen oxides and carbon monoxide emissions declined or at least stabilized in many urban areas as a result of environmental control measures, about half of the population of urban areas worldwide - some 990 million - are still exposed to unhealthy levels of sulphur dioxide and more than one billion people exposed to excessive levels of particulates. In some areas, tropospheric ozone, the principal ingredient in urban smog, is of particular concern. Recently, another oxidant - hydrogen peroxide - that may significantly degrade air quality has been identified in urban air environments. Some 260 volatile organic compounds (VOCs) have been measured in outdoor air and 66 VOCs in indoor air; the health effects of these compounds still have to be evaluated. Exposure to the radioactive decay products of radon in homes is a leading cause of lung cancer. Studies have shown that more than 90 per cent of the lung cancer risk associated with radon could be controlled by eliminating tobacco smoking.

Acidic deposition continues to be a major international environmental issue. It threatens fisheries, agriculture and wildlife, and has been implicated as one of the reasons behind the extensive dieback of forests in Europe. A recent assessment of forest damage in Europe indicates that of a total forest area of 141 million ha, some 50 million ha (or 35 per cent) are damaged to varying degrees. In 1987, the Protocol to the Convention on Long-range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent entered into force. The Protocol requires participating nations to reduce either national sulphur emissions or their transboundary flows by 30 per cent from 1980 levels by 1993. The Protocol concerning the Control of Emissions of Nitrogen Oxides and their Transboundary Fluxes, signed in November 1988, calls for a freeze on

emissions at the 1987 levels in 1994, as well as further discussions beginning in 1996 aimed at actual reductions. A November 1988 directive by the EEC would lower community-wide emissions of sulphur dioxide from existing power plants by a total of 57 per cent from 1980 levels by 2003, and emissions of nitrogen oxides by 30 per cent by 1998. These regulatory measures represent milestones in efforts to reduce airborne emissions.

Further progress has been made to protect stratospheric ozone from depletion. The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer - which came into force on 1 January 1989 - has been strengthened in the light of recent extensive studies carried out by four international panels under the auspices of UNEP. At a meeting convened in June 1990 in London, the Parties to the Montreal Protocol agreed that controlled chlorofluorocarbons should be phased out by 2000 with intermediate cuts of 50 per cent by 1995, and 85 per cent by 1997. Halons and carbon tetrachloride are also to be phased out by 2000. Methyl chloroform will be frozen at 1989 levels by 1993, and phased out by 2005. The 1990 London meeting also agreed to establish an international fund to help developing countries meet the costs of complying with the revised Protocol and to provide the necessary transfer of technology.

The Intergovernmental Panel on Climate Change (IPCC), created under the auspices of UNEP and WMO, carried out extensive studies on greenhouse gases and the possibility of climate change, the impacts of such changes and the formulation of response strategies. The IPCC studies were presented at the Second World Climate Conference, convened in 1990. The international community is preparing to start negotiating an international agreement to deal with climate change, particularly through controlling the emission of greenhouse gases other than chlorofluorocarbons, which have been regulated under the Montreal Protocol.

The goals set by the International Drinking Water Supply and Sanitation Decade (IDWSSD) (1981-1990) - to provide all people with clean water supplies and adequate sanitation facilities by 1990 - were not achieved, in spite of the fact that IDWSSD has been able to provide about 1.4 billion people in developing countries with safe, clean water and about 1.5 billion with sanitation services. There are still some 1.2 billion people - or 31 per cent of the population in developing countries - without access to safe clean water: and 1.8 billion - 43 per cent of the population - are without access to appropriate sanitation facilities. The slow progress towards achieving the goals of IDWSSD has been attributed to population growth, the unfavourable world economic situation and the debt burden of developing countries, which has been a major obstacle to investment in infrastructure projects.

Recent studies from a number of countries have shown that the rate of deforestation is higher than previously estimated. Based on these studies, it has been estimated that global tropical deforestation is most likely in the range of 14-20 million hectares per year. More than 60 countries have decided to prepare national forestry action plans to guide management of their forests, within the framework of the Tropical Forestry Action Plan (TFAP) initiated in 1985. This TFAP planning process has helped stimulate an increase in investment in tropical forestry to US $ one billion in 1989 or 70 per cent of the amount originally called for by TFAP.

Focus on: Biological Diversity

The number of living species on Earth varies from 5 to 80 million, of which only 1.4 million have been briefly described. Species richness increases from the poles to the equator; species are more concentrated in tropical forests. Wild species and the genetic variation within them make substantial contributions to the development of agriculture, medicine, and industry. They also have many benefits for the environment. The total economic value of the full range of goods and services which biological diversity provides is difficult to estimate. There is no precise estimate of the number of species that have been lost in major habitats. Experts have concluded, however, that 25 per cent of the Earth's total biological diversity is at serious risk of extinction during the next 20-30 years. Recognizing the growing severity of threats to biological diversity and the increasingly international nature of the actions required to address the threats, a global strategy dealing with all aspects of biological diversity is being prepared by the World Resources Institute, the International Union for the Conservation of Nature and Natural Resources (IUCN), and UNEP, in collaboration with several other institutions, and will be published in 1992. Furthermore, IUCN, FAO and UNEP have embarked on the preparation of an International Convention on the Conservation of Biological Diversity.

Focus on: Shared Water Resources

Many of the water resources in the world are shared by two or more states. About 50 countries have 75 per cent or more of their total area within international river basins, and an estimated 35-40 per cent of the world population live in these basins. The joint use of international watercourses has always depended on co-operation among the riparian states. Treaties to regulate the use of shared water resources exist for virtually all international river basins and lakes. Some of these treaties have been modified over the years to include provisions for controlling the discharge of wastes into joint water bodies and to improve their quality. Since international water basins provide considerable opportunities for socio-economic development, especially in developing countries, new comprehensive approaches to water management have been proposed. One of these approaches is embodied in the environmentally sound management of inland waters' programme of UNEP (the EMINWA programme). Within the framework of this programme, an action plan for the environmentally sound management of the common Zambezi river system (the ZACPLAN) was adopted in 1987. Another project in the final stages of development is a master plan for the management of the Lake Chad basin area.

Focus on: Marine Environment

Oceans cover more than 70 per cent of the Earth's surface and contain some of the Earth's most complex and diverse ecosystems. Although the coastal zone constitutes only about 10 per cent of the total oceanic area, it accounts for more than half of the ocean's biological productivity and supplies nearly all the world's catch of fish. In addition, coastal areas contain many kinds of ecosystems that are vital to marine life and humankind. In fact, about 60 per cent of the world population, or nearly 3 billion people, live on or within some 100 km of a sea coast. Coastal areas receive discharges from rivers, surface run-off and drainage from the hinterland, domestic and industrial effluents through outfalls, and various

contaminants from ships. All these discharges have affected the marine environment in many ways. Several kinds of international and national legislation have been enacted to protect the marine environment. Although this legislation is essential, the most important prerequisite for the protection of the marine environment is the appropriate and environmentally sound planning of human activities, especially in densely populated coastal areas. Such an approach has been reflected in the regional action plans developed by UNEP's Regional Seas Programme

Chapter 1

THE SOCIO-ECONOMIC ENVIRONMENT

1. In 1989 and 1990, about 180 million people were added to the human family; the world's population reached 5.3 billion in 1990 and is expected to grow by another one billion to reach 6.3 billion by 2000. (1,2) About 93 per cent of this population growth has been in the developing countries. The annual rate of population growth in the developed countries decreased from 0.65 per cent per year in the period 1980-1985 to 0.53 per cent per year in the period 1985-1990. In contrast, the annual rate of population growth in the developing countries as a whole remained constant throughout the entire decade of the 1980s, at 2.10 per cent per year. However, regional differences existed. In East Asia, South-East Asia, Central America and the Caribbean, there have been marked declines in population growth rates in the 1980s. In Africa, by contrast, the growth rate has actually increased over the last decade, and is estimated at 3 per cent per year. In Asia, growth rates show significant differences from one sub-region to another. China, with nearly a quarter of the world's population, has dramatically reduced its population growth rate in recent years, from 2.20 per cent per year in 1970-1975 to 1.23 per cent per year in 1980-1985, but showed a slight increase to 1.39 per cent per year in 1985-1990. (1) The five most populous countries: China, India, USSR, USA and Indonesia accounted for 51 per cent of the world's population in 1990 and will account for half of the world's population in 2000. The five countries will account for 42 per cent of the total growth in the world's population between 1990 and 2000.

2. In the 1980s there has been marked progress in improving health conditions throughout the world. Infant mortality has fallen (from an average of 79 per 1000 births per year in 1980-1985 to 71 per 1000 births per year in 1985-1990) and life expectancy at birth has risen (from an average of 60 years to 62 years during the same periods). Yet enormous gaps remain between the rich and poor in developed and developing countries, and especially between the two groups of countries. Life expectancy at birth now exceeds 73 years in the developed countries, as compared to 60 years in developing nations. Differences also exist between developing regions. In Africa, life expectancy at birth is only 52 years while in South Asia it is 57 years and in Latin America 66 years. Infant mortality rates have fallen in nearly 150 countries in the last decade. Industrial countries now have the lowest infant mortality rate (9 per 1000 live births). But childhood deaths remain high in developing countries, particularly in Africa south of the Sahara. Infant mortality in 34 developing countries (2 countries in Latin America and the Caribbean, 2 in the Middle East and North Africa, 23 in Africa south of the Sahara, and 7 countries in Asia) is still more than 100 per 1000 live births. (3) Diarrhoeal diseases, acute respiratory infections, measles, tetanus and malaria are the immediate causes of the death of 40,000 children below the age of five every day. But malnutrition, lack of access to safe water or to sanitation and primary health care, and ignorance and poverty are all major factors in these deaths.

The lost decade

3. Economic performance in the 1980s was erratic and has varied widely among countries and continents. Economic turbulence and uncertainty persisted by the end of 1990. After a sharp recession at the beginning of the 1980s, there was a gradual slow recovery in industrial countries and the average gross domestic product (GDP) increased from 1.9 per cent in 1981 to 4.6 per cent in 1984. In 1985, however, GDP dropped to 2.8 per cent, but recovered in 1988 to 4.3 per cent then dropped again to 2.7 per cent in 1990. (4,5) A more or less similar picture prevailed in the developing countries in which GDP increased to 5.1 per cent in 1984 then dropped to 3.1 per cent in 1990. In both the developing countries and industrial market economies economic growth was much slower in the 1980s than in the 1970s. However, in parts of Asia, economic growth in the 1980s was greater than ever before. But in Africa and Latin America hundreds of millions of people have seen economic decline and regression rather than growth and development. The living standards of millions in Latin America are now lower than in the early 1970s. In most of Sub-Saharan Africa, living standards have fallen to levels last seen in the 1960s. (4) In general, the 1980s have seen economic deterioration in much of the developing world. This has resulted both from external events beyond nations' control, as well as from policy decisions on the part of developing world Governments. The decade has seen escalating external debt, falling prices for raw commodities, and adjustment policies that have exacted a severe toll from the poor. For many of the world's poor, the 1980s was a "lost decade" - a disaster indeed, as concluded by the World Bank. (4)

4. Poverty has been defined in several ways. Perhaps the most eloquent definition is that of Robert MacNamara, the former president of the World Bank, who described absolute poverty as "a condition of life so limited by malnutrition, illiteracy, disease, squalid surroundings, high infant mortality, and low life expectancy as to be beneath any reasonable definition of human decency". (6) This means that poverty is, indeed, far more than just an economic condition. The World Bank (4) has recently used two poverty lines to estimate the number of poor people in developing countries. Those whose annual consumption is less than $370 per person per year are considered poor, and those whose annual consumption is less than $275 per person per year are considered extremely poor. The use of the upper poverty line $370 gives an estimate of 1,116 million people in the developing countries living in poverty in 1985. That is roughly one-third of the total population of the developing countries. Of these, 630 million people were classified as extremely poor. The World Bank estimates that the number of poor people could be reduced to 825 million by 2000 (i.e. to 18 per cent of the population of the developing countries) if strategies aiming at efficient labour-intensive growth and adequate provision of social services gain wider acceptance.

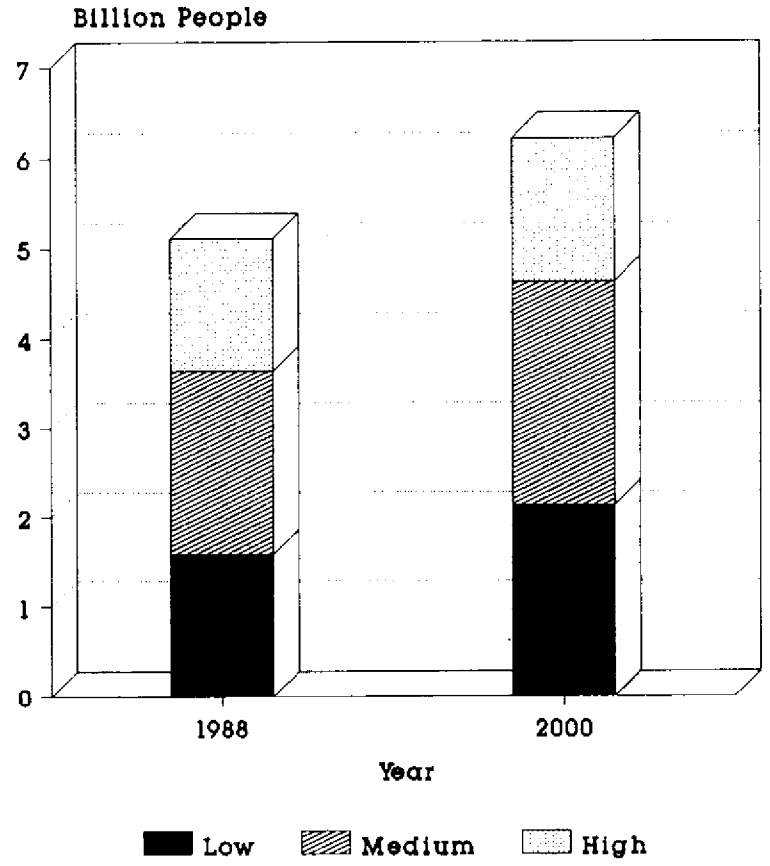
5. The numbers given above conceal considerable variations within and among countries. As a matter of fact, the burden of poverty is spread unevenly among the regions of the developing world, among countries within those regions, and among localities within those countries. Nearly half of the world's poor live in South Asia, a region that accounts for roughly 30 per cent of the world's population. Within regions and countries, the poor are often concentrated in certain places: in rural and semi-urban areas with high population densities, or in resource-poor areas.

6. Poor people have the lowest degree of human development. The latter has been recently defined by UNDP (7) by an index - the human development index - based on three essential elements of human life: life expectancy at birth, literacy and a decent standard of living. UNDP has estimated that in 1988 about 1.5 billion people had a low degree of human development; in 2000 the number will rise to 2.1 billion.

7. As countries have foundered in the inhospitable world economy of the 1980s, many developing countries pursued what has been known as "structural adjustment" policies. These policies have usually taken the form of a dampening down of demand, a devaluation of the currency, a withdrawal of subsidies on fuel and staple food stuffs, and deep cuts in government spending. As the 1980s continued, it became clear that

Figure I

HUMAN DEVELOPMENT



Source :El-Hinnawi (1991)
Based on data from UNDP (1990)

economic recovery and structural change were slow in coming. Not only that: the impacts of declines in incomes and of cutbacks in social services began also to be evident. Studies by UNICEF (8) showed that in 37 poor nations, spending per head on schools fell by about 25 per cent in the 1980s. Health spending per person has declined in more than three quarters of African and Latin American nations. In several countries in Latin America and Sub-Saharan Africa, the historical decline in infant mortality has stopped and been reversed, and the incidence of malnutrition has increased.

8. The basic problem with structural adjustment is that little attention has been paid to its effects on the poor. Evidence accumulating suggests that many structural adjustment measures have hurt the poor disproportionately. By the end of the 1980s, the manner of structural adjustment has become an issue which is both complex and controversial. In 1989, UNICEF (9) pointed out that adjustment policies which lead to an increase in malnutrition, a decline in health services and a decrease in school enrolment rates are inhuman and ultimately inefficient. UNICEF called for an alternative adjustment - an adjustment with a human face - which protects the poor, for example by maintaining well-targeted food subsidies, expanding primary health care services, etc. By the end of 1980s, the issue of adjustment had become important for all agencies and it is now reviewed, for example, in all adjustment programmes financed by the World Bank. (4)

9. The foreign debts of developing countries, more than $1.3 trillion, now require nearly $200 billion a year in debt servicing alone. (7) But more importance lies in the way resources are moving across the North-South boundary. Before 1984, the net flow was progressive: industrial countries gave more to developing countries in loans each year than they took back in interest and principal payments. Today, the South transfers at least $20 billion a year to the North. If the effective transfer of resources implied in the reduced prices paid by industrialized nations for the developing world's raw materials is taken into account, the annual flow from the poor to the rich could be as much as $60 billion each year. (9) No impoverished nation can reform its economy sufficiently in the short term to compensate for massive debt burdens and falling prices for its goods. The economy that most needs adjustment is the global one. Until that takes place, structural adjustment will continue to be little better than, in the words of UNICEF, "a rearranging of the furniture inside the debtors' prison". (9)

Impact on environment

10. The state of the world environment cannot be isolated from the state of the world economy. It is a closed cycle. Economic problems cause or aggravate environmental despoliation which, in turn, makes economic and structural reform difficult to achieve. It has long been recognized that poverty is one of the greatest threats to the environment. The poor not only suffer disproportionately from environmental damage caused by the better-off, they have become a major cause of ecological decline themselves. Many choices that degrade the environment are made in the developing countries because of the imperative of immediate survival, not because of a lack of concern for the future. Pushed to marginal lands by population growth and inequitable development patterns, the poor people raze plots in the rain-forest, plough steep slopes, overgraze fragile rangeland, settle in crowded slums and disaster-prone areas, pollute water and accelerate desertification. Economic deprivation and environmental

degradation have thus come to reinforce one another to perpetuate destitution in many developing countries.

11. The need for alternative patterns of development has long been recognized. Already in the mid-1970s, the Executive Director of UNEP called for "development without destruction" - development that is sustainable and recognizes the opportunities and constraints provided by the environment. (10) The World Commission on Environment and Development re-emphasized the need for sustainable development in its report "Our Common Future" published in 1987. (11) And UNICEF recently advocated the concept of "adjustment with a human face". (9) But putting the world on the path of sustainable development will not be easy, given the environmental degradation and economic confusion that now prevail. The planning and implementation of development initiatives will have to change significantly, the global economy will have to be fundamentally restructured, and there will have to be a quantum leap in international co-operation. Unless the desire to ensure a sustainable future becomes a central concern of national Governments, the continuing deterioration of the economy's natural support systems will eventually overwhelm efforts to improve the human condition. Many Governments remain pre-occupied with short-term economic and political crises. And in their efforts to adjust in the 1980s, environmental and natural resource management and conservation have ranked extremely low on their priority lists. For many developing countries, the decade of the 1980s has been a "lost decade"; environmental degradation has continued unchecked.

Chapter 2

ENVIRONMENTAL QUALITY

12. Concern about environmental quality remains high in virtually all countries. Different polls indicate that both the public and the leadership in different countries are highly concerned about environmental degradation. Both demand stronger action by Governments and by international organizations to protect the environment. Furthermore, the public and leaderships are willing to make material sacrifices and to work with others in their communities to improve the environment there. International support has grown significantly in the past few years. The Declaration of the Hague issued in March 1989 by representatives of 24 countries, including 17 Heads of State, emphasized the need for international co-operation to protect the global environment, especially to combat any further global warming of the atmosphere. The G-7 Summit, held in Paris in July 1989, (attended by the Heads of State of the seven major industrialized nations - Canada, France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, and the United States of America) declared that there is an urgent need for an umbrella convention on climate change. This was reaffirmed at the next G-7 Summit, held in Houston, in July 1990. Similar concerns and commitments were also voiced at the Noordwijk Ministerial Conference on atmospheric pollution and climatic change in November 1989 and at the Bergen Ministerial Conference in May 1990.

1. Air Quality and Atmospheric Issues

A. Air Quality

13. Air pollution continues to be a major environmental problem in most countries, especially in urban and industrial areas. It affects human health, agriculture, forest growth, water resources and buildings and structures; and it is costly. It has been estimated, for example, that air pollution costs the United States as much as $40 billion annually in health care and lost productivity. (12)

14. Concern about air pollution has triggered national and international action. Programmes have been established, especially in developed countries, to monitor and assess air quality, observe trends, and assess the relationship between pollution and human health. The GEMS/AIR monitoring project concluded in an assessment published in 1988 (13) that, in terms of average annual concentrations, 27 of the 54 cities with data available on sulphur dioxide for 1980 - 1984 were on the borderline or in excess of the WHO health standard (40-60 micrograms/cubic metre). High on the list were Milan, Tehran, Seoul, Rio de Janeiro, Sao Paulo, Paris, Beijing, Madrid and Manila. Indeed, Milan topped the list of average annual concentrations, with a reading more than three times the WHO norm. Though conditions are gradually

improving in most of the cities surveyed, several in developing countries reported a worsening trend. Suspended particulate matter (SPM) poses an even more pervasive threat, especially in the developing countries. Thirty-seven of the 54 cities monitored for particulate matter averaged either borderline or excessive levels. Twenty-four cities had SPM concentrations within the WHO guideline values (60-90 micrograms/cubic metre); 20 cities had SPM concentrations above the WHO values. The extraordinary levels noted in some cities in developing countries can be partially explained by natural dust; other culprits include the black, particulate-laden smoke spewed out by diesel-fueled vehicles lacking even rudimentary pollution control. The GEMS/AIR assessment concluded that nearly 900 million people living in urban areas around the world are exposed to unhealthy levels of sulphur dioxide and more than one billion people are exposed to excessive levels of particulates.

15. Of particular concern, especially in urban areas, are pollutants that stem predominantly from cars. One of the worst of these is ozone, the principal ingredient in urban smog. This ozone - also known as tropospheric ozone - is not emitted directly, but is formed when hydrocarbons and nitrogen oxides react in the presence of sunlight. At ground level, ozone, in lower concentrations than previously believed, causes temporary breathing difficulty and long-term lung damage. Ozone also damages crops, trees and building material. Studies have shown that in many cities in the United States and other OECD countries, ozone levels in excess of WHO-suggested levels (one hour mean concentration of 0.05 to 0.1 ppm, not to be exceeded more than once per month) occur frequently. (12)

16. Ozone has long been considered to be the oxidant that determines the air quality of an urban atmosphere. During the 1980s, however, atmospheric chemists identified hydrogen peroxide, a photochemical product in air, as another oxidant that may significantly degrade air quality. (14) Measurements of hydrogen peroxide carried out at various locations in Canada, Brazil, Europe, Japan and the United States show concentrations generally less than 10 parts per billion (ppb) by volume. The concentrations are highest in the afternoon and lowest at night; they are also highest in summer and lowest in winter. Hydrogen peroxide contributes to acidity of rain, clouds and fog. Studies strongly suggest that photochemical processes are largely responsible for the observed atmospheric levels of hydrogen peroxide. This conclusion is supported by the fact that no significant emissions of hydrogen peroxide from natural and industrial sources have been detected. (14)

17. Volatile organic chemicals (VOCs) have recently been detected in both outdoor and indoor air. Some 261 VOCs have been measured in outdoor air and 66 in indoor air. (15) In most cases, the concentrations are quite low, with a majority of chemicals at sub-ppbv levels. However, the concentration of some VOCs, such as formaldehyde, chloroform, trichloroethane and tetrachloroethane, are higher in the indoor environment than in the outdoor air. The major sources of these VOCs are building materials (including adhesives), consumer products, and indoor fuel combustion. Indoor pollution from VOCs is exacerbated by poor ventilation. The health effects of these VOCs remain to be assessed.

18. Exposure to the products of radioactive decay of radon in homes is a leading cause of lung cancer. Radon itself does not pose a substantial health risk; however, it decays into a series of short-lived, chemically active

species (Polonium-218, Lead-214, Bismuth-214, Polonium-214 and Lead-210) that can become deposited in the respiratory tract if inhaled. Subsequent alpha decays irradiate adjacent tissues. For most areas of the United States, estimated mean outdoor radon concentration is 9 becquerels/cubic metre (Bq/cubic metre). Indoor radon concentrations are generally higher than nearby outdoor concentrations. A mean indoor concentration of about 55 Bq/cubic metre has been reported in the United States. (16) Indoor radon concentrations differ greatly from one house to another within a neighbourhood and from one area to another, depending on composition of soil and of building materials and on the geology of the area. Average indoor radon varies from as low as 15 Bq/cubic metre in the United Kingdom to as high as 122 Bq/cubic metre in Sweden. (17) The United States Environmental Protection Agency recommends remedial action for dwellings with 148 Bq/cubic metre or above, although the International Commission on Radiation Protection (ICRP) uses 296 Bq/cubic metre before remedial action is taken. Studies in the United States have indicated that the current annual mortality rate from lung cancer attributable to indoor radon exposure is estimated to be about 16,000 cases. Only 3 per cent of this mortality is estimated to occur among individuals who have never smoked tobacco. Thus, more than 90 per cent of the lung cancer risk associated with radon could be controlled by eliminating smoking. (16)

B. Acidic Deposition

19. Acidic deposition continues to be a major international environmental issue. A considerable body of evidence shows that it threatens fisheries, forestry, agriculture and wildlife (see the UNEP State-of-the-Environment Report 1987 for details). Though the exact mechanism of forest dieback in Europe and elsewhere is still not precisely understood, most scientists believe that a complex mixture of pollutants - including acid deposition - renders forests susceptible to a range of natural stresses, such as droughts, extremes of heat and cold, and blights, that combine to cause the decline. A recent assessment of forest damage in Europe indicates that of a total forest area of 141 million ha, some 50 million ha (or 35 per cent) are damaged to varying degrees. (18)

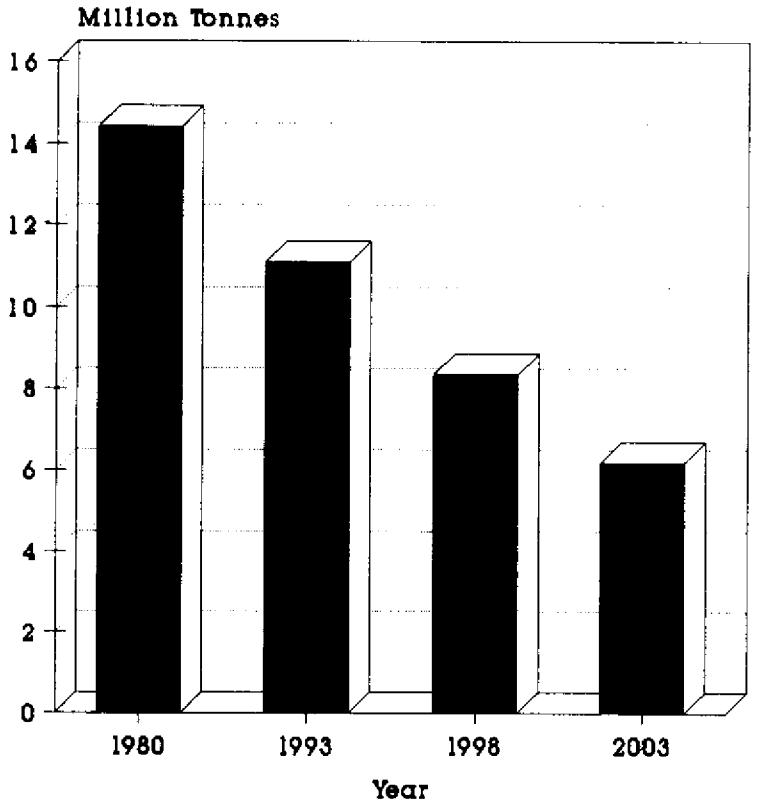
20. Several efforts have been under way at the national and regional levels to limit various airborne emissions. The signing of the Convention on Long-range Transboundary Air Pollution in 1979 demonstrated the determination of different countries to work together to cut back sulphur and nitrogen oxide emissions (the main agents of acidic deposition) to acceptable levels. In 1987, the Protocol to the Convention on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent from 1980 levels by 1993 - entered into force. The Protocol Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes, signed in November 1988, calls for a freeze on emissions at the 1987 levels in 1994, as well as further discussions beginning in 1996 aimed at actual reductions. Some countries have made commitments to go beyond both protocols. At least nine countries have pledged to bring sulphur dioxide levels down to less than half of 1980 levels by 1995. Austria, Sweden, and the Federal Republic of Germany have committed themselves to reducing them by two-thirds. Concerning nitrogen oxides, 12 Western European nations have agreed to go beyond the freeze and reduce emissions by 30 per cent by 1998. A November 1988 directive by the European Economic Community (EEC) represents a binding commitment by the members to reduce significantly the emissions that cause acid

rain. The directive will lower community-wide emissions of sulphur dioxide from existing power plants by a total of 57 per cent from 1980 levels by 2003, and of nitrogen oxides by 30 per cent by 1998. (12)

that upset the balance between the production and destruction of stratospheric ozone. The most important are chloro-fluorocarbons, halons, carbon tetrachloride, and methyl chloroform. All are chemically

Figure II

REDUCTION TARGETS FOR SULPHUR DIOXIDE EMITTED FROM EXISTING PLANTS IN EEC



Source : El-Hinnawi (1991)
Based on EEC Directive 88-609 (1988)

C. Stratospheric Ozone

21. Ozone acts as a natural filter in the stratosphere absorbing the sun's harmful ultraviolet radiation (UV-B). Human activities add compounds to the atmosphere inert in the lower atmosphere, and drift up to the stratosphere. There, ultraviolet radiation attacks them, releasing chlorine and bromine, which act as catalysts to destroy ozone.

22. The recent analysis of the total-column ozone data from ground-based instruments shows that from 1970 through 1988 the total ozone was depleted in the Northern Hemisphere by an average of -1.7 per cent between latitudes 30-39 N, by -3.0 per cent between latitudes 40-52 N, and by -2.3 per cent between latitudes 53-64 N. (19,20) The heaviest losses occur in winter. Under the special meteorological conditions of the Antarctic winter stratosphere, chlorine and nitrogen chemistry occurs which permits massive ozone depletion in the lower stratosphere when sunlight returns in the spring (the so-called Antarctic ozone hole). Although different theories have been put forth to explain the massive Antarctic ozone depletion (19), recent scientific evidence strongly indicates that chlorinated and brominated chemicals (largely man-made) are primarily responsible for this depletion. (20) While, at present, ozone changes over the Arctic are not comparable to those over the Antarctic, the same potentially ozone-destroying processes have been identified in the Arctic stratosphere. The degree of any future ozone depletion will probably depend on the particular meteorology of each Arctic winter and future atmospheric levels of chlorine and bromine.

23. With depletion of the ozone layer, the intensity of the UV-B radiation reaching the ground increases and the wavelength composition is shifted to shorter wavelengths. Most effects of ultraviolet radiation depend strongly on the wavelength, with the largest impacts associated with the shorter wavelengths. UV-B radiation is known to have a multitude of effects on humans, animals, plants and materials. A recent assessment of the environmental impacts of increased UV-B radiation (21) indicates that exposure to increased UV-B radiation can cause suppression of the body's immune system, which might lead to an increase in the occurrence or severity of infectious diseases such as herpes and malaria and a possible decrease in the effectiveness of vaccination programmes. Enhanced levels of UV-B radiation can lead to increased damage to the eyes, especially cataracts, the incidence of which is expected to increase by 0.6 per cent per 1 per cent total-column ozone depletion (this would result in an increase of about 100,000 blind persons worldwide). Also, every 1 per cent decrease of total-column ozone is predicted to lead to a 3 per cent rise in the incidence of non-melanoma skin cancer. There is also concern that an increase in the more dangerous cutaneous malignant melanoma could also occur. (21)

24. Efforts to address the possible threats of ozone depletion led to the adoption of the Vienna Convention for the Protection of the Ozone Layer in 1985. The subsequent Montreal Protocol on Substances that Deplete the Ozone Layer, signed in September 1987 outlined, a procedure for eventual restriction of global emissions of CFCs to 50 per cent of the 1986 level. The controls established by the Montreal Protocol first took effect in mid-1989 with a cutback to 1986 CFC emission levels, to be followed by further reductions of 20 per cent by 1994 and an additional 30 per cent by 1999.

25. Since the signing of the Montreal Protocol, studies have shown that the global ozone depletion problem is much more imminent and severe than the consensus political/scientific view prior to the Montreal negotiations indicated. The studies pointed out that it is highly desirable to phase out CFCs completely by 2000. (19,20,22,23) Under UNEP auspices, a strengthening of the Montreal Protocol was agreed at the Second Meeting of the Parties to the Montreal Protocol, convened in June 1990 in London. The Parties agreed that CFCs should be phased out by 2000 with

intermediate cuts of 50 per cent by 1995, and 85 per cent by 1997. Halons are to be phased out by 2000, with a 50 per cent cut by 1995. Two other substances were added to the Protocol for the first time - carbon tetrachloride and methyl chloroform. Carbon tetrachloride will be phased out by 2000, with an interim cut of 85 per cent in 1995. Methyl chloroform will be frozen at 1989 levels by 1993, cut by 30 per cent by 1995, 70 per cent by 2000, and phased out by 2005. All CFC substitutes have been included on a separate list with a requirement for annual reports on their production and consumption, strict guidelines for their use, plus a commitment to phase them out within a specified period. The replacement hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) have lower atmospheric lifetimes and lower chlorine-loading potentials than the fully halogenated CFCs and are, therefore, less ozone-depleting. However, they are considered as "bridging" chemicals that should be phased out by 2020-2040. Completely acceptable substitutes for long-term use must have no ozone-depleting or global-warming potential. Such replacements still have to be developed. (24) The 1990 London meeting also agreed to establish an international "ozone defence" fund to help developing countries meet the costs of complying with the revised Protocol and to provide the necessary transfer of technology.

D. Climate Change

26. The greenhouse effect of carbon dioxide has been known for more than a century. But it is only relatively recently that widespread attention has been given to the prospect that human activities can accentuate it and cause a global warming of the climate, with serious environmental, economic and social repercussions for present and future generations. Human activities are artificially increasing the amount of carbon dioxide and other greenhouse gases in the atmosphere, disturbing their natural geochemical cycles.

27. In the past few years, there has been a great deal of international activity on scientific, technical, and policy aspects of the greenhouse issue (see UNEP State-of-the-Environment Report 1989 for a review of greenhouse gases and climate). In 1988, an Intergovernmental Panel on Climate Change (IPCC) was created, under the auspices of UNEP and WMO, with a mandate to study the climate change issue and report to the Second World Climate Conference, convened in October 1990 in Geneva. Several hundred scientists from more than 35 countries have participated in the activities of IPCC, which were shared among three working groups: a science working group (WG I), a working group studying social and environmental impacts of climate change (WG II), and a working group dealing with response strategies (WG III). The main findings of the IPCC are summarized in the following paragraphs; useful accounts of the greenhouse effect and possible climate change are also given in several recent publications (see, for example, 25, 26, 27, 28, 29, 30, 31, 32, 33).

28. Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons and nitrous oxide. These increases will enhance the greenhouse effect, resulting in additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it. If present rates of emissions of greenhouse gases prevail (the IPCC Business-as-Usual scenario), the rate of increase of global mean temperature during the next century will be about 0.3 degree C per decade; this is greater than that seen over the past 10,000 years.

This will result in a likely increase in global mean temperature of about 1 degree C above the present value by 2025, and 3 degrees C before the end of the next century. The rise will not be steady, because of the influence of other factors. Regional climate changes may differ from the global mean. For example, temperature increases in Southern Europe and central North America are predicted to be higher than the global mean, accompanied on average by reduced summer precipitation and soil moisture. There are less consistent predictions for the tropics and the southern hemisphere. Sea-level rise due to this predicted global warming will be about 20 cm in global mean sea level by 2030, and 65 cm by the end of the next century. There will be significant regional variations. (34)

29. Sufficient evidence is now available to indicate that changes in climate would have an important effect on agriculture and livestock. Negative impacts could be felt at the regional level as a result of changes in weather and the arrival of pests associated with climate change, necessitating innovations in technology and agricultural management practices. There may be a severe decline in production in some regions (e.g. Brazil, the Sahel region of Africa, South-East Asia and the Asian region of the USSR and China), but there may be an increase in production in other regions because of a prolonged growing season. The effects of global warming on forests may also be mixed, and will vary from one region to another.

30. Natural terrestrial ecosystems could face significant consequences as a result of the global increases in the atmospheric concentrations of greenhouse gases and the associated climatic changes. Projected changes in temperature and precipitation suggest that climatic zones could shift several hundred kilometres towards the poles over the next fifty years. Flora and fauna would lag behind these climatic shifts, surviving in their present location and, therefore, could find themselves in a different climatic regime. These regimes may be more or less hospitable and, therefore, could increase the productivity of some species and decrease that of others. Ecosystems are not expected to move as a single unit, but would have a new structure as a consequence of alterations in distribution and abundance of species.

31. Relatively small climate changes can cause large water resource problems in many areas, especially arid and semi-arid regions and those humid areas where demand or pollution has led to water scarcity. Little is known about regional details of greenhouse-gas-induced hydrometeorological change. It appears that many areas will have increased precipitation, soil moisture and water storage, thus altering patterns of agricultural, ecosystem and other water use. Water availability will decrease in other areas, a most important factor for already marginal situations, such as the Sahelian zone in Africa.

32. Global warming will accelerate sea-level rise, modify ocean circulation and change marine ecosystems, with considerable socio-economic consequences. A 30-50 cm sea-level rise (projected by 2050) will threaten low islands and coastal zones. A one-metre rise by 2100 would render some island countries uninhabitable, displace tens of millions of people, seriously threaten low-lying urban areas, flood productive land, contaminate freshwater supplies and change coastlines. In coastal lowlands such as in Bangladesh, China and Egypt, inundation due to sea-level rise and storm surges could lead to significant social disruptions and economic losses. (35)

33. Greenhouse warming is a global problem; effective responses would require a global effort which may have a considerable impact on humankind and individual societies. The most pressing need in preserving the integrity of the climate system is for early, environmentally meaningful reductions in emissions of greenhouse gases on a multilateral basis. A number of international legal mechanisms exist which have a bearing on the climate change issue, in particular those dealing with the environment, science and technology, energy, natural resources, and financial assistance. One of these existing international legal mechanisms, the Vienna Convention on the Protection of the Ozone Layer and its associated Montreal Protocol (recently strengthened at the 1990 London meeting) deals specifically with phasing out ozone-depleting gases, which are also important greenhouse gases. However, there is a general view that, while existing legal instruments and institutions related to climate change should be fully utilized, alone they are insufficient to meet the challenge. An international concensus emerged at the United Nations General Assembly at its forty-fourth session on the need to prepare, as a matter of urgency, a framework convention on climate change. A framework convention should articulate a multilateral greenhouse gases control strategy, while simultaneously encouraging unilateral action by the largest emitters and the establishment of specific national commitments. For this reason, a greenhouse gas convention analogous to the Vienna Convention on the Protection of the Ozone Layer would not suffice. A Global Climate Change Convention should establish global goals regarding future emissions of greenhouse gases, and at a minimum covering carbon dioxide and afforestation. This agreement should also address other institutional issues, such as co-operation with developing countries in the areas of additional financial resources and transfer of technology as well as in the establishment of efficacious decision-making processes. Protocols to establish specific national requirements to assure attainment of global targets set out in the convention should be negotiated simultaneously with the convention. (36,37)

2. Water Quality

34. The GEMS water monitoring project (GEMS/WATER), launched in 1977, consists of 344 stations (240 river, 43 lakes, and 61 groundwater stations) in 59 countries. The GEMS/WATER global databank is located at the Canada Centre for Inland Waters, Burlington, Ontario, where all data are statistically processed and stored. The GEMS/WATER project provides for the collection of data on about 50 different parameters of water quality, including basic measurements such as dissolved oxygen, biochemical oxygen demand, fecal coliforms and nitrates, as well as analyses of chemical trace constituents and contaminants (heavy metals and organic micropollutants).

35. On the basis of available data, a first assessment of global freshwater quality has been carried out. (38) The assessment has revealed that concern over water pollution varies not only geographically and thematically, but also with the socio-economic situation of a country or a region.

36. The bulk of polluting matter discarded into water courses worldwide is organic material in the form of domestic sewage and effluents from agriculture-related industries. Bacteriological contamination of water courses, as measured by indicator organisms, is a common problem throughout all continents wherever urban areas discharge their sewage. The high population

concentrations in Europe, for example in the Rhine River basin, result in high fecal contamination levels, despite extensive sewage treatment throughout the region. The high coliform counts in European rivers have less significance than for some other world regions, since virtually all municipal water supplies in Europe are treated and disinfected. This is not the case for large parts of Asia, Africa, and Central and South America. As a result, high coliform counts in these regions are a contributory factor to the high morbidity and mortality rate of infants, arising from diarrhoea and other symptoms resulting from gastro-intestinal infections.

37. The greatest quantities of any pollutant discharged into water courses comprise organic matter, either dissolved in effluents or associated with suspended material. The most significant characteristic of this pollutant is the biodegradability, which is measured as the biochemical oxygen demand (BOD). About 10 per cent of all the rivers monitored in the GEMS/WATER project may be described as polluted, as they have a BOD of more than 6.5 mg/l. (38) The two most important nutrients, nitrogen and phosphorus, are well above natural levels in the waters measured by the network. The median nitrate level in unpolluted rivers is 100 micrograms/l. The European rivers monitored by GEMS show a median value of 4500 micrograms/l. In contrast, rivers monitored by GEMS outside Europe show a much lower median value of 250 micrograms/l. The median phosphate level in GEMS/WATER is 2.5 times the average for unpolluted rivers (10 micrograms/l). The high content of nutrients in rivers has created eutrophication in stretches of many rivers in central Europe and elsewhere. Apart from ecological and aesthetic damage, eutrophication brings increasing difficulties and costs for water treatment works which have to produce safe, palatable drinking water. (38)

38. Industrial processing of raw material and the use of chemicals in manufacturing usually involve release of potentially toxic materials into the air or water. Among these compounds, heavy metals and synthetic organic chemicals cause the main concern, due to their adverse effects on organisms, even at relatively low concentrations. Various levels of organochlorine pesticides and polychlorinated biphenyls have been reported in rivers and lakes from different regions. Heavy metals have been found in rivers and lakes where wastewater discharged into these water bodies contains such contaminants. Regulatory actions in Europe have contributed to a marked drop in concentrations of lead, cadmium, chromium and copper in most OECD rivers since 1975. (39)

39. The assessment provided by the GEMS/WATER project has some limitations, the most important of which are: (a) not all of the major world rivers and lakes are included in the global network; and (b) not all of the individual chemical pollutants are measured adequately at many stations. (38) The geographic coverage of the GEMS/WATER network is largely determined by the co-operation afforded the project by the countries and their participating institutions. Monitoring activities which are well developed in the USSR are still not part of GEMS/WATER and only a limited part of the Chinese Water Quality Network has been reported to the programme. African water resources are very rarely monitored for their quality, whereas government water quality surveillance programmes are operational in several countries in Latin America and South-East Asia. Data processing and evaluation, however, still require substantial development and improvement.

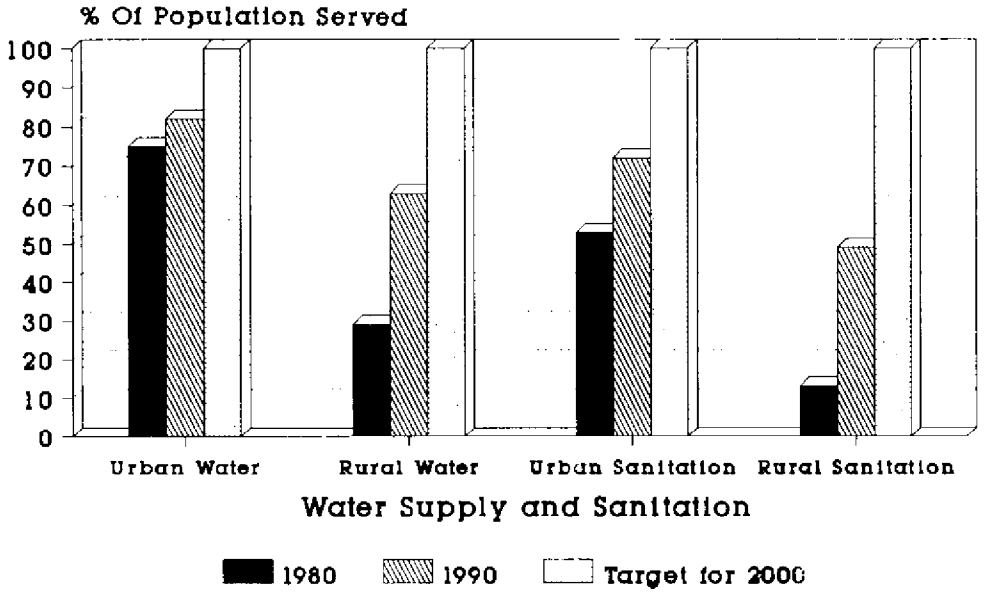
The State of Water Supply and Sanitation

40. Large numbers of people, especially in rural areas of the developing countries, still have no access to safe, clean water or sanitation services. The International Drinking Water Supply and Sanitation Decade (IDWSSD) (1981-1990), launched by the United Nations in 1980, aimed to provide everyone with a clean water supply and adequate sanitation facilities by 1990. At the start of the IDWSSD, 25 per cent of the population in urban areas of the developing countries did not have access to safe clean water and 47 per cent did not have access to sanitation services. At the same time, 71 per cent of the population in rural areas did not have access to clean water and 87 per cent of them did not have access to sanitation services. By the end of the IDWSSD, these percentages dropped to 18 per cent of people in urban areas without access to safe clean water and to 28 per cent without access to sanitation services. In rural areas, the percentages were 37 without clean water and 51 without access to sanitation services. (3,40)

41. Although the original targets of the IDWSSD were not met, the IDWSSD has been able to provide about 1.4 billion people in developing countries with safe, clean water and about 1.5 billion with sanitation services, as calculated from data given in (3) and (40). However, some 1.2 billion people - or 31 per cent of the population - still remain without access to safe clean water, and 1.8 billion - 43 per cent of the population - are without access to appropriate sanitation. (3)

Figure III

WATER SUPPLY AND SANITATION IN DEVELOPING COUNTRIES



Source: El-Hinnawi (1991)
Based on data from WHO and UNICEF

42. The slow progress towards achieving the goals of the IDWSSD has been attributed to several factors, including population growth, the unfavourable world economic situation and the debt burden of developing countries, which has been a major obstacle to investment in infrastructure projects. However, enough knowledge and experience have been gained to reach the goal of the IDWSSD by the end of this century. The provision of appropriate low-cost technologies, coupled with wider grass-roots participation, could constitute an important driving force to achieve the IDWSSD targets by 2000. (3)

3. Land and Terrestrial Biota

43. Serious soil erosion is occurring in most of the world's important agricultural regions, and erosion is increasing as more marginal land is farmed. Soil erosion, especially in developing countries, is seriously damaging agricultural productivity, shortening the life of dams and irrigation projects, filling in canals and harbours, and harming productive wetlands. In many regions, rates of soil loss exceed rates of soil formation by at least tenfold. It has been estimated that about 25 billion tons of topsoil are lost from the world's croplands each year in excess of new soil formation. (41) Soil losses due to cultivation of steep marginal lands, reduced forest and vegetative cover, and improper irrigation are expected to accelerate, especially in North and Central Africa, the humid and high-altitude areas of Latin America, and much of South Asia.

44. In the early 1980s, it was estimated that 11.1 million hectares of tropical forests were being felled each year. (42) Several recent studies show, however, that the rate of deforestation is much higher. Recent satellite data indicate that in 1987, some 8 million hectares of forested land may have been burned in Brazil alone. (43) The range of annual deforestation rates from Brazil's Amazon is between 1.7 and 8 million hectares per year. High rates of deforestation have also been recorded in Cameroon, Costa Rica, India, Indonesia, the Philippines, Thailand and Viet Nam. Based on these recent studies, it has been estimated that global tropical deforestation is most likely in the range of 14-20 million hectares per year. (43)

45. The Tropical Forestry Action Plan (TFAP) - initiated in 1985 to co-ordinate human needs, environmental management, and sustainable forest development - is gaining recognition by concerned countries. Since its beginning, TFAP has faced criticism; critics point out that the programme is too Government-oriented and does not seek the participation of non-governmental organizations or forest dwellers. (43) However, there is considerable evidence of progress in efforts to curb deforestation. More than 60 countries have decided to prepare national forestry action plans to guide management of their forests. This TFAP planning process has helped stimulate an increase in investment in tropical forestry from $500 million in 1985 to $1 billion in 1989 - 70 per cent of the amount originally called for by TFAP. The programme has made many Governments aware of the economic costs of deforestation and has mobilized many people and organizations to discuss how to address the cause of deforestation and forest degradation. (43)

46. Global agricultural production stagnated in 1987-1989; overall output remained at approximately 1986 levels. (44) Substantial regional differences exist. Asia has increased its per-capita food production over the past decade (about 1.7 per cent per year). Over the same period, Latin America

barely maintained its per-capita food production (about 0.7 per cent per year). In Africa, however, per-capita food output suffered a negative growth of about -0.6 per cent per year.

47. At present, the world's cropland averages about 0.28 ha per capita, but varies widely. Latin America has nearly double the world average; Asia, in contrast, has only 0.15 ha per capita and Africa 0.30 ha per capita (43). If world food production is to increase 60 per cent by the year 2025 - as it must to maintain current nutritional levels for a population projected at 8.5 billion - then either croplands must expand or crop yields must increase.

48. Most areas of potential expansion for agriculture either lack water or have physical or chemical constraints such as steep slopes, easily eroded or poorly drained soils, alkalinity or other conditions toxic to plants. New agricultural lands often prove illusory. Although modern irrigation systems can bring water from long distances, careful terracing can make steep slopes usable, and new technical solutions may overcome soil limitations, these are not solutions for subsistence agriculture. All too often, expansion into new and marginal agricultural land is, out of basic necessity, led by those least able to overcome its difficulties or to farm it in a sustainable manner.

49. Increasing crop yield is likely to require more inputs of fertilizer, pesticides, and irrigation - with the risk of worsening water and soil pollution. The advent of biotechnologies is about to change the form of agricultural production that man has followed for thousands of years. It is still early to predict the full impact of biotechnologies on the world's agricultural production and trade, and on the environment. Unlike the Green Revolution technologies, which were developed largely by national and international public sector institutions, biotechnology research and marketing is being undertaken mainly by the private sector. This means that the diffusion of biotechnologies would not be as free or as rapid as the Green Revolution technologies. This could place most developing countries in a serious disadvantaged position in international production and trade. (45)

50. Clearing land for agriculture and environmental degradation of other kinds have accelerated the rate of habitat loss and species extinction (for a detailed discussion on biological diversity, see Chapter 3).

Chapter 3

BIOLOGICAL DIVERSITY

51. Biological diversity (or biodiversity) encompasses all species of plants, animals, and micro-organisms and the ecosystems and ecological processes of which they are parts. It is usually considered at three different levels: genetic diversity, species diversity, and ecosystem diversity. Genetic diversity is the sum total of genetic information, contained in the genes of individual plants, animals, and micro-organisms that inhabit the Earth. Species diversity refers to the variety of living organisms on Earth. Ecosystem diversity relates to the variety of habitats, biotic communities, and ecological processes in the biosphere, as well as the tremendous diversity within ecosystems in terms of habitat differences and the variety of ecological processes.

A. Distribution of Species

52. No one knows the number of species on Earth, even to the nearest order of magnitude. Estimates vary from 5 to 80 million species or more. Only about 1.4 million of these living species have been briefly described. Of these about 750,000 are insects, 41,000 are vertebrates and 250,000 are plants; the remainder consists of a complex array of invertebrates, fungi, algae and other micro-organisms. (46,47)

53. Like other natural resources, the distribution of living species in the world is not uniform. Species richness increases from the poles to the equator. Freshwater insects, for example, are 3 to 6 times more abundant in tropical areas than in temperate zones. Tropical regions have also the highest richness of mammal species per unit area, and vascular plant species diversity is much richer at lower latitudes. (48) Forty to one hundred species of trees may occur on one hectare of tropical rain forest in Latin America, compared to only ten to thirty on a hectare of forest in eastern North America. In one area of about 15 hectares of rain forest in Borneo, about 700 species of trees were identified, as many as in all of North America. A region in lowland Malaysia near Kuala Lumpur has some 570 plant species greater than 2 cm in diameter per hectare. (49) In comparison, all of Denmark possesses less than twice as many species - of all sizes - as there are in one hectare in Malaysia. Global patterns of species diversity in the marine environment resemble those on land. The number of tunicate (sea squirt) species increases from 103 in the Arctic to some 629 in the tropics, the diversity of planktonic foraminifera increases from only two species near the poles to some 16 in tropical waters, and deep sea species diversity also tends to be higher at lower latitudes.

54. Tropical forests are not, however, the only highly diverse ecosystems. Mediterranean-climate regions also have very rich flora with high levels of endemism. For example, of the 23,200 species of plants estimated to occur in South Africa, Lesotho, Swaziland, Namibia and Botswana (which

are temperate areas), 18,560 (i.e. 80 per cent) are endemic to the region. (50) This gives the area the highest species richness in the world, 1.7 times greater than that of Brazil. Some 30 per cent of California's 5,046 plant species and 68 per cent of southwest Australia's 3,600 plants are endemic to these regions. (48)

B. Importance of Biological Resources

55. Biological diversity provides the basis for life on Earth. The fundamental social, ethical, cultural, and economic values of these resources have been recognized in religion, art, and literature from the earliest days of recorded history. Wild species and the genetic variation within them make substantial contributions to the development of agriculture, medicine, and industry. Perhaps even more important, many species have been fundamental to stabilization of climate, protection of watersheds, protection of soil, and to the protection of nurseries and breeding grounds. It is difficult to determine the total economic value of the full range of goods and services which biological diversity provides.

56. Biological resources have made substantial contributions to human welfare, especially in rural areas of developing countries. For example, fuelwood and dung provide over 90 per cent of the energy needs in many areas in Nepal, Tanzania, and Malawi and more than 80 per cent in many other countries. In Botswana, over 50 species of wild animals provide animal protein, which constitutes up to 40 per cent of diet in some areas. In Ghana, about 75 per cent of the population depends largely on traditional sources of protein, mainly wildlife. In Nigeria, game constitutes about 20 per cent of the mean annual consumption of animal protein by people in rural areas. (47) Human beings have used about 7,000 kinds of plants for food, but only 20 species supply 90 per cent of the world's food, and just three - wheat, maize and rice - supply more than half. (51) Although the major food crops in use today were domesticated thousands of years ago, the potential for other species to play increasingly prominent roles in world agriculture is great. (52) Numerous locally important less known species of wild and domesticated plants could be cultivated and used much more widely. For example, quinua, a staple grain of the ancient Incas, is little known outside of the highlands of Bolivia, Chile, Ecuador, and Peru, yet it is one of the world's most productive sources of plant protein. Biological resources are also major industrial feedstocks, and can have a major impact on national economies.

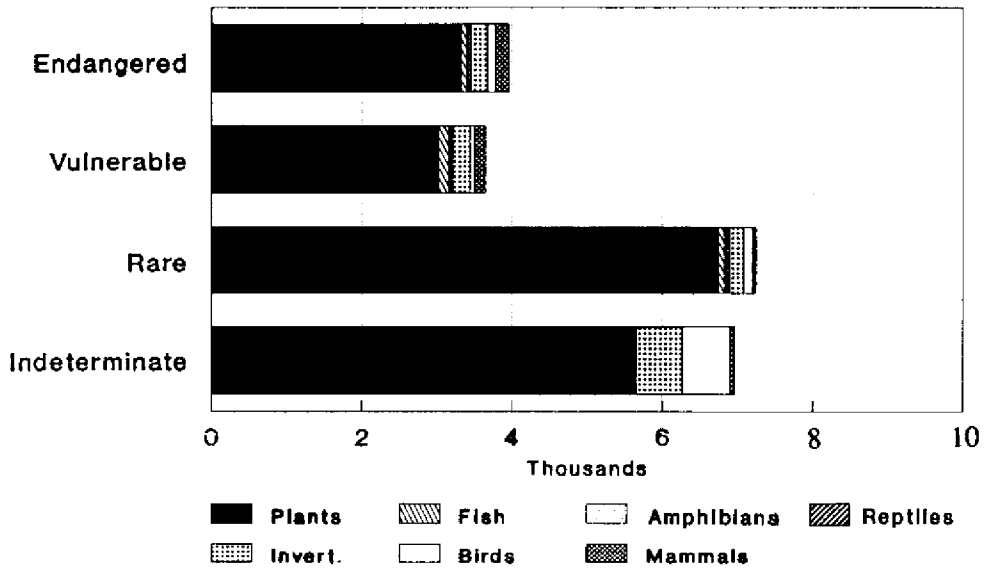
C. Loss of Species

57. Throughout the geological history of the Earth, species of plants and animals had been subjected to various evolutionary processes. Some species became extinct during the different geological periods, the length of which is measured by millions of years. The last major extinction of some species occurred at the close of the Cretaceous Period, some 65 million years ago, when birds and mammals were particularly affected. The total disappearance of all dinosaurs occurred during that great extinction. Although the causes of those extinctions are a matter of scientific speculation, it is generally agreed that they were triggered by natural environmental phenomena during the geological evolution of the Earth. In recent history, biological resources have been lost at an accelerated rate, mainly due to anthropogenic causes.

58. No precise estimate can be made of the number of species that have been - or are being - lost in major habitats. This is mainly due to the lack of systematic monitoring and baseline information. Many species may become extinct before they are even discovered or described. The extinction of other species may be detected years later because of inadequate monitoring. Most land surface, but contain more than half of the species in the entire world biota) may eliminate between 5 and 15 per cent of the world's species. This would amount to a potential loss of 15,000 to 50,000 species per year, or about 40 to 140 species per day. (48) The World Conservation Monitoring Centre has recorded that some 22,000 species of plants and animals are actually

Figure IV

THREATENED SPECIES



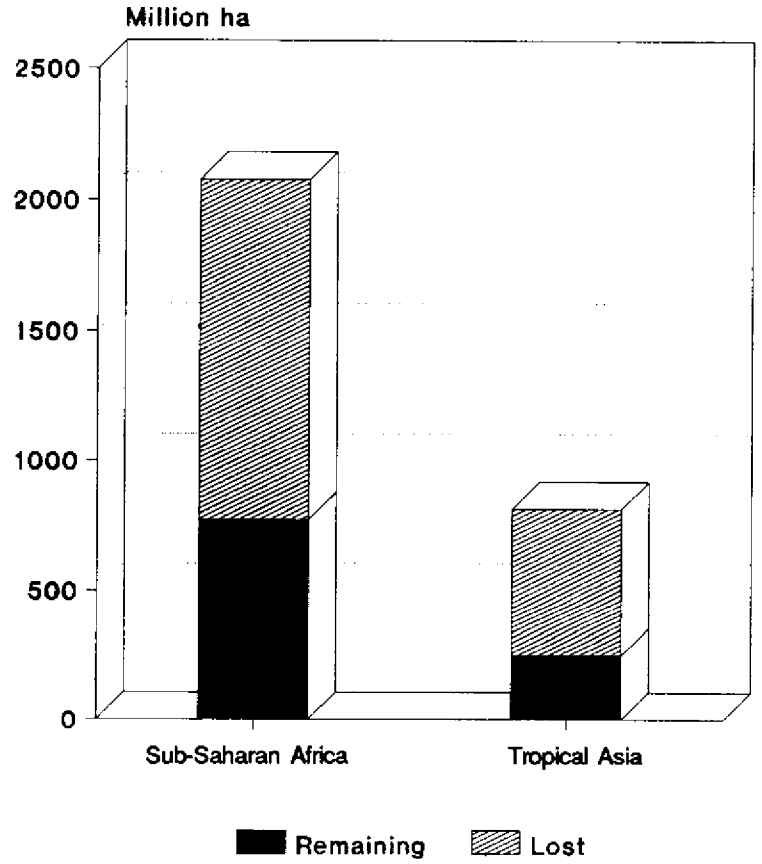
Source: EL-Hinnawi (1991)
Based on data from
World Conservation Monitoring Centre

experts have concluded that perhaps a quarter of the Earth's total biological diversity is at serious risk of extinction during the next 20-30 years. (53) Between 1990 and 2020, species extinctions caused primarily by tropical deforestation (tropical forests cover only 7 per cent of the Earth's threatened with extinction. Historically, extinction threatened mainly isolated ecosystems such as fresh water and island-dwelling species but currently 66 per cent of endangered and vulnerable vertebrates are continental.

59. Four main causes have been identified for the loss of biological diversity. The first is habitat loss, fragmentation and modification. As forests are cleared, wetlands drained, valleys flooded and roads built, so habitats are transformed and

Figure V

HABITAT LOSS



Source : El-Hinnawi (1991)
Based on data from IUCN/UNEP (1986a)

effectively lost for certain species. It has been estimated that 11.1 million ha of tropical forests are eliminated each year (i.e. 21 ha every minute). A reduction of say 70 per cent of a tropical forest leads not only to the elimination of entire species restricted to the removed part of the forest, but also reduces the number of other species living in the forest to 30 per cent of their original population size, rendering them more vulnerable to future extinction. Habitat changes in sub-Saharan Africa and in tropical Asia have caused a loss of 65 per cent and 67 per cent of wildlife, respectively. (54,55)

60. The second reason for the loss of biological diversity is over-exploitation of resources. Commercial harvesting has been a threat to many marine species. Over-exploitation has been the cause of extinction of some large terrestrial animals, and well-known species like the African Elephant are under threat today.

61. Pollution is the third reason for the growing loss of biodiversity. Pesticides have affected several species of birds and other organisms. Both air and water pollution stress ecosystems and reduce populations of sensitive species. For example, air pollution and acid rain have been linked to forest diebacks in Europe and North America. Acid rain has resulted in the loss of a number of fish species in Northern European lakes. The excessive use of agrochemicals and the release of many compounds of heavy metals and other toxic substances from industrial processes have caused ecological imbalance in water bodies, wetlands and land areas with various detrimental effects on plant and animal species. A recent report by IPCC on climate change due to greenhouse gases pointed out that because species respond differently to climate change, some will increase in abundance while others will decrease. (34) Over time some species may be displaced to higher latitudes or altitudes. Rare species with small ranges may be prone to local or even global extinction. Global warming would raise sea level and this could threaten almost all existing wetlands in the world.

62. The fourth reason for the loss of biological diversity is the impact of introduced exotic species as they threaten natural flora and fauna by predation, competition or altering natural habitat. Introduced species of plants have virtually replaced native species in many areas. The introduction in the Middle East and Asia of new high-yielding wheat and rice varieties since the mid 1960s has caused a loss of the gene pools in such centres of crop diversity as Turkey, Iraq, Iran, Afghanistan, Pakistan, and India. (56) In some of the African Rift Valley lakes, which have remarkably high levels of endemism, introduced species of fish have threatened most native species with extinction. (57) The introduction of herbivores such as goats and reindeer can extinguish the native flora. It has been estimated that introduced species threaten 19 per cent of all endangered, vulnerable and rare species of vertebrates particularly on islands. (48)

63. Biological resources are the basis of human life. The intense pressures on biological diversity are a direct reflection of increasing human numbers. These pressures are expected to increase until populations stabilize as projected by the United Nations by about the year 2050-2070 at about 10 billion. Such stabilization will be achieved only if present efforts to curtail population growth are pursued vigorously. As population grows, however, the pressure on biological resources will reach levels far beyond those prevalent now. The continued erosion of these resources poses a serious threat of ecosystem collapse. Biological diversity losses have serious worldwide implications for agriculture, medicine and industry; in fact for human welfare and his very existence.

64. Biological diversity is threatened because people are out of balance with their environment; benefits are being gained from exploiting natural habitats without paying the full costs of such exploitation. Current human populations and standards of living are subsidized by non-renewable resources that have accumulated over hundreds of millions of years, yet are being consumed in a few generations. (47)

D. Conservation of Biological Diversity

65. The World Conservation Strategy I and II, (58,59), the report of the World Commission on Environment and Development (11) and the Environmental Perspectives to the Year 2000 and Beyond (60) have stressed that the conservation of natural resources has to be provided for within strategies for sustainable development because these resources are the essential base for such development. Meeting the needs of the present without compromising the ability of future generations to meet their own needs implies prudent management of available resources. Inter-generational equity requires each generation to conserve the diversity of the natural and cultural resource base, so that it does not unduly restrict the options of future generations; each generation is entitled to diversity comparable to that of past generations.

66. Four kinds of actions have been taken by the international community and by governments to promote the conservation and sustainable use of biological diversity: (a) measures to protect particular habitat as National Parks, Biosphere Reserves or other protected areas; (b) measures to protect particular species or groups of species from over-exploitation; (c) measures to promote ex situ conservation of species in botanic gardens or in gene banks; and (d) measures to curb the contamination of the biosphere with pollutants. Several national, regional and global conventions and programmes have been formulated to implement these measures. For example, the Convention on Wetlands of International Importance (Ramsar, 1971), the Convention Concerning the Protection of World Cultural and Natural Heritage (Paris, 1972), the International Convention for the Regulation of Whaling (Washington, 1946), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973), the Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979), Regional Seas Conventions and Programmes, the Convention for the Protection of the Ozone Layer, and others.

67. All these conventions and programmes have provided important means of promoting the conservation of biological diversity. Yet none of these has the explicit purpose of conservation of *global* biological diversity. Most national efforts for conservation and management are not adequate. Five main obstacles have been identified: (a) national development objectives give insufficient value to biological resources. Development tends to emphasize short-term exploitation to earn income or foreign exchange rather than long-term sustainable utilization of such resources; (b) the species and ecosystems upon which human survival depends are still poorly known; (c) the available science is insufficiently applied to solve management problems; (d) the narrow focus of most conservation activities; and (e) the grossly insufficient resources (human as well as financial) allocated to conservation of biological resources. An example of the inadequacy of national efforts can be given by protected areas. Legally protected areas in the world cover 485 million ha, or 3.2 per cent of the Earth's land surface area. Yet most of these areas exist on maps only. It is unlikely that such areas provide adequate protection from a biogeographic perspective.

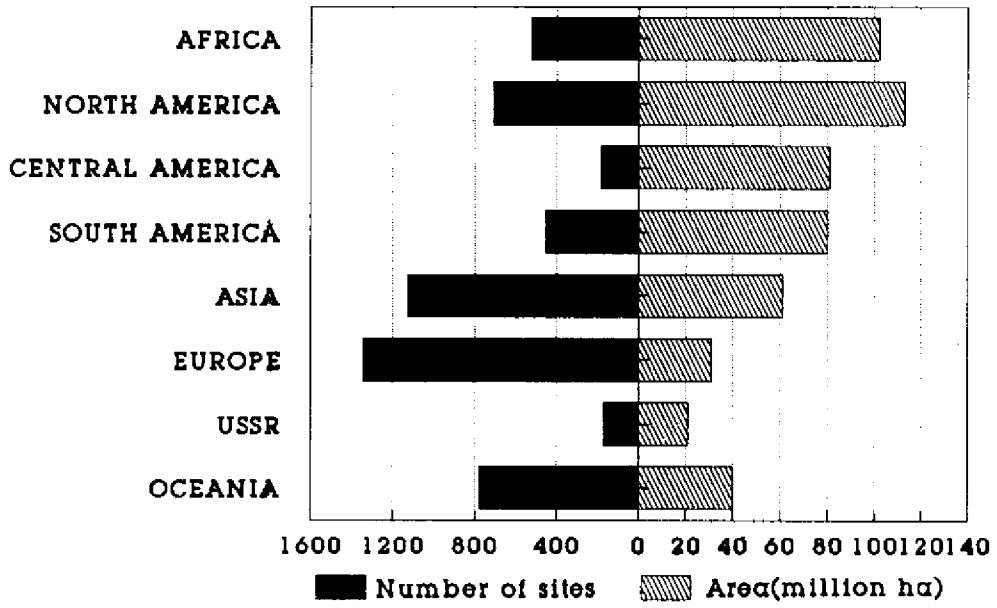
68. Recognizing the growing severity of threats to biological diversity and the increasingly international nature of the actions required to address the threats, a global strategy dealing with all aspects of biological diversity is being prepared by the World Resources Institute, IUCN and UNEP in collaboration with WWF, the

World Bank and other governmental and non-governmental institutions in both tropical and temperate nations. The strategy which will be launched in 1992 aims to: (a) establish a common perspective, foster international co-operation, and agree to priorities for action at the international level; (b) examine the major obstacles to progress and analyze the needs for national and international policy reform; (c) specify how conservation of biological resources can be integrated with development more effectively and identify the linkages with other related issues facing humanity; and (d) promote the further development of regional, national, and thematic action plans for the conservation of biological diversity, and promote their implementation. Furthermore, IUCN, FAO and UNEP have embarked on the preparation of an International Convention on the Conservation of Biological Diversity.

69. The time has come to appreciate the Earth's biological resources as assets to be conserved and managed for the benefit of all humanity. All nations have the duty to safeguard species within their territories, on behalf of everyone. But there is a need for a global effort in which developed and developing countries infuse a new spirit of co-operation for the conservation of

Figure VI

PROTECTED AREAS



Source : El-Hinnawi (1991)
Based on data by WRI (1990)

biological diversity as a fundamental element of environmentally sound and sustainable development. Any agreement or measure should not infringe upon the sovereignty of nation States over their natural resources. It must protect the interests of the States in which the resources are located and provide incentives for conservation of biological diversity without inhibiting growth or sustainable development. Yet the agreement should cover *inter alia*: (a) measures for conservation of the full range of biological diversity; (b) measures for sustainable utilization of biological diversity; (c) research, training, education and public awareness; (d) environmental impact assessments; e) access to biological diversity; (f) transfer of technology for the conservation and utilization of biological diversity; (g) technical and financial co-operation with developing countries to allow them to participate fully in the conservation of biological diversity; and (h) institutional arrangements at the national and international levels.

Chapter 4

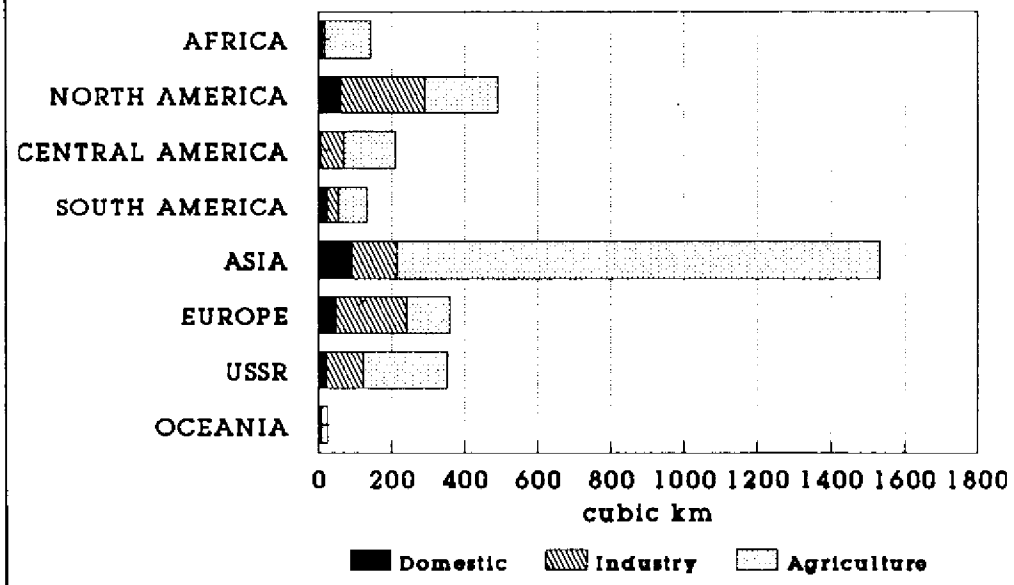
SHARED WATER RESOURCES

70. Water covers three-quarters of the Earth's surface, but more than 97 per cent of the Earth's water is saltwater in the oceans, and less than 3 per cent is freshwater. Of the latter, 77 per cent is frozen in polar ice caps and glaciers, 22 per cent is groundwater, and the remaining small fraction is in lakes, rivers, plants and animals.

71. Freshwater from surface and underground sources provides sustenance to plants and animals, constitutes the habitat for aquatic organisms, and meets important agricultural, industrial and domestic needs. Although the Earth's supply capability of freshwater (about 9,000 cubic km annually) is sufficient, in theory, to sustain a total world population of some 20 billion people, freshwater is very unevenly distributed around the world and in many regions subject to seasonal and yearly fluctuations. Much of the Middle East and North Africa, parts of Central America and the western United States are already short of water. By

Figure VII

WATER WITHDRAWAL Cubic km (1990)



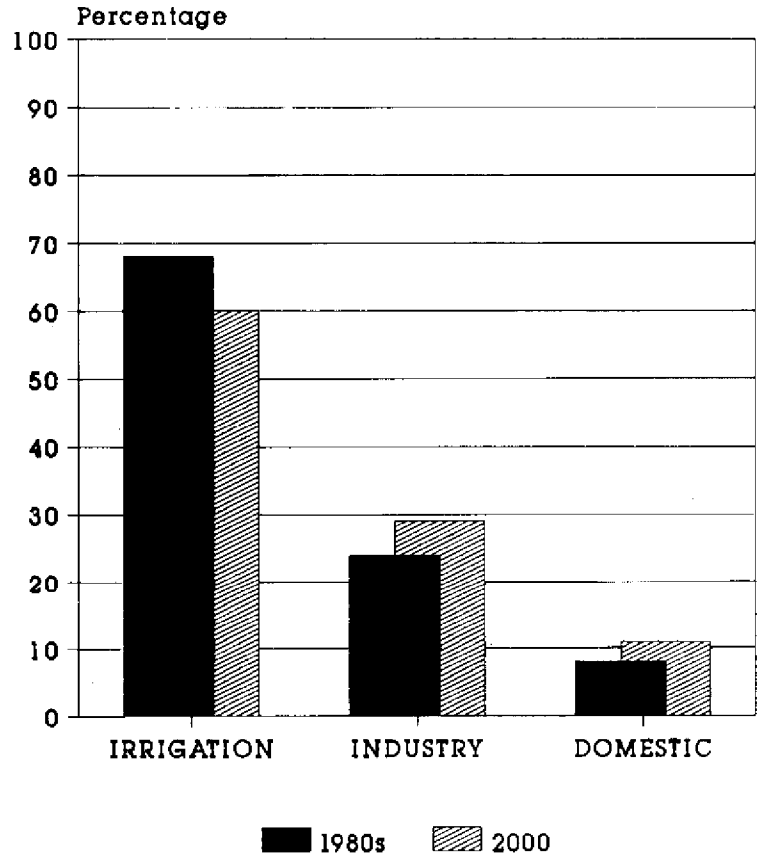
Source : El-Hinnawi (1991)
Based on data from WRI (1990)

the year 2000, many countries will have about half as much water per capita as they had in 1975, and many will experience much greater demands on water for agriculture, industry and domestic use. (61)

markedly from one country to another and depends on population and on the prevailing level and pattern of socio-economic development. At present, worldwide water withdrawal for irrigation accounts for about

Figure VIII

WORLD WATER USE



Source: EL-Hinnawi (1991)
Based on data from WRI (1990)

72. Population growth, with consequent increase in demand for water, and environmental degradation have contributed to shortage of water, especially of good-quality water. Demand for water varies

68 per cent of water use, 24 per cent goes to industry and the other 8 per cent to domestic, livestock, recreational and other uses (as calculated from data given by the World Resources Institute). (43)

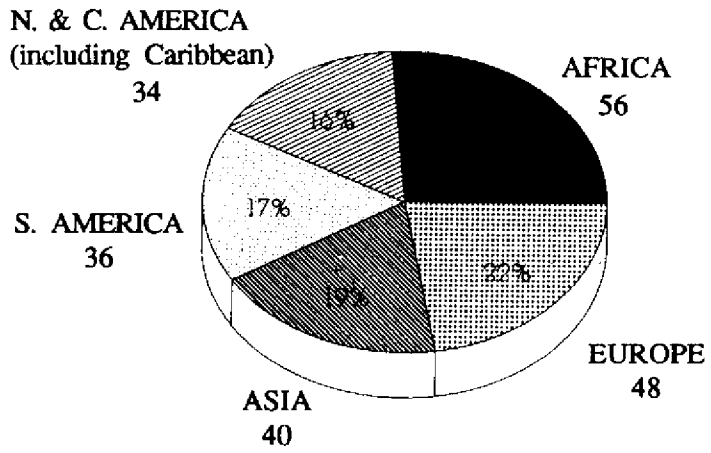
73. An important feature of the geographical distribution of freshwater resources in the world is that many of these resources are shared by two or more states. At least 214 river basins are multinational: 155 of these are shared between two countries; 36 among three countries; and the remaining 23 among four to 12 countries. In Africa and Europe most river basins are multinational (see, the Centre for Natural Resources, Energy and Transport Report, in parallel, sharing the river as an international border.

A. Use of International Watercourses

74. The joint use of international watercourses has always depended on co-operation among the riparian States. Some of the oldest international treaties and organizations were created to regulate the use of some shared water bodies. For example, agreements were formulated in the middle of the eighteenth century to manage navigation on the Rhine and the Danube in Europe, and the Boundary Waters Treaty of 1909 was signed by Canada and the United States to regulate the use of the waters of the Great Lakes. Over the years, population

Figure IX

INTERNATIONAL RIVER BASINS



Source: El-Hinnawi (1991)
Based on data from CNRET (1978)

(62) for a register of international rivers). About 50 countries have 75 per cent or more of their total area falling within international river basins, and an estimated 35-40 per cent of the world population lives in these basins. (63) Countries may be sequentially aligned in a river basin, so that the river passes from one country to another, or they may be placed

growth, industrial development and changes in agricultural practices have increased the demand for freshwater and, concomitantly, the pollution of shared water resources. Pollution of shared waters is generally understood as the introduction, directly or indirectly, of any hazardous substances or of energy into those waters as a result of normal human economic activities or incidents, originating wholly or partly within an area under the jurisdiction of a given country and causing or threatening to cause impairment of the quality of those waters and/or of related ecosystems in an area under the jurisdiction of another country. Forest clearance, hydro-electric installations, irrigation and water supply works and pollution in one country can reduce water availability to another, increase its costs of making water suitable for different uses, and destroy, degrade or deplete its valuable ecosystems and species.

75. Treaties to regulate the use of shared water resources exist for virtually all international river basins and lakes. As of 1972, 27 treaties exist in Africa, 38 in North and Central America, 31 in South America, 31 in Asia and 175 in Europe. (62) Most of these treaties dealt with issues such as allocation of water shares, regulation of navigation and fishing, and construction of some public works such as barrages, etc. In many cases, the countries concerned have established a joint river (or lake) commission to monitor the implementation of the treaty and sort out any conflicts that may arise from the use of the shared water resource. The accomplishments of such river (or lake) commissions have varied greatly from one region to another.

76. One of the principles (Principle 21) adopted by the United Nations Conference on the Human Environment in 1972 states that:

> "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

The above-quoted Principle reflects the context of the principle of good-neighbourliness well established in international law, namely, "*sic utere tuo ut alienum non laedas*" (use your property and perform your activities without damage to others). Principle 21 of the Stockholm Conference applies to all resources, including water resources, with special emphasis on environmental damage. In 1977, the United Nations Water Conference, held in Mar del Plata, Argentina, urged that national policies take into consideration the right of each state to equitably utilize water resources shared with other countries, and that countries sharing water resources should review existing and available techniques for managing shared water resources and co-operate in the establishment of programmes, machinery and institutions necessary for the co-ordinated development of such resources.

B. Management of Shared Water Resources

77. The increase in demand for good water and the evidence of the growing vulnerability of many regional ecosystems, where man has escalated his impacts upon the land and water resources, have triggered a marked concern around the world about the future quantity and quality of water resources. Many States have agreed to, or have undertaken, concrete measures for the

study of the condition and operation of their shared water resources, and the land and other resources linked with those waters. Such studies are now being broadened to include the social and economic dimensions of land and water use and conservation.

78. In 1957, four countries - Cambodia, Laos, Thailand and Viet Nam, - planned the development of the Lower Mekong river basin on a co-operative international basis. Over one hundred million people live in the Mekong countries, about half of them in the Lower Mekong basin. The majority are engaged in agriculture and live close to the margin of subsistence. Although about 3 per cent of the cultivable land area is now being irrigated, there is plenty of water available for this purpose - enough to irrigate 10 million ha. Furthermore, the hydropower potential of the basin is of the order of 40,000 MW. The development of the Lower Mekong basin is, therefore seen as a key to socio-economic development in the region, and to solving problems of poverty and instability that stem from under-development. (64)

79. In Latin America, co-operation between Argentina, Bolivia, Brazil, Paraguay and Uruguay has been under way to develop the La Plata river basin. Emphasis has hitherto been on production of hydropower and navigation. (65) A Treaty for Amazonian Co-operation was signed in 1978 between the eight Amazon basin States: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela. (66)

80. In Africa, the Senegal River Basin Development Project was initiated by Senegal, Mali and Mauritania to control the river with a view to irrigating a total area of 375,000 ha in the three riparian States, producing 800 GWh of hydro-electricity per year, and enhancing navigation from the river mouth at St. Louis in Senegal to Kayes in Mali, some 900 km. The three riparian States, entered into a convention in 1972 to co-ordinate the development of the Senegal River for the rational exploitation of its resources.(67) Other examples of agreements to develop shared water resources in Africa include those of the Gambia river basin, the Niger river basin, the Nile basin, and the Lake Chad basin.

C. Environmental Protection Measures

81. The above-mentioned examples and early agreements related to the Great Lakes in North America, the Rhine and the Danube in Europe and other international water bodies focused on some isolated issues (water quotas, navigation, etc.). Until recently, little attention has been given to environmental and conservation issues. There is now a growing concern in many regions over the discharge into water bodies of highly toxic, persistent and bio-accumulative substances which threaten ecosystems and human health, either in the short or the long term. Many transboundary waters eventually reach the sea, which leads to the accumulation of pollutants in estuaries, which is often of great biological importance. In efforts to prevent the pollution of shared water resources emphasis has been placed on the control of source points. However, diffuse pollution resulting essentially from agricultural practices has become a particular concern in many regions. Such diffuse pollution is closely related to groundwater pollution. Groundwaters are the most important resources for the supply of drinking water in many countries. The concentrations of nitrates and phosphates have increased in many transboundary watercourses and international lakes, due in particular to the growing use of fertilizers and detergents. The negative effect has been to intensify

eutrophication, thereby adversely affecting the drinking water supply, recreation and tourism, and threatening aquatic ecosystems.

82. The Great Lakes are one of the most important natural resources shared by Canada and the United States. One seventh of the United States population resides in the Great Lakes basin and 60 per cent of Canada's total population lives in the basin. Controlling pollution within the Great Lakes basin has proven to be a more difficult issue than controlling water use. The Great Lakes Water Quality Agreements of 1972 and 1978 focused respectively on pollution from traditional sources, such as municipal sewers, that were causing severe eutrophication of the lower Great Lakes, and on toxic pollutants. (68) Although eutrophication of the lakes has been slowed, and in some places stopped, effective cleaning up of the lakes is more limited, especially for toxic pollutants. The Great Lakes Water Quality Board of the International Joint Commission (IJC) has identified some 450 toxic compounds in the Great Lakes. Some *ad hoc* actions have been successful in reducing the concentrations of a few compounds, for example DDT, PCB and lead and mercury compounds. (38) However, a comparative evaluation of toxic pollutants is under way and may well result in a more co-ordinated effort that will lead to an overall plan for dealing with such contaminants in the Great Lakes.

83. The Rhine is the most important navigable river in Western Europe. Almost 40 million people live in the Rhine basin as a whole, and a large part of European industry and almost 20 per cent of the world's chemical industry are concentrated there. For many decades the river has been subject to large volumes of industrial effluents. A joint programme for the rehabilitation of the Rhine's water and the management of the Rhine groundwater aquifer has been undertaken by the riparian countries (Switzerland, Federal Republic of Germany, France, the Netherlands and Luxembourg) since 1980, following a series of regional agreements dating back to 1963 (notably the Agreement Concerning the International Commission for the Protection of the Rhine against Pollution, Berne, 1963 and the Convention on the Protection of the Rhine against Chemical Pollution, adopted in Bonn in 1976, which entered into force in February 1979). The Sandoz-Basel accident that occurred in November 1986 led to the release of about 10 tonnes of highly toxic substances into the Rhine. The water quality of the river was severely affected for weeks and the groundwaters in the extensive Rhine alluvial aquifer are still polluted. The Basel accident has made it clear that industrial accidents can have harmful transboundary impacts on shared water resources. This has prompted the Economic Commission for Europe to initiate work towards the formulation of a regional convention on the transboundary impacts of industrial accidents and of a convention on the protection and use of transboundary watercourses and lakes.

84. An important indirect effect on water quality as a result of irrigated agriculture is becoming increasingly apparent in the Aral Sea, shared by three republics in the USSR. The sea level is retreating because excessive irrigation withdrawals are reducing inflow from the catchment area. The Aral Sea level has dropped by 3 m since 1960 and, if the same trend continues, its level will drop another 9-13 m by the year 2000. Reduced inflow, with enhanced salinity from irrigations returns, has already increased the salinity of the Aral Sea threefold to 1 g/litre and by the year 2000 this is expected to rise to 3.5 g/litre. The proposed transfer of water from the Siberian rivers to the region will minimize the problems in the Aral Sea basin. (38)

D. Sustainable Development of Shared Water Resources

85. The traditional approach to water resources management has hitherto dealt with water as a natural resource *per se*, without due consideration for the relationship between watercourses and the surrounding ecosystems. Since international basins (whether rivers, lakes, or groundwater aquifers) provide considerable opportunities for socio-economic development, especially in developing countries, new and more comprehensive approaches to water management should be adopted. What is needed is development and management of water resources in such a way that the resource base is maintained and enhanced in the long run. In addition to economic growth, the objectives of water resources development should be the improvement of environmental and social conditions in the shared water basin. The three objectives - economic, environmental and social - should not be seen as mutually exclusive, but rather as complementary and, in the long run, mutually reinforcing.

86. These objectives can be achieved through the Environmentally Sound Management of Inland Waters (EMINWA) programme launched by UNEP in 1986. The programme is designed to assist Governments to integrate environmental considerations into the management and development of inland water resources, with a view to reconciling conflicting interests and ensuring the regional development of water resources in harmony with the water-related environment throughout entire water systems.

87. Within the framework of EMINWA, the Zambezi Action Plan (ZACPLAN) for the environmentally sound management of the common Zambezi river system was adopted in 1987. The Zambezi River with its tributaries drains an area of about 1.3 million square kilometres. It flows eastwards about 3,000 km from its source on the Central African Plateau to the Indian Ocean. About 20 million people live within the river basin, which includes eight countries: Angola, Botswana, Malawi, Mozambique, Namibia, United Republic of Tanzania, Zambia and Zimbabwe. The basin is a fast-developing region with great dynamism in population growth and development changes. That development will place demands on the freshwater resources of the Zambezi and on the fish, wildlife, forests, soil and mineral resources in the region. The river itself is integral to that development. Therefore, its management must be integrated into national and regional economic planning. That management must, in turn, be environmentally sound so that development may be sustainable. And, more important, that management must be co-ordinated and agreed upon so that conflicts on use and development can be avoided. ZACPLAN aims to fulfill these goals (see David (69) for a detailed description of the ZACPLAN)). Another project in the final stages of development for adoption is a master plan for the development and environmentally sound management of the natural resources of the conventional Lake Chad basin area, which covers parts of Cameroon, Central African Republic, Chad, Niger and Nigeria.

88. The development and management of shared water resources is an ambitious undertaking. It can be accomplished only through the political will and determination of the riparian States, through administrative commitment and the allocation of appropriate financial and human resources. The strategies for the development of shared water basins will differ from one region to another, depending on the geographical, geopolitical and socio-economic conditions

of the region, as well as on the nature and magnitude of the environmental problems encountered or likely to be encountered. Although the development and management of shared water resources is the responsibility of the riparian States, in developing regions many states may not have the financial and trained human resources to implement the formulated strategies. Such countries should be assisted, to enable them to achieve their development goals.

Chapter 5

MARINE ENVIRONMENT

89. Oceans cover more than 70 per cent of the Earth's surface and contain some of the Earth's most complex and diverse ecosystems. In addition to serving as the habitat for a vast array of plants and animals, the oceans also supply people with food, energy and mineral resources. Over half the people in the developing countries obtain 40 per cent or more of their total animal protein from fish.

90. The coastal zone constitutes only about 10 per cent of the total oceanic area, but accounts for more than half of the ocean's biological productivity and supplies nearly all the world's catch of fish. Coastal areas contain many kinds of ecosystems that are vital to marine life and humankind; four of the most productive are salt marshes, mangroves, estuaries, and coral reefs. About 60 per cent of the world's population, or nearly 3 billion people, live on or within some 100 km of a sea coast. In parts of South-East Asia, 75 per cent of the population live along the coast. Along the coastlines of Bangladesh, India, Pakistan and Sri Lanka, population densities often reach up to 500 per square kilometre, representing more than twice the number of people living in the interior. The recreational use of coastal waters attracts large numbers of people, at least seasonally, in many countries. In some areas this represents the major or even the only industry, and often the major source of foreign exchange earnings.

A. Sources of Marine Pollution

91. Coastal areas are the most vulnerable and most abused zones of the oceans. They receive direct discharges from rivers, surface run-off and drainage from the hinterland, domestic and industrial effluents through outfalls, and various contaminants from ships. Equally important are the physical changes in natural habitats, especially salt marshes, sea-grass beds, coral reefs and mangrove forests, resulting from increasing population pressures and often ill-planned development activities in coastal areas.

92. Rivers have carried large amounts of dissolved and particulate matter to the sea since ancient geological times. In many regions, discharged sediments formed deltas at the outlets of rivers. Along deltaic coastal areas, biogeochemical balances were established in spite of the seasonal variations of river discharges. During these geological ages the composition of material discharged into the sea was more or less constant; the material consisted of naturally weathered continental material. Estimates of river discharges into the sea vary from 10 to 64 billion tonnes of particulate matter per year, but a recent figure of 13.5 billion tonnes has been given. (70) Nearly 50 per cent of this material comes from Asian rivers, although they constitute only 17 per cent of the world's total drainage area.

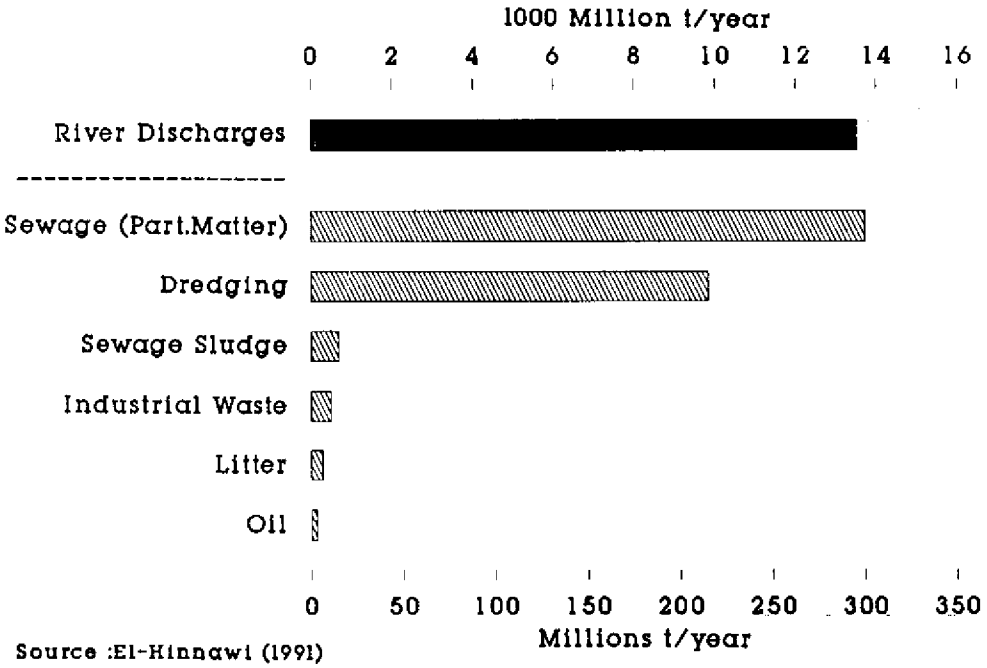
93. The biogeochemical balances that prevailed at the mouths of rivers and along the continental shelves have been disturbed in recent history by human activities on land and along coastal areas. Many rivers of the world can no longer be considered to be in their original natural states in terms of their dissolved and particulate loads. The construction of dams and reservoirs and the diversion of portions of rivers have reduced

discharges into the sea in many areas. This led to increases in coastal erosion, increases in the salinity of estuaries and coastal groundwaters, and significant effects on aquatic organisms that reproduce at the freshwater/seawater interface. The composition of river discharges has also been altered in several regions. Rivers act as large-scale collectors and carriers of wastewaters from diverse sources (especially domestic and industrial wastes) within their drainage basins and offload them into the sea. A number of other activities conducted inland also affect the sea and its resources. The use of agrochemicals, deforestation, irrigation and several other land-use practices result in various discharges into the marine environment.

94. Wastewaters (domestic sewage and industrial effluents) are a major cause of pollution of coastal zones. They normally reach the sea directly through outfalls, or indirectly through river discharges. The amount and the nature of wastewaters discharged into the sea vary from one area to another, depending on population densities in coastal areas, prevailing socio-economic conditions (industrialization and other activities), and the level of treatment of wastewaters prior to their discharge into the sea. It has been estimated that about 300 billion cubic metres of wastewaters is discharged annually into the sea (more than 90 per cent sewage and the rest industrial wastewaters, discharged separately or mixed with domestic wastewaters), containing some 300 million tonnes of dissolved and

Figure X

DISCHARGES IN THE MARINE ENVIRONMENT



Source :El-Hinnawi (1991)

particulate matter. Most of the sewage discharged into the sea is raw sewage, for example, in the Mediterranean only 30 per cent of the sewage from over 700 coastal towns and cities receives any form of treatment before being discharged into the sea. (71) Even after treatment, the effluent still contains oxygen-demanding material, suspended solids, nitrates, phosphates, viruses, heavy metals, pesticides, etc.

95. In addition to the above-mentioned discharges, a variety of material is dumped at sea. About 80 to 90 per cent of all material dumped at sea results from dredging. It has been estimated that some 215 million tonnes of dredged material is dumped at sea annually. (72) About two-thirds of this material is associated with operations to keep harbours, rivers and other waterways from silting up, and the remainder is associated with new works. About 10 per cent of dredged material is contaminated from various sources with oil, heavy metals, nutrients and organochlorine compounds. Industrial wastes and sewage sludge are also dumped at sea. On average, some 11 million tonnes of industrial waste and 15 million tonnes of sewage sludge are dumped annually. (73) Incineration of chemical wastes at sea has been practiced since the late 1960s. Between 1981 and 1984, European countries burned about 624,000 tonnes of wastes at sea. In 1987, eight North Sea countries agreed to reduce waste incineration and phase it out altogether by 1994. (74) A number of countries have dumped low-level radioactive waste in the sea. Between 1967 and 1982, about 94,000 tonnes of nuclear waste was dumped in the Atlantic Ocean. (75) However, dumping of radioactive waste has been halted since 1982. (72)

96. The surface waters, the floor and the beaches of the world's oceans are being visibly soiled by litter. Some 6.5 million tonnes of litter finds its way into the sea each year. In the past, much of such solid matter disintegrated quickly, but resistant synthetic substances have been replacing many natural, more degradable materials. Plastics, for example, persist for up to 50 years and, because they are usually buoyant, they are widely distributed by ocean currents and the wind. Most beaches near population centres are littered with a multitude of plastic residues washed up from the sea, contributed by rivers, ships and outfalls, dumped by illegal refuse operators, or left behind by beach users. A major source of plastic debris is the fishing industry, whose nets, ship lines, buoys and other equipment are now manufactured largely from synthetic materials. There is no estimate of how much plastic debris the oceans contain, but it has been estimated that more than 150,000 tonnes of fishing gear is lost (or discarded) in the oceans each year. (72) Also, it has been estimated that at least 450,000 plastic containers were dumped from the world's shipping fleet in 1985. Along the beaches of the Mediterranean, up to 70 per cent of the debris examined was plastic; in the Pacific, the figure reached more than 80 per cent. (76)

97. The introduction of petroleum into the marine environment is a direct consequence of the production and transportation of crude oil and refined products. Recent estimates indicate that the amount of petroleum, from all sources, entering the marine environment is 3.2 million tonnes (22.3 million barrels) annually. (77,78) Of this amount, 45 per cent is from marine transportation, including tanker operations, other shipping activities and accidental spills from ships. Municipal and industrial waste discharges and runoff account for 36 per cent of oil in the marine environment. The most dramatic occurrences of marine oil pollution - those that make headline news - result from offshore drilling-platform accidents or tanker accidents that spill large quantities of oil. Time-series data show that from 1976

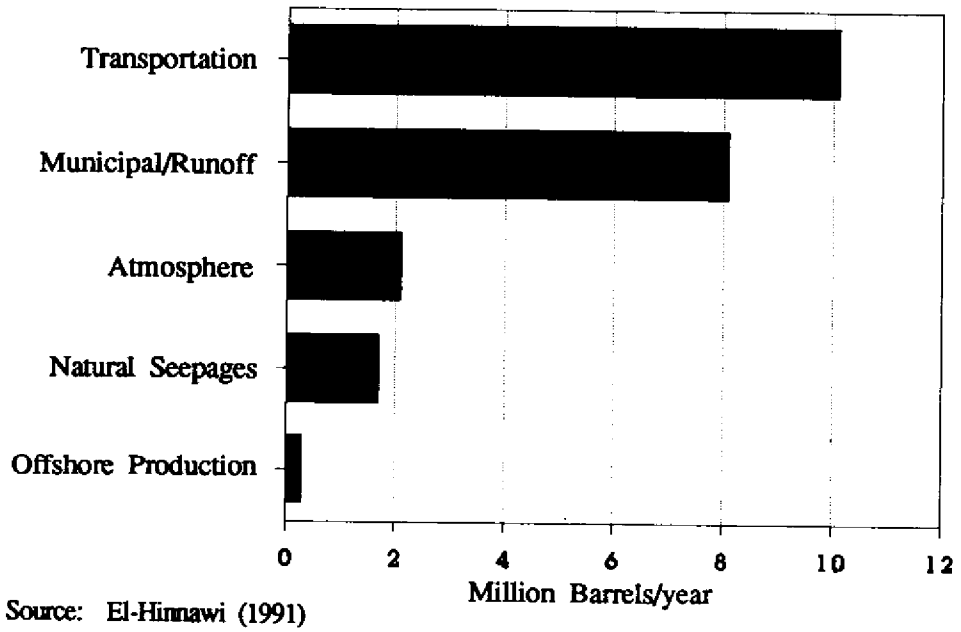
to 1986 the total number of oil-spill incidents dropped from 1099 to 118. For major accidents with over 5,000 barrels (about 700 tonnes) spilled, the cor- responding figures were 25 and 6. (79) That decrease in the number of accidents, and consequently the amount of oil spilled into the ocean, was mainly due to a drop of 25 per cent in the amount of oil moved by sea in the period 1976 to 1986. The reduction of oil movement has also cut operational inputs of oil into the marine environment. This has been aided by the entry into force of the 1973 International Convention for the Prevention of Pollution from Ships and its 1978 Protocol, requiring among other things, that tankers be fitted with segregated ballast and crude oil washing systems.

B. Impacts of Marine Pollution

98. Material discharged into the sea can exert varying impacts on the marine environment. The magnitude of the impact is a function of the chemical and biological characteristics of the material, its form, total amount and concentration, persistence, and the dilution potential and characteristics of the receiving marine environment. Some marine organisms have a remarkable ability to accumulate substances from seawater, even when the materials are present in extremely low concentrations. Others have the ability to convert some compounds into more toxic ones; for example, the well-known conversion of inorganic mercury into

Figure XI

INPUT OF PETROLEUM IN THE MARINE ENVIRONMENT

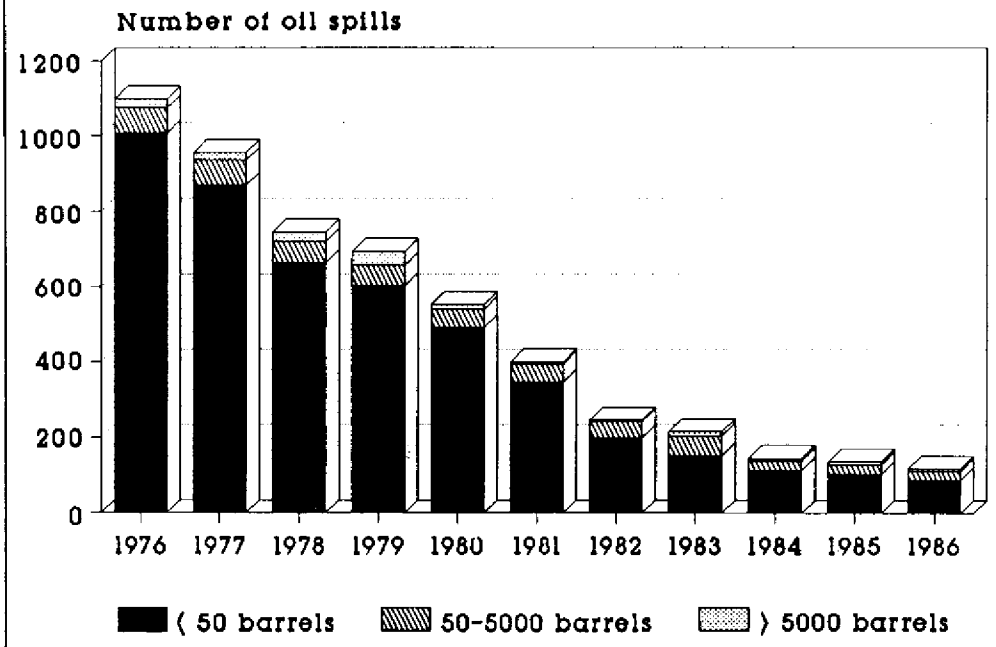


Source: El-Hinnawi (1991)
Based on data from NAS (1989)

methylmercury. Both the quality of seawater and that of the marine living resources have impacts on human health and well-being.

99. The principal problem for human health on a world-wide scale is the existence of pathogenic organisms discharged with domestic sewage into coastal waters, estuaries or rivers and drainage canals that carry these organisms to the sea. Sewage contains pathogenic organisms, such as enteric bacteria, viruses, protozoa and helminth worms. Bathing in seawater receiving such sewage and consumption of contaminated fish and shellfish are the causes of a variety of infections. Epidemiological studies have provided unequivocal evidence that swimmers in sewage-polluted seawater have an above-normal incidence of gastric disorders and that the increase is correlated with *Enterococcus* counts in the water rather than with *Escherichia coli* counts. (72) Studies have also indicated increased incidence of non-gastric disorders, such as ear, respiratory and skin infections. The consumption of contaminated seafood is firmly linked with serious illness, including viral hepatitis and cholera.

Figure XII
INCIDENCE OF OIL SPILLS



Source: EL-Hinnawi (1991)
Based on data from Walder (1990)

100. Both sewage and agricultural runoff introduce large quantities of nitrogen and phosphorus into coastal water. These compounds, from sources such as detergents, fertilizers and human and animal waste, nourish algae and can cause an explosive growth. Excessive algal growth can deplete the water of oxygen and suffocate other species. Oxygen-depleted

waters are known as "dead zones"; a 4,000-square-kilometre dead zone has been found in the Gulf of Mexico, near the mouth of the Mississippi River. Algae clusters can block sunlight and stunt the growth of other marine life. Over the past two decades, the frequency of algal blooms has been increasing in the coastal areas around the world. Some of the algae produce toxins which are detrimental, even fatal, to other marine life. The toxins may also be consumed by other organisms, become enriched in the marine food chain, and ultimately affect people who consume marine food. An outbreak of paralytic shellfish poisoning (PSP) in Guatemala in 1987 killed 26 people; the organism involved is believed to have been a toxic alga, *Pyrodinium bahamense*. The incidence of PSP is increasing globally. (80) The term "red tide" is in general used to describe the discolouration of water caused by any algal bloom. Red tides (dominantly toxic) are annual events in many parts of the world. Japan's Inland Sea is affected by some 200 red tides each year. The number of red tides in Hong Kong harbour has increased from two in 1977 to 19 in 1987. (43) In 1988, blooms of algae occurred in the seas around southern Scandinavia, damaging marine life in some seas and in some fish farms along the coast of Norway. (81) Although unusual occurrences of algal blooms have been attributed to a combination of many factors, especially to disturbances in the marine ecological balance caused by climatic factors, considerable evidence suggests that the increased incidence of blooms is related to the nutrient enrichment of coastal waters and inland seas on a global scale. (43)

101. Several chemical compounds reach the sea through direct or indirect industrial discharges, rivers, storm and irrigation runoff from land, ocean dumping, and atmospheric deposition. Many of these compounds are not biodegradable and tend to accumulate in various organisms. Halogenated hydrocarbons accumulate in fatty tissues, the amount accumulated increases through the food chain, so that high concentrations are found in the bodies of the top predators among birds, fish, and mammals. Where the contamination has built up over decades, such as in enclosed areas like the Baltic and the Netherland's Wadden Sea, the reproductive capacity of marine mammals and birds has been affected. (72) Polychlorinated biphenyls (PCBs) accumulated in seafood can reach levels unacceptable for marketability. In some areas, such as parts of the middle Atlantic Bight of the United States, fish consumption has been restricted because of the high levels of PCBs in fish tissues. Organometallic compounds, such as tributyltin (TBT), are used as fungicides and biocides (TBT has been widely used as an antifoulant in marine paints). TBT affects a wide range of invertebrates and its use in marine paints was recently restricted in France, the United Kingdom, and several states in the United States. (72) Normally, heavy metals concentrations in the sea are considerably below those that produce toxic effects in organisms. However, in areas highly polluted by industrial discharges (the so-called "hot spots") and in the case of industrial accidents, heavy metals are of particular concern. The mercury poisoning at Minamata, Japan, in the mid-1950s spurred widespread concern over metal pollution in the oceans, (82) and edible fish and shellfish are regularly monitored by some countries for their metal content. Concentration limits set internationally through the FAO/WHO Codex Alimentarius and also by many national food inspection services protect the consumer from exposure to high levels of metals in food.

102. Oil in the sea is normally found in concentrations too low to pose a threat to

marine organisms. However, oil spills, especially major ones, are notorious for their various effects. For example, the Ixtoc blow-out off the Mexican coast in 1979 discharged about 400,000 tonnes of oil, producing an oil slick which spread across the Gulf of Mexico and contaminated beaches in Texas, damaging birds and marine life. Oil spilled from the "Exxon Valdez" tanker accident in 1989 killed more than 36,000 birds and 1,000 sea otters and polluted more than 2,600 square kilometres of pristine coasts in Alaska. (43) In addition to aesthetic and ecological concerns, coastal regions can suffer economically from damage done by oil spills to recreational areas, harbours and vessels, commercial shellfish grounds, and intake sources for desalination and power plants.

103. Several human activities have direct effects on coastal areas, especially on sensitive ecosystems such as salt marshes, mangroves and coral reefs. For example, mangrove forests on the East African coast have been depleted for fuelwood and building materials. Along East Asian coasts, extensive conversion of mangrove forest to rice fields has eliminated natural barriers to flooding from storms. Indonesia has converted large areas of coastal mangroves to rice paddies and shrimp ponds. In Central and South America, mangroves are being cleared for fish farming. Coral reefs also face a variety of threats and are being damaged in some tropical regions by excessive uncontrolled tourism and by construction works near the coast.

104. In the open ocean, in contrast to coastal zones, the direct impact of man's activities is slight. For the most part, human fouling of the open ocean results either directly from shipping activities or indirectly from atmospheric pollution. Although contaminants such as organochlorines, metals, radionuclides, and oily residues can be detected in deep waters, they occur only in low concentrations. (72)

C. Living Marine Resources

105. Of the nearly 20,000 known species of fish, about 9,000 are currently harvested, but only 22 species are regularly caught in significant quantities. Just six groups - herrings, cods, jacks, redfishes, mackerels and tunas - account for nearly two-thirds of the total annual catch. The world marine fish catch (including aquatic plants) rose from 66 million tonnes in 1978 to 88 million tonnes in 1988. (44) The FAO estimates that the world catch ought not to exceed 100 million tonnes per year if the risk of a substantial depletion of fish stocks is to be avoided. However, pressures on stocks in certain areas already amount to overfishing. Overfishing in regions close to the industrial areas of the northern hemisphere, for example, has resulted in a decline in the size and quality of some species of fish and the increasing scarcity of others. Overfishing has led to a sharp drop in catches of cod and herring in particular, and fishing for these species in the north-east Atlantic was made subject to quotas in the 1970s and subsequently banned altogether for certain stocks, in order to allow them to recuperate.

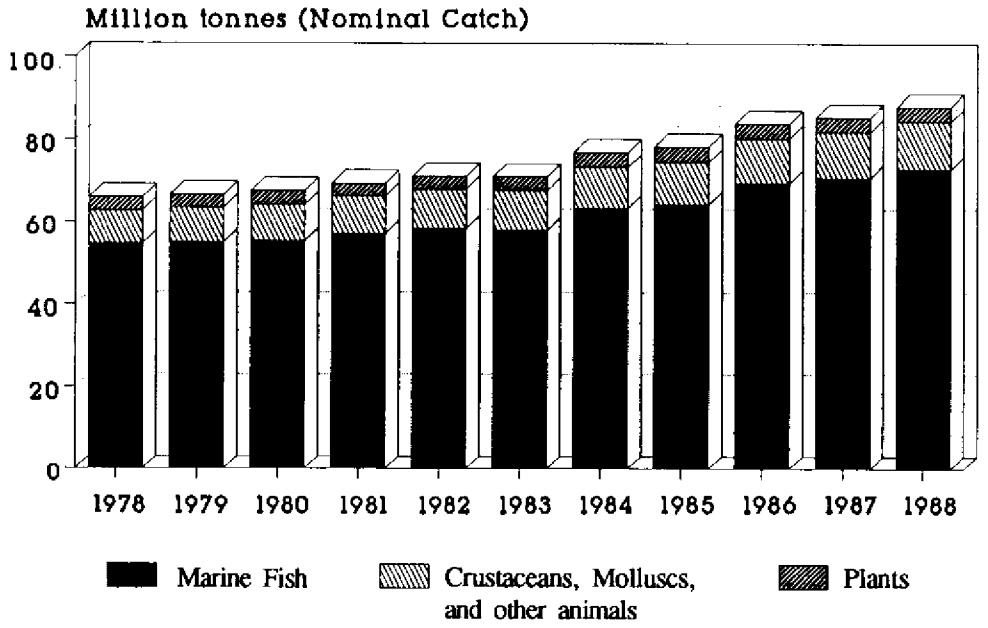
106. Excessive harvesting of whales, dolphins, seals and polar bears is one of the clearest examples of overexploitation of marine resources. At its peak, the whaling industry killed some 66,000 whales a year and depleted many species to near extinction. In 1989, new provisional International Whaling Commission figures indicated that of the million Sperm whales that once roamed the oceans, only 10,000 are thought to be left. Humpbacks seem to be down from 20,000 to 4,000, Fin whales from more than 100,000 to 2,000, and Blue whales from 250,000 to around 500. (83) In 1985, the International Whaling Com-

mission imposed a five-year moratorium on commercial whaling. But since then more than 11,000 whales have been killed.

D. Protection of the Marine Environment

107. Protection of the marine environment depends primarily on the appropriate and environmentally sound planning of many human activities, especially in densely populated coastal areas. Such planning should minimize or prevent undesirable discharges into the marine environment and should curb the destruction of sensitive coastal ecosystems and their extensive biological resources. A legal framework, both national and international, for the protection of the marine environment is also indispensable. Internationally, oil pollution was the initial concern, because it is the most visible and has long been the most objectionable form of pollution. For this reason, legislation to control it was enacted early. More recently, dumping at sea and pollution from land-based sources through chemicals and litter and, increasingly, nutrients have become the subject of regulation (see the report of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (72) for a brief review of such legislation). Although coastal development is subject to regulation in some countries, in many cases the regulations are ineffective for the protection of the marine environment and coastal ecosystems. No international agreements or guidelines on coastal development are available. (72)

Figure XIII
PRODUCTION OF MARINE FISHERIES



Source: El-Hinnawi (1991)
Based on data from FAO (1989)

108. In 1982, the United Nations Convention on the Law of the Sea was adopted. Its provisions on the protection and preservation of the marine environment established an overall framework of governing principles and general obligations - notably, those requiring States to take all necessary measures to prevent, reduce and control marine pollution from any source, and to co-operate, on a global and regional bases, as appropriate, in the formulation and elaboration of international rules, standards and recommended practices and procedures and in the establishment of appropriate scientific criteria for these purposes. The obligation to co-operate also extends to the notification of imminent or actual damage, the adoption of contingency plans against pollution, and the carrying out of research programmes.

109. Because the state of enclosed and semi-closed regional seas is in general more disturbing than that of the open oceans, UNEP has accorded high priority to the development of regional plans of action to prevent the further deterioration of the state of the regional seas and to improve it. So far, action plans for nine regions have been adopted; (the Mediterranean, Kuwait Action Plan, the Wider Caribbean, West and Central Africa, East Africa, South-east Pacific, Red Sea and the Gulf of Aden, South Pacific and East Asia) and regional conventions have been signed in all of them except East Asia, where the action plan was adopted in 1981. An action plan was recently drafted for the South Asian region, and it is hoped that it will be formally adopted by the concerned Governments in 1991, along with a convention and associated protocols to combat oil spills. All in all, the regional seas programme involves some 130 countries.

110. Recently, the Inter-governmental Panel on Climate Change predicted that, with the present rate of emission of greenhouse gases into the atmosphere, there may be an increase in global mean temperature which would result in a global sea-level rise due to thermal expansion of the surface water of the oceans and the melting of some land ice (see Chapter 2). The predicted rise is about 20 cm in global mean sea-level by 2030, and 65 cm by the end of the next century. There will be significant regional variations. Global warming and sea-level rise of that magnitude can cause fundamental changes in marine ecosystems, with considerable socio-economic consequences; sea-level rise would destroy low-lying islands and coastal areas, resulting in massive human displacements, loss of property and massive economic losses. In addition, it would destroy many sensitive coastal ecosystems and their biological resources. The international community is preparing to start negotiating an international agreement to deal with climate change (see Chapter 2).

111. In spite of various efforts to protect the marine environment, progress has been rather slow, especially in the developing regions. Even some of UNEP's regional seas programmes are in danger of neglect, as other concerns head government agendas. The 1990 report of GESAMP and the present Chapter highlight the rapid deterioration in the coastal areas of the world's oceans and the threat of significant harm to the marine environment in the near future, unless strong co-ordinated national and international action is taken now. At the national level in particular, the concerted application of measures to reduce discharges into the sea and to manage coastal areas in a rational and environmentally sound way will be essential. The efforts may be great and the costs high, but nothing less will ensure the continued health of the sea and the sustainability of its resources.

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